Warren Smith & Partners

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CIVIL ENGINEERING SERVICES

Taronga Zoo

STORMWATER, FLOODING & UTILITY IMPACT ASSESSMENT SEARS REPORT

DOCUMENT CONTROL

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CONTENTS

APPENDIX

CIVIL ENGINEERING SERVICES

1. INTRODUCTION

Warren Smith & Partners Pty Ltd (WS&P) has been engaged by SDA Structures (SDA) on behalf of Taronga Zoo to prepare the following as required by the SEARs for the State Significant Development Application (SSDS) submission associated with the proposed development.

- Stormwater management plan
- Water sensitive urban design (WSUD) treatment plan
- Sediment and erosion control plan
- Utility impact assessment
- Flood impact assessment

The Taronga Zoo project includes the redevelopment of the Upper Australia animal exhibit. The project involves redeveloping the existing macropod and koala exhibits which will include new walkways and animal enclosures.

1.1 SITE LOCATION

The site is located in the north east corner of the Taronga Zoo precinct and is bound by Bradleys Head Road to the east and the main Zoo entrance area to the north. The development site boundary is presented in Figure 1-1.

Figure 1-1 Proposed Site Boundary

2. ABBREVIATIONS AND DEFINITIONS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
DN	Diameter (mm)
EY	Exceedances per Year
IFD	Intensity-Frequency-Duration
L/s	Litres per second
m/s	Metres per second
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
OSD	On-Site Detention
PSD	Permissible Site Discharge
RCP	Reinforced Concrete Pipe
RWT	Rainwater Reuse Tank
SID	Safety In Design
SSR	Site Storage Requirement
WSC	Water Services Coordinator
WSUD	Water Sensitive Urban Design

The Use of Must, Shall & Should:

In accordance with the international Organisation for Standardisation (ISO) Directives, the word “shall” is used to state that a requirement is strictly to be followed in order to conform to a Performance Requirement. Consequently, there can be no deviation from that requirement, other than a specific tolerance.

It is noted that in legislation and specifications it is common to use the word “must” to express a requirement. The word “shall” in this document should be considered as equivalent to “must” in the legislation.

The word “should” introduces a suggestion or recommendation that is not a requirement. It is not necessary that such recommendations or suggestions be followed in order to comply with the Performance Requirement.

3. STORMWATER DRAINAGE DESIGN

3.1 EXISTING STORMWATER DRAINAGE INFRASTRUCTURE

A desktop review and site inspection were carried out by WS&P to determine the existing drainage infrastructure and overland flow paths within the development site. The inspection and desktop review revealed the following:

- The existing development site grades in a southernly direction at an average grade of approximately 8%.
- There are existing ponds within the development site which having five (5) existing stormwater pits within the ponds to facilitate draining.
- There is an existing mud rock swale that run around the perimeter of the existing Macropod enclosure, stormwater runoff is captured in this channel and reticulated to existing stormwater pits which are located in the channel's low points.
- There are two separate pipe and pipe networks within the development area that capture stormwater flow and reticulate it south through the Zoo's internal private stormwater drainage system.
- The existing private stormwater drainage system reticulates south to the Zoo's water treatment plant where it is treated prior to being discharge to Sydney harbour.
- There are a number of existing stormwater pit onsite that are not shown on the current survey. These existing pits have been identified on the SSDA stormwater plans, noting that they require detailed survey prior to the detailed design commencing.

Please refer to Figure 3-1 for an illustration of the existing stormwater drainage infrastructure.

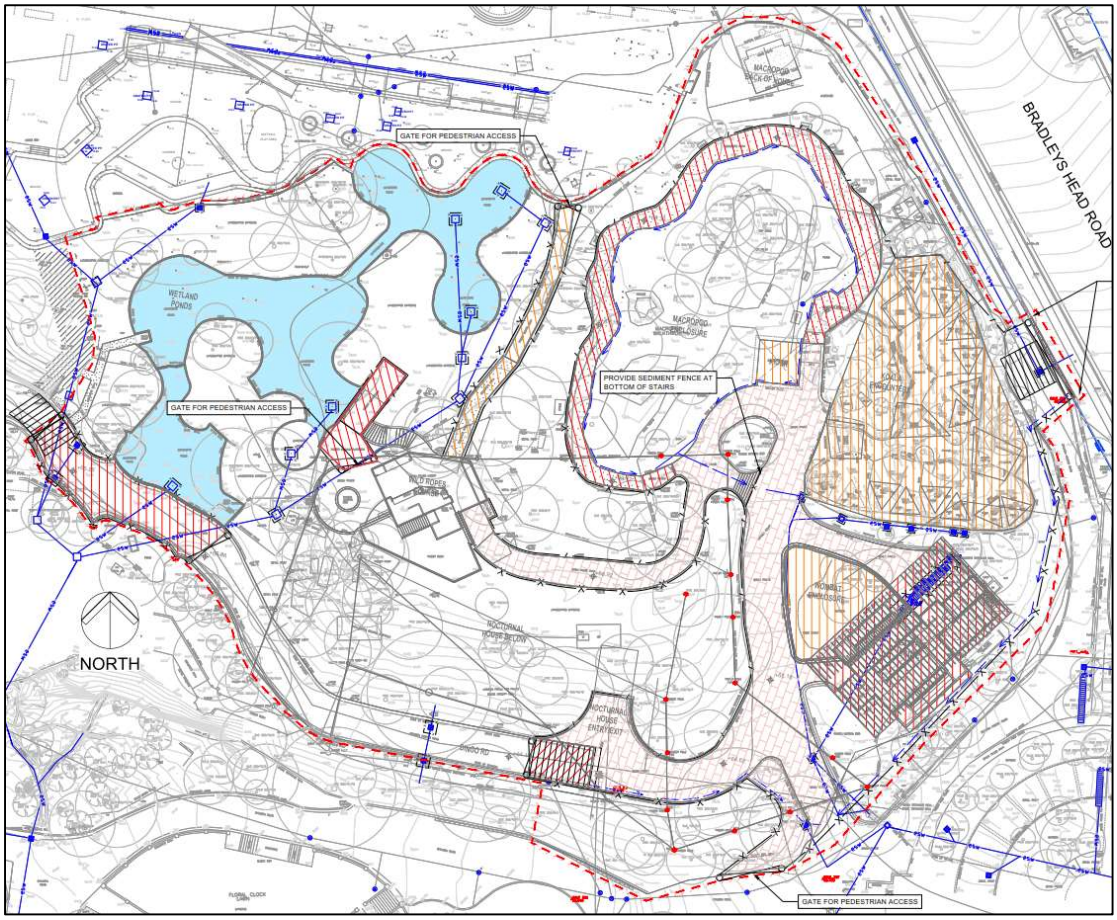


Figure 3-1 Existing Site Drainage Infrastructure

3.2 AUTHORITY AND REGULATORY REQUIREMENTS

With reference to the *Mosman Council Policy for Stormwater Management, dated October 2006*, it states that "on-site detention (OSD) is not required if the increase in impervious area on the site is less than 5% of the total site area". The proposed development will result in an impervious area increase of 3.6% and therefore, OSD is not require for the proposed development. Refer to Table 3-1 for a comparison of existing and proposed impervious and pervious areas.

Table 3-1 Existing Versus Proposed Catchment Breakdown

Catchment	Total Area (Ha)	Impervious (Ha)	Pervious (Ha)
Existing	0.7862	0.2201	0.5661
Proposed	0.7862	0.2485	0.5377

As the proposed stormwater system will discharge to the Zoo's existing private stormwater drainage system, the proposed stormwater system has been designed to ensure that post development discharge flows from the development site are not greater than the pre-existing discharge flows.

As per the *Mosman Council Policy for Stormwater Management, dated October 2006*, the proposed stormwater design will adhere to the following requirements:

- The piped system must drain all roof areas and all impervious areas such as pathways, driveways, and paved areas.
- The piped system must be designed to cater for the 20 year average recurrence internal (ARI) (5% annual exceedance probability (AEP) storm event.
- The overland flow mechanism shall be designed to accommodate the 5 minute storm duration during the 100 year ARI (1% AEP) storm event.
- Overland flows shall have a freeboard of 300 mm to adjacent habitable floor levels of the development site and adjoining properties.

3.3 PROPOSED STORMWATER DESIGN

It is proposed that stormwater within the new development shall be captured via a series of pit and pipe systems that reticulate south and connect into the Zoo's existing private stormwater drainage system. The proposed development site has a significant number of existing trees and so the one combined discharge point is not achievable. The proposed stormwater design utilises multiple discharge points and connects into existing infrastructure where possible.

The stormwater system has been designed such that post development discharge flows do not exceed predevelopment discharge flows for all storms up to and including the 1% AEP storm event, so to avoid exceeding the capacity of the downstream stormwater system. Refer to Section 3.5 for further details on the pre and post developments discharge flows.

Please refer to Figure 3-2 for the proposed stormwater layout plan.

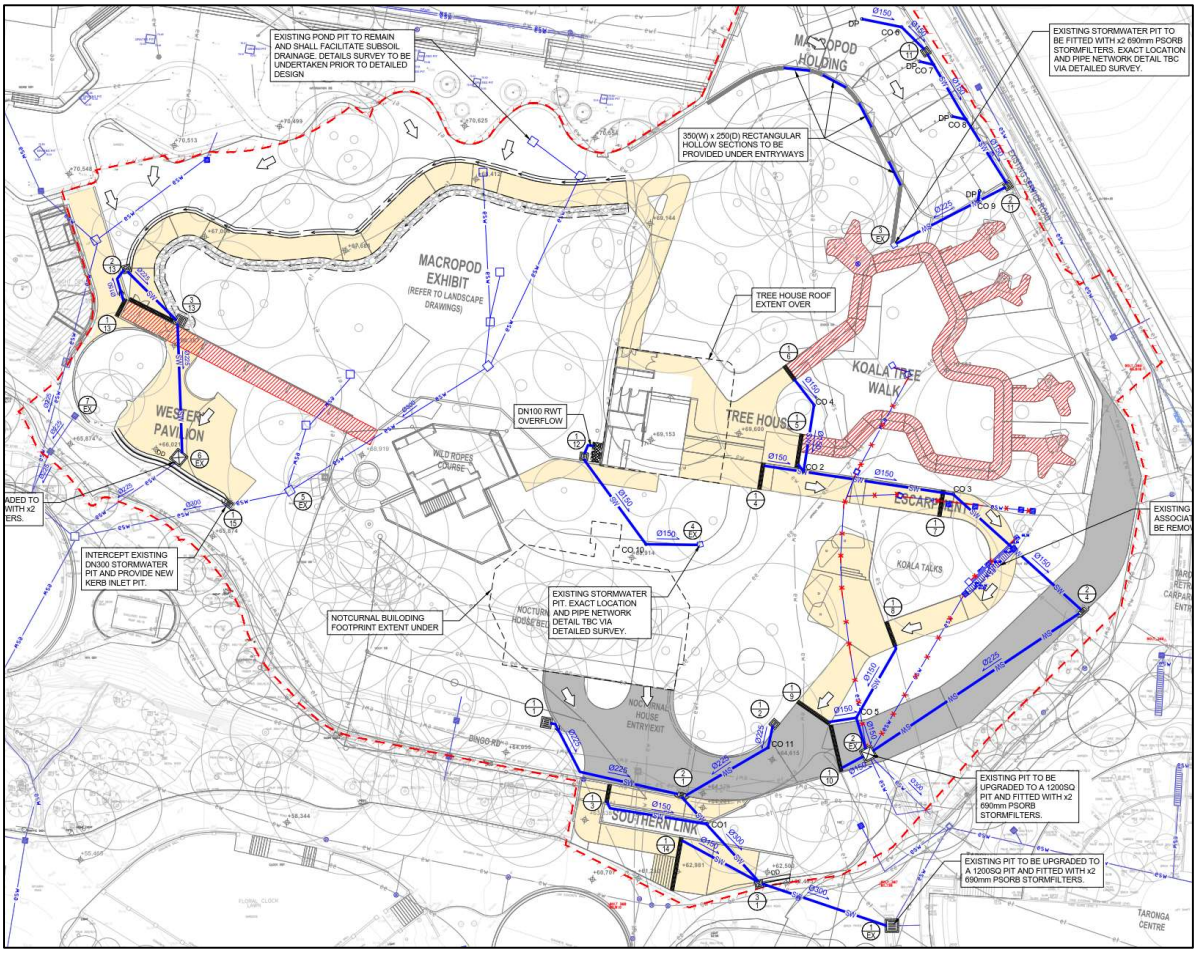


Figure 3-2 Proposed Stormwater Layout

3.4 DRAINS MODEL INPUT PARAMETERS

DRAINS is a stormwater drainage design and analysis program which performs hydraulic grade line analysis and generates the flows which would occur for a particular AEP storm event.

