marchesepartners

STORMWATER MANAGEMENT REPORT

FOR

WATERBROOK DEVELOPMENT
BAYVIEW GOLF CLUB
CABBAGE TREE ROAD,
BAYVIEW NSW 2104

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Revision No	Status	Issue Date	Prepared By	Reviewed By	Approved By
A	Draft	12/10/2017	I Yip	L Panagopoulos	P Sancandi
C	Draft DA	13/11/2017	I Yip	L Panagopoulos	P Sancandi
D	DA Issue	17/11/2017	I Yip	L Panagopoulos	P Sancandi
E	DA Issue	21/11/2017	I Yip	L Panagopoulos	P Sancandi
F	Revised DA Issue	31/07/2018	I Yip	L Panagopoulos	P Sancandi
G	Revision for Court Proceedings	24/08/2018	I Yip	L Panagopoulos	P Sancandi

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1.0 INTRODUCTION AND OVERVIEW

This report discusses the internal site stormwater drainage system for the proposed seniors housing development and the management of stormwater runoff generated by the Bayview Golf Club land beside Cabbage Tree Road, Bayview.

The following engineering drawings have been prepared by Marchese Partners Engineering in support of the architectural drawings prepared by the Architects, Marchese Partners: -

STORMWATER DRAWINGS

- DA-STW-001 STORMWATER DRAINAGE COVER SHEET AND DRAWING LIST
- DA-STW-002 STORMWATER DRAINAGE LEGEND AND ABBREVIATIONS
- DA-STW-003 STORMWATER DRAINAGE GENERAL NOTES
- DA-STW-004 STORMWATER DRAINAGE SURVEY PLAN
- DA-STW-005 STORMWATER DRAINAGE EROSION AND SEDIMENT CONTROL PLAN
- DA-STW-006 STORMWATER DRAINAGE EROSION AND SEDIMENT CONTROL DETAILS
- DA-STW-101 STORMWATER DRAINAGE SITE PLAN
- DA-STW-102 STORMWATER DRAINAGE BASEMENT 3
- DA-STW-103 STORMWATER DRAINAGE BASEMENT 2 SHEET 1 OF 2
- DA-STW-104 STORMWATER DRAINAGE BASEMENT 2 SHEET 2 OF 2
- DA-STW-105 STORMWATER DRAINAGE BASEMENT 1
- DA-STW-106 STORMWATER DRAINAGE GROUND LEVEL
- DA-STW-201 STORMWATER DRAINAGE DETAIL SHEET

This report is to be read in conjunction with the above stormwater drainage drawings. Additional reference is made to supporting documentation for the proposed roundabout and driveway entry:-

CIVIL DRAWINGS

- DA-C-101 CIVIL WORKS CABBAGE TREE ROAD ROUNDABOUT LAYOUT PLAN
- DA-C-121 CIVIL WORKS CABBAGE TREE ROAD LONGITUDINAL SECTIONS
- DA-C-131 CIVIL WORKS CABBAGE TREE ROAD CROSS SECTIONS
- DA-C-201 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LAYOUT PLAN
- DA-C-202 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL PLAN
- DA-C-221 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LONG SECTION
- DA-C-222 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 1
- DA-C-223 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 2
- DA-C-224 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 3
- DA-C-301 CIVIL WORKS CABBAGE TREE ROAD PAVEMENT PLAN

This report addresses the following key areas:-

1. Local flooding effects;
2. Overland flow characteristics;
3. Street drainage connection;
4. On-Site Detention storage;
5. Rainwater reuse storage;
6. Stormwater quality improvement; and
7. Temporary erosion and sediment control measures.

2.0 THE EXISTING SITE

Bayview Golf Club is located within the Northern Beaches local government area (formerly Pittwater Council area) and owns land on the north side and south side of Cabbage Tree Road. A portion of the northern golf club area is intended for the construction of a multi-unit seniors housing development by Waterbrook (a developer of resort-style retirement facilities). The designated area of proposed works occupies approximately 1.881 hectares. The aerial phograph below (Figure 1) indicates the approximate location of the development site with a yellow outline.

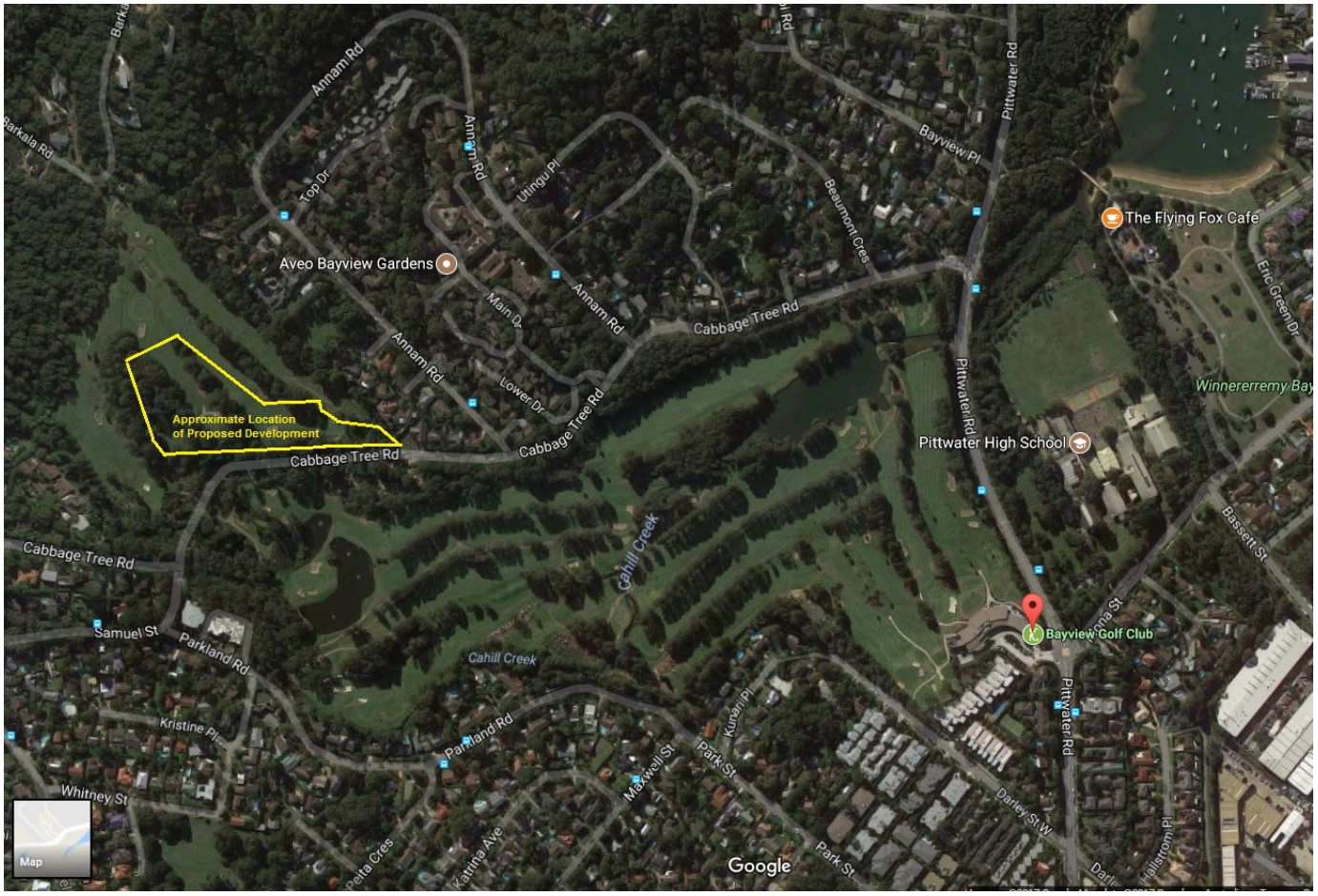


FIGURE 1 – Site Location

The Survey Plan prepared by Bee & Lethbridge Quality Surveying & Development Solutions (Plan Ref 18990 – dated 07/08/2014) together with Sixmaps web site contour information indicates that :-

- The existing topography associated with the northern Golf Club property generally directs stormwater runoff in a southerly direction towards Cabbage Tree Road.
- Existing surface levels in the vicinity of the proposed development range from approximately RL28.00 down to about RL3.00 at Cabbage Tree Road.
- The natural site slope is relatively steep, being approximately 14%

- Existing contours generally indicate steeper upper golf course areas (with contour lines closer together) and a flatter low-lying golf course area draining towards Pittwater (with contour lines further apart, and a number of lake storage ponds).

Below (Figure 2) is an approximate contour plan obtained from the Sixmaps web site with approximate flow direction arrows and site location added.

