Robert
Bird
Group

Stormwater Management Plan
Tweed Valley Hospital
Prepared for Stage 2 State Significant Development Application

Issue: E

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Prepared For: Lendlease Building Pty Ltd

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Report Amendment Register

Issue	Section & Page No.	Issue / Amendment Details	Author	Reviewer	Date
A	All	First Issue	Colin Rope	Chris Waite	01/07/2019
B	All	SEARs added to report	Colin Rope	Chris Waite	19/07/2019
C	All	Hydrology report added	Colin Rope	Chris Waite	16/08/2019
D	1.4, 4.0	Site Plan, Consultation	Colin Rope	Chris Waite	13/09/2019
E	1.1, 1.4	Report reference, scope description	Colin Rope	Chris Waite	19/09/2019

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1.0 Introduction

1.1 Purpose of Document

Robert Bird Group (RBG) has been engaged by Lendlease Building (LLB) to design the Civil Engineering works for the proposed Tweed Valley Hospital at Cudgen, NSW.

This report has been prepared to respond to the Planning Secretary's environmental assessment requirements (SEARs) relating to drainage and stormwater, issued on 18th July 2019.

SEAR	Addressed in this report	Addressed elsewhere
14 Utilities *Prepare an Integrated Water management Plan detailing any proposed alternative water supplies, proposed end uses of potable and non-potable water, and water sensitive urban design.*	WSUD is addressed in Section 6.0	Refer to Hydraulic Engineer's report for details of rainwater re-use proposals
16. Drainage *- Detail Measures to minimise operational water quality impacts on surface waters and groundwater.* *- Provide Stormwater Management Plans, detailing the proposed methods of drainage in accordance with the conditions imposed under SSD 9575.* *Relevant Policies and Guidelines:* *- Guidelines for development adjoining land and water managed by DECCW (OEH, 2013)*	Section 6.0 Section 5.0, EIS App B	
17. Flooding *Identify flood risk on site (detailing the most recent flood studies for the project area) and consideration of any relevant provisions of the NSW Floodplain Development Manual (2005), including the potential effects of climate change, sea level rise and an increase in rainfall intensity. If there is a material flood risk, include design solutions for mitigation.*	Section 2.0	Flooding Report (WBM, 2018)
20. Sediment, Erosion and Dust Controls *Detail measures and procedures to minimise and manage the generation and off-site transmission of sediment, dust and fine particles.* *Relevant Policies and Guidelines:* *- Managing Urban Stormwater – Soil and Construction Volume 1 2004 (Landcom)* *- Guidelines for development adjoining land and water managed by DECCW (OEH, 2013)*	Section 7.0	Construction Environmental Management Plan

This report supports the Environmental Impact Statement (EIS) to assist in the State Significant Development (SSD) Stage 2 Application for the Tweed Valley Hospital which will be assessed under Part 4 Division 4.7 of the Environmental Planning and Assessment Act.

The stormwater design addresses the following conditions of consent from the NSW Department of Planning and Environment:

Consent Condition	Addressed in this report	Addressed elsewhere
B18. The future development application is required to address the implementation of water sensitive urban design principles (WSUD) in accordance with the best practice guidelines (such as Water by Design 2014). Including but not limited to: *a. Rainwater harvesting and re-use*	WSUD is addressed in Section 6	Refer to Hydraulic Engineer's report for details of rainwater re-use proposals
B3. Stormwater and Flooding. The stage 2 application must be accompanied by:		
a. An emergency Flood Evacuation Management Plan for the users of the site, in case of a major flood event in the region.	Section 2.0	Refer to Flooding Report
b. Stormwater Management Plans with details of drainage infrastructure including the following:		
i) Detailed stormwater analysis and drawings to demonstrate that there would be no increase in pre-development peak flows from the range of design storm events and storm durations relevant to flooding in the local catchment;	Section 5.0	
ii) Detailed flow regime analysis that demonstrates that the development would not impact significantly on the quantity of surface and groundwater flows to and from the adjacent coastal wetland. This analysis must include evaluation of hydrology from the development over a representative continuous long-term period (20 years minimum). The analysis must also include consideration of a range of indicators relevant to protection of the downstream coastal wetland ecology (eg. dry spells, low flow duration and high flow frequency analysis);	Section 8.0	Refer to Hydrology Report (Appendix B)
iii) Assessment of the localised impact of the stormwater discharges to the coastal wetlands including proposed mitigation measures to prevent scouring, sedimentation and other physical impacts at the stormwater drainage system outlets into the coastal wetlands on the northern boundary of the site;	Section 8.0	Refer to Hydrology Report (Appendix B)
iv) Details of measures to manage increased stormwater volumes from the development surfaces (eg. stormwater harvesting, distributed infiltration, increased surface area to enhance evapotranspiration and infiltration and diversion of stormwater – where feasible).		Refer to Hydraulic Engineer's Report
v) Consistency of the sizes, volumes and number of on-site detention basins and headwalls with the existing sediment basins and headwalls on the site;	Section 5.0, drawings	
vi) Demonstrate that gross pollutant, total suspended solid, phosphorus and nitrogen loads discharged from the development into the coastal	Section 6.0	

wetland after stormwater treatment comply with Council's load-based water quality targets;		
vii) Demonstrate that the proposed development would not significantly impact on the quality of surface and groundwater flows to and from the adjacent coastal wetland; and	Section 6.0	
viii) Demonstrate how WSUD design principles have been considered across the development to mitigate potential impacts on the mapped coastal wetlands.	Section 6.0	
c. A report prepared by a suitably qualified ecologist assessing the impacts of any changes to hydrology (flow regimes) and stormwater runoff quality associated with the development on the EECs, TECs, threatened species located within the coastal wetlands NSW Government 17 New Tweed Valley Hospital Department of Planning and Environment (SSD 9575) to the north of the site and on the overall biophysical, hydrological and ecological integrity of the mapped wetlands within the site and adjoining lands; and	Section 8.0	Refer to Hydrology Report (Appendix B)
d. Evidence of consultation with Council to determine the locations of the stormwater assets and in the preparation of the stormwater plans and flood reports, plans for relocating Council assets (if any), proposed connections and the protection of relevant assets.	Section 4.0	

The stormwater design has been prepared with regard to the *Guidelines for Development Adjoining Land* managed by the Office of Environment and Heritage (**OEH**) – NSW Government, 2013, which has the following aims relating to stormwater:

- To prevent erosion and the movement of sediment onto OEH land, and ensure no detrimental change to hydrological regimes;
- Nutrient levels are minimised, and stormwater flow regimes and patterns mimic natural levels before it reaches OEH land.
- Proposed changes to stormwater related to the development where the following stormwater management standards should be met (for subdivisions, multi-unit dwellings, commercial and industrial development):
  - no increase in pre-development peak flows from rainfall events with a 1 in 5 year and 1 in 100 year recurrence interval
  - no increase in the natural annual average load of nutrients and sediments
  - no increase in the natural average annual runoff volume

The design has also been developed in accordance with the Tweed Shire Council Development Design Specifications *D5 – Stormwater Drainage Design* and *D7 – Stormwater Quality.*

A range of water management and drainage works have been documented as part of an enabling works package of earthworks and infrastructure works. These Stage 1 works were subject to a separate SSDA approval process.

