LANDCOM

HILLS SHOWGROUND STATION PRECINCT
INTEGRATED WATER CYCLE MANAGEMENT STRATEGY

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Hills Showground Station Precinct
Integrated Water Cycle Management Strategy

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REV	DATE	DETAILS
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1	23/10/19	Revised Draft Hills Showground Integrated Water Cycle Management Strategy
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

LIST OF APPENDICES

GLOSSARY

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
DA Area	The Hills Showground Precinct Development Lots
DCP	Development Control Plan
DPE	Department of Planning and Environment
GPT	Gross pollutant trap
IWCMS	Integrated Water Cycle Management Strategy
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
PMF	Probable Maximum Flood
NWRL	North West Rail Link
NRT	Northwest Rapid Transit
OSD	On Site Detention
The Site	The Hills Showground Station Precinct
SSDA	State significant development application
SMNW	Sydney Metro Northwest
WSUD	Water Sensitive Urban Design

1 PROJECT BACKGROUND

1.1 OVERVIEW

This report has been prepared for Landcom on behalf of Sydney Metro to support a Concept development application (DA) under Section 4.22 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The concept for which approval is sought (the 'Concept Proposal') is for a high-density mixed-use precinct with a new public park and plaza, and associated facilities on land located within the Hills Showground Station Precinct (the 'Site') on development lots (Lot 53, Lot 55 and 56 in DP 1253217) (the 'DA Area') (Refer Figure 1.1).

With the following: "The Concept Proposal comprises residential and non-residential land uses and building envelopes of varying heights from four (13m) to up to twenty storeys (68m). The proposal also includes a new road, landscaping, services and the provision of publicly accessible open space in the form of Doran Drive Plaza and a park. Concept Proposal comprises a total gross floor area (GFA) of 175,796m2 across all three development lots.

The Concept Proposal meets the criteria to be declared a State Significant Development (SSD) under State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP).

Source: Cox Architecture, 2019

Figure 1.1 Proposed development location

1.2 SITE DESCRIPTION

1.2.1 HILLS SHOWGROUND STATION PRECINCT

Within this report, the term 'the Site' reflects the Hills Showground Station Precinct boundary identified in the SRDP SEPP and includes the areas detailed in Table 1-1 and illustrated in Figure 1.1. The Site has a total area of 8.4 hectares.

Table 1-1 Hills Showground Station lots

EXISTING USE	LEGAL DESCRIPTION	ADDRESS
Sydney Metro commuter carpark and plaza	Lot 52 1253217	3 De Clambe Drive, Castle Hill
Development Lot – Hills Showground Precinct West	Lot 53 DP 1253217	5 De Clambe Drive, Castle Hill
Development Lot – Doran Drive Precinct	Lot 55 DP 1253217	2 Mandala Parade Castle Hill
Development Lot – Hills Showground Precinct East	Lot 56 DP 1253217	3 Andalusian Way, Castle Hill
Hills Showground Station Box and service facility boxes	Lot 54 & Lot 50 1253217	1 Mandala Parade, Castle Hill
Mandala Parade, De Clambe Drive, Doran Drive, Andalusian Way	N/A	N/A

The eastern part of the Site (Hills Showground Precinct East – Lot 56 DP 1253217) currently contains the former Council administration building and associated parking and landscaping. It was being used as a Sydney Metro's construction site office but is proposed to be demolished by way of a separate DA (304/2020/LA) currently under consideration by Council.

The western part of the Site contains the recently opened Hills Showground Metro Station, plaza and commuter car park. The remainder was cleared to create the two development lots (Lots 53 and Lot 55 DP 1253217) and the roads listed in the table above.

Former development on the western part of the Site consisted of The Hills Entertainment Centre which included an Auditorium and Council's works depot that were demolished to make way for the metro.

The Site is bordered by the following:

- North and northwest – De Clambe Drive with a drainage basin and the Castle Hill and The Showground further north
- West – De Clambe Drive and Cattai Creek riparian zone with commercial/industrial warehouses further west
- South to southeast – Carrington Road across which are low density residential developments, a child care and medical/physiotherapy
- East – Showground Road across which are low density residential development.

1.2.2 HILLS SHOWGROUND STATION DEVELOPMENT LOTS (DA AREA)

The Concept Proposal relates to the three development lots detailed in Figure 1.1 and Table 1-2 and referred to herein as the 'DA Area'. This land is currently owned by Sydney Metro.

Table 1-2 Hills Showground Station Precincts

PRECINCT NAME	LEGAL DESCRIPTION	ADDRESS	DESCRIPTION OF EXISTING DEVELOPMENT	PRECINCT AREA (M^2)
Hills Showground Precinct West	Lot 53 DP 1253217	5 De Clambe Drive, Castle Hill	L shaped vacant lot with existing stormwater drainage easement on the portion adjacent to De Clambe Drive.	3,293
Hills Showground Doran Drive	Lot 55 DP 1253217	2 Mandala Parade, Castle Hill	Rectangular vacant lot with no vegetation.	7,969
Hills Showground Precinct East	Lot 56 DP 1253217	3 Andalusian Way, Castle Hill	Former two storey Council administration building and associated parking and landscaping.	28,226

1.3 PROPOSED CONCEPT PLAN

The DA will specifically seek approval for a Concept Proposal comprising:

- A maximum gross floor area (GFA) of 175,796m^2 equating to up to approximately 1,900 dwellings including affordable housing
- A maximum GFA of 13,600m^2 for non-residential development (commercial, retail and community facilities)
- Building envelopes, and allocation of 175,796m^2 GFA to the three precincts
- Landscape concept for the public domain detailing the extent of public domain including streets, pedestrian pathways, provision of Doran Drive Plaza to be a minimum of 1,405m^2 and a new Park on Precinct East to be a minimum of 3,500m^2
- Provision of car parking and bicycle parking
- Strategies for utilities and services provision, managing stormwater and drainage, achievement of ecologically sustainable development (ESD) and design excellence
- Staging plan addressing the timing of future subdivision, construction, release and development of land
- Concept principal subdivision of development Lot 56 DP 1253217 into future major lots, public domain areas and roads.

The Concept Proposal Reference Scheme is shown in Figure 1.2.

No building or construction works are proposed to be undertaken as part of this Concept Proposal. Once the SSDA is approved, the successful purchasers of the development precincts and/or lots from Sydney Metro, will be responsible for submitting subsequent DAs for the design and construction of the buildings and public domain areas in accordance with the approved Concept.

Source: *Cox Architecture 2019*

Figure 1.2 Concept Plan

1.4 REPORT SCOPE

Integrated Water Cycle Management (IWCM) aims to review each element of the water cycle and develop a coordinated management approach to holistically manage the entire water cycle. This ensures water is conserved, treated to a standard that is fit for the intended use and reused where appropriate. Interaction with the environment (water quality, waterway ecosystem health), protection of flood corridors, management of stormwater runoff quality and quantity, and interaction with groundwater systems are considered in conjunction with water supply.

The report presents an IWCM strategy for the site which has been developed through:

- Review of background data
- A visit to the site (conducted on 5 June 2019) to confirm site conditions and constraints, confirm existing stormwater infrastructure and to understand the local topography and surface water environment.
- Liaison with authorities – this included the Hills Shire Council and DPIE and allowed further site details to be obtained and confirmation of planning requirements and constraints for the site
- Review of SEARS that have been issued in relation to SSDA/EIS approval for this project. Where relevant, this report documents how these requirements have been addressed
- MUSIC modelling to ensure concept strategy for the site will satisfy required pollutant reduction targets
- Review of previous flood modelling completed at the site to inform flood planning constraints, identify flood impacts of the project and inform flood emergency management procedures for the site.

1.5 BACKGROUND DATA

1.5.1 PREVIOUS REPORTS

The following reports and data have been used to inform this report:

- Hills Showground Station Precinct Concept Master Plan, Cox Architecture (2019). This provides details of the concept plan for the precinct for which this report has been based.
- Design Report for North West Rail Link Operations, Trains & Systems Package No.2109 Package Title WAD Package 9 – Showground Road at New Precinct Street B (August 2016). This report contains details of flood impacts of the works associated with development of the Hills Showground station. It also provides details of the constructed onsite detention (OSD) basin and water quality modelling (MUSIC) that was completed as part of the design of the recently constructed drainage infrastructure.
- Flood mapping extracts based on the Hills Shire Council commissioned Urban Overland Flow Study (Rev 4 April 2017 – Final draft version). This study provides flood information for the site.
- Showground Station Precinct Hydrology and Drainage Report by ARUP (2016) This report provides flood level information for the Showground precinct and an overview of water quality in Cattai Creek.
- North-West Rail Link (NWRL) EIS Stage 2, Technical Paper 7, Surface Water and Hydrology AECOM (2012). This report provides flood level information based on HEC RAS modelling for the site and general water quality information for Cattai Creek.

1.5.2 HILLS SHIRE COUNCIL DATA

The following information was obtained from the Hills Shire Council (email correspondence, Hills Shire Council, 17 May 2018)

- Water quality data for Cattai Creek (2011 – 2013);
- Council Stormwater network information;
- Flood mapping extracts based on the Hills Shire Council commissioned Urban Overland Flow Study (Rev 4 April 2017 – Final draft version);
- Confirmation that there is no groundwater extraction at the site (email correspondence, Hills Shire Council, 9 May 2018).

Further information was obtained from the Hills Shire Council in relation to the current status of a drainage easement currently located within the Hills Showground Precinct West area (email correspondence, Hills Shire Council, 22 August 2019). This information is presented in Section 3.2.2 and Section 4.2.2 below.

2 RELEVANT GUIDELINES AND POLICIES

2.1 NSW GOVERNMENT GUIDELINES

2.1.1 INTEGRATED WATER CYCLE MANAGEMENT

The NSW Department of Industry has developed information sheets and checklists relating to Integrated Water Cycle Management to assist local water utilities with developing and evaluating IWCM strategies. These tools focus on enabling development of integrated systems that rely less on limited natural water sources, produce less pollutant loads to the environment, have strong pricing signals and demand management measures.

2.1.2 FLOOD MANAGEMENT

The following documents provide key guidance to best practice flood assessment and management and have been referred to in preparing this report:

- Australian Rainfall and Runoff: A Guide to Flood Estimation (Commonwealth of Australia, 2019) (ARR 2019).
- Managing the Floodplain: A guide to Best Practice in Flood Risk management in Australia (Handbook 7, Australian Institute for Disaster Resilience, 2017).
- NSW Government's Floodplain Development Manual (2005)

2.1.3 WATER SENSITIVE URBAN DESIGN

The following publications provide guidance for design of WSUD elements

- Australian Runoff Quality (Engineers Australia 2005);
- Water Sensitive Urban Design Technical Guidelines for Western Sydney (NSW Government Stormwater Trust and UPRCT, May 2004).
- Adoption Guidelines for Stormwater Biofiltration Systems - Cities as Water Supply Catchments – Sustainable Technologies (CRC for Water Sensitive Cites, 2015).