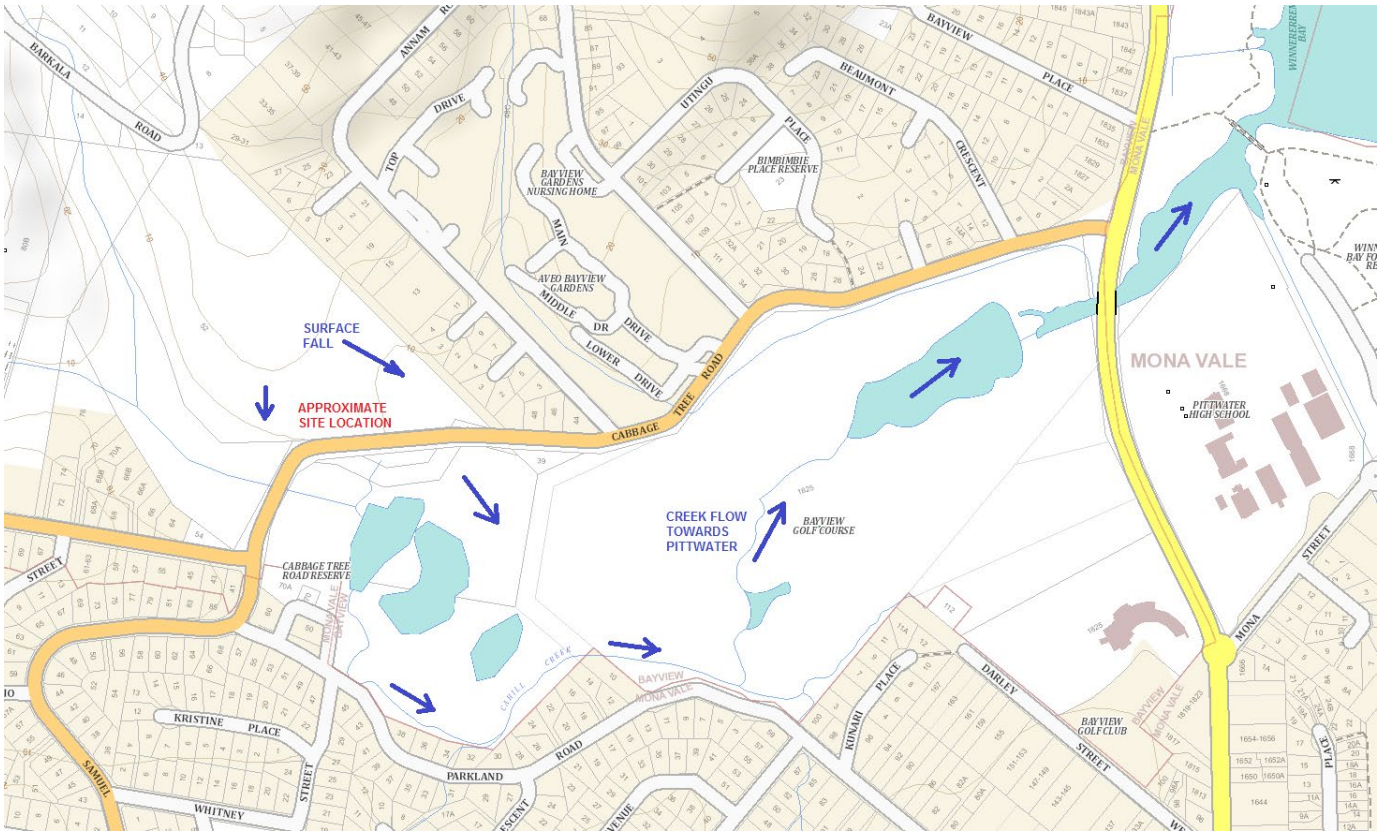


FIGURE 2 – Approximate Contour Plan

3.0 FLOODING EFFECTS

A description of flooding effects in the vicinity of Bayview Golf Course has been addressed in a Site Compatibility Certificate Flooding Report prepared by Cardno dated 16 November 2015. The report concluded that the proposed development is not flood affected for all events up to the Probable Maximum Flood (PMF), although portions of the lower Cabbage Tree Road surface is subject to some flooding effects. Subsequent supporting reports were prepared by Cardno for the Bayview Golf Course (lower area south of Cabbage Tree Road) and the Seniors Living Development dated 10 November 2017.

The flood planning area map below (Figure 3) is extracted from the abovementioned 2015 Cardno report and was taken from the Pittwater LGA Overland Flow Flood Study (Cardno, 2013). Anticipated flood-affected areas are shaded with colour.

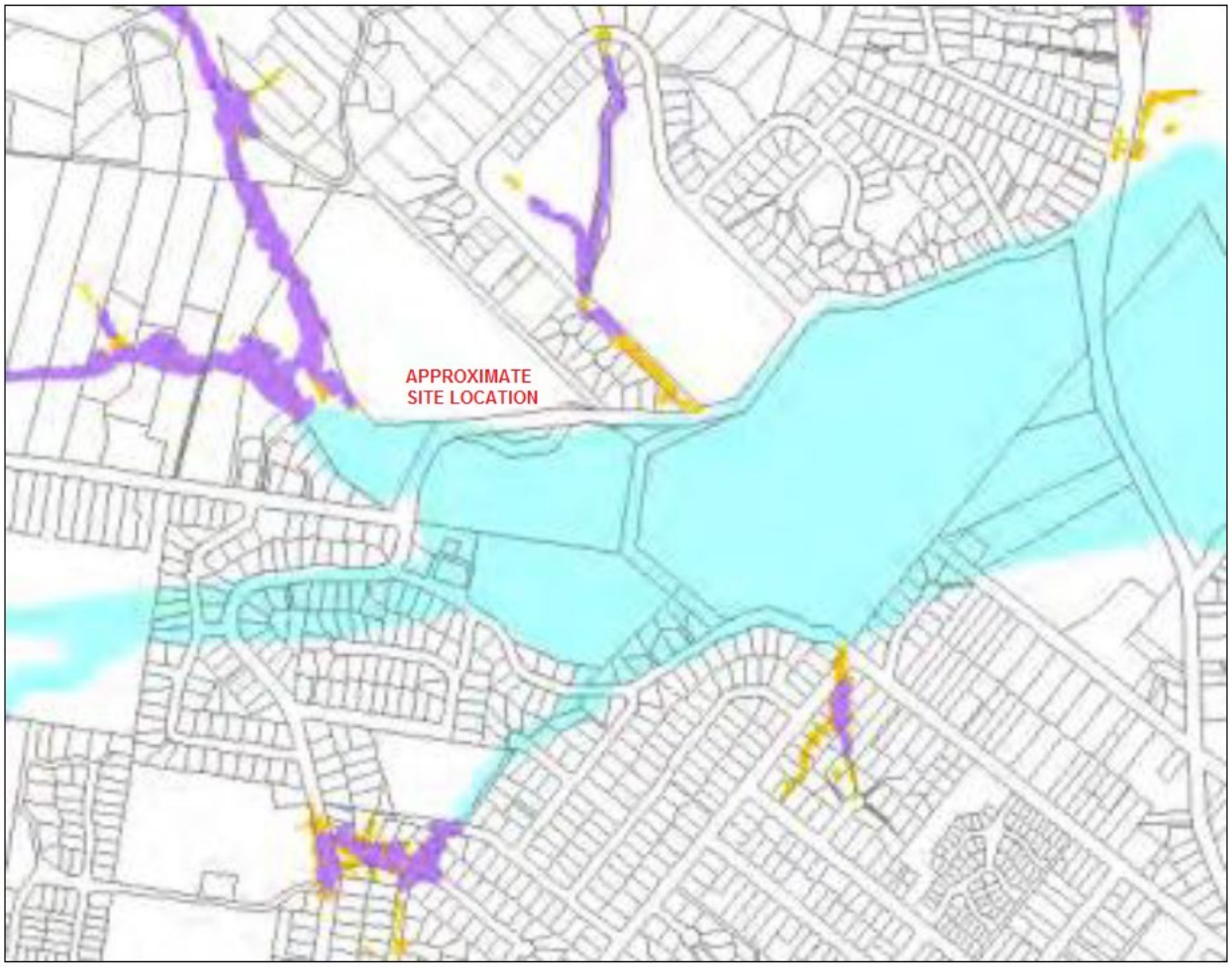


FIGURE 3 – Flood Planning Area Map

The subsequent Flood Impact Assessment for the Seniors Living Development issued by Cardno (Ref 59915160 - dated 23 November 2017) confirmed no adverse flood impacts for the proposal.

4.0 LOCAL OVERLAND FLOW

The main overland flow paths adjacent to the proposed development generally tend to direct runoff around or away from the proposed development site. However, the northwestern side (upper left) of the works area is associated with some upslope runoff draining towards the site and this stormwater discharge is intended to be collected and directed to a proposed detention tank in the lower part of the works area. The tank is to be situated clear of the main eastern overland flow path and this space is to continue serving as an exit point for natural surface runoff from the upper golf course grounds and any neighbouring runoff that may find its way into the golf course property during severe storm events.

Some localised slope adjustment is also proposed along the northern side of the private rear yards, but the finished landscaping levels are to be shaped to direct surface flow generally along the same easterly direction accommodated by natural site falls.

The survey plan below (Figure 4) displays indicative flow arrows perpendicular to contour lines, directing surface runoff towards Cabbage Tree Road.