The design and coordination of rainwater reuse, water supply and wastewater services are the responsibility of the services engineer, JHA Consulting Engineers.

1.2 Site Description

The site is described as Lot 11 DP1246853 at 771 Cudgen Road, Cudgen NSW and has an overall area of approximately 19 Hectares. It falls generally from south to north with an overall fall from approximately RL 27m AHD at the highest point near the southern boundary, to approximately RL 1m AHD at the lowest point on the northern boundary. The site and the adjacent land to the west are currently used for agriculture.

As shown on Figure 1.1, the site has frontage to Cudgen Road to the south and Turnock Street to the east. Kingscliff TAFE College is located on the opposite side of Cudgen Road. The land to the north of the site is an existing low-lying coastal wetland which is within the floodplain of Tweed River with flood levels of approximately RL 3 – 3.5m AHD in the 1% annual exceedance probability (AEP) flood.

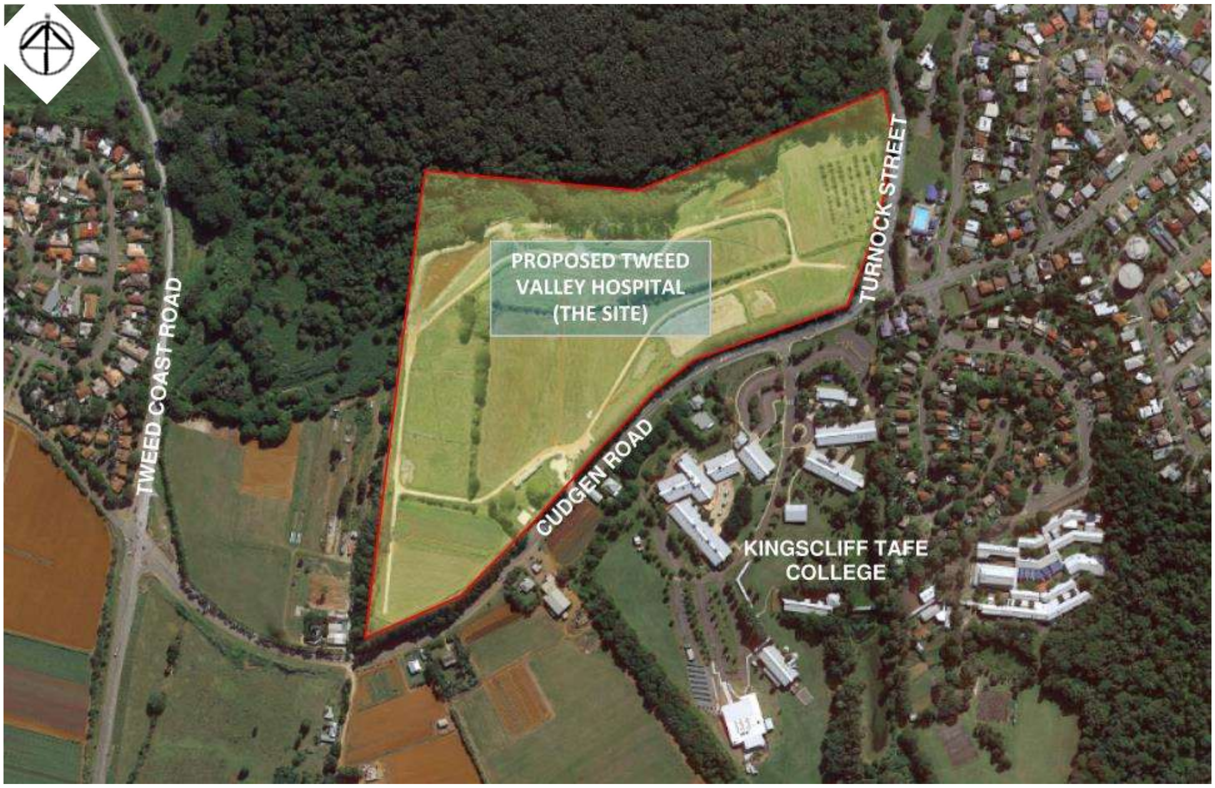

Figure 1.1 – Site Location

1.3 Survey

A detailed topographical survey has been used in the preparation of the report. The survey was prepared by B&P Surveys. Ref T16452-22633 Rev G Jan 2019.

1.4 Project Scope

The scope of the project is generally described by the architectural drawings by Silver Thomas Hanley and Bates Smart Architects. An extract from the architectural site plan is included in Figure 1.2. The Tweed Valley Hospital Project broadly consists of:

- Delivery of the Tweed Valley Hospital, a new Level 5 major regional referral hospital to provide the health services required to meet the needs of the growing population of the Tweed-Byron Region in conjunction with the other hospitals and community health facilities across the region.

- Delivery of the supporting infrastructure required for the Tweed Valley Hospital, including green space and other amenities, roads, car parking, utilities and other supporting infrastructure.