The catchment characteristic factor values which have been used in the DRAINS model are summarised below:

- Paved (impervious) Area Depression Storage 1 mm
- Supplementary Area Depression Storage 1 mm
- Grassed (Pervious) Area Depression Storage 5 mm
- Soil Type - Normal 3.0
- Minimum Pit Freeboard 300mm
- Blockage Factor for On-Grade Pits 50%
- Blockage Factor for Sag Pits 50%

The rainfall data has been taken from the Bureau of Meteorology Rainfall IFD Data System using local coordinates.

3.5 SITE DISCHARGE RESULTS

The existing site and proposed development scenarios were both modelled in DRAINS. Refer to Table 3-2 for the pre-development and post development discharge flows.

Table 3-2 Pre vs Post Site Discharge Results

Storm Event (% AEP)	Pre-Development Discharge (L/s)	Post Development Discharge (L/s)
20% AEP Event	280	214
10% AEP Event	338	266
5% AEP Event	396	326
2% AEP Event	477	387
1% AEP Event	540	445

The results shown that the development results in reduced discharge flows for all storms up to and including the 1% AEP storm event.

4. WATER SENSITIVE URBAN DESIGN (WSUD)

4.1 POTENTIAL POLLUTANTS GENERATED

The pollutants that could potentially be generated as a result of the development are as follows:-

- Gross Pollutants, e.g. Litter;
- Sediments;
- Nutrients (Phosphorus and Nitrogen), and;
- Hydrocarbons.

The development has been modelled to demonstrate the performance of the stormwater treatment system utilising a program called MUSIC (Model for Urban Stormwater Improvements Conceptualisation). MUSIC models the proposed stormwater treatment devices and estimates their respective performance against the performance targets of the project. The pollutants modelled in MUSIC are Gross Pollutants (GP), Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).

4.2 AUTHORITY AND REGULATORY REQUIREMENTS

Mosman Council do not set out preferred pollutant reduction targets for new developments. The pollutant reduction targets adopted for the development are set out in Table 4.1 which are in line with standard practice throughout New South Wales.

Table 4.1: WSUD Adopted Pollutant Reduction Targets

Pollutant Type	Reduction Target (%)
Gross Pollutants (GP)	90%
Total Suspended Solids (TSS)	85%
Total Phosphorus (TP)	65%
Total Nitrogen (TN)	45%

4.3 RAINFALL

The rainfall data used in the MUSIC model was based on Bureau of Meteorology data and is presented in Table 4.2.

Table 4.2: Rainfall Data for MUSIC Modelling

Rainfall Station	Rainfall Period	Rainfall Period Dates	Time Step (min)
066062 Sydney Observatory	5 years	5 January 1962- 31 December1966	6 minutes

The average monthly potential evapotranspiration (PET) data used in the MUSIC model was based on the average monthly PET data for the Sydney region and is presented in Table 4.3.

Table 4.3: Monthly Evapotranspiration Data for MUSIC Modelling

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PET (mm)	180	135	128	85	58	43	43	58	88	127	152	163

4.4 RAINFALL RUNOFF PROPERTIES

Table 4.4 and Table 4.5 present the rainfall runoff properties which have been utilised in the MUSIC model.

Table 4.4: Soil Properties for MUSIC Source Nodes

Parameter	Units	Rainfall Period Dates
Impervious Area Parameters		
Rainfall Threshold	mm	1.0 (for grassed areas/paths etc.) 0.3 (for roofs) & 1.5 (for driveways)
Pervious Area Parameters		
Soil Capacity	mm	120
Initial Storage	%	30
Field Capacity	mm	80
Infiltration Capacity Coefficient – a		200
Infiltration Capacity Coefficient – b		1.0
Groundwater Properties		
Initial Depth	mm	10
Daily Recharge Rate	%	25
Daily Baseflow Rate	%	5
Deep Seepage	%	0

Table 4.5: Stormwater Water Quality Parameters for MUSIC Source Nodes

Land Use Category		Log_{10}TSS (mg/L)		Log_{10}TP (mg/L)		Log_{10}TN (mg/L)	
		Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
Roofs	Mean	1.30	N/A*	-0.89	N/A*	0.30	N/A*
	Std Dev	0.32	N/A*	0.25	N/A*	0.19	N/A*
Sealed Roads with Pervious Fractions	Mean	2.43	1.10	-0.30	-0.82	0.34	0.32
	Std Dev	0.32	0.17	0.25	0.25	0.19	0.12
Landscaped Areas	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

* Base flows are only generated from previous areas; therefore, these parameters are not relevant to impervious areas.

4.5 MUSIC MODEL CATCHMENT AREAS AND TREATMENT PLAN

The proposed site treatment will utilise two (2) products by Ocean Protect. The first level of treatment will consist of OceanGuards, which intercept surface runoff at the pit grates and filter the runoff prior to entering the piped stormwater system. It is proposed that fifteen (15) grated stormwater pits within the development area be fitted with OceanGuard filter baskets. An OceanGuard is fitted with a monofilament 200 micron pore size filter bag that removes gross pollutants such as sediment, trash and debris, as well as suspended solids. Please refer to Figure 4-1 for an illustration of a typical OceanGuard.

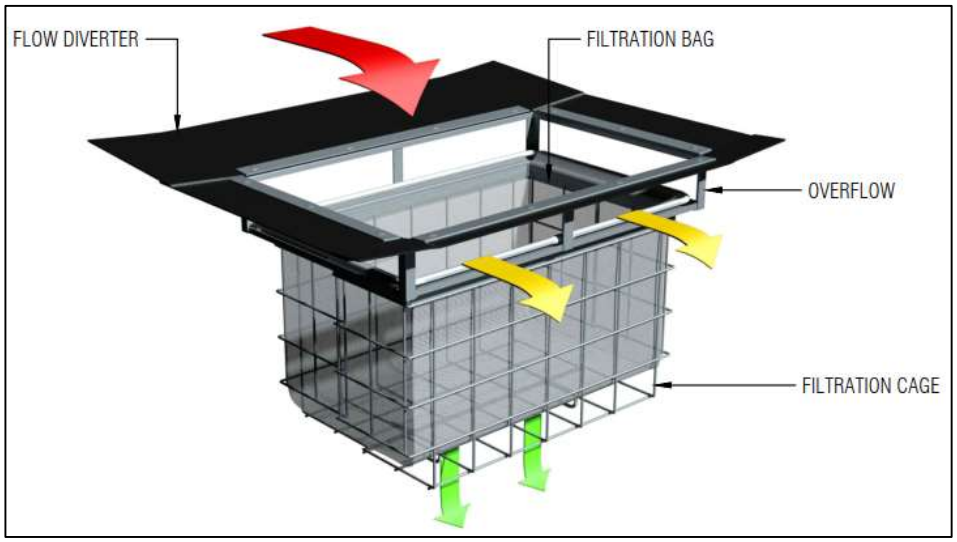


Figure 4-1 Typical OceanGuard

The second level of treatment which will be incorporated into the system is a stormfilter system. The stormfilters will be contained four (4) stormwater pits and will treat the stormwater prior to stormwater being discharged to the existing private stormwater network. To achieve the reduction targets, it is proposed that a total of eight (8) 690mm phosphorus stormfilter absorption cartridges, supplied by Ocean Project, be installed within the stormwater system. A PSorb stormfilter cartridge system is provided to remove and suspended sediments and nutrients which have entered the stormwater system. Please refer to Figure 4-2 for an illustration of a typical PSorb stormfilter.

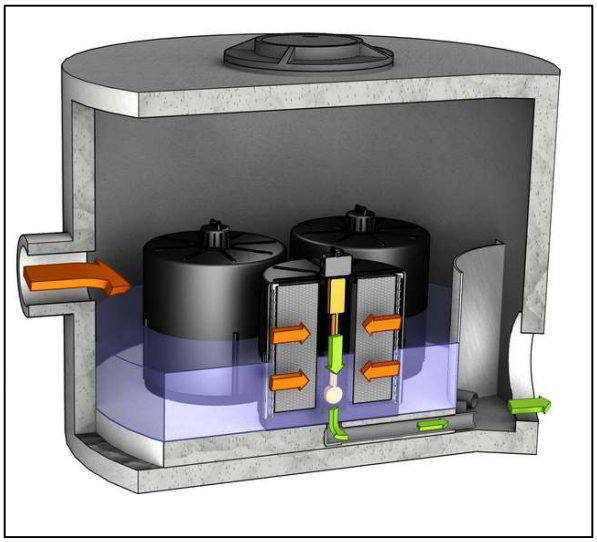


Figure 4-2 Typical PSorb Stormfilter

Refer to Appendix A for the Ocean Protect OceanGuard and StormFilter specification drawings.

4.6 MUSIC MODELLING RESULTS

The stormwater quality treatment system has been modelled using the MUSIC software as shown in Figure 4-3. Please refer to Table 4-6 and Appendix B for the MUSIC modelling results.

