
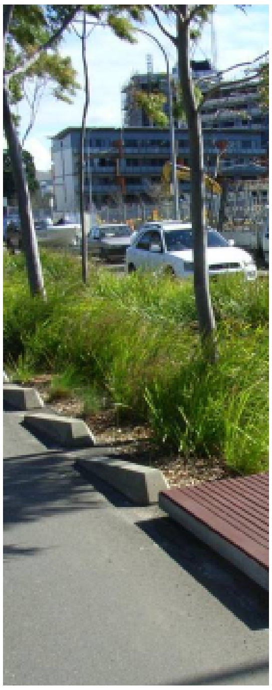


ST PATRICKS ESTATE, SPRING COVE, MANLY

STORMWATER QUALITY ASSESSMENT REPORT

November 2011

Spring Cove Developments Pty Ltd

Mott MacDonald
Hughes Trueman

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Level 10, 503-505 Kent Street
Sydney NSW 2000

Mott MacDonald Hughes Trueman Pty Limited, Level 2, 60 Pacific Highway, St Leonards, NSW 2065, Australia
PO Box 151, St Leonards, NSW 1590, Australia
T +61 (0)2 9439 2633 F +61 (0)2 9438 4505, www.hughestrueman.com.au

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Mott MacDonald Hughes Trueman Pty Limited, Level 2, 60 Pacific Highway, St Leonards, NSW 2065, Australia
PO Box 151, St Leonards, NSW 1590, Australia
T +61 (0)2 9439 2633 F +61 (0)2 9438 4505, www.hughestrueman.com.au

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1. Introduction

1.1 Background

This Stormwater Quality Assessment Report was originally prepared by Mott MacDonald Hughes Trueman on behalf of Lend Lease Development and pertains to the Spring Cove residential Development in Manly (formerly Precincts 5, 6 & 10, St Patrick's Estate). This amended report has been prepared on behalf of Spring Cove Development - the current site owners, and addresses relevant consent conditions from Development Application No. 482/04 and other construction related matters.

The report describes the overall strategy for managing stormwater and outlines the analysis undertaken for the assessment of stormwater quality aspects of the proposed development. The report also provides details of the expected changes in pollutant loads resulting from the proposed water quality improvement best management practices which are included in the stormwater management strategy for the site.

1.2 Stormwater Management Strategy

The aim of this strategy is to demonstrate that there will be no net increase in the average annual pollutant load from the developed site when compared with the existing site conditions.

In developing the water management strategy for the Spring Cove development, prime consideration has been given to the environmental and landscape values of the site and its surroundings. The plan has been prepared based on best practical management practice in stormwater management to prevent degradation of these values. In this context the major objectives of the water management strategy are to:

- Protect the environmental values of land and aquatic ecosystems downstream of the development areas by achieving zero net increase of sediment and nutrient loads leaving the site.
- Maximising opportunities for recycling of stormwater within the Estate.
- Minimise the disturbance to the hydrologic regime of the surrounding landscape.
- Using proven and reliable technology and / or management methods for the control of stormwater quantity.
- Complying with all relevant statutory requirements for development and operation of the site.

1.3 Study Objectives and Scope

The objectives of this report are as follows:

- Describe the main features of the stormwater drainage system and the associated water quality control systems
- Establish through modelling the existing water quality and quantity of stormwater runoff from the site;
- Establish through modelling the quality and quantity of stormwater runoff from the site due to the proposed development; and
- Assessment of the proposed changes in water quality and quantity which have the potential to impacts on the ecological health of the downstream receiving waters.

1.4 Overview of Report

Section 2 of this report describes physical characteristics of the site including topography, soils and climate.

Section 3 details the stormwater runoff under pre-development conditions and provides the rationale behind the modelling to provide a representation of the baseline stormwater runoff quality. The post development stormwater runoff is detailed and the connectivity and operation of the proposed sources, and treatment zones are provided.

Section 4 provides an overview of modelling results, and Section 6 provides a summary and recommendations to ensure that the objectives will be met.

Details of the modelling input data and results are included in Appendix A and Appendix B respectively.

2. Site Characteristics

2.1 Overview

The southern precincts of the Spring Cove development extend south from Darley Road to Spring Cove and currently house St Paul's College and the Archbishop's residence. Until recently, Gilroy House was a significant constructed feature of the site, and there are also a number of historically significant features of the site including steps and pathways.

To the east of the site is the Sydney Harbour National Park, and to the west is residential development. Drainage from the site flows to Spring Cove which borders the North Harbour Aquatic Reserve. Spring Cove is a documented site for Fairy Penguin colonies, and is therefore an environment sensitive to any change in runoff quality resulting from the proposed development.

2.2 Topography

The site drains from Darley Road in the north down to Spring Cove in the south. The average slope through the proposed development area of the site is approximately 16%. Benching of the site is evident at the location of the former Gilroy House, which was due to filling associated with the construction of the building (now removed).

There are some specific portions of the site with stands of Melaleucas which indicate the potential for perched water tables due to the shallow rock ledges, with associated water-logging.

2.3 Soils

The Spring Cove site south of Darley Road is generally characterised by shallow, sandy loam soil with sandstone rock outcrops. According to the Soil Landscapes of Sydney 1:100,000 Sheet (Chapman & Murphy, 1989), the dominant soil is the Gymea landscape.

The Gymea soil landscape is an erosional soil landscape. The limitations of this type of landscape are shallow highly permeable soils, high soil erosion hazard, and rock outcrops. The soil erosion hazard for concentrated flows is extreme to high.

2.4 Climatic Data

Rainfall data utilised in the assessment of the Spring Cove site is a compilation of data used in previous water quality and water balance models for the site. The daily rainfall data comprises a compilation of 20 years of rainfall data from North Head, Manly. Daily evaporation data for Sydney Airport was used with a constant of 0.87 applied to calculate evapotranspiration as required in the stormwater quality.

The average annual rainfall during the period 1974 – 1993 was 1,215 mm and the corresponding evaporation was 1,550 mm.

3. Stormwater Management System Overview

Stormwater runoff from the land immediately adjacent to Darley Road (principally St Paul's College and the Archbishop's Residence) drains through the Spring Cove site before discharging into Spring Cove.

Runoff from the areas proposed for development south of St Paul's College will be directed through "treatment zones". These provide water quality treatment, reduce connection of impervious surfaces to the piped stormwater drainage system and feed the natural infiltration areas which exist under pre-development conditions to maintain existing significant vegetation identified on the site. Figure 3.1 below shows a schematic of the proposed stormwater management system under post-development conditions.

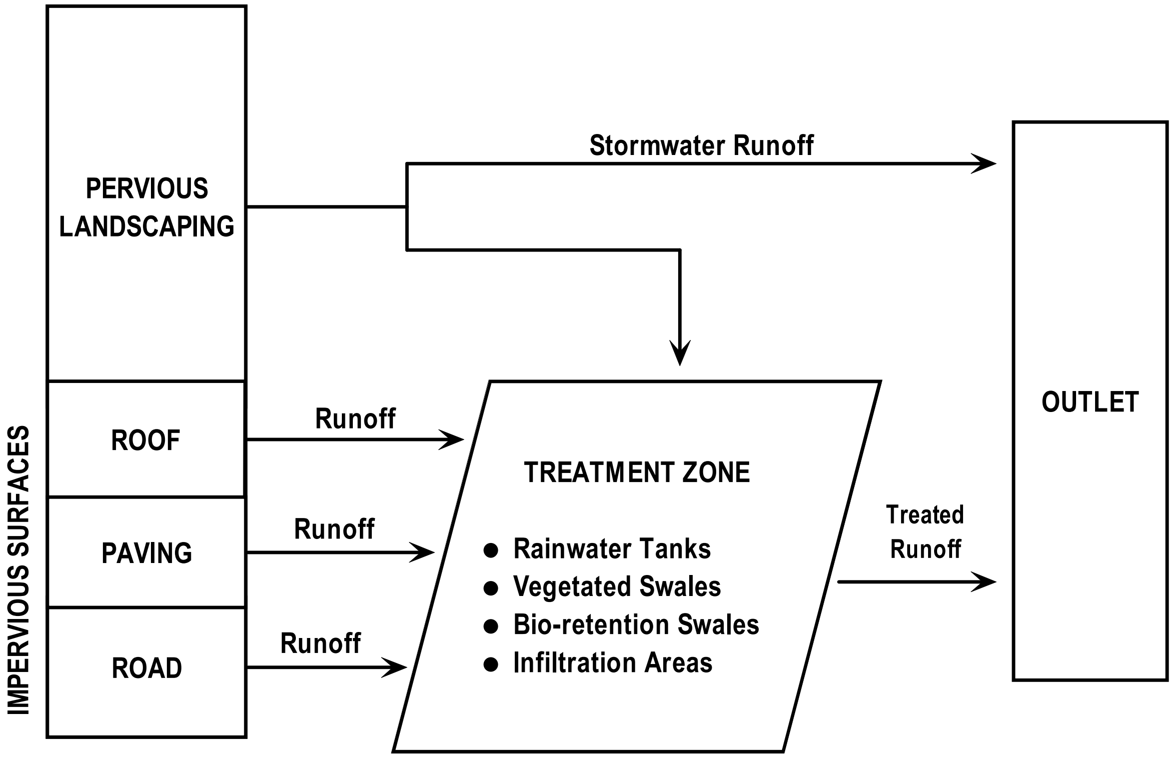
The "treatment zones" are detailed in Section 4.9 and include rainwater tanks for the capture and reuse of roof runoff, vegetated swales, bio-retention swales and infiltration areas. The infiltration areas are located in sites which currently receive a fair degree of water logging and require frequent high water tables to maintain the health of the existing vegetation.

Under proposed development conditions, drainage components which reduce connection of runoff from impervious surfaces to the piped drainage system are included. This "disconnection" from the piped drainage system increases the opportunities for natural treatment processes including seepage, infiltration and nutrient uptake.

The proposed stormwater strategy therefore comprises the following components:

- To the extent possible, diversion of runoff from upstream catchments around the development site;
- Disconnection of impervious surface runoff from the piped stormwater drainage system utilising "treatment zones" which include rainwater reuse and infiltration;
- Incorporating water sensitive urban design principles in the conveyance and water quality treatment of stormwater runoff utilising swales and bio-retention systems; and
- Identifying the naturally wet areas of the site and recognising that these areas require shallow ponding and infiltration of water to maintain the health of the existing vegetation.

Figure 3.1: Conceptual Stormwater Management System Post-Development Conditions



4. Water Quality Assessment

4.1 Background and Methodology

The Model for Stormwater Improvement Conceptualisation or MUSIC (developed by the CRC for Catchment Hydrology and version 3 released in 2005) has been chosen to develop a representative model of pollutant generation from the catchment and the effect of various treatment processes in capturing stormwater pollutants. MUSIC utilises soil:water storage relationships, rainfall and evapotranspiration to represent the hydrology of the catchment. The model then generates pollutant loads from sub-catchments according to broad land use types. Pollutant loads can be generated according to either a stochastic model or event mean concentrations, and the model generates runoff and pollutant loads for both surface and sub-surface components of runoff from a catchment.

The rainfall component of the model is specified by the user. A daily timestep has been used for the Spring Cove site analysis. The model also incorporates user-defined water quality improvements and is able to assess the effectiveness of a treatment train approach for water quality improvement within a catchment. The treatment train can include best management practices including swales, bio-retention zones, as well as re-use of stored water such as rainwater tanks.

4.2 Water Quality Objectives

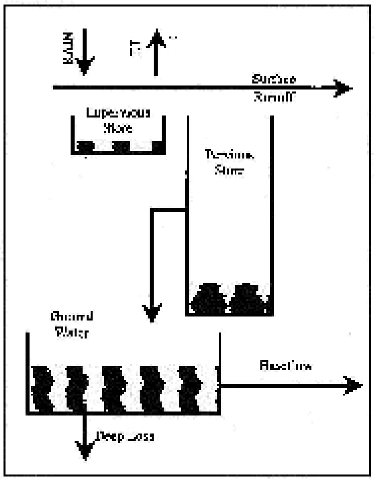
The water quality objectives for the proposed development of the Spring Cove site are a zero net increase (from existing conditions) in average annual pollutant loads leaving the site.

4.3 Rainfall and Runoff Analysis

The structure of the rainfall-runoff model within MUSIC and the conceptual representation of the processes involved are shown in Figure 4.1. The model allows for separate runoff generation processes on impervious and pervious portions of a catchment.

In order to calibrate the hydrologic component of the MUSIC model, the soil moisture parameters may be varied, until the desired runoff characteristics are achieved (see Section 4.5).

Figure 4.1: Conceptual Rainfall-Runoff Model as adopted for MUSIC (V3.0.1)



Source: **MUSIC User Guide, 2005**

4.4 Pollutant Exports

The MUSIC model includes default pollutant generation parameters for three landuse types (“Urban”, “Agricultural” and “Forest”) which are the result of an extensive data search and compilation by the CRC for Catchment Hydrology. The *Australian Runoff Quality* (IEAust 2005) provides a detailed breakdown of the expected mean pollutant loads according to landuse (urban, residential, industrial, rural or forest) and by land use type (i.e. roads, roofs etc). In developing a model for the Spring Cove site, the dominant landuse type is residential, which is represented by the “Urban” land use (or source node) in the MUSIC model. An alternative landuse type that could be chosen in the model is “Forest” which would represent undisturbed areas of natural bushland.

The proposed development of the site will include landscaping using native species and preservation of the existing stands of significant trees. It could be argued that under post-development conditions, the garden areas of the site could be represented by the “Forest” landuse type in the model which generates a much lower pollutant load (particularly phosphorus). However, in view that the past landuse includes landscaping with open lawns and exotic plant species, it is likely that the phosphorus content of soils on site has increased over time, and would no longer be representative of the natural bushland.

Adopting an "urban" pollutant generating landuse type may overestimate stormwater pollutant loads from garden areas of the post-developed site, but provides a conservative approach to stormwater pollutant generation.