2.2 HILLS SHIRE COUNCIL

Section 19 of the Hills Shire Development Control Plan 2012 provides controls for development within the Showground Station Precinct. In the event of any inconsistency between this section and other sections of DCP 2012, this section prevails to the extent of the inconsistency. The following list notes relevant sections of the DCP that have been relied upon to develop the IWCMS:

- Part D Section 19 Showground Station Precinct
- Part C Section 6 Flood Controlled Land
- Appendix B Water Sensitive Urban Design
- The Hills Shire Council Design Guidelines Subdivision/Developments (2011).

Landcom's Sustainable Places Strategy (refer to section 2.3) is consistent with the DCP.

2.2.1 INTEGRATED WATER MANAGEMENT

Part D Section 19 of the DCP lists the following integrated water management objectives:

- The quality and integrity of urban waterways is maintained and enhanced through both the construction and occupation phases of development.
- Urban form minimises risks to life and property as a result of either minor or major flooding.
- Developments adopt a best practice Water Sensitive Urban Design approach at the individual lot, overall development and regional scales.
- Developments meet the required water quality objectives prior to discharging to receiving waterways and minimise impacts such as streamflow erosion potential on receiving waterways.
- Stormwater runoff is treated as a valuable resource and its use for non-potable purposes is maximised.
- Nuisance flooding is minimised to a level acceptable.

To achieve these objectives controls are listed relating to stormwater management, water sensitive urban design and flood risk management. Requirements of these controls are summarised below.

2.2.1.1 STORMWATER MANAGEMENT

The DCP requires that all Stormwater Management Plans are to include consideration of various sustainable practices including stormwater harvesting and re-use and water conservation. Any discharge to, or construction within the Cattai Creek Corridor zoned RE1 Public Recreation will require the approval of NSW Office of Water. Design of stormwater drainage systems are to comply with the most up to date revision of Council's Design Guidelines Subdivision/Developments (September 2011) and Contributions Plan No.19 – Showground Station Precincts.

During the construction phase of development, the relevant Stormwater Management Objectives for new development as set out in the most up to date revision of "Managing Urban Stormwater: Soils and Construction" (NSW Department of Housing) must be complied with in full. Erosion and sediment control measures are to be implemented and regularly maintained on site, while sediment trapping measures are to be located at all points where stormwater runoff can enter inlets to stormwater systems, or where runoff may leave the construction site.

2.2.1.2 WATER SENSITIVE URBAN DESIGN (WSUD)

Water Sensitive Urban Design (WSUD) principles are to be adopted to provide sustainable and integrated management of land and water resources, incorporating best practice stormwater management, water conservation and environmental protection measures. A WSUD Management Plan is required for all developments and is to take into account water quality and stream erosivity objectives, together with attenuating flow rates and runoff volumes to acceptable levels following urban development. As part of a WSUD management plan, residential, employment and commercial developments are to install rainwater tanks to meet a portion of water supply demand such as outdoor use laundries and toilets.

The DCP does not provide water quality controls but it does provide the following table describing water quality targets and environmental flow targets. Table 2-1 shows the water quality targets for the Showground Precinct (Hills Shire Council DCP, 2012). The Landcom Sustainable Places Strategy (2017) which outlines Landcom's approach and goals with regards to sustainability, describes water quality targets that are consistent with those in Table 2-1.

Table 2-1 Water quality and environmental flow targets

OBJECTIVE	WATER QUALITY (% REDUCTION IN POLLUTANT LOADS)				ENVIRONMENTAL FLOWS* (STREAM EROSION CONTROL RATIO)
	GROSS POLLUTANTS	TOTAL SUSPENDED SOLIDS	TOTAL PHOSPHORUS	TOTAL NITROGEN	
STORMWATER MANAGEMENT OBJECTIVE	90	85	65	45	3.5-5.0:1
IDEAL STORMWATER OUTCOME	100	95	95	85	1:1

* For the purposes of these objectives, the 'stream forming flow' is defined as 50% of the 50% AEP flow rate estimated for the catchment under natural conditions. This ratio should be minimised to limit stream erosion to the minimum practicable. Development proposals should be designed to achieve a value as close to one as practicable, and values within the nominated range should not be exceeded. A specific target cannot be defined at this time.

2.2.2 FLOOD RISK MANAGEMENT

2.2.2.1 DEVELOPMENT CONTROLS

The Hills Shire DCP - Part C Section 6: Flood Controlled Land provides requirements for developments on flood prone land. Details of existing flood levels at the site and extent of flood prone land are provided in Section 3.4 below. The following requirements relate to flood levels and garage/ parking levels for developments within the Hawkesbury River floodplain:

- For residential and commercial developments, the minimum habitable floor levels shall be at the levels of the 1% annual exceedance probability (AEP) plus 0.5m;
- Non-habitable floor levels are to be equal to or greater than 1%AEP water level where possible, or otherwise no lower than 5% AEP flood level.
- The minimum surface level of open car parking spaces or carports shall be as high as practical, and not below the 5%AEP flood level.
- Garages or enclosed car parking (for more 20 or more vehicles) must be protected from inundation by flood waters up to the 1% AEP plus 0.5m.

2.2.2.2 EMERGENCY PLANNING

The general arrangements for managing floods in NSW are outlined within the NSW State Flood Plan. The Hawkesbury Nepean Flood Emergency Sub Plan (Wallacia to Spencer) (2015) forms a subplan to the State Plan and covers the floodplain of Cattai Creek. The Hills Shire also have the Hills Shire Local Flood Plan which forms a sub-plan of the Hills Shire Local Emergency Management Plan (EMPLAN, 2017).

The Hills Shire Local Flood Plan covers the preparedness measures, the conduct of response operations and the co-ordination of immediate recovery measures for all levels of flooding on the eastern side of the Hawkesbury River and its tributaries within the boundaries of The Hills Shire, other creek systems and overland flooding. The NSW State Emergency Service is listed as the agency responsible for the flood plan.

2.2.3 RIPARIAN CORRIDOR

Part D Section 19 of the DCP lists the following key objectives for ecology and riparian corridors:

- To protect and enhance areas of significant native vegetation

— To protect and enhance wildlife habitat

— To protect and enhance the integrity and environmental functionality of riparian corridors

The DCP provides controls for development adjoining the Cattai Creek riparian corridor through 3 defined areas (a, b and c). The section of riparian corridor at this site is noted as interface area (b) and is required to allow for an adopted riparian width of 30m from the 'top of bank' on each side of the creek. A minimum 7.5m built form setback is required to be provided to the riparian corridor. It is also noted that underground carparks are not permitted within 5m of the riparian corridor boundary. This is most relevant to any development on De Clambe Drive.

2.3 LANDCOM SUSTAINABLE PLACES STRATEGY

The Landcom Sustainable Places Strategy (2017) outlines Landcom's approach and goals with regards to sustainability, including in developing climate resilient places. Table 2-2 shows the targets relevant to this IWCMS.

Table 2-2 Landcom Sustainable Places Strategy Water targets and measures

TARGET	MEASURE
All projects to embed Water Sensitive Urban Design or other water sensitive strategies to reduce stormwater pollutant loads to minimise discharge from project sites	Pollutant reduction Nitrogen – 45% Phosphorus - 65% Suspended solids – 85% Gross pollutants – 90%
All new projects modelled to reduce mains potable water demand by 50% at the precinct scale, against a 2016 reference case	Report modelled % potable water reduction across whole portfolio

The water pollutant reduction targets are consistent with the Hills Shire Council targets shown in Table 2-1.

3 SURFACE WATER ENVIRONMENT

3.1 CATCHMENT OVERVIEW

3.1.1 CATCHMENT DRAINAGE

The topography of the Site generally falls from east to west, draining most of the site directly to Cattai Creek. A small area on the eastern portion of the Site drains towards a tributary of Cattai Creek that flows in a north westerly direction and meets Cattai Creek at Fred Caterson Recreation Reserve to the north of Castle Hill showground as shown in Figure 3.1.

Cattai Creek first becomes an open channel at Cockayne Reserve which is about 750m upstream of Carrington Road. At the site Cattai Creek drains a catchment area of approximately 327 hectares. Cattai Creek is a tributary of the larger Hawkesbury River, joining the Hawkesbury River at Cattai.

Source: Image Source Google Maps

Figure 3.1 Catchment Drainage

3.1.2 CLIMATE AND RAINFALL

The average annual rainfall in this area was 967mm between 1965 and 2019 (Bureau of Meteorology, station 066124). The average annual potential evapotranspiration in the area is around 1200 mm based on data from between 1961 and 1990 (Source: BOM average areal potential evapotranspiration map, www.bom.gov.au).

Climatic condition in the area are moderate with a warm summer, cool to cold winter and reliable rainfall throughout the year. The mean monthly maximum temperature is 29^0C in summer and mean monthly minimum of around 6^0C in winter (Bureau of Meteorology, station 066124).

3.1.3 CLIMATE CHANGE

There is now widespread acceptance that human activities are contributing to observed climate change. Climate change projections for the area can be found on the Office of Environment and Heritage (OEH) website (https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW). These projections note that:

- By 2030 maximum temperatures are projected to rise by 0.6 ºC and continue to rise by 2.0 ºC by 2070; and
- By 2030 annual rainfall is predicted to increase by 2.3% and continue to increase to 9.3% by 2070.

3.2 HILLS SHOWGROUND SITE

3.2.1 EXISTING LAND USE

The eastern part of the Site currently contains the former Council administration and associated parking and landscaping. It was being used as a Sydney Metro North West construction site office but will soon be demolished to create development precinct no. 3, also known as Hills Showground Precinct East.

The southern portion of the Site contains the recently opened Hills Showground station and commuter car park. The remainder of the Site was cleared to create the development lots No. 1 Hills Showground Precinct West and No. 2 Doran Drive Precinct and the roads. Former development on the Site consisted of an Auditorium and Council's depot and chambers.