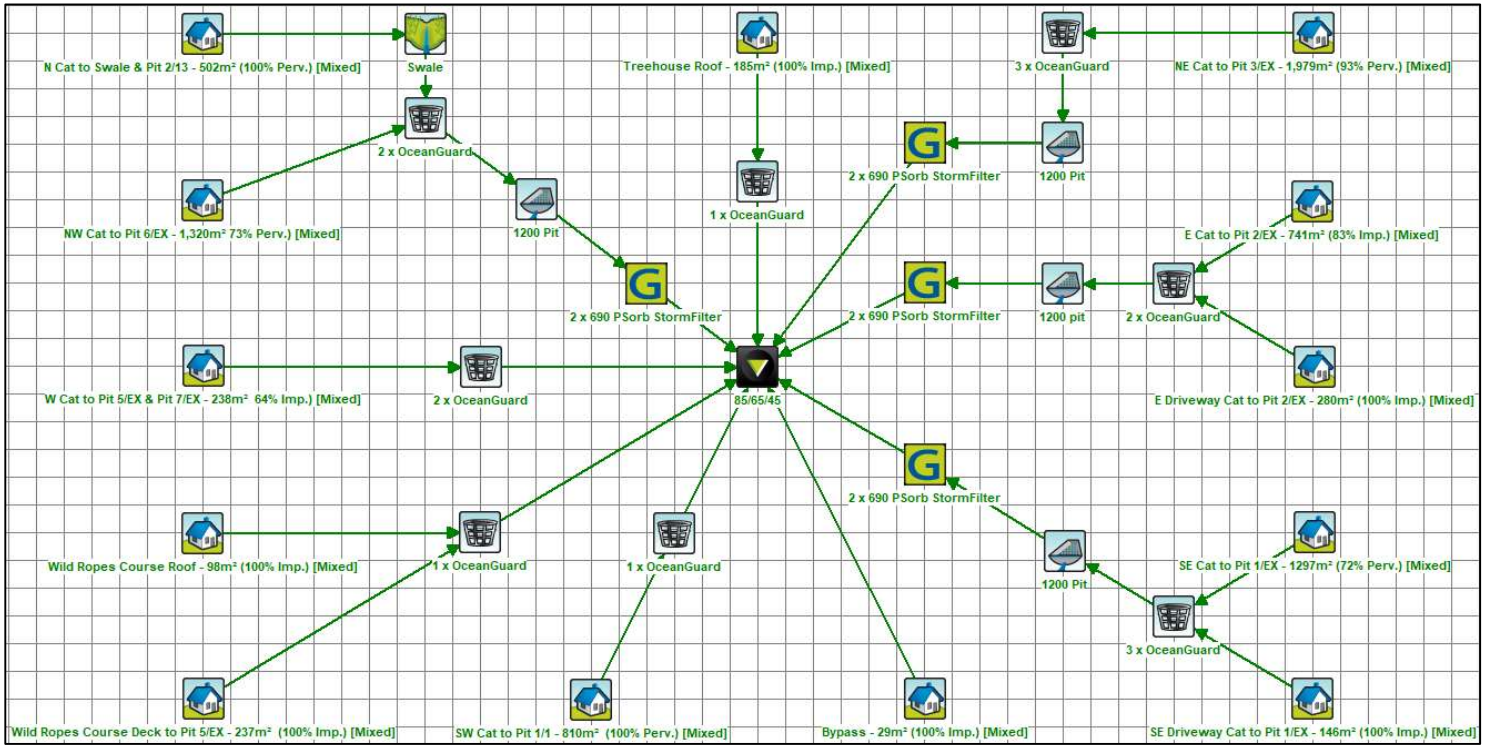


Figure 4-3 MUSIC Model Treatment Plan

Table 4-6: MUSIC Modelling Results

Pollutant	Sources	Residual Load	% Reduction	Target (%)
Gross Pollutants (kg.yr)	97	0.839	99.1	90
Total Suspended Solids (kg/yr)	765	78.9	89.7	85
Total Phosphorus (kg/yr)	1.44	0.49	66	65
Total Nitrogen (kg/yr)	11.4	6.07	46.6	45

5. SEDIMENT AND EROSION

The Contractor for the works is required to provide Sedimentation and Erosion Control in accordance with the general requirements outlined below.

5.1 SITE PROTECTION MEASURES

It is proposed to provide the following in order to inhibit the movement of sediment off the site during the demolition and construction phases.

5.1.1 SITE ACCESS

Construction vehicles leaving the site shall be required to pass over a Temporary Construction Vehicle Entry consisting of a 1.5m long by 3m wide 'cattle rack'.

5.1.2 SEDIMENT CONTROL

All exposed earth areas where it may be possible for runoff to transport silt down slope shall be protected with a sediment and erosion control silt fence generally installed along the boundaries of the site.

The fence will be constructed in accordance with details provided by the Department of Conservation and Land Management incorporating geotextile fabric which will not allow suspended particles greater than 50mg/L non-filterable solids to pass through, and as such comply with the appropriate provisions of the Clean Waters Act 1970.

The construction of the silt fence will include the following:-

- Geotextile fabric buried to a maximum of 100mm below the surface;
- Overlapping any joins in the fabric, and;
- Turning up on the ends for a length of 1 metre in order to prevent volumes of suspended solids escaping in a storm event.

Refer efer to Figure 5-1 for details.

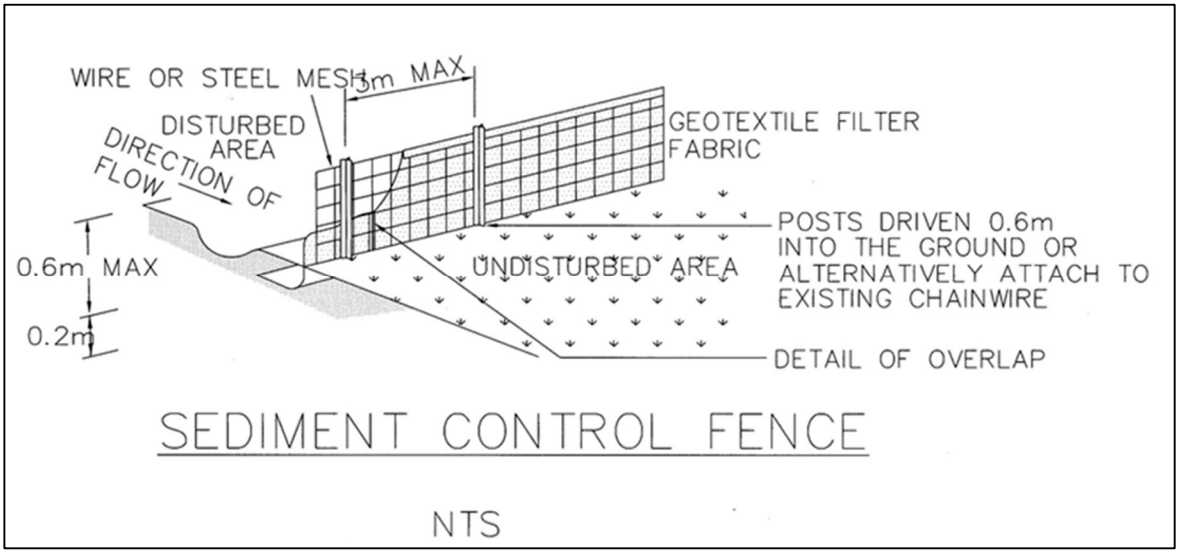


Figure 5-1: Sediment Control Fence Illustration

Existing stormwater infrastructure is also to be protected from incoming sediment using the following methods:

- Any Council owned road kerb entry and/or gully pits will be protected by Filter Bales and EcoSocks. Additional protection will be provided by inserting Water Clean Filter Cartridges into the gully opening, and;
- Internal site drainage pits shall be protected by Sediment Traps consisting of hay bales.

Please refer to Figure 5-2, Figure 5-3 and Figure 5-4 for details.

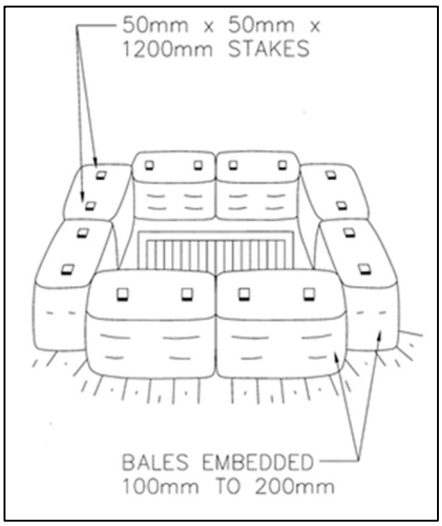


Figure 5-2: Stormwater Pit Sediment Trap (NTS)

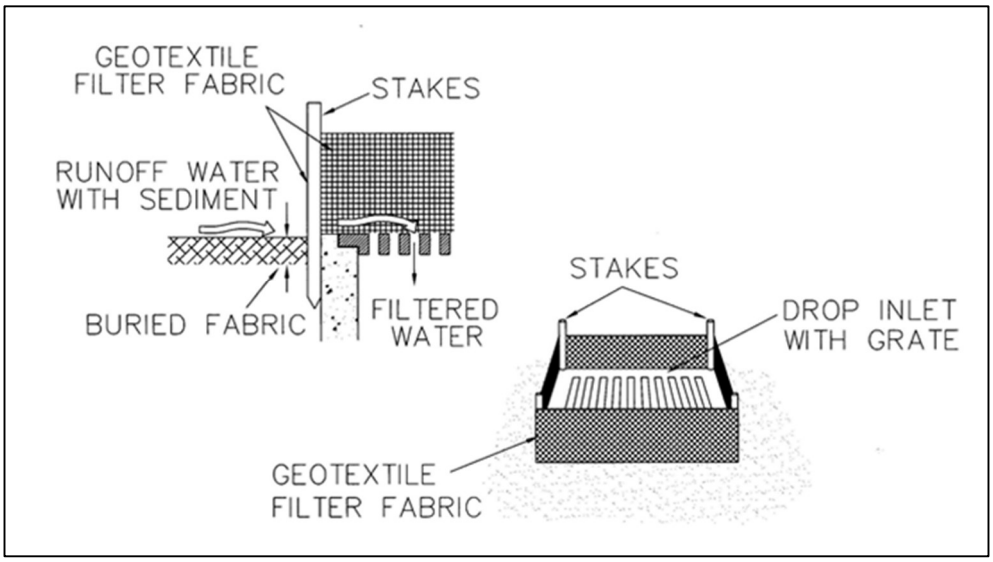


Figure 5-3: Geotextile Filter Fabric Drop Inlet Sediment Trap (NTS)

What are FilterBales?

Water Clean FilterBales are a unique new patented 7 stage sediment filter device developed to substantially reduce the migration of sediment and contaminants into drainage systems while allowing filtered water to easily pass through. FilterBales reduce customers' time and money by providing solutions to comply witht environmental and regulatory requirements.

Durable, Dependable, Reusable.
Replacing hay bales and other inadequate attempts to stop sediment run-off, FilterBales are durable and re-useable, effectively stopping your money from "pouring down the drain". They are also lightweight and easy to handle. Replaceable Water Clean Filter Cartridges guarantee peak performance is maintained.

Ask your local FilterBales stockist about replacement frequencies in your area. Cartridges and filter covers should be changed when the infiltration rate decreases. Water Clean FilterBales are suitable for a wide range of sediment and water management situations and can be easily secured in place for long term use. The unique multi-directional filter system allows you to position Water Clean FilterBales in any direction without reducing performance.
Water Clean FilterBales can be fixed to concrete or bitumen surfaces using an epoxy mortar-binder or fixed to earth surfaces using 6-10 mm pegs or stakes. When positioning, the side with the red reflective marker should be facing traffic.

1. FilterBales frames are a perforated plastic structure made from recycled wheelie bins, battery cases, milk bottles etc.

2. Filter medium (bio engineered soil media) used in the filter cartridges is made from a special blend of recycled organic (RO) materials from kerbside and vegetation drop off centres. The RO hosts enhanced naturally occurring micro-organisms. The blend also contains natural minerals to capture nutrients. The filter medium is as safe as normal soil.

3. FilterBales have a seven (7) stage filtration system:

1. In through the filter bag
2. Through the perforated plastic structure wall
3. In through the filter cartridge bag
4. Through the bio engineered filter medium
5. Out through the filter cartridge bag
6. Out through the perforated plastic structure wall
7. Out through the filter bag

4. The filter bag is made from 300-micron (one third of a millimetre) pore size geotextile. This is the first stage that filters much of the sediment and other suspended solids from the run-off water. The geotextile is designed to stop sediment and reduce clogging but allow water to pass through easily. The filter cartridge bags are made from a similar geotextile.

5. FilterBales work effectively up to "a one-in-one-year 48 hours, 100 mm "storm events". This is the largest storm event experienced since the commercialisation of FilterBales. Having handled this easily, Filter Bales are considered capable of handling much greater "storm events'. During these storm events FilterBales were used inside gully pits in one application and on the ground surrounding the gully pit in another application.

6. EcoSocks are made from a similar geotextile to the filter cartridge bags and contain the same bio engineered soil media as the FilterBales. They appear able to stand up to as much wear and tear as a sandbag.