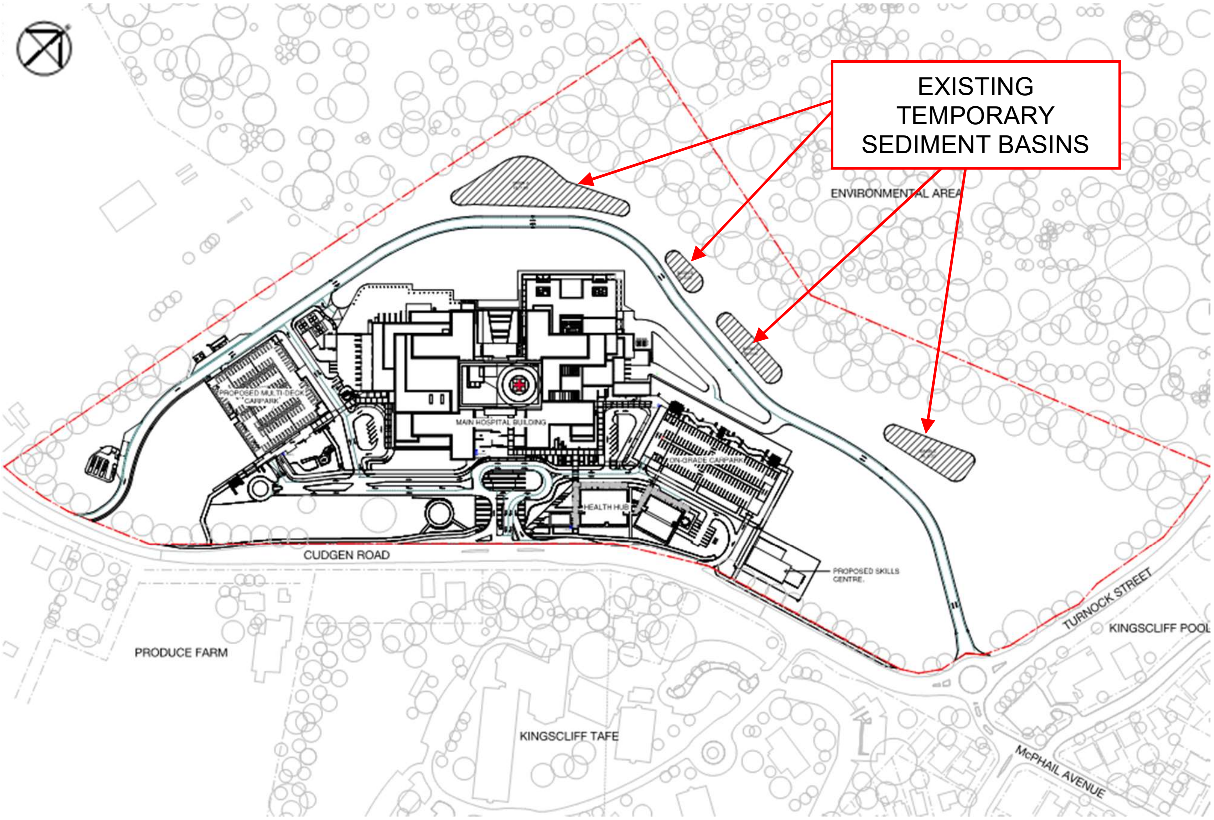

Figure 1.2 – Tweed Valley Hospital, Proposed Site Plan

The civil engineering scope of works is shown above and on drawings in Appendix B of the Environmental Impact Statement (EIS) and includes the internal road network, at grade car park, pavements, kerbs, footpaths, and stormwater.

External to the site, there will be upgrades to the adjacent road network. The proposed road upgrades include the following measures:

- a new signalised main hospital entry and exit from Cudgen Road to include widening of Cudgen Road, bus laybys;
- a new left-in only slip lane;
- widening of Tweed Coast Road to provide an additional lane at the southbound approach to Cudgen Road; and
- stormwater drainage modifications.

External civil works which have been approved under a separate approvals process include:

- a new connection to the existing roundabout at Cudgen Road roundabout;
- a new slip lane entry from Cudgen Road at the western side of the site.

The internal stormwater proposals for the site consist of the following measures:

- Internal road drainage – network of swales, pits and pipes;
- Conversion of the four existing temporary sediment basins constructed as enabling works (under separate approvals process) to bio-detention basins for stormwater discharge control and water quality treatment;
- Discharge from the four bio-detention basins via headwalls at surface level with appropriate scour protection, allowing sheet flows to the wetland area, emulating the existing flow characteristics;
- Erosion and sediment control during construction.
- Backfilling of an existing agricultural dam in the NW corner of the site

2.0 Flooding

A flood assessment has been carried out for the project (Tweed Valley Hospital, Flooding and Coastal Hazards Assessment – BMT, October 2018) which concludes that the northern part of the site are within the Tweed River floodplan and are subject to regular inundation. The outlet pipes from the four proposed bio-detention basins are above the existing 1% AEP flood level (approx. RL 3.5m AHD). All roads, buildings and other infrastructure will be constructed above the PMF flood level (approx. RL 8.0m AHD).

3.0 Agricultural Dam

An existing agricultural dam is situated in the north west corner of the site. The dam consists of a excavated area and an earth bund to retain water for irrigation. The former pump station for the dam has been decommissioned and removed. Currently, there is an infestation of *salvinia molesta* growing in the dam which is considered undesirable – refer to the Long Term Biodiversity Management Plan for details on the proposed rehabilitation.

In order to prevent further infestation, it has been recommended that the Salvinia is removed and the dam is backfilled so that this corner of the site returns to a more natural state of flow to the wetland to the north. Pending detailed survey of the area, the finished ground levels will be designed to ensure that water no longer ponds on the surface. The location of the existing dam is shown in Figure 1.3.

The hydrology assessment by SMEC (Appendix B) has considered the effect on the wetland of the development with and without the dam backfilling and concludes that there is no effect on the hydrology of the wetland to filling the dam. The assessment recommends that a low flow channel is provided in the backfilled dam to allow low flows of water to drain.