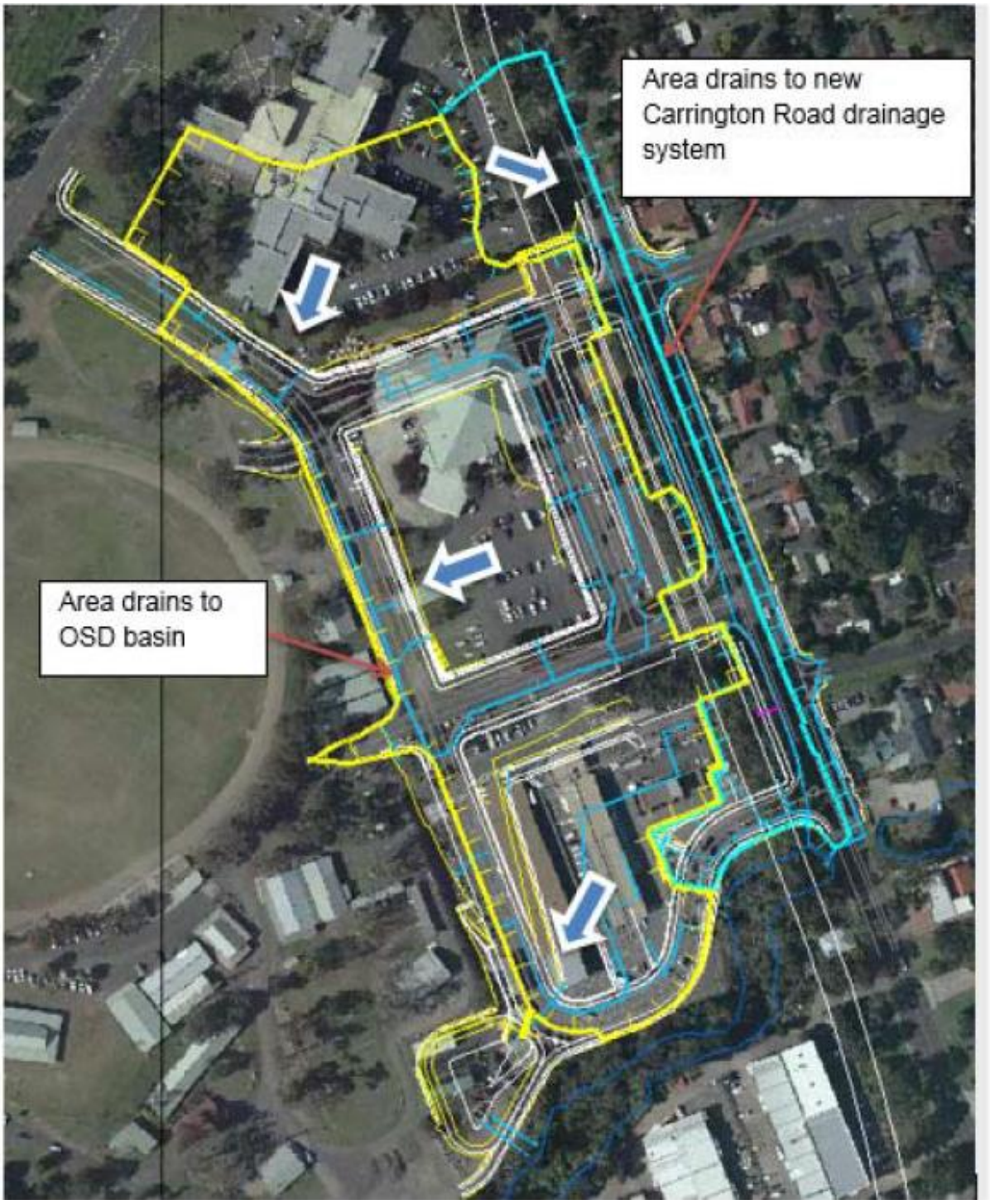
Hills Showground Precinct West and the Doran Drive Precinct are zoned as local centre (B2) and Hills Showground Precinct East zoned General Residential (R1) (Design Advisory Panel, 2019) (refer to Figure 1.1 for precinct locations).

3.2.2 EXISTING SITE DRAINAGE

The existing drainage system within the Hills Showground precinct has recently been upgraded as part of works for the development of the Hills Showground station and commuter carpark. The majority of the Site drains towards Cattai Creek through a system of stormwater pits/pipes and via overland flow. The yellow areas shown in Figure 3.2 drain via an On Site Detention (OSD) basin which has been designed in accordance with the Hills Shire Council Engineering Design Guidelines (NRT, 2016). The blue areas shown in Figure 3.2 drain via a Humes stormwater filtration device which treats stormwater runoff prior to discharge to Cattai Creek. Several similar stormwater quality treatment devices are located within the stormwater network that drains to the OSD basin (NRT Work as Executed Drawings, 2019: *NWRLOTS-NRT-SHW-DR-DRG 431721 – 431982).*

Site plans show a designated drainage easement adjacent to the commuter carpark. This consists of a vegetated swale with base width 0.5m, depth 0.5m and slope of 3:1 (H:V). This swale connects to the OSD via a 600mm diameter pipe. It is noted that vegetation growth is still to develop in this swale (refer to Photo 3.1). The car park and the station box are the main contributors of flow to this easement.

A high point on the eastern end of the site indicates runoff from the eastern most portion of the Site will drain towards the intersection of Carrington Road and Showground Road. Drainage infrastructure in this portion of the Site has not recently been upgraded as per the remainder of the Site. This area is drained by a pipe network that crosses Showground Road and heads north towards a tributary of Cattai Creek. The tributary joins Cattai Creek at Fred Caterson Recreation Reserve, just to the north of the Precinct area.



Source: *Figure 6.2 in Northwest Rapid Transit Design Report Package 2109: WAD Package 9 (2016) (NRT Ref: Document No. NWRLOTS-NRT-SHW-CW-RPT-431602 Revision C)*

Figure 3.2 Existing site drainage

Photo 3-1 Existing site drainage features

3.2.3 WATER SUPPLY & WASTEWATER

The Site is currently serviced by municipal water supply. There is no groundwater extraction at the Site (email correspondence with The Hills Shire Council, 9/5/18). It has been noted that there is a Sydney Water sewer overflow into Cattai Creek near the Castle Hill Showground (Arup, 2015).

There is currently no infrastructure on Site to enable rainwater to be captured for reuse.

3.3 RIPARIAN CORRIDOR

The Showground Precinct Draft DCP (September 2017) defines ecology and riparian corridors (30m from the top of bank of Cattai Creek) to protect and enhance areas of native vegetation and wildlife habitat. The riparian corridor also provides a focus for passive and active recreation along the creek corridor (with zoning noted as 'Public Recreation' within the riparian area).

Cattai Creek, located to the west of the Site, has a deeply incised open channel that is heavily vegetated. Its upstream catchment consists of a mix of residential and industrial land use.

Photo 3-2 Cattai Creek looking downstream from Carrington Road

Photo 3-3 Cattai Creek dense vegetation within riparian corridor

Photo 3-4 Cattai Creek culvert under Carrington Road

3.4 FLOODING

Flood levels at the Site have been determined based on the following sources:

- A HEC RAS model that was developed for the NWRL EIS (Surface Water and Hydrology Stations, Rail Infrastructure and Systems - EIS 2, as reported by AECOM, 2012)
- A revised HEC RAS model to review project impacts at design stage (as reported by NRT, 2016)
- Flood information from the Hills Shire Council Flood (based on 'Urban Overland Flow Study Rev 4 April 2017 – Final draft version). This study was based on a 1d/2d TUFLOW model developed specifically for the study.

These sources all show that the Cattai Creek 1%AEP flood extent is largely confined to within the existing riparian corridor. The information provided by Council does not show that there are any significant overland flow paths across the Site (refer Figure 3.4). This information also shows that Cattai Creek flood levels at Carrington Road are 83.15 mAHD during a 1% AEP event and 82.89 mAHD during a 5%AEP event. Further downstream (adjacent to the detention basin), Cattai Creek flood levels are 78.22 mAHD during a 1% AEP event and 77.95 mAHD during a 5%AEP event.

The flood information obtained from the Hills Shire Council provides an understanding of the hazard of the flood conditions. The Velocity and Velocity Depth product values provided with the Council information indicate that flood conditions on Carrington Road where it crosses Cattai Creek would have a Hazard Vulnerability Classification of H4 indicating it is unsafe for vehicles and people to use this section of road during flood conditions (based on classifications defined in ARR2019).

The NRT report considered climate change impacts to the 1% AEP event and noted the PMF extent (NRT, 2016). An extract from the report showing these extents is provided in Figure 3.4. The 1%AEP flood extent with climate change considered (by assuming 10% increase to rainfall intensity) is still contained within the riparian corridor so does not impact on the Site or DA Area. The PMF extent inundates the road areas along De Clambe Drive. The carpark entrance has been located outside of this flood extent. The NRT report noted impacts to flood levels associated with the works associated with the NWRL infrastructure. This assessment noted that:

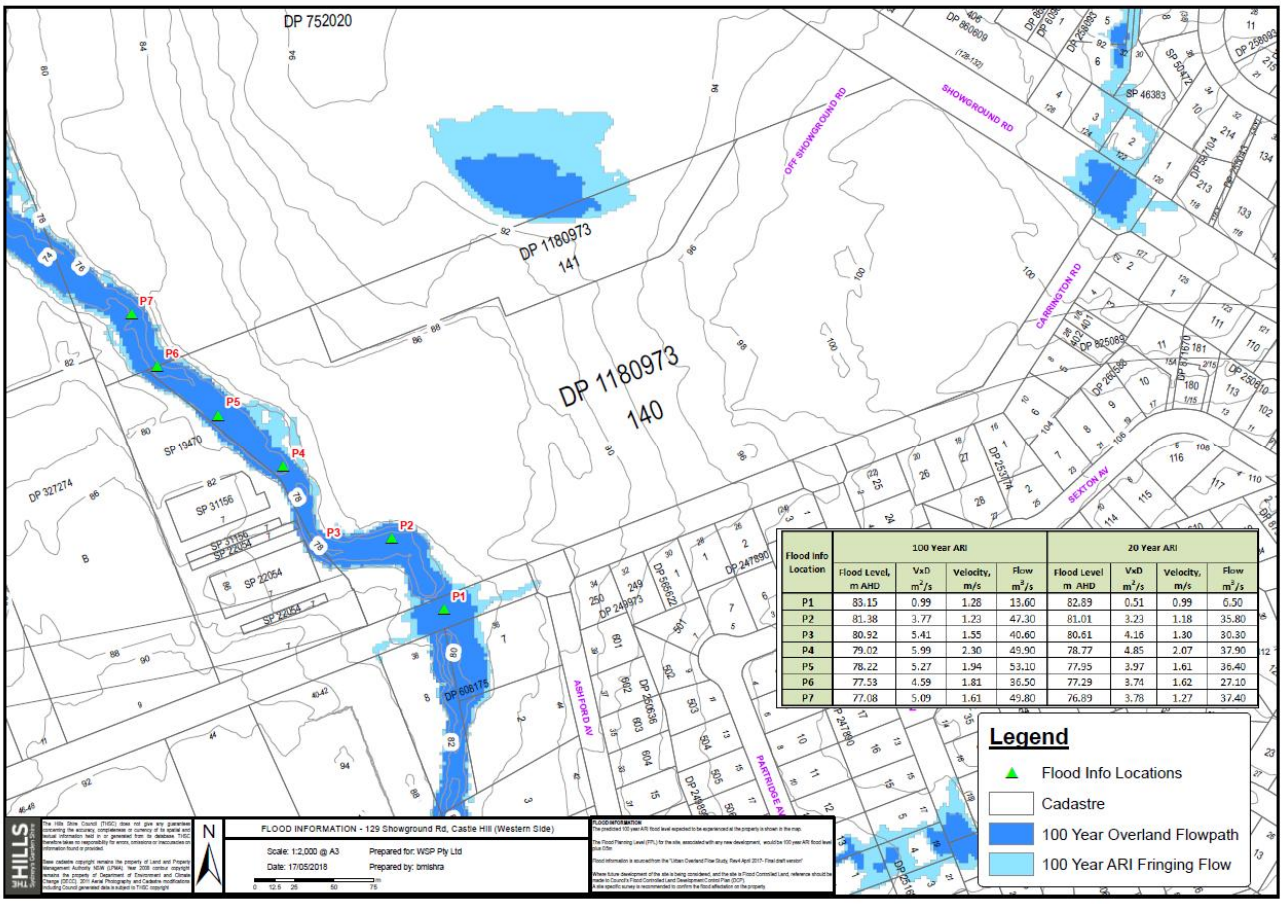
— the Site is located outside of the 1% AEP flood extent so no changes to the flooding regime in Cattai Creek would occur as a result of the project works. This included no change to flooding regime during assessment of the 1%AEP event incorporating climate change;