7. FilterBales are much lighter (at around 15 kgs dry weight) than hay bales. This reduces exposure to Occupational Health and Safety problems

Product Range

Item No.	Description	
HFB001	**High FilterBale,** suitable for high flow situations and higher retention time applications. Contains two standard size WaterClean Filter Cartridges in upright formation to treat contaminated waters. (605mm x 485mm x 460mm)	
LFB002	**Low FilterBale,** suitable for low flow situations and kerb & gutter applications. Multi-directional module containing two standard size WaterClean Filter Cartridges. (605mm x 485mm x 220mm)	
ESF004	**Directional EcoSock,** can be used in conjunction with FilterBales to direct water. Will also provide some sediment filtration from seepage through bio-remediating media contained within the EcoSock (1135mm x 160mm x 30mm)	

Accessories

Item No.	Description	
FCR004	**WaterClean Filter Cartridges** contain a unique blend of fixating and bio-remediating products that treat common pollutants. To achieve maximum performance, each FilterBale uses two WaterClean Filter Cartridges. (440mm x 400mm x 100mm)	
HBC005 (High bale)	**Replaceable FilterBale covers,** made from specially designed geotextile. FilterBale covers have a standard aperture of 300 microns.	
HBC006 (Low bale)	**Replaceable FilterBale covers,** made from specially designed geotextile. FilterBale covers have a standard aperture of 300 microns.	

Figure 5-4: Erosion Control Filter Products

5.1.3 SEDIMENT BASIN

The following works are required to be carried out during installation of the sediment basins:-

- Installation of a fence around the perimeter of the basin;
- Removal of existing reeds;
- Installation of rip rap to allow for bobcat access for periodic removal of sediment;
- Installation of a perforated riser outlet pipe as per the detail shown in Figure 5-5, and;
- Connection of the riser pipe to an existing pit.

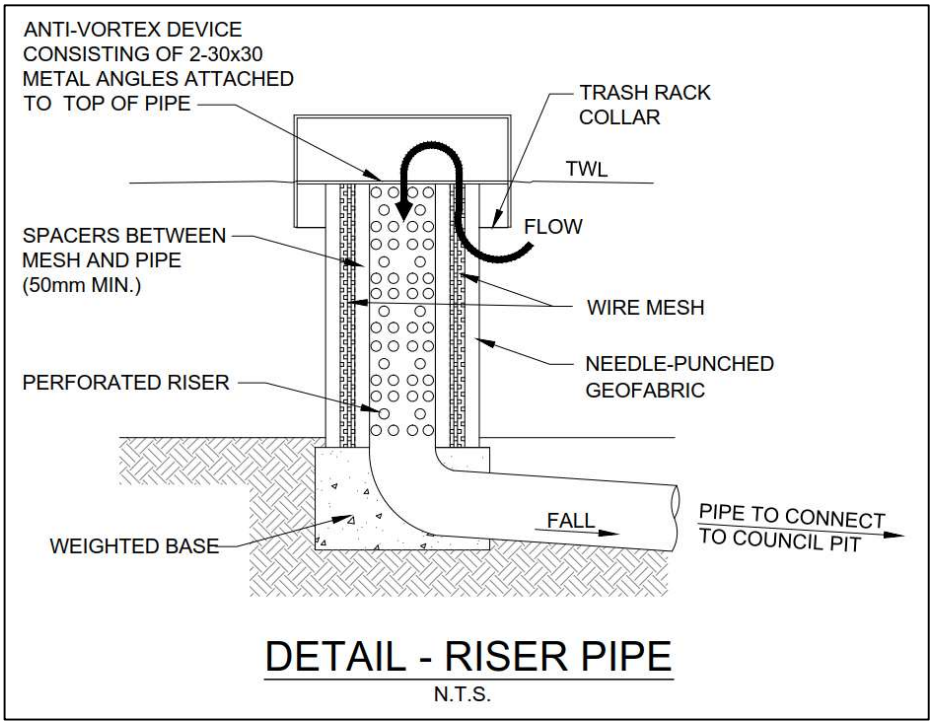


Figure 5-5: Sediment Basin Outlet Pipe Detail

5.1.4 TEMPORARY STORMWATER SYSTEM (WHERE REQUIRED)

Site runoff within the zones of the excavation will be drained into a central holding well within the excavation. Runoff will be allowed to settle out suspended particles and debris, and an acceptable water of 50mg per litre of Non Filterable Residues (NFR) is required to be achieved prior to discharge.

5.1.5 DUST CONTROL

The following dust control procedures will be adhered to:-

- Loose loads entering or leaving the site will be securely covered by a tarpaulin or like material in accordance with RMS and local Council Guideline;
- Soil transport vehicles will use the single main access to the site;
- There will be no burning of any materials on site;
- Water sprays will be used across the site to suppress dust. The water will be applied either by water sprinklers or water carts across ground surfaces whenever the surface has dried out and has the potential to generate visible levels of dust either by the operation of equipment over the surface or by wind. The watercraft will be equipped with a pump and sprays;
- Spraying water at the rate of not less than three (3) L/s and not less than 700kPa pressure. The area covered will be small enough that surfaces are maintained in a damp condition and large

enough that runoff is not generated. The water spray equipment will be kept on site during the construction of the works;

- During excavation all trucks/machinery leaving the site will have their wheels washed and/or agitated prior to travelling on Council Roads, and;
- Fences will have shade cloth or similar fabric fixed to the inside of the fence.

5.1.6 MAINTENANCE

- It will be the responsibility of the contractor to ensure sediment and erosion control devices on site are maintained. The devices shall be checked daily and the appropriate maintenance undertaken as necessary;
- Prior to the closing of the site each day, the road shall be swept and materials deposited back onto the site.;
- Gutters and roadways will be kept clean regularly to maintain them free of sediment;
- Appropriate covering techniques, such as the use of plastic sheeting will be used to cover excavation faces, stockpiles and any unsealed surfaces;
- If dust is being generated from a given surface, and water sprays fail;
- If fugitive emissions have the potential to cause the ambient as quality to foul the ambient air quality;
- The area of soils exposed at any one time will be minimised wherever possible by excavating in a localised progressive manner over the site, and;
- Materials processing equipment suitably comply with regulatory requirements. The protection will include the covering of feed openings with rubber curtains or socks.

It is considered that by complying with the above, appropriate levels of protection are afforded to the site, the adjacent public roads, footpaths, and environment.

6. UTILITY IMPACT ACCESSMENT

6.1 WATER

6.1.1 WATER SUPPLY DEMAND

As the proposed development intends on housing the existing exhibits that are currently within the existing site, it is not anticipated that the water demand for the exhibit will increase.

Similarly, the new nocturnal house will replace the existing nocturnal building and will continue to provide the same functions. The proposed nocturnal building will also include a kitchenette, laundry and a toilet. The proposed treehouse building will include a kitchenette and three toilets.

Refer to Figure 6-1 below for an illustration of the proposed water supply points.

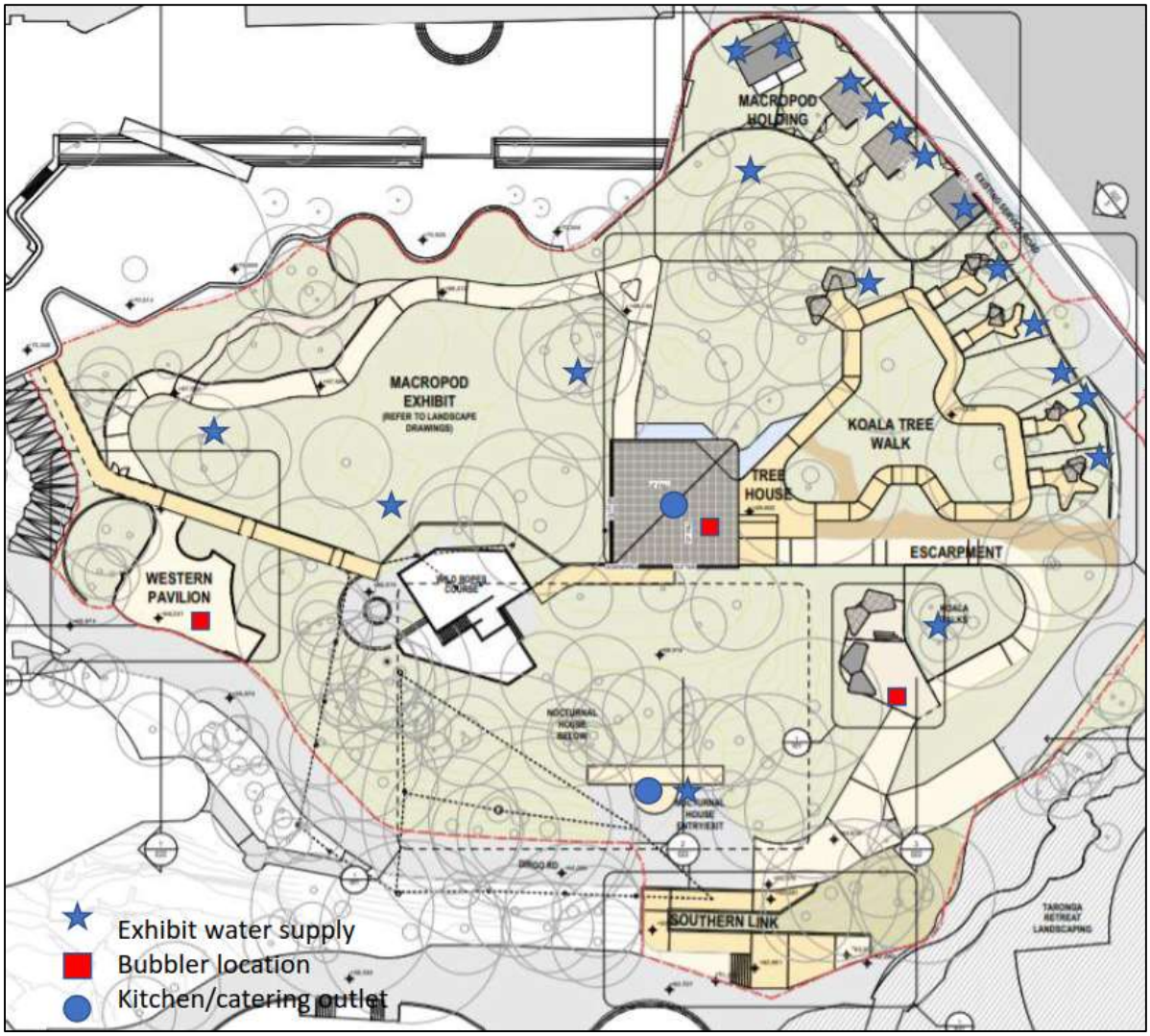


Figure 6-1: Proposed Water Supply Points

For further information on the water supply demand for the development, refer to the Edge Environment sustainability report.

6.1.2 WATER MAIN CONNECTION

Taronga Zoo has a private water network, refer to Figure 6-2 for an illustration of the existing potable water supply and Appendix C for the existing water network survey plans. A private ring main reticulates around the north, east and south of the proposed development site. There is also a Sydney Water DN150 watermain in Bradleys Head Road, however, there does not appears to be any direct connection to the proposed development site from this asset. Refer to Appendix D for the Sydney Water Hydra plan.