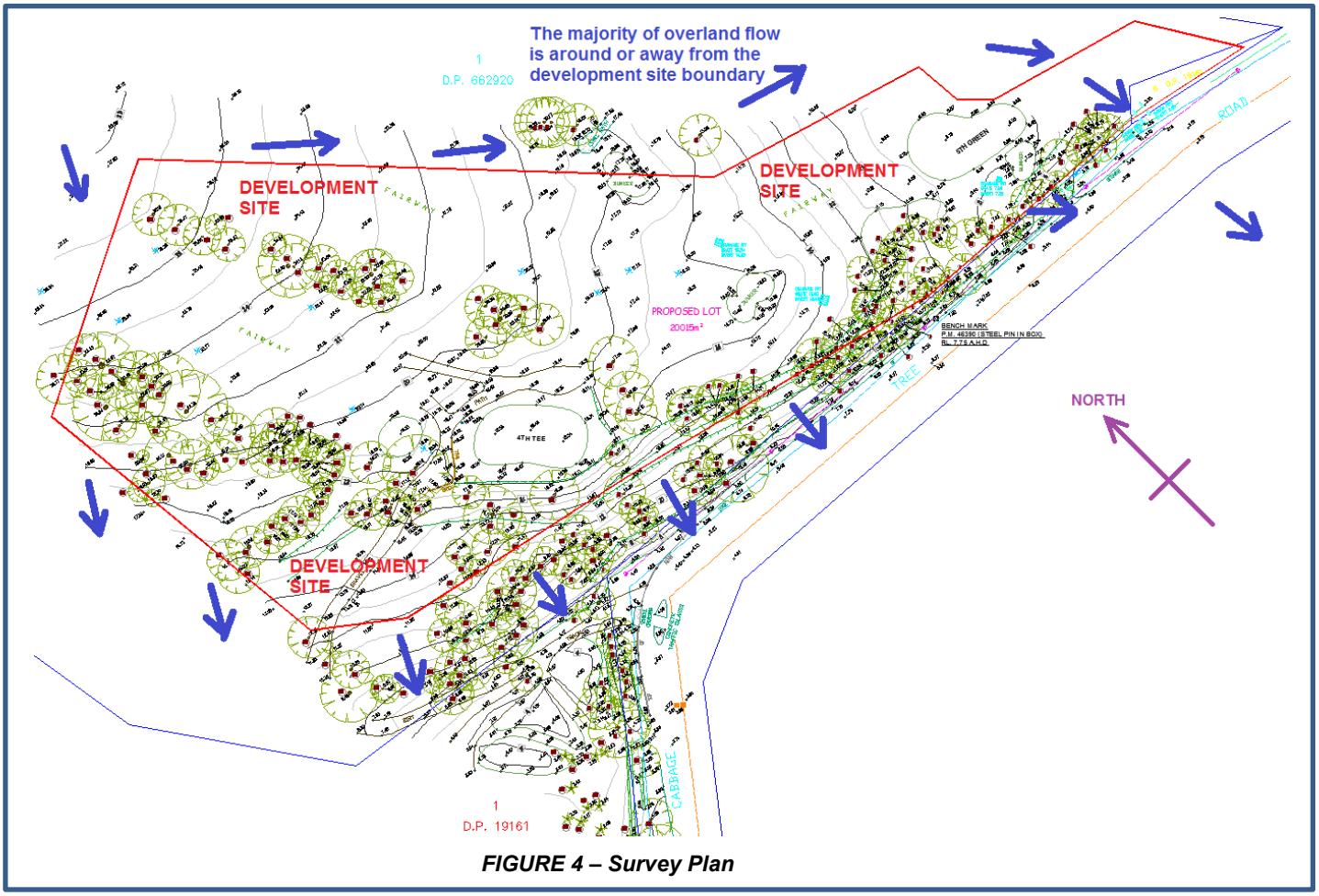


FIGURE 4 – Survey Plan

In relation to overland flow on the eastern side of the development, a recent Flood Impact Assessment for the Seniors Living Development was issued by Cardno (Ref 59915160 - dated 23 November 2017) with drainage works proposed to meet required flow constraints within the proposed area of site works for the Seniors Living Development.

An indicative conceptual sketch of the associated drainage works is included below (Figure 5).

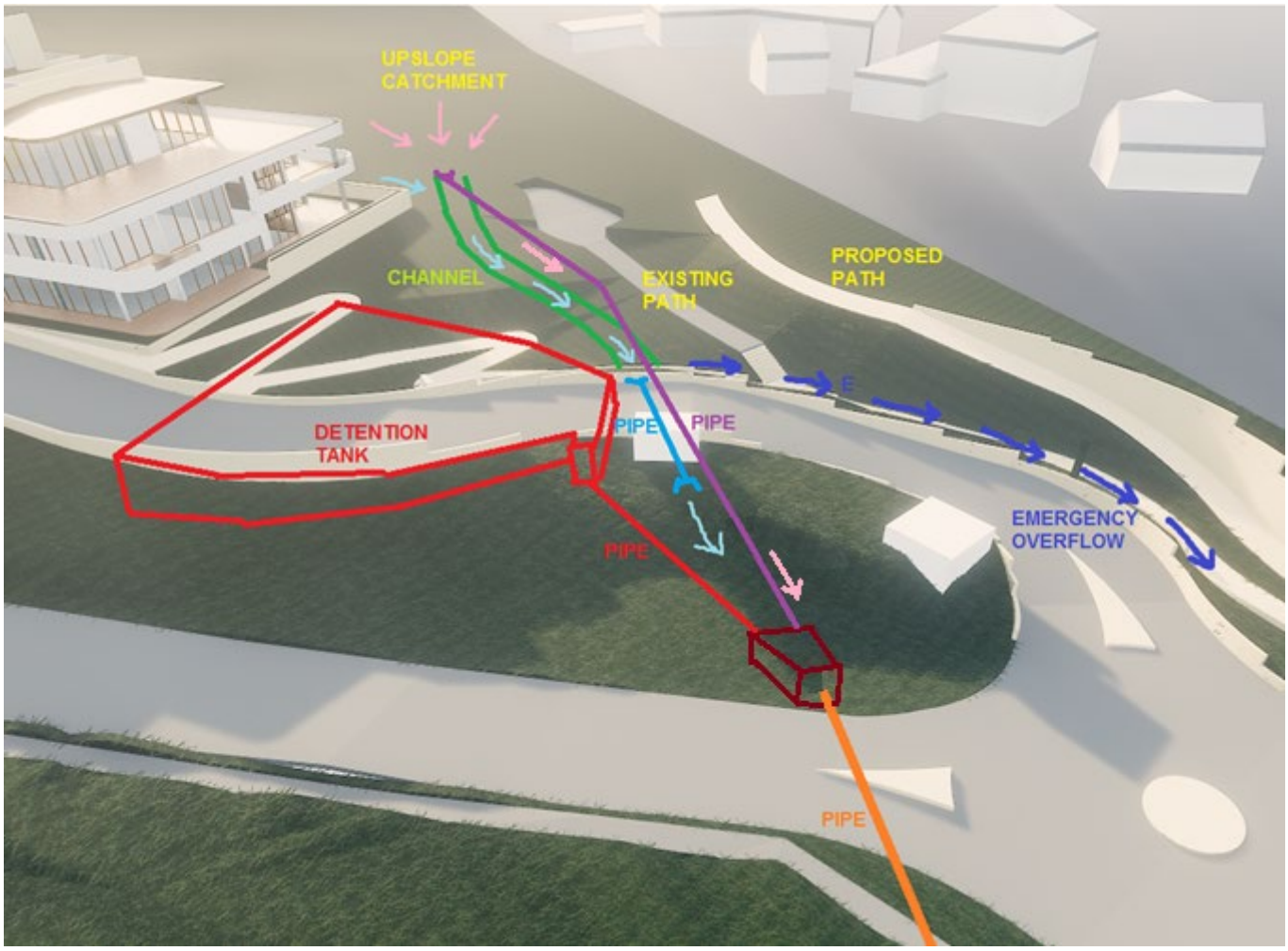


FIGURE 5 – Conceptual Sketch of Overland Flow Drainage Works

The majority of upper catchment flow outside the development site area is intended to be collected with the purple line (twin 750mm pipes) and the remaining reduced surface flow is to be conveyed with shallow flow depth of no more than 150mm in a landscaped channel with 3000mm base width and 1:3 sloping sides draining to the light blue line (twin 1500x450 box culverts under a proposed path and driveway). A detention tank (shown in red) is proposed to restrict flows discharging from the new buildings.

Flood mapping plans from the Flood Impact Assessment are shown below (Figures 6 & 7) for the 100 year Average Recurrence Interval (= 1% Annual Exceedance Probability) and Probable Maximum Flood (PMF) storm events.

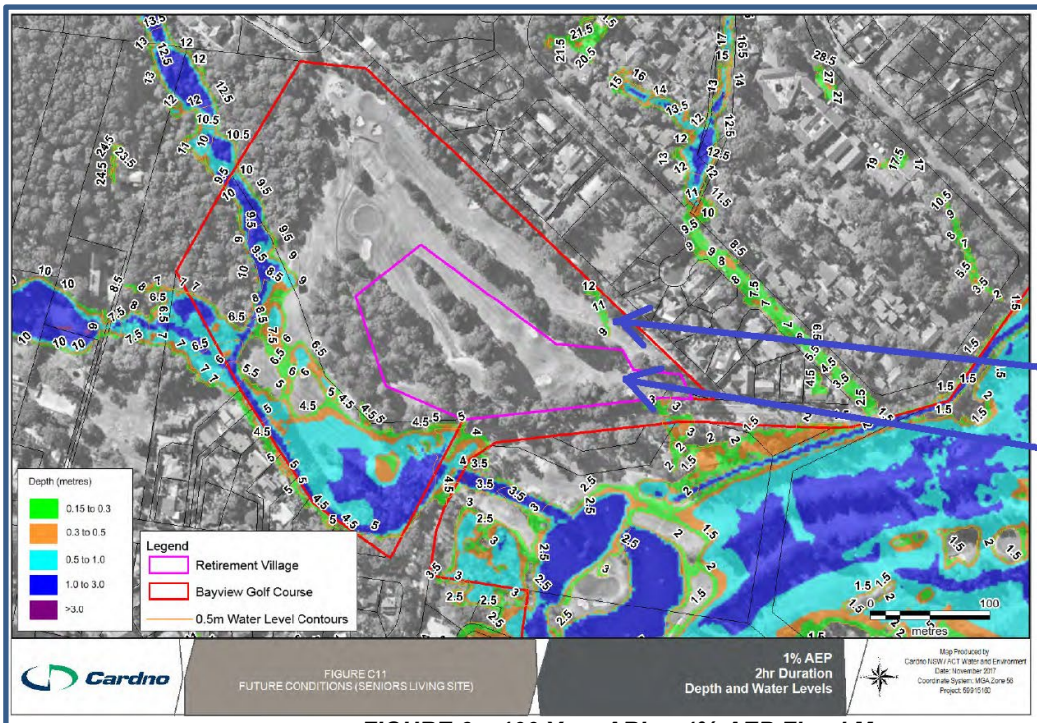


FIGURE 6 – 100 Year ARI or 1% AEP Flood Map

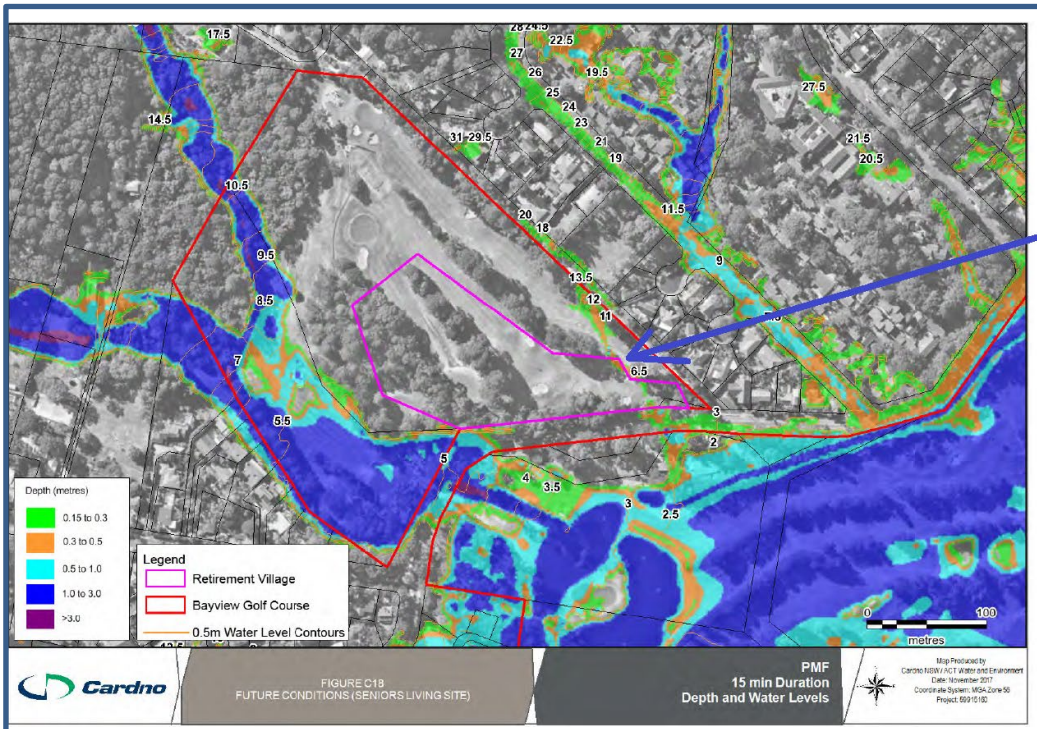


FIGURE 7 – Probable Maximum Flood Map

5.0 STREET DRAINAGE CONNECTION

A site inspection of the proposed street entrance location on Cabbage Tree Road was undertaken in sunny conditions on 17 September 2017 and existing street drainage pipes were observed beside the roadway. The main pipe passing below the road surface was noted by the surveyor as exceeding 600mm diameter and the ends of the pipe were located in a drainage depression on each side of the road.