Table 4.1 below shows the pollutant loads applied to the Spring Cove site. The default parameters have been altered according to the mean values provided in the *Draft Australian Runoff Quality* which better represent expected pollutant load by surface type. These values have been used to produce expected pollutant loads under both pre-development and post-development conditions for the Spring Cove site.

MUSIC has the option to generate pollutants stochastically according to a log-normal relationship. This option was used in the water quality modelling of the Spring Cove site.

Table 4.1: MUSIC Default and Proposed Water Quality Parameters

Source Catchment	Flow Component	TSS (mg/L)		TP (mg/L)		TN (mg/L)	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
All Urban Runoff (MUSIC Default)	Baseflow	**12.6**	**1.5**	**0.2**	**1.5**	**2.1**	**1.3**
	Stormflow	**158.5**	**2.1**	**0.35**	**1.8**	**2.6**	**1.5**
Roof Runoff	Baseflow	**0**	**0**	**0**	**0**	**0**	**0**
	Stormflow	**35.0**	**2.1**	**0.15**	**1.8**	**2.6**	**1.5**
Urban Road Runoff	Baseflow	**12.6**	**1.5**	**0.2**	**1.5**	**2.1**	**1.3**
	Stormflow	**260**	**2.1**	**0.25**	**1.8**	**2.2**	**1.5**

4.5 MUSIC Model Calibration

In previous work (for Ku-ring-gai Council) a MUSIC model for Burnt Bridge Creek was developed using data from the Sydney Water Monitoring Project (1993, 1994). Using the recommended procedure, the "Effective" Imperviousness for the Burnt Bridge Creek catchment was determined to be 13%. When compared with a measured actual imperviousness of about 43%, this would indicate that about 30% of the catchment could be considered unconnected to the formal (piped) drainage system.

According to the Sydney Water Monitoring Project (1993, 1994), rainfall:runoff ratios for Burnt Bridge Creek were 21% for 1994 and 17% during 1993, and Greendale Creek 26% in 1994 and 37% in 1993. Unfortunately, 1993 and 1994 were two of the driest rainfall years on record and are not an appropriate means of establishing the runoff ratio for the Spring Cove site.

The MUSIC model is sensitive to the imperviousness of catchments, and accordingly impervious areas have the greatest impact on generating both runoff and pollutant loads. At the Spring Cove site, under the pre-developed or existing conditions, the actual imperviousness of the site is 20%. This would indicate an effective imperviousness of about 7% (assuming 30% connection to the drainage system). Therefore, disconnection from a drainage system was introduced by incorporating swales in the model, to represent conditions as they currently exist. This is discussed in detail in Section 4.8.

In the absence of any runoff volumes or water quality data for the Spring Cove site which could be reliably used in the MUSIC model, the following approach has been adopted:

- The pre-development and post-development conditions models have been developed in MUSIC using the stochastic pollutant generation option, using pollutant characteristics shown in Table 4.1.
- The hydrology of the pre-development conditions has been calibrated to generate an average annual site runoff of about 24% of the average annual rainfall volume over the 20 year period of record.

The soil parameters adopted for the Spring Cove site are detailed below.

Table 4.2: MUSIC Urban Rainfall Runoff Parameters

Parameter	Input Value
Impervious Areas	
Rainfall Threshold (mm/day)	1.5
Pervious Area Properties	
Soil Storage Capacity (mm)	300
Initial Storage (% of Capacity)	30
Field Capacity (mm)	200
Infiltration Capacity Coefficient – a	200
Infiltration Capacity Coefficient – b	1
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (mm)	5
Daily Deep Seepage Rate (mm)	1

The treatment train included in the pre-development conditions model is described in detail in Section 4.8. The treatment train includes swales throughout the site which represent the existing level of treatment achieved prior to discharge from the site. The adopted seepage rate from these swales is 2 mm/hour in recognition that the shallow soils will allow a shallow seepage of ponded water within the swales.

The runoff from the site under pre-development conditions is calibrated to a percentage rainfall:runoff of 24%. This is based on an average annual rainfall of 1,215 mm over the site area of 6.11 ha, and an average annual runoff of 17.3 ML/year.

4.6 Sub-catchment Definition

The layout of the site under post-development conditions has been used as a basis to identify the sub-catchment areas which were input to the MUSIC models. These sub-catchments were defined according to the location of areas draining to a treatment zone which might be a swale, an infiltration area, or a formalised overland flow path. Therefore the terminology applied is as follows:

Treatment Zone: an area or specific constructed device which provides water quality improvement. These zones include infiltration areas which provide sub-surface drainage and shallow ponding to existing Melaleuca stands, formalised swales, and bio-retention swales which include an infiltration zone and sub-surface drainage. Treatment Zones are identified by a number (i.e. Treatment Zone 1, Treatment Zone 2, etc).

Sub-catchment – the sub-catchment areas have been broken down by landuse type. Broadly the landuse is either residential development, school or treatment zone. The sub-catchments follow the proposed drainage layout so that sub-catchments drain to the water quality feature proposed under the drainage strategy. Sub-catchments without treatment zones are identified by a letter (i.e. Sub-catchment A, Sub-catchment B, Sub-catchment C, etc). There also some Treatment Zones with a contributing sub-catchment area identified as the number of the treatment Zone (i.e. Sub-catchment 1, Sub-catchment 2, etc)

Source Sub-catchment - Each sub-catchment has been further divided to identify source sub-catchments according to each surface type. The pollutant load specific to each surface type (outlined in Table 4.1) was then modelled. The source sub-catchments identified in the model are:

- Pervious areas (Urban Runoff)
- Roof areas (Roof Runoff)
- Paved Surfaces (as part of the landscaping features for each house) (Urban Runoff)
- Road areas (Road Runoff)

The existing St Pauls College areas north of the development have been divided into two sub-catchments: A and B. Detailed separation of source sub-catchments in A and B has not been undertaken. A conservative estimate of the impervious areas has been applied where sub-catchment A is 20% impervious and sub-catchment B is 35% impervious.

4.7 MUSIC Model Development

Models were developed to establish the pre-development and post-development water quality of runoff from the Spring Cove site. A part of the treatment train under the developed conditions is rainwater tanks for re-use of roof runoff for toilet flushing and laundry. A sensitivity analysis was also undertaken to characterise the effect of different sized rainwater tanks on the overall quality of runoff from the whole site.

Although Sub-catchments A and B do not constitute part of the proposed development of the site, the treatment of stormwater from sub-catchment B is included in the assessment of post-development conditions. The treatment of this sub-catchment has been included to ensure that the net change in average annual pollutant load in stormwater runoff from the site is zero. Additionally, if required, runoff from sub-catchment A could also be provided with some water quality treatment to further improve stormwater runoff quality from the site. However, assessment of treatment of Area A is not included in this report.

The following Models were developed to characterise the water quality of the stormwater runoff from the Spring Cove site:

- Pre-development Conditions - described in Section 4.8 below
- Post-development Conditions - described in Section 4.9 below

4.8 Pre-development Water Quality

The pre-development conditions of the Spring Cove site south of Darley road are shown on Drawing 01S828-DA-FIG1. Overlaid are the sub-catchment boundaries defined for the post-development development scenario. Under pre-development conditions, the majority of the site drains towards the south-east corner of the site where flows are discharged through a doorway in the existing boundary wall. There are two small outlets located along the southern boundary of the site which discharge very small flows from the site. Under pre-development conditions, the site has the following features:

- Gilroy House (now demolished) was located in the area now identified as Sub-catchments 1, C, D, E and M;
- Stone drain through the area defined as Treatment Zone 1.
- Drainage path following the east boundary wall which has formed a natural drainage channel collecting runoff from Area A and sub-catchments 7 and 8.
- Drainage outlet through the doorway of the pre-development concrete block wall at the south-east corner of the site identified as Outlet 3.
- Pathway and steps through the site identified as Zones 12 and 13
- Two small drainage outlets along the southern boundary of the site identified as Outlets 1 and 2.
- Stands of Melaleucas indicating poorly drained areas of the site these areas are shown as treatment zones 5, 8, 9, 10, 12 and 13.
- Various semi-formalised, natural drains through the site which are represented as swales.

A MUSIC model was developed to represent the water quality of stormwater runoff from the Spring Cove site under pre-development conditions. Incorporating these existing features into the Pre-development Conditions Model is described below.

The source sub-catchment areas used in the pre-development conditions stormwater quality assessment are detailed in Table 4.3 below. The total site area is 6.1 ha and the impervious area is 1.2 ha.

Table 4.3: Pre-development Conditions Sub-catchment Areas

Sub-catchment	Total Area (ha)	Area Impervious (ha)	Area Pervious (ha)
Area A	2.63	0.92	1.71
Area B	1.1	0.06	1.04
Gilroy House	0.15	0.15	-
1 C D E M Pervious	0.81	0.04	0.77
F+G-Pervious	0.06	-	0.06
H-Pervious	0.14	-	0.14
I-Pervious	0.23	-	0.23
J-Pervious	0.16	-	0.16
K-Pervious	0.11	-	0.11
L-Pervious	0.12	0.01	0.11
N-Pervious	0.08	-	0.08
P-Pervious	0.08	-	0.08
5-Pervious	0.07	-	0.07
6-Pervious	0.02	-	0.02
7-Pervious	0.09	-	0.09
8-Pervious	0.05	-	0.05
9+10-Pervious	0.02	-	0.02
12-Pervious	0.07	-	0.07
13-Pervious	0.05	-	0.05

4.8.1 Gilroy House

Gilroy House (now demolished) was located within the areas identified as sub-catchments 1, C, D, E and M and had a roof surface area of 1,530 m^2. Drainage from the roof was directed to the edge of the embankment shown as the boundary between sub-catchments E and N. Under pre-development conditions, these roof drainage outlets provided additional stormwater runoff to the vegetation in sub-catchment N and a stand of Melaleucas in Treatment Zone 5.

Under pre-development conditions, roof runoff from Gilroy House was treated separately through wide, shallow overland flow shown as Treatment Zone 5.

The remaining sub-catchment area around Gilroy House is 8,100 m^2 and includes pathways, driveway and landscaping. Drainage from this area flows towards outlet O-3 located at the south-east corner of the site.

Details of the MUSIC input parameters representing Gilroy House are included in Appendix A.

4.8.2 St Paul's College

The area of the site between Gilroy House and Darley Road which will not be re-developed, houses the school and Archbishops residence areas of St Paul's College. This area extends from Darley Road in the north to the boundary of the sub-catchment areas identified as C and D. As shown on Drawing 01S828-DA-FIG1, the St Paul's College area has been divided into Sub-catchment A and Sub-catchment B.

Sub-catchment A represents the eastern portion of St Paul's College which includes the school buildings, tennis courts, and paved areas. The estimated imperviousness for this area is 35%. Under pre-development conditions, within this sub-catchment, small informal swales direct stormwater runoff towards the eastern boundary, and a drainage channel has formed along the eastern boundary wall which carries runoff to the outlet O-3 at the south-east corner of the site.

The small swales located throughout Sub-catchment A provide stormwater quality improvement as well as provide disconnection from the drainage system. These swales have been incorporated in the pre-development conditions drainage system as an extension of the swale along the east boundary wall (also described in Section 4.8.3 below). This swale then connects to further sections of swale downstream which will change under the post-development conditions. Pre-development conditions for Sub-catchment A will not change under post-development conditions.

Sub-catchment B represents the western portion of St Paul's College south of Darley Road. Stormwater runoff from this area drains through the existing stone drain in Treatment Zone 1 and is piped underneath the benched area which includes Gilroy House. This pipe discharges at a pipe outlet within Sub-catchment I, and then follows an informal swale towards the outlet through the opening in the wall identified as outlet O-3.

Details of the parameters used in the MUSIC model to represent the swales draining Sub-catchments A and B are included in Appendix A.

4.8.3 Drainage along East Boundary Wall

As discussed above, drainage from the majority of the site flows towards the drain along the east boundary wall. This swale then discharges at Outlet O-3 which is located at the south-east corner of the site.

There are three distinct sections to this swale according to the areas which will drain to it under pre- and post-development conditions. As shown on 01S828-DA-FIG1, the swale can be broken into three distinct sections according to the sub-catchments it traverses:

- Sub-catchment A (as described above in Section 4.8.2);
- Sub-catchment 7; and
- Sub-catchment 8.

The input parameters for the swales representing the East Boundary Drain are included in Appendix A.

4.8.4 Treatment Zones 12 and 13

Treatment Zones 12 and 13 operate as wide, shallow overland flowpaths located through the areas following the heritage path and stairs to the south of Gilroy House. Under pre-development conditions, stormwater runoff from Sub-catchment Areas 6, 12 and 13 flows overland through these treatment zones and receives nutrient removal by vegetation, and seepage before discharge at Outlet O-2.

Details of the MUSIC Model parameters applied to these treatment zones are included in Appendix A.

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4.8.5 Treatment Zones 5, 8, 9 & 10

These treatment zones were identified in the post-development conditions of the site and indicate stands of Melaleucas or significant vegetation which will be maintained under post-development conditions. These treatment zones are areas that naturally become water logged which has influenced the healthy growth of the Melaleucas.

Treatment zone 5 acts as a wide, shallow swale which receives and provides treatment for roof runoff from Gilroy house. Under pre-development conditions, the remaining treatment zones do not specifically treat the surface runoff from any portion of the site. These remaining treatment zones are more likely to receive sub-surface drainage or base flows from uphill areas of the site and therefore will not be specifically treating runoff at these points.

The MUSIC input parameters for Treatment Zone 5 are included in Appendix A.

4.9 Post-development Water Quality

A MUSIC model was developed to represent the post-development water quality of stormwater runoff from the Spring Cove site. The post-development conditions are those outlined in the Stormwater Quality Management Plan (Hughes Trueman Dwg No. DA-SW01). Drawing 01S828-DA-FIG2 (attached) shows the proposed layout of the site including stormwater drainage and treatment, overlaid are the sub-catchment and treatment zone boundaries as described in Section 4.6.