— potential changes in flood levels in Cattai Creek during the PMF event are limited to areas immediately adjacent PMF inundation of precinct roads. These potential increases in level do not contribute any increase in flooded area due to the relatively steep topography adjacent the tributary;

— as the Site is located outside of the mainstream flood extents in the 1%AEP flood, changes to the Site would not result in time of inundation impacts to mainstream flooding; and

— the project does not have a significant impact on existing flooding regimes in terms of time of inundation or velocity. Ths is indicated by the modelling results as the profile of the water level curve against time does not change significantly in the 1%AEP modelling from existing to proposed scenarios.

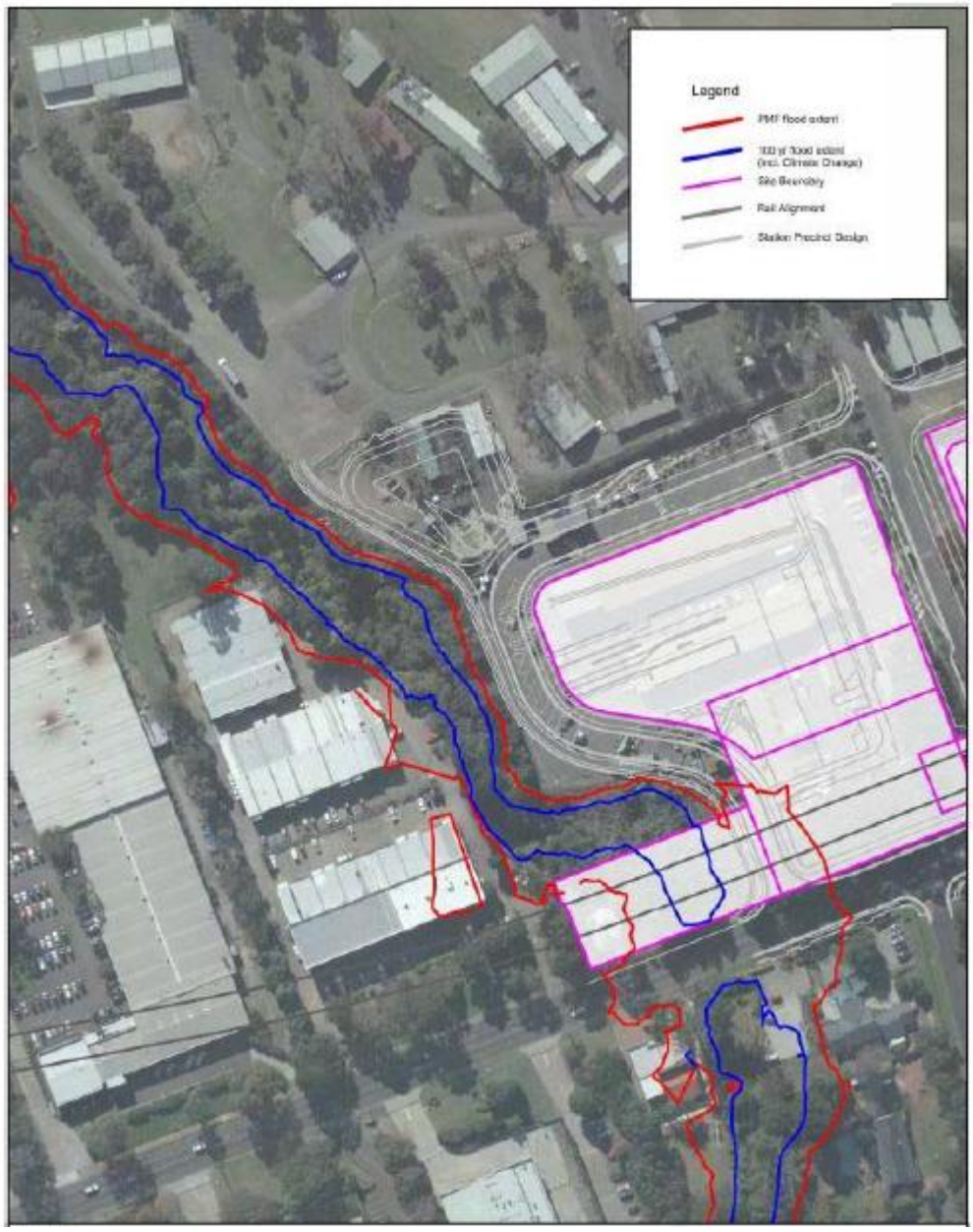
The Council information also provided details of flood levels within the tributary of Cattai Creek that the eastern portion of the site drains towards (see Figure 3.6). It can be seen in this figure that the Site is not inundated for events up to the 1% AEP from this tributary. Flood levels shown on Showground Road at the intersection with Carrington Road are 96.76mAHD during a 1%AEP event. The velocity and velocity depth product values provided indicate a Hazard Vulnerability Classification of H1 for this section of road, which would mean that during flood conditions this area would generally be safe for vehicles and people to use.



Flood Info Location	100 Year ARI				20 Year ARI			
	Flood Level, m AHD	VxD m^2/s	Velocity, m/s	Flow m^3/s	Flood Level m AHD	VxD m^2/s	Velocity, m/s	Flow m^3/s
P1	83.15	0.99	1.28	13.60	82.89	0.51	0.99	6.50
P2	81.38	3.77	1.23	47.30	81.01	3.23	1.18	35.80
P3	80.92	5.41	1.55	40.60	80.61	4.16	1.30	30.30
P4	79.02	5.99	2.30	49.90	78.77	4.85	2.07	37.90
P5	78.22	5.27	1.94	53.10	77.95	3.97	1.61	36.40
P6	77.53	4.59	1.81	36.50	77.29	3.74	1.62	27.10
P7	77.08	5.09	1.61	49.80	76.89	3.78	1.27	37.40

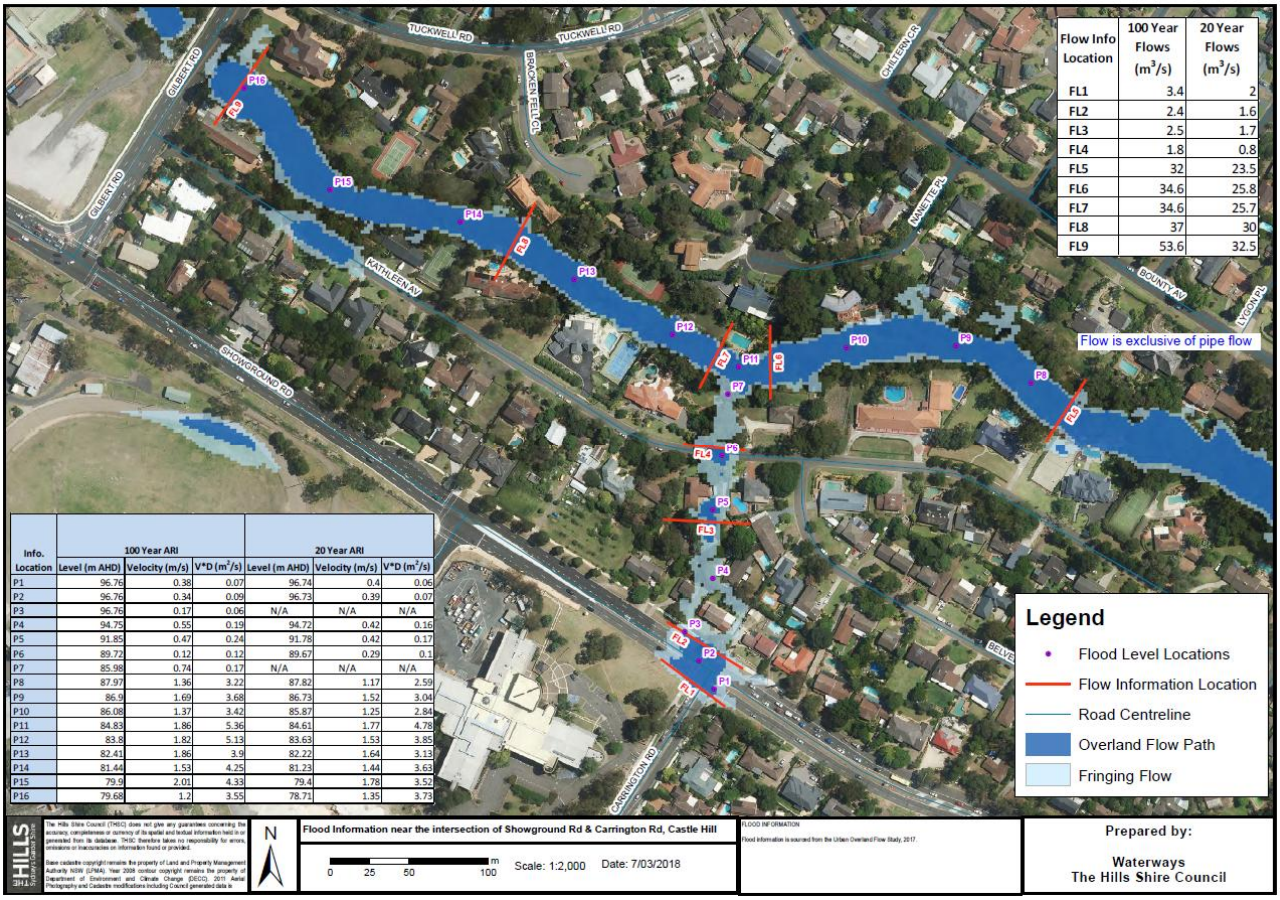
Source: Hills Shire Council, Urban Overland Flow Study Rev 4 April 2017