The photograph below (Figure 8) indicates the positions of the existing drainage depressions.

FIGURE 8 – Existing Drainage Depressions

It is intended that the construction of a new roundabout at this location will provide opportunities :-

- to formalise the street drainage system with new pits replacing existing depressions located clear of the new roundabout roadway alignment;
- to re-lay new pipework as required to serve the relevant contributing catchments; and
- to provide pit surcharge structures which will allow overflows to drain in the natural direction of fall.

The existing street drainage appears to be isolated from the Council drainage infrastructure system and evidently drains across the existing ground surface towards the low-lying lakes and creeks within Bayview Golf Course. This open channel system eventually drains in a northeasterly direction towards the Pittwater estuary.

The final route and connection of street drainage will be subject to Council approval, with consideration for existing tree roots and structures in the lower golf course area.

The photograph below (Figure 9) indicates the existing inlet depression on the north side of the road.

FIGURE 9 – Existing Inlet Depression

The photograph below (Figure 10) indicates the existing outlet depression on the south side of the road.

FIGURE 10 – Existing Outlet Depression

The survey plan extract below (Figure 11) indicates initial site survey information received in July 2017.

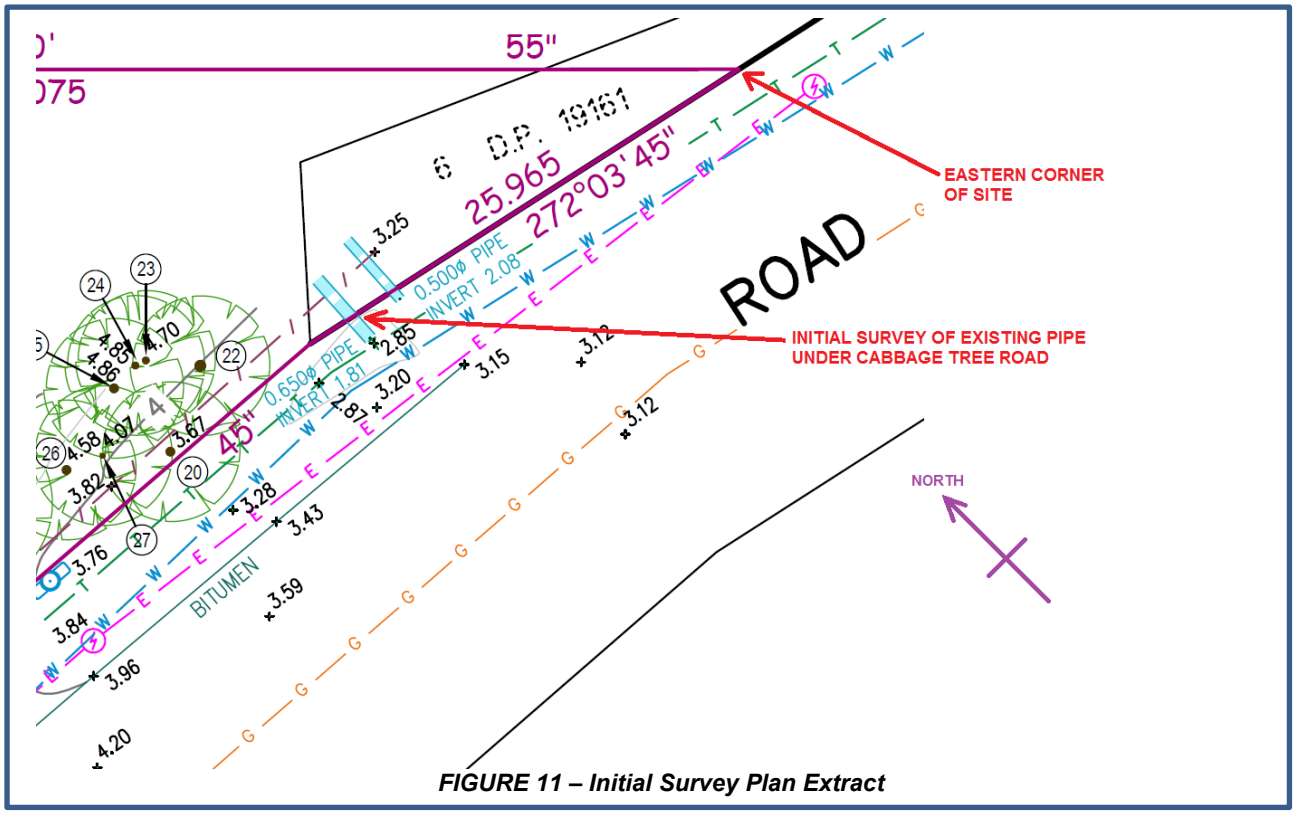


FIGURE 11 – Initial Survey Plan Extract

The survey plan extract below (Figure 12) indicates subsequent survey information received in August 2017 and includes roadway levels.

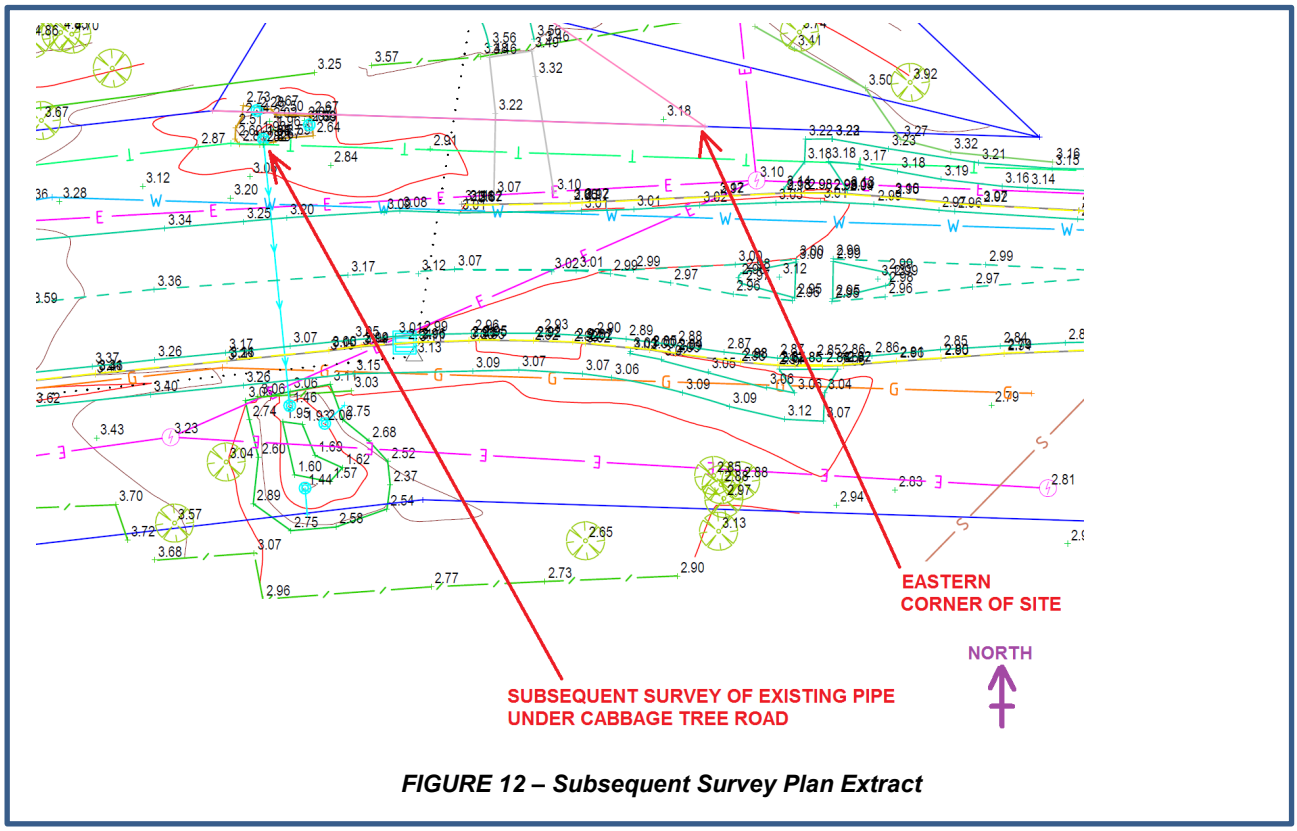


FIGURE 12 – Subsequent Survey Plan Extract

6.0 ON-SITE DETENTION STORAGE & SITE DRAINAGE

Reference is made to the requirements of Northern Beaches Council and specifically to the Pittwater 21 Development Control Plan 2014 – Section B5.7 Stormwater Management – On-Site Stormwater Detention. The table below (Figure 13) indicates Council's detention storage requirement based on proposed impervious surface area.