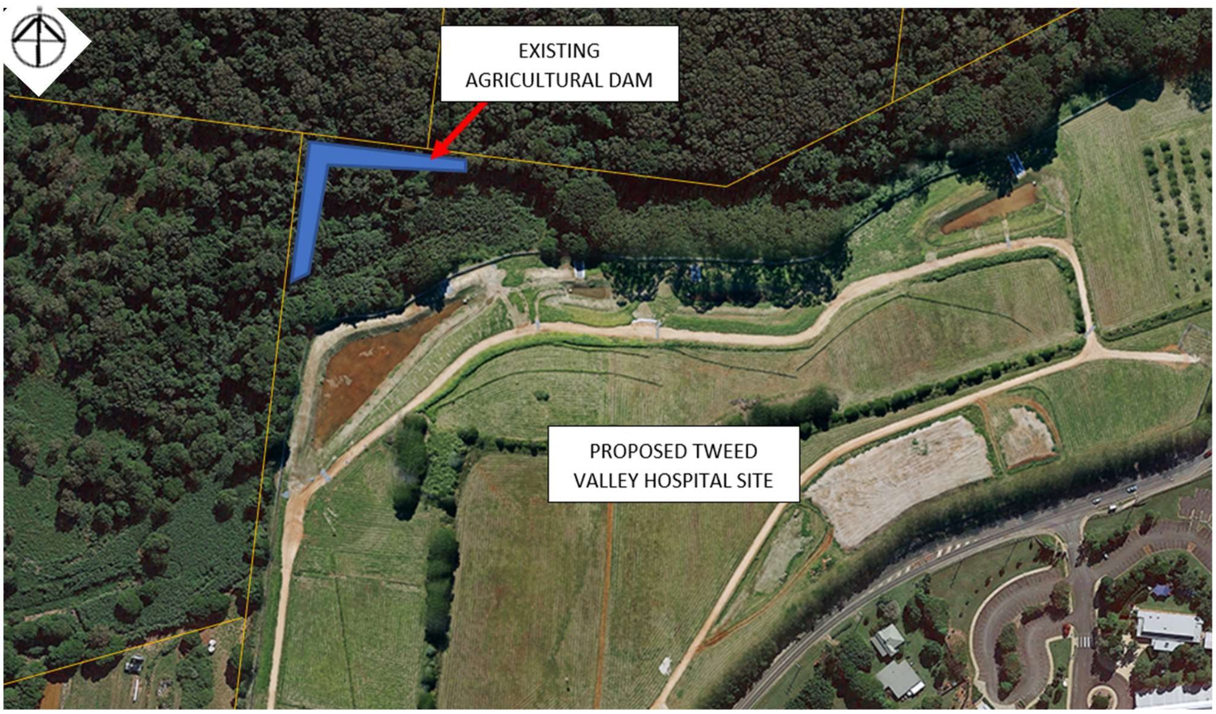

Figure 1.3 – Location of Existing Agricultural Dam

4.0 Consultation

Tweed Shire Council have been consulted about the proposals and specifically the minor modifications to the stormwater flows in the road reserve to the south of the site. TSC have not raised any objections in principal to the proposals and have requested formalisation of the existing historic right to discharge stormwater from the road reserve into the southwest corner of the site. A summary of all consultation with Council to date is provided below.

Date	Summary of Consultation	Summary of Response
28/06/19	TSA/HI requested a meeting with Council to discuss the stormwater proposals	Council's preference is for HI to put to Council a brief e-mail explanation/plan of how you intend to comply with the conditions and Council can then review and request a meeting if needed.
12/07/19	TSA/HI/LL submitted revised Entry A Civil Stormwater concept Drawing allowing Road Stormwater to discharge onto site and then be drained via Swale through site to NW corner	Council responded quickly the next week on 15/07/19, and noted concept was acceptable and to proceed with Detailed Design for Resubmission of S138 drawing pack and concept for site wide stormwater as separate pack
06/08/19	TSA/HI/LL submitted Draft DD Aux Lane with stormwater finalised to council for clarification that design was correct.	Council responded 13/08/19 that Draft DD was acceptable to go to full design pack and to submit to council
29/08/19	LL Submitted final design to council for aux Lane and Stormwater connection from Road and discharging into site	Council approved DWY19/0126 on 6/09/19
10/09/19	TSA/HI submitted to council final LL / RBG site wide engineering Drawing on 10/09/19	

5.0 Stormwater Drainage Design

5.1 Overview

The proposed stormwater works address the need to collect stormwater from the new impervious areas of the site, including buildings, roads, car parks and other hardstandings, and discharge treated water at a controlled rate to the existing wetland (receiving water course) to the north of the site.

The key issues addressed in the stormwater design include:

- Collection of stormwater using standard pits and pipes (design in accordance with the *Tweed Shire Council Development Design Specification D5 – Stormwater Drainage Design*).

- Detention of stormwater to ensure that the post development discharge rate does not exceed the pre-development rate in the 100 year and 5-year ARI storms (In accordance with the requirements of the *Guidelines for Development Adjoining Land managed by the Office of Environment and Heritage).* This will be achieved by converting existing sediment basins along the northern part of the site to bio-detention basins and is further discussed in Section 5.5 of this report. In their response to the Stage 1 SSDA submission, Tweed Shire Council have confirmed that "limiting post-development discharge to pre-development levels would be appropriate".

- Treatment of stormwater runoff, to ensure no increase in nutrient flows from the pre-existing state and to achieve the pollutant reduction targets as described in the *Tweed Shire Council Development Design Specification D7 – Stormwater Quality*. This will be achieved by using a standard treatment train approach, utilising grass swales, buffers and pit filter baskets in conjunction with the proposed bio-detention basins and is further discussed in Section 6.2.

- Rainwater will be stored and reused for irrigation of landscape areas and for the cooling tower to reduce the demand for potable water and to mitigate the increase in total annual stormwater flow volumes resulting from the development

- Landscape planting areas and bio-detention basins will not have impermeable liners to provide opportunities for infiltration to ground water. However, the opportunities for infiltration are limited due to the concerns raised by the geotechnical engineer that significant infiltration could result in instability of the steep batter slopes within the site.

5.2 Codes and Specifications

The stormwater design has been carried out in accordance with the relevant local, state and national design guidelines (where not over-ridden by Tweed Shire Council requirements) and Australian Standard Codes of Practice, including:

- Australian Rainfall and Runoff – A Guide to Flood Estimation, Volumes 1 and 2 (1987, 2016) – The Institution of Engineers, Australia.

- AS/NZS 3500.3 (2015) National Plumbing and Drainage Part 3: Stormwater Drainage – Acceptable Solutions.

- Managing Urban Stormwater – Soils and Construction Volume 1 (4th Edition, March 2004) – NSW Department of Housing.

- Queensland Urban Drainage Manual (3rd Edition, October 2013)

- Guidelines for Development Adjoining Land Managed by the Office of Environment and Heritage

- Tweed Shire Council Development Design Specifications:
  - D5 Stormwater Drainage Design; and
  - D7 Stormwater Quality.

5.3 Design Criteria

Stormwater management controls from Tweed Shire Council's Development Design Specifications and additional design considerations were addressed in the design of the stormwater infrastructure and are summarised in Table 5.1.

STORMWATER MANAGEMENT DESIGN CONTROLS	
Item	**Control or Design Objective**
Design Rainfall Data	Design Intensity-Frequency-Duration (IFD) rainfalls have been obtained from the Australian Bureau of Meteorology (BOM) for this location. The IFD data used in the design is shown in Table 4.2.
Minor and Major Storms (ARI)	Minor Storm – All new pipes and associated components designed to cater for the 5 year ARI storm. Major Storm – All overland flow paths and major storm discharge to the bio-detention basins to be designed to cater for the 100 year ARI storm.
Pit Blockage Factors	Pit blockage factors shall be applied to all grated inlet pits in the hydrological models in accordance with D5.10.6.
Pipe Grades	The minimum pipe grade shall be generally 1.0%, however under exceptional circumstances a grade of 0.5% may be permitted. The maximum pipe grade shall be 5% - trench stops to be used for grades between 5% - 15%).
Overland Flow Paths	Overland flow paths for surface flows exceeding the minor storm event will follow the internal road network. A factor of 1.2 will be applied to the IFD to account for blockages. The design of the overland flow path considers the velocity-depth hazard. For this project, depth x velocity values should not exceed 0.4 m^2/s and max depth of 0.2m in locations where footpaths may be crossed by overland flows. 0.6 m^2/s is permitted in vehicle only areas.