Figure 3.3 Hills Shire Council Flood Mapping Cattai Creek 1%AEP



Source: *Northwest Rapid Transit Design Report Package 2109: WAD Package 9 (2016) (NRT Ref: Document No. NWRLOTS-NRT-SHW-CW-RPT-431602 Revision C)*

Figure 3.4 NRT proposed conditions flood mapping 1%AEP with climate change and PMF



Source: *Hills Shire Council, Urban Overland Flow Study Rev 4 April 2017*

Figure 3.5 Hills Shire Council Flood Mapping Cattai Creek Tributary

3.5 WATER QUALITY

Water quality within Cattai Creek was reported on within the NWRL EIS (AECOM, 2012) based on 3 monitoring sites operated by the Hills Shire Council within the vicinity of the Hills Showground Site. The NWRL EIS reported that in general E.coli and nutrients, Total Nitrogen and Total Phosphorous were found to be above the ANZECC guidelines in over half the samples, with dissolved oxygen readings below recommended guidelines. The Hills Shire Council provided additional water quality data from the same sites as reported on within the EIS for a period up to and including 2013 (email from Mishra Bishwa, the Hills Shire Council, 17 May 2018). This data showed similar water quality trends to that noted in the NWRL EIS.

Other than the NWRL and Council monitoring, there is little available information in relation to water quality within Cattai Creek and little information relating to the current ecological heath of the waterway. It is noted that a Sydney Water sewer overflow spills into Cattai Creek from the industrial estate to the west of the Site. Information in relation to the spill volume or frequency however is not known (Arup, 2015).

4 INTEGRATED WATER CYCLE MANAGEMENT STRATEGY

4.1 INTENT

The IWCMS is based on the Concept Proposal for the Site as presented in Figure 1.2. The intent of the strategy is to provide a set of objectives and to recommend measures to be employed at the Site to achieve the integrated water management objectives outlined in the DCP (see section 2.2). The IWCMS focuses on the development as a whole as it is assumed that the individual buildings will manage water within the building footprint on an individual basis. Features included within the IWCMS can be incorporated into landscaping plans for the Site and add to visual amenity of the area. Consideration should be given to highlighting key features with signage at the Site noting what the feature is and what it achieves to provide for community education relating to stormwater management.

4.2 STORMWATER QUANTITY

Stormwater controls are included in the concept plan to ensure that the proposed development does not adversely impact on stormwater flows and water quality of the receiving waterways. The proposed stormwater drainage and water quality treatment system has been developed in accordance with the following guidance documents:

- AS3500 – 'National Plumbing and Drainage Code' – Part 3: Stormwater Drainage
- Australian Rainfall and Runoff, 2016 – Parts 1 & 2
- The Hills Development Control Plan (DCP) 2012 Part D Section 19 Showground Station Precinct (Draft, 2017)
- The Hills Development Control Plan (DCP) 2012 Part C Section 6 Flood Controlled Land
- The Hills Development Control Plan (DCP) 2012 Appendix B Water Sensitive Urban Design
- The Hills Shire Council Design Guidelines Subdivision/Developments (2011)
- Guidelines for development adjoining land and water managed by DECCW (OEH, 2013).

A piped stormwater drainage system will be provided to collect all concentrated flows from the proposed buildings and hardstand surfaces. The DA Area will drain to the detention basin on the north western boundary before discharge to Cattai Creek. Rock rip rap, gravel and vegetation are provided at the outlet of the drainage system to act as energy dissipators to reduce scour potential.

4.2.1 ON SITE DETENTION

Council's Design Guidelines Subdivision/Developments (September 2011) provide methods for calculating the permissible site discharge (PSD) and site storage volume (SSV) requirements for development sites. Table 4-1 shows the PSD and SSV requirements for three sites.

Table 4-1 OSD requirements

	SITE AREA (HA)	GRADIENT	PSD(L/S)	SSV (M^3)
Hill Showground Precinct West	0.33	8%	34	119
Doran Drive Precinct	0.80	8%	83	290

	SITE AREA (HA)	GRADIENT	PSD(L/S)	SSV (M^3)
Hill Showground Precinct East	2.88	7%	300	1043

An OSD basin was designed and constructed on site as part of the NRT works (NRT, 2016). The NRT Design Report shows the basin has been designed to have a volume of 2135m^3 and sized to cater for the entire site (8.4ha) including the station (section 6.4.3.7 and 6.4.3.12, NRT design report, 2016).

4.2.2 DRAINAGE EASEMENT

There is a private drainage easement within the Hills Showground Precinct West which currently comprises a vegetated channel. This channel drains stormwater runoff from the carpark and the station box areas. The concept plan shows buildings are proposed to be constructed where this channel is currently located. To enable the concept plan to proceed, this drainage easement would need to be moved. Changes to this drainage easement would need to be designed in accordance with Council's Design Guidelines Subdivision/Developments (September 2011) and would require approval from Council. Any plans to move the easement would need to ensure that the current intent (size/ amount of stormwater it coveys/ provision of an overland flow route) is maintained at any new location. A new easement would need to fit between the current location and the carpark (within the open space area shown on the concept plans in this corridor) and it would likely also need to connect to the outlet location it currently connects to so that water will discharge to the detention basin. Hydraulic modelling will be required to be undertaken to complete design and sizing of proposed changes to drainage within the easement to ensure the areas benefitting from the easement are adequately catered for (primarily the carpark and station box areas). Ongoing maintenance of the easement should also be considered in consultation with Council. Being a private drainage easement, the land owner (Landcom) would be responsible for maintenance. Inadequate maintenance could result in flood impacts to properties. Designating an official drainage easement under section 88 of the *Conveyancing Act 1919* may be considered to transfer ownership of the easement to Council to ensure that function of the easement of maintained.

4.3 STORMWATER QUALITY

Existing stormwater quality treatment provided as part of the NWRL development includes:

- Water quality treatment devices (gross pollutant traps (GPTs), specifically SPEL Ecoceptor units) on surface inlets and grated drains
- A vegetated swale and a rock lined swale to carry flow to the OSD and to provide additional treatment of runoff from the site.
- A 2135m^3 detention basin (OSD) at the north-west corner of the site.

Taking these existing treatment devices into account a concept water cycle management strategy has been designed to consider the development of the remainder of the site. This strategy is intended to ensure that stormwater leaving each DA area meets the water quality targets for the Showground Precinct as specified within the Hills Shire Council DCP. This plan includes the following stormwater quality treatment measures in addition to what has been recently constructed on site:

- Gross pollutant traps and stormwater filtration devices at surface inlet pits and grated drains (EnviroPod units and Jellyfish filtration units have been included in the concept plan)
- Rainwater tanks for capture and re-use of stormwater from roof areas
- Linear bioretention in garden and tree beds to provide additional capture and treatment of runoff from the site.

Details of the stormwater quality modelling are provided in section 5.

4.3.1 OCEANGUARD UNITS

The concept strategy incorporates OceanGuard units upstream of all other stormwater quality treatment devices. These units are simple polyester mesh insets that can be retrofitted into new and existing stormwater pits and require no additional construction or land areas.

4.3.2 JELLYFISH FILTER UNITS

Jellyfish filtration units have been incorporated within each of the DA areas as part of the concept strategy. These are underground treatment devices that use membrane filtration to capture pollutants in stormwater runoff. Figures 4.4 and 4.5 provide an overview of what these units look like and how they function. The concept strategy incorporates 1.2m diameter units for the Doran Drive and Precinct West DA areas and 2.25m diameter units for Precinct East.

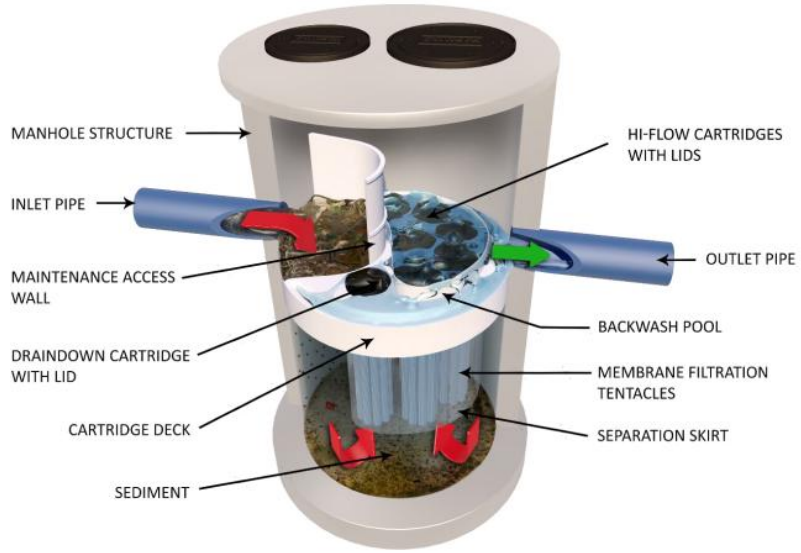


Figure 4.1 Indicative Operation - Jellyfish filter

Figure 4.2 Jellyfish precast manhole

4.3.3 LINEAR BIORETENTION

Photo 4-1, Figure 4.3, Figure 4.4 and Figure 4.5 show an example of typical bioretention measures that may be included in the landscaped areas within the Hills Showground Precinct East. The concept strategy incorporates a minimum of 150m of 1m width bioretention areas within garden and tree beds that are proposed along the pedestrian and vehicle pathways within the concept plan. Indicative areas where this could be considered within Precinct East are shown by green arrows in Figure 4.6.