REQUIREMENTS FOR SIZE AND ALLOWABLE DISCHARGE FROM ON-SITE DETENTION SYSTEMS

Additional Hard (Impervious) Surface Area (square metres)	Minimum Capacity of On-Site Detention Tank (Litres)	Discharge Rate Litres/Sec
0 -50	Nil	Nil
>50 - 75	4,500	2
>75 - 100	6,000	3
>100 - 150	9,000	4
>150 - 200	12,000	6
>200 - 250	15,000	7
>250 - 300	18,000	9
>300 - 400	24,000	12
>400 - 500	30,000	15
>500 - 600	36,000	18
>600 - 700	42,000	21
>700 - 800	48,000	24
>800 - 900	54,000	27
>900 - 1,000	60,000	30
>1,000*	A minimum storage capacity of 60 litres per m2 of additional hard/impervious surface area, and a discharge rate which replicates the discharge from the site were it to be undeveloped.	

*Developments exceeding 1,000 square metres of additional hard (impervious) surface area must also provide with the Water Management Plan, an Integrated Water Management Strategy prepared by a suitably qualified and experienced Water Engineer, demonstrating that stormwater flows discharged from the site is to be no greater than what would have occurred predevelopment, and that Water Sensitive Urban Design principles have been practically maximised within the proposed development.

FIGURE 13 – Extract from Council for Detention Requirements

The proposed impervious site area is anticipated to be 14,154m^2. Based on the tabular requirement for an area exceeding 1,000m2 the minimum storage capacity allowance is therefore calculated as 14154m^2 x 60L/m^2 = 849240L or 849m^3

Using DRAINS software as distributed by Watercom, modelling of the existing and proposed flows from a development area of 1.881 hectares was undertaken, with 0% existing impervious proportion increasing to 75% proposed impervious proportion for a range of statistical frequencies and storm durations. The results determined that a minimum storage volume of 1,037m^3 was required to demonstrate that post-development flows would not exceed pre-development flows. This value also satisfies the minimum requirement derived from Council's tabular values.

The table below (Figure 14) provides a summary of flows and water levels derived from the DRAINS software model. For each Average Recurrence Interval (ARI), the green column proposed flow values must be no higher than the corresponding yellow column existing flow values.

STORMWATER DETENTION CALCULATION SUMMARY

Project: 2015-0440 Waterbrook Bayview Development

Effective detention storage up to RL 6.60 (lowest connected grate)

	5 YEAR ARI					20 YEAR ARI					100 YEAR ARI				
Storm Duration	Existing Runoff L/s	Detained Flow L/s	Overflow L/s	Total Outflow L/s	Max Water RL m	Existing Runoff L/s	Detained Flow L/s	Overflow L/s	Total Outflow L/s	Max Water RL m	Existing Runoff L/s	Detained Flow L/s	Overflow L/s	Total Outflow L/s	Max Water RL m
5min	125	99	0	99	4.32	227	110		110	4.47	377	123		123	4.65
10min	212	115	0	115	4.53	368	130		130	4.77	594	147		147	5.07
15min	264	126	0	126	4.70	447	142		142	4.98	727	163		163	5.36
20min	295	133	0	133	4.81	504	152		152	5.16	788	174		174	5.61
25min	321	137	0	137	4.89	535	158		158	5.27	770	182		182	5.77
30min	329	140	0	140	4.94	520	162		162	5.34	738	187		187	5.9
45min	333	146	0	146	5.05	510	171		171	5.53	719	199		199	6.19
1.0hr	352	151	0	151	5.14	550	178		178	5.68	764	206		206	6.36
1.5hr	325	151	0	151	5.14	525	178		178	5.69	750	209		209	6.43
2.0hr	319	151	0	151	5.14	508	179		179	5.70	691	208		208	6.41

ORIFICE DIAMETER =	246 mm
INTERNAL TANK AREA =	426.0 m2
AVAILABLE STORAGE VOLUME =	1082 m3
SITE AREA =	18810 m2
EXISTING IMPERVIOUS PROPORTION =	0 %
PROPOSED IMPERVIOUS PROPORTION =	75 %

FIGURE 14 – Detention Flow & Depth Calculation Summary

In accordance with the DRAINS model detention storage analysis, a minimum 1,035m3 detention tank is proposed to be constructed below the driveway and landscaping in the lower part of the development site.

To determine hydrological and hydraulic effects for the proposed site drainage system, a DRAINS software model was prepared in conjunction with the detention tank component. The model was analysed for the 5 year, 20 year and 100 year Average Recurrence Interval (ARI) storm events and incorporated a range of various storm durations (5 min, 10 min, 15min, 20 min, 25 min, 30 min, 45min, 1 hr, 1.5 hr & 2 hr).

The following characteristic design values were used for the model:

- Paved area depression storage 1mm
- Grassed area depression storage 5mm
- Soil Type 3 (for slow infiltration rates)
- Antecedent Moisture Content (AMC) 3 (rather wet soil at the start of a storm)

Surface flow travel times were calculated using the Kinematic Wave Equation within the DRAINS software. Flow path length, subcatchment slope, impervious and pervious percentage and roughness values were input into each catchment node to determine the flow time and associated runoff for each subcatchment.

The indicative node diagram below (Figure 15) was developed for preliminary conceptual DRAINS on-site detention and drainage modelling purposes. The final drainage analysis and pipe routes will be subject to consent being obtained for the mutually agreed architectural building and basement layout.

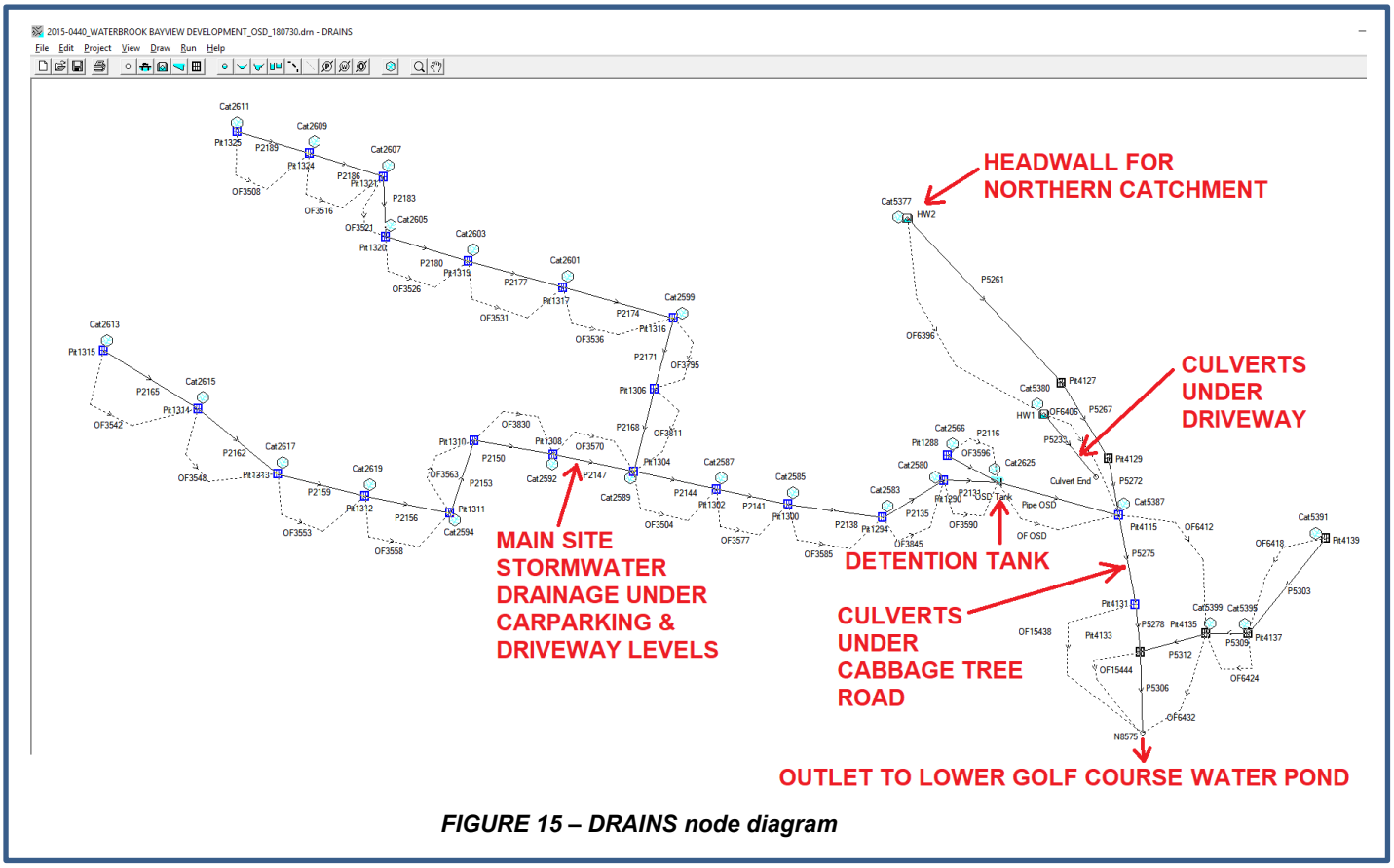


FIGURE 15 – DRAINS node diagram

A longitudinal section of the main external pipe system draining the northern golf course grounds (see Figure 16 below) has been extracted from the DRAINS model and is intended to approximate the Cardno design concept and TUFLOW model arrangement as proposed in the Flood Impact Statement.