Under post-development conditions, the site has the following features:

- A unit development of sixteen units located in sub-catchment D,
- Twenty-two houses located in sub-catchments C, E, H, I, J, K, L, and P,
- Rainwater tanks will be fitted to each dwelling to capture and re-use roof water for toilet flushing and laundry,
- Bio-retention swales located at treatment zones 1, 2, 14, 15 and 16,
- Infiltration areas located at treatment zones 4, 5 and 7,
- Wide, shallow swales representing overland flow and shallow ponding through treatment zones 1, 4, 5, 6, 7, 8, 9+10, 12, 13; and
- Three outlet points from the site identified as Outlet-1, 2 and 3.

The proposed features of the stormwater management system under post-development conditions are described below. The layout of the Post-development Conditions Model is shown on Drawing 01S828-DA-FIG2.

4.9.1 Sub-catchment Area Details

As outlined in Section 4.6, sub-catchments have been further divided into source sub-catchments according to surface type. The source sub-catchment areas are detailed in Table 4.4 below.

Table 4.4: Sub-catchment Definition for Post-development Development

Sub-catchment	Total Area (m2)	Road area (m2)	Roof Area (m2)	Paving Area (m2)	Pervious Area (m2)
A	26,270				17,076
B	10,950				8,760
C	3,173	532	795	180	1,666
D	3,709	510	1,586	90	1,523
E	2,428		1,290	329	809
F	309	166			123
G	273	129			144
H	1,406	498	702	86	120
I	2,193		967	277	949
J	1,638	336	400		902
K	1,100		637	35	448
L	1,208		710	40	458
M	536	288			248
N	827				827
P	1135	68	225	42	800
1	248				248
5	659				659
6	192				192
7	881				881
8	547				547
9	143				143
10	67				67
12	652				
13	455	72			383
Total	**60,999**	**2,599**	**7,312**	**1,079**	**37,973**

As discussed, the estimated impervious areas for sub-catchments A and B are 35% and 5% respectively.

4.9.2 Rainwater Tanks and Re-use

It is proposed that rainwater tanks be incorporated into the stormwater strategy for the capture and re-use of roof runoff for laundry and toilet flushing. The estimated usage per household is 350 L/day as detailed in Table 4.5 below.

Table 4.5: Estimated Laundry and Toilet Flushing per Household per Day (Manly)

Per capita indoor use	260 L/person/day
Manly mean household size	3 people
Total daily indoor use	780 L/day
Daily rainwater re-use:	
Toilets (25% indoor use))	195 L/household/day
Laundry(20% indoor use)	156 L/household/day
Daily rainwater re-use	351 L/household/day

The sub-catchments representing roof runoff are a grouping of the houses within each catchment. The “Rainwater Tank” treatment node in the MUSIC model has been used to model rainwater capture and re-use. Rainwater tanks have been grouped together within the sub-catchments, as shown in Table 4.6 below. The parameters entered in the MUSIC model to represent rainwater re-use for each sub-catchment are detailed in Appendix A.

Table 4.6: Rainwater Tank and Re-use Details

Sub-catchment	Roof Area (m2)	Daily rainwater Re-use (kL)	Number of Dwellings	Rainwater Tank Volume (kL)	Model Tank Surface Area (m2)
C	795	1.4	4	20	13.3
D	1,586	5.6	16	80	53.3
E	1,290	1.8	5	25	16.7
H	702	0.7	2	13	8.7
I	967	1.4	4	20	13.3
J	400	0.7	2	10	6.7
K	637	0.7	2	13	8.7
L	710	0.7	2	13	8.7
P	225	0.4	1	5	3.3

The majority of houses will include a 5,000L rainwater tank. House 19 (sub-catchment H), House 20 (sub-catchment K) and House 23 (sub-catchment L) include a swimming pool or spa and therefore have rainwater tanks with 8,000 L capacity. The sizing of these tanks is based on the requirements for improved sustainability and as an outcome of the BASIX assessment which has been undertaken for each house on the site. Further details of the rainwater tank locations and sizes are included in Appendix A.

4.9.3 Treatment Zone 1

Located near the entrance to the site is Treatment Zone 1. This area includes the existing heritage feature of the stone drain and steps. Under post-development conditions, all runoff from Sub-catchment B will be directed into Treatment Zone 1.

Treatment Zone 1 will form wide, vegetated swale with ponding to a depth of 0.3 m. Drainage from Area B will enter Treatment Zone 1 at the north western side and ponding will be encouraged by elevating the outlet pit at the eastern side of the swale. Outflows from Treatment Zone 1 will then be piped to Treatment Zone 6 (discussed in Section 4.9.8).

Small, infiltrating drains (or “leaky” pipes) from the stone drain across the swale will be incorporated into the landscaping of Sub-catchment 1. This will allow water collected in the stone drain during small rainfall events to soak across the swale area. During larger storm events, it is proposed that water can pond across the full width of the area to a depth of about 0.3 m. It is expected that seepage in this treatment zone will occur at a rate of 10 mm/hour.

Details of the MUSIC model inputs for Treatment Zone 1 are included in Appendix A and MUSIC model results are included in Appendix B.

4.9.4 Treatment Zone 2

This treatment zone consists of a bio-retention swale which captures and treats runoff from Sub-catchment D. The proposed development within this sub-catchment includes an access road and a sixteen-unit development. Runoff from the pervious and road areas will be collected in Treatment Zone 2. This swale will be also collect flow from Treatment Zone 15. Overflow from rainwater tanks and runoff from the pavement from Sub-catchment D will enter stormwater pipes connected to the infiltration area in Treatment Zone 4.

A seepage rate of 2 mm/hour has been included with this bio-retention swale which will pond to a depth of approximately 0.3 m. The swale will be vegetated with grasses and sedges to suit the location and depth of ponding.

The proposed bio-retention swale will have a filter area of approximately 80 m^2 and a minimum filter depth of 0.3 m. The bio-retention component of the swale will consist of sand or a sandy loam filter media laid over a perforated pipe which will collect treated stormwater. It is recommended that the hydraulic conductivity of the filter media in the bio-retention swale is significantly higher than the surrounding natural soil to ensure that the flow path of infiltrated water is well-defined. This pipe will be connected to the infiltration area in Treatment Zone 5.

During large rainfall events, high flows (greater than 0.5 m^3/s) will effectively by-pass the bio-retention swale. Flows entering the bio-retention swale will receive minimal treatment within the infiltration zone as runoff entering the swale will overflow directly to the piped drainage system. A raised drainage grate will be built into the swale to create a high level outlet which will convey flows from large storms up to the 1% event.

Details of the MUSIC model input are included in Appendix A.

4.9.5 Treatment Zone 3

This treatment zone consists of a bio-retention swale which captures and treats runoff from Sub-catchment C. The proposed development within this sub-catchment includes an access road and four houses. Runoff from the pervious, road and pavement areas will be collected in Treatment Zone 3. Overflow from rainwater tanks in Sub-catchment C will be connected directly to the piped drainage system and will flow towards outlet O-1.

Seepage will occur at a rate of 2 mm/hour within this bio-retention swale which will pond to a depth of approximately 0.3 m. The swale will be vegetated with grasses and sedges to suit the location and depth of ponding.

The bio-retention swale will have a filter area of approximately 40 m^2 and a minimum filter depth of 0.3 m. The bio-retention component of the swale will consist of sand or a sandy loam filter media laid over a perforated pipe which will collect treated stormwater. This pipe will be connected to the piped drainage system and will flow to the outlet located in the south-western corner of the site at O-1. It is recommended that the hydraulic conductivity of the filter media is significantly higher than the surrounding natural soil to ensure that the flow path of infiltrated water is well-defined.

During large rainfall events, high flows (greater than 0.5 m^3/s) entering the bio-retention swale will overflow into the piped drainage system with minimal treatment. An arrangement incorporating a raised drainage grate will be built into the swale to create a high level outlet which will convey flows from large storms up to the 1% event. By-passed flows will receive no further treatment and will discharge at outlet O-1.

Details of the MUSIC model input are included in Appendix A, and Appendix B includes the MUSIC model results.

4.9.6 Treatment Zone 4

This treatment zone consists of a series infiltration areas. The purpose of these infiltration areas is to provide water to landscaping between the five houses to be located in Sub-catchment E. Runoff from pavements and rainwater tank overflows from Sub-catchment E will enter stormwater pipes connected to the infiltration area in Treatment Zone 5.

As shown on Drawing 01S828-DA-FIG2, the infiltration zones are located at the boundary between Sub-catchments E and N and consists of four sub-surface infiltration areas located in corridors between the buildings. These infiltration areas will act as a flow-spreader which will encourage water to seep into the surrounding soil, providing water to landscaping and down slope to Treatment Zone 5. Rainwater tank overflow and runoff from pavement areas of Sub-catchment D as well as flows from Treatment Zone 2 will enter this infiltration zone.

The filter area will operate as a gravel-filled trench with a saturated hydraulic conductivity greater than 1,000 mm/hr. When the capacity of the infiltration zone (approximately 0.1 m^3/s) is exceeded during large storm events, flows will by-pass the infiltration component of Treatment Zone 4 and will flow towards Treatment Zone 5.

Details of the MUSIC input parameters for Treatment Zone 4 are included in Appendix A and model results are included in Appendix B.

4.9.7 Treatment Zone 5

Treatment Zone 5 is located between Sub-catchment N and the access way forming part of Sub-catchment H. This area has a slope of approximately 12% and is located at the base of the benching and steep grade forming Sub-catchment N. Under pre-development conditions, this area is frequently water logged which sustains stands of significant trees. To maintain the sub-surface seepage conditions, Treatment Zone 5 consists of an infiltration zone which will be connected to drainage from Sub-catchment E and a swale which will receive treated runoff from Treatment Zone 4, untreated runoff from Sub-catchment N, the pervious portion of Sub-catchment E and its own surrounding pervious sub-catchment.

The swale will be wide and shallow which could pond to a depth of 0.03 m. Flows entering Treatment Zone 5 via the infiltration system will be distributed across the width of the area using a flow spreader. This spreader will consist of a gravel-filled trench allowing seepage into the surrounding soil as well as distribution of runoff across the surface of Treatment Zone 5.

Runoff from Treatment Zone 5 will be collected and piped to Treatment Zone 8.

Details of the MUSIC input parameters for Treatment Zone 5 are included in Appendix A.

4.9.8 Treatment Zone 6

Treatment Zone 6 is a sub-catchment 19 m long located south of Sub-catchment M. It includes a pathway along the length of the sub-catchment and under post-development conditions, this area will be landscaped with native species and an elevated walkway. The average slope is 7% and the area will act as a wide, shallow swale for improving stormwater quality.

Under post-development conditions, drainage from Treatment Zone 1 will be connected to Treatment Zone 6. Drainage will be evenly distributed across the width of Treatment Zone 6 and will flow overland along the length of the landscaped area.

Treatment Zone 6 will behave as a wide, shallow swale and a weir arrangement at the boundary with Treatment Zone 12 will allow ponding within Treatment Zone 6 up to a depth of 0.3 m. The expected seepage rate is 2 mm/hr with the expectation that sub-surface flows will continue downhill to replicate natural conditions, filling localised “depressions” in the underlying rock to form wet, boggy areas.

The MUSIC input details for Treatment Zone 6 are detailed in Appendix A and results are included in Appendix B.

4.9.9 Treatment Zone 7

Treatment Zone 7 includes three sub-surface infiltration areas which will treat runoff from sub-catchments F and G which consists of predominantly road runoff and operate as flow spreaders discharging overland flows across the width of Sub-catchment 7.

This zone is located adjacent to the existing drainage swale running along the eastern boundary wall and will act as a wide, shallow swale capturing and treating runoff from Sub-catchment A and its own surrounding pervious sub-catchment. The extended detention depth will be approximately 0.3 m and a seepage at a rate of 10 mm/hr would be expected by the sandy of the soils in the area.

Runoff from Treatment Zone 7 naturally flow into Treatment Zone 8.

Details of the model input parameters are included in Appendix A.

4.9.10 Treatment Zone 8

Treatment Zone 8 is located in the south-east corner of the site, adjacent to the outlet. As noted in Section 4.9.7, runoff from Treatment Zone 5 will be directed to Treatment Zone 8 which, like Treatment Zone 7, will operate as a wide, shallow swale. Treatment Zone 8 also has its own contributing pervious sub-catchment area.

The swale represented by Treatment Zone 8 will operate as a wide, shallow overland flow path. The extended detention depth will be approximately 0.3 m and a seepage at a rate of 10 mm/hr would be expected by the sandy of the soils in the area.

Runoff leaving Treatment Zone 8 will receive no further treatment and will combine with outflows at outlet O-3.

MUSIC model inputs for Treatment Zone 8 are included in Appendix A.

4.9.11 Treatment Zones 9 and 10

Treatment Zones 9 and 10 are located between houses close to the southern boundary of the site. These treatment zones will receive low flows from Treatment Zone 14 as well as their own pervious sub-catchments.

Treatment Zones 9 and 10 will operate as wide, shallow swales and are positioned for supply of runoff to existing natural vegetation. As shallow ponding will be expected, seepage will occur at a rate of 10 mm/hr.

Outflows from Treatment Zones 9+10 will receive no further treatment and will combine with outflows at outlet O-3. Details of the MUSIC model inputs for Treatment Zone 9+10 are included in Appendix A.

4.9.12 Treatment Zone 12

The sub-catchment that incorporates Treatment Zone 12 includes a pathway and steps along the length of the sub-catchment. Under post-development conditions, this area will be landscaped with native species, and an elevated walkway constructed above the existing path. The section of the sub-catchment incorporating the stairs is steep and includes rock outcrops, and will not contribute any water quality improvement features. From the base of the stairs to the boundary with Treatment Zone 13 the average slope is 10% and the area will act as a wide shallow swale for improving stormwater quality.