Photo 4-1 Linear bioretention

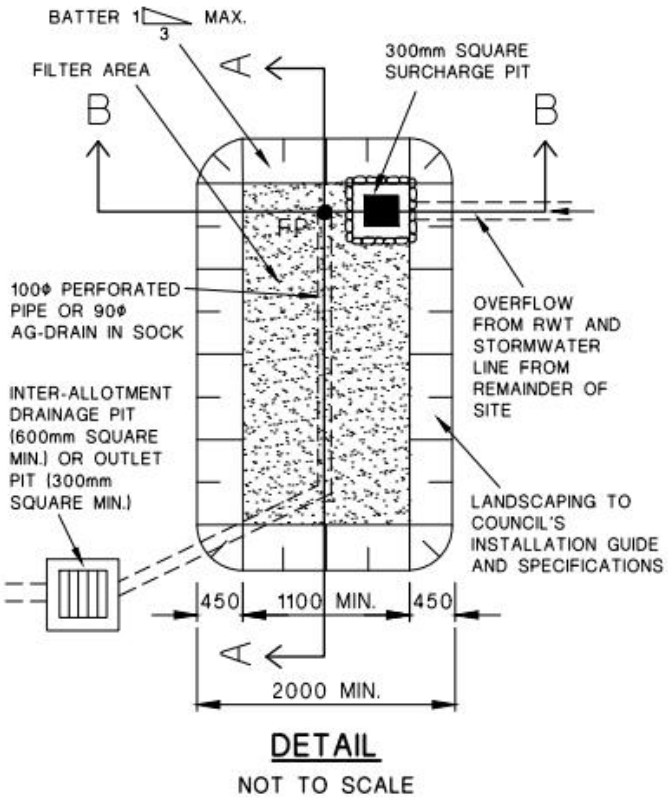


Figure 4.3 Indicative schematic of bioretention (plan view)

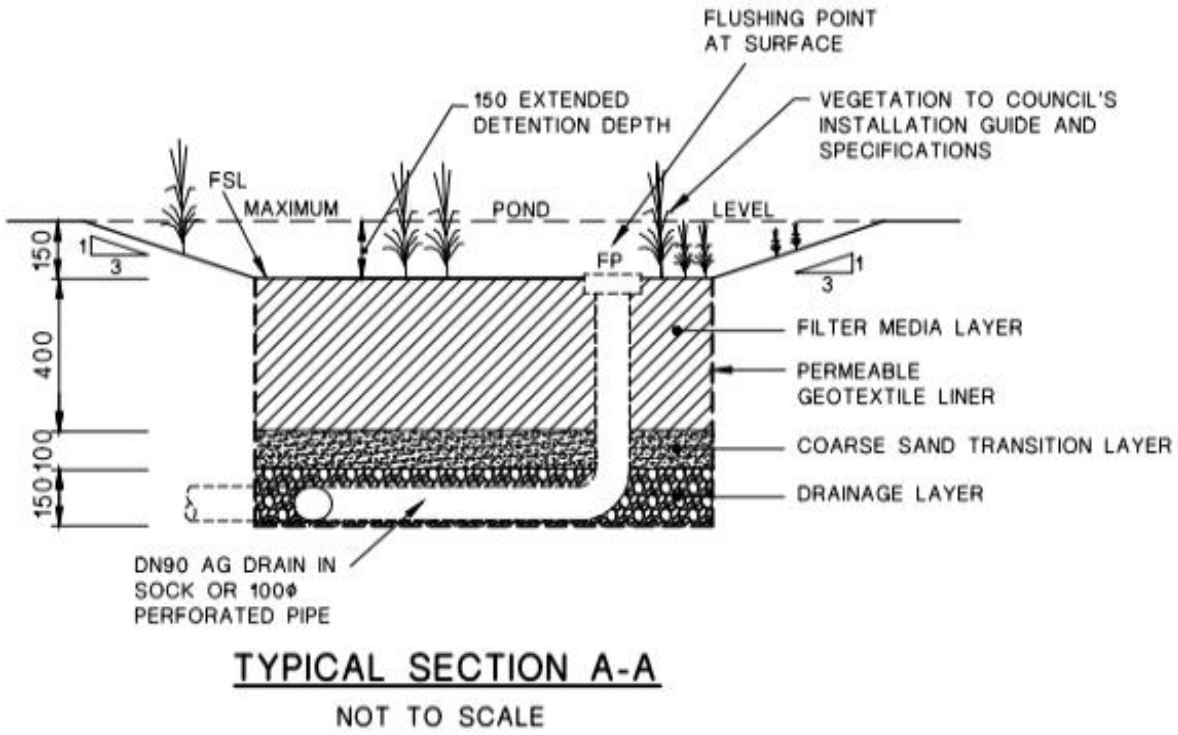


Figure 4.4 Indicative schematic of bioretention (cross section)

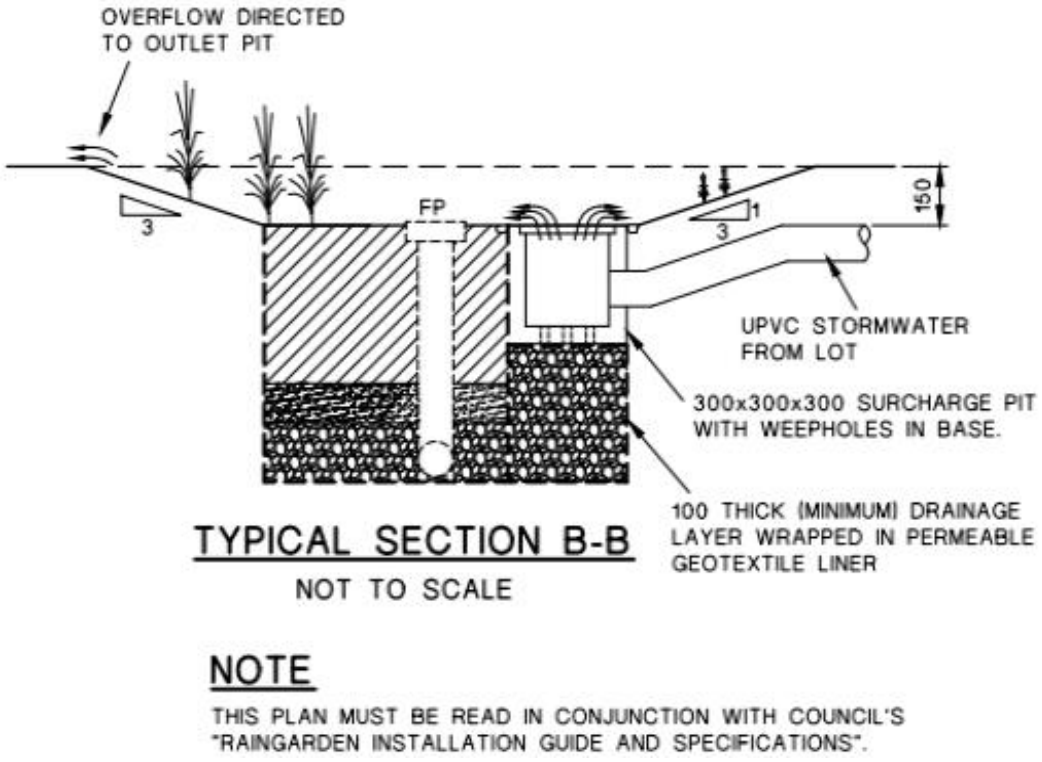


Figure 4.5 Indicative schematic of bioretention (cross section)

Figure 4.6 Indicative areas for bioretention Precinct East

4.4 RAINWATER HARVESTING

As part of WSUD management, Part D Section 19 of the DCP requires developers to install rainwater tanks to meet a portion of water supply demand. The following requirements shall be met:

- The capacity of rainwater to be provide on the development to be determined through a detailed water balance assessment.
- The tanks are to be used for external uses such as garden/landscape irrigation and may be used for other purposes such as any wash down bays and laundry facilities.
- Each rainwater tank is to be provided with potable water trickle top-up with a back flow prevention device, complying Sydney Water requirements.
- Diversion of the "first flush" of up to 180 litres is to be incorporated into the design of the rainwater tank and associated plumbing based on a minimum first flush of 1L/m^2 of roof area.

The size requirements for a rainwater tank are dependent on the collection area, localised rainfall and uses of the rainwater. Models would be used to appropriately size the tanks for the most effective solution. Rainwater can be used for landscape irrigation and non-potable water uses such as toilet flushing and laundry washing. The use of native drought resistant species in landscaping would reduce the amount of water required for irrigation and may assist in rainwater tanks being able to cover the irrigation requirements of the precinct. Due to the amount of green spaces within the precinct (rooftop courtyards, at grade courtyards and public plaza) that will require irrigation and the moderate rainfall generally experienced in the Sydney region, rainwater tanks are likely to be a viable option.

4.5 WATER USE

Incorporating water saving measures into building design would be required to achieve water demand reduction goals within Landcom Sustainable Places Strategy (2017). Measures such as dual flush toilets, water efficient taps and shower heads and efficient use of water captured in rainwater tanks could all be considered. Further detailed investigations are recommended to identify the most appropriate measures to incorporate.

4.6 WASTEWATER

4.6.1 GREY WATER REUSE

Greywater is water collected from showers, basins and taps. Depending on the treatment methods greywater can be used for landscape irrigation, indoor toilet flushing and laundry washing. Usually council only requires either one of grey water and rainwater reuse. Based on high level advice from hydraulic specialists, grey water reuse is generally not recommended due to high initial and ongoing maintenance cost and reduction of architectural space.

4.6.2 BLACK WATER REUSE

Blackwater is typically water that has been mixed with toilet waste and often includes kitchen and dishwater water due to the potential for pathogens and grease. Blackwater recycling requires biological or chemical treatment and disinfection therefore is a more costly system to implement and maintain and has more stringent regulations for its reuse after treatment. Therefore it is not recommended for this project.

Further detailed studies are recommended if greywater or blackwater reuse are to be considered. They are not being recommended as part of the IWCMS at this stage.

4.7 RIPARIAN CORRIDORS

4.7.1 SCOUR PROTECTION AT DISCHARGE POINT

Scour protection shall be installed at each drainage outlets to the creek to minimise erosion of materials due to high velocity.

4.7.2 SETBACKS

Riparian corridor setbacks as recommended in the DCP (and noted in Section 2.2.3 above) are to be applied. The concept plans comply with these requirements.

4.7.3 WATER QUALITY

Any discharge to the Cattai Creek Corridor zoned RE1 Public Recreation will require the approval of NSW Office of Water. This would also require implementation of a surface water quality monitoring program to help protect water quality in Cattai Creek. Monitoring procedures and criteria should be established in consultation with Hills Shire Council and NSW Office of Water.

4.8 FLOOD MANAGEMENT & FLOOD EMERGENCY MANAGEMENT

4.8.1 FLOOD MANAGEMENT

As noted in Section 3.4, the Cattai Creek 1%AEP flood extent is largely confined to within the existing riparian corridor and flooding from the tributary of Cattai Creek on the eastern side of the site does not inundate the site. The modelling presented in the NRT report (NRT, 2016) showed that the 1%AEP flood extent with climate change considered (by assuming 10% increase to rainfall intensity) is still contained within the riparian corridor and does not impact on the site. The PMF extent inundates the road areas along De Clambe Drive near the intersection with Carrington Road.

The provision of the detention basin for the attenuation of the proposed scenario runoff ensures that there is no increase in peak flows reaching Cattai Creek. All works associated with the proposed concept plan are located outside the extents of the 1%AEP flood extent, with no negative impacts influencing flood levels.

