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23 December 2021

NL213311

Upper Hunter Shire Council
Paul Smith
PO Box 208
Scone NSW 2337

Dear Paul,

Re: Review of Stormwater Management Plan at 150 Gundy Road, Scone

Northrop Consulting Engineers have been engaged by Upper Hunter Shire Council (UHSC) to review the Stormwater Management Plan prepared for the proposed development (DA163/2017) at 150 Gundy Road, Scone.

This desktop review has been undertaken generally in accordance with the below methodology:

- General review of the applicants stormwater and flooding reports and the proposed stormwater management strategy.
- Technical review of model parameters including a comparison of the applicants peak flow, generated using DRAINS, with other studies compelted in the area.
- Review of the proposed development and the documentation provided to confirm the proposal satisfies, or otherwise, the relevant stormwater and flood related Local Environmental Plan (LEP) and Development Control Plan (DCP) requirements.

This assessment has considered the following legislation policies and guidelines:

- Upper Hunter Shire Council Local Environmental Plan (LEP) (2013).
- Upper Hunter Shire Council Development Control Plan (DCP) (2015) in particular Sections 3 (Subdivisions),10a (Floodplain Management), 11f (Soil and Water Mangement) and 13a (Specific Localitities - St Aubin's Estate).
- Upper Hunter Shire Council Draft Engineering Guidelines for Subdivisions and Developments
- National Resources Access Regulator (NRAR) Guidelines for controlled activities on waterfront land (2018)
- NSW Government Flood Prone Land Policy.
- NSW Floodplain Development Manual (2005).
- Australian Rainfall and Runoff (2019).

		Date
Prepared by	NM	23/12/2021
Checked by	LG	23/12/2021
Admin	BBR	23/12/2021

This correspondence has been prepared based the following reports and studies which have been provided by Council for the purposes of this investigation:

- Stormwater Management Plan for DA – Peppertree Estate, Gundy Road, Scone prepared by ACOR Consultants Pty Ltd Revision 01 dated the 19th of August 2021, herein refered to as the "Stormwater Mangement Plan (ACOR, 2021)".
- Stormwater Drainage Strategy Peppertree Estate Scone prepared by MM Hyndes Bailey and dated November 2017.
- The Scone Bypass Flood Study prepared by GHD and dated December 2015.
- Scone Floodplain Management Study and Plan prepared by Bewsher Consulting and dated 1999.

Presented below is a technical review of the DRAINS models, a review of the concept stormwater management strategy, and an assessment of the proposal with respect to the relevant Upper Hunter Shire Council Development Control Plan (DCP) and Local Environmental Plan (LEP) controls.

Technical Review

Modelling Approach

The Stormwater Management Plan (ACOR, 2021) has used DRAINS to estimate the peak flow approaching the western and south-western boundaries.

The modelling methodology involved:

- Generating peak flows for pre to post developed scenarios for a range of design storm events from the 20% to 1% AEP and durations ranging from 5 minutes to 6 hours.
- Comparing peak flow results at the western and south-western boundaries of the site.

The DRAINS model was prepared generally using ARR 2019 procedures. Two runoff routing methods have been adopted, namely:

- The RAFTS storage routing model has been used for the large rural catchments upstream and existing catchment conditions.
- The proposed developed catchment has been modelled using the Initial Loss – Continuing Loss (IL-CL) model.

Model Parameters

The model parameters presented in the Stormwater Mangement Plan (ACOR, 2021) report as well as the DRAINS models provided have been reviewed with the results of the investigation summarised in the following ***Table 1***.

Table 1 - DRAINS Model Review

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment
Initial Losses	• Storm Initial Loss values used in the DRAINS model are summarised below. ○ Impervious Area Initial Loss (mm): 1.0 ○ Pervious Area Initial Loss (mm): 34.0	• The latest advice commissioned by the NSW Office of Environment and Heritage (OEH), recommends practitioners undertaking hydrological modelling in NSW should use the NSW Specific Hierarchy Approach. • Based on this hierarchy, Option 5 is expected to be the most suitable strategy for this study. Which includes the use of the ARR Data Hub storm losses combined with the Transformational Pre-burst rainfall, and a reduction of the data hub continuing losses by a factor of 0.4. • Options 1, 2, 3 and 4 of the hierarchy are expected to be omitted due to following reasons. 1. Both adopted flood studies for Scone (1999) and the most recent Scone Bypass flood study (2015) do not present any calibrated catchment losses. 2. The subject site is not located in an NSW FFA-reconciled losses catchment with the closest gauge located in Rouchel Brook (The Vale) approximately 19km away. • Further to the above, ARR 2019 recommends consideration to in-directly connected impervious areas as a fraction of the total impervious area, with a suggestion of 60-80% of the rural pervious losses to be used for indirectly connected impervious losses. • It is noted that it is not possible to adopt this strategy when using RAFTS routing (due to single impervious and pervious catchments) however, may be adopted for the developed areas when using the IL/CL method.

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment

Continuing Losses	• Storm Initial Loss parameters values used in the DRAINS model are summarised below.
	  ○ Impervious Area Continuing Loss (mm/hr): 0.0
	  ○ Pervious Area Continuing Loss (mm/hr): 1.5
		• As mentioned above, it is recommended that the default continuing loss value provided by the ARR Data Hub be reduced by a factor of 0.4 in accordance with the latest NSW Specific advice.

Pre-Burst Rainfall	Section 5.3.3 suggests: • Median Pre-Burst depths have been used for the investigation	• As mentioned above, the latest NSW Specific advice recommends the Probability Neutral Burst Initial Losses (PNBIL) should be used for studies in NSW. The PNBILs are generated through the use of the Transformational Pre-Burst rainfall and the storm losses provided in the ARR Data Hub discussed above. • DRAINS uses the Transformational Pre-Burst rainfall automatically in lieu of the Median pre-burst, if the ARR Data Hub text file contains the Transformational data (which is the case when requesting this data across NSW). • Review of the DRAINS models provided suggests the Transformational Pre-Burst rainfall has been loaded into the DRAINS models correctly, rather than the Median Pre-Burst as suggested in Section 5.3.3.
Rainfall Data	Section 5.3.3 suggests: • Bureau of Meteorology IFD Depths have been used.	• Review of the rainfall depths contained in the DRAINS models suggests the correct depths have been used for the area.
Impervious Fraction	Section 5.3.5 suggests: • For the upstream catchments, a fraction impervious of 0.35 has adopted. • A fraction impervious of 0 has been adopted for the predeveloped site (existing rural property). • A fraction impervious of 0.75 has been adopted for the proposed subdivision.	• The adopted impervious fractions are generally in accordance with the UHSC Draft Engineering Guidelines for Subdivisions and Developments. • It is noted that an open space impervious percentage of 35% for the upstream rural catchments is considered high given these catchments are largely undeveloped and made up of pastural grasses. As such, a sensitivity test is recommended

Item	Stormwater Management Plan (ACOR, 2021)	Northrop Comment
		to review the impact this assumption has on the detention modelling. • In addition, as mentioned above, the latest ARR 2019 guidelines recommend consideration to splitting the Total Impervious Area (TIA) into the Effective Impervious Areas (EIA) and In-Directly Connected Impervious Areas (ICIA). This strategy may be adopted for the developed areas when using the IL/CL method. • As a minimum a sensitivity test using this strategy should be considered to review the impact this assumption has on the detention modelling.
Time of Concentration	Section 5.3.5 suggests: • The time of concentration for the catchments that are modelled using RAFTS are determined automatically by the program. • For the catchments utilising IL-CL model a minimum of 5 minutes has been used for the impervious catchments and 10minutes for the pervious catchments.	• This strategy for determining the time of concentration is considered reasonable.
Surface Roughness	Section 5.3.5 suggests: The following Manning's roughness values have been adopted for the catchments modelled using RAFTS: • A Manning's value of 0.05 for the external catchments. • A Manning's value of 0.04 for the predeveloped catchments. • A Manning's value of 0.04 for the stream traversing through the site (waterways and minimal vegetation and trees).	• The adopted hydrological roughness values are considered to be within a reasonable range, based on a review of aerial imagery and google street view.

Peak Flow Comparison

The modelled pre-developed peak flows have been compared against the flows observed in the Scone Bypass Flood Study (GHD, 2015) and the MM Hyndes Bailey Study (2017) as presented in ***Table 2*** below.

Note that, due to the larger modelled catchment size in the Scone Bypass Flood Study (GHD, 2015), peak flows were reduced by a factor of ~0.6 (based on the ratio of catchment size) to provide an approximation of the flows to compare with the Stormwater Mangement Plan (ACOR, 2021).

Table 2 - Peak Flow Comparison at the Western Site Boundary

Model	10% AEP	1% AEP
Scone Bypass Flood Study (GHD, 2015)	6.93	28.56
Stormwater Mangement Plan (ACOR, 2021)	25.40	47.60
MM Hyndes Bailey (2017) (Table 4)	-	29.8

The results presented in ***Table 2*** suggests a higher peak flow is observed in the Stormwater Management Report (ACOR, 2021) when compared to other studies performed in the area. The higher peak flow is expected to result in a wider flood extent when compared to the extents presented in MM Hyndes Bailey report (2017). As such, flooding in the second order creek should be re-assessed using the latest guidelines. These differences in peak flow should be discussed in the Stormwater Management Plan (ACOR, 2021).

Stormwater Management Strategy

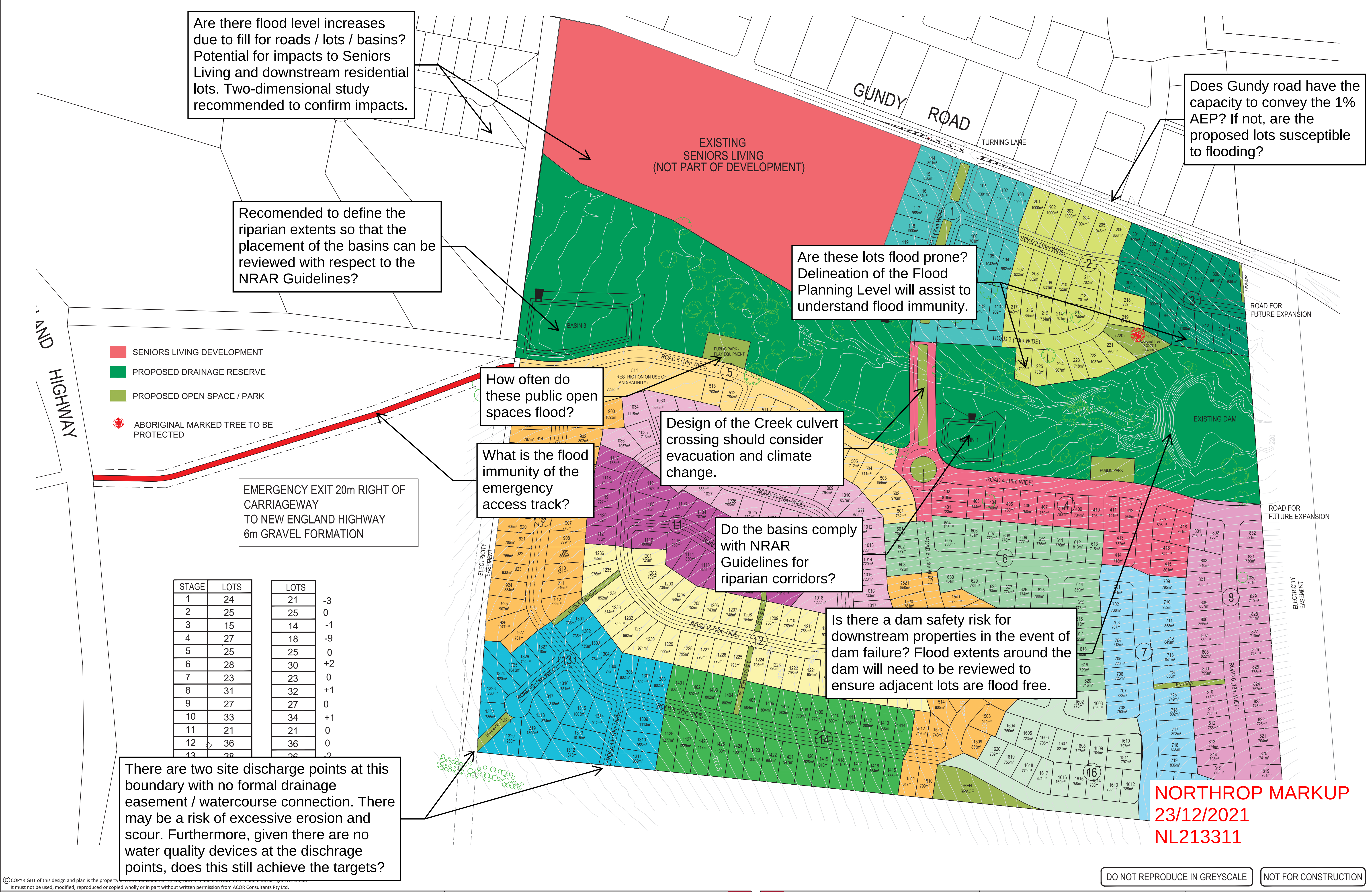
A review of the proposed Concept Stormwater Management Plan (ACOR, 2021) has been prepared with comments presented in **Figure 1** and summarised below.

Flooding

The Stormwater Management Plan (ACOR, 2021) refers to the MM Hyndes Bailey report (2017) for the flood extents through the second order creek. The modelling presented in the MM Hyndes Bailey report (2017) has been prepared with flows derived using the Regional Flood Frequency Estimation tool and flood extents determined using HEC-RAS.

As previously discussed, peak flows are considerably higher in the Stormwater Management Report (ACOR, 2021) than the MM Hyndes Bailey report (2017). The modelling has also been prepared based on an old layout with the flood extents not reflective of the development layout presented in the Stormwater Management Report (ACOR, 2021).

Following a review of the above studies, we are unable to accurately determine the extent of the 1% AEP flood event and evidently the extent of the Flood Planning Area for the proposed layout. This information is required to determine whether the proposed lots, roads and infrastructure are susceptible to flood and whether they are sited in accordance with the LEP / DCP / NSW Floodplain Development Manual.



STAGE	LOTS	LOTS	
1	24	21	-3
2	25	25	0
3	15	14	-1
4	27	18	-9
5	25	25	0
6	28	30	+2
7	23	23	0
8	31	32	+1
9	27	27	0
10	33	34	+1
11	21	21	0
12	36	36	0
13	28	26	[illegible]

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This drawing has been assigned an electronic code that signifies the drawing has been checked and approved by: NAME&CREDENTIALS

Issue	Description	Date	Drawn	Approved
B	LOT BOUNDARIES UPDATED, ISSUED FOR CLIENT REVIEW	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK

North

Client: CHARLES DAVID PTY LTD

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ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: STORMWATER MANAGEMENT PLAN
LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title: PROPOSED DEVELOPMENT LAYOUT

Drawn	Date	Scale A1	Q.A. Check	Date
ADS	MAR 2021	N.T.S.	UK	12.03.21

Designed	Project No.	Dwg. No.	Issue
UK	NSW202732	FIGURE 4	B

Aug 20, 2021 - 11:59am

In addition, it is possible the section of the development located on the southern side of the creek may become a high flood island during a major / extreme flooding event. An emergency exit track from the development is proposed however, it is not possible to determine the flood immunity of this track from the documentation provided. It is recommended the design of emergency access track, or the creek culvert crossing be reviewed with consideration to risk to life and evacuation from this area.

As mentioned, the MM Hyndes Bailey report (2017) reviews an old development layout and does not consider existing case flood behaviour. As such, it is not possible to determine if there are any adverse flood impacts due to fill for roads, lots and the bio retention basins within the existing second order creek.

There are sensitive sites adjacent to the proposed development, namely the senior's living village (HammondCare Strathearn House) as well as residential properties downstream. We recommend a two-dimensional flood study be prepared using the latest developed layout to confirm whether there are any significant adverse flood impacts in these properties. This study may also be used to verify the requirement for no stormwater detention for the proposed development.

Furthermore, Section 3.4 of the Stormwater Management Report (ACOR, 2021) highlights the potential for the existing road-side swales in Gundy Road to overtop during major events. An assessment on the capacity of Gundy Road to convey overland flow during the 1% AEP should be prepared and stormwater upgrades proposed as necessary to ensure the proposed lots fronting Gundy road are not flood prone.

Stormwater Infrastructure

There is an inconsistency in the size of the creek culvert crossing between the MM Hyndes Bailey (2017) report and those proposed in the Stormwater Management Report (ACOR, 2021). Each report suggests the following:

- MM Hyndes Bailey (2017): 10 x 1500mm x 750mm
- Stormwater Management Report (ACOR, 2021): 11 x 2400mm x 750mm

This discrepancy should be discussed in the Stormwater Management Report (ACOR, 2021) with consideration to the risk to life and evacuation requirements as discussed in the above flooding section.

Furthermore, it is unclear whether blockage has been considered in the design of the proposed culvert crossing. Similarly, it is not possible to determine the flood immunity and available freeboard to the culvert crossing under todays and future climate scenarios. These should be discussed in the Stormwater Management Report (ACOR, 2021).

Riparian Extents

The Stormwater Management Report (ACOR, 2021) suggests the creek bisecting the proposed development is a second order watercourse. The applicant should address whether the proposed bio-retention basins, that are to be placed adjacent to the watercourse, comply with the NSW Natural Resources Access Regulator (NRAR) guidelines for Controlled Activities on Waterfront Land.

Riparian extents are not presented in the documentation and as such, it is not possible to assess the NRAR requirements with the information provided.

South-Western Corner

There are two site discharge points in the south-western corner of the site; one discharging into the electrical easement and another to connect to a future road corridor. From the information provided, it does not appear that these outlets connect to a formal drainage easement or watercourse connection.

Without a formal drainage connection, there is a risk of excessive erosion and scour downstream of these discharge points. The applicant should review whether mitigation measures are required to ensure the downstream ecosystem, road and stormwater infrastructure, farms and properties are not adversely impacted.

Furthermore, there are no end of line water quality devices proposed at this location (GPT / Bio-retention). As this catchment discharges to a separate watercourse, the water quality assessment should confirm that the treatment targets can be met at each site discharge point.

Existing Dam

Section 3.5 notes that the existing farm dam is to remain as part of the development. The applicant should consider whether there is a dam safety risk for the proposed and existing properties downstream of the dam in the event of failure.

Similarly, an access track will be required to ensure the condition of the dam can be assessed and maintained as required.

Local Environmental Plan

The proposed development has been reviewed with respect to the Upper Hunter Shire Council Local Environmental Plan (2013), in particular Par 5.21 – Flood Planning. A summary of how the Stormwater Management Plan (ACOR, 2021) archives, or otherwise, the LEP requirements is presented in the below ***Table 3***.

Table 3 - UHSC LEP (2013) requirements

Item	Discription	How Addressed?
Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development:		
(a)	• is compatible with the flood function and behaviour on the land, and	• As the existing and latest developed case flood behaviour has not been defined, it is not possible to assess this adequately.
(b)	• will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and	• A pre-to-post detention assessment has been performed however, there is the potential for flood impacts to occur as a result of fill within the creek. • As the Flood Planning Area and site flood behaviour for the latest layout has not been defined, it is not possible to assess this adequately
(c)	• will not adversely affect the safe occupation and efficient evacuation of people or exceed	• As the existing and developed case flood behaviour has not been defined

Item	Discription	How Addressed?
	the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	for the latest layout, it is not possible to assess this adequately.
(d)	• incorporates appropriate measures to manage risk to life in the event of a flood, and	• It is not possible assess this adequately based on the information provided.
(e)	• will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	• It is not possible assess this adequately based on the information provided. • There is the potential for erosion and siltation of the watercourse downstream of the south-western site discharge points.
In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters:		
(a)	• the impact of the development on projected changes to flood behaviour as a result of climate change,	• Climate change has not been considered as part of the investigation. • As such, it is not possible assess this adequately based on the information provided.
(b)	• the intended design and scale of buildings resulting from the development,	• A concept layout has been provided and therefore, the scale of the development can be adequately assessed.
(c)	• whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,	• Risk to Life and evacuation is not discussed in the information provided. • As such, it is not possible assess this adequately based on the information provided.
(d)	• the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion	• As the site flood behaviour has not been defined using the latest layout, it is not possible to assess this adequately.

Development Control Plan

The proposed development has been reviewed with respect to the Upper Hunter Shire Council Development Control Plan (2015). The controls with respect to both flooding and stormwater management have been assessed.

Flooding

Development controls defined in Part 10a (Floodplain Management) of Council's DCP are applicable for land that is located below the Flood Planning Level and/or has been classified by it's Planning Certificate to be susceptible to flooding. The Section 149 Planning Certificate provided by Council suggests part of the subject site is susceptible to flooding and as such, Part 10a of the DCP applies.

Table 16 of Part 10a presents the provisional matrix and provisional development controls for development susceptible to flooding. The matrix has been reproduced as **Table *5*** below.

Table 4 - Floodplain Management Prescriptive provisions matrix (Table 16 of UHSC DCP Part 10a)

Proposed Land use	Section of Floodplain			
	Flood Planning Level (FPL) to Probable Maximum Flood (PMF)	Low Hazard	High Hazard	Other Flood Prone Land (Hazard Unknown)
1 Single Dwelling Houses		1,2,5		
2 Agriculture & Recreation		2,5		
3 Sheds / Garages / ancillary Residential		1,2,5		
4 Commercial and Industrial Uses		2, 6		
5 Medium to High Density Residential				
6 Critical or Sensitive Facilities	3			
7 Land Subdivision	4			
8 Tourist Development				
9 Caravan parks - short-term sites		5,6		
10 Permissible Earthworks		7		

Green	Flood related development controls do not apply
Yellow	Flood related development controls apply (refer to numbered prescriptive criteria in Table 17 Prescriptive Criteria)
Orange	If the proposal is to be pursued further, a performance based assessment is to be provided demonstrating that the proposed development is compatible with the flooding characteristics of the site (refer to the section "Performance based assessment" and Table 19 Detailed Assessment Criteria).

As part of the site is expected to be located between the FPL and the PMF as well as below the 1% AEP, a joint civil and flood report and a performance-based assessment is required in accordance with the requirements set out in the DCP.

The requirements to be satisfied for the performance-based assessment are summarised below:

- Development will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.
- Development incorporates appropriate measures to manage risk to life and property from flood;
- Development will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses;
- Development is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.
- Development is consistent with the principles of Ecologically Sustainable Development.