Under post-development conditions, outflow from Treatment Zone 6 and stormwater runoff from the pervious area of Sub-catchment I will contribute to flows through Treatment Zone 12. Landscaping through the area below the stairs will include low, pervious bunds across the flow path to ensure that overland flows do not become concentrated causing erosion or channelling through the area.

Treatment Zone 12 will act as a wide, shallow overland flow path. The extended detention depth will be about 0.05 m and seepage will occur at a rate of 2 mm/hr.

The MUSIC input details for Treatment Zone 12 are detailed in Appendix A, and MUSIC model results are included in Appendix B.

4.9.13 Treatment Zone 13

The sub-catchment that incorporates Treatment Zone 13 is located south of Treatment Zone 12 and an access road running along the boundary of the two areas. Treatment Zone 13 includes a pathway and as with Treatment Zone 12, under post-development conditions, this area will be landscaped with native species, and an elevated walkway constructed above the existing path. The average slope through Treatment Zone 13 is 10% and the area will act as a wide shallow swale carrying overland flows.

Flows entering Treatment Zone 13 will include runoff from the road in Sub-catchment J which will be piped and drained back to the Treatment Zone. It will also include drainage from the portion of the access road crossing the area, the pervious area of Treatment Zone 13 and contributions from Treatment Zones 12. Flows entering Treatment Zone 13 from Treatment Zone 12 will be spread across the full width of the area using low, porous bunding which will be incorporated into the landscaping. Landscaping along the length of the swale will provide flow obstructions and porous bunding to ensure that overland flow remains spread and does not concentrate or become channellised.

Treatment Zone 13 will have an extended detention depth of 0.05 m and it is expected that seepage will occur at a rate of 2 mm/hr. Flows from Treatment Zone 13 will exit the site at outlet O-2.

The MUSIC input details for Treatment Zone 12 are detailed in Appendix A.

4.9.14 Treatment Zone 14

The bio-retention swale proposed along the northern side of the access road adjacent to Sub-catchment H is identified as Treatment Zone 14. It is proposed that all drainage from Sub-catchment H which includes pervious runoff, and runoff from roads and pavements, as well as overflow from rainwater tanks is collected in this bio-retention swale. All runoff from the access road which extends from the boundary of Treatment Zone 13 to Sub-catchment G will be directed into the Treatment Zone 14.

The proposed bio-retention swale will have a filter area of approximately 63 m^2 and a minimum filter depth of 0.3 m. The bio-retention component of the swale will consist of sand or a sandy loam filter media laid over a perforated pipe which will collect treated stormwater. This pipe will be connected to Treatment Zones 9 and 10. It is recommended that the hydraulic conductivity of the filter media is significantly higher than the surrounding natural soil to ensure that the flow path of infiltrated water is well-defined.

The bio-retention swale will have a minimum ponding depth of 0.3 m and a maximum slope of 2% to ensure ponding within the swale is able to occur. The swale will be vegetated with grasses and sedges, but clumping vegetation will be avoided.

A raised inlet pit will be constructed within the bio-retention swale so that during large storm events, when the capacity of Treatment Zone 14 is exceeded, excess flows will overflow to the piped stormwater drainage system. These overflows will effectively receive no water quality improvement.

Details of the input parameters for Treatment Zone 14 are included in Appendix A. MUSIC model results are detailed in Appendix B.

4.9.15 Treatment Zone 15

Treatment Zone 15 consists of a short length of bio-retention swale on the eastern side of the access road between Sub-catchments D and M. Runoff from the road and pervious areas of Sub-catchment M will be directed to this terraced bio-retention swale.

The proposed bio-retention swale will have a filter area of approximately 100 m^2 and a minimum filter depth of 0.3 m. The bio-retention component of the swale will consist of sand or a sandy loam filter media laid over a perforated pipe which will collect treated stormwater. This perforated pipe will be connected to Treatment Zone 2. It is recommended that the hydraulic conductivity of the filter media is significantly higher than the surrounding natural soil to ensure that the flow path of infiltrated water is well-defined.

The bio-retention swale will have a minimum ponding depth of 0.3 m and a maximum slope of 2% to ensure ponding within the swale is allowed to occur. It is likely that this swale will consist of a series of cascading ponds (or flow forms) which provide aeration, detention and filtration. If when constructed the ponding depth is greater than 0.3 m, increased stormwater treatment will be achieved. The swale will be vegetated with grasses and sedges to suit the location and depth of ponding.

A raised inlet pit will be included in the bio-retention swale to ensure that during large storm events, excess stormwater will flow directly into the piped stormwater drainage system.

Details of the input parameters for Treatment Zone 15 are included in Appendix A. MUSIC model results are detailed in Appendix B.

4.9.16 Treatment Zone 16

Treatment Zone 16 consists of a short, 10 m length of bio-retention swale on the northern side of the access road between Sub-catchments P and J. Runoff from all surfaces in Sub-catchment P will be collected in Treatment Zone 16.

The proposed bio-retention swale will have a filter area of approximately 10 m^2 and a minimum filter depth of 0.3 m. The bio-retention component of the swale will consist of sand or a sandy loam filter media laid over a perforated pipe which will collect treated stormwater. It is recommended that the hydraulic conductivity of the filter media is significantly higher than the surrounding natural soil to ensure that the flow path of infiltrated water is well-defined. The perforated pipe will discharge treated stormwater from Treatment Zone 16 directly to outlet O-1.

The bio-retention swale will have a ponding depth of 0.3 m and a maximum slope of 2% to ensure ponding within the swale is allowed to occur. The swale will be vegetated with grasses and sedges to suit the location and depth of ponding. A raised inlet pit will be included in the bio-retention swale to ensure that during large storm events, excess stormwater will over flow directly into the piped stormwater drainage system.

Details of the input parameters for Treatment Zone 16 are included in Appendix A. MUSIC model results are detailed in Appendix B.

4.10 Stormwater Quality Results

MUSIC models were developed for the pre-development and post-development conditions with sub-catchment areas and treatment zones as described above. Details of the input values applied are included in Appendix A, and detailed results are included in Appendix B.

The resulting output from the site under pre-development and post-development conditions is summarised in Table 4.7 below where a negative value indicates a reduction in the pollutant load. As shown there is a zero increase in loads due to the proposed development and reductions in annual runoff and pollutant loads are achieved.

Table 4.7: Summary of Pre- and Post-Development MUSIC Model Results

	Runoff Volume (ML/y)	Total Suspended Solids (kg/y)	Total Phosphorus (kg/y)	Total Nitrogen (kg/y)
Pre-Development Conditions	17.4	465	2.9	33.0
Post Development Conditions	14.3	366	2.2	27.8

	% Change Flow	% Change TSS	% Change TP	% Change TN
Comparison of Models	-17%	-21%	-23%	-16%

Appendix B includes the results of the performance of each source sub-catchment and each treatment zone included in the post-development stormwater management system.

5. Construction and Operational Requirements

5.1 Summary of DA Conditions

The development consent with respect to Development Application No. 482/04 dated 24/01/07 imposes a number of conditions relevant to the water management aspects of the Spring Cove development. These are summarised in Table 5.1 below. Refer to the consent document for full text of the respective conditions.

Table 5.1: DA Conditions Summary

Condition	Summary	Comment
63	Separate application for the Part 3A Permit to NSW Maritime to be made	Application to be made prior to CC
80	Removable litter baskets to be incorporated in surface inlet pits	Litter baskets to be incorporated in design
190	Sediment/Erosion control plan required for approval	Refer to Drawings 291428C-CC301 – CC303 attached as Appendix D
196	De-watering from the site to comply with the Protection of the Environment Operations Act 1997 and additional conditions	All temporary dewatering to be treated on-site in sedimentation ponds and tested prior to discharge. Refer to Sediment Basin Sizing Report (May 2006) attached as Appendix C
198	Capacity and Effectiveness of Sediment and Erosion Control measures to be maintained	Contractor to maintain sediment and erosion control measures to council's satisfaction
199	Building operations to be isolated from the roadway or public footway or locations such that discharge could occur to the stormwater drainage system	Contractor to isolate operations from roadways and public footways and control discharge location
200	Erosion and sediment control measures to be installed at site periphery	Contractor to implement sediment and erosion control measures at site periphery prior to commencement
209	Revegetation/stabilisation required to all disturbed surfaces	Contractor to undertake revegetation/stabilisation of all disturbed surfaces
275	Details of method of site clearing, excavation and haulage to be approved	Contractor to provide details for approval prior to commencement
276	Stabilised access and wash down facilities to be provided	Contractor to provide appropriate facilities
278	Stockpiles to be sorted and maintained within the site's boundaries and clear of drain line easements, water, footpaths, kerbs or road surfaces	Contractor to maintain stockpiles within site boundary within designated areas
279	All disturbed areas to be stabilised within 21 days of cessation of earthworks	Contractor to undertake revegetation/stabilisation within designated time
280	Installation and maintenance of erosion and sediment control measures to be supervised by applicant or applicant's nominee	Applicant (or applicant's nominee) to supervise erosion and sediment control measures until site restoration
281	GPTs to be inspected and cleared at regular intervals	GPTs to be inspected and cleared at regular intervals by applicant until handover to council
282	Works to be done such that material does not escape to receiving waters	Contractor to manage all materials within site boundary and ensure proper treatment prior to

Condition	Summary	Comment
		discharge
283	Soil and water management works on the site to be overseen by suitably qualified consultant	Soil and water management consultant to oversee works and provide weekly report certifying compliance
284	Applicant to provide on-site training for all works, subcontractors, consultants and personnel in relation to soil and water management plans and works	Soil and water management consultant to facilitate training for all site personnel

5.2 Site Discharge – Construction Phase

The three (3) existing stormwater outlet locations are to be retained so that flow patterns to Spring Cove and the vegetation below the site remain similar to existing. The two (2) western outlets will cater for a relatively small portion of the site while the eastern outlet will cater for the majority of the site. The existing outlets discharge water at the site boundary, which then flows overland to Spring Cove.

The Spring Cove development has been the subject of a number of appeals to the Land and Environment Court over the past decade. During these court cases a significant concern was raised by Manly Council regarding maintaining the existing water regime to the vegetation below the site. To address these concerns, it was agreed that future stormwater flows from the site would replicate the existing situation, both in terms of location and in the manner in which the stormwater left the site. For these reasons, future stormwater flows from the site will occur as overland flows, as currently occurs, rather than as a piped outlet. In this manner, the water regime to the existing vegetation below the site will be maintained.

Water quality at the site discharge points will be controlled in accordance with the relevant DA conditions summarised above. Temporary dewatering will be treated on-site and tested prior to discharge in accordance with the Sediment Basin Sizing Report (May 2006) attached as Appendix C to this report and the DA conditions.

5.3 Site Discharge – Operational Phase

It is proposed to maintain the existing methods and points of discharge, as described in Section 5.2. The proposed method of discharge generally accords with the stated aims and objectives of the NSW Office of Water, outlined in the document "Controlled Activities: Guidelines for Outlet Structures (August 2010)", namely,

The design and construction of stormwater outlets should aim to be 'natural', yet provide a stable transition from a constructed drainage system to a natural flow regime,

It is considered that the proposal respects the intention of this objective in that the existing, long-standing flow regime to the watercourse is maintained and the quantity of discharge reduced.

Water run-off from the site should be of appropriate quality and quantity before being discharged into a riparian corridor or watercourse

The proposed quantity of discharge is anticipated to be reduced by 17% (from 17.4 ML/yr to 14.3 ML/yr) and the water quality improved by more than 15%, as per Table 4.7.

The Controlled Activities Guideline further outlines principles to be considered in the design and construction of outlet structures. Comments with respect to each principle are included in Table 5.2 below.

Table 5.2: Considerations in the Design and Construction of Outlet Structures

Principle	Comment
Define the infrastructure route and identify the specific point of discharge. Where possible select a route along an existing cleared or disturbed area that avoids trees, preferably beyond their drip line	The existing points of discharge are to be maintained with reduced rates of outflow.
Choose a stable section of the stream for the discharge point, preferably mid-way between bends. Alternatively, incorporate outlet discharge points into disturbed/eroded areas which are to be stabilised or rehabilitated	The retention of the existing points of discharge addresses this consideration
Minimise construction footprint and proposed extent of disturbance to soil and vegetation within the watercourse or waterfront land	No works are proposed within the watercourse or areas beyond the existing outlet structures
Demonstrate that changes to the hydrology of the receiving watercourse have been assessed and there is no detrimental impact on discharge volumes and channel velocities. Discharge velocities and flow rates should mimic 'natural' flows and not initiate erosion	Discharge volumes to the watercourse are reduced post-development by approximately 17%
Discharge from an outlet should not cause bed or bank instability	n/a, existing outlets to be maintained. No direct connection to watercourse
Protect the bed of the watercourse below the outlet (if not bedrock), or if bed scour is likely. Consider bank material and outlet 'jet' effect and protect the opposite streambank if required	n/a, existing outlets to be maintained. No direct connection to watercourse
Point outlet structure and direct discharge downstream	n/a, existing outlets to be maintained. No direct connection to watercourse
The outlet should not protrude beyond the streambank but tie in with the adjoining bank alignment	n/a, existing outlets to be maintained. No direct connection to watercourse
Calculate tractive stresses generated from outlet discharges and from bank full discharges to determine appropriate rock size requirements for the structure	n/a, discharge sheets overland prior to discharge to watercourse
Rock rip-rap is the preferred material to provide a 'natural' outlet. Rip-rap should extend for the full extent of the design scour apron and adjoining flanks/streambank. Rip-rap must be appropriately 'keyed in' (to withstand the velocities of runoff or discharge from the site) and cut-off trenches should be provided where necessary	n/a, existing outlets to be maintained. No direct connection to watercourse
Rip-rap should consist of durable, angular run-of-quarry rock placed over a bedding layer of angular cobbles over geotextile. Where possible, incorporate vegetation such as sedges and rushes into scour management for further stability	Note only
Grade scour apron to bed level of watercourse or just below any permanent water created by any stable feature such as a rock bar within the watercourse	n/a, existing outlets to be maintained. No direct connection to watercourse
Stabilise and rehabilitate all disturbed areas including topsoiling, revegetation/regeneration, mulching, weed control and maintenance	Noted. Any areas disturbed as a result of construction activities will be rehabilitated by the contractor

6. Conclusions and Recommendations

Detailed water quality models were developed using the MUSIC program to assess the impact of development of the Spring Cove site. The proposed stormwater management strategy for the Spring Cove Development includes the following features:

- Rainwater tanks fitted to each dwelling for re-use of rainwater for laundry and toilet flushing
- Stormwater drainage directed to landscaped areas as shallow, overland flow paths
- Use of infiltrating bio-retention systems as well as sub-surface drainage outlets

Utilising these best management practices for water sensitive urban design assists with meeting the overall objective of a zero net increase of pollutants leaving the site. Therefore, to ensure that this objective is met, the following minimum criteria are recommended for the water sensitive urban design components of the stormwater management system:

- The minimum rainwater tank size is 5,000 L per dwelling with houses 19, 20 and 23 with 8,000 L tanks.
- Bio-retention swales should have a minimum ponding depth of 300 mm.
- The minimum filter depth for infiltration zones is 300 mm.
- Filter material in bio-retention swales and infiltration areas should have a saturated permeability much higher than the surrounding soil, at a minimum, sandy loam could be used.
- Where swales are to operate as shallow overland flow paths, low, porous bunding should be incorporated into the landscape design to ensure even spreading of flows across the full width.