The following flood management controls should be noted for the site:

- All floor levels are to be above the 1% AEP level + 0.5m freeboard (ie above 83.6 mAHD at the intersection of DeClambe Drive and Carrington Road, and above 78.7mAHD at the detention basin);
- All garages/ carpark entrances must be protected from inundation by flood waters up to the 1% AEP + 0.5m.

These controls do not impact on the current concept plans as current building locations and carpark entrances are located on land that is higher than these levels. Given the small portion of the site that is impacted by the PMF extent, it is recommended that the entry threshold levels for the buildings and underground structures are set above PMF levels or protected with raised ground levels to prevent the ingress of flood water for all events up to and including the PMF.

4.8.2 EMERGENCY MANAGMENT

As most of the precinct is not inundated during flood events up to and including the PMF event, the site would be considered a safe place to shelter during flood events. However, as noted in Section 3.4, flood conditions on Carrington Road at Cattai Creek during a 1% AEP event are considered unsafe for vehicles and people. Any traffic leaving the site during flood conditions would need to leave via Showground Road and not attempt to cross Cattai Creek on Carrington Road.

5 CONCEPT PLAN OF WATER CYCLE MANAGEMENT

5.1 MUSIC MODEL SETUP

Model for Urban Storm Water Conceptualisation (MUSIC) predicts the performance of storm water quality management systems. A MUSIC model was prepared for the site to assess the pre-and post-development stormwater conditions for the site and to assess the effectiveness of the water quality treatment devices against the Hills Shire Council targets. The model was prepared in line with the Hills Shire Council's DCP.

The MUSIC software was deemed suitable for this assessment because it can estimate volumes and pollutant loads for stormwater based on historic continuous rainfall data. Stormwater management typically deals with regular rainfall events so use of a continuous rainfall provides an understanding of how the system behaves over a year or more. This can help inform the water balance model for the site.

The models were set up based on the following guidelines:

- DCP 2012 Part D Section 19 Showground Station Precinct (Draft, 2017) – MUSIC modelling parameters etc
- NSW MUSIC Modelling Guideline (BMT WBM, 2015)
- Australian Runoff Quality (Engineers Australia 2005)
- Water Sensitive Urban Design Technical Guidelines for Western Sydney (NSW Government Stormwater Trust and UPRCT, May 2004)
- Adoption Guidelines for Stormwater Biofiltration Systems - Cities as Water Supply Catchments – Sustainable Technologies (CRC for Water Sensitive Cites, 2015).

The MUSIC model was set-up with rainfall-runoff data from the MUSIC provided file from the Parramatta BoM station. This data is considered appropriate for this assessment. The model was set up with source nodes to account for roof area, paved and landscaped/open park area which all have a rainfall runoff relationship that is based on research of real site (BMT WBM, 2015). The treatment nodes, including gross pollutant traps and other treatment devices were then linked to the source nodes. Table 5-1 shows the impervious area parameters used for the model. Further details of the rainfall and pervious area parameters are provided in Appendix A.

Table 5-1 Impervious area parameters

LANDUSE	SOURCE NODE TYPE	% IMPERVIOUS	% PERVIOUS
Roof	Roof	100	0
Pavement	Commercial	90	10
Open space/park	Commercial	0	100

5.1.1 DRAINAGE CATCHMENTS

The existing drainage catchments were set up as described in sections 3.1 and 3.2.2 with the majority of the site draining to Cattai Creek at the west of the site. A small amount of the Precinct East drains to the Carrington Road drainage system and approximately 40% the Precinct East drains to a tributary of Cattai Creek.

5.2 CONCEPT OPTION INPUTS AND RESULTS

To model the proposed concept plan, the source node areas were estimated based on the concept provided (Cox Architecture, 2019). Precinct East and Doran Drive Precinct contain roof, paved, landscaped and open green space park areas. Space allocated as roof area was modelled as paved area. The Precinct West contains roof, paved and landscpared areas. Details of how these measures were assessed in the MUSIC model are provided in Appendix A.

5.2.1 SOURCE AREAS

The source node areas were estimated based on the concept plan provided. Table 5-2 shows the areas for all source nodes in the concept plan.

Table 5-2 Concept Plan - Source node areas

SOURCE NODE	PRECINCT EAST (HA)	DORAN DRIVE (HA)	PRECINCT WEST (HA)
Roof	0.90	0.35	0.31
Pavement	1.03	0.24	0.004
Landscaped	0.68	0.16	0.018
Park	0.21	0.04	
TOTAL	2.82	0.80	0.33

5.2.2 STORMWATER QUALITY TREATMENT MEASURES

It is noted that there is limited space available in the Precincts. As such, stormwater quality treatment devices were selected that would be able to be implemented within the existing proposed concept plan. The following additional stormwater quality treatment measures were included in the MUSIC model:

- Rainwater tanks for capture and re-use of stormwater from roof areas. One rainwater tank has been assumed per major building proposed in the concept plan (refer to section 5.2.3).
- Gross pollutant traps (GPT) and filtration devices at major low points of the precincts and catchments. A GPT (EnviroPod unit) and Jellyfish filtration device was provided at the discharge point for each Precinct and for the section of the Precinct East which discharge to the east.
- Linear bioretention in garden beds to provide additional treatment of runoff from the site. These bioretention measures would be contained within the garden and tree beds that are proposed along the pedestrian and vehicle pathways in the concept plan. These are only proposed to be used within Precinct East.

Table 5-3 shows the results of the model for the developed condition without treatment, with treatment and the percentage reduction of pollutant from the untreated to treated conditions. Table 5-3 also shows the target pollutant reduction as per the Hills Shire Council DCP and Landcom's Sustainable Places Stratgey. Where the modelled load reduction is compliant with the these targets, the column is highlighted in green.

Table 5-3 MUSIC Model results

PARAMETER	WITHOUT TREATMENT	WITH TREATMENT	MODELLED % LOAD REDUCTION	TARGET LOAD REDUCTION	COMPLIANT
Hills Showground Precinct West					
Flow (ML/yr)	2.39	1.15	51.9%	-	-

PARAMETER	WITHOUT TREATMENT	WITH TREATMENT	MODELLED % LOAD REDUCTION	TARGET LOAD REDUCTION	COMPLIANT
Total Suspended Solids (kg/yr)	76.9	3.92	94.9%	85%	Yes
Total Phosphorus (kg/yr)	0.382	0.068	82.2%	65%	Yes
Total Nitrogen (kg/yr)	5.21	1.11	78.6%	45%	Yes
Gross pollutants (kg/yr)	61.5	0.0611	99.9%	90%	Yes
Hills Showground Doran Drive					
Flow (ML/yr)	4.96	3.27	34.2%	-	-
Total Suspended Solids (kg/yr)	463	62.1	86.6%	85%	Yes
Total Phosphorus (kg/yr)	1.07	0.341	68.1%	65%	Yes
Total Nitrogen (kg/yr)	10.6	3.47	67.2%	45%	Yes
Gross pollutants (kg/yr)	115	1.48	98.7%	90%	Yes
Hills Showground Precinct East					
Flow (ML/yr)	15	11.7	21.4%	-	-
Total Suspended Solids (kg/yr)	1710	168	90.2%	85%	Yes
Total Phosphorus (kg/yr)	3.47	1.02	70.5%	65%	Yes
Total Nitrogen (kg/yr)	31.9	11.6	63.5%	45%	Yes
Gross pollutants (kg/yr)	341	0.372	99.9%	90%	Yes

The MUSIC modelling indicates that the proposed water quality treatment measures would meet Council and Landcom water quality pollutant reduction targets for new developments.

5.2.3 RAINWATER REUSE

Rainwater tanks are proposed at roofed areas to harvest and re-use stormwater. Rainwater tanks were assumed to capture 75% of total roof area run-off with the remaining flow bypassing to the stormwater system. The assumed annual water demand for each Precinct was based on the assumed apartment yields and retail and commercial gross floor areas provided in the concept option report (Landcom, June 2019).

Typical water demands are provided by Sydney Water and the NSW MUSIC Modelling Guideline (BMT WBM, 2015). The values for residential uses were taken for reuse in toilets only in multi-residential dwellings (BMT WBM, 2015). The

for commercial office buildings and shopping centres with and ‘efficient’ benchmark score (Sydney Water, 2019). Table 5-4 shows the typical water use demands for various building uses.

Typical water demands are provided by Sydney Water and the NSW MUSIC Modelling Guideline (BMT WBM, 2015). The values for residential uses were taken for reuse in toilets only in multi-residential dwellings (BMT WBM, 2015). The for commercial office buildings and shopping centres with and ‘efficient’ benchmark score (Sydney Water, 2019). Table 5-4 shows the typical water use demands for various dwelling capacities.

Table 5-4 Typical water use demands per building

DWELLING CAPACITY	% YIELD	INDICATIVE NO.OF OCCUPANTS	TYPICAL WATER DEMAND (L/DAY)
Residential - 1 bed	35	1.55	40.5 (L/day)
Residential - 2 bed	55	3	81 (L/day)
Residential - 3 bed	10	4	108 (L/day)
Retail/ commercial	n/a	n/a	2.30 (L/m^2/day)

Based on the above water demands and apartment yields, a typical water demand (kL/day) was calculated for each Precinct as shown in Table 5-5. A 60kL tank was provided for each building, with an additional 60kL tank for the building located in the north-east corner of Precinct East. These were modelled as 48kL tanks to account for losses as per the NSW MUSIC Modelling guidelines (BMT WBM, 2015). Table 5-5 shows the number of tanks modelled for each Precinct and the reuse rate achieved.

Table 5-5 Indicative water demand, number of tanks and achieved reuse per precinct

PRECINCT	TYPICAL WATER DEMAND (KL/DAY)	NUMBER OF TANKS	REUSE SUPPLIED (ML/YEAR)	REUSE ACHIEVED (%)
Precinct East	67.9	6	3.03	11.26%
Doran Drive	61.33	2	1.70	5.12%
Precinct West	35.06	2	1.24	8.20%

5.3 RECOMMENDATIONS AND FURTHER INVESTIGATIONS FOR STORMWATER QUALITY

The modelled stormwater quality treatment measures have been shown to achieve the required water quality outcomes and pollutant load reductions. Other water quality treatment and reuse to be investigated may include:

- Use of vegetated bioretention measures as part of urban design visual amenity
- Placement and sizing of rainwater tanks to improve rainwater capture and reuse applications in the Precincts
- Incorporation of signage at key stormwater management features (eg rainwater tanks and bioretention gardens) to provide community education relating to water management. Typical information to include on signage is provided in Appendix B.