It is noted that the information contained in the Stormwater Management Report (ACOR, 2021) and MM Hyndes Bailey report (2017) by does not provide enough information to enable assessment of the proposed development with respect to the relevant flood items outlined in the LEP and DCP. As outlined in the DCP, a joint flood and civil report will need to be prepared to enable assessment of latest layout.

Stormwater Management

The DCP requirements relating to Stormwater Management contained in part 11f.6 of Council's DCP are summarised in the below **Error! Reference source not found.**. A summary of how the proposal satisfies, or otherwise, these Stormwater Management requirements is also presented in **Table *5***.

Table 5 - DCP requirements

<table>
<tr><th>Item</th><th>DCP Requirement</th><th>How addressed?</th></tr>
<tr><td rowspan="3">M. Stormwater design objectives</td><td>• Apply the stormwater drainage approach advocated by Engineers Australia in ‘Australian Rainfall and Runoff’ to design surface levels so that very large (major system) 1% AEP (100year ARI) events can flow around the buildings without relying on underground pipes and that the Main drainage system design and construction:
○ retains, and where practical, restores natural water courses, native riparian vegetation, wetlands and other natural landscape features,
○ incorporates effective measures to manage and treat stormwater and maintain healthy aquatic ecosystems,
○ satisfies acceptable risk management standards for public safety and flood protection, and
○ within new developments local drainage shall be designed to avoid local flooding in accordance with the aims and objectives of the NSW Floodplain Development Manual. (April 2005).</td><td>• Riparian extents are not presented or discussed in the Stormwater Management Report (ACOR, 2021).
• Water Quality devices are proposed however, confirmation of the treatment effectiveness at the south-western discharge point is requested.
• Public safety, flood protection (including the Flood Planning Area), risk to life and evacuation is not discussed in the Stormwater Management Report (ACOR, 2021)
• The Stormwater Management Report (ACOR, 2021) proposes a suitable major and minor design strategy for the local stormwater network which is expected to be progressed with greater detail during future detailed design project phases.</td></tr>
<tr><td>• Pipe (minor) systems are installed to cater for frequent surface flows up to 20% AEP (5 year ARI). This balances cost of drainage and occurrence of inundation.</td><td>• Section 5.2.1 of the Stormwater Management Report (ACOR, 2021) notes the minor system stormwater network will be designed to cater for the 20% AEP.
• A preliminary layout for the stormwater drainage system is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)</td></tr>
<tr><td>• Runoff from impermeable surfaces is to be managed by stormwater source controls that:
○ Contain frequent, low-magnitude flows,</td><td>• Section 6.2 of the Stormwater Management Report (ACOR, 2021) presents a range of water quality improvement devices, including rainwater tanks, Ecosol GPTs and</td></tr>
</table>

Item	DCP Requirement	How addressed?
M. Stormwater design objectives cont. .	○ Maintain the natural balance between runoff and infiltration, so as to promote appropriate groundwater, soil salinity and stream flow characteristics, ○ Remove some pollutants prior to discharge to receiving waters, and ○ Prevent nuisance flows from affecting adjoining properties.	bioretention basins. This treatment train is generally in accordance with current best practice. • A MUSIC model has been prepared to demonstrate that the proposed treatment devices treat stormwater runoff generally to the satisfaction of Council • Further review is requested to confirm discharge in the south-western corner achieves the necessary treatment targets and frequent discharge via the two headwalls will not create excessive scour, and impact downstream waterways, properties and infrastructure.
	• Ensure that appropriate long-term arrangements are in place to allow for continued use and maintenance of existing drainage systems.	• Maintenance access into the basins and the existing farm dam is not presented in the design drawings. • Assuming Council will eventually take ownership of the proposed GPTs and bio-retention basins, maintenance schedules and frequency is expected to be similar to other similar water quality throughout the LGA.
	• The ultimate discharge for collected stormwater runoff shall be to a street drainage system, to an inter-allotment drainage line, or by approval, to a public area. The system shall be "gravity" drained. Pumping of stormwater is not permitted.	• Individual lot runoff is expected to be assessed on a lot-by-lot basis. Runoff from the proposed development is proposed primarily to the second order water course. • As mentioned, discharge through the electrical easement and to private land in the south-western corner will need to be reviewed to ensure it does not create a significant adverse impact. A formal drainage easement is expected to be required. • All lines proposed are expected to be drained under gravity.
	• The development site shall provide an overland flow path for the major storm event (1% AEP).	• Section 5.2.2 notes the major local conveyance network will include overland flow through the road carriageway and footpath. Flows through the road network will be limited to a maximum velocity-depth product of less than 0.4m2/s. It is

Item	DCP Requirement	How addressed?
		anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
N. Stormwater drainage design – residential	• All public stormwater management assets are to be installed outside the riparian zone of creek lines.	• It is not possible to assess this accurately as the riparian zones are not presented in the design drawings.
	• All urban lots must have connection to the Council's stormwater management system via direct access to the street gutter or interallotment drainage via a dedicated easement.	• A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	• New buildings are not to be constructed over or compromise the integrity of drainage lines or easements originating from outside the site.	• Not applicable.
	• Where an existing drainage line runs under a proposed building, the drainage line and any associated easement is to be diverted around the building. Redundant easements are to be extinguished and new easements are to be created.	• Not applicable.
	• Where an existing drainage system across the site is retained, access to the existing system is not to be affected by the proposed development. Also, the development is to be designed so as not to degrade the structural integrity of the system.	• Section 3.5 notes that the existing farm dam is to remain on site. Access to the second order watercourse and the existing dam will need to be provided as part of the proposed development to ensure they can be monitored and maintained as required.
	• Water re-use within the dwelling and for landscaping purposes is encouraged, through the installation of rainwater tanks.	• Section 6.2.2.7 notes roof rainwater runoff will be captured in 3kL rainwater tanks and reused within the household.

Item	DCP Requirement	How addressed?
N. Stormwater drainage design – residential cont.	• Stormwater drainage complies with AS 3500.3.	• Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	• Pits are installed to collect water from the low points in yards.	• A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	• Down pipes and pits are to be connected to the 'discharge controls' for the site.	• Individual lot runoff is expected to be assessed on a lot-by-lot basis and designed in accordance with AS3500.3. • A preliminary layout for the stormwater drainage system presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	• The site discharge indicator for the development is no more than 0.3 determined under Water Smart Practice Note No. 11 – Site Discharge Indicator. Preliminary storm water design details demonstrating ability to comply with this requirement are to be submitted with the development application.	• It is not possible to assess this requirement based on the information contained in the Stormwater Management Report (ACOR, 2021).
P. Flooding, runoff regimes & stormwater collection	• Development is to be designed so that runoff from low intensity, common rainfall is equivalent to the runoff from a natural catchment. This can be achieved by intercepting and storing runoff in extended storage detention basins and discharging at greatly reduced rates. • Alternatively, existing degraded downstream streams can be sympathetically engineered to re-establish a natural	• Section 5.3.8 and Section 5.3.9 note that post developed flows on the western site boundary, through the second order creek, do not increase beyond the pre-developed state. As such, no detention is required. • Section 5.3.9 notes the post developed flows have increased compared to the predeveloped flows on the south-western boundary. However, as there is no

Item	DCP Requirement	How addressed?
P. Flooding, runoff regimes & stormwater collection cont.	riparian eco system that can cope with the changed hydrological regime.	downstream development that can be impacted by this increase, a detention basin is not proposed. The Stormwater Management Report (ACOR, 2021) suggests this has been previously agreed by with Council. • Section 3.5 notes that a hydraulic analysis has been undertaken by MM Hyndes Bailey (Stormwater Drainage Strategy Peppertree Estate Scone, 2017) on the second order stream traversing through the site. Review of this report suggests flood impacts have not been assessed as a result of the introduction of fill within the 1% AEP.
	• Developments are to be designed in accordance with Australian Rainfall and Runoff and the NSW Floodplain Development Manual.	• The development has been modelled using DRAINS, the RFFE tool and HEC-RAS. As previously discussed, some updates to this modelling methodology and the parameters used are recommended to ensure the investigation is prepared in accordance with current best practice guidelines.
	• Development is to be designed so that overflows do not adversely affect neighbouring properties by way of intensification, concentration or inappropriate disposal across property boundaries. This can be achieved by securing appropriate easements over downstream properties or discharging overflows directly to the street system where feasible.	• As mentioned, discharge through the electrical easement and to private land in the south-western corner will need to be reviewed to ensure it does not create a significant adverse impact. A formal drainage easement is expected to be required. • Section 3.5 notes that a hydraulic analysis has been undertaken by MM Hyndes Bailey (Stormwater Drainage Strategy Peppertree Estate Scone, 2017) on the second order stream traversing through the site. Review of this report suggests flood impacts have not been assessed as a result of the introduction of fill within the 1% AEP.
P. Flooding, runoff regimes	• Overflows from paved areas adjacent to the property boundary are to be directed by a kerb or formed gutter to drain away from neighbouring properties.	• A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with

Item	DCP Requirement	How addressed?
& stormwater collection cont.		greater detail during future detailed design project phases (such as at Subdivision Works Certificate). • Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	• Surface levels are to be graded such that sites are generally free draining with sufficient overflow capacity to ensure that waters do not enter buildings when underground drainage systems are beyond their capacity.	• A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate). • Design of the local major and minor network will need to be performed assuming the sites fully developed state (without infiltration or detention). • Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	• Drainage pits are to be installed so that nuisance water does not collect at low points.	• A preliminary layout for the stormwater drainage system and site grading is presented in the concept design drawings. It is anticipated this will be progressed with greater detail during future detailed design project phases (such as at Subdivision Works Certificate)
	• Gutters, down pipes and pits are to be connected to the stormwater management system for the site. Australian Standard 3500.3 sets appropriate standards for stormwater collection and is to be followed when constructing new development.	• Individual lot runoff is expected to be assessed and designed on a lot-by-lot basis and designed in accordance with AS3500.3.
	• Public use areas satisfy relevant flood safety criteria as assessed with reference to the NSW Floodplain Development Manual.	• Section 4 notes that the development will consist of three public parks and an open space which are shown in the design drawings.

Item	DCP Requirement	How addressed?
		• Public safety, flood protection (including the Flood Planning Area), risk to life and evacuation is not discussed in the Stormwater Management Report (ACOR, 2021). Not enough information is provided in the XXXX to be able to assess this accurately.

Recommendations

Presented below is a summary of the recommended updates to the Stormwater Management Strategy (ACOR, 2021).

- Model hydrology should be updated to consider the use of the latest NSW Specific Rainfall Losses and Hierarchy Approach recommended by NSW OEH and the ARR 2019 EIA / ICIA split.
- Definition of riparian extents should be prepared and placement of Water Quality devices in accordance with NRAR Controlled Activities on Waterfront Land guidelines should be reviewed.
- The design for the creek culvert crossing should be reviewed with respect to blockage and climate change and the difference in sizing with previously completed studies for the area should be discussed.
- The proposed evacuation access track and / or culvert crossing should be reviewed with respect to risk to life and evacuation.
- The difference between peak flows observed in the Stormwater Management Plan (ACOR, 2021) and other similar studies in the area should be discussed.
- A detailed two-dimensional flood assessment and report be prepared in accordance with the UHSC DCP Part 10a to analyse (as a minimum):
  - The existing case flood behaviour including hydraulic categories (i.e. floodway, flood storage and flood fringe).
  - The developed case flood behaviour, including a review of the sizing of the proposed creek culvert crossing.
  - The flood impact of the proposed development for the full range of storm events up to and including the PMF.
  - Define the Flood Planning Area (FPA) for the proposed development.
  - Ensure all proposed lots, roads and infrastructure are positioned in accordance with Council's LEP/ DCP and the NSW Floodplain Policy.
  - Define tailwater levels for the proposed local stormwater network.
  - Review the impact of climate change.
  - Measures to manage the risk to life and property including a review of the sizing of the proposed creek culvert crossing and / or the proposed evacuation access track.
  - Review Gundy Road overland flow capacity to confirm whether the proposed lots fronting Gundy Road are flood prone.
  - Review development compliance with the necessary flooding related LEP/ DCP requirements and the NSW Floodplain Policy.
  - Review the findings with respect to stormwater detention presented in the Stormwater Management Plan (ACOR, 2021).
- Review necessary stormwater management measures for the south-western corner to ensure stormwater discharge does not adversely impact both water quality and quantity at the site discharge point and within downstream waterways.

- The existing Dam, to be maintained post development, should be reviewed from a dam safety perspective to determine whether it is required to be declared for the purposes of the Dam Safety Act 2015.

Conclusion

A peer review of the Stormwater Management Report (ACOR, 2021) has been presented herein.

It was concluded that a Flood Study should be prepared, and the Stormwater Management Plan updated, to enable a detailed assessment of the proposed development in accordance with Upper Hunter Shire Council's Local Environmental Plan (2013) and Development Control Plan (2015). A number of recommendations have been made for the reports to assist in satisfying the LEP / DCP requirements.

We trust this is what you require and if you have any queries, please feel free to contact the undersigned on (02) 4943 1777.

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Attachment 1 – Stormwater Management Report (ACOR, 2021)

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Stormwater Management Plan for DA

Peppertree Estate, Gundy Road SCONE

Prepared for: Charles David Pty Ltd

Document no: NSW202732_R01.01

Revision no: 01

Source: Near Maps

Disclaimer

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Revisions

Revision	Description	Date	Prepared by	Approved by
01	For Approval	19 August 2021	Ulrika Knight	Josh Rhodes

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Appendices

1 Introduction

ACOR Consultants have been engaged by Charles David Pty Ltd C/- MM Hyndes Bailey & Co to prepare a Stormwater Management Plan for Development Approval for a residential subdivision development at Lot 2 (DP1169320) Gundy Road, Scone.

The stormwater drainage items addressed in this report include:

- Stormwater conveyance/network;
- Stormwater detention
- Operational water quality management incorporating Water Sensitive Urban Design (WSUD) principles
- Construction water quality management incorporating soil and water management.

2 Previous Stormwater Drainage Assessments

The following stormwater drainage assessment have been completed previously for the proposed subdivision development at this site by others:

- *Stormwater Drainage Strategy Peppertree Estate Scone* by MM Hyndes Bailey dated November 2017
- *Stormwater Quality Report* by Barker Ryan Steward dated November 2017
- *Stormwater Drainage Strategy Supplementary Report 70-80% Impervious Peppertree Estate Scone* by MM Hyndes Bailey dated November 2019

The site layout for the proposed subdivision has been revised and as such an updated Stormwater Drainage Management Plan is required and is contained within this report.

3 Site

3.1 Location

The site is located east of Scone at Lot 2 Gundy Road, Scone. The proposed development is bounded by Gundy Road to the north, rural properties to the easy and south, and abuts to the age care facility “Strathearn” to the north west. Refer to Figure 1 for Locality Plan.

3.2 Topography

The existing site comprises of approximately 57 Hectares of gently sloping grasslands. There is a second order stream traversing through the site from east to west. The stream divides the proposed development into a northern section and a southern section.

The northern section of the site grades at approximately 4% from the north east to the south west towards the stream. The levels on site for the northern section range from approximate RL 226m AHD at the north east boundary to RL 214m AHD at the south west boundary at the stream.

Most of the southern section of the site grades at approximately 5% from the south east to the north west towards the stream. There is a crest in the southern section of the site that runs from east to west which means that a small section of the southern area grades to the south west. The levels for the southern section range from approximately RL 243m AHD at the south east boundary to RL 208m AHD at the north west boundary at the stream and RL 215m AHD at the south west boundary.

A farm dam is located within the site at the eastern end of the stream.

Refer to Figure 2 for the existing site topography.

3.3 Existing Land Use and Vegetation

The site in its current condition is mostly cleared grassland with some trees within the stream.

3.4 External Catchments

There is an upstream catchment north east of the site that drains to the culverts under Gundy Road and then feeds the stream through the development site from the east. This catchment is approximately 98 Hectares and is mostly grassland with some trees. The most northern part of this catchment is within the Scone Mountain National Park and has more vegetation than the lower section of the catchment.

There is an upstream catchment to the east of the site that feeds the stream through the development site. This catchment is approximately 53 Hectares and is mostly grassland.

The development site has frontage to Gundy Road. Gundy Road has a grassed swale along both sides of the road. In minor storm events, flows are directed to the west along Gundy Road but in major storm events the flows that cannot be contained within the grassed swale overflow into the development site and are directed south west to the stream traversing through the site.

The upstream external catchments draining through the development site are shown in Figure 3.

3.5 Existing Flowpaths and Water Bodies

There is a second order stream traversing through the site from east to west. This stream is fed from the upstream catchments to the north east under Gundy Road and to the east of the site. The stream is not well defined in places but is generally in good condition with minimal scouring.

A hydraulic analysis was undertaken by MM Hyndes Bailey on the second order stream. The results from the study are detailed in MM Hyndes Bailey report *Stormwater Drainage Strategy Peppertree Estate Scone* dated November 2017, Section 5.

There is a farm dam located at the eastern site boundary within the stream. This dam is to remain, but further investigation will be required at the construction certificate stage to ensure that the overflows from the dam for 1% AEP flows are safe and do not impact the proposed residential lots.

4 Proposed Development

The proposed development will consist of four hundred and one (401) residential lots, three (3) public parks and an open space, as well as associated roads, stormwater drainage infrastructure including detention and water quality basins. The subdivision is proposed to be development in sixteen (16) stages. The lot areas and staging details are shown in Table 1.

Table 1: Lot areas and staging details

Development Stage	Lot numbers	Lot areas m^2
1	101 – 121 (21 lots)	701 – 1301
2	201 – 226 (25 lots and a park)	701 – 1032
3	301 – 314 (14 lots)	739 – 1100
4	401 - 418 (18 lots and a park)	703 – 898
5	501 – 525 (25 lots and a park)	703 – 1094
6	601 – 630 (30 lots)	705 – 1055
7	701 – 723 (23 lots)	707 – 982
8	801 – 832 (32 lots)	701 - 1348

9	901 – 927 (27 lots)	706 - 1077
10	1001 – 1034 (34 lots)	708 - 1222
11	1101 – 1121 (21 lots)	701 - 1016
12	1201 – 1236 (36 lots)	709 - 1070
13	1301 – 1327 (26 lots and drainage easement)	702 - 1373
14	1401 – 1428 (28 lots)	770 - 1277
15	1501 – 1521 (21 lots)	707 - 977
16	1601 – 1620 (20 lots and open space)	704 – 821

Access to the subdivision will be from Gundy Road.

Stages 1, 2 and 3 are located on the northern side of the stream adjacent to Gundy Road.

The remainder of the stages are located on the southern side of the stream. A road crossing with reinforced concrete box culverts is proposed to span the stream to the southern side of the development.

Figure 4 shows the development layout for the subdivision.

5 Stormwater Quantity Management

5.1 Objectives

The objectives of the stormwater quantity management for the site are:

- Provide a stormwater conveyance system in accordance with Australian Rainfall and Runoff's minor/major system philosophy and the requirements of Upper Hunter Shire Council (UHSC). The minor stormwater conveyance system will be designed to convey peak flows from the 20% Annual Exceedance Probability (AEP) storm event and the major stormwater conveyance system will be designed to convey the peak flows from the 1% AEP storm events.
- Provide stormwater detention to reduce the peak flows from the site to or below the current peak runoff from the site.

5.2 Stormwater Conveyance

5.2.1 Minor Storm Event Conveyance

Minor system stormwater conveyance for the development will be a via a traditional pit and pipe system. The minor stormwater system will have the capacity to convey the peak flows from a 20% AEP storm event.

Figures 5 and 6 show a preliminary layout for the stormwater drainage system.

5.2.2 Major Storm Event Conveyance

Major system stormwater conveyance for the proposed development will be via overland flow. This will be via traditional trunk drainage utilising the road carriage way and footpath. The major stormwater system will have the capacity to convey the peak flows from a 1% AEP storm event, containing flows within the road reserve and limiting velocity depth product to or below 0.4 m^2/s.

5.3 Stormwater Detention

5.3.1 General

Stormwater detention needs to be provided to ensure that the post development flows from the total site are reduced to the predevelopment flows for AEPs from 20% to 1% so that downstream properties are not impacted by increased flows from this proposed development.

The previous stormwater drainage study only considered the development site in the modelling.

This stormwater drainage study is a full catchment analysis and includes the upstream catchments that drain through the stream traversing through the proposed development.

5.3.2 DRAINS Modelling

DRAINS modelling was undertaken to determine the predeveloped and developed peak flows at the western boundary for a range of AEPs from 20% to 1%, for storm durations ranging from 5 minutes to 6 hours. ARR 2019 procedures were utilised in the DRAINS models.

The available detention volumes from the rainwater tanks which are a requirement of BASIX for each dwelling were not accounted for in the modelling.

The large undeveloped rural catchments were modelled using RAFTS storage routing model within DRAINS. For sub-catchment routing, RAFTS uses the equation:

S = BX . IBFL . PERN . 0.285 A0.52. (1+U)-1.97. Sc-0.50. Q0.715

where BX is a calibration factor similar to RORB's kc, IBFL is a factor for modelling overbank flow, PERN is a factor that adjusts the catchment routing factor to allow for catchment roughness, A is the sub-catchment area (km2), U is the fraction of the catchment that is urbanized, and Sc is the main drainage slope of the sub-catchment.

For routing along stream reaches, RAFTS applies a translation over a nominated time, or performs Muskingum-Cunge routing based on the stream cross-section and roughness.

The proposed developed catchments were modelled using the Initial Loss – Continuing Loss (IL-CL) model. The IL-CL hydrology procedure in DRAINS is an alternative to Horton (ILSAX). Both methods are accepted in the ARR 2019 guidelines and discussed in Book 5 Chapter 3. The IL-CL model and its parameters are set out in Section 3.5.3 of ARR 2019.

5.3.3 Rainfall Data

The Australian Rainfall and Runoff Data Hub was used to obtain data (Storm Losses, Temporal Patterns, BOM IFD Depths, Median Preburst Depths and Ratios and Interim Climate Change Factors) for the development site.

5.3.4 Fraction Impervious

The fraction impervious to be used in stormwater drainage modelling is outlined with UHSC DRAFT Engineering Guidelines for Subdivisions and Developments Table 5.5 and shown in Table 2.