Table 5.1 – Stormwater Management Controls and Design Objectives

Annual Exceedance Probability (AEP)							
Duration	63.2%	50%	20%	10%	5%	2%	1%
1 min	166	187	253	298	341	397	440
2 min	139	157	216	257	299	362	413
3 min	130	147	202	240	278	334	379
4 min	124	140	191	227	262	311	350
5 min	118	133	182	215	247	291	326
10 min	96	108	146	171	195	226	249
15 min	81.1	91.4	123	144	164	189	208
20 min	70.6	79.6	107	126	143	166	182
25 min	62.8	70.8	95.5	112	128	148	164
30 min	56.7	64	86.5	102	116	136	150
45 min	44.7	50.5	68.7	81.3	93.6	110	123
1 hour	37.5	42.4	58.1	69.1	80	95.2	107
1.5 hour	29	33	45.7	54.8	64.1	77.3	87.9
2 hour	24.2	27.6	38.6	46.6	54.8	66.6	76.3
3 hour	18.9	21.5	30.5	37.2	44.1	54.1	62.3
4.5 hour	14.8	16.9	24.3	29.8	35.6	43.8	50.6
6 hour	12.5	14.4	20.7	25.5	30.5	37.6	43.4
9 hour	9.9	11.4	16.6	20.5	24.5	30.1	34.7
12 hour	8.42	9.73	14.2	17.4	20.9	25.5	29.3
18 hour	6.69	7.75	11.3	13.8	16.5	20	22.7
24 hour	5.66	6.56	9.51	11.6	13.7	16.6	18.7
30 hour	4.96	5.75	8.28	10.1	11.9	14.2	16
36 hour	4.43	5.13	7.37	8.92	10.5	12.5	14.1
48 hour	3.69	4.26	6.07	7.3	8.51	10.1	11.3
72 hour	2.78	3.21	4.52	5.4	6.25	7.4	8.26
96 hour	2.24	2.58	3.62	4.31	4.98	5.89	6.57
120 hour	1.88	2.16	3.02	3.61	4.17	4.94	5.51
144 hour	1.62	1.85	2.6	3.11	3.62	4.28	4.78
168 hour	1.42	1.62	2.29	2.75	3.22	3.81	4.26

Table 5.2 – Storm Intensity / Frequency Data (IFD) (mm per hour)

5.4 Stormwater model

The stormwater runoff produced within the site will be captured and conveyed within a pit and pipe system to mitigate against site inundation. To analyse this system a model has been produced using 12D software to calculate the peak flow hydrology and hydraulics of the stormwater network. It is also proposed that the pit and pipe system will discharge the stormwater runoff into four bio-detention basins, to allow for a controlled discharge. The computer software DRAINS has been used to analyse the preliminary basin design.

5.5 On-Site Detention

On-site stormwater detention is a stormwater management measure which will be used to limit the peak stormwater flow from the site to match the pre-development peak flows. Stormwater detention measures for the area have been applied in accordance with the *Guidelines for Development Adjoining Land managed by the Office of Environment and Heritage.* The four existing sediment basins along the northern edge of the site will be converted to provide stormwater detention storage.

5.6 Stormwater Model Results

The storage volumes of the converted basins have been modelled to ensure that the combined post development discharge from the basins is no greater that the pre-development flow. Flow rates will be controlled by using orifice plates at the discharge headwall for each basin. The minimum required storage volume for each basin is shown on drawing RBG-CV-DWG-RIE-86-310.

The hydrologic model setup within DRAINS uses the Ilsax/Horton method of analysis to calculate peak flows. A soil type/classification of “4” has been assessed based on a preliminary geotechnical permeability of $1.60x10^{-09}$. This classification is suitable for soil material with very high runoff potential and is typically consisted of a fine-textured clay. By having both the pre and post development analysis completed in the same model we were able to compare the pre and post conditions using the same conditions. The Horton/Ilsax type hydrological model parameters are shown in Figure 5.1.

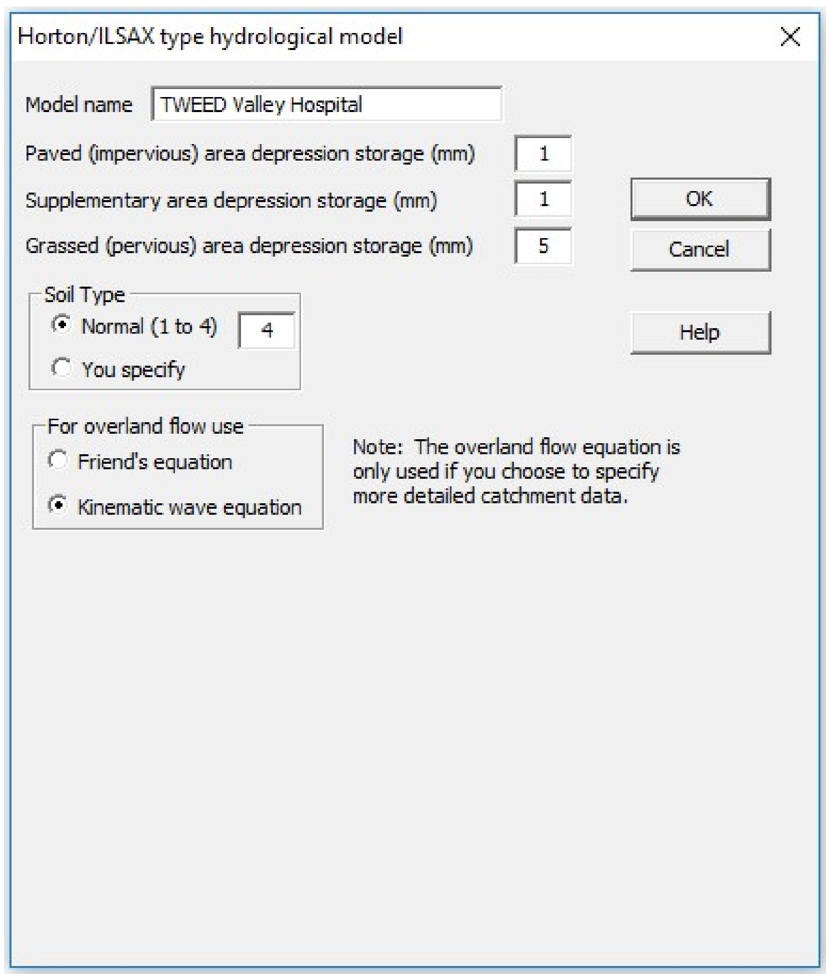

Figure 5.1 – DRAINS Hydrological Parameters

For the pre-development catchment a time of concentration of 20min has been conservatively calculated.

The basins required for the post development scenario were modelled in drains using their "detention basin" node. The basins were then modelled based on their cross sectional area and removing any area/volume being used for the water quality treatment.

The DRAINS model comparing the flows for pre-development and post-development have been summarised in Table 5.3.