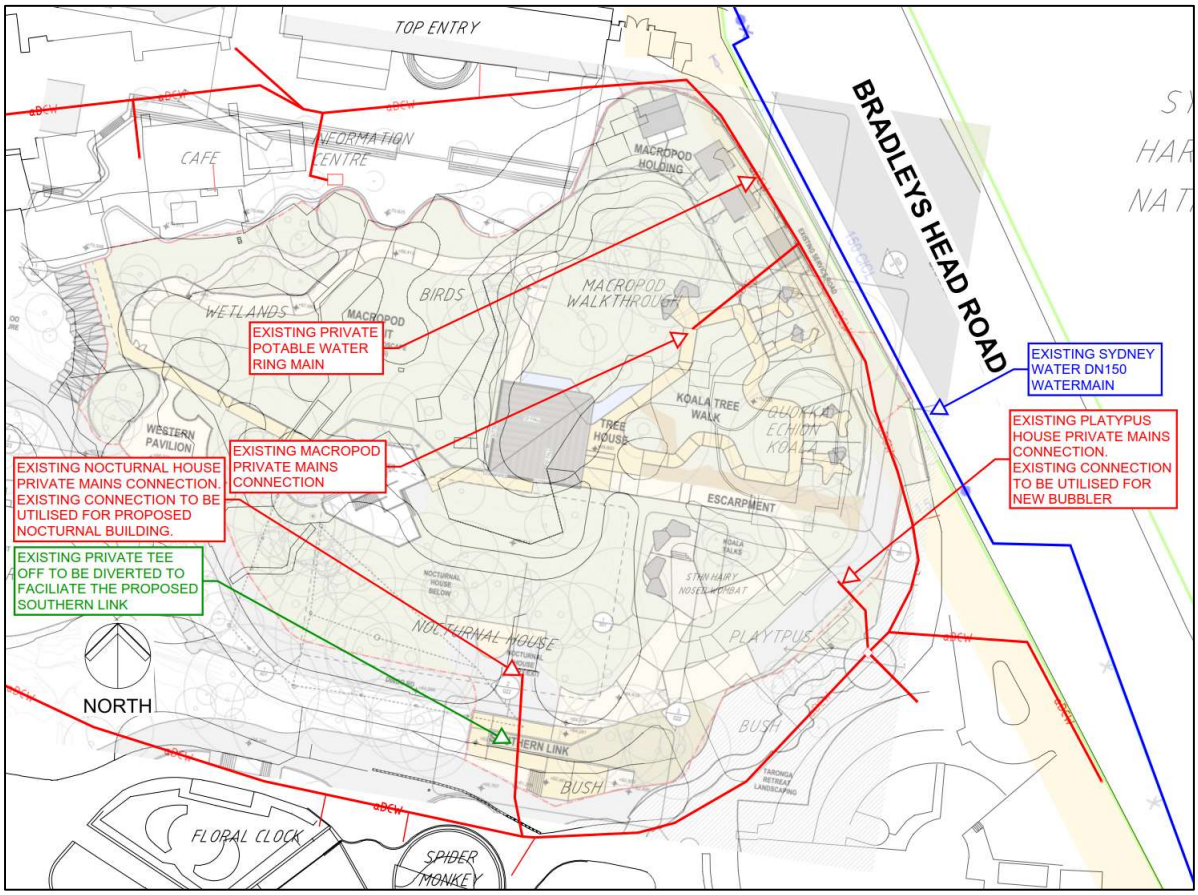


Figure 6-2: Existing Potable Water Supply

The existing Platypus house connection can be utilised for the proposed bubbler in this location. Similarly, the existing nocturnal house connection can be maintained however, the tee off from the private ring main will likely need deviation to facilitate the construction of the proposed southern link. The existing macropod walkthrough connection can also be utilised for the exhibit water supply points.

Taronga Zoo also has a private recycled water network, refer to Figure 6-3 for an illustration of the existing recycled water supply. The private main reticulates along Dingo Road at the south of the development site and turns north to the east of the existing nocturnal house. From here it continues north reticulating around the west of the existing Macropod walkthrough, to the top entry pavilion.

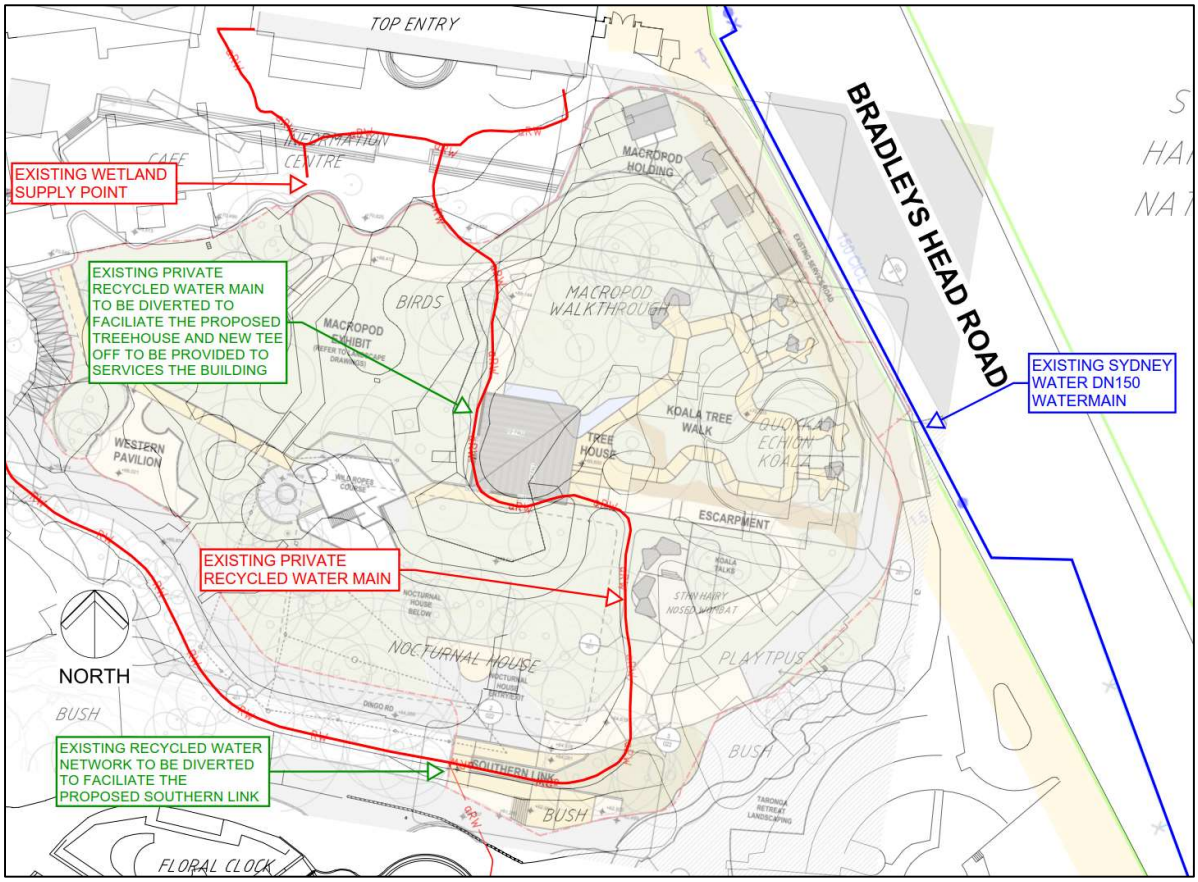


Figure 6-3: Existing Recycled Water Supply

The existing main can be utilised for the water supply to the proposed Treehouse building, however it will need to be deviated to facilitate the construction of the Treehouse. The new tee off connection shall be part of these deviation works. Similarly, the main will likely need deviation to facilitate the construction of the proposed southern link. At the northern end of the recycled water network, the existing wetland supply point will become redundant with the deletion of the ponds.

6.2 SEWER

6.2.1 SEWER DISCHARGE LOADING

As the proposed development intends on housing the existing exhibits that are currently within the existing site, it is not anticipated that the sewer discharge loadings for the exhibit will increase.

Similarly, the new nocturnal house will replace the existing nocturnal building and will continue to provide the same functions. The proposed nocturnal building will also include a kitchenette, laundry and a toilet. The proposed treehouse building will include a kitchenette and three toilets.

In order to determine the average daily sewer discharge for the proposed development, an estimate can be made by adopting information derived by the NSW Water Directorate. The Directorate states that standard equivalent tenement figures suggest that a 60% water to sewer discharge factor is appropriate. For further information on the water supply demand for the development, refer to the Edge Environment sustainability report.

6.2.2 SEWER CONNECTION

There is an existing Sydney Water DN225 VC sewer asset that traverses the development site, reticulating in a southerly direction. Refer to the Appendix E for the Sydney Water existing sewer work order drawings. There are also a number of private sewer assets that reticulate and discharge to this Sydney Water asset. Refer to Figure 6-4 for an illustration of the existing private and Sydney Water sewer assets onsite. Refer to Appendix F for the existing sewer survey plans.

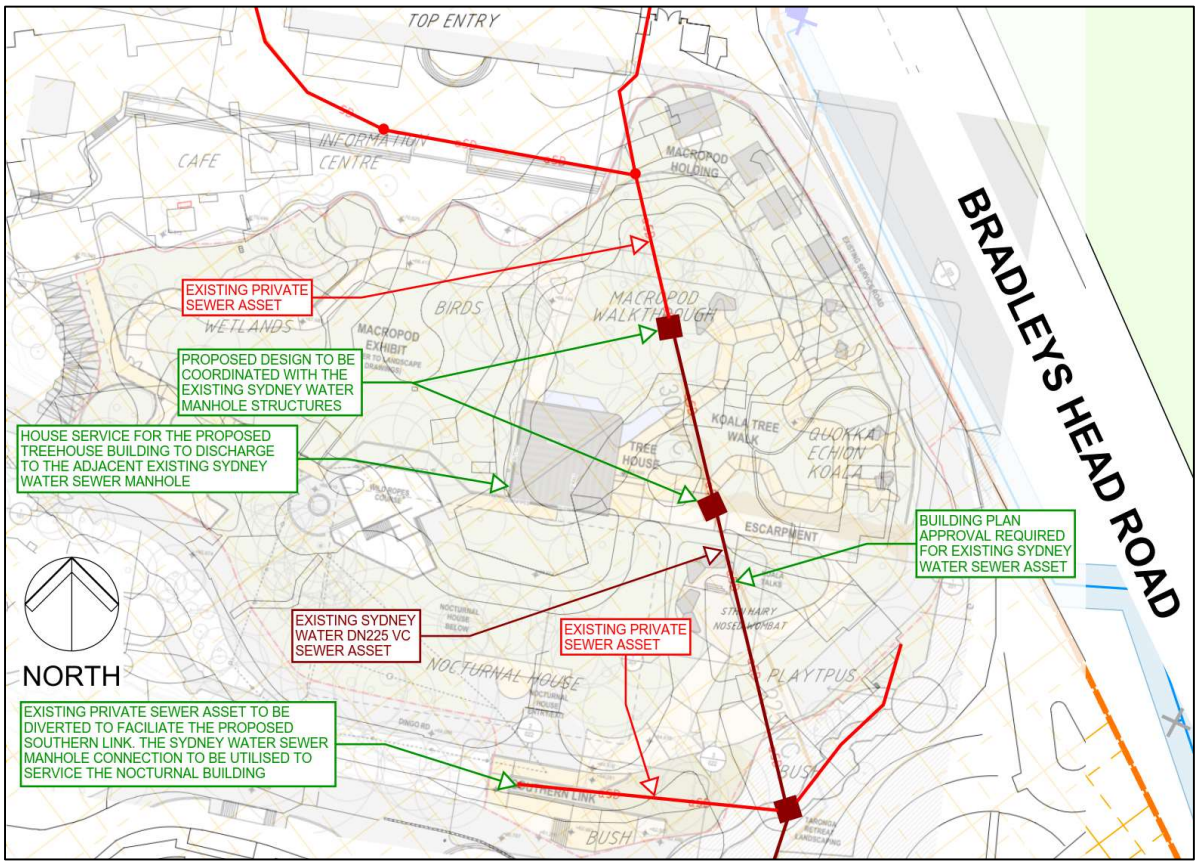


Figure 6-4 Existing Private & Sydney Water Sewer Assets

The proposed development will need to coordinate with the existing sewer manholes, to avoid impacting the existing surface levels of the structures. A building plan approval will need to be undertaken by an accredited Sydney Water, Water Servicing Coordinator, to demonstrate that the proposed development will not impact the Sydney Water asset. WS&P, as an accredited Water Servicing Coordinators, will undertake this application on behalf of Taronga Zoo following receipt of a detailed survey showing the accurate location of the existing sewer asset. This detailed survey is concurrently being undertaken during the writing of this report.