Table 2: Fraction Impervious for Various Land Use

Land Use	Fraction Impervious
Normal residential lot only	0.6
Normal residential lot including half road	0.65
Half width road reserve	0.8
Public recreation areas	0.4
Open space (natural bushland)	0.35

For the upstream catchments, a fraction impervious of 0.35 was adopted for rural/natural bushland.

To be conservative in determining the predeveloped and post developed flows at the western boundary, a fraction impervious of zero (0) was adopted for the predeveloped site (existing rural property) and a fraction impervious of 0.75 was adopted for the proposed subdivision in the DRAINS models.

5.3.5 Time of Concentration

Time of concentration for the catchments that are modelled using RAFTS was determined by the program. Catchment information such as area, fraction impervious, catchment slope and a Manning's n value are entered into the Sub-Catchment Data.

The Manning's n values adopted for the modelling are in line with recommendations from Australian Rainfall and Runoff: A Guide to Flood Estimation Table 6.2.2. The relevant land use and the recommended Manning's n range are shown in Table 3.

Table 3: Land Use Type and Recommended Manning's n

Land Use Type	Recommended Manning 'n'
Open pervious areas, nominal vegetation (grassed)	0.03 – 0.05
Open pervious areas, moderate vegetation (shrubs)	0.05 – 0.07
Open pervious areas, thick vegetation (trees)	0.07 – 0.12
Waterways/channels – minimal vegetation	0.02 – 0.04
Waterways/channels – vegetated	0.04 – 0.1

A Manning's n value of 0.05 was adopted for the external catchments (rural/natural bushland).

A Manning's n value of 0.04 was adopted for the predevelopment site catchment (rural grassed).

A Manning's n value of 0.04 was adopted for the stream traversing through the development site (waterways with minimal vegetation and trees).

The minimum time of concentration adopted for the developed catchments utilising the Initial Loss – Continuing Loss Model are 5 minutes for the impervious catchments and 10 minutes for pervious catchments. This is the time of concentration for lot runoff. Additional flow travel times were added to the developed catchments in accordance with Queensland Urban Drainage Manual Section 4.6.7.

5.3.6 Predeveloped Peak Discharge

The peak discharge for the predeveloped catchments in accordance with Figure 3 are shown in Table 4.

The two upstream catchment (EXTL A and B) and Site A catchment all discharge at the western boundary of the site. Site B catchment discharges at the south west boundary of the site.

Table 4: Predeveloped Catchment Flows

Catchment Name	Area (Ha)	Predeveloped Peak Discharge m^3/s (AEP)				
		20%	**10%**	**5%**	**2%**	**1%**
EXTL A	97.773	12.9	17.3	20.8	25.9	30.3
EXTL B	52.601	6.11	7.5	9.39	12.1	14.5
SITE A	48.752	2.3	3.07	3.89	4.89	602
Peak discharge at west boundary		**20.9**	**25.4**	**31.8**	**40.3**	**47.6**
SITE B	9.217	0.523	0.737	0.921	1.18	1.42
Peak discharge at south west boundary		**0.523**	**0.737**	**0.921**	**1.18**	**1.42**

The DRAINS input data and results are contained in Appendix A.

5.3.7 Post Development Peak Discharge

The details for catchments EXTL A and EXTL B are as per the predeveloped model and the flows are the same.

Catchment Site A has been divided into catchments to represent the existing stream traversing the site, and the subdivision development at relevant discharge points. Refer to Figure 7 for the post development catchment plan.

The proposed road crossing the existing stream was also incorporated into the DRAINS model. Reinforced concrete box culverts (RCBC) were modelled as detailed below:

- Top of road RL 216.0
- Pavement thickness allowed for 500mm
- 2400x750 RCBC – 11 culverts required
- Invert of RCBC RL214.575
- Length of culverts 30m

The peak discharge for the post developed catchments at the western boundary and the south west boundary are shown in Table 5.

Table 5: Post developed Peak Flows

Storm Event (AEP)	Post Developed Peak Discharge m^3/s (AEP)	
	At west boundary	**At south west boundary**
20%	20.3	0.891
10%	25.6	1.1
5%	31.5	1.3
2%	40.2	1.58
1%	47.2	1.81

The DRAINS input data and results are contained in Appendix A.

5.3.8 Post versus Predeveloped Peak Discharge

The comparison of the predeveloped and post developed peak flows at the western boundary are shown in Table 6.

Table 6: Post versus Predeveloped Peak Flows at Western Boundary

Storm Event (AEP)	Peak Discharge at Western Boundary m³/s (AEP)		
	Predeveloped	Post developed	Difference %
20%	20.9	20.3	-2.9%
10%	25.4	25.6	0.8%
5%	31.8	31.5	-0.9%
2%	40.3	40.2	-0.2%
1%	47.6	47.2	-0.8%

The comparison of the predeveloped and post developed peak flows at the south west boundary are shown in Table 7.

Table 7: Post versus Predeveloped Peak Flows at South West Boundary

Storm Event (AEP)	Peak Discharge at South West Boundary m³/s (AEP)		
	Predeveloped	Post developed	Difference %
20%	0.523	0.891	70%
10%	0.737	1.100	49%
5%	0.921	1.300	41%
2%	1.180	1.580	34%
1%	1.420	1.810	27%

5.3.9 Detention Basins

It is a standard requirement for most councils including UHSC, that stormwater detention be provided to ensure that the post developed from are reduced to the predeveloped flows for AEPs from 20% to 1% so that downstream properties are not impacted by increased flows from this proposed development.

The stormwater drainage modelling undertaken is a catchment wide analysis and includes the upstream catchments running through the site as well as the proposed development. As the proposed development is at the downstream end of the overall catchment draining to the western boundary of the site, the flow travel times from each catchment are important.

Generally, with this sort of catchment configuration, the post development flows are found to only increase marginally or not at all. As the post developed catchment times of concentrations are shorter, the flows from the developed catchment have already travelled downstream before the flows from the larger undeveloped upstream catchment have arrived downstream.

This is evident in the post developed peak flows draining to the western boundary via the existing stream shown in Table 6. The post developed peak flows are below the predeveloped peak flows for all storm events except for 10% AEP. The increase in flows for the 10% AEP is less than 1% which is within the accuracy of the stormwater drainage modelling and will have minimal impact downstream. Therefore, no detention basins are required to reduce the post developed flows at the western boundary.

With the catchment configuration for this site, providing detention at the downstream end of the catchment will only increase the flows at the western boundary as the travel flow times for the developed catchments are lengthened due to the detention basin. This will result in the flows discharging from the basin aligning with the large upstream flows and increasing the overall peak flows at the western boundary.

As detailed above, approximately 9.2 hectares of the southern catchment of the site currently drains to the south west. With the proposed development, this area will be reduced to approximately 4.9 hectares.

As can be seen from Table 7, the post developed flows have increased compared to the predeveloped flows due to the increased fraction impervious of 75% for the proposed development.

As there is no downstream development that can be impacted by this small flow increase, a detention basin to reduce the flows will not be provided at this location. This strategy was previously agreed to by council.

6 Stormwater Quality Management

6.1 Objectives

The objectives of the Stormwater Quality for the site are:

- Meet the water quality objectives of Upper Hunter Shire Council (UHSC) for the operational phase of the site by using best practice stormwater treatment measures.
- The strategy for stormwater quality management as detailed in the report prepared by Barker Ryan Stewart *Stormwater Quality Report* dated November 2017 has been approved by Council, and states:

  "Consultation was undertaken with Council to set a water quality target that would meet the objectives of the UHSC DCP, that is 'to ensure that stormwater generated from development does not result in pollution of water courses or receiving waters'. Mathew Pringle, Director of Environmental and Community Services advised that the pre-development forested condition of the site would be a suitable guide and an acceptable target for this development."

6.2 Operational Phase Water Quality Management

6.2.1 General

To meet the water quality requirements of UHSC, a range of water quality improvement devices will be required.

The proposed water quality improvement devices for the site will include:

- rainwater tanks
- Ecosol GPTs
- bioretention basins

The above water quality improvement devices act as a treatment train, progressively reducing pollutants as they pass through each one.

6.2.2 Stormwater Quality Modelling

6.2.2.1 Introduction

The MUSIC model version 6.3 was used to assess the pollutant generation from the development and the performance of the stormwater quality treatment train.

6.2.2.2 Rainfall Data and Evaporation Data

The rainfall data and evapotranspiration data collected from the Liddell Power Station was used in line with the previous MUSIC modelling undertaken by Barker Ryan Stewart (as discussed above).

6.2.2.3 Soil Types

As detailed in the Barker Ryan Steward report, the soil profile at the development site is composed of heavy clay underlain by coarse light medium clay. This information was obtained from *"The Soils Essential Report – NSW Soil and Land Information System for Scone High School".*

6.2.2.4 Catchments

The catchments for the MUSIC modelling are the same as the catchment used in the DRAINS modelling discussed above. Refer to Figure 7 for the post development catchment plan.

The catchments for the MUSIC modelling were subdivided into road areas, roof areas and remaining lot areas as detailed in Table 8.

Table 8: MUSIC Modelling Catchments

Catchment	CAT 1	CAT 2	CAT 3 & 6	CAT 4
Number of lots	70	60	235	36
Lot areas (Ha)	3.83	3.74	13.29	2.67
Roof areas (Ha)	1.75	1.50	5.88	0.90
Road areas (Ha)	1.67	2.64	6.73	1.37
Total catchment area (Ha)	**7.25**	**7.87**	**25.90**	**4.94**

A fraction impervious of 80% was adopted for the roads.

The residential lots were divided up into roof areas and remaining lot areas. It was assumed that for an average size lot (800m²) with a fraction impervious of 75% and a roof area is 250m², the remaining lot is 550m² with a fraction impervious of 64%. Therefore, conservatively a fraction impervious of 65% was adopted for lots (excluding roof area).

In line with UHSC advice, the pre-existing (forest) catchment was model in MUSIC to compare the mean annual pollutants loads with the post developed catchment.

Currently the site is used for farming/agriculture, so this catchment type was also model in MUSIC for comparison.

6.2.2.5 MUSIC Model Source Inputs

The source data for the MUSIC model was adopted from the Sydney Catchment Authority (SCA) MUSIC Manual in line with the modelling undertaken by Barker Ryan Stewart.

Table 9: MUSIC Source Node Soil Properties

Soil Parameter	Value
Rainfall Threshold (mm/day)	Roofs 0.3 / Roads 1.5 / Land uses 1.0
Soil Storage Capacity (mm)	90
Initial Storage (% of Capacity)	25
Field Capacity	58
Infiltration Capacity Coefficient – a	135
Infiltration Capacity Coefficient – b	4
Groundwater Initial Depth (mm)	10
Groundwater Daily Recharge Rate (%)	10
Groundwater Daily Base Flow (%)	10
Groundwater Daily Deep Seepage Rate (%)	0

6.2.2.6 Catchments Pollutant Mean Concentrations

The pollutant Event Mean Concentration (EMC) values were adopted from SCA MUSIC Manual for both the base flows and storm flows. The base flow values are shown in Table 10 and the storm flow values are shown in Table 11 for various catchment types.

Table 10: Base Flow Pollutant Event Mean Concentration Values

	Base Flow Pollutant Event Mean Concentration Values					
	TSS (log 10)		TP (log 10)		TN (log 10)	
Catchment Type	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Forest	0.78	0.13	-1.52	0.13	-0.52	0.13
Agriculture	1.30	0.13	-1.05	0.13	0.04	0.13
Road (mixed)	1.10	0.17	-0.82	0.19	0.32	0.12
Roof	0	0	0	0	0	0
Residential lots	1.20	0.17	-0.85	0.19	0.11	0.12

Table 11: Storm Flow Pollutant Event Mean Concentration Values

	Storm Flow Pollutant Event Mean Concentration Values					
	TSS (log 10)		TP (log 10)		TN (log 10)	
Catchment Type	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24
Agriculture	2.15	0.31	-0.22	0.3	0.48	0.26
Road (mixed)	2.20	0.32	-0.45	0.25	0.42	0.19
Roof	1.30	3.20	-0.89	0.25	0.30	0.19
Residential lots	2.15	0.32	-0.60	0.25	0.30	0.19

6.2.2.7 MUSIC Model Treatment Train

The stormwater quality treatment train consist of three parts; rainwater tanks, Ecosol GPTs and bioretention basins. A schematic of the MUSIC model is shown in Appendix B.

A brief description on each treatment measure is listed below.

- Rainwater Tanks - Rainwater tanks receive water from the roof area of each lot. A 3kL rainwater tank was assumed for each standard residential lot. Water captured in the rainwater tanks is expected to be reused for toilet flushing, clothes washing, hot water and garden irrigation. An average of 4 persons was assumed for each house. The reuse per house was adopted from SCA MUSIC Manual Table 5.4. The reuse adopted for each lot is shown in Table 12.

Table 12: Rainwater Tank Reuse (per lot)

Rainwater Reuse	
Internal (kL/yr/dwelling)	343
External (kL/yr/dwelling)	55
Total (kL/yr/dwelling)	398

- Ecosol GPTs are proposed to be installed at all pipe outlets. The GPTs remove gross pollutants, sediment and attached nutrients. The MUSIC node for the GPT was provided by Ecosol. The removal efficiencies have been confirmed via independent testing. An equivalent product could be used. The flows to the GPT will be limited to the 50% of the peak 63.2% AEP storm in accordance with SCA MUSIC Manual Table 5.5. Table 13 shows the removal efficiencies of the Ecosol GPT.

Table 13: Ecosol GPT Removal Efficiencies

Gross Pollutant Removal (%)	TSS Removal (%)	TP Removal (%)	TN Removal (%)
98	**61**	**29**	**1**

- Bioretention Basins are the final part of the treatment train for this development. Three bioretention basin are proposed to be provided. Bioretention systems remove sediments (TSS) as well as nutrients (TN and TP) from the stormwater. The bioretention basin consists of a shallow dry basin with deep rooted vegetation and grass on the surface, over an infiltration/filtration area and an underdrain area.

  Vegetation in the bioretention basins will be in accordance with Upper Hunter Shire Council requirements.

  To avoid potential salinity problems, an impermeable HDPE liner is to be provided in the bioretention basins to prevent any water infiltrating into the surrounding basin areas.

  The MUSIC inputs for the three bioretention basins are shown in Table 14.

Table 14: Bioretention Basin MUSIC Model Inputs

	Basin 1	Basin 2	Basin 3
Extended Detention Depth (m)	0.3	0.3	0.3
Surface Area (m2)	1800	480	4800
Filter Area (m2)	1500	400	4000
Unlined Filter Material (m)	80	80	80
Saturated Hydraulic Conductivity (mm/hr)	100	100	100
Filter Depth (m)	0.4	0.4	0.4
TN Content of Filter Media (mg/kg)	800	800	800
Orthophosphate of Filter Media (mg/kg)	55	55	55
Exfiltration Rate (mm/hr)	0	0	0
Base Lined	Yes	Yes	Yes
Vegetation Removing Plants	Yes	Yes	Yes
Under Drain Present	Yes	Yes	Yes

6.2.2.8 Stormwater Quality Modelling Results

The mean annual pollutant loads from the MUSIC model for the pre-existing site (forest), predeveloped site (agricultural) and the post developed site (residential subdivision) are shown in Table 15.

Table 15: Mean Annual Pollutant Loads

	Mean Annual Pollutant Loads		
	Pre-existing Forest	**Predeveloped Agricultural**	**Post developed Residential Subdivision**
TSS (kg/yr.)	2610	11000	1290
TP (kg/yr.)	5.35	45.1	12.6
TN (kg/yr.)	61.6	212	107
Gross Pollutants (kg/yr.)	2480	2480	7.79

For the post developed (residential subdivision), the Mean Annual Pollutant Loads for TSS have been reduced below the pre-existing conditions (forest), but the TP and TN could not be reduced with the proposed treatment train.

The Mean Annual Loads for the post developed site have been reduced to below the predeveloped site conditions (agriculture) as shown in Table 15.

Most councils within the Hunter provide targets for the pollutant reductions for TSS, TP and TN. For example, the reductions in the average annual loads for Maitland Council are 85% for TSS, 45% for TP and 45% for TN.

Table 16 below shows the reductions achieved in the average annual loads for the proposed development, and hence the effectiveness of the proposed treatment train. The percentage reductions are higher than required for most councils in the Hunter.

Table 16: MUSIC Model Treatment Train Effectiveness

	Source Mean Annual Load	Residual Mean Annual Load	% Developed Reduction
TSS (kg/yr.)	16900	1290	92.4
TP (kg/yr.)	33.7	12.6	62.5
TN (kg/yr.)	282	107	62
Gross Pollutants (kg/yr.)	4250	7.79	99.8

The results of the MUSIC modelling show that the proposed water quality treatments sufficiently reduce the pollutants to an acceptable level. The MUSIC modelling summary report detailing the inputs and results are shown in Appendix B.

6.3 Construction Phase Water Quality Management

6.3.1 General

During the construction phase of the development, an Erosion and Sediment Control Plan will be implemented to minimise the water quality impacts. The erosion and sediment controls will be in accordance with Landcom's Managing Urban Stormwater: Soils and Construction Volume 1, 4th Edition (Landcom, 2004) and the requirements of UHSC. Erosion and sediment controls will be required preconstruction, during construction and post construction until the site is stabilized. The expected erosion and sediment control measures will include stabilized site access, sediment fence, gully pit sediment barriers, rock outlet scour protection and a temporary sediment basin. Erosion and sediment control plans will be provided for the development at the Construction Certificate stage.

6.3.2 Pre-Construction Erosion and Sediment Control

Due to the topography of the site, the preconstruction erosion and sediment controls will be limited to stabilized site access, sediment fence and a temporary sediment basin until the initial bulk earthworks is undertaken. The proposed water quality basins will be used as a sediment basin while construction is being undertaken.

6.3.3 During Construction Erosion and Sediment Control

During the construction phase of the development, the erosion and sediment controls will consist of installed sediment fence, a constructed sediment basin, gully pit sediment barriers and permanent rock outlet scour protection.

Regular inspection and maintenance of the erosion and sediment controls is required during the construction process.

6.3.4 Post Construction Erosion and Sediment Control

The contractor/developer will be responsible for the maintenance of the erosion and sediment control devices from the practical completion of the works for a minimum of 6 months or until stabilization has occurred to the satisfaction of Council.

It is standard practice to delay the construction of the bioretention filtration media in the basin until a significant proportion of the contributing lots are built on and established.

7 Conclusion

The catchment wide modelling undertaken using DRAINS has shown that stormwater detention is not required for the proposed development. Due to the large upstream catchments draining through the existing stream traversing the development site, the post developed flows at the downstream boundary are generally below the predeveloped flows. The proposed installation of the reinforced box culverts under the road crossing between the northern and southern sections of the subdivision also provide some control to the post development flows downstream.

The MUSIC modelling undertaken has shown that the proposed treatment train of rainwater tanks, GPTs and bioretention basins has sufficiently reduced the mean annual pollutants loads from the proposed development. The bioretention basin configuration, levels and inlet/outlet details will need to be confirmed at the Construction Certificate design stage.

During the construction phase of the development, an Erosion and Sediment Control Plan will be implemented to minimise the water quality impacts. Erosion and Sediment Control Plans and details will need to be prepared at the Construction Certificate design stage.