The preliminary DRAINS model confirms that there is no increase in the total site discharge rate in the 5 year and 100 year ARI storm events. A full summary of the DRAINS results has been provided in Appendix A.

Basin	**Catchment Area (% Impervious)**	**Min Detention Volume**	**Peak Discharge**	
			5 year ARI	**100 year ARI**
A	73,500 m^2 (45%)	5,450 m^3	1.500 m^3/s	1.690 m^3/s
B	3,000 m^2 (70%)	455 m^3	0.176 m^3/s	0.187 m^3/s
C	14,400m^2 (80%)	1,080 m^3	0.417 m^3/s	0.475 m^3/s
D	34,100 m^2 (30%)	2,080 m^3	1.030 m^3/s	1.220 m^3/s
Bypass	10,900 m^2 (5%)	N/A	0.650 m^3/s	0.826 m^3/s
TOTAL	**135,900 m^2**	**9,065 m^3**	**3.773 m^3/s**	**4.398 m^3/s**
Pre-Development	**118,700 m^2**	**N/A**	**4.3 m^3/s**	**5.440 m^3/s**

Table 5.3 – DRAINS Basin Summary

Basin	**Existing Sediment Basin Volume with their spillways infilled**	**Proposed**		
		Required Volume for stormwater detention	**Required volume for water treatment**	**Total Volume**
A	6,780 m^3	5,450 m^3	520 m^3	5,970 m^3
B	682 m^3	455 m^3	30 m^3	485 m^3
C	1,520 m^3	1,080 m^3	200 m^3	1,280 m^3
D	2,900 m^3	2,080 m^3	345 m^3	2,425 m^3

Table 5.4 – Basin Volume Summary

Table 5.4 demonstrates that the existing sediment basins can be adapted as bio-detention basins for the project and that the existing size will be suitable following infill of the spillways.

6.0 Water Sensitive Urban Design (WSUD)

6.1 Water Quality Objectives

Water Sensitive Urban Design (WSUD) measures are being provided in order to comply with the following standards:

- Guidelines for Development Adjoining Land managed by the Office of Environment and Heritage
  - no increase in the natural annual average load of nutrients and sediments
- Tweed Shire Council Development Design Specification D7 – Stormwater Quality.
  - Tweed Shire Council Water Quality Objectives as shown in Table 5.1

Pollutant	Minimum reductions in mean annual load from unmitigated development
Total Suspended Solids (TSS)	80% reduction
Total Phosphorous (TP)	60% reduction
Total Nitrogen (TN)	45% reduction
Gross Pollutants >5mm (GP)	90% reduction

Table 6.1 – Water Quality Objectives

6.2 WSUD Approach

Stormwater quality modelling has been undertaken for the site to quantify the WSUD measures required to meet the development controls. Water quality control will be achieved through converting the four existing sediment basins to bio-detention basins in combination with the use of proprietary pit filter baskets (Enviropods or similar) to be provided in all stormwater pits.

The treatment aspect of the bio-detention is provided by vegetated soil media filters, which treat stormwater by allowing it to pond on the vegetated surface and slowly infiltrate downwards through the soil media. Treated water is collected via subsoil perforated pipes before being discharged to downstream waterways. They are effective in reducing the concentration of suspended solids (TSS), phosphorus (TP) and especially nitrogen (TN) via nutrient uptake and denitrification.

The filtration will be provided by three sub-surface layers.

- **Filtration Layer** – The filtration layer is the main media through which water is filtered and treated. Typically, it consists of a sandy loam mix with a saturated hydraulic conductivity of 100mm/hr to 300mm/hr under compaction. The depth of media may range from 600mm to 800mm, dependant on the vegetation and/or tree species selected;

- **Transition Layer** – The transition layer typically consists of coarse sand (particle size 1mm) and is installed to prevent the filtration media washing into the perforated subsoil drainage. A transition layer of 100mm to 150mm is typical.

- **Drainage Layer** – The drainage layer is at the bottom of the bioretention system and is placed to encase the subsoil drainage pipe. The typical thickness is 150mm and is to be a fine gravel mix (particle size 2-5mm).

Treatment can be enhanced by creating temporary ponding (extended detention depth) over the filter media. This increases the amount of time that runoff can infiltrate and also increase the volume to be treated before being diverted to a bypass weir. Typically, the extended detention depth is around 200mm deep.

Vegetation plays an important role in the efficiency of bio-retention and bio-detention systems. The surface will be densely planted with grasses, sedges and select shrub or tree species, which acts to retard and distribute the flows across the filter media. Below ground the root zone of the plants is highly biologically active. As water passes through this zone, materials (both fine soils and soluble nutrients) can be physically trapped or be actively taken up by the plant roots of other plant biota (bacteria and fungi). The plant growth and death cycle also plays an important role, maintaining the soil structure and hydraulic conductivity of the media.

6.3 Maintenance of Water Quality Treatment Devices

Water quality treatment devices require regular maintenance. An indicative maintenance plan for the bioretention basin is provided below.

- Routine inspection (3-6 monthly and after heavy rain), cleaning and maintenance of the bio-detention systems. Check inlets and overflow structures/drainage pipes for scour and sediment. Removal of litter, debris and sediment;
- Inspection of filter media porosity (3-6 monthly and after heavy rain). Check for accumulation of impermeable layers of sediment on top of the filter media. Remove sediment and scarify;
- Over time, the filter media will accumulate fine sediments. The filter media should be replaced when its infiltration capacity is reduced due to binding. Typically, filtration media should be replaced every 5-7 years.
- Pit filter baskets

In-pit proprietary filter baskets are to be monitored and cleaned routinely and in accordance with the manufacturer’s specifications.

6.4 Stormwater Quality Model

The stormwater quality outcomes have been modelled using MUSIC Version 6.2.1 software. For the purposes of this analysis, only those parts of the site which are directly affected by the development have been included in the model. Areas to the north of the proposed internal roads which will remain in their natural state and are outside of the bulk earthworks extents have not been included in the model.

The pollutant parameters chosen for use within this development are in accordance with Water by Design Music Modelling Guidelines November 2018 Consultation Draft.