There is an existing private house services that will need to be deviated to facilitate the proposed southern link. This existing house service likely services the existing nocturnal house, and its existing manhole connection to the Sydney Water asset can be utilised for the proposed nocturnal building house service.

It is proposed that the Treehouse building's house service will connect to the adjacent Sydney Water manhole.

6.3 GAS

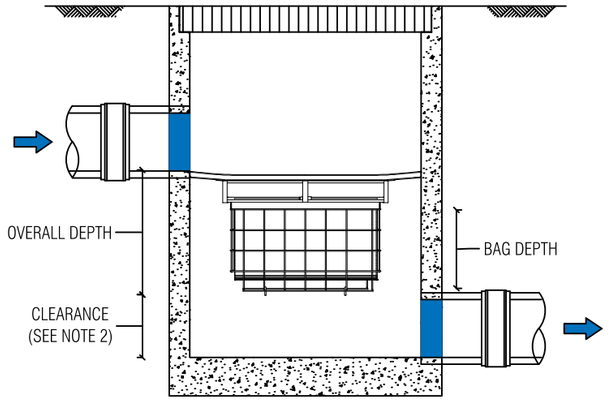
There are no existing gas services within the development site and no gas services are proposed as part of the development.

7. FLOOD STUDY

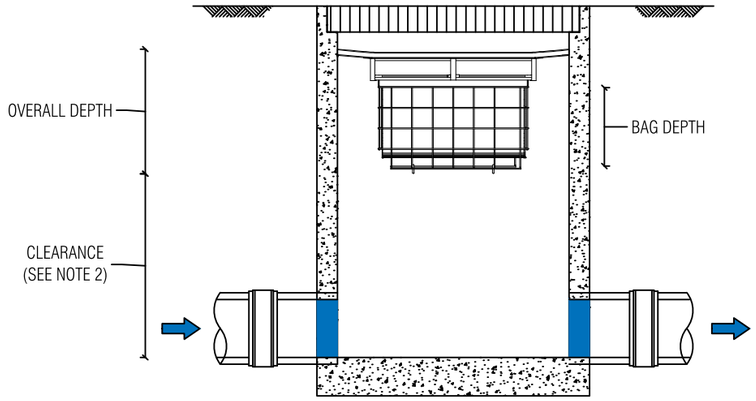
In accordance with the requirements of the SEARs, WS&P were required to provide a flood impact assessment for the proposed development.

The site is on the west side of Bradleys Head Road, a peninsula that extends into Sydney Harbour. A flood assessment was undertaken by GRC Hydro and the finding indicated that the development site has little to no flood affectation. Refer to Appendix G for the flood impact assessment by GRC Hydro, dated 25 June 2020.

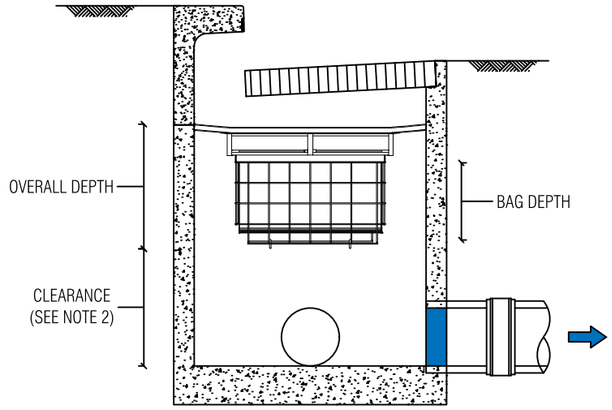
APPENDIX A OCEAN PROTECT WSUD TREATMENT DEVICES



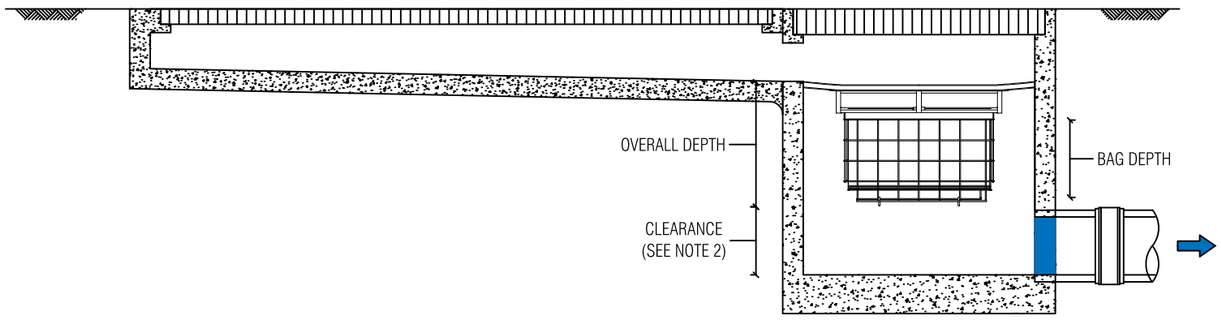
PIPE FLOW CONFIGURATION



SURFACE FLOW CONFIGURATION



SURFACE FLOW CONFIGURATION

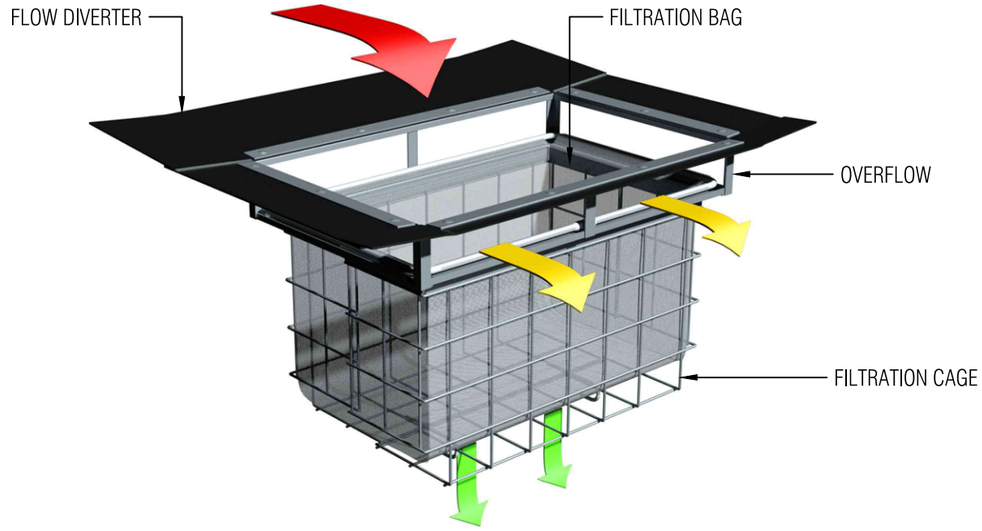


GRATED STRIP DRAIN CONFIGURATION

PLAN ID	MAXIMUM PIT PLAN DIMENSIONS
S	450mm x 450mm
M	600mm x 600mm
L	900mm x 900mm
XL	1200mm x 1200mm

DEPTH ID	BAG DEPTH	OVERALL DEPTH
1	170	270
2	300	450
3	600	700

		DEPTH ID		
		1	2	3
PLAN ID	S	■		
	M	■	■	
	L	■	■	■
	XL	■	■	■



GENERAL NOTES

1. THE MINIMUM CLEARANCE DEPENDS ON THE CONFIGURATION (SEE NOTE 2) AND THE LOCAL COUNCIL REQUIREMENTS.
2. CLEARANCE FOR ANY PIT WITHOUT AN INLET PIPE (ONLY USED FOR SURFACE FLOW) CAN BE AS LOW AS 50mm. FOR OTHER PITS, THE RECOMMENDED CLEARANCE SHOULD BE GREATER OR EQUAL TO THE PIPE OBVERT SO AS NOT TO INHIBIT HYDRAULIC CAPACITY.
3. OCEAN PROTECT PROVIDES TWO FILTRATION BAG TYPES:- 200 MICRON BAGS FOR HIGHER WATER QUALITY FILTERING AND A COARSE BAG FOR TARGETING GROSS POLLUTANTS.
4. DRAWINGS NOT TO SCALE.

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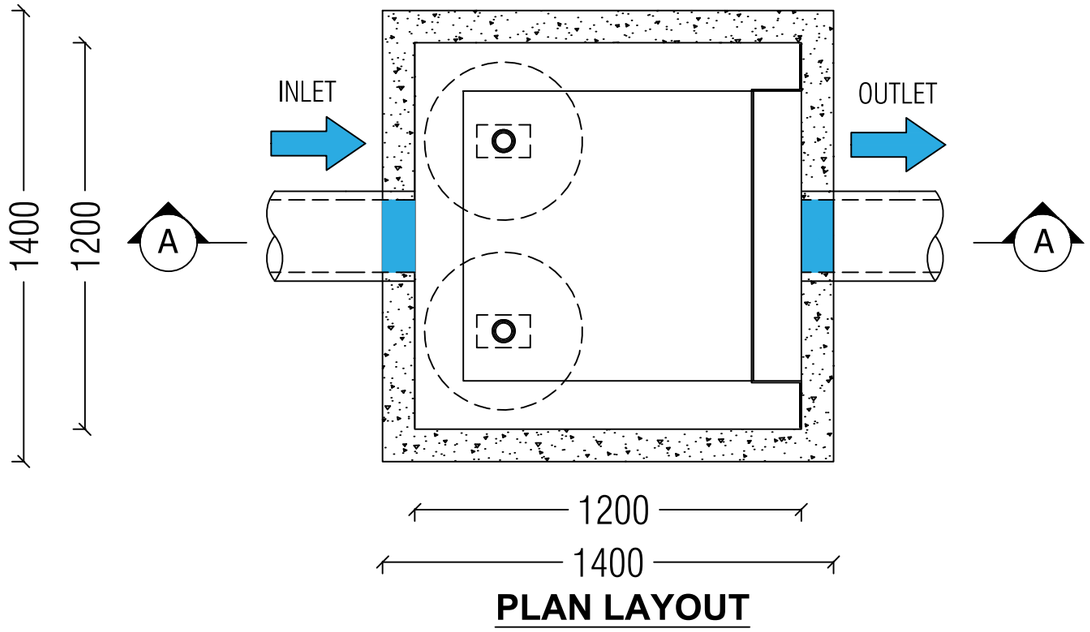
OCEAN PROTECT
OCEANGUARD
TYPCIAL ARRANGEMENTS
SPECIFICATION DRAWING