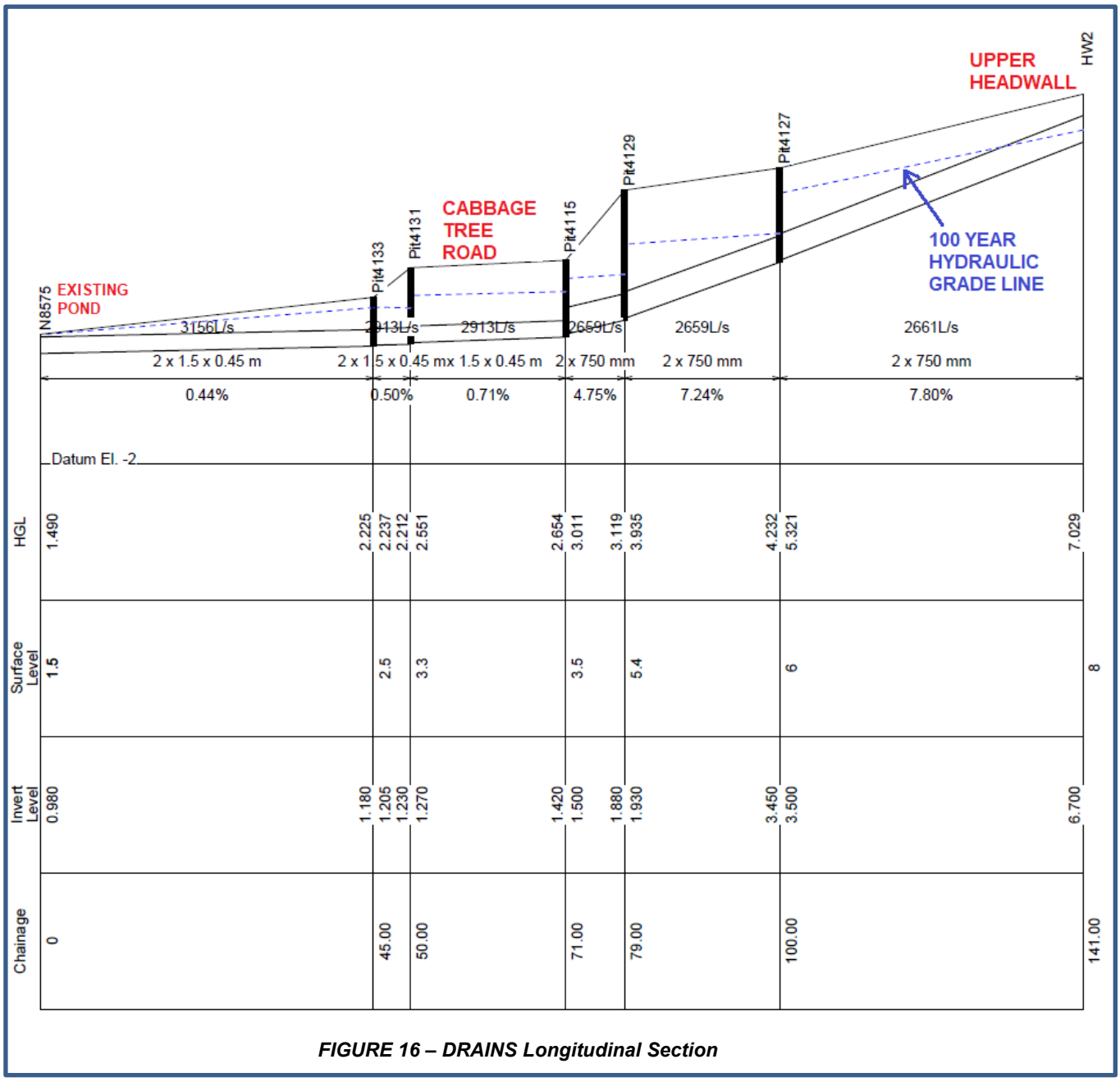


FIGURE 16 – DRAINS Longitudinal Section

7.0 RAINWATER STORAGE

Reference is made to the requirements of Northern Beaches Council and specifically to the Pittwater 21 Development Control Plan 2014 – Section B5.5 Rainwater Tanks – Business, Light Industrial and Other Development. The table below (Figure 17) indicates Council's rainwater storage requirement based on proposed impervious surface area.

Controls

All development creating an additional hard (impervious) roof area of greater than 50m2 must provide a rainwater tank for non-potable use connected to external taps for the purpose of landscape watering and car washing and a functional water reuse system including, water supply for toilet flushing and other uses as permissible under the current Code of Practice for Plumbing and Drainage.

Rainwater tanks may be above or below ground and are required to have storage capacities in accordance with the following table:

Additional Hard (Impervious)Surface Area (square metres)	Minimum Rainwater Tank Storage Capacity
0 - 50	Nil
50 - 75	1,500 litres
75 - 100	2,000 litres
100 - 150	3,000 litres
150 - 200	4,000 litres
200 - 300	6,000 litres
300 - 400	8,000 litres
400 - 500	10,000 litres
500 - 600	12,000 litres
600 - 700	14,000 litres
700 - 800	16,000 litres
800 - 900	18,000 litres
900 - 1,000	20,000 litres
Above 1,000*	See note (1) below, minimum size 20,000 litres

Note (1): Developments exceeding 1,000 square metres of additional hard (impervious) surface area must also provide with the Water Management Plan, and Integrated Water Management Strategy including rainwater tank sizing prepared by a suitably qualified and experienced Water Engineer, demonstrating that Water Sensitive Urban Design principles have been practically maximised within the proposed development. The rainwater tank storage shall be no less than 20,000 litre capacity.

FIGURE 17 – Extract from Council for Rainwater Storage Requirements

Rainwater storage requirements for new residential dwellings are typically provided to satisfy State Environmental Policy Building Sustainability Index (BASIX) assessment requirements. Relatively clean runoff from the roof drainage system is normally collected for reuse purposes, and remains separate from the more contaminated runoff collected from surface drainage which may accumulate leaves, sediment and other debris. Non-potable uses such as the supply to garden hose taps, irrigation and toilet flushing may be nominated in the BASIX tool.

According to the BASIX web site (Figure 18) the target requirement is to reduce potable mains supply by 40%. More information can be viewed online at https://www.basix.nsw.gov.au/iframe/basix-help-notes/water/water-targets-3.html

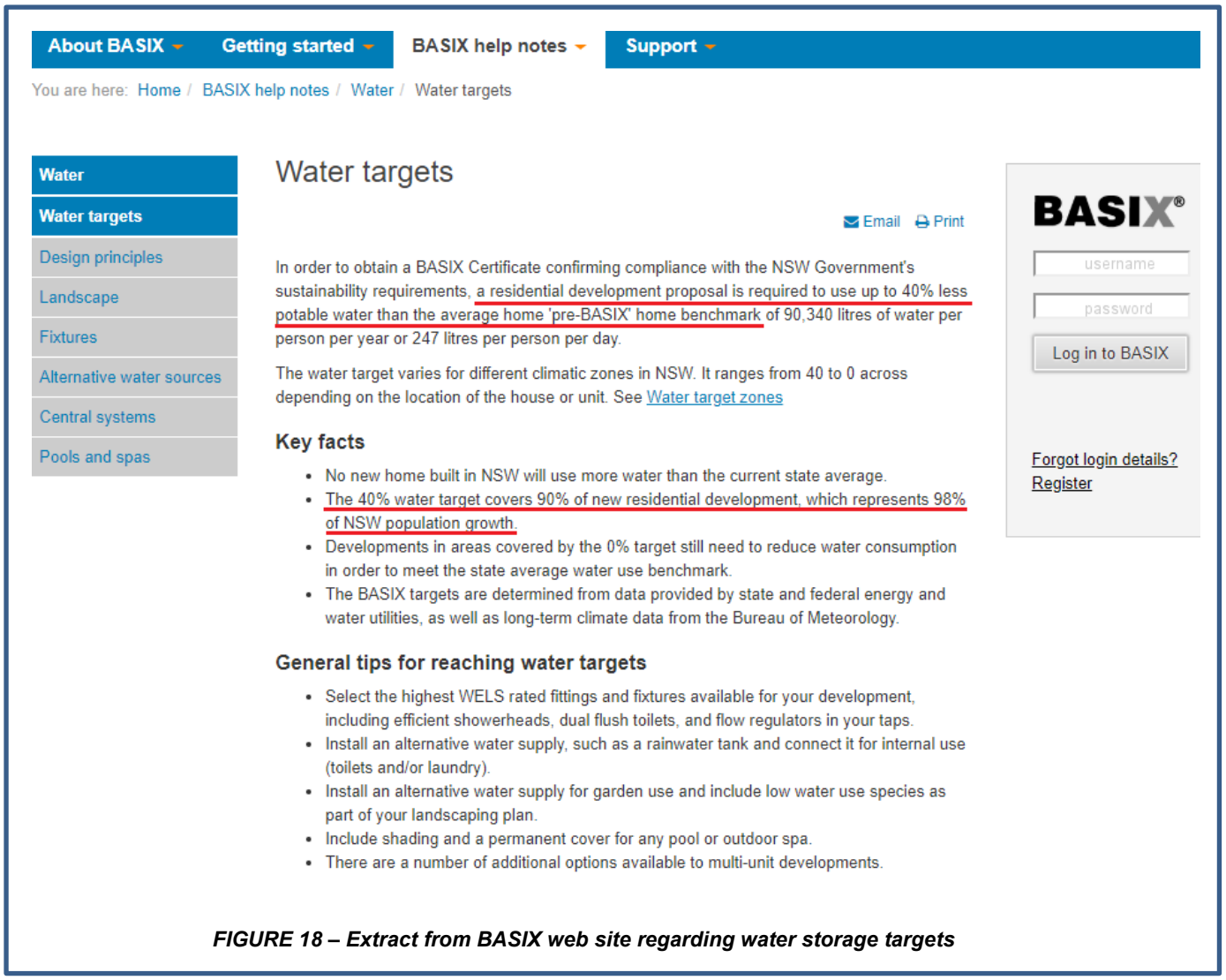


FIGURE 18 – Extract from BASIX web site regarding water storage targets

Leafguards provided on lengths of roof guttering are recommended prior to rainwater storage, particularly in bushfire prone areas where dry leaves and other flammable debris may be collected at roof level. This can also reduce the pollutants which may find their way into a rainwater storage tank and cause discolouration of the non-potable water supply. A rainwater pump is to be provided to pressurise the rainwater service and maintain minimum flow performance requirements at the relevant fixtures and taps. A backup mains supply should be fitted with an appropriate backflow prevention device to ensure that contaminants in the rainwater tank will not pollute the public drinking water system and that taps will still function during a power failure.

To reduce the “doubling up” of the drainage pipe systems with extensive rainwater reuse and stormwater pipe networks, it is proposed that the closest residential building to the detention tank (Block A) would provide roof runoff for rainwater storage purposes, and the remaining downpipe systems for the development would be merged with the main stormwater drainage network. Based on BASIX assessment rainwater storage requirements as summarised below (Figure 19), a minimum volume of 5m3 would be anticipated to have sufficient storage to meet the required BASIX target. However, a minimum volume of 20m3 (or 20,000L) is proposed to provide additional capacity for non-potable supply.