It has been demonstrated using MUSIC to model the pre-development and post-development conditions of stormwater runoff from the Spring Cove site (south of Darley Road) that there will be a zero increase in pollutant loads leaving the site. Modelling shows that >15% pollutant reductions are achievable, including a 17% reduction in runoff volume from the site.

As described in Section 5.2, the future stormwater flows from the site will replicate the existing situation, both in terms of location and in the manner in which the stormwater leaves the site. For these reasons, future stormwater flows from the site will occur as overland flows, as currently occurs, rather than as a piped outlet. In this manner the water regime to the existing vegetation below the site will be maintained, noting the reduced outflows post-development.

Construction works will be carried out in accordance with the conditions outlined in DA No. 482/04, as summarised in Section 5.

Mott MacDonald
Hughes Trueman

7. References

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Sub-catchment	Total Area (m^2)
A	26,270
B	10,950
C	3,029
D	3,779
E	2,301
F	289
G	273
H	1,406
I	2,340
J	1,638
K	1,122
L	1,248
M	536
P	838
1	248
N	827
5	659
6	192
7	894
8	547
9	114
10	67
12	652
13	455
Total	**60,674**

PRELIMINARY - NOT FOR CONSTRUCTION

Rev	Amendment or reason for issue	Issue date	dwg by	Designed & checked by	Verified	authorised (*)
B	ISSUED FOR REVIEW	16.07.04	RAS	FC	X	
A	ISSUED FOR REVIEW	07.07.04	RAS	FC	X	

* Drawing Status
Warning: Unless there is an authorised Hughes Trueman signature at * , this drawing is not authorised for issue.

Branches at:
St Leonards Canberra Parramatta Wagga Wagga

C O N S U L T A N T S

ARCHITECTS
Alex Popov Architects ph: 9955–5604
Grose Bradley ph: 8297–7200
Jahn Associates ph: 9211–2191
Tonkin Zulaikha Greer ph: 9215–4900

ELECTRICAL ENGINEER
Brian Kinght & Associates ph: 9997–5244

MECHANICAL ENGINEER
Timar Partnership ph: 9966–0037

LANDSCAPE ARCHITECTS
McGregor + Partners ph: 9977–3853

SURVEYOR
Whelans ph: 8234–8300

HERITAGE CONSULTANT
Tanner & Associates ph: 9281–4399

PLANNING CONSULTANT
Ingham Planning ph: 9416–9111

Lend Lease
LACHLAN Project Management

HughesTrueman
Consulting Engineers Planners & Managers
ABN 53 831 529 091
Level 2, 60 Pacific Highway, P.O. Box 151, ST LEONARDS NSW 2065
T 02 9439 2633 F 02 9438 4505 stleonards@hughestrueman.com.au

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Precinct 5, 6 & 10
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D R A W I N G T I T L E
PRE–DEVELOPMENT SITE LAYOUT WITH SUB–CATCHMENT AREAS

Drawn RAS
Architect Authorised
Client Lend Lease
Date 21.06.04
Scale 1:666
Status Preliminary
File

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JOB NUMBER 01S828
DRAWING NUMBER / ISSUE DA–FIG1/B

FILENAME: P:\ST_LEONARDS\2001\01S828\DWGS\CIVIL\SPRING COVE DA SET\01S828DA FIG1.DWG
PLOTTED BY : rstaunton
TIME :15:31
DATE :02-05-2006

PRELIMINARY - NOT FOR CONSTRUCTION

Rev	Amendment or reason for issue	Issue date	dwg by	Designed & checked by	Verified	authorised (*)
C	ISSUED FOR REVIEW	02.05.06	RAS	AS	X	
B	ISSUED FOR REVIEW	16.07.04	RAS	FC	X	
A	ISSUED FOR REVIEW	07.07.04	RAS	FC	X	

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ph: 9416–9111

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Consulting Engineers Planners & Managers
ABN 53 831 529 091
Level 2, 60 Pacific Highway, P.O. Box 151, ST LEONARDS NSW 2065
T 02 9439 2633 F 02 9438 4505 stleonards@hughestrueman.com.au

ACEA

P R O J E C T
St. Patricks Estate Manly
Precinct 5, 6 & 10
For Lend Lease Development

D R A W I N G T I T L E
POST–DEVELOPMENT SITE LAYOUT WITH SUB–CATCHMENT AREAS

Drawn RAS
Architect Authorised
Client Lend Lease
Date 21.06.04
Scale 1:500
Status Preliminary
File

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JOB NUMBER 01S828
DRAWING NUMBER / ISSUE DA–FIG2/C

PLOTTED BY : rstaunton TIME :15:34 DATE :02-05-2006

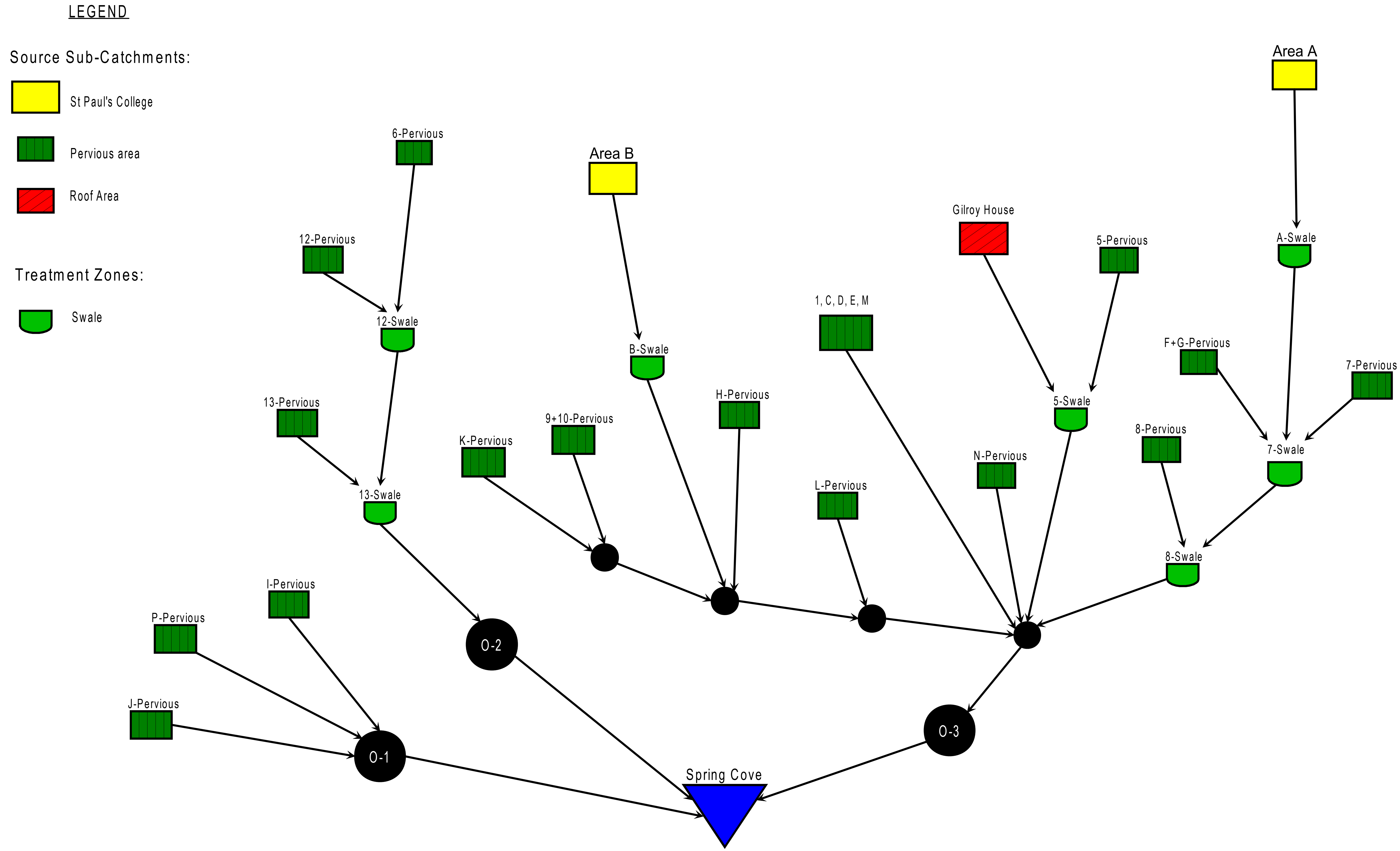

Figure 3
Pre-Development Conditions
MUSIC Model Layout

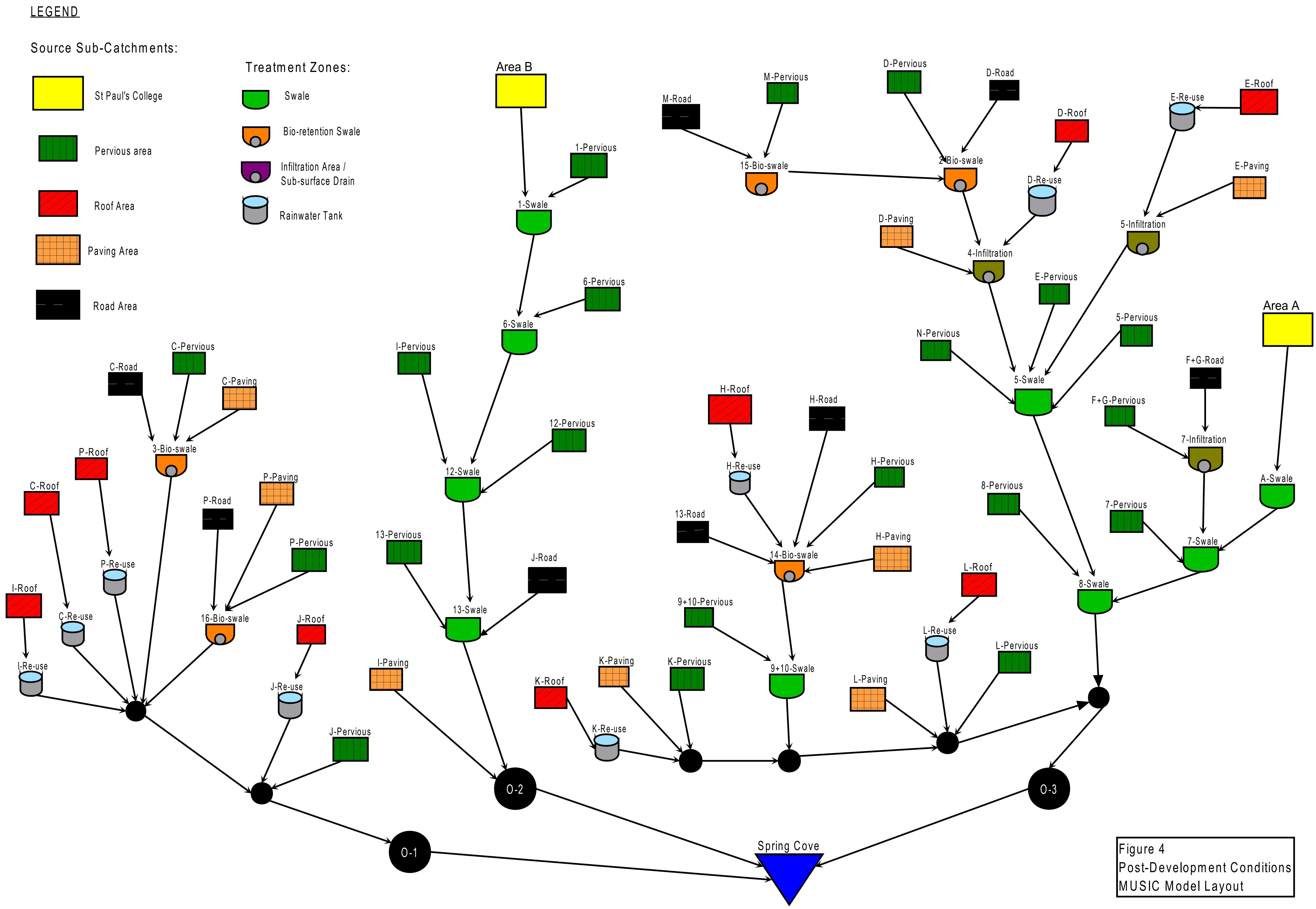

Figure 4
Post-Development Conditions
MUSIC Model Layout

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Appendices

Appendix A. MUSIC Input Parameters

A.1. Pre-Development Conditions

A.1.1. Sub-catchment Areas

Table A.1 below includes the input data for each source sub-catchment in the pre-development conditions model.