Impervious Area Parameters	
Rainfall Threshold	1.0mm
Pervious Area Parameters	
Soil Storage Capacity	18mm
Initial Storage (% of capacity)	10
Field Capacity	80mm
Infiltration Capacity Coefficient – a	243
Infiltration Capacity Exponent – b	0.6
Groundwater Properties	
Initial Depth	50mm
Daily Recharge Rate	0%
Daily Baseflow	31%
Daily Deep Seepage Rate	0%

For the post development analysis the parameters chosen are in accordance with commercial developments as follows;

Flow Type	**Surface Type**	**TSS LOG[10] Values**		**TP LOG[10] Values**		**TN LOG[10] Values**	
		MEAN	ST. DEV	MEAN	ST. DEV	MEAN	ST. DEV
Baseflow Parameters	Roof (Commercial)	N/A	N/A	N/A	N/A	N/A	N/A
	Roads (Commercial)	0.78	0.39	-0.60	0.50	0.32	0.30
	Ground Level (Commercial)	0.78	0.39	-0.60	0.50	0.32	0.30
	Agriculture	1.00	0.13	-1.155	0.13	-0.155	0.13
Stormflow Parameters	Roof (Commercial)	1.30	0.38	-0.89	0.34	0.37	0.34
	Roads (Commercial)	2.43	0.38	-0.30	0.34	0.37	0.34
	Ground Level (Commercial)	2.16	0.38	-0.39	0.34	0.37	0.34
	Agriculture (Commercial)	2.477	0.31	-0.495	0.30	0.29	0.26

The results from the MUSIC model are shown in Table 5.2 and demonstrate compliance of the system with the WSUD objectives in Table 5.1. An extract from the MUSIC model is shown in Figure 5.1:

	Pre-development Annual Load	Post-development Annual Load (Untreated)	Post-development Annual Load (Treated)	% Reduction	TSC Target
Total Flow	78.7	136	134	1.7	N/A
TSS	29,900	32,200	5,580	82.7	80%
TP	31,500	71.6	21.3	70.3	60%
TN	183	429	201	53.2	45%
GP	415	2100	0.054	100	90%

Table 5.2 - Stormwater Quality outcomes (from MUSIC model)

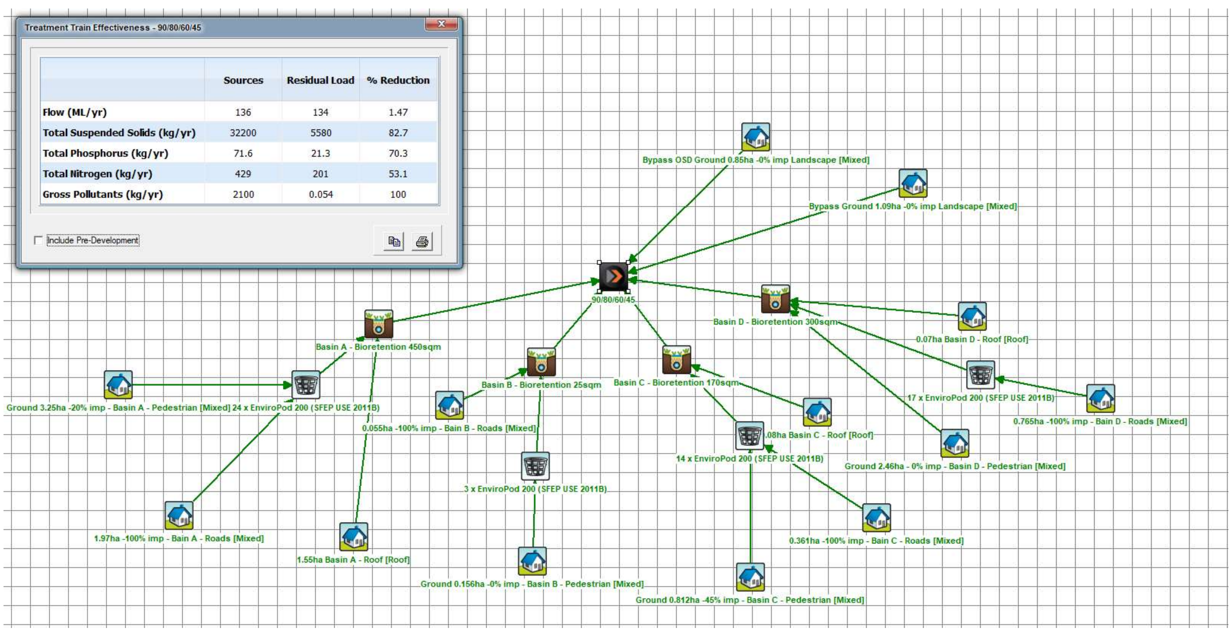

Figure 5.1 Stormwater Quality - MUSIC Model

7.0 Erosion and Sediment Control

The quality of stormwater discharge from the site during the construction stage will be managed using erosion and sediment control and surface water management measures in accordance with the *Landcom guidelines – Managing Urban Stormwater Runoff: Soils and Construction* (“Blue Book”) and *Tweed Shire Council Development Design Specification D7 – Stormwater Quality*.

During the initial bulk earthworks and construction stages, and until the excavation and fill surfaces have been surfaced or revegetated, the primary sediment control measure will be the use of the existing sediment basins. A series of bunds and swales will be used to ensure that runoff from the majority of the earthworks areas are directed to the four existing basins at the northern side of the site. The basins have been sized using the methodology described in the Landcom guideline for a 5-day storm duration.

The sediment basins function by providing a large, standing body of water such that stormwater runoff entering the basins, which is laden with sediments, has a chance to settle to the base of the basin before it is discharged by pumping into the receiving watercourse. The basins have been sized in accordance with the Landcom Blue Book for a 5-day storm duration. A flocculant will be used to dose the water to accelerate the naturally slow settlement rate of the natural soils. Water captured in the basins will be tested for pH and TSS (Total Suspended Solids) prior to pump out. Each basin will be dosed with flocculant per rain event and the sediment will typically settle and water quality will be confirmed by site specific testing prior to being pumped out within five days from the conclusion of a rainfall event. Sediment fences will be used to treat any water which overflows from the basins, however, in the event of an uncontrolled discharge, a monitoring event will be triggered to assess potential impacts resulting from surface water discharges on the receiving environment.

Any runoff from areas or earthworks which cannot be directed to the sediment basins will be treated by means of grass buffer strips and sediment fences.

The construction of the sediment basins has been subject to a separate approval process.

8.0 Impacts to Coastal Wetland

A hydrological assessment has been carried out (SMEC 2019 – refer to Appendix B) to assess the impacts of the proposed project on the adjacent coastal wetland to the north of the site and specifically to address DA conditions B3 (parts b. and c.), copied below.

b. *ii) Detailed flow regime analysis that demonstrates that the development would not impact significantly on the quantity of surface and groundwater flows to and from the adjacent coastal wetland. This analysis must include evaluation of hydrology from the development over a representative continuous long-term period (20 years minimum). The analysis must also include consideration of a range of indicators relevant to protection of the downstream coastal wetland ecology (eg. dry spells, low flow duration and high flow frequency analysis);*

iii) Assessment of the localised impact of the stormwater discharges to the coastal wetlands including proposed mitigation measures to prevent scouring, sedimentation and other physical impacts at the stormwater drainage system outlets into the coastal wetlands on the northern boundary of the site;

c. *A report prepared by a suitably qualified ecologist assessing the impacts of any changes to hydrology (flow regimes) and stormwater runoff quality associated with the development on the EECs, TECs, threatened species located within the coastal wetlands NSW Government 17 New Tweed Valley Hospital Department of Planning and Environment (SSD 9575) to the north of the site and on the overall biophysical, hydrological and ecological integrity of the mapped wetlands within the site and adjoining lands;*

The hydrology assessment has modelled the long term effects of the stormwater proposals for all rainfall events (not just the peak storm flows), and in particular to the receiving wetland at the northern side of the site.