9. Commitments for common areas and central systems/facilities for the development (non-building specific)

(b) Common areas and central systems/facilities

(i) Water	Show on DA plans	Show on CC/CDC plans & specs	Certifier check
(a) If, in carrying out the development, the applicant installs a showerhead, toilet, tap or clothes washer into a common area, then that item must meet the specifications listed for it in the table.		✔	✔
(b) The applicant must install (or ensure that the development is serviced by) the alternative water supply system(s) specified in the "Central systems" column of the table below. In each case, the system must be sized, be configured, and be connected, as specified in the table.	✔	✔	✔
(c) A swimming pool or spa listed in the table must not have a volume (in kLs) greater than that specified for the pool or spa in the table.	✔	✔	
(d) A pool or spa listed in the table must have a cover or shading if specified for the pool or spa in the table.		✔	
(e) The applicant must install each fire sprinkler system listed in the table so that the system is configured as specified in the table.		✔	✔
(f) The applicant must ensure that the central cooling system for a cooling tower is configured as specified in the table.		✔	✔

Common area	Showerheads rating	Toilets rating	Taps rating	Clothes washers rating
All common areas	no common facility	no common facility	no common facility	no common laundry facility

Central systems	Size	Configuration	Connection (to allow for...)
Central water tank - rainwater or stormwater (No. 1)	5000.0	To collect run-off from at least: - 400.0 square metres of roof area of buildings in the development	- irrigation of 9000.0 square metres of common landscaped area on the site

FIGURE 19 – Minimum BASIX rainwater tank requirement

8.0 STORMWATER TREATMENT MEASURES

Reference is made to the requirements of Northern Beaches Council and specifically to the Pittwater 21 Development Control Plan 2014 – Section B5.9 Stormwater Management – Water Quality – Other than Low Density Residential. The described measures and table below (Figure 20) indicate Council's stormwater quality improvement requirements based on site area and development type.

Land Size greater than 1500 sqm ← Site area = 18810m2

Development shall incorporate stormwater quality improvement measures (as indicated on Table 1) to undertake (where specified) the following:

- Pre-screening of organic matter (eg. leaf litter) prior to collection of rainwater.
- Primary treatment (eg. physical screening, rapid sedimentation techniques) of stormwater to collect and retain gross pollutants (i.e. litter and organic matter), coarse sediments (with associated entrained pollutants), and oil and grease prior to the discharge of stormwater from the land
- Secondary treatment (eg. fine particle sedimentation and filtration techniques) of stormwater to collect and retain medium to fine sediments (with associated entrained pollutants) prior to the discharge of stormwater from the land
- Tertiary treatment (eg. enhanced sedimentation and filtration, biological uptake, absorption onto sediments) to remove dissolved pollutants (including nutrients and heavy metals) prior to the discharge of stormwater from the land.

Table1: Stormwater Treatment Requirements

LEVEL OF TREATMENT	Pre	Primary	Secondary	Tertiary
DEVELOPMENT TYPE				
Shop top housing	X	X		
Business development	X	X		
Industrial development	X	X		
Subdivision		X	X	X
Tennis court		X		
Multi dwelling housing	X	X	X	
Residential flat building	X	X		
Seniors housing	X	X	X	
Child care centre	X	X	X	
Hospital	X	X	X	
Rural industry	X	X	X	X
Other development	X	X	X	

← SENIORS HOUSING does not require tertiary treatment

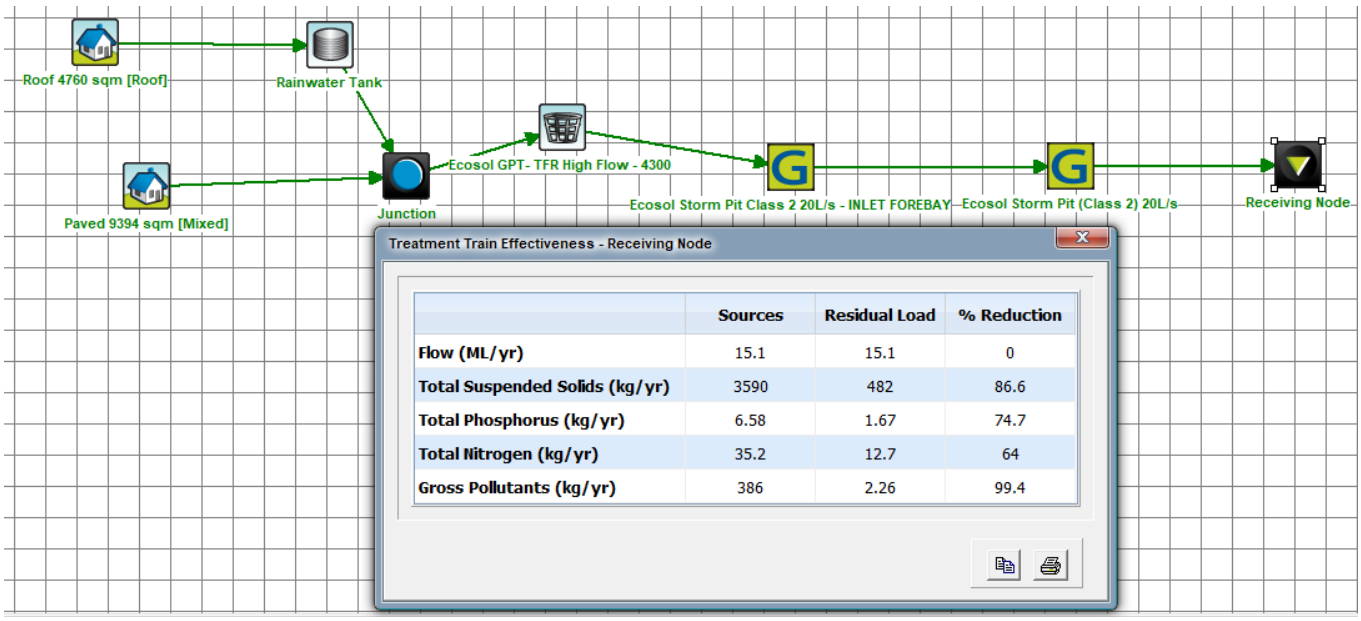
Note: **X** Indicates the minimum level of stormwater pollution treatment required for the development.

All stormwater quality improvement devices (SQIDs) must be compatible with site constraints and the integrated water management system.

All stormwater quality improvement devices must make provision for convenient and safe regular inspection, periodic cleaning, and maintenance.

FIGURE 20 – Extract from Council for Stormwater Treatment Requirements

Stormwater quality improvement devices are typically selected to satisfy the relevant pollutant target performance criteria as demonstrated by a software package known as MUSIC (Model for Urban Stormwater Improvement Conceptualisation). A screenshot of this analysis is included below (Figure 21) to demonstrate the proposed performance characteristics of the treatment system and the particular devices considered to be appropriate for this application.



	Sources	Residual Load	% Reduction
Flow (ML/yr)	15.1	15.1	0
Total Suspended Solids (kg/yr)	3590	482	86.6
Total Phosphorus (kg/yr)	6.58	1.67	74.7
Total Nitrogen (kg/yr)	35.2	12.7	64
Gross Pollutants (kg/yr)	386	2.26	99.4

FIGURE 21 – MUSIC Model Results

Proposed measures include the following items to achieve the indicated pollutant reduction values :-

- ❖ Rainwater tank storage collecting roofwater runoff for non-potable purposes;
- ❖ Ecosol gross pollutant trap GPT 4450 (to suit larger pipe than 4300 model)
- ❖ Ecosol Storm Pit Class 2_20L filtration device

9.0 TEMPORARY EROSION & SEDIMENT CONTROL

During construction works the management of soil and water movement requiring erosion and sediment control is to be undertaken in accordance with the Landcom publication *Soils and Construction: Managing Urban Stormwater 4th Edition, March 2004* (also known as "the Blue Book"), as referenced in Pittwater Council Stormwater Management Strategy 2015-2019 – Appendix D: Improving stormwater quality - Section 10.1.1.2 managing urban stormwater – soils and construction.

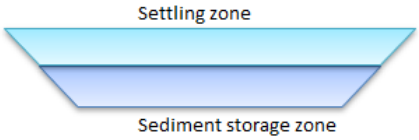
The following **Erosion and Sediment Control Assessment** references the Blue Book guidelines.

Assumed area of soil disturbance = 18810m2
Take Rainfall Erosivity Factor R = 4000 for Bayview (from Appendix B: Map 10 on Page B-12)
Take Site Slope = 14%
Indicative Erosion Hazard is High (based on Section 4.4.1 Figure 4.6 on Page 4-10)
Used Revised Universal Soil Loss Equation (RUSLE) to check:
Take Soil Erodibility Factor K = 0.018 (from Appendix C: Table 20 for Warriewood on Page C-106)
Take Slope Length/Gradient Factor LS = 4.61 (from Appendix A: Using 80m Length in Table A1 on Page A-9)
Take Erosion Control Practice Factor P = 1.3 (from Appendix A: Figure A5 on Page A-12)
Take Ground Cover & Management Factor C = 1.0 (from Appendix A: Figure A5 on Page A-12)
Soil Loss = 4000 x 0.018 x 4.61 x 1.3 x 1.0 = 431t/ha/yr
Soil Loss Class = 4 (between 351 & 500t/ha/yr) (based on Section 4.4.2 Table 4.2 on Page 4-13)
Erosion hazard is therefore Moderate & there are no seasonal restrictions on site activity
For a soil density of 1.0t/m3 Average Annual Soil Loss = 431m3/yr
Since this is greater than 150m3/yr, a sediment basin is considered necessary where excavated site portions & areas of soil disturbance exceed 2500m2 (refer to Section 6.3.2(d) on Page 6-8).
For the area to be disturbed on this site, sediment fences are considered satisfactory where they can be arranged to limit areas draining towards a single section of sediment fencing to 1850m2 (refer to Section 2.1 on Page 2-1, Section 4.4.1(a) on Page 4-9 & Section 4.3.2(h)(iv) on Page 4-4). This can be arranged by introducing return angles in the sediment fencing and indicated in the Blue Book. Runoff from the main works area shall be collected by a sediment basin in the vicinity of the proposed detention tank excavation until the upper areas have been progressively stabilised and the tank construction can be undertaken.
Lengths of sediment fencing should be arranged to limit subcatchment flows to 50L/s (refer to Section 6.3.7(e) on Page 6-34 & Section 2.3.1(e) on Page 2-4)
For 10yr 5min Intensity = 177mm/h & 10yr 1hr Intensity = 58.6mm/h a fully pervious area of up to 1850m2 can be accommodated by one length of sediment fencing (refer to Figure 6-10 on Page 6-34).