Table A.2 shows the soil parameters input to the model as also described in Section 4.5.

Table A.1: Pre-development Conditions MUSIC Input Data

Source Sub-catchment	MUSIC Node Type	Total Area (ha)	Area Impervious (ha)	Area Pervious (ha)	Stormflow TSS Mean (log mg/L)	Stormflow TP Mean (log mg/L)	Stormflow TN Mean (log mg/L)
12-Pervious	Urban	0.07	-	0.07	2.2	-0.45	0.42
13-Pervious	Urban	0.05	-	0.05	2.2	-0.45	0.42
5-Pervious	Urban	0.07	-	0.07	2.2	-0.45	0.42
6-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
7-Pervious	Urban	0.09	-	0.09	2.2	-0.45	0.42
8-Pervious	Urban	0.05	-	0.05	2.2	-0.45	0.42
9+10-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
Area A	Urban	2.63	0.92	1.71	2.2	-0.45	0.42
Area B	Urban	1.1	0.06	1.04	2.2	-0.45	0.42
C D E M Pervious	Urban	0.82	0.04	0.78	2.2	-0.45	0.42
F+G-Pervious	Urban	0.05	-	0.05	2.2	-0.45	0.42
Gilroy House	Urban	0.15	0.15	-	1.54	-0.82	0.42
H-Pervious	Urban	0.15	-	0.15	2.2	-0.45	0.42
I-Pervious	Urban	0.24	-	0.24	2.2	-0.45	0.42
J-Pervious	Urban	0.18	-	0.18	2.2	-0.45	0.42
K-Pervious	Urban	0.11	-	0.11	2.2	-0.45	0.42
L-Pervious	Urban	0.13	-	0.13	2.2	-0.45	0.42
N-Pervious	Urban	0.08	-	0.08	2.2	-0.45	0.42
P-Pervious	Urban	0.08	-	0.08	2.2	-0.45	0.42

Table A.2: MUSIC Urban Rainfall Runoff Parameters

PARAMETER	INPUT VALUE
Impervious Areas	
Rainfall Threshold (mm/day)	1.5
Pervious Area Properties	
Soil Storage Capacity (mm)	300
Initial Storage (% of Capacity)	30
Field Capacity (mm)	200
Infiltration Capacity Coefficient – a	200
Infiltration Capacity Coefficient – b	1
Groundwater Properties	
Initial depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (mm)	5
Daily Deep Seepage Rate (mm)	1

A.1.2. Treatment Zones

The MUSIC input parameters describing the swales which represent the drainage of the site under pre-existing conditions are detailed in Table A.3 below.

Table A.3: Pre-existing Conditions Swale Input Parameters

Treatment Zone Location	Description	Extended detention depth (m)	Length (m)	Bed slope	Base Width (m)	Top width (m)	Vegetation height (m)	Seepage Rate (mm/hr)
12	Swale	0.01	43	9%	10.2	10.2	0.05	2
13	Swale	0.01	37.5	10%	10.2	10.2	0.05	2
5	Swale	0.01	13	12%	50	50	0.05	2
7	Swale	0.3	45	16%	1.5	3	0.05	2
8	Swale	0.3	38	10%	2.0	5	0.05	2
A	Swale	0.3	250	15%	1.5	3	0.05	2
B	Swale	0.25	90	11%	1.5	3	0.05	2

Where:

Extended Detention Depth – is the maximum depth of water expected to pond within the swale. Note that for shallow overland flow, a depth of 0.01 m has been applied.

Length – the length of the swale in the direction that stormwater will travel

Bed Slope – the longitudinal slope of the base of the swale in the direction that stormwater will travel. Note that the typical slopes of well-designed swales are generally in the order of 2% – 4%. The slopes applied in the model are used for representing water quality improvement due to overland flow paths and some are existing, naturally formed swales, therefore the average bed slope for each swale has been applied.

Base Width – the width of the base of the swale. Note that base widths greater than 2.5 m represent wide, shallow overland flow paths. Base widths less than 2.5 m indicate a confined, traditional drainage swale

Top Width – the maximum width of flow within the swale when carrying the maximum depth of water. Typically, the top width of a swale is dependent on the base width plus the side slope. This is the case for the swales representing drainage from Sub-catchments A and B, 7-Swale and 8-Swale. The remaining swales represent wide, shallow overland flow paths with a minimal depth of ponding, therefore the top width will be same as the base width.

Vegetation Height – Typically, the vegetation within swales is chosen to be 75% inundated under design flow conditions. The vegetation height chosen in the model represents the pre-development conditions which is generally mown grass with a vegetation height of 50 mm.

Seepage Rate – the seepage rate applied to treatment zones under pre-development conditions is 2 mm/hr which is representative of the shallow soils overlying rock.

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A.2. Post-Development Conditions

A.2.1. Sub-catchment Areas

Table A.4 below includes the input data for each source sub-catchment in the post-development conditions model. The soil parameters input to the model are as shown in

Table A.2 above.

Table A.4: Post-development Conditions MUSIC Input Data

Source Sub-catchment	MUSIC Node Type	Total Area (ha)	Area Impervious (ha)	Area Pervious (ha)	Stormflow TSS Mean (log mg/L)	Stormflow TP Mean (log mg/L)	Stormflow TN Mean (log mg/L)
12-Pervious	Urban	0.04	-	0.04	2.2	-0.45	0.42
13-Pervious	Urban	0.04	-	0.04	2.2	-0.45	0.42
13-Road	Urban	0.01	0.01	-	2.41	-0.6	0.34
1-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
5-Pervious	Urban	0.07	-	0.07	2.2	-0.45	0.42
6-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
7-Pervious	Urban	0.09	-	0.09	2.2	-0.45	0.42
8-Pervious	Urban	0.05	-	0.05	2.2	-0.45	0.42
9+10-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
Area A	Urban	2.63	0.92	1.71	2.2	-0.45	0.42
Area B	Urban	1.10	0.05	1.05	2.2	-0.45	0.42
C-Paving	Urban	0.01	0.01	-	2.2	-0.45	0.42
C-Pervious	Urban	0.17	-	0.17	2.2	-0.45	0.42
C-Road	Urban	0.05	0.05	-	2.41	-0.6	0.34
C-Roof	Urban	0.08	0.08	-	1.54	-0.82	0.42
D-Paving	Urban	0.01	0.01	-	2.2	-0.45	0.42
D-Pervious	Urban	0.15	-	0.15	2.2	-0.45	0.42
D-Road	Urban	0.05	0.05	-	2.41	-0.6	0.34
D-Roof	Urban	0.15	0.15	-	1.54	-0.82	0.42
E-Paving	Urban	0.03	0.03	-	2.2	-0.45	0.42
E-Pervious	Urban	0.08	-	0.08	2.2	-0.45	0.42

Source Sub-catchment	MUSIC Node Type	Total Area (ha)	Area Impervious (ha)	Area Pervious (ha)	Stormflow TSS Mean (log mg/L)	Stormflow TP Mean (log mg/L)	Stormflow TN Mean (log mg/L)
E-Roof	Urban	0.13	0.13	-	1.54	-0.82	0.42
F+G-Pervious	Urban	0.03	-	0.03	2.2	-0.45	0.42
F+G-Road	Urban	0.03	0.03	-	2.41	-0.6	0.34
H-Paving	Urban	0.01	0.01	-	2.2	-0.45	0.42
H-Pervious	Urban	0.01	-	0.01	2.2	-0.45	0.42
H-Road	Urban	0.05	0.05	-	2.41	-0.6	0.34
H-Roof	Urban	0.07	0.07	-	1.54	-0.82	0.42
I-Paving	Urban	0.03	0.03	-	2.2	-0.45	0.42
I-Pervious	Urban	0.09	-	0.09	2.2	-0.45	0.42
I-Roof	Urban	0.10	0.10	-	1.54	-0.82	0.42
J-Pervious	Urban	0.09	-	0.09	2.2	-0.45	0.42
J-Road	Urban	0.03	0.03	-	2.41	-0.6	0.34
J-Roof	Urban	0.04	0.04	-	1.54	-0.82	0.42
K-Paving	Urban	0.01	0.01	-	2.2	-0.45	0.42
K-Pervious	Urban	0.04	-	0.04	2.2	-0.45	0.42
K-Roof	Urban	0.06	0.06	-	1.54	-0.82	0.42
L-Paving	Urban	0.01	0.01	-	2.2	-0.45	0.42
L-Pervious	Urban	0.05	-	0.05	2.2	-0.45	0.42
L-Roof	Urban	0.07	0.07	-	1.54	-0.82	0.42
M-Pervious	Urban	0.02	-	0.02	2.2	-0.45	0.42
M-Road	Urban	0.03	0.03	-	2.41	-0.6	0.34
N-Pervious	Urban	0.08	-	0.08	2.2	-0.45	0.42
P-Pervious	Urban	0.08	-	0.08	2.2	-0.45	0.42
P-Road	Urban	0.01	0.01	-	2.41	-0.6	0.42
P-Roof	Urban	0.02	0.02	-	1.54	-0.82	0.42

A.2.2. Post-development Treatment Zones

Under post-development conditions, three types of treatment zone have been applied in the MUSIC model: Swales, Infiltration, and rainwater tanks for Re-use.

A.2.2.1. Swale Treatment Zones

The Swale Treatment Zones are the areas which have been modelled as swales in the MUSIC model. Table A.5 below details the input parameters for swales used in treatment zones.

Table A.5: Swale Treatment Zones - Input Parameters

Treatment Zone	Description	Extended detention depth (m)	Length (m)	Bed slope	Base Width (m)	Top width (m)	Vegetation height (m)	Seepage Rate (mm/hr)
1	Swale	0.3	22	2%	7	7	0.25	10
5	Swale	0.03	13	12%	50	50	0.25	10
6	Swale	0.3	19	7%	10.2	10.2	0.25	2
7	Swale	0.3	45	16%	19.9	19.9	0.25	10
8	Swale	0.3	35	10%	2	5	0.25	10
9+10	Swale	0.01	30	4%	6	6	0.25	10
12	Swale	0.05	43	9%	10.2	10.2	0.25	2
13	Swale	0.05	37.5	10%	10.2	10.2	0.25	2
A	Swale	0.3	250	15%	1.5	3	0.05	2

Where:

Extended Detention Depth – is the maximum depth of water expected within the swale. Note that for shallow overland flow, a depth of 0.01 m has been applied. Where ponding across the swale will occur, a depth of 0.05 m has been assumed, while in confined drainage swales (A and Treatment Zones 1, 6, 7 and 8) a depth of 0.3 m has been input as these treatment zones will operate as more traditional drainage swales rather than overland flow paths.

Length – the length of the swale in the direction that stormwater will travel.

Bed Slope – the longitudinal slope of the base of the swale in the direction that stormwater will travel. Note that the typical slopes of well-designed swales are generally in the order of 2% – 4%. The slopes applied in the model are used for representing water quality improvement due to overland flow paths and some existing, naturally formed swales, rather than new, well-designed swales.

Base Width – the width of the base of the swale. Note that base widths greater than 2.5 m are used when representing wide, shallow overland flow.

Top Width – the maximum with of flow within the swale when carrying the maximum depth of water. Typically, the top width of a swale is dependent on the base width plus the side slope. This is the case for the swale representing drainage from Sub-catchment A. The remaining swales represent wide, shallow overland flow paths with a minimal depth of ponding, therefore the top width will be same as the base width, with the exception of 4-Swale which will be shaped to provide a conveyance area.

Vegetation Height – Typically, the vegetation within swales is chosen to be 75% inundated under design flow conditions. The vegetation height chosen in the model represents the possible landscaping throughout the site under post-development conditions. A vegetation height of 250 mm has been assumed to be a reasonable estimate throughout the post-developed area. Within sub-catchment A, the vegetation height of 50 mm has been assumed to represent mown grass, which would not change from the pre-development conditions.

Seepage Rate – the seepage rate applied to treatment zones under pre-development conditions is 2 mm/hr. Under post-development conditions, this rate has been increased to 10 mm/hr in the treatment zones where ponding will be encouraged for supplying water to existing stands of trees (mostly Melaleucas).

A.2.2.2. Infiltration Treatment Zones

The bio-retention swales, sub-surface drains, and infiltration zones included in the drainage for post-development are modelled in MUSIC using the Infiltration Treatment Node. Table A.6 below outlines the input parameters for the Infiltration Treatment Zones included in the MUSIC model.

Table A.6: Infiltration Treatment Zones - Input Parameters

Treatment Zone Location	Description	Hi-flow bypass rate (m^3/sec)	Area (m^2)	Extended detention depth (m)	Filter area (m^2)	Filter depth (m)	Filter particle effective diameter (mm)	K_{sat} (mm/hr)	Seepage Rate (mm/hr)
2	Bio-retention Swale	0.5	80	0.3	80	0.3	0.7	360	2
3	Bio- retention Swale	0.5	40	0.3	40	0.3	0.7	360	2
4	Infiltration Area	0.1	25	0.01	25	0.3	1	1,000	2
5	Infiltration Area	0.1	10	0.01	10	0.3	1	1,000	2
7	Infiltration Area	0.1	9	0.01	9	0.3	1	1,000	2

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Treatment Zone Location	Description	Hi-flow bypass rate (m^3/sec)	Area (m^2)	Extended detention depth (m)	Filter area (m^2)	Filter depth (m)	Filter particle effective diameter (mm)	K_{sat} (mm/hr)	Seepage Rate (mm/hr)
14	Bio-retention Swale	0.5	63	0.3	63	0.3	0.7	360	2
15	Bio- retention Swale	0.1	100	0.3	100	0.3	0.7	360	2
16	Bio- retention Swale	0.2	10	0.3	10	0.3	0.7	360	2

Where:

Hi-flow Bypass – has been estimated to ensure that during large storm events, when the capacity of the treatment zone will be exceeded, high flows will by-pass the treatment zone in the model without receiving any water quality treatment or improvement.

Area - the surface area of the water ponded in the infiltration zone when ponding to the maximum depth occurs.