8 FIGURES

SCALE 1:2500 @ A1
SCALE 1:5000 @ A3
0 25 50 100 150 200 250 metres

DO NOT REPRODUCE IN GREYSCALE

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Issue	Description	Date	Drawn	Approved
B	ISSUED FOR APPROVAL	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK

-1 0 1cm at full size 10cm 20cm

North

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Project
STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title
LOCALITY PLAN

Drawn	Date	Scale A1	Q.A. Check	Date
ADS	MAR 2021	1:2500	UK	12.03.21

Designed	Project No.	Dwg. No.	Issue
UK	NSW202732	FIGURE 1	B

\\192.168.2.1\Synergy\Projects\NSW20\NSW202732\D… Aug 20, 2021 - 11:58am

SCALE 1:2500 @ A1
SCALE 1:5000 @ A3

0 25 50 100 150 200 250 metres

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Issue	Description	Date	Drawn	Approved
B	LOT BOUNDARIES UPDATED, ISSUED FOR CLIENT REVIEW	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK

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Project
STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title
EXISTING SITE TOPOGRAPHY

Drawn	Date	Scale A1	Q.A. Check	Date
ADS	MAR 2021	1:2500	UK	12.03.21

Designed	Project No.	Dwg. No.	Issue
UK	NSW202732	FIGURE 2	B

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Aug 20, 2021 - 11:58am

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SCALE 1:10000 @ A3
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Issue	Description	Date	Drawn	Approved
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Project
STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title
PREDEVELOPED CATCHMENT PLAN

Drawn	Date	Scale A1	Q.A. Check	Date
ADS	MAR 2021	1:2500	UK	12.03.21

Designed	Project No.	Dwg. No.	Issue
UK	NSW202732	FIGURE 3	B

Aug 20, 2021 - 11:58am

STAGE	LOTS	LOTS	
1	24	21	-3
2	25	25	0
3	15	14	-1
4	27	18	-9
5	25	25	0
6	28	30	+2
7	23	23	0
8	31	32	+1
9	27	27	0
10	33	34	+1
11	21	21	0
12	36	36	0
13	28	26	-2
14	29	28	-1
15	29	21	-8
16	22	20	-2
TOTAL	423	401	-22

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Issue	Description	Date	Drawn	Approved
B	LOT BOUNDARIES UPDATED, ISSUED FOR CLIENT REVIEW	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK

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Project: STORMWATER MANAGEMENT PLAN
LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title: PROPOSED DEVELOPMENT LAYOUT

Drawn	Date	Scale A1	Q.A. Check	Date
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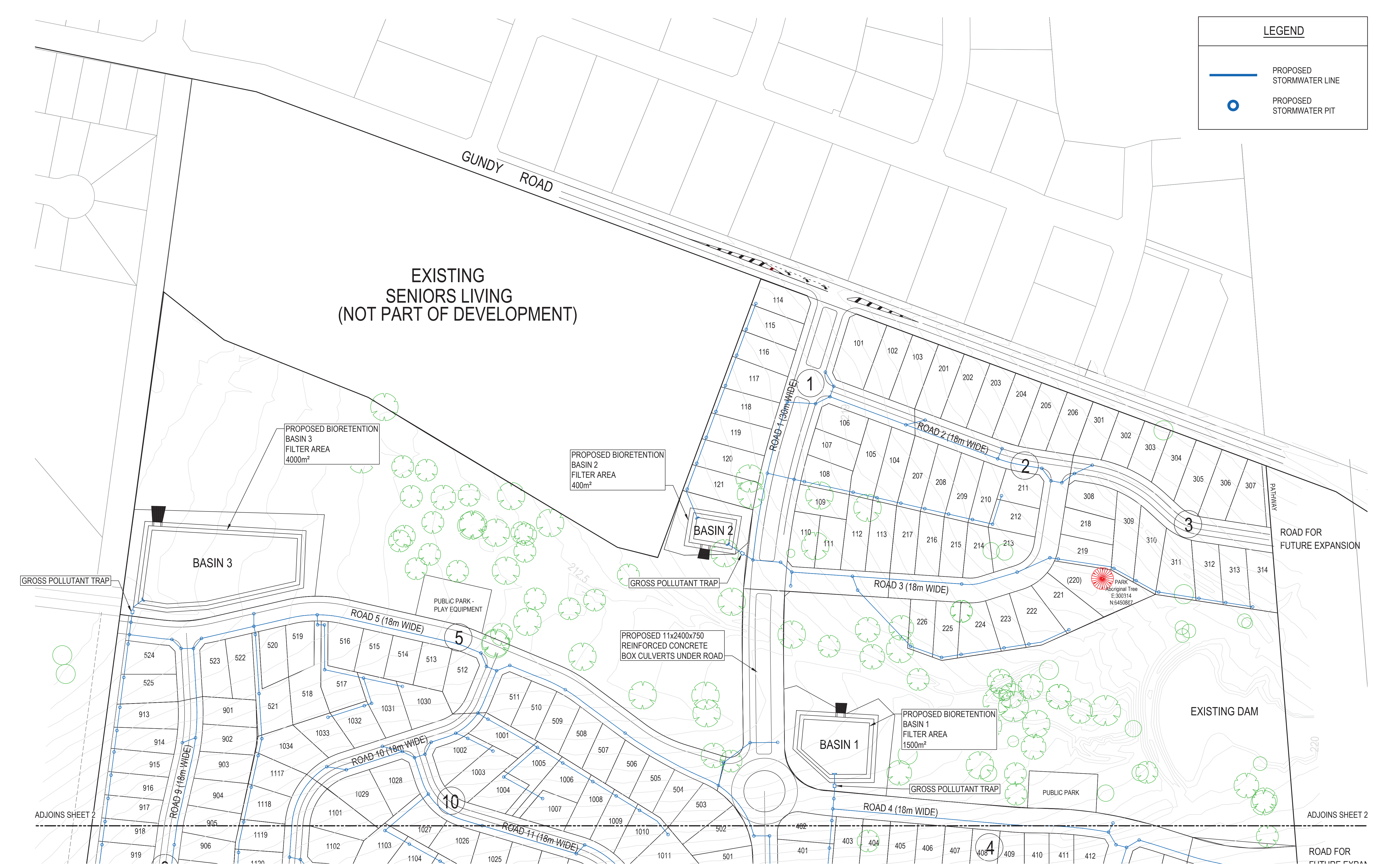
Designed	Project No.		Dwg No.	Issue
UK	NSW202732		FIGURE 4	B



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Issue	Description	Date	Drawn	Approved
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Project: STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title: STORMWATER DRAINAGE SYSTEM PRELIMINARY LAYOUT

Drawn	Date	Scale A1	Q.A. Check	Date
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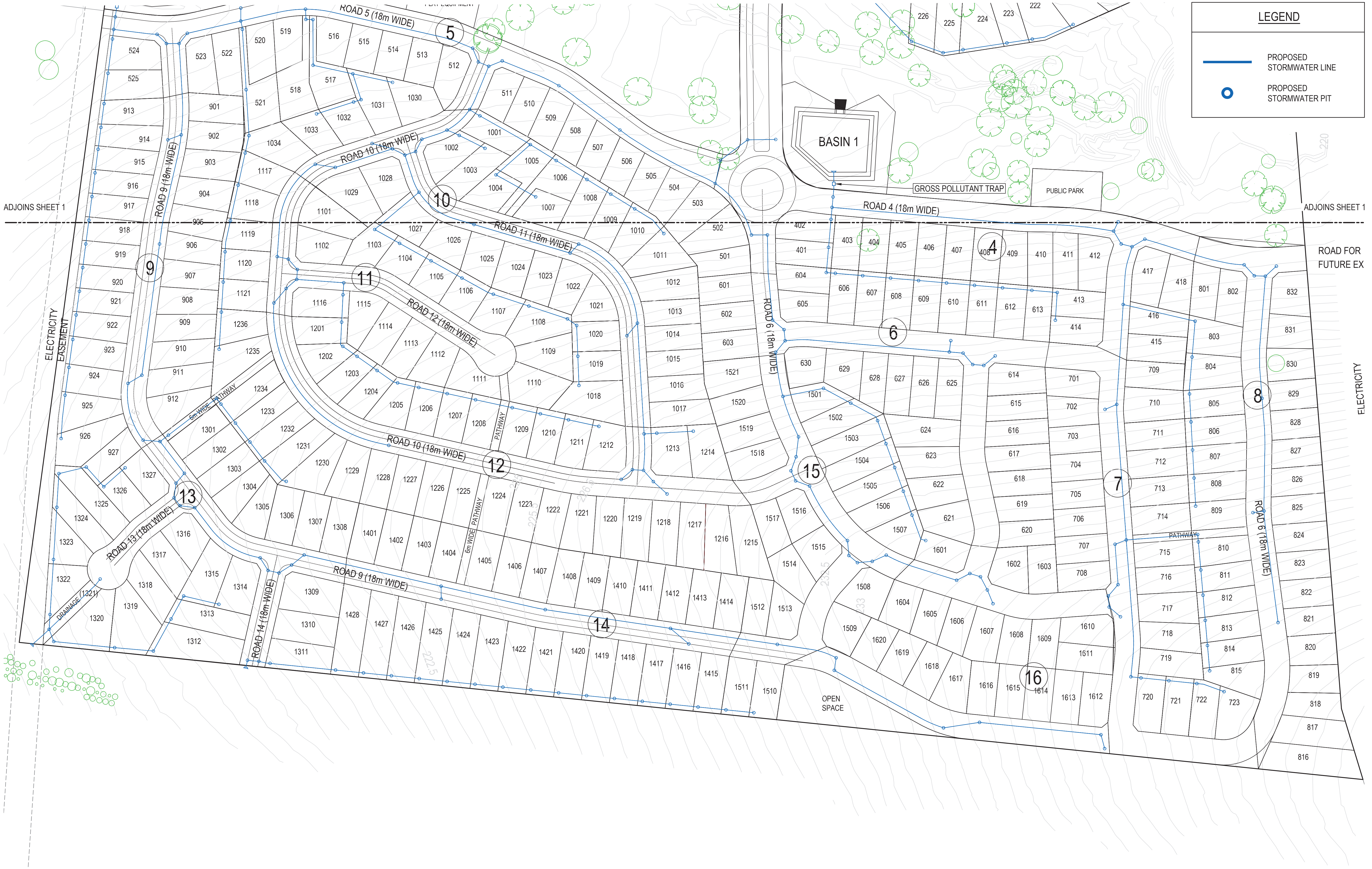
Designed	Project No.		Dwg. No.	Issue
UK	NSW202732		FIGURE 5	B



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Project
STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title
STORMWATER MANAGEMENT PLAN

Drawn	Date	Scale A1	Q.A. Check	Date
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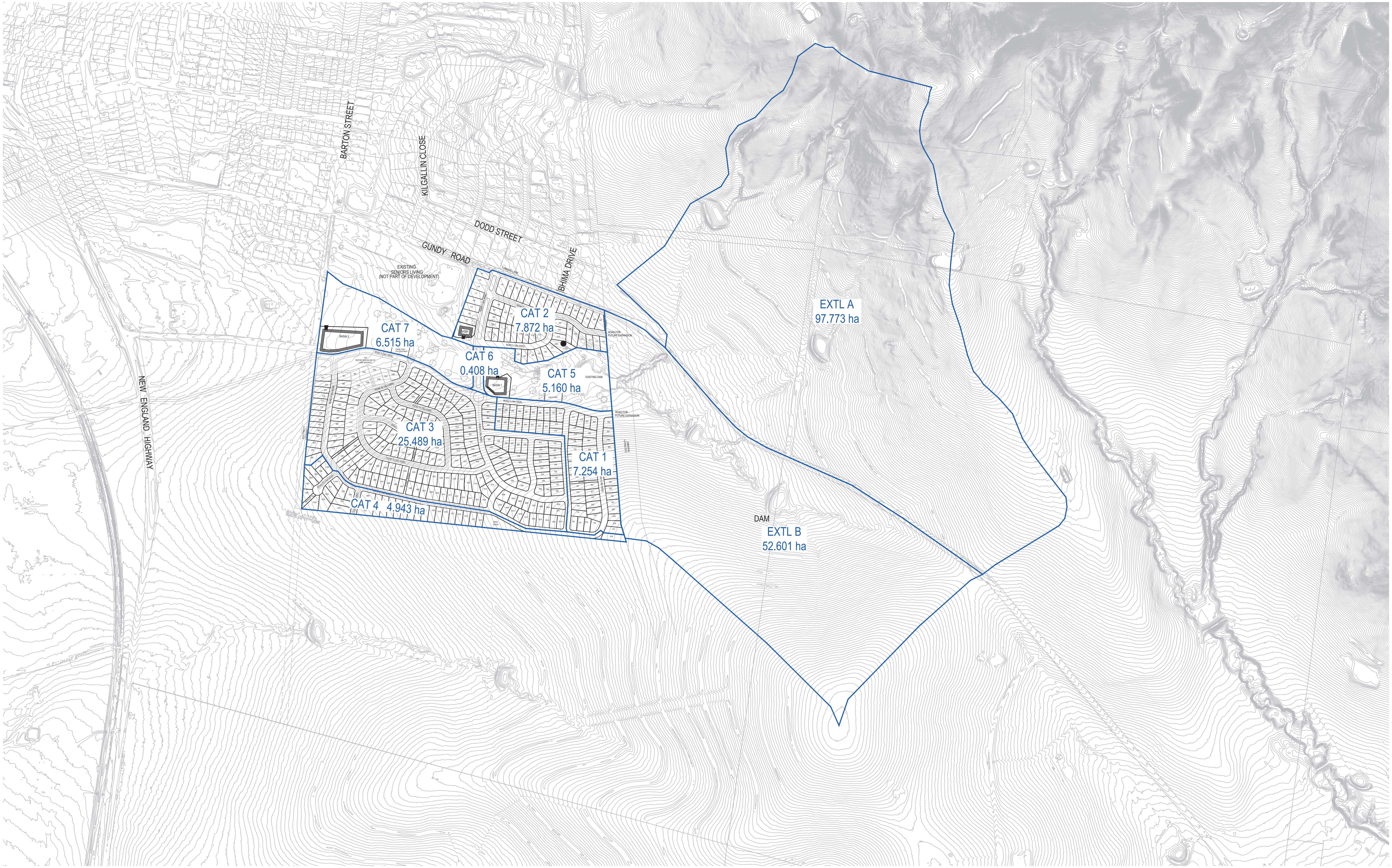
Designed	**Project No.**		**Dwg. No.**	**Issue**
UK	NSW202732		FIGURE 6	B



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Issue	Description	Date	Drawn	Approved
B	ISSUED FOR APPROVAL	19.08.21	ADS	UK
A	ISSUED FOR CLIENT REVIEW	21.03.21	ADS	UK

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Project
STORMWATER MANAGEMENT PLAN

LOT 2, DP1169320
GUNDY ROAD, SCONE

Drawing Title
EROSION AND SEDIMENT PLAN

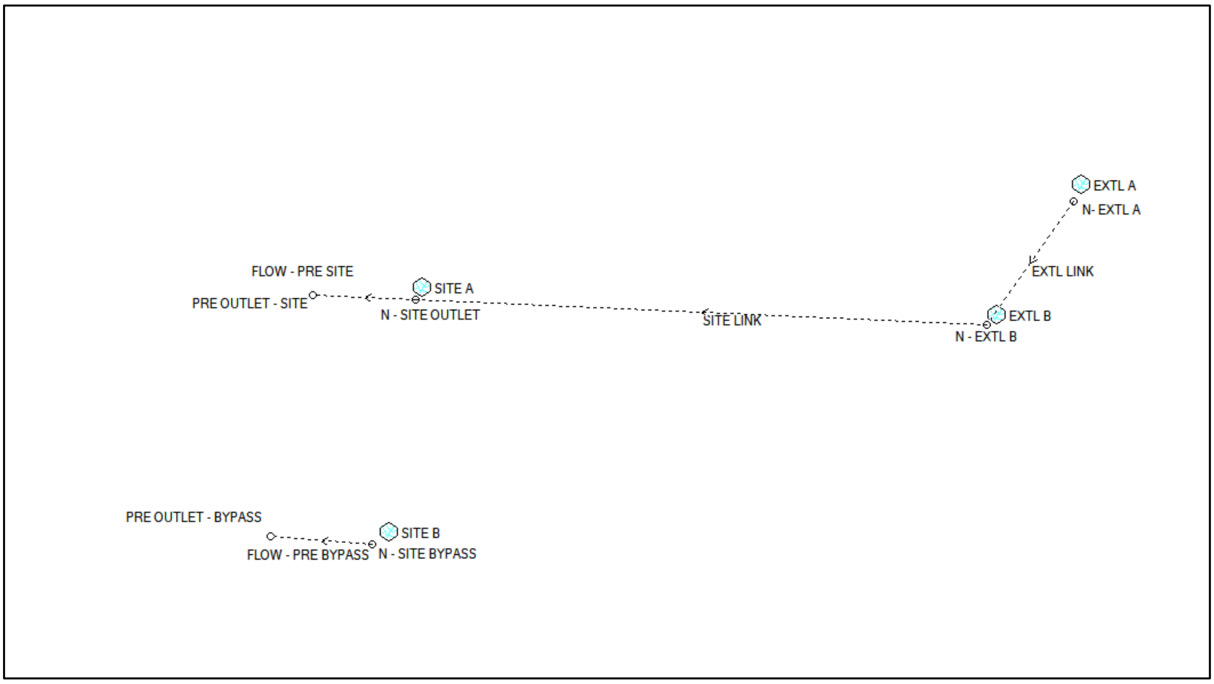
Drawn	Date	Scale A1	Q.A. Check	Date
ADS	MAR 2021	1:1000	UK	12.03.21

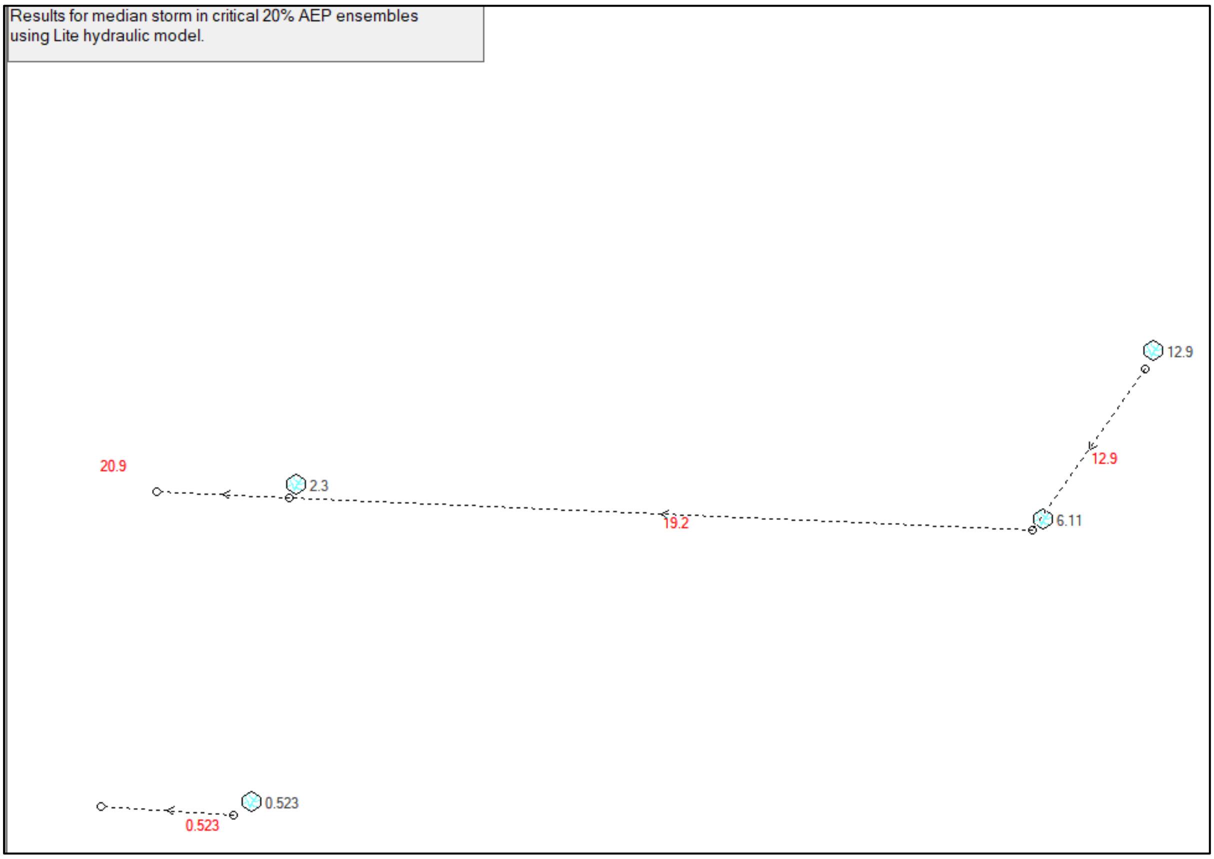
Designed	Project No.	Dwg. No.	Issue
UK	NSW202732	FIGURE 7	B

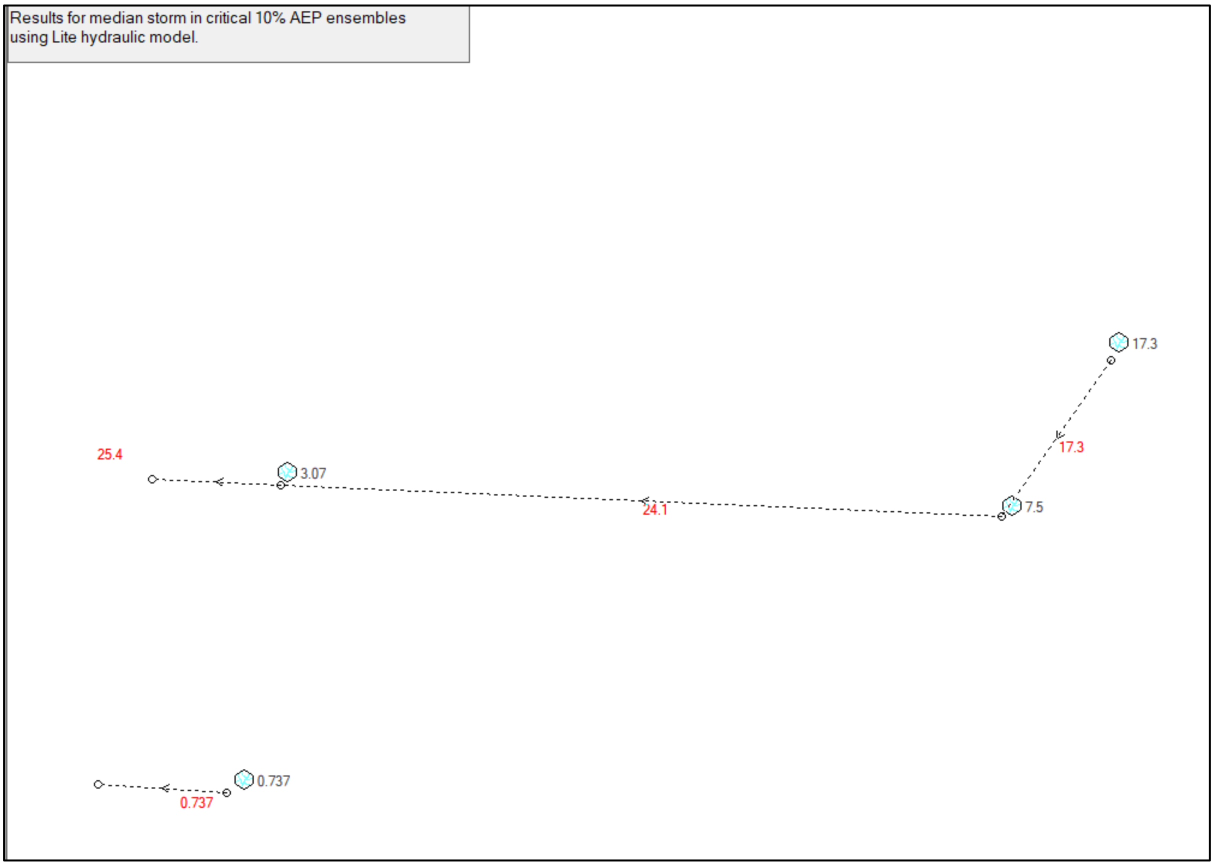
Aug 20, 2021 - 12:00pm

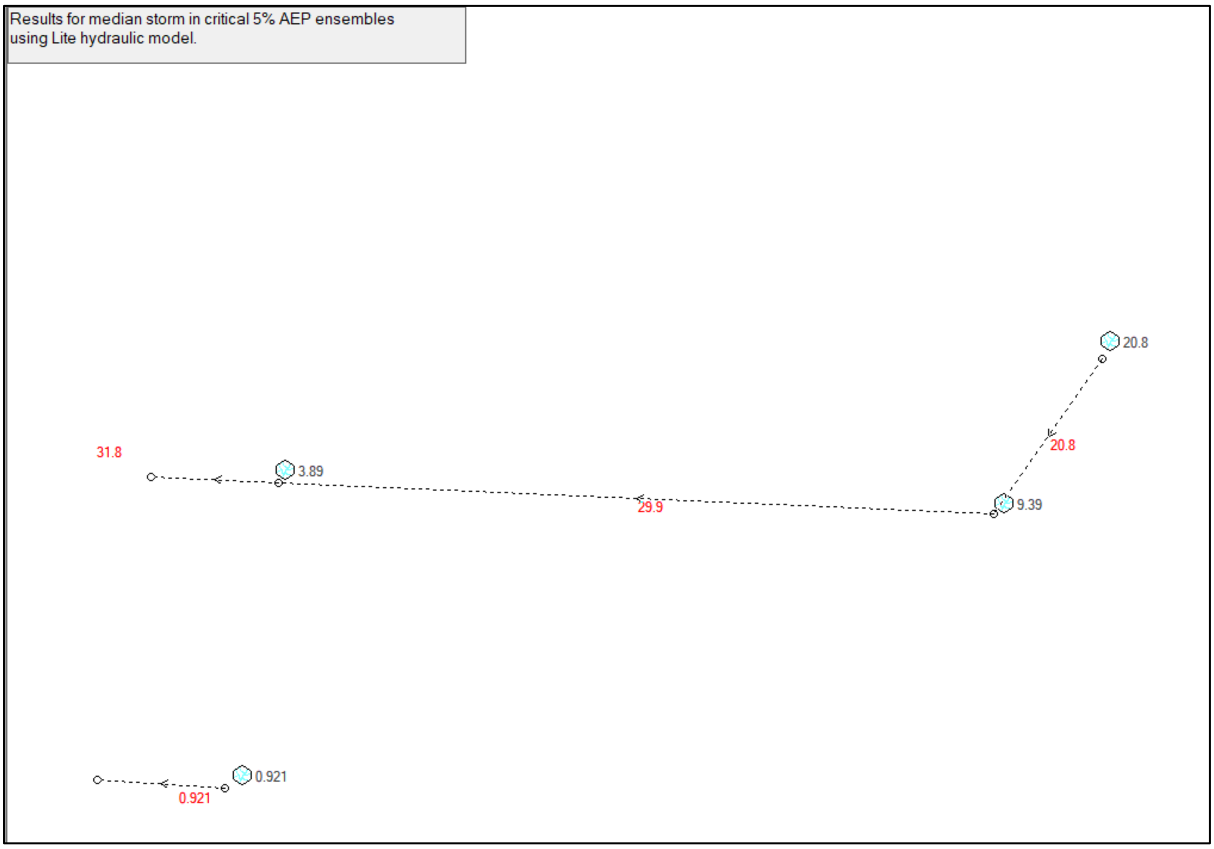
Appendix A - DRAINS Modelling Inputs and Results