All pits & pipework associated with proposed drainage systems shall be kept free of soil, water & debris for the duration of the construction works.
All loose imported fill & excavated material shall be stockpiled as far as possible from sediment fences prior to final placement, compaction or removal from site.
Excessive sediment buildup shall be avoided by regular maintenance of sediment fences.
Where applicable, approved landscaping & revegetation of disturbed areas shall commence at the earlies opportunity after completion of earthworks operations.
Where basement excavation extends lower than the surrounding ground surface, the deepest part of the area shall effectively function as a temporary sediment basin until dewatering operations convey the contaminated runoff up to the formal sediment basin area at ground level. Where pump discharge is directed to the street system, the Contractor must ensure adequate settlement of particulate matter has occurred (e.g. 50mg/L total suspended solids) prior to pumping.

SEDIMENT BASIN VOLUME CALCULATION (for Type C Soils)

Area of catchment	=	1.881	ha
Average rainfall intensity for 1 year storm event	=	98.4	mm/h
Frequency factor for 1 year	=	0.62	
C10 runoff coefficient for ARI of 10 years	=	0.8	
Conversion factor to derive half 1 year event	=	0.5	
Conversion factor for 2 months out of a year		0.17	
Erosivity factor R		4000	
Soil erodibility factor K		0.018	
Slope length gradient factor LS		4.61	



Average annual soil loss	=	431	m3/yr
Peak flow for 3 month storm	=	0.13	m3/s
Minimum basin surface area	=	523	m2 based on 4100m2 per m3/s of flow
Minimum basin length for 3:1 length:width ratio	=	39.6	m
Minimum basin width for 3:1 length:width ratio	=	13.2	m
Two month soil loss volume	=	106	m3
SETTLING ZONE VOLUME (based on minimum 0.6m depth)	=	314	m3
SEDIMENT STORAGE ZONE VOLUME	=	314	m3
TOTAL BASIN VOLUME	=	**628**	**m3**

During construction works temporary measures are anticipated to include:-

- Sediment basin with minimum dimensions as calculated above
- Sediment fencing on the low side of earthmoving operations;
- A gravel layer at the construction vehicle access point into the area of works
- Regular monitoring of soil movement characteristics and cleaning of sediment deposits as required during construction

10.0 WATER MANAGEMENT PLAN

Opportunities for the implementation of water sensitive urban design components are usually readily applied to development sites retaining extensive landscaped areas that can produce a similar environment to a property in its natural predeveloped greenfield state, encouraging the normal water cycle of rainfall precipitation, soil infiltration and vegetation growth. However, in the case of large impervious building works incorporating basements excavated to underlying sandstone, opportunities become more limited for natural subsurface recharge. The deep soil landscaped areas around the proposed building footprints for this development are estimated to occupy about 25% of the Waterbrook development works area, with the remaining 75% of the property comprising impervious roof and paved areas.

The conceptual location of water management plan components is indicated on the plan below (Figure 22) and should be read in conjunction with the final stormwater concept drawings prepared for the development application, which supersede the conceptual design with more detailed pipe route definition.

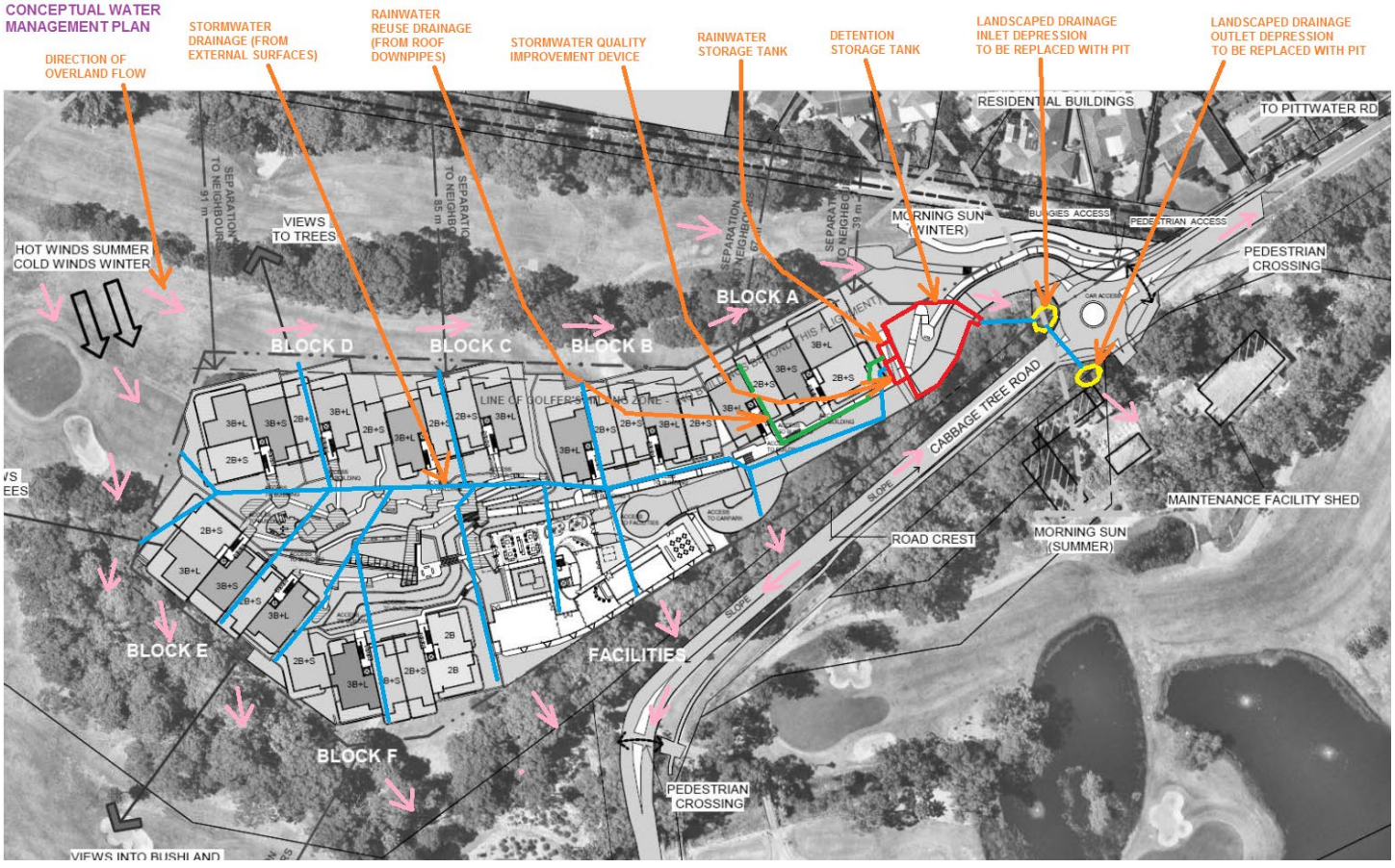


FIGURE 22 – Conceptual Water Management Plan

Based on the Geotechnical and Acid Sulfate Soils Assessment prepared by Martens Consulting Engineers (Ref: P1706099 JR02V02) dated November 2017, most of the borehole investigation results indicated underlying sandstone to a relatively shallow depth of approximately one or two metres.

The plan below (Figure 23) indicates the locations of boreholes.

FIGURE 23 – Borehole Location Plan

Approximate (relatively shallow) depths to sandstone generally range from 0.6m up to 2.0m.

<u>Due the extensive basement footprint area and the presence of underlying sandstone, soil infiltration and absorption systems are not considered desirable or appropriate for this development.</u>

11.0 INTEGRATED WATER MANAGEMENT STRATEGY

Proposed Water Sensitive Urban Design (WSUD) strategy measures to be integrated within this development site include the following components and provisions:-

- Pervious vegetation or landscaping is generally to be provided along the nominal boundary of proposed development, to promote and maintain some degree of natural soil infiltration generally along the perimeter of the site works, and support the processes associated with the natural water cycle.
- Rainwater storage and alternative supply of non-potable demand is intended for toilet flushing and irrigation of landscaped areas in the vicinity of the proposed Block A building. When partially empty, the rainwater tank also provides some degree of flood attenuation benefit prior to becoming full and overflowing into the downstream drainage infrastructure. Refer also to the BASIX assessment contained in the Rainwater Storage section of this report.
- Water efficient fittings are proposed for new tapware in accordance with the BASIX assessment.
- On-site detention storage is to be provided such that pre-development flows from a fully landscaped site will not be exceeded in the post-development condition. Refer to the DRAINS modelling results in the On-Site Detention Storage & Site Drainage section of this report.
- Stormwater quality improvement devices to capture gross pollutants and litter are to be installed on the inlet system to the detention tank.
- Overland flow paths are to be managed around the development so that no unacceptably adverse impacts will be generated within or around the development site.

12.0 CONCLUSION

This Stormwater Management Report for the proposed Waterbrook development identifies and addresses the following items for the Site Compatibility Certificate assessment by the Department Planning and Environment :-

- Mainstream flooding effects are not considered to be applicable to the site of the proposed works;
- Local overland flow paths are to be managed in and around the area of development works as described in the Cardno Flood Impact Assessment;
- The street drainage connection is to incorporate replacement of existing pipes to suit a new roundabout layout;
- Appropriate discharge to the existing natural drainage system in the lower golf course grounds via upgraded drainage under Cabbage Tree Road with suitable headwall construction arrangements;
- On-site detention is to be provided in accordance with Council requirements;
- Rainwater storage is to be provided in association with the proposed Block A building and is to comply with BASIX assessment requirements;
- Stormwater treatment is proposed to reduce the level of gross pollutants and litter being conveyed through the stormwater drainage system. It is intended that suitable proprietary units will be utilised from a recognised supplier such as Ecosol; and
- Erosion and sediment movement is to be controlled during construction with suitable measures to prevent undesirable soil deposits around the works area.