The key findings from the hydrology assessment are summarised below.

- The peak flows from the site in the major and minor storm events (100 year and 5 year ARI) are no greater than the pre-existing runoff discharges.
- Controls have been provided to mitigate any scouring or other physical impacts at the basin outlet points.
- There is a minor increase in the flood level in the wetland during minor storms (more frequent than the 5 year ARI design storm event).
- There is an increase in the total annual average volume of water discharged to the wetland.
- The water quality proposals have beneficial impacts in relation to the removal of suspended solids and nutrients from the stormwater discharge

There are no ecological impacts from the increase in total flow volume.

Appendix A
DRAINS Results

5 Year Storm event results

DRAINS results prepared from Version 2019.03

PIT / NODE DETAILS				Version 8			
Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboa (m)	Overflow (cu.m/s)	Constraint
Node A	8.93		5.826				
N42218	7.52		0				
Node B	8.97		0.236				
N57288	7.82		0				
Node C	10.03		1.142				
N57291	9.08		0				
Node D	6.97		2.685				
N57293	5.9		0				

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Pre-existing 11.87ha	4.303	0	4.303	20	20	20	5% AEP, 25 min burst, Storm 9
bypass 1.09ha	0.65	0.033	0.617	5	5	5	5% AEP, 15 min burst, Storm 10
Cat Basin A 7.385ha	4.471	2.712	1.759	5	5	5	5% AEP, 15 min burst, Storm 10
Cat Basin B 0.3ha	0.181	0.092	0.089	5	5	5	5% AEP, 15 min burst, Storm 10
Cat Basin C 1.44ha	0.908	0.8	0.108	5	5	5	5% AEP, 5 min burst, Storm 1
Cat Basin D 3.41ha	2.059	1.043	1.016	5	5	5	5% AEP, 15 min burst, Storm 10

PIPE DETAILS

Name	Max Q	Max V	Max U/S	Max D/S	Due to Storm

	(cu.m/s)	(m/s)	HGL (m)	HGL (m)	
Basin A inlet	4.443	3.93	8.928	8.575	5% AEP, 15 min burst, Storm 1C
Basin A Outlet	1.496	3.01	8.105	7.522	5% AEP, 1 hour burst, Storm 2
Basin B Inlet	0.181	1.64	8.973	8.515	5% AEP, 15 min burst, Storm 1C
Basin B Outlet	0.176	2.51	8.338	7.816	5% AEP, 15 min burst, Storm 1C
Basin C Inlet	0.908	2.07	10.027	9.975	5% AEP, 5 min burst, Storm 1
Basin C Outlet	0.417	2.69	9.661	9.081	5% AEP, 1 hour burst, Storm 9
Basin D Inlet	2.059	3.24	6.971	6.809	5% AEP, 15 min burst, Storm 1C
Basin D Outlet	1.028	3	6.399	5.904	5% AEP, 1 hour burst, Storm 3

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max Dx\	Max Width	Max V
Weir 1	0	0	1.459	0	0	0	0
Weir 2	0	0	1.444	0	0	0	0
Weir 3	0	0	1.444	0	0	0	0
Weir 4	0	0	1.444	0	0	0	0

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
Basin A	8.58	2488.9	1.496	1.496	0
Basin B	8.52	2.6	0.176	0.176	0
Basin C	9.97	277.3	0.417	0.417	0
Basin D	6.81	606.8	1.028	1.028	0

Run Log for 19005_Basin sizing for report run at 17:14:48 on 1/7/2019

Flows were safe in all overflow routes.

100 Year Storm event results

DRAINS results prepared from Version 2019.03

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboa (m)	Overflow (cu.m/s)	Constraint
Node A	9.35		7.633				
N42218	7.55		0				
Node B	9.23		0.31				
N57288	7.82		0				
Node C	10.31		1.494				
N57291	9.09		0				
Node D	7.35		3.519				
N57293	5.93		0				

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Pre-existing 11.87ha	5.438	0	5.438	20	20	20	1% AEP, 25 min burst, Storm 1
bypass 1.09ha	0.826	0.044	0.784	5	5	5	1% AEP, 10 min burst, Storm 1
Cat Basin A 7.385ha	5.973	3.855	2.118	5	5	5	1% AEP, 5 min burst, Storm 1
Cat Basin B 0.3ha	0.238	0.13	0.108	5	5	5	1% AEP, 5 min burst, Storm 1
Cat Basin C 1.44ha	1.22	1.065	0.155	5	5	5	1% AEP, 5 min burst, Storm 1
Cat Basin D 3.41ha	2.706	1.483	1.223	5	5	5	1% AEP, 5 min burst, Storm 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
Basin A inlet	5.993	5.3	9.35	8.888	1% AEP, 5 min burst, Storm 1
Basin A Outlet	1.691	3.3	8.291	7.552	1% AEP, 1 hour burst, Storm 3
Basin B Inlet	0.238	2.15	9.229	8.877	1% AEP, 5 min burst, Storm 1
Basin B Outlet	0.187	2.66	8.608	7.822	1% AEP, 10 min burst, Storm 1
Basin C Inlet	1.208	2.73	10.308	10.257	1% AEP, 5 min burst, Storm 1
Basin C Outlet	0.475	3.03	9.847	9.091	1% AEP, 45 min burst, Storm 8
Basin D Inlet	2.708	4.26	7.353	7.185	1% AEP, 5 min burst, Storm 1
Basin D Outlet	1.224	3.49	6.616	5.929	1% AEP, 25 min burst, Storm 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max Dx\	Max Width	Max V

Weir 1	0	0	1.438	0	0	0	0
Weir 2	0	0	1.444	0	0	0	0
Weir 3	0	0	1.444	0	0	0	0
Weir 4	0	0	1.444	0	0	0	0

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
Basin A	8.89	3426.3	1.691	1.691	0
Basin B	8.88	8.5	0.187	0.187	0
Basin C	10.26	404.5	0.475	0.475	0
Basin D	7.19	856.8	1.224	1.224	0

Run Log for 19005_Basin sizing for report run at 17:04:38 on 1/7/2019

Flows were safe in all overflow routes.

Appendix B

Hydrology Report

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