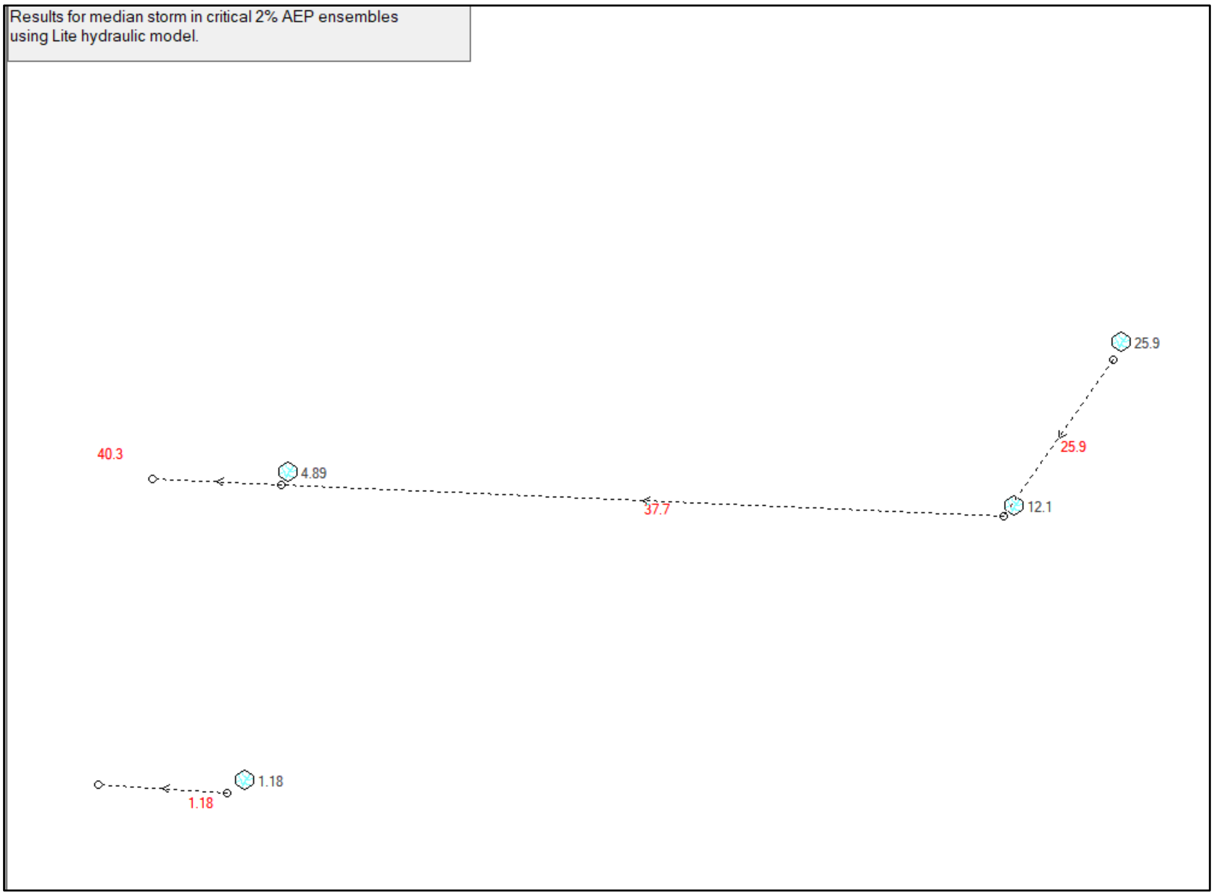
DRAINS PREDEVELOPED SCHEMATICS

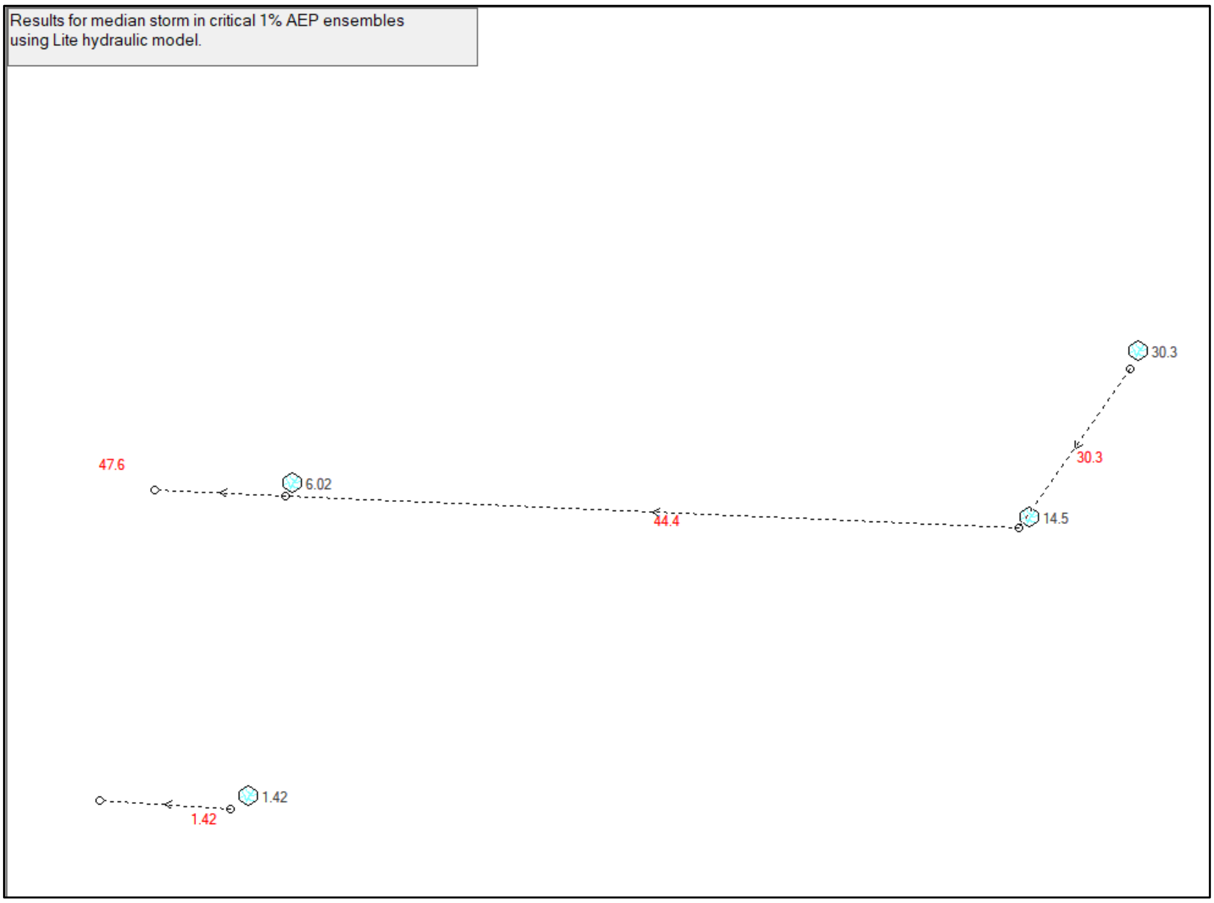




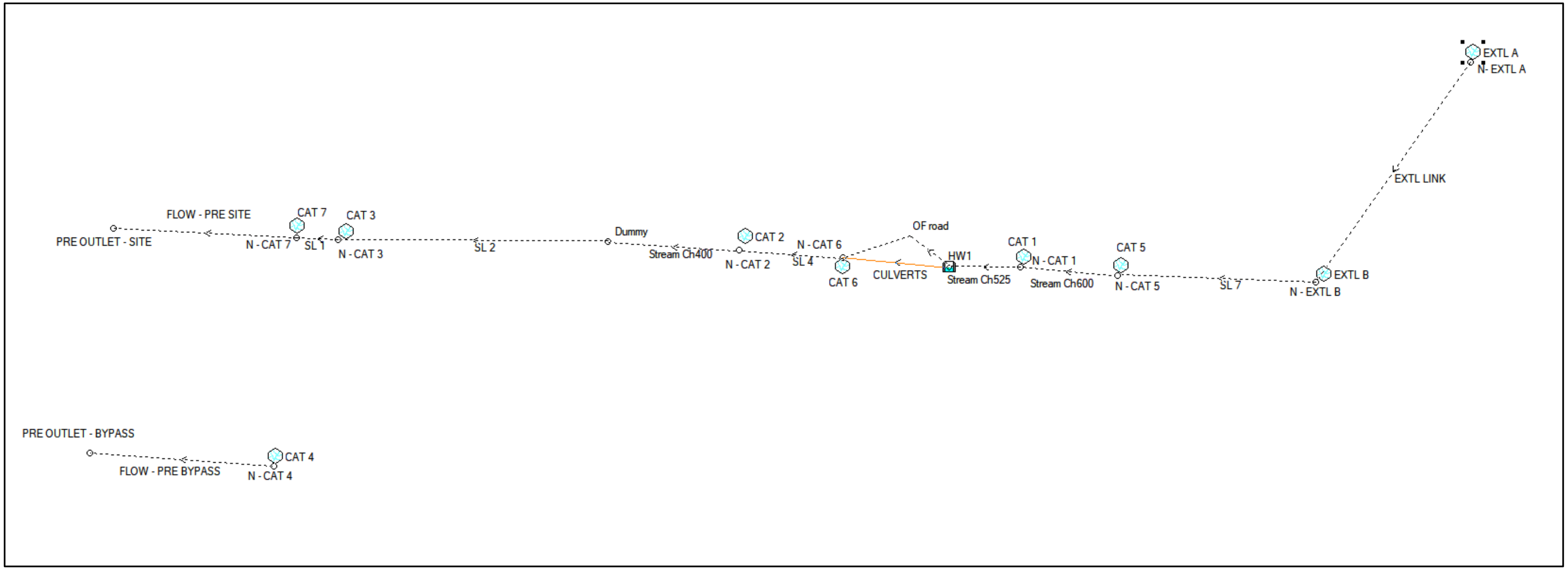

Results for median storm in critical 10% AEP ensembles
using Lite hydraulic model.
17.3
17.3
25.4
3.07
24.1
7.5
0.737
0.737

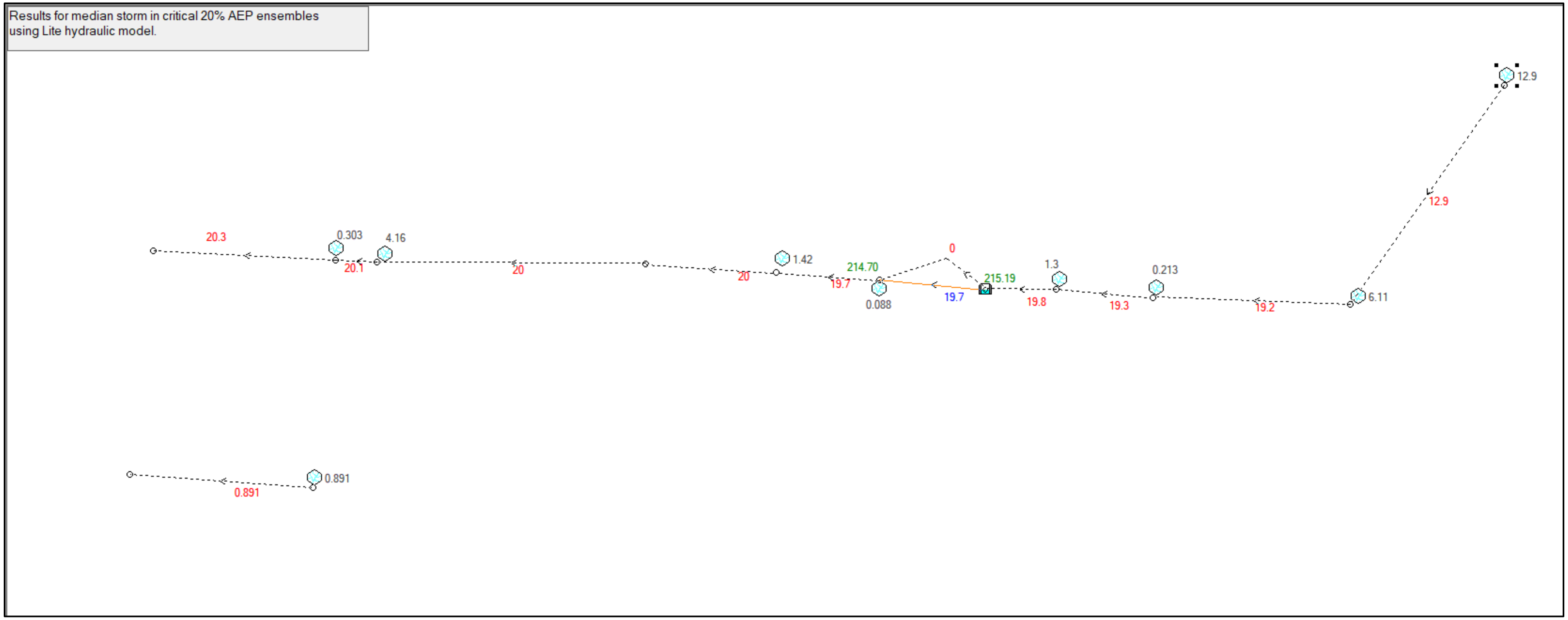

Results for median storm in critical 5% AEP ensembles
using Lite hydraulic model.
20.8
20.8
31.8
3.89
29.9
9.39
0.921
0.921


Results for median storm in critical 2% AEP ensembles
using Lite hydraulic model.
25.9
25.9
40.3
4.89
37.7
12.1
1.18
1.18


Results for median storm in critical 1% AEP ensembles
using Lite hydraulic model.
30.3
30.3
47.6
6.02
44.4
14.5
1.42
1.42

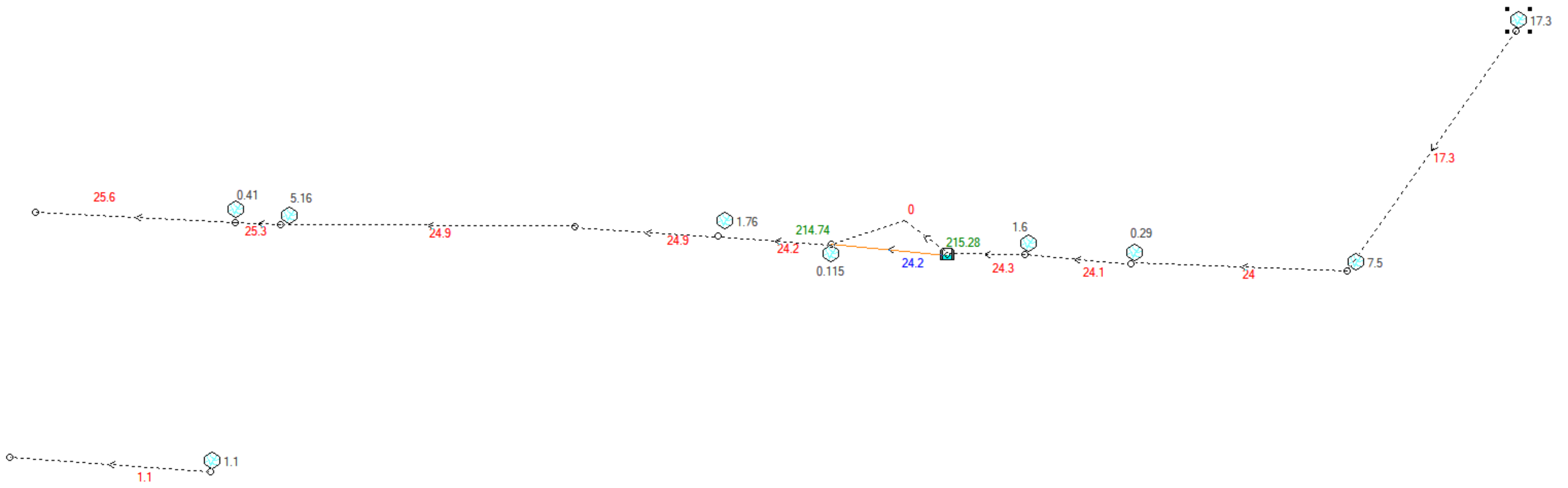
DRAINS POST DEVELOPED SCHEMATICS



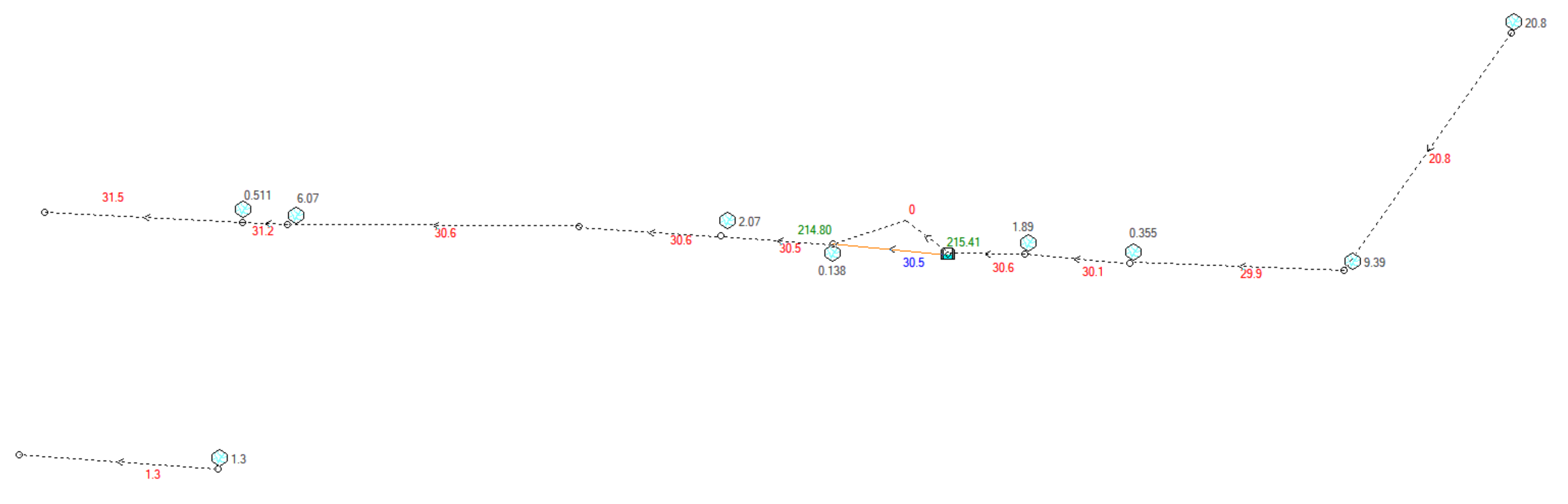


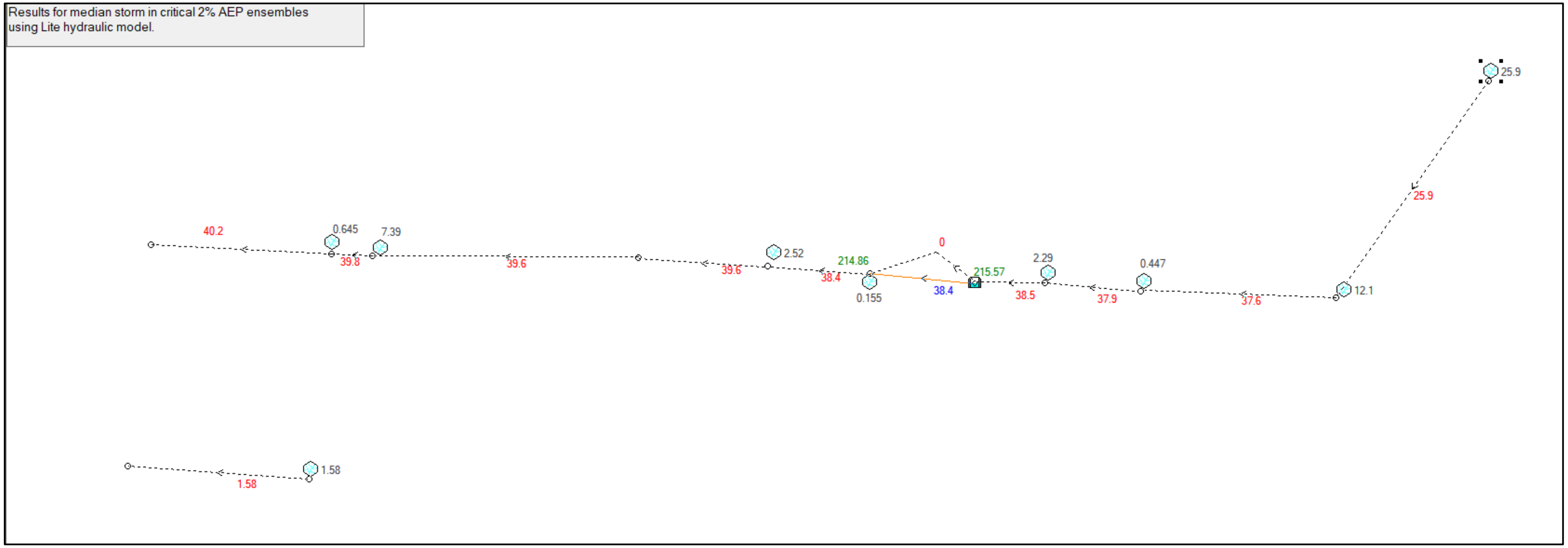
Results for median storm in critical 20% AEP ensembles
using Lite hydraulic model.
12.9
12.9
20.3
0.303
4.16
20.1
20
1.42
20
214.70
19.7
0.088
0
215.19
19.7
1.3
19.8
0.213
19.3
19.2
6.11
0.891
0.891

Results for median storm in critical 10% AEP ensembles
using Lite hydraulic model.