Extended Detention Depth – the maximum depth of ponding that would be expected to occur during a storm event. Note that the infiltration area (Treatment Zone 4,5 and 7) has a very shallow ponding of 0.01 m.

Filter Area - the area of the base of the bio-retention swale or sub-surface drain which will be acting as a filtration zone (a minimum filter width of 1 m has been assumed).

Filter Depth – the depth of the filter media overlaying a sub-surface perforated drainage pipe. A minimum of 0.3 m filter depth has been assumed. A greater filter depth will increase the level of stormwater treatment.

Filter particle Effective Diameter – has been chosen according to the filter material to be used within the infiltration zone. Details are included in Table A-7 below.

K_{sat} - Filter hydraulic conductivity which has been chosen according to the filter material chosen for the infiltration zone. More details are included in Table A.7 below.

Table A.7: Hydraulic Conductivity for a range of filter media

Soil Type	Particle Size (mm)	Saturated Hydraulic Conductivity (mm/hr)
Gravel	2	up to 36,000
Sand	0.7	360
Sandy Loam	0.45	180

Source: Draft ARQ, 2003

A.2.2.3. Rainwater Re-use

Rainwater re-use has been included in the MUSIC model The location of rainwater tanks according to the dwelling numbers is outlined below.

Table A.8: Rainwater Tank Size and Location

Dwelling Number	Tank Volume (L/Household)	Sub-catchment Location
1	5,000	C
2	5,000	C
3	5,000	C
4	5,000	C
5	5,000	D
6	5,000	E
7	5,000	E
8	5,000	E
9	5,000	E
10	5,000	E
11	5,000	I
12	5,000	I
13	5,000	I
14	5,000	I
15	5,000	P
16	5,000	J

Dwelling Number	Tank Volume (L/Household)	Sub-catchment Location
17	5,000	J
18	5,000	H
19	8,000	H
20	8,000	K
21	5,000	K
22	5,000	L
23	8,000	L

It is proposed that rainwater tanks will be constructed underneath each dwelling, therefore, the surface area of each tank has been based on a maximum depth of 1.5 m. Table A.9 below details the input parameters for rainwater tanks for each sub-catchment in the MUSIC model.

Table A.9: Re-use Treatment Zones - Input Parameters

Re-use Treatment Zone	Hi-flow bypass rate (m3/sec)	Surface Area (m2)	Depth above overflow (m)	Volume below overflow pipe (kL)	Daily Demand (kL/day)
C-Re-use	100	13.3	0.2	20	1.4
D-Re-use	100	53.3	0.2	80	5.6
E-Re-use	100	16.7	0.2	25	1.8
H-Re-use	100	8.7	0.2	13	0.7
I-Re-use	100	13.3	0.2	20	1.4
J-Re-use	100	6.7	0.2	10	0.7
K-Re-use	100	8.7	0.2	13	0.7
L-Re-use	100	8.7	0.2	13	0.7
P-Re-use	100	3.3	0.2	5	0.4

Where:

Hi-flow Bypass Rate – has been set at a very high rate to ensure that the model assumes that all roof runoff will pass through the rainwater tank and receive treatment. Although in reality, the first flush will be diverted away from the tank, the first flush may still be treated by release onto landscaped areas after or during the storm event. By assuming that 100% of rainwater passes through the tank, the model ensures that all roof runoff will be receive some treatment.

Surface Area – is the combined surface area of tanks in each sub-catchment. The model relies on the surface area of the tank to determine the level of treatment (which will be similar to a settling pond). Therefore, the sum of the tank area for each sub-catchment is used in the model.

Depth Above Overflow Pipe – Is the depth between overflow pipe and top of tank.

Volume Below Overflow Pipe – is the sum of the tank capacities for each sub-catchment (as outlined in Table A-8 above).

Daily Demand – is the sum of the daily demand for the dwellings located in each sub-catchment based on the re-use estimated in Table A10 below.

Table A.10: Estimated Re-use per Household per Day

Per capita indoor use	260 L/person/day
Manly mean household size	3 people
Total daily indoor use	780 L/day
Daily rainwater re-use:	
Toilets (25% indoor use))	195 L/household/day
Laundry(20% indoor use)	156 L/household/day
Daily rainwater re-use	351 L/household/day

Appendix B. Music Model Results

B.1. Pre-Development Conditions Water Quality Results

The rainfall data used for the MUSIC model is described in Section 2.4. The model was run for the 20 years of daily rainfall data to generate the following results.

The output from each source sub-catchment in the pre-development conditions model is detailed in Table B.1 below.

Table B.1: Source Sub-catchment Output, Pre-development Conditions

Source Sub-catchment	Area (ha)	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
12-Pervious	0.07	0.16	6.84	0.03	0.37
13-Pervious	0.05	0.12	5.55	0.02	0.25
5-Pervious	0.07	0.16	5.70	0.03	0.36
6-Pervious	0.02	0.05	2.71	0.01	0.11
7-Pervious	0.09	0.21	13.20	0.05	0.47
8-Pervious	0.05	0.12	4.35	0.02	0.26
9+10-Pervious	0.02	0.05	1.95	0.01	0.10
Area A	2.63	13.60	2,040.00	4.65	36.50
Area B	1.1	2.98	229.00	0.75	7.31
C D E M Pervious	0.82	2.22	161.00	0.54	5.42
F+G-Pervious	0.05	0.12	4.32	0.02	0.26
Gilroy House	0.15	1.58	76.00	0.29	4.49
H-Pervious	0.15	0.34	13.80	0.07	0.84
I-Pervious	0.24	0.55	25.40	0.11	1.24
J-Pervious	0.18	0.41	18.90	0.09	1.02
K-Pervious	0.11	0.25	12.80	0.05	0.58
L-Pervious	0.13	0.30	16.00	0.07	0.68
N-Pervious	0.08	0.18	7.20	0.04	0.41
P-Pervious	0.08	0.18	8.80	0.04	0.44

This table shows that the highest pollutant loads are originating from Sub-catchments A and B, which would be expected because these sub-catchment have the largest areas. The roof area of Gilroy House also provides a fairly significant source of suspended solids and nitrogen.

Table B.2 below shows the MUSIC model results for the drainage swales included in the MUSIC model. These results are for the average annual loads entering and leaving each treatment zone.

These results show that the majority of site runoff is carried along the drainage swale which follows the eastern boundary wall.

Table B.2: Treatment Zone Output, Pre-development Conditions

		Mean Annual Load IN				Mean Annual Load OUT			
Treatment Zone Location	Description	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
12	Swale	0.21	9.18	0.04	0.47	0.01	0.18	0.00	0.02
13	Swale	0.13	7.35	0.03	0.27	0.02	0.23	0.00	0.03
5	Swale	1.74	79.10	0.31	4.92	0.43	5.78	0.06	0.71
7	Swale	11.10	164.00	1.61	20.00	10.70	170.00	1.58	18.80
8	Swale	10.80	176.00	1.61	19.10	10.40	165.00	1.54	18.10
A	Swale	13.60	2,020.00	4.61	36.80	10.80	147.00	1.54	19.20
B	Swale	2.98	199.00	0.70	7.00	2.07	28.20	0.30	3.64

Table B.3 shows the effectiveness of the existing treatment zones in improving stormwater quality under pre-development conditions where a negative value indicates a load reduction.

Table B.3: Treatment Zone Effectiveness, Pre-development Conditions

Treatment Zone Location	Description	Mean Annual Flow Reduction	TSS Mean Annual Load Reduction	TP Mean Annual Load Reduction	TN Mean Annual Load Reduction
12	Swale	-94%	-98%	-95%	-95%
13	Swale	-87%	-97%	-92%	-89%
5	Swale	-76%	-93%	-80%	-85%
7	Swale	-4%	4%	-2%	-6%
8	Swale	-4%	-6%	-4%	-5%
A	Swale	-21%	-93%	-67%	-48%
B	Swale	-31%	-86%	-58%	-48%

Table B.4 below provides a summary of the pollutant loads leaving the site at the three outlets identified as O-1, O-2 and O-3.

Table B.4: Pre-development Pollutant Loads at Outlets

Outlet	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
O-1	1.15	53.20	0.23	2.70
O-2	0.02	0.23	0.00	0.03
O-3	16.20	412.00	2.67	30.30
Spring Cove	**17.4**	**465**	**2.9**	**33.1**

B.2. Post-Development Conditions Water Quality Results

The output from each source sub-catchment in the post-development conditions model is detailed in Table B.5 below.

As shown in Table B.5, the sub-catchments producing the highest pollutant loads are Sub-catchments A and B. This is because these sub-catchments have the largest areas and constitute 60% of the total site area south from Darley Road. The next largest contribution of pollutants is generated by the road source sub-catchments.

Table B.5: Source Sub-catchment Output, Post-development Conditions

Source Sub-catchment	Total Area (ha)	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
12-Pervious	0.04	0.10	4.08	0.02	0.23
13-Pervious	0.04	0.09	4.42	0.02	0.20
13-Road	0.01	0.11	34.40	0.03	0.25
1-Pervious	0.02	0.05	1.47	0.01	0.11
5-Pervious	0.07	0.16	7.61	0.03	0.36
6-Pervious	0.02	0.05	1.71	0.01	0.10
7-Pervious	0.09	0.21	10.50	0.04	0.46
8-Pervious	0.05	0.12	4.40	0.02	0.25
9+10-Pervious	0.02	0.05	3.09	0.01	0.10
Area A	2.63	13.60	2,200.00	4.85	36.20
Area B	1.10	2.98	272.00	0.80	7.04
C-Paving	0.18	0.19	39.20	0.08	0.56
C-Pervious	0.18	0.38	12.40	0.07	0.91
C-Road	0.05	0.56	181.00	0.16	1.31
C-Roof	0.08	0.84	39.10	0.15	2.49
D-Paving	0.01	0.09	20.50	0.04	0.27
D-Pervious	0.15	0.34	19.30	0.07	0.84

Source Sub-catchment	Total Area (ha)	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
D-Road	0.05	0.53	171.00	0.15	1.26
D-Roof	0.16	1.69	80.20	0.31	4.81
E-Paving	0.03	0.35	73.00	0.15	1.04
E-Pervious	0.08	0.18	7.53	0.04	0.42
E-Roof	0.13	1.37	64.20	0.24	3.80
F+G-Pervious	0.03	0.06	2.57	0.01	0.14
F+G-Road	0.03	0.32	105.00	0.10	0.73
H-Paving	0.01	0.95	189.00	0.39	2.75
H-Pervious	0.01	0.03	1.24	0.01	0.06
H-Road	0.05	0.53	180.00	0.16	1.25
H-Roof	0.07	0.74	34.70	0.14	2.12
I-Paving	0.03	0.29	60.20	0.12	0.81
I-Pervious	0.10	0.22	12.20	0.05	0.49
I-Roof	0.10	1.05	45.70	0.19	3.15
J-Pervious	0.09	0.21	7.83	0.04	0.47
J-Road	0.03	0.35	120.00	0.11	0.84
J-Roof	0.04	0.42	18.70	0.07	1.21
K-Paving	0.01	0.04	8.16	0.01	0.12
K-Pervious	0.04	0.10	4.77	0.02	0.25
K-Roof	0.06	0.63	27.70	0.11	1.83
L-Paving	0.01	0.04	9.29	0.02	0.12
L-Pervious	0.05	0.11	4.10	0.02	0.24
L-Roof	0.07	0.74	33.60	0.13	2.16
M-Pervious	0.02	0.05	2.15	0.01	0.10
M-Road	0.03	0.32	107.00	0.09	0.77
N-Pervious	0.08	0.18	6.69	0.04	0.43
P-Pervious	0.08	0.18	8.13	0.04	0.41
P-Road	0.01	0.07	26.4	0.02	0.21
P-Roof	0.02	0.23	9.80	0.04	0.67

Table B.6 below details the model results for each treatment zone under the post development conditions. The effectiveness of these treatment zones for removing pollutants is shown in Table B.7.