6 CONCLUSIONS

This report outlines the IWCMS for the Hills Showground SSDA application. This strategy has established the water quality environment of the Site and described the model prepared to assess the effects of the proposed concept plan on stormwater quality and to identify measures to protect the receiving environment from adverse water quality impacts. The strategy also aims to complement existing features that have recently being built with the Metro station works to limit re-work at the site.

The water quality regime has been established through MUSIC modelling of the Precincts. The following stormwater quality treatment devices have been included in this IWCMS:

- Rainwater tanks for capture and re-use of stormwater from roof areas. One rainwater tank has been provided per major building proposed in the concept plan (refer to section 5.2.3). These will contribute to meeting the demand for non-potable water for the Precincts.
- Gross pollutant traps and filtration devices at major discharge points of the precincts and catchments (enviropod and Jellyfish filtration units have been incorporated into the concept strategy).
- Linear bioretention in garden beds to provide additional treatment of runoff from Precinct East. These bioretention measures would be contained within the garden and tree beds that are proposed along the pedestrian and vehicle pathways in the concept plan.

It is noted that there is limited space available in the Precincts but the proposed layout as presented in Figure 1-2 has sufficient land area to accommodate the proposed water quality treatment. As such, water quality treatment devices were selected that would be able to be implemented within the existing proposed concept plan. The MUSIC modelling indicates that the proposed water quality treatment measures would meet Council water quality pollutant reduction targets for new developments for each of the DA Areas.

There is an existing private drainage easement within the Precinct West and the current concept plans show buildings are proposed for construction where this channel currently flows. To enable the concept plan to proceed, this drainage easement would need to be moved. This would require approval from Council. Any plans to move the easement would need to ensure that the current intent (size/ amount of stormwater it coveys/ provision of an overland flow route) is maintained at any new location.

The flood management controls listed below should be noted for the site. The Concept Plan meets these requirements:

- All floor levels are to be above the 1% AEP level + 0.5m freeboard (ie above 83.6 mAHD at the intersection of DeClambe Drive and Carrington Road, and above 78.7mAHD at the detention basin);
- All garages/ carpark entrances must be protected from inundation by flood waters up to the 1% AEP + 0.5m.

Elements of the IWCMS that would require further assessment would include:

- Further detailed studies are recommended if greywater or blackwater reuse are to be considered. They are not being recommended as part of the IWCMS at this stage.
- Use of vegetated bioretention measures as part of urban design visual amenity
- Placement and sizing of rainwater tanks to improve rainwater capture and reuse applications in the Precincts.

Further investigation would be required to confirm the specifications required for individual water quality treatment devices throughout the Precincts.

7 LIMITATIONS

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OTHER LIMITATIONS

- MUSIC model – local standard parameters have been adopted in the model, 6min rainfall data (commonly used by MUSIC) was accessed from the Bureau of Meteorology. The outputs from the MUSIC model are suitable for conceptual strategy development but should not be relied upon for design. It is noted that MUSIC does not complete a hydraulic analysis of underground pipe networks it only checks the hydraulics of above ground WSUD features.
- The strategy is conceptual only. No hydraulic analysis has been completed for the proposed strategy.
- No hydraulic modelling has been completed. Flood information reported has been obtained from previous reports as referenced.

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APPENDIX A

MUSIC MODELLING

A1. BASE PARAMETERS

Default MUSIC rainfall-run-off data from the Parramatta station was used for the model. This data provides the following input parameters:

- Modelling Time-step: 6 Minutes
- Modelling Period: 25/12/1984 – 31/05/2010 11:54:00PM
- Rainfall Station and evapotranspiration: 66124 PARRAMATTA
- Mean Annual Rainfall: 856mm
- Evapotranspiration: 1173mm

A2. SOURCE NODES

An impervious rainfall threshold of 1.4mm was adopted. Table A-1 shows the impervious area percentages used for the model.

Table A-1 Impervious area parameters

Node type	% IMPERVIOUS	% PERVIOUS
Roof	100	0
Pavement (Mixed)	90	10
Green space (Commercial)	0	100

Pervious area parameters were taken from the Hills Shire Council DCP 2012 – Part D Section 19 and are shown in Table A-2.

Table A-2 Pervious area parameters

PERVIOUS AREA PARAMETER	VALUE
Pervious Area Soil Storage Capacity (mm)	170
Pervious Area Soil Initial Storage (% of Capacity)	30
Field Capacity (mm)	70
Pervious Area Infiltration Capacity coefficient – a	210
Pervious Area Infiltration Capacity exponent – b	4.7
Groundwater Initial Depth (mm)	10
Groundwater Daily Recharge Rate (%)	50
Groundwater Daily Baseflow Rate (%)	4
Groundwater Daily Deep Seepage Rate (%)	0

Baseflow and stormflow pollutant parameters were taken from the Hills Shire Council DCP 2012 – Part D Section 19 and are shown in Table A-3.

Table A-3 Baseflow and stormflow pollutant parameters

SOURCE NODE	FLOW	TOTAL SUSPENDED SOLIDS (MG/L)		TOTAL PHOSPHORUS (MG/L)		TOTAL NITROGEN (MG/L)	
		Mean log	SD log	Mean log	SD log	Mean log	SD log
Roof area	Baseflow[1]	-	-	-	-	-	-
	Stormflow	1.30	0.32	-0.89	0.25	0.30	0.19
General urban	Baseflow	1.20	0.17	-0.85	0.19	0.11	0.12
	Stormflow	2.15	0.32	-0.60	0.25	0.30	0.19
Pavement	Baseflow	1.20	0.17	-0.85	0.19	0.11	0.12
	Stormflow	2.43	0.32	-0.30	0.25	0.34	0.19
Open space	Baseflow	0.78	0.13	-1.22	0.13	-0.52	0.13
	Stormflow	1.60	0.20	-1.10	0.22	-0.05	0.24

1. Roof/impervious areas consist of 100% impervious area so there is no baseflow generated in these areas

A3. WATER QUALITY TREATMENT

The following water quality treatment measures were included for the proposed concept plan:

— Gross pollutant traps at surface inlet pits and grated drains

— Rainwater tanks for capture and re-use of stormwater from roof areas

— Linear bioretention in garden and tree beds to provide additional capture and treatment of runoff from the site.

Details of how these measures were assessed in the MUSIC model are provided in the following sections.

A3.1 RAINWATER TANKS

Rainwater tanks are proposed at roofed areas to harvest and re-use stormwater. Rainwater tanks were assumed to capture 75% of total roof area run-off with the remaining flow bypassing to the stormwater system.

Rainwater reuse for the site was assessed based on assumed apartment yields provided in the concept option report. and the typical water demands for reuse in toilets only in multi-residential dwellings as provided in the NSW MUSIC Modelling Guideline (BMT WBM, 2015). The rainwater tanks were modelled with the following parameters:

— Low flow bypass as 0 m^3/s

— High flow bypass as 100 m^3/s

— Depth above overflow as 0.2 m

— Initial volume as 0kL.

A3.2 OCEANGUARD - GROSS POLLUTANT TRAPS

Properties for the OceanGuard gross pollutant traps units were obtained from the manufacturer and are shown in Table A-4. The high flow bypass rate was input from manufacturers specifications. Table A-4 OceanGuard - Gross pollutant trap parameters

PARAMETER	INPUT VALUE	
Low flow bypass (m^3/s)	0	
High flow bypass (m^3/s)	0.02	
Transfer function properties		
	Input	**Output**
TSS (mg/L)	0	0
	121	30
TP (mg/L)	0.00	0.00
	10.0	7.0
TN (mg/L)	0.0	0.0
	50	39.5
Gross pollutants (kg/ML)	0	0
	14.7808	0

A3.3 JELLYFISH – FILTRATION DEVICES

Properties for the jellyfish filtration units were obtained from the manufacturer and are shown in Table A-5. The high flow bypass rate was input from manufacturers specifications.

Table A-5 Jellyfish filtration device parameters

PARAMETER	INPUT VALUE	
Low flow bypass (m^3/s)	0	
High flow bypass (m^3/s)	0.01250 (1.2m diameter units) / 0.04000 (2.25m diameter units)	
Transfer function properties		
	Input	**Output**
TSS (mg/L)[1]	0	0
	200.0000	14.0000
TP (mg/L)[2]	0.00	0.00
	0.4000	0.1720
TN (mg/L)[3]	0.0	0.0
	7.0000	3.5000
Gross pollutants (kg/ML)	0	0
	100.0000	1.0000

A3.4 BIORETENTION MEASURES

Table A-6 shows the parameters adopted in the proposed concept plan model for the bioretention measures. These parameters were based on the NSW Modelling guidelines (BMT WBM, 2015).

Table A-6 Bioretention parameters modelled in MUSIC

PARAMETER	VALUE
Low flow bypass (m^3/s)	0
High flow bypass (m^3/s)	100
Extended detention depth (m)	0.2
Surface area (m^2)	75-150
Filter area (m^2)	Half of surface area
Unlined Filter Media Perimeter (m)	0.01
Evaporative loss as % of PET	0.75
Saturated hydraulic conductivity (mm/hr)	100.00
Filter depth (m)	0.5
TN content of filter media (mg/kg)	400
Orthophosphate content of filter media (mg/kg)	40.0
Low flow pipe diameter (mm)	100
Exfiltration rate (mm/hr)	0
Vegetated with effective nutrient removal plants	Yes
Base lined?	No
Underdrain present?	No

APPENDIX B

TYPICAL WSUD SIGNAGE

B1. STENCILING

Storm drain stencilling is a way to paint messages on stormwater drains so that people do not dump anything down the drains. The drains typically have messages such as ‘Keep It Clean, Drains to Stream’, ‘Drains are just for rain’, ‘this drain goes to Cattai Creek’. Some examples of stencils are provided below.

B2. STANDARD WORDING FOR DEVICES

B2.1 RAINWATER TANK

This rainwater tank captures and stores roofwater so that it can be used for *(please insert here what the tank is connected to ie toilet flushing or irrigation*).
Note: Taps using this rainwater should be marked with a sign similar to this.

B2.2 BIORETENTION

A bioretention (also known as a raingarden) improves the quality of stormwater running off the site. Stormwater will pond on the surface of the bioretention for several hours before infiltrating through its sandy filter material. Healthy and dense vegetation will help improve stormwater treatment.

B2.3 OCEANGUARD® PIT LITTER BASKET

The OceanGaurd has a filter bag and sits within the drainage pit. It captures and retains debris and litter before it enters the stormwater drainage system, minimising pollution entering our local waterways.

B2.4 STORMWATER360 JELLYFISH® FILTER

The Jellyfish is a below ground device that captures fine sediment, nutrients and oils from stormwater before it enters the stormwater drainage system, minimising pollution entering our local waterways.

These filters must only be maintained in accordance with manufactures requirements. For more information www.stormwater360.com.au