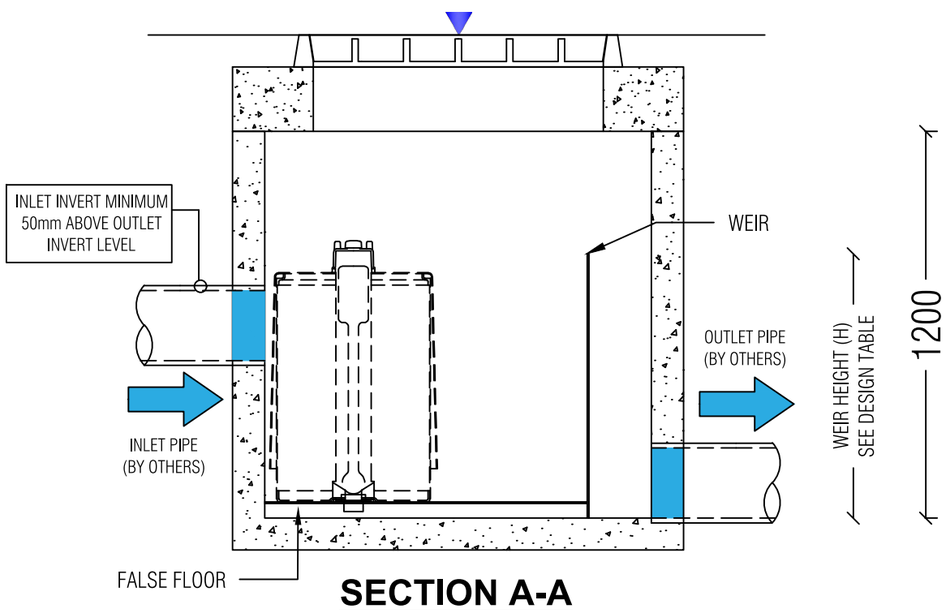
LAST MODIFIED: 15-10-19

NOT FOR CONSTRUCTION



PLAN LAYOUT

900 SQUARE CAST-IRON SOLID TOP
ACCESS COVER SUPPLIED LOOSE
(OR CAST INTO LID IF REQUIRED)



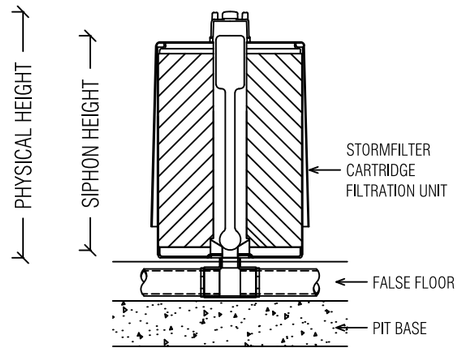
SECTION A-A

LAST MODIFIED: 01-05-19

STORMFILTER DESIGN TABLE

- STORMFILTER TREATMENT CAPACITY VARIES BY NUMBER OF FILTER CARTRIDGES INSTALLED.
- THE STANDARD CONFIGURATION IS SHOWN. ACTUAL CONFIGURATION OF THE SPECIFIED STRUCTURE(S) PER CERTIFYING ENGINEER WILL BE SHOWN ON SUBMITTAL DRAWING(S).
- FILTER CARTRIDGES SHALL BE MEDIA-FILLED, PASSIVE, SIPHON ACTUATED, RADIAL FLOW, AND SELF-CLEANING. RADIAL MEDIA DEPTH SHALL BE 178mm.

CARTRIDGE NAME / SIPHON HEIGHT (mm)	690	460	310
CARTRIDGE PHYSICAL HEIGHT (mm)	840	600	600
TYPICAL WEIR HEIGHT [H] (mm)	820	590	440
CARTRIDGE FLOW RATE FOR ZPG MEDIA (L/s)	1.6	1.1	0.7
CARTRIDGE FLOW RATE FOR PSORB MEDIA (L/s)	0.9	0.46	0.39



STORMFILTER CARTRIDGE DETAIL

SITE SPECIFIC DATA REQUIREMENTS

STRUCTURE ID	[ ]
NUMBER OF CARTRIDGES REQ'D	[ ]
SIPHON HEIGHT (310 / 460 / 690)	[ ]
MEDIA TYPE (ZPG / PSORB)	[ ]
WATER QUALITY FLOW RATE (L/S)	[ ]
HYDRAULIC CAPACITY (L/S)	[ ]

PIPE DATA:	I.L.	MATERIAL	DIAMETER
INLET PIPE #1	[ ]	[ ]	[ ]
INLET PIPE #2	[ ]	[ ]	[ ]
INLET PIPE #3	[ ]	[ ]	[ ]
OUTLET PIPE	[ ]	[ ]	[ ]

PRECAST PIT WEIGHT	TBA
LID WEIGHT	TBA

GENERAL NOTES

1. PRECAST STRUCTURE SUPPLIED WITH CORE HOLES TO SUIT OUTER DIAMETER OF NOMINATED PIPE SIZE / MATERIAL.
2. PRECAST STRUCTURE SHALL MEET W80 WHEEL LOAD RATING ASSUMING A MAXIMUM EARTH COVER OF 2.0m AND A GROUND WATER ELEVATION AT, OR BELOW, THE OUTLET PIPE INVERT ELEVATION. CERTIFYING ENGINEER TO CONFIRM ACTUAL GROUNDWATER ELEVATION. PRECAST STRUCTURE SHALL BE IN ACCORDANCE WITH AS3600.
3. IF THE PEAK FLOW RATE, AS DETERMINED BY THE SITE CERTIFYING ENGINEER, EXCEEDS THE PEAK HYDRAULIC CAPACITY OF THE SYSTEM, AN UPSTREAM BYPASS STRUCTURE IS REQUIRED.
4. ALL WATER QUALITY TREATMENT DEVICES REQUIRE PERIODIC MAINTENANCE. REFER TO OPERATION AND MAINTENANCE MANUAL FOR GUIDELINES AND ACCESS REQUIREMENTS.
5. SITE SPECIFIC PRODUCTION DRAWING WILL BE PROVIDED ON PLACEMENT OF ORDER.
6. DRAWING NOT TO SCALE.

INSTALLATION NOTES

1. ANY SUB-BASE, BACKFILL DEPTH, AND/OR ANTI-FLOTATION PROVISIONS ARE SITE-SPECIFIC DESIGN CONSIDERATIONS AND SHALL BE SPECIFIED BY CERTIFYING ENGINEER.
2. CONTRACTOR TO PROVIDE ALL EQUIPMENT WITH SUFFICIENT LIFTING AND REACH CAPACITY TO LIFT AND SET THE STORMFILTER STRUCTURE (LIFTING DETAIL PROVIDED SEPARATELY).
3. CONTRACTOR TO APPLY SEALANT TO ALL JOINTS AND TO PROVIDE, INSTALL AND GROUT INLET AND OUTLET PIPES.

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OCEAN PROTECT
2 CARTRIDGE STORMFILTER SYSTEM
1200 PIT
SPECIFICATION DRAWING

APPENDIX B MUSIC MODELLING RESULTS

85/65/45

30/06/2020 7:02:17 PM

Treatment Train Effectiveness

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Sources	5.68	765	1.44	11.4	97.0
Residual Load	5.68	78.9	0.490	6.07	0.839
% Reduction	0.0	89.7	66.0	46.6	99.1

APPENDIX C EXISTING WATER NETWORK SURVEY PLANS

FOR CONTINUATION SEE DRAWING 60044290-DCW 01

FOR CONTINUATION SEE DRAWING 60044290-DCW 04

Rev	Date	Amendment Description	By	Chk
01	15.05.09	PRELIMINARY DRAWING	MK	LK

LEGEND

ASSUMED DOMECTIC COLD WATER — aDCW —

Client

Zoological Parks Board of NSW
Bradleys Head Road
Mosman, NSW, 2088

Consulting Engineer

BASSETT

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Project

Taronga Zoo
Infrastructure Records

Drawing Title

DOMESTIC COLD WATER

Scale @ B1	1:500	Checked	DL
Date	May' 09	Approved	
Drawn	MK	Verified	

Project No.	Drawing No.	Revision
60044290	**02**	**01**

Status **PRELIMINARY**

Sheet No. 1 of 16

FOR CONTINUATION SEE DRAWING 60044290–RECYCLED WATER 01

FOR CONTINUATION SEE DRAWING 60044290–RECYCLED WATER 04

Rev	Date	Amendment Description	By	Chk
01	15.05.09	PRELIMINARY DRAWING	MK	LK

LEGEND

RECYCLED WATER — RW

ASSUMED RECYCLED WATER — aRW

Client
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Bradleys Head Road
Mosman, NSW, 2088

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Project
Taronga Zoo
Infrastructure Records

Drawing Title
RECYCLED WATER

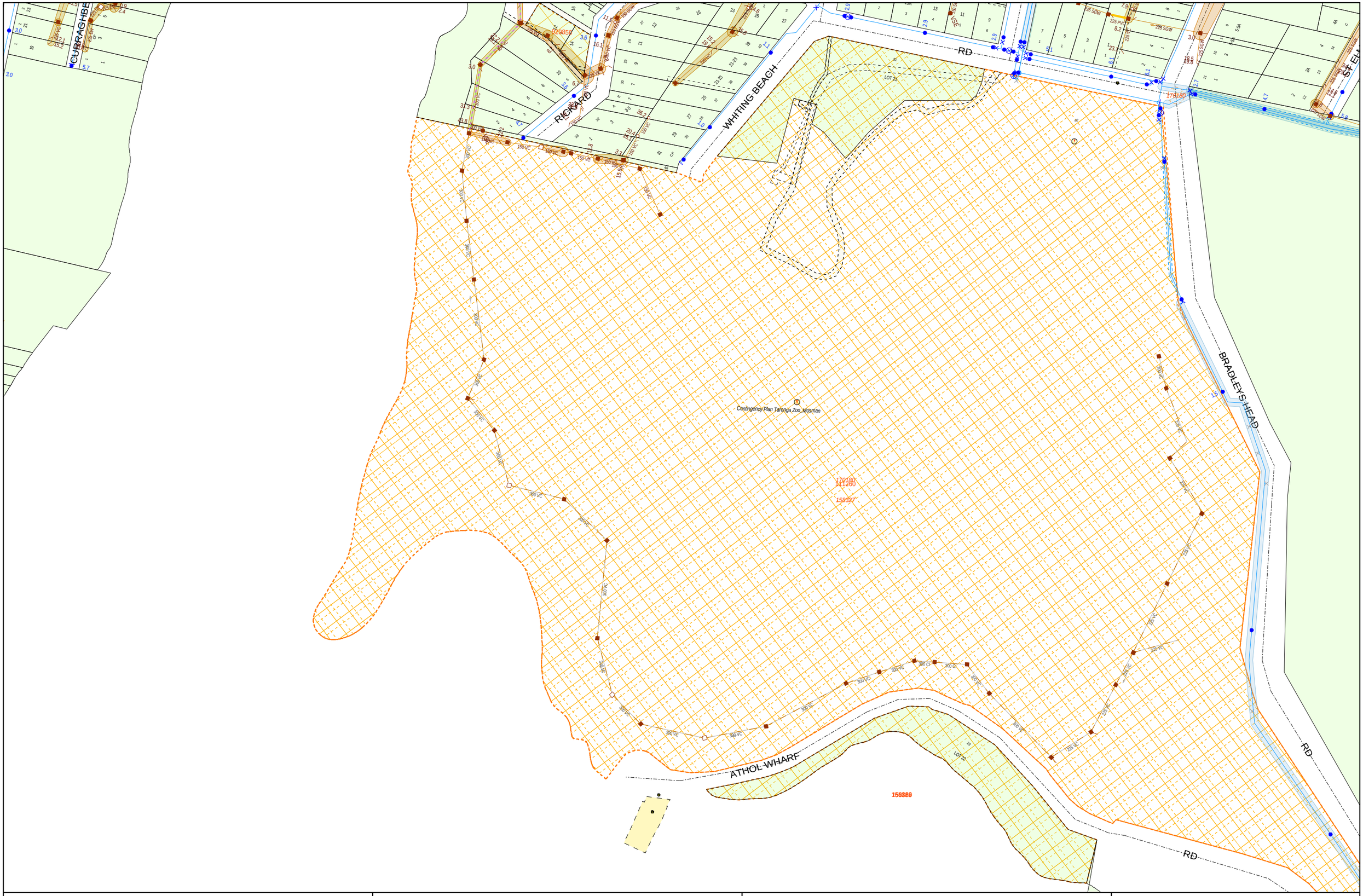
Scale @ B1	1:500	Checked	DL
Date	May' 09	Approved	
Drawn	MK	Verified	