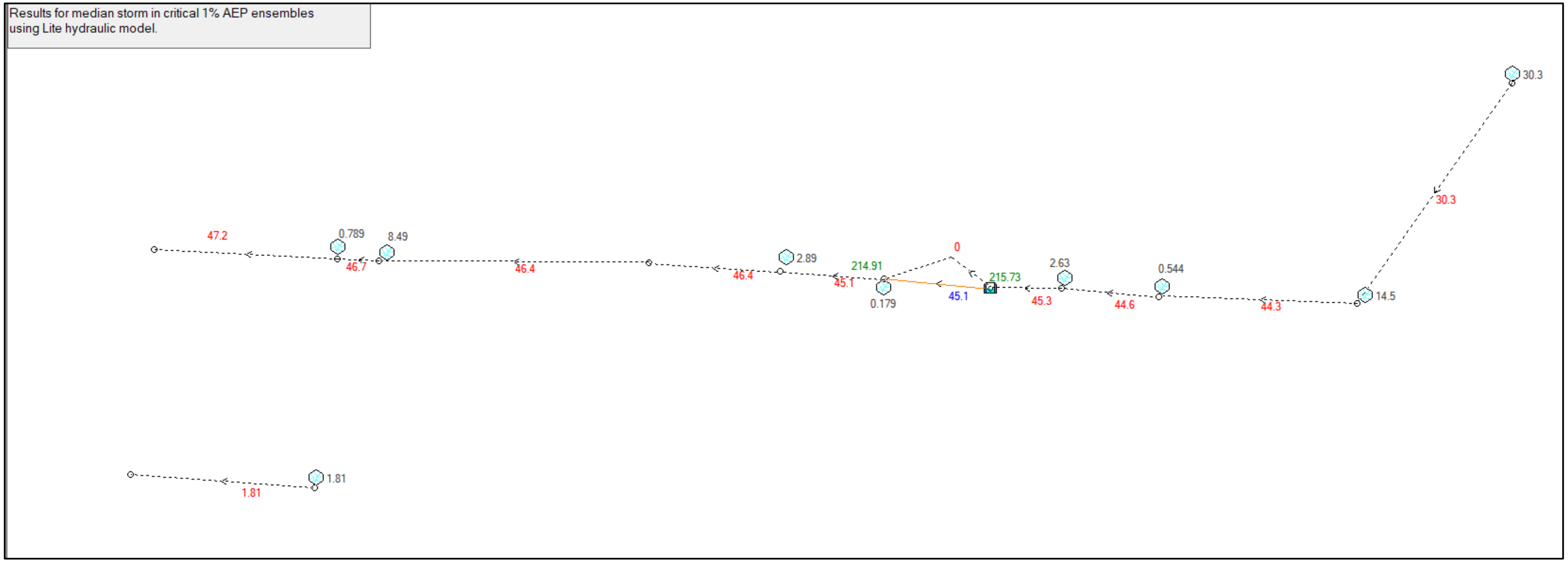


Results for median storm in critical 5% AEP ensembles
using Lite hydraulic model.

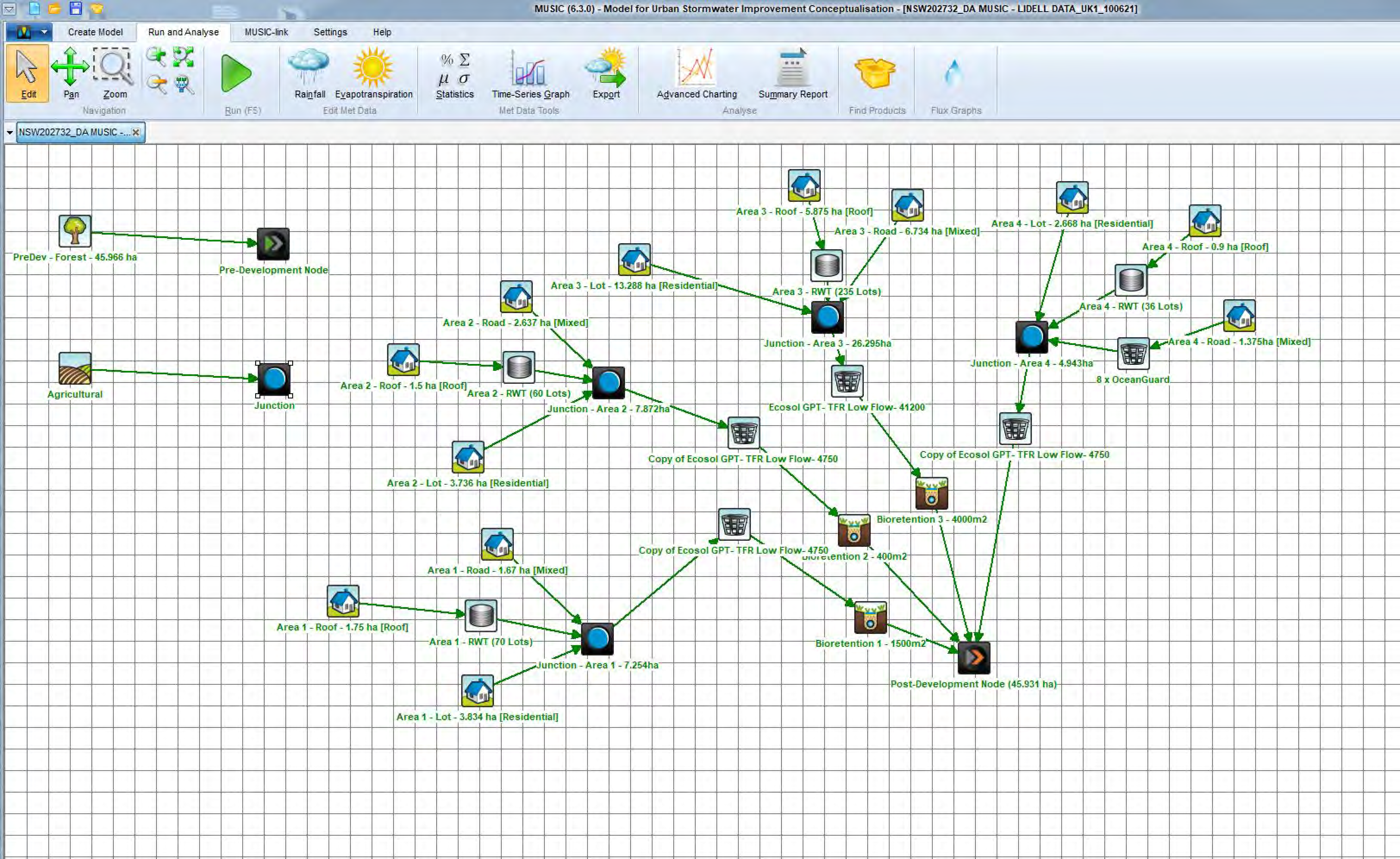




Results for median storm in critical 2% AEP ensembles
using Lite hydraulic model.
25.9
25.9
40.2
0.645
7.39
39.8
39.6
39.6
2.52
214.86
38.4
0
215.57
2.29
0.447
0.155
38.4
38.5
37.9
37.6
12.1
1.58
1.58


Results for median storm in critical 1% AEP ensembles
using Lite hydraulic model.
30.3
30.3
47.2
0.789
8.49
46.7
46.4
2.89
46.4
45.1
214.91
0
215.73
2.63
0.544
0.179
45.1
45.3
44.6
44.3
14.5
1.81
1.81

Appendix B - MUSIC Modelling Report


MUSIC (6.3.0) - Model for Urban Stormwater Improvement Conceptualisation - [NSW202732_DA MUSIC - LIDELL DATA_UK1_100621]
Create Model
Run and Analyse
MUSIC-link
Settings
Help
Edit
Pan
Zoom
Navigation
Run (F5)
Rainfall
Evapotranspiration
Edit Met Data
Statistics
Time-Series Graph
Export
Met Data Tools
Advanced Charting
Summary Report
Analyse
Find Products
Flux Graphs
NSW202732_DA MUSIC -...
PreDev - Forest - 45.966 ha
Pre-Development Node
Agricultural
Junction
Area 3 - Roof - 5.875 ha [Roof]
Area 3 - Road - 6.734 ha [Mixed]
Area 3 - Lot - 13.288 ha [Residential]
Area 3 - RWT (235 Lots)
Junction - Area 3 - 26.295ha
Ecosol GPT- TFR Low Flow- 41200
Area 4 - Lot - 2.668 ha [Residential]
Area 4 - Roof - 0.9 ha [Roof]
Area 4 - RWT (36 Lots)
Area 4 - Road - 1.375ha [Mixed]
Junction - Area 4 - 4.943ha
8 x OceanGuard
Copy of Ecosol GPT- TFR Low Flow- 4750
Area 2 - Road - 2.637 ha [Mixed]
Area 2 - Roof - 1.5 ha [Roof]
Area 2 - RWT (60 Lots)
Junction - Area 2 - 7.872ha
Area 2 - Lot - 3.736 ha [Residential]
Copy of Ecosol GPT- TFR Low Flow- 4750
Bioretention 3 - 4000m2
Copy of Ecosol GPT- TFR Low Flow- 4750
Bioretention 2 - 400m2
Area 1 - Road - 1.67 ha [Mixed]
Area 1 - Roof - 1.75 ha [Roof]
Area 1 - RWT (70 Lots)
Junction - Area 1 - 7.254ha
Area 1 - Lot - 3.834 ha [Residential]
Bioretention 1 - 1500m2
Post-Development Node (45.931 ha)

SCONE SUBDIVISION NSW202732
MUSIC MODEL REPORT – 18 AUGUST 2021

Source nodes
Location,PreDev - Forest - 45.966 ha,Area 1 - Road - 1.67 ha,Area 1 - Roof - 1.75 ha,Area 1 - Lot - 3.834 ha,Area 2 - Road - 2.637 ha,Area 3 - Road - 6.734 ha,Area 3 - Roof - 5.875 ha,Area 2 - Roof - 1.5 ha,Area 3 - Lot - 13.288 ha,Area 2 - Lot - 3.736 ha,Area 4 - Lot - 2.668 ha,Area 4 - Roof - 0.9 ha,Area 4 - Road - 1.375ha,Agricultural
ID,1,2,3,4,7,8,9,10,11,12,19,20,21,28
Node Type,ForestSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,UrbanSourceNode,AgriculturalSourceNode
Zoning Surface Type,,Mixed,Roof,Residential,Mixed,Mixed,Roof,Roof,Residential,Residential,Residential,Roof,Mixed,
Total Area (ha),45.966,1.67,1.75,3.834,2.637,6.734,5.875,1.5,13.288,3.736,2.668,0.9,1.375,45.966
Area Impervious (ha),15.9371668656716,1.33219888059701,1.75,2.47579119402985,2.11353582089552,5.3718726119403,5.875,1.5,8.68083223880597,2.42658776119403,1.74296059701493,0.9,1.10205223880597,15.8805669402985
Area Pervious (ha),30.0288331343284,0.337801119402985,0,1.35820880597015,0.523464179104477,1.3621273880597,0,0,4.60716776119403,1.30941223880597,0.925039402985074,0,0.27294776119403,30.0854330597015
Field Capacity (mm),58,58,58,58,58,58,58,58,58,58,58,58,58,58
Pervious Area Infiltration Capacity coefficient - a,135,135,135,135,135,135,135,135,135,135,135,135,135,135
Pervious Area Infiltration Capacity exponent - b,4,4,3.5,1,4,4,3.5,3.5,1,1,1,4,4,4
Impervious Area Rainfall Threshold (mm/day),1,1,0.3,1,1,1,0.3,0.3,1,1,1,0.3,1,1
Pervious Area Soil Storage Capacity (mm),90,90,90,90,90,90,90,90,90,90,90,90,90,90
Pervious Area Soil Initial Storage (% of Capacity),25,25,25,25,25,25,25,25,25,25,25,25,25,25
Groundwater Initial Depth (mm),10,10,10,10,10,10,10,10,10,10,10,10,10,10
Groundwater Daily Recharge Rate (%),10,10,10,10,10,10,10,10,10,10,10,10,10,10
Groundwater Daily Baseflow Rate (%),10,10,10,10,10,10,10,10,10,10,10,10,10,10
Groundwater Daily Deep Seepage Rate (%),0,0,0,0,0,0,0,0,0,0,0,0,0,0
Stormflow Total Suspended Solids Mean (log mg/L),1.6,2.2,1.3,2.15,2.2,2.2,1.3,1.3,2.15,2.15,2.15,1.3,2.2,2.15
Stormflow Total Suspended Solids Standard Deviation (log mg/L),0.2,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.32,0.31
Stormflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0

Stormflow Total Phosphorus Mean (log mg/L),-1.1,-0.45,-0.89,-0.6,-0.45,-0.45,-0.89,-0.89,-0.6,-0.6,-0.6,-0.89,-0.45,-0.22
Stormflow Total Phosphorus Standard Deviation (log mg/L),0.22,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.25,0.3
Stormflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0
Stormflow Total Nitrogen Mean (log mg/L),-0.05,0.42,0.3,0.3,0.42,0.42,0.3,0.3,0.3,0.3,0.3,0.3,0.42,0.48
Stormflow Total Nitrogen Standard Deviation (log mg/L),0.24,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.19,0.26
Stormflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Stormflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Suspended Solids Mean (log mg/L),0.78,1.1,0,1.2,1.1,1.1,0,0,1.2,1.2,1.2,0,1.1,1.3
Baseflow Total Suspended Solids Standard Deviation (log mg/L),0.13,0.17,0,0.17,0.17,0.17,0,0,0.17,0.17,0.17,0,0.17,0.13
Baseflow Total Suspended Solids Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Suspended Solids Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Phosphorus Mean (log mg/L),-1.52,-0.82,0,-0.85,-0.82,-0.82,0,0,-0.85,-0.85,-0.85,0,-0.82,-1.05
Baseflow Total Phosphorus Standard Deviation (log mg/L),0.13,0.19,0,0.19,0.19,0.19,0,0,0.19,0.19,0.19,0,0.19,0.13
Baseflow Total Phosphorus Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Phosphorus Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0
Baseflow Total Nitrogen Mean (log mg/L),-0.52,0.32,0,0.11,0.32,0.32,0,0,0.11,0.11,0.11,0,0.32,0.04
Baseflow Total Nitrogen Standard Deviation (log mg/L),0.13,0.12,0,0.12,0.12,0.12,0,0,0.12,0.12,0.12,0,0.12,0.13
Baseflow Total Nitrogen Estimation Method,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic,Stochastic
Baseflow Total Nitrogen Serial Correlation,0,0,0,0,0,0,0,0,0,0,0,0,0,0
Flow based constituent generation - enabled,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off,Off
Flow based constituent generation - flow file, , , , , , , , , , , , , ,
Flow based constituent generation - base flow column, , , , , , , , , , , , , ,
Flow based constituent generation - pervious flow column, , , , , , , , , , , , , ,
Flow based constituent generation - impervious flow column, , , , , , , , , , , , , ,
Flow based constituent generation - unit, , , , , , , , , , , , , ,

OUT - Mean Annual Flow
(ML/yr),60.0,4.36,6.19,8.25,6.89,17.6,20.8,5.30,28.6,8.04,5.74,3.18,3.59,
60.0
OUT - TSS Mean Annual Load
(kg/yr),2.63E3,916,163,1.53E3,1.45E3,3.66E3,546,136,5.23E3,1.43E3,1.05E3,
83.0,749,10.9E3
OUT - TP Mean Annual Load
(kg/yr),5.36,1.82,0.949,2.41,2.89,7.33,3.12,0.809,8.41,2.34,1.69,0.482,1.
51,44.6
OUT - TN Mean Annual Load
(kg/yr),61.8,12.6,13.6,18.0,20.0,50.8,45.7,11.6,62.3,17.5,12.6,7.00,10.4,
216
OUT - Gross Pollutant Mean Annual Load
(kg/yr),2.48E3,154,207,314,243,621,694,177,1.09E3,306,218,106,127,2.48E3
Rain In
(ML/yr),170.614,6.19863,6.49556,14.2309,9.78789,24.995,21.8065,5.56763,49
.3218,13.8671,9.90293,3.34057,5.10366,170.614
ET Loss
(ML/yr),110.757,1.83636,0.308961,5.98082,2.89968,7.40485,1.03725,0.264822
,20.7285,5.82796,4.16191,0.158895,1.51197,110.757
Deep Seepage Loss (ML/yr),0,0,0,0,0,0,0,0,0,0,0,0,0,0
Baseflow Out
(ML/yr),0.963763,0.0107737,0,0.1272,0.0170122,0.0434434,0,0,0.440854,0.12
3949,0.0885158,0,0.00887059,0.963763
Imp. Stormflow Out
(ML/yr),51.3905,4.26761,6.1866,7.96057,6.73874,17.2084,20.7693,5.3028,27.
59,7.75709,5.53959,3.18169,3.51375,51.3905
Perv. Stormflow Out
(ML/yr),7.6021,0.0849826,0,0.166739,0.134191,0.342678,0,0,0.577889,0.1624
77,0.11603,0,0.0699707,7.6021
Total Stormflow Out
(ML/yr),58.9926,4.35259,6.1866,8.1273,6.87293,17.5511,20.7693,5.3028,28.1
678,7.91956,5.65562,3.18169,3.58372,58.9926
Total Outflow
(ML/yr),59.9564,4.36337,6.1866,8.2545,6.88994,17.5945,20.7693,5.3028,28.6
087,8.04351,5.74414,3.18169,3.59259,59.9564
Change in Soil Storage (ML/yr),-0.0995297,-0.00111261,0,-0.00447016,-
0.00175687,-0.00448646,0,0,-0.0154928,-0.0043559,-0.00311069,0,-
0.000916074,-0.0995297
TSS Baseflow Out
(kg/yr),6.08172,0.146577,0,2.17652,0.231412,0.59024,0,0,7.54458,2.12105,1
.51557,0,0.120538,20.1079
TSS Total Stormflow Out
(kg/yr),2625.78,916.215,162.662,1524.27,1445.27,3664.05,546.247,136.428,5
226.08,1431.75,1050.29,83.0104,748.878,10910.4
TSS Total Outflow
(kg/yr),2631.86,916.362,162.662,1526.44,1445.5,3664.64,546.247,136.428,52
33.62,1433.87,1051.81,83.0104,748.999,10930.5
TP Baseflow Out
(kg/yr),0.0304059,0.00179846,0,0.0197638,0.00283984,0.00723776,0,0,0.0685
476,0.019237,0.013762,0,0.00147704,0.0896778
TP Total Stormflow Out
(kg/yr),5.33286,1.81418,0.948978,2.3889,2.88253,7.32657,3.11965,0.809475,
8.3427,2.31692,1.68007,0.481501,1.50487,44.5437
TP Total Outflow
(kg/yr),5.36327,1.81598,0.948978,2.40866,2.88537,7.33381,3.11965,0.809475
,8.41125,2.33616,1.69383,0.481501,1.50635,44.6334

TN Baseflow Out
(kg/yr),0.303964,0.0233563,0,0.170473,0.0369324,0.0943716,0,0,0.590385,0.
165819,0.118529,0,0.0192166,1.10461
TN Total Stormflow Out
(kg/yr),61.4981,12.527,13.5661,17.7823,19.9739,50.7309,45.6886,11.6094,61
.7327,17.3611,12.4956,7.00352,10.3337,214.63
TN Total Outflow
(kg/yr),61.8021,12.5503,13.5661,17.9527,20.0108,50.8253,45.6886,11.6094,6
2.3231,17.5269,12.6141,7.00352,10.3529,215.735
GP Total Outflow
(kg/yr),2479.04,154.151,206.707,313.958,243.411,621.589,693.944,177.178,1
088.12,305.932,218.477,106.306,126.921,2479.04