Table B.6: Post Development Conditions Treatment Zone Results

		Mean Annual Load IN				Mean Annual Load OUT			
Treatment Zone Location	Description	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)
1	Swale	3.03	249.00	0.79	7.39	0.74	10.10	0.11	1.49
8	Swale	10.10	164.00	1.51	17.80	8.72	151.00	1.32	15.20
7	Swale	11.30	184.00	1.63	20.00	9.52	153.00	1.41	16.70
9+10	Swale	1.88	65.70	0.26	3.17	0.56	9.28	0.08	0.94
5	Swale	2.92	66.40	0.37	5.32	0.51	6.88	0.07	0.85
6	Swale	0.77	11.80	0.12	1.59	0.62	8.42	0.09	1.12
12	Swale	0.94	24.60	0.16	1.84	0.55	7.47	0.08	0.94
13	Swale	0.99	132	0.20	1.99	0.54	7.37	0.08	0.92
A	Swale	13.60	2,200.00	4.85	36.20	10.80	146.00	1.54	19.10
14	Bio-retention Swale	2.15	420.00	0.68	5.72	1.83	62.60	0.28	3.07
15	Bio-retention Swale	0.36	109.00	0.10	0.90	0.09	4.87	0.01	0.14
16	Bio-retention Swale	0.30	43.30	0.08	0.75	0.22	5.67	0.03	0.35
2	Bio-retention Swale	0.96	195.00	0.24	2.23	0.51	19.40	0.06	0.77
3	Bio-retention Swale	1.13	233.00	0.31	2.78	0.84	31.90	0.10	0.13
4	Infiltration Area	1.25	54.40	0.19	2.62	1.15	14.60	0.10	1.73
5	Infiltration Area	1.29	100.00	0.30	3.40	1.23	29.90	0.16	2.40
7	Infiltration Area	0.38	108.00	0.11	0.87	0.31	27.20	0.05	0.52
C	Re-use	0.84	39.10	0.15	2.49	0.52	13.30	0.08	1.40
D	Re-use	1.69	80.20	0.31	4.81	0.64	14.50	0.10	1.57
E	Re-use	1.37	64.20	0.24	3.80	0.94	27.00	0.15	2.37
H	Re-use	0.74	34.70	0.14	2.12	0.55	15.20	0.09	1.40
I	Re-use	1.05	45.70	0.19	3.15	0.72	18.60	0.11	1.99
J	Re-use	0.42	18.70	0.07	1.21	0.26	6.14	0.04	0.67
K	Re-use	0.63	27.70	0.11	1.80	0.44	11.1	0.07	1.17
L	Re-use	0.74	33.60	0.13	2.16	0.55	14.4	0.09	1.45
P	Re-use	0.23	9.80	0.04	0.67	0.15	3.53	0.02	0.38

Table B.7: Treatment Zone Effectiveness, Post-development Conditions

Treatment Zone Location	Description	Mean Annual Flow Reduction	TSS Mean Annual Load Reduction	TP Mean Annual Load Reduction	TN Mean Annual Load Reduction
1	Swale	-76%	-96%	-87%	-80%
8	Swale	-56%	-95%	-80%	-71%
7	Swale	-33%	-94%	-74%	-56%
9+10	Swale	-77%	-98%	-89%	-86%
5	Swale	-90%	-99%	-94%	-94%
6	Swale	-80%	-97%	-89%	-85%
12	Swale	-84%	-97%	-91%	-89%
13	Swale	-86%	-98%	-92%	-91%
A	Swale	-21%	-93%	-68%	-48%
14	Bio-retention Swale	-22%	-86%	-66%	-52%
15	Bio-retention Swale	-76%	-96%	-89%	-85%
16	Bio-retention Swale	-26%	-87%	-68%	-53%
2	Bio-retention Swale	-58%	-94%	-83%	-74%
3	Bio-retention Swale	-26%	-86%	-68%	-53%
4	Infiltration Area	-62%	-96%	-86%	-79%
5	Infiltration Area	-28%	-78%	-59%	-51%
7	Infiltration Area	-19%	-75%	-54%	-41%
C	Re-use	-38%	-66%	-47%	-44%
D	Re-use	-62%	-82%	-69%	-67%
E	Re-use	-31%	-58%	-39%	-38%
H	Re-use	-26%	-56%	-36%	-36%
I	Re-use	-32%	-59%	-40%	-37%
J	Re-use	-38%	-67%	-49%	-45%
K	Re-use	-30%	-60%	-40%	-36%
L	Re-use	-26%	-57%	-36%	-33%
P	Re-use	-38%	-64%	-46%	-44%

Table B.7 shows that the treatment zones selected for the post-development conditions provide a high level of treatment and achieve pollutant reductions generally in the range of 56% to 99% for suspended solids, 36% to 94% for phosphorus and 33% to 94% for nitrogen. The reduction in flow generated by the treatment zones ranges from 19% to 90%. The rainwater re-use achieves flow reductions in the order of 26% to 62%. Table B.8 details the expected pollutant loads at each of the outlets from the site.

Table B.8: Post-development Pollutant Loads at Outlets

Outlet Location	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
O-1	2.91	87.00	0.42	6.56
O-2	0.83	67.50	0.19	1.73
O-3	10.60	212.00	1.63	19.50
Spring Cove	**14.34**	**366.50**	**2.24**	**27.79**

B.3. Comparison of Results

Comparing Table B.8 with Table B.4, it can be seen that a zero increase in stormwater pollutants leaving the site under post-development conditions can be achieved. Table B.9 details the expected reduction in loads.

Table B.9: Change in Pollutant Loads at Outlets (Post-development – Pre-development)

Outlet Location	Mean Annual Flow (ML/yr)	TSS Mean Annual Load (kg/yr)	TP Mean Annual Load (kg/yr)	TN Mean Annual Load (kg/yr)
O-1	1.76	33.80	0.19	3.86
O-2	0.81	67.27	0.19	1.70
O-3	-5.60	-200.00	-1.04	-10.80
Spring Cove	**-3.03**	**-98.93**	**-0.66**	**-5.24**
Reduction at Spring Cove	**-17%**	**-21%**	**-23%**	**-16%**

As shown, there will be an increase in the loads at Outlets O-1 and O-2. This is because under pre-development conditions, there is a much smaller runoff reaching these outlets. Under post-development conditions the runoff from Area B is directed to O-2, where as previously this was directed to Outlet O-1. Under the post-development conditions, stormwater runoff from Sub-catchments C, I and P is directed to Outlet O-1 where as previously these areas would have drained to O-2.

Overall, Table B.9 shows that the combined average annual loads discharging from the Spring Cove site to Spring Cove will be less than under the pre-development conditions. That is, capture and re-use of rainwater and incorporating bio-retention swales and infiltration zones into the stormwater management of the site is an effective means of improving water quality. The proposed stormwater management strategy will therefore meet the objective of no net increase of flow or pollutant loads under post-development conditions when compared with existing site conditions.

Appendix C. Sediment Basin Sizing Report

LEND LEASE DEVELOPMENT

ST PATRICK'S ESTATE, MANLY

SPRING COVE PRECINCT 5, 6 & 10

SEDIMENT BASIN SIZING REPORT

HUGHES TRUEMAN

MAY 2006

PREPARED BY:	Q.A. CHECK:	CO-ORDINATED:	APPROVED FOR ISSUE:	DATE:
RH	RH	RH	RH	5 May 2006

1 SIZING OF SEDIMENT BASINS

a) Managing Urban Stormwater: Soils and Construction by Landcom (2004) was used for guidelines in sizing the sediment basins required for St. Patrick's Estate, Manly. The sediment basins form part of the erosion and sediment control plan for construction of the development.

The development will be constructed in four (4) stages as described below:

Stage 1 – Construction of the roadworks and services for the development and the bulk earthworks platforms for Houses 1 - 4 and the Apartments

Stage 2 – Building works associated with the construction of the Apartments

Stage 3 – Building works associated with the construction of Houses 1 - 4 and Houses 6 - 14

Stage 4 – Building works associated with the construction of Houses 15 - 23

There are 9 sediment basins proposed for the different stages of the development as shown on Drg Nos 01S828-DA-C110 to DA-C114. The sizes of the basins are based on the disturbed area of catchment draining to each basin.

b) The Stormwater Management Plan (Hughes Trueman Reinhold, 1997) contains a soil and site assessment report that states the soils present would be generally classified as Type C soils. Type C soils are those soils with more than 33% of the soil material greater than 0.02 mm in size. There is also indication that Type F soils are present. Type F soils have more than 33% of the soil material less than 0.02 mm in size. Type C relates to coarse particle size and Type F to fine particle size.

Therefore, the basins have been sized taking into account that both fine and coarse particles need to settle.

Since Type F soils are finer than Type C soils, they settle at slower rates and require a larger settling volume within a basin and have been used as the prevalent soil type for basin design.

c) The design criteria as outlined in Landcom (2004) for basins where soils of Type F are prevalent, suggests total storm containment is adopted for a nominal design rainfall depth. The guidelines state that such basins are normally empty and fill after rainfall events with water remaining in them long enough to be properly treated with settling agents. They are then either pumped out or allowed to drain under gravity.

d) A 5-day rainfall depth is adopted as standard where the disturbed soils are Type F. The 75th percentile storm depth is used.

e) Sediment basins where soils are Type F are sized according to:

V = settling zone + sediment storage zone

f) The settling zone capacity to capture Type F soils is determined from:

Settling zone (Type F) = $10*C_v*A*R_{75th\ \%ile,\ 5\ day}$

Where:

- 10 is a unit conversion factor
- C_v is a volumetric runoff coefficient; **0.56** from Table F2, Appendix F (Landcom, 2004)
- A is the catchment area of the basin (hectares); **Varies according to development stage and basin location (see**
- **Table** 1)
- $R_{75th\%ile,5day}$ is the 5-day total rainfall depth (mm) that is not exceeded in 75% of rainfall events; **26.2 mm** from Mosman location, Table 6.3a (Landcom, 2004)

g) The capacity of sediment storage zones for Type F soils is 50% of the settling zone capacity.

h) Table 1 presents input data and results for determining sediment basin size for these particles:

Table 1: Input Data and Results for Sediment Basin Sizing

Type F/D soil, 5 day design storm										
Stage & Basin	Area (ha)	Runoff Coefficient	Duration (days)	Depth (mm)	Runoff (m3)	Basin Surface Area (m2)	Settling Depth (m)	Basin Volume (m3)	Sediment Storage Volume (m3)	Total Basin Volume (m3)
1	0.595	0.560	5	26.2	87.3	145	0.6	87	44	131
2	0.644	0.560	5	26.2	94.5	157	0.6	94	47	142
3	0.120	0.560	5	26.2	17.6	29	0.6	18	9	26
4	0.155	0.560	5	26.2	22.7	38	0.6	23	11	34
5	0.220	0.560	5	26.2	32.3	54	0.6	32	16	48
6	0.295	0.560	5	26.2	43.3	72	0.6	43	22	65
7	0.055	0.560	5	26.2	8.1	13	0.6	8	4	12
8	0.095	0.560	5	26.2	13.9	23	0.6	14	7	21
9	0.095	0.560	5	26.2	13.9	23	0.6	14	7	21

P:\St_Leona.rds\2001\01s828\Docs\Enviro\Sed Basin Sizing\IFD data (SP version).xls [Basin sizing]

i) In summary, Table 2 presents sediment basin sizes and surface areas.

Table 2: Sediment Basin Properties

Sediment Basin	Basin Surface Area	Total Basin Volume (m^3)
SB 1	145	131
SB 2	157	142
SB 3	29	26
SB 4	38	34
SB 5	54	48
SB 6	72	65
SB 7	13	12
SB 8	23	21
SB 9	23	21

2 REFERENCES

Hughes Trueman Reinhold (1997) *St. Patrick's Estate, Manly. Southern Side of Darley Road. Stormwater Management Plan.* August 1997. Joint report with Lyall and Macoun Consulting Engineers.

Landcom (2004) *Managing Urban Stormwater: Soils and Construction.* 4th Edition. New South Wales Government.

St Patricks Estate Manly
Sediment Basin Sizing

Type F/D soil, 5 day design storm

Stage & Basin	Area (ha)	Runoff Coefficient	Duration (days)	Depth (mm)	Runoff (m3)	Basin Surface Area (m2)	Settling Depth (m)	Basin Volume (m3)	Sediment Storage Volume (m3)	Total Basin Volume (m3)
1	0.595	0.560	5	26.2	87.3	145	0.6	87	44	131
2	0.644	0.560	5	26.2	94.5	157	0.6	94	47	142
3	0.120	0.560	5	26.2	17.6	29	0.6	18	9	26
4	0.155	0.560	5	26.2	22.7	38	0.6	23	11	34
5	0.220	0.560	5	26.2	32.3	54	0.6	32	16	48
6	0.295	0.560	5	26.2	43.3	72	0.6	43	22	65
7	0.055	0.560	5	26.2	8.1	13	0.6	8	4	12
8	0.095	0.560	5	26.2	13.9	23	0.6	14	7	21
9	0.095	0.560	5	26.2	13.9	23	0.6	14	7	21

St Patricks Estate Manly
Sediment Basin Sizing

Type C soil

Stage	Area (ha)	Length (m)	Roughness	Slope (m/m)	t*I^(0.4)	3 month ARI Duration (min)	Intensity (mm/hr)	Q (m3/s)	Basin Surface Area (m2)	Settling Volume (m3)	Basin Volume (m3)	5 yr ARI Duration (min)	Intensity (mm/hr)	Q (m3/s)
1	0.595	70	0.013	0.13	12.09	5	96	0.044	28.2	17	34	5	158	0.17
2	0.644	75	0.013	0.12	12.91	5	96	0.048	30.5	18	37	5	158	0.19
3	0.120	80	0.013	0.11	13.78	5	96	0.009	5.7	3	7	5	158	0.04
4	0.155	90	0.013	0.02	24.66	5	96	0.012	7.3	4	9	5	158	0.05
5	0.220	75	0.013	0.05	16.79	5	96	0.016	10.4	6	13	5	158	0.06
6	0.295	105	0.013	0.06	19.45	5	96	0.022	14.0	8	17	5	158	0.09
7	0.055	70	0.013	0.08	13.99	5	96	0.004	2.6	2	3	5	158	0.02
8	0.095	55	0.013	0.07	12.60	5	96	0.007	4.5	3	5	5	158	0.03
9	0.095	40	0.013	0.10	9.35	5	96	0.007	4.5	3	5	5	158	0.03

Type F/D soil, 5 day design storm

Stage	Area (ha)	Length (m)	Roughness	Slope (m/m)	Runoff Coef	Duration (days)	Depth (mm)	Runoff (m3)	Basin Surface Area (m2)	Settling Depth (m)	Basin Volume (m3)	Sediment Storage Volume (m3)	Total Basin Volume (m3)
1	0.595	70	0.013	0.13	0.560	5	26.2	87.3	145	0.6	87	44	131
2	0.644	75	0.013	0.12	0.560	5	26.2	94.5	157	0.6	94	47	142
3	0.120	80	0.013	0.11	0.560	5	26.2	17.6	29	0.6	18	9	26
4	0.155	90	0.013	0.02	0.560	5	26.2	22.7	38	0.6	23	11	34
5	0.220	75	0.013	0.05	0.560	5	26.2	32.3	54	0.6	32	16	48
6	0.295	105	0.013	0.06	0.560	5	26.2	43.3	72	0.6	43	22	65
7	0.055	70	0.013	0.08	0.560	5	26.2	8.1	13	0.6	8	4	12
8	0.095	55	0.013	0.07	0.560	5	26.2	13.9	23	0.6	14	7	21
9	0.095	40	0.013	0.10	0.560	5	26.2	13.9	23	0.6	14	7	21

Basin depth (m)	0.6	(min)	
Particle size (mm)	Settling Velocity (m/s)	Basin Surface Area (m2/m3/s)	
0.05	**0.0019**	635	<-- Input variables