Project No.	Drawing No.	Revision
60044290	**02**	**01**

Status
PRELIMINARY

Sheet No. 1 of 16

APPENDIX D SYDNEY WATER HYDRA PLAN



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Date of Production: 12/05/2020

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SYDNEY WATER CORPORATION

Map:217 Grid:A14 Edition:Sydney UBD Edition 41

0m 20m 40m 60m 80m 100m

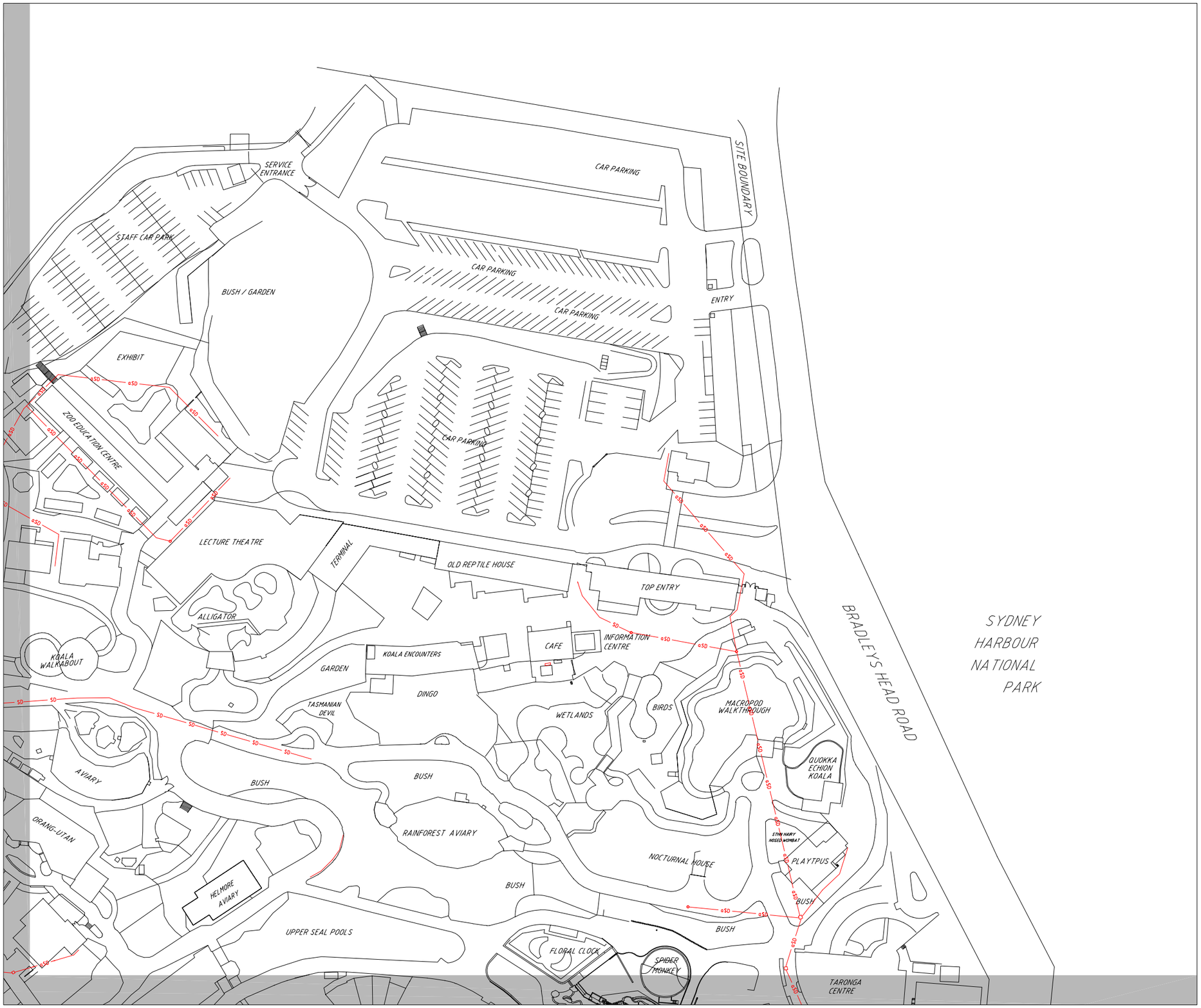
Scale 1:2500

Page

APPENDIX E SYDNEY WATER DN225 SEWER ASSET WORK ORDER DRAWINGS

APPENDIX F EXISTING SEWER NETWORK SURVEY PLAN

FOR CONTINUATION SEE DRAWING 60044290–SEWER DRAINAGE 01



FOR CONTINUATION SEE DRAWING 60044290–SEWER DRAINAGE 04

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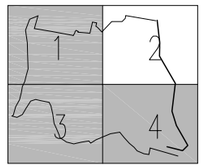

LEGEND

SEWER DRAINAGE — SD

ASSUMED SEWER DRAINAGE — aSD

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Mosman, NSW, 2088

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Taronga Zoo
Infrastructure Records

Drawing Title
SEWER DRAINAGE

Scale @ B1 1:500		Checked DL	
Date May 09		Approved	
Drawn MK		Verified	
Project No. **60044290**	Drawing No. **02**	Revision **01**	

Status **PRELIMINARY**

Sheet No. 1 of 16

APPENDIX G GRC HYDRO FLOOD IMPACT ASSSESSMENT

Job Number: *200062*
Date: *25 June 2020*

GRC Hydro
Level 9, 233 Castlereagh Street
Sydney NSW 2000

Tel: +61 432 477 036
www.grchydro.com.au

Laura Shaughnessy
Warren Smith and Partners
Level 9, 233 Castlereagh Street
Sydney, NSW 2000

Dear Laura,

Re: Taronga Zoo Flood Impact Assessment

Introduction

Development is proposed for a portion of Taronga Zoo at it's 'Upper Australia' exhibit. The development consists of a Koala enclosure, some associated small buildings and a new access path on the south side of the site. A SEARs (Secretary's Environmental Assessment Requirements) item requires that the development proponent "Assess flooding impacts in accordance with the Floodplain Development Manual".

Site Description

Taronga Zoo is located in Mosman on a sloped site abutting Sydney Harbour. The site is on the west side of Bradleys Head, a peninsula that extends into Sydney Harbour, while residential areas of Mosman lie to the north of the site. The site is around 500 m from north to south and has an elevation range of 77 mAHD down to around 10 mAHD. The north-east corner of the site is located on the natural topographic ridge that separates Great Sirius Cove and Taylors Bay.

The area of development is located in the northern portion of the zoo, just south of the main entrance building on Bradleys Head Road. Bradleys Head Road is separated from the area by a large stone wall. The area of development slopes down to the south, with an elevation range of around 60-70 mAHD.

Flood Assessment

The site is assessed to have little to no flood affectation. Figure 1 shows the topography in the upstream area, with approximate building locations marked in grey and the development area marked by the red rectangle. The catchment ridge is shown at the top-right corner, which then extends through the site.

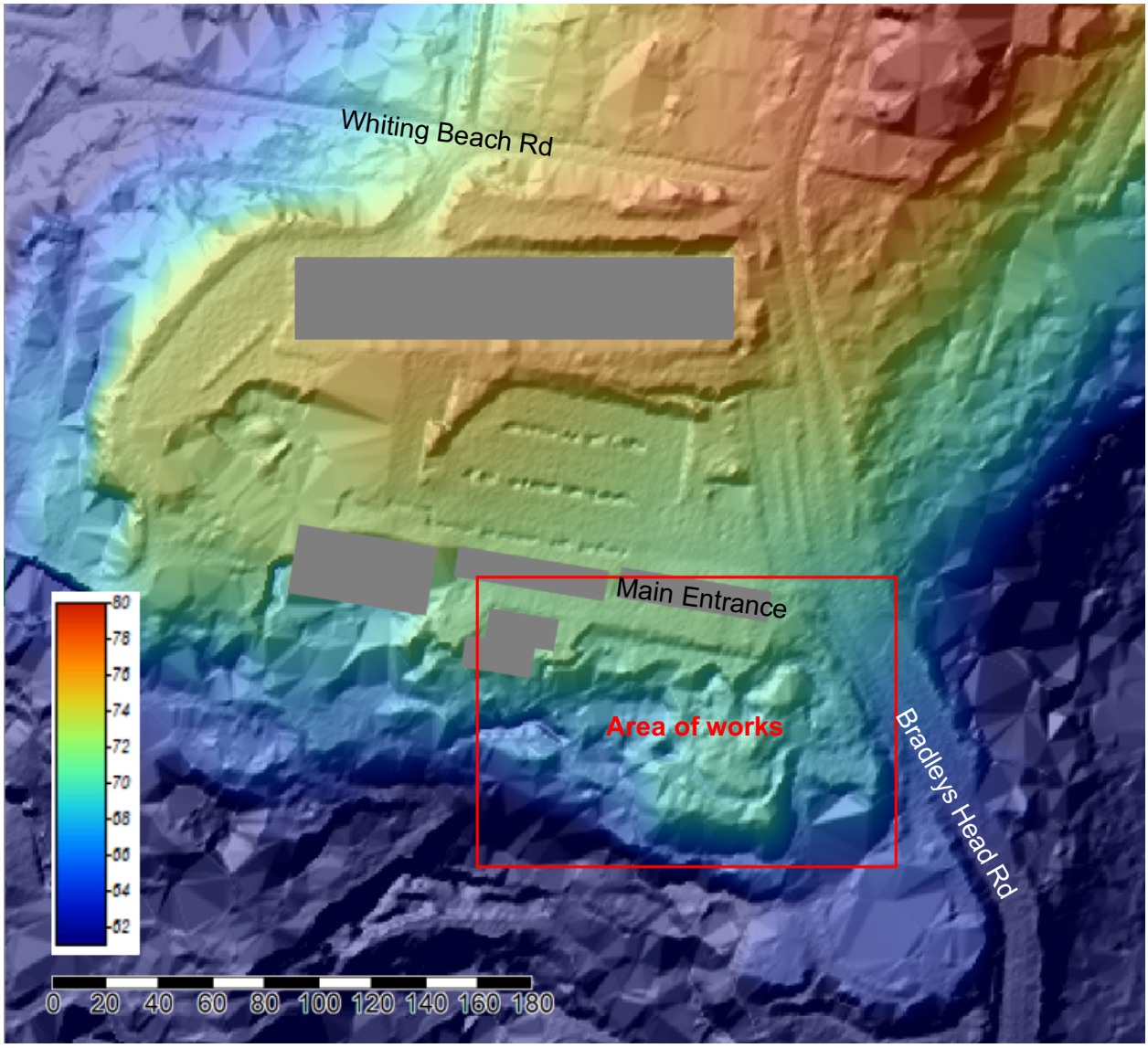

Figure 1: Elevation in the vicinity of the site, buildings shown in gray

Examining the topography in more detail, there is a slope from the north boundary of the site at Whiting Beach Road to the car park area. Just north of the main entrance building there is a paved open space that slopes away from the building and onto Bradleys Head Road. Overall, topographic data indicates that the residential areas of Mosman direct little or no flow towards the zoo site, and grading north of the main entrance building directs any localised runoff towards Bradleys Head Road. The area of work has no significant upstream catchment and would drain only runoff from rainfall in the immediate area.

Small-scale overland flow at the area of works, which would be characterised as local drainage and not major drainage as per the Floodplain Development Manual, may bypass the stormwater pit and pipe system in events greater than its design capacity. There may be localised areas of shallow ponding or flow within the area, before the stormwater system drains the area.

Flooding in the area of works is negligible and the works themselves will not cause flooding impacts, as set out in the Floodplain Development Manual. Any flooding would be characterised as local drainage and can be resolved via the stormwater system.

Yours Sincerely

Steve Gray
Director

Email: gray@grchydro.com.au
Tel: +61 413 631 447