No Imported Data Source nodes

USTM treatment nodes
Location,Area 1 - RWT (70 Lots),Area 3 - RWT (235 Lots),Area 2 - RWT (60
Lots),Area 4 - RWT (36 Lots),Bioretention 2 - 400m2,Bioretention 1 -
1500m2,Bioretention 3 - 4000m2
ID,5,13,14,22,23,24,27
Node
Type,RainWaterTankNode,RainWaterTankNode,RainWaterTankNode,RainWaterTankN
ode,BioRetentionNodeV4,BioRetentionNodeV4,BioRetentionNodeV4
Lo-flow bypass rate (cum/sec),0,0,0,0,0,0,0
Hi-flow bypass rate (cum/sec),0.35,1.175,0.3,0.18,100,100,100
Inlet pond volume,0,0,0,0, , ,
Area (sqm),126,423,108,64.8,480,1800,4800
Initial Volume (m^3),0,0,0,0, , ,
Extended detention depth (m),0.05,0.05,0.05,0.05,0.3,0.3,0.3
Number of Rainwater tanks,70,235,60,36, , ,
Permanent Pool Volume (cubic metres),210,705,180,108, , ,
Proportion vegetated,0,0,0,0, , ,
Equivalent Pipe Diameter (mm),837,1533,775,600, , ,
Overflow weir width (m),10,10,10,10,5,5,5
Notional Detention Time (hrs),4.79E-3,4.80E-3,4.79E-3,4.80E-3, , ,
Orifice Discharge Coefficient,0.6,0.6,0.6,0.6, , ,
Weir Coefficient,1.7,1.7,1.7,1.7,1.7,1.7,1.7
Number of CSTR Cells,2,2,2,2,3,3,3
Total Suspended Solids - k (m/yr),400,400,400,400,8000,8000,8000
Total Suspended Solids - C* (mg/L),12,12,12,12,20,20,20
Total Suspended Solids - C** (mg/L),12,12,12,12, , ,
Total Phosphorus - k (m/yr),300,300,300,300,6000,6000,6000
Total Phosphorus - C* (mg/L),0.13,0.13,0.13,0.13,0.13,0.13,0.13
Total Phosphorus - C** (mg/L),0.13,0.13,0.13,0.13, , ,
Total Nitrogen - k (m/yr),40,40,40,40,500,500,500
Total Nitrogen - C* (mg/L),1.4,1.4,1.4,1.4,1.4,1.4,1.4
Total Nitrogen - C** (mg/L),1.4,1.4,1.4,1.4, , ,
Threshold Hydraulic Loading for C** (m/yr),3500,3500,3500,3500, , ,
Horizontal Flow Coefficient, , , , ,3,3,3
Reuse Enabled,On,On,On,On,Off,Off,Off
Max drawdown height
(m),1.66666666666667,1.66666666666667,1.66666666666667,1.66666666666667,
, ,
Annual Demand Enabled,On,On,On,On,Off,Off,Off
Annual Demand Value (ML/year),24.01,80.605,20.58,12.348, , ,
Annual Demand Distribution,PET,PET,PET,PET, , ,
Annual Demand Monthly Distribution: Jan, , , , , , ,
Annual Demand Monthly Distribution: Feb, , , , , , ,

Annual Demand Monthly Distribution: Mar, , , , , , ,
Annual Demand Monthly Distribution: Apr, , , , , , ,
Annual Demand Monthly Distribution: May, , , , , , ,
Annual Demand Monthly Distribution: Jun, , , , , , ,
Annual Demand Monthly Distribution: Jul, , , , , , ,
Annual Demand Monthly Distribution: Aug, , , , , , ,
Annual Demand Monthly Distribution: Sep, , , , , , ,
Annual Demand Monthly Distribution: Oct, , , , , , ,
Annual Demand Monthly Distribution: Nov, , , , , , ,
Annual Demand Monthly Distribution: Dec, , , , , , ,
Daily Demand Enabled,On,On,On,On,Off,Off,Off
Daily Demand Value (ML/day),0.0658,0.2209,0.0564,0.03384, , ,
Custom Demand Enabled,Off,Off,Off,Off,Off,Off,Off
Custom Demand Time Series File, , , , , , ,
Custom Demand Time Series Units, , , , , , ,
Filter area (sqm), , , , ,400,1500,4000
Filter perimeter (m), , , , ,80,80,80
Filter depth (m), , , , ,0.4,0.4,0.4
Filter Median Particle Diameter (mm), , , , , , ,
Saturated Hydraulic Conductivity (mm/hr), , , , ,100,100,100
Infiltration Media Porosity, , , , ,0.35,0.35,0.35
Length (m), , , , , , ,
Bed slope, , , , , , ,
Base Width (m), , , , , , ,
Top width (m), , , , , , ,
Vegetation height (m), , , , , , ,
Vegetation Type, , , , ,Vegetated with Effective Nutrient Removal Plants,Vegetated with Effective Nutrient Removal Plants,Vegetated with Effective Nutrient Removal Plants
Total Nitrogen Content in Filter (mg/kg), , , , ,800,800,800
Orthophosphate Content in Filter (mg/kg), , , , ,55,55,55
Is Base Lined?, , , , ,Yes,Yes,Yes
Is Underdrain Present?, , , , ,Yes,Yes,Yes
Is Submerged Zone Present?, , , , ,No,No,No
Submerged Zone Depth (m), , , , , , ,
B for Media Soil Texture,-9999,-9999,-9999,-9999,13,13,13
Proportion of upstream impervious area treated, , , , , , ,
Exfiltration Rate (mm/hr),0,0,0,0,0,0,0
Evaporative Loss as % of PET,0,0,0,0,100,100,100
Depth in metres below the drain pipe, , , , , , ,
TSS A Coefficient, , , , , , ,
TSS B Coefficient, , , , , , ,
TP A Coefficient, , , , , , ,
TP B Coefficient, , , , , , ,
TN A Coefficient, , , , , , ,
TN B Coefficient, , , , , , ,
Sfc, , , , ,0.61,0.61,0.61
S*, , , , ,0.37,0.37,0.37
Sw, , , , ,0.11,0.11,0.11
Sh, , , , ,0.05,0.05,0.05
Emax (m/day), , , , ,0.008,0.008,0.008
Ew (m/day), , , , ,0.001,0.001,0.001
IN - Mean Annual Flow (ML/yr),6.19,20.8,5.30,3.18,16.5,14.4,52.2
IN - TSS Mean Annual Load (kg/yr),163,546,136,83.0,1.27E3,1.07E3,4.07E3
IN - TP Mean Annual Load (kg/yr),0.949,3.12,0.809,0.482,3.99,3.28,12.3
IN - TN Mean Annual Load (kg/yr),13.6,45.7,11.6,7.00,40.8,34.4,126
IN - Gross Pollutant Mean Annual Load (kg/yr),207,694,177,106,27.1,20.5,104

OUT - Mean Annual Flow (ML/yr),1.79,6.01,1.53,0.921,15.8,12.3,46.4
OUT - TSS Mean Annual Load (kg/yr),43.6,147,36.3,22.5,312,67.1,309
OUT - TP Mean Annual Load (kg/yr),0.272,0.882,0.232,0.137,2.40,1.70,6.42
OUT - TN Mean Annual Load (kg/yr),3.91,13.2,3.34,2.02,22.9,12.3,48.6
OUT - Gross Pollutant Mean Annual Load
(kg/yr),0.317,1.07,0.272,0.163,0.00,0.00,0.00
Flow In (ML/yr),6.18488,20.7763,5.30389,3.18178,16.4573,14.4,52.1649
ET Loss (ML/yr),0,0,0,0,0.630399,2.10171,5.80648
Infiltration Loss (ML/yr),0,0,0,0,0,0,0
Low Flow Bypass Out (ML/yr),0,0,0,0,0,0,0
High Flow Bypass Out
(ML/yr),0.0167255,0.0561499,0.0143361,0.00860168,0,0,0
Orifice / Filter Out
(ML/yr),1.7718,5.95154,1.51855,0.910824,9.9694,11.6644,42.3855
Weir Out
(ML/yr),0.00176905,0.00255442,0.00165388,0.00129914,5.84958,0.624385,3.93
3
Transfer Function Out (ML/yr),0,0,0,0,0,0,0
Reuse Supplied (ML/yr),4.39749,14.7596,3.7699,2.26142,0,0,0
Reuse Requested (ML/yr),47.9198,161.986,41.1606,24.8324,0,0,0
% Reuse Demand Met,9.17678,9.11163,9.15901,9.10676,0,0,0
% Load Reduction,71.0537,71.0717,71.0676,71.0626,3.87856,14.6613,11.2075
TSS Flow In
(kg/yr),162.662,546.25,136.428,83.0103,1271.17,1073.92,4066.59
TSS ET Loss (kg/yr),0,0,0,0,0,0,0
TSS Infiltration Loss (kg/yr),0,0,0,0,0,0,0
TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TSS High Flow Bypass Out (kg/yr),0.606496,1.66918,0.231796,0.153861,0,0,0
TSS Orifice / Filter Out
(kg/yr),42.9868,145.236,36.0257,22.2853,30.574,38.6256,137.946
TSS Weir Out
(kg/yr),0.050705,0.0638998,0.0389031,0.0333229,281.159,28.3748,170.842
TSS Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TSS Reuse Supplied (kg/yr),81.8337,274.714,69.2843,41.7958,0,0,0
TSS Reuse Requested (kg/yr),0,0,0,0,0,0,0
TSS % Reuse Demand Met,0,0,0,0,0,0,0
TSS % Load
Reduction,73.1689,73.0949,73.3952,72.9281,75.4767,93.7611,92.4067
TP Flow In
(kg/yr),0.948978,3.11965,0.809476,0.481501,3.98802,3.27613,12.2791
TP ET Loss (kg/yr),0,0,0,0,0,0,0
TP Infiltration Loss (kg/yr),0,0,0,0,0,0,0
TP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TP High Flow Bypass Out
(kg/yr),0.00323844,0.00816684,0.00223317,0.00163247,0,0,0
TP Orifice / Filter Out
(kg/yr),0.26872,0.87376,0.229781,0.135371,1.32619,1.59054,5.74669
TP Weir Out
(kg/yr),0.000311286,0.000412005,0.000234591,0.000189081,1.06967,0.105761,
0.666524
TP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TP Reuse Supplied (kg/yr),0.625395,2.08338,0.535264,0.319421,0,0,0
TP Reuse Requested (kg/yr),0,0,0,0,0,0,0
TP % Reuse Demand Met,0,0,0,0,0,0,0
TP % Load
Reduction,71.3092,71.7167,71.3087,71.5074,39.9237,48.2224,47.7715
TN Flow In
(kg/yr),13.5661,45.6884,11.6094,7.00351,40.8108,34.3519,126.155

TN ET Loss (kg/yr),0,0,0,0,0,0,0
TN Infiltration Loss (kg/yr),0,0,0,0,0,0,0
TN Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
TN High Flow Bypass Out (kg/yr),0.0333056,0.12295,0.0263195,0.0211619,0,0,0
TN Orifice / Filter Out (kg/yr),3.86845,13.0867,3.3116,2.00071,9.11843,10.9148,39.6175
TN Weir Out (kg/yr),0.00374066,0.00548263,0.00386822,0.00306083,13.7423,1.37399,8.91788
TN Transfer Function Out (kg/yr),0,0,0,0,0,0,0
TN Reuse Supplied (kg/yr),9.2538,31.0823,7.92315,4.76868,0,0,0
TN Reuse Requested (kg/yr),0,0,0,0,0,0,0
TN % Reuse Demand Met,0,0,0,0,0,0,0
TN % Load Reduction,71.2113,71.0756,71.2148,71.087,43.9838,64.2268,61.5272
GP Flow In (kg/yr),206.707,693.944,177.178,106.307,27.1103,20.4569,103.558
GP ET Loss (kg/yr),0,0,0,0,0,0,0
GP Infiltration Loss (kg/yr),0,0,0,0,0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0,0,0,0,0
GP High Flow Bypass Out (kg/yr),0.31747,1.06579,0.272118,0.16327,0,0,0
GP Orifice / Filter Out (kg/yr),0,0,0,0,0,0,0
GP Weir Out (kg/yr),0,0,0,0,0,0,0
GP Transfer Function Out (kg/yr),0,0,0,0,0,0,0
GP Reuse Supplied (kg/yr),0,0,0,0,0,0,0
GP Reuse Requested (kg/yr),0,0,0,0,0,0,0
GP % Reuse Demand Met,0,0,0,0,0,0,0
GP % Load Reduction,99.8464,99.8464,99.8464,99.8464,100,100,100
PET Scaling Factor, , , , ,2.1,2.1,2.1

Generic treatment nodes
Location,8 x OceanGuard,Copy of Ecosol GPT- TFR Low Flow- 4750 ,Copy of Ecosol GPT- TFR Low Flow- 4750 ,Copy of Ecosol GPT- TFR Low Flow- 4750 ,Ecosol GPT- TFR Low Flow- 41200
ID,26,30,31,32,33
Node Type,GPTNode,GPTNode,GPTNode,GPTNode,GPTNode
Lo-flow bypass rate (cum/sec),0,0,0,0,0
Hi-flow bypass rate (cum/sec),0.08,0.219,0.219,0.219,0.561
Flow Transfer Function
Input (cum/sec),0,0,0,0,0
Output (cum/sec),0,0,0,0,0
Input (cum/sec),10,10,10,10,10
Output (cum/sec),10,10,10,10,10
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Input (cum/sec), , , , ,
Output (cum/sec), , , , ,

Input (cum/sec), , , , ,
Output (cum/sec), , , , ,
Gross Pollutant Transfer Function
Enabled,True,True,True,True,True
Input (kg/ML),0,0,0,0,0
Output (kg/ML),0,0,0,0,0
Input (kg/ML),14.7808,1000,1000,1000,1000
Output (kg/ML),0,20,20,20,20
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Input (kg/ML), , , , ,
Output (kg/ML), , , , ,
Total Nitrogen Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),10,1000,1000,1000,1000
Output (mg/L),8.5,999,999,999,999
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Total Phosphorus Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),10,1000,1000,1000,1000
Output (mg/L),7.5,710,710,710,710
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,

```
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Total Suspended Solids Transfer Function
Enabled,True,True,True,True,True
Input (mg/L),0,0,0,0,0
Output (mg/L),0,0,0,0,0
Input (mg/L),100,1000,1000,1000,1000
Output (mg/L),45,390,390,390,390
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
Input (mg/L), , , , ,
Output (mg/L), , , , ,
TSS Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TSS Flow based Efficiency, , , , ,
TP Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TP Flow based Efficiency, , , , ,
TN Flow based Efficiency Enabled,Off,Off,Off,Off,Off
TN Flow based Efficiency, , , , ,
GP Flow based Efficiency Enabled,Off,Off,Off,Off,Off
GP Flow based Efficiency, , , , ,
IN - Mean Annual Flow (ML/yr),3.59,10.3,16.5,14.4,52.2
IN - TSS Mean Annual Load (kg/yr),749,1.43E3,2.92E3,2.49E3,9.05E3
IN - TP Mean Annual Load (kg/yr),1.51,2.98,5.45,4.50,16.6
IN - TN Mean Annual Load (kg/yr),10.4,23.5,40.9,34.4,126
IN - Gross Pollutant Mean Annual Load (kg/yr),127,220,549,468,1.71E3
OUT - Mean Annual Flow (ML/yr),3.59,10.3,16.5,14.4,52.2
OUT - TSS Mean Annual Load (kg/yr),351,594,1.27E3,1.07E3,4.07E3
OUT - TP Mean Annual Load (kg/yr),1.14,2.15,3.99,3.28,12.3
OUT - TN Mean Annual Load (kg/yr),8.85,23.5,40.8,34.4,126
OUT - Gross Pollutant Mean Annual Load (kg/yr),1.44,7.79,27.1,20.5,104
Flow In (ML/yr),3.5902,10.2481,16.4573,14.4,52.1649
ET Loss (ML/yr),0,0,0,0,0
Infiltration Loss (ML/yr),0,0,0,0,0
Low Flow Bypass Out (ML/yr),0,0,0,0,0
High Flow Bypass Out (ML/yr),0.125624,0.424586,1.30565,1.00622,5.43972
Orifice / Filter Out (ML/yr),0,0,0,0,0
Weir Out (ML/yr),0,0,0,0,0
Transfer Function Out (ML/yr),3.46458,9.82409,15.1523,13.3939,46.7309
```

Reuse Supplied (ML/yr),0,0,0,0,0
Reuse Requested (ML/yr),0,0,0,0,0
% Reuse Demand Met,0,0,0,0,0
% Load Reduction,-0.00023845,-0.00525508,-0.00389603,-0.00100612,-0.0109207
TSS Flow In (kg/yr),748.887,1423.97,2913.84,2484.84,9039.53
TSS ET Loss (kg/yr),0,0,0,0,0
TSS Infiltration Loss (kg/yr),0,0,0,0,0
TSS Low Flow Bypass Out (kg/yr),0,0,0,0,0
TSS High Flow Bypass Out (kg/yr),24.9553,63.0644,220.923,171.887,887.497
TSS Orifice / Filter Out (kg/yr),0,0,0,0,0
TSS Weir Out (kg/yr),0,0,0,0,0
TSS Transfer Function Out (kg/yr),325.771,530.807,1050.3,902.038,3179.33
TSS Reuse Supplied (kg/yr),0,0,0,0,0
TSS Reuse Requested (kg/yr),0,0,0,0,0
TSS % Reuse Demand Met,0,0,0,0,0
TSS % Load Reduction,53.167,58.2948,56.373,56.7809,55.0106
TP Flow In (kg/yr),1.50555,2.97333,5.44916,4.49339,16.6149
TP ET Loss (kg/yr),0,0,0,0,0
TP Infiltration Loss (kg/yr),0,0,0,0,0
TP Low Flow Bypass Out (kg/yr),0,0,0,0,0
TP High Flow Bypass Out (kg/yr),0.0594721,0.132595,0.409922,0.296643,1.66924
TP Orifice / Filter Out (kg/yr),0,0,0,0,0
TP Weir Out (kg/yr),0,0,0,0,0
TP Transfer Function Out (kg/yr),1.08463,2.01708,3.57831,2.97989,10.6113
TP Reuse Supplied (kg/yr),0,0,0,0,0
TP Reuse Requested (kg/yr),0,0,0,0,0
TP % Reuse Demand Met,0,0,0,0,0
TP % Load Reduction,24.0079,27.7017,26.8101,27.0809,26.087
TN Flow In (kg/yr),10.3451,23.4748,40.8479,34.3842,126.269
TN ET Loss (kg/yr),0,0,0,0,0
TN Infiltration Loss (kg/yr),0,0,0,0,0
TN Low Flow Bypass Out (kg/yr),0,0,0,0,0
TN High Flow Bypass Out (kg/yr),0.35909,0.995099,3.20427,2.35046,13.1781
TN Orifice / Filter Out (kg/yr),0,0,0,0,0
TN Weir Out (kg/yr),0,0,0,0,0
TN Transfer Function Out (kg/yr),8.49052,22.4571,37.6082,32.0025,112.983
TN Reuse Supplied (kg/yr),0,0,0,0,0
TN Reuse Requested (kg/yr),0,0,0,0,0
TN % Reuse Demand Met,0,0,0,0,0
TN % Load Reduction,14.4559,0.0962825,0.0867622,0.0909152,0.0854201
GP Flow In (kg/yr),126.903,219.873,549.287,468.117,1709.64
GP ET Loss (kg/yr),0,0,0,0,0
GP Infiltration Loss (kg/yr),0,0,0,0,0
GP Low Flow Bypass Out (kg/yr),0,0,0,0,0
GP High Flow Bypass Out (kg/yr),1.4368,3.51999,16.716,11.5081,71.8107
GP Orifice / Filter Out (kg/yr),0,0,0,0,0
GP Weir Out (kg/yr),0,0,0,0,0
GP Transfer Function Out (kg/yr),0,4.2662,10.3943,8.94777,31.7462
GP Reuse Supplied (kg/yr),0,0,0,0,0
GP Reuse Requested (kg/yr),0,0,0,0,0
GP % Reuse Demand Met,0,0,0,0,0
GP % Load Reduction,98.8678,98.3991,96.9568,97.5416,95.7997

Other nodes

Location,Post-Development Node (45.931 ha),Junction - Area 1 - 7.254ha,Junction - Area 2 - 7.872ha,Junction - Area 3 - 26.295ha,Junction - Area 4 - 4.943ha,Pre-Development Node,Junction
ID,6,15,16,17,18,25,29
Node Type,PostDevelopmentNode,JunctionNode,JunctionNode,JunctionNode,JunctionNode,PreDevelopmentNode,JunctionNode
IN - Mean Annual Flow (ML/yr),84.8,14.4,16.5,52.2,10.3,60.0,60.0
IN - TSS Mean Annual Load (kg/yr),1.28E3,2.49E3,2.92E3,9.05E3,1.43E3,2.63E3,10.9E3
IN - TP Mean Annual Load (kg/yr),12.7,4.50,5.45,16.6,2.98,5.36,44.6
IN - TN Mean Annual Load (kg/yr),107,34.4,40.9,126,23.5,61.8,216
IN - Gross Pollutant Mean Annual Load (kg/yr),7.79,468,549,1.71E3,220,2.48E3,2.48E3
OUT - Mean Annual Flow (ML/yr),84.8,14.4,16.5,52.2,10.3,60.0,60.0
OUT - TSS Mean Annual Load (kg/yr),1.28E3,2.49E3,2.92E3,9.05E3,1.43E3,2.63E3,10.9E3
OUT - TP Mean Annual Load (kg/yr),12.7,4.50,5.45,16.6,2.98,5.36,44.6
OUT - TN Mean Annual Load (kg/yr),107,34.4,40.9,126,23.5,61.8,216
OUT - Gross Pollutant Mean Annual Load (kg/yr),7.79,468,549,1.71E3,220,2.48E3,2.48E3
% Load Reduction,28.5,23.4,18.6,22.0,18.1,0.00,0.00
TSS % Load Reduction,92.4,4.57,3.32,4.23,24.4,0.00,0.00
TN % Load Reduction,62.0,21.9,16.8,20.4,21.6,0.00,0.00
TP % Load Reduction,62.5,13.1,9.57,11.9,19.2,0.00,0.00
GP % Load Reduction,99.8,30.6,24.4,28.8,51.3,0.00,0.00

Links
Location,Drainage Link
Source node ID,10,14,7,12,3,2,4,5,24,9,11,13,8,19,20,22,1,21,26,27,23,28,18,30,16,15,17,33,31,32
Target node ID,14,16,16,16,5,15,15,15,6,13,17,17,17,18,22,18,25,26,18,6,6,29,30,6,31,32,33,27,23,24
Muskingum-Cunge Routing,Not Routed
Muskingum K, ,
Muskingum theta, ,
IN - Mean Annual Flow (ML/yr),5.30,1.53,6.89,8.04,6.19,4.36,8.25,1.79,12.3,20.8,28.6,6.01,17.6,5.74,3.18,0.921,60.0,3.59,3.59,46.4,15.8,60.0,10.3,10.3,16.5,14.4,52.2,52.2,16.5,14.4
IN - TSS Mean Annual Load (kg/yr),136,36.3,1.45E3,1.43E3,163,916,1.53E3,43.6,67.1,546,5.23E3,147,3.66E3,1.05E3,83.0,22.5,2.63E3,749,351,309,312,10.9E3,1.43E3,594,2.92E3,2.49E3,9.05E3,4.07E3,1.27E3,1.07E3

IN - TP Mean Annual Load
(kg/yr),0.809,0.232,2.89,2.34,0.949,1.82,2.41,0.272,1.70,3.12,8.41,0.882,
7.33,1.69,0.482,0.137,5.36,1.51,1.14,6.42,2.40,44.6,2.98,2.15,5.45,4.50,1
6.6,12.3,3.99,3.28
IN - TN Mean Annual Load
(kg/yr),11.6,3.34,20.0,17.5,13.6,12.6,18.0,3.91,12.3,45.7,62.3,13.2,50.8,
12.6,7.00,2.02,61.8,10.4,8.85,48.6,22.9,216,23.5,23.5,40.9,34.4,126,126,4
0.8,34.4
IN - Gross Pollutant Mean Annual Load
(kg/yr),177,0.272,243,306,207,154,314,0.317,0.00,694,1.09E3,1.07,621,218,
106,0.163,2.48E3,127,1.44,0.00,0.00,2.48E3,220,7.79,549,468,1.71E3,104,27
.1,20.5
OUT - Mean Annual Flow
(ML/yr),5.30,1.53,6.89,8.04,6.19,4.36,8.25,1.79,12.3,20.8,28.6,6.01,17.6,
5.74,3.18,0.921,60.0,3.59,3.59,46.4,15.8,60.0,10.3,10.3,16.5,14.4,52.2,52
.2,16.5,14.4
OUT - TSS Mean Annual Load
(kg/yr),136,36.3,1.45E3,1.43E3,163,916,1.53E3,43.6,67.1,546,5.23E3,147,3.
66E3,1.05E3,83.0,22.5,2.63E3,749,351,309,312,10.9E3,1.43E3,594,2.92E3,2.4
9E3,9.05E3,4.07E3,1.27E3,1.07E3
OUT - TP Mean Annual Load
(kg/yr),0.809,0.232,2.89,2.34,0.949,1.82,2.41,0.272,1.70,3.12,8.41,0.882,
7.33,1.69,0.482,0.137,5.36,1.51,1.14,6.42,2.40,44.6,2.98,2.15,5.45,4.50,1
6.6,12.3,3.99,3.28
OUT - TN Mean Annual Load
(kg/yr),11.6,3.34,20.0,17.5,13.6,12.6,18.0,3.91,12.3,45.7,62.3,13.2,50.8,
12.6,7.00,2.02,61.8,10.4,8.85,48.6,22.9,216,23.5,23.5,40.9,34.4,126,126,4
0.8,34.4
OUT - Gross Pollutant Mean Annual Load
(kg/yr),177,0.272,243,306,207,154,314,0.317,0.00,694,1.09E3,1.07,621,218,
106,0.163,2.48E3,127,1.44,0.00,0.00,2.48E3,220,7.79,549,468,1.71E3,104,27
.1,20.5

Catchment Details
Catchment Name,NSW202732_DA MUSIC - LIDELL DATA_UK1_100621
Timestep,6 Minutes
Start Date,23/08/1964
End Date,31/03/1995 11:54:00 PM
Rainfall Station, 61212 LIDDELL
ET Station,User-defined monthly PET
Mean Annual Rainfall (mm), 372
Mean Annual ET (mm), 1606

Attachment 2 – MM Hyndes Bailey Report (2017)

Stormwater Drainage Strategy

PEPPERTREE ESTATE SCONE

LOT 2 IN DP1169320

Ref: 217133
MM Hyndes Bailey November 2017

1 Proposal

It is proposed to develop residential lots to the east of Scone on the Gundy Road. The land abuts the age care facility Strathearn. The location is shown in Figure 1 below.

Location Plan
Figure 1

The area is proposed for development of 423 residential lots.

Urbanisation of this area will impact on the existing stormwater runoff. This report outlines the broad strategy for storm water drainage for the proposed residential development and analyses the impact of urbanization at the point of discharge from the site. The report proposes measures that will be necessary to meet the Council's quantitative requirements of stormwater discharge from the catchment.

Details of the layout and stormwater treatment proposals are shown in Annex 'A'.

2 Topography

The site comprises approximately 57 Has of gently sloping grassland. The existing waterway which traverses through the site is a second order stream with its source in the adjacent hills to the east of the site. The stream is not well defined in places but is generally stable with no significant scouring evident. The proposed development drains into this natural waterway.

A farm dam is located within the site to the east.

3 Subdivision Proposal

It is proposed to develop an urban residential development with roads fully developed with kerb and gutter. A fully developed piped drainage system will also be provided.

3.1 STORMWATER DISCHARGE STRATEGIES

To meet the requirements of Scone Shire Council, it will be necessary to embrace the following objectives:

- Ensure that peak runoff from the developed catchment does not exceed the peak runoff from the existing catchments for all return periods. This includes sub-catchments within the development.;

- Ensure that concentrated flows do not cause an increased number of erosion events in natural waterways.

Using these criteria, the flow data will be examined and any additional interventions recommended as part of the drainage strategy.

To meet these objectives the following strategy is proposed:

1. Provide detention basins at major discharge points from the site;
2. Maintain the natural waterways as drainage reserves and shape these waterways only where erosion is evident or where hydraulic efficiency is required;
3. Where necessary place scour protection at pipe outlets and other areas of flow concentration.

4 Hydrology

4.1 HYDROLOGY ASSUMPTIONS

The proposed development has been analysed using ILSAX hydrological model from “Drains” drainage program, based on rainfall data for Scone. Analysis has been completed for annual exceedance probabilities of 50%, 20%, 5% and 1%, for storm durations of 15minutes, 30 minutes, 1 hour, and 2 hours..

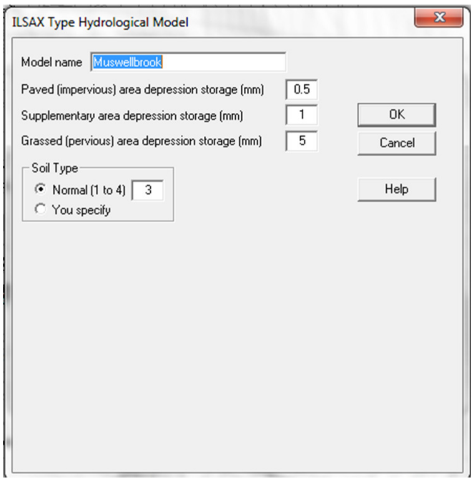
Australian Rainfall and Runoff 2016 has recently been introduced and it is proposed to analyse the catchment using the 2016 rainfall data.

The 2016 Rainfall and Runoff manual places more emphasis on temporal rainfall patterns and severalcritical rainfall patterns have been used for each return period analysed. The temporal patterns have been adopted for East Coast South region.

“Frequent” patterns have been adopted for 2 year and 5 year return periods, “intermediate” for 20 year return period and “rare” for the 100 year return period, all as recommended by the new manual.

For each return period, a total of 12 cases have been analysed.

The ILSAX hydrological model criteria adopted for the analysis are shown in Figure 3 below.



ILSAX Hydrological Model Input
Figure 2

Impervious areas relate to paved roads.

Supplementary Areas refer to roofs and hardstand areas in properties. The total area assumed is 500m^2 for normal residential blocks. . A slightly higher depression storage of 1mm has been selected to account for on site water tanks.

Grassed pervious areas refer to lawns, grassed footpaths and open reserves.

“Rather” wet antecedent soil conditions are assumed.

The pervious and impervious areas for each fully developed catchment are shown in the table below:

Catchment	Area Has	Impervious Area %	Pervious Area %
Catchment A	8.4	50.8	49.2
Catchment B	15.6	56	44
Catchment C	22.8	55.9	44.1

Catchment Details
Table 1

To achieve acceptable reductions in peak flows it will necessary to establish a series of detention basins located on the periphery of the natural waterway. The location of these basins is shown in ‘Annex A’.

4.2 FLOW ATTENUATION / WATER QUALITY

The size of each basin modelled in this analysis is tabled below.

In accordance with the water quality plan prepared by Barker Ryan Stewart (MUSIC MODEL) all basins to be bio retention with a gross pollutant trap, sediment trap and be of an impermeable construction, to comply with water quality and salinity requirements (REF: HU170046)

Detention Basin	Crest Width m	Crest RL	Volume of Basin @ max discharge
Basin A	10	214.5	1440
Basin B	10	214.5	4480
Basin C	15	210	9230

Detention Basin Sizing
Table 2

4.3 FLOW MODELLING

4.3.1 2016 R&R Analysis

Modelling using the 2016 data gives the following results:

Cat	Q_2 m³/s		Q_5 m³/s		Q_{20} m³/s		Q_{100} m³/s	
	Exist	**Dev**	**Exist**	**Dev**	**Exist**	**Dev**	**Exist**	**Dev**
A	0.21	0.22	0.5	0.24	0.96	0.88	1.84	2.28
B	0.26	0.19	0.59	0.23	1.12	0.65	2.18	2.27
C	0.27	0.19	0.62	0.23	1.17	0.25	2.26	1.56

Pre/post Development Peak Discharges
2016 R&R Analysis
Table 3

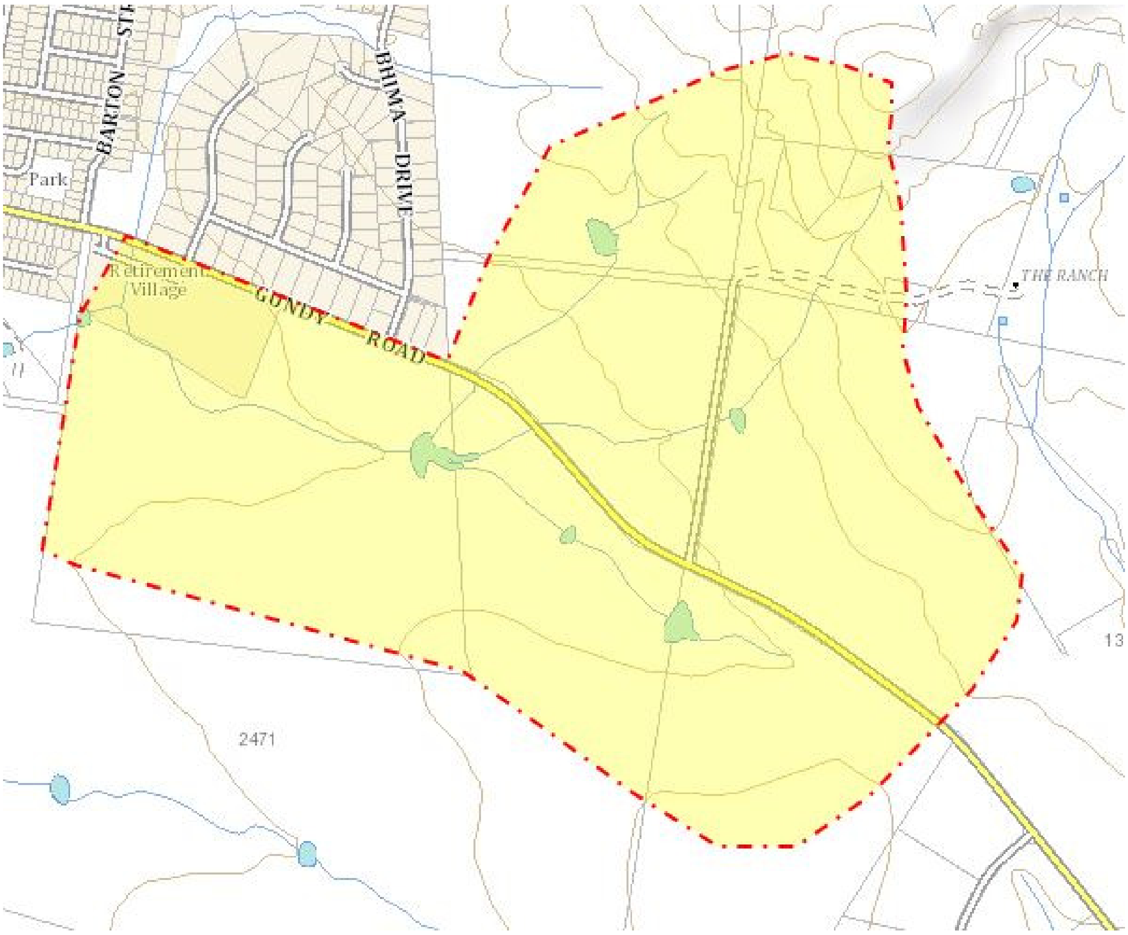
The table above demonstrates that in all cases except the Q100 event, the peak discharges for the post development flows are equal or less than the pre-development flows. Overall at the point of discharge, at the downstream end of the natural channel the Q100 discharge for the developed catchment is less than the existing discharge.

The detailed design may show that some modifications to basin size can be achieved.

5 Natural Waterway

5.1 EXTERNAL CATCHMENT

The natural waterway which traverses through the proposed development has a catchment of 2.3km² at the point of exit from the development as shown in Figure 3 below.



External Catchment Area
Figure 3

Estimates of flow were determined using the Regional Flood Frequency Estimation model developed in the 2016 R&R document. Results of this analysis are tabled below.

AEP %	Discharge m^3/s
50	2.86
20	6.56
5	14.8
1	29.8

2016 Regional Flood Frequency Analysis
Table 4

5.2 STREAM HYDRAULICS

The 1%AEP flood has been routed through the natural waterway using the HEC RAS model, taking into account the natural contours and the additional constrictions of roads and detention basins located in the waterway.

The levels of flooding for this flood have determined and are shown below. The extent of flooding is also shown in the stormwater treatment proposal in Annex 'A'.

Chainage	RL
50	208.84
150	210.7
250	212
350	213.51
450	214.85
Road crossing*	215.3
550	216.32
650	217.44

*Note: Level of flooding over road causeway with level of 215.1

1%AEP (1 in 100yr) Flood Levels
Table 5

At the eastern end of the natural waterway there exists a farm dam. It is proposed to leave this dam in place, however it will be necessary to properly design the bywash of the dam to ensure it has adequate capacity for the 1% AEP flood and at the same time not encroach on proposed residential lots.

5.3 ROAD CAUSEWAY

A detailed analysis of the road crossing the natural waterway has been undertaken . In accordance with Natspec, the causeway has been designed to pass the 5%AEP (1 in 20yr) flood. The causeway has also been designed to pass the 1% AEP flood with a proportion of the flow passing through the culverts and the remaining flow passing over the causeway with the overflow meeting the following pedestrian safety standards outlined in Natspec.

- Max depth: 200mm
- Depth x Velocity 0.4

To meet these standards the following causeway design is recommended:

Causeway RL	215.1 to 215.3
Causeway Length	60m
Culverts	10/1500x750 RCBC
Floodway depth 1% AEP flood	0.2m
Floodway velocity 1% AEP flood	0.75 m/s

Causeway Details
Table 6

The causeway will need to be protected either by rock or concrete lined embankments with adequate downstream aprons to avoid under-scour.

6 Erosion Events

The urbanisation of catchments creates the potential for increased erosion events because of the additional impervious areas. The criteria for "erosion events" will be determined based on flow velocities and duration of flows.

Scouring in the natural waterway will be controlled by ensuring:

- peak flows (and velocities) are restricted by detention basins;
- the natural waterway will be reinforced where necessary with appropriate turf treatments at the detailed design stage;
- discharges from culverts and piped systems are treated with adequate scour protection.

6.1 VELOCITY- DURATION STANDARD

Table 1.18 of Volume 1 Book VIII of Australian Rainfall and Runoff 1987 gives limiting velocities for the erosion resistance of grasses as follows:

Table 1.18. Limiting velocities for erosion resistance of grasses.

FLOW DURATION (*h*)	VELOCITIES (*m/s*) FOR: QUALITY OF COVER Good	Normal	Poor
2	5.0	3.8	2.8
4	3.7	2.9	2.1
6	3.3	2.5	1.8
9	3.0	2.3	1.6
12	2.8	2.1	1.5
18	2.7	2.0	1.3
24	2.6	1.9	1.2
48	2.5	1.7	1.0
72	2.4	1.6	0.9

(Source: Whitehead, 1976)

Limiting velocities for grasses
Table 7

Table 5.2 of the publication "Soils and Construction - Managing Urban Stormwater" (the Blue Book), allows the following velocities for couch, Rhodes and carpet grass on highly erodible soil:

Flow Duration (hrs)	Velocity (m/s)
6	1.4
12	1.2
24	1.1
48	0.9

Velocity – Duration
Table 8

It is proposed to use the slightly more conservative standards adopted in the "Blue Book".

The maximum velocity for the 1%AEP flood using HEC RAS was 1.38m/s. Because of the relatively small external catchment, the duration of flow at this velocity is likely to be less than an hour, well short of the 6hr criteria given in the Blue Book.

Discharges from overflows from detention basins in the 1% AEP flood can be in the order of an hour for longer duration rainfall events, however the maximum velocities that will occur will be no greater than 1.2m/s, providing overflows are properly dissipated.

7 Conclusion

The stormwater proposals outlined in this report demonstrate that the objectives in Section 3.1 Stormwater Discharge Strategies, can be achieved using detention basins as the main strategy.

- Peak flows for each of the 4 flood frequencies analysed have been demonstrated to be less than the preexisting discharges at the point of discharge from the development, using the recommended detention basins.

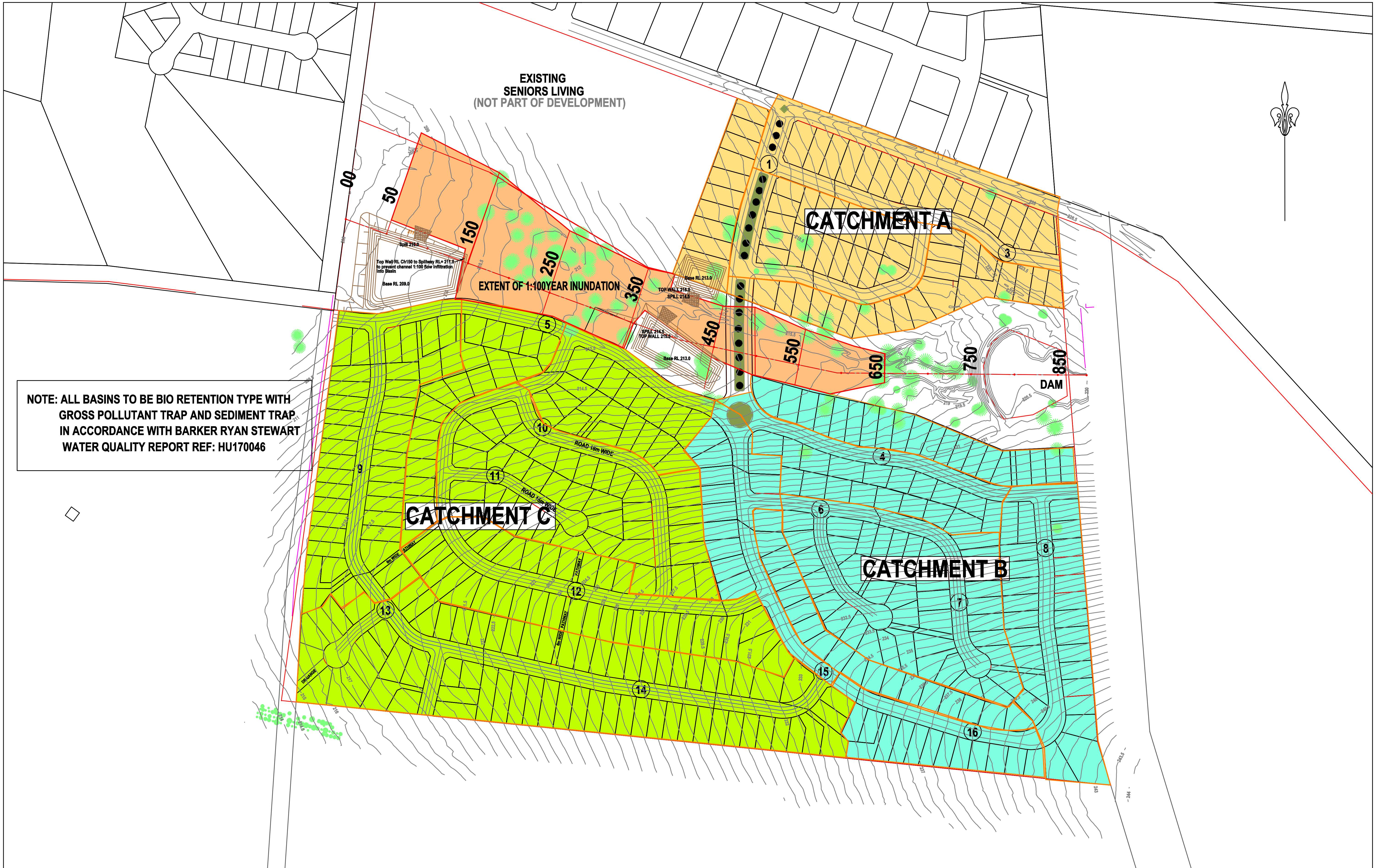
- Velocities of flow are well within the accepted scouring velocities set out in the Blue Book.
- The causeway can be constructed as outlined in the report and meet the safety requirements of Natspec with regard to water depth and velocity.

Your faithfully,

Bruce MacFarlane
Consulting Engineer
MM Hyndes Bailey & Co.

Annexure 'A'

Drawing; Drain_001



MM HYNDES BAILEY & Co. REGISTERED SURVEYORS - TOWN PLANNING - CIVIL DESIGN *Surveying the Hunter since 1920* Ph: 02 65432475 Email: office @hbsurveys.com.au	PROPOSEDSTORMWATER DRAINAGE STRATEGY CATCHMENTS / DETENTION / FLOODING PROPOSED SUBDIVISION LOT 2 IN DP1169320, GUNDY ROAD SCONE	H.SCALE: 1:4000 A3 V.SCALE DATE 15/11/2017	CONT. INT: 0.5m DATUM: AHD DRAWING: DRAIN_001	CLIENT: CHARLES DAVID PTY LTD	LGA: UPPER HUNTER PARISH: SCONE COUNTY: BRISBANE	JOB REF: 217133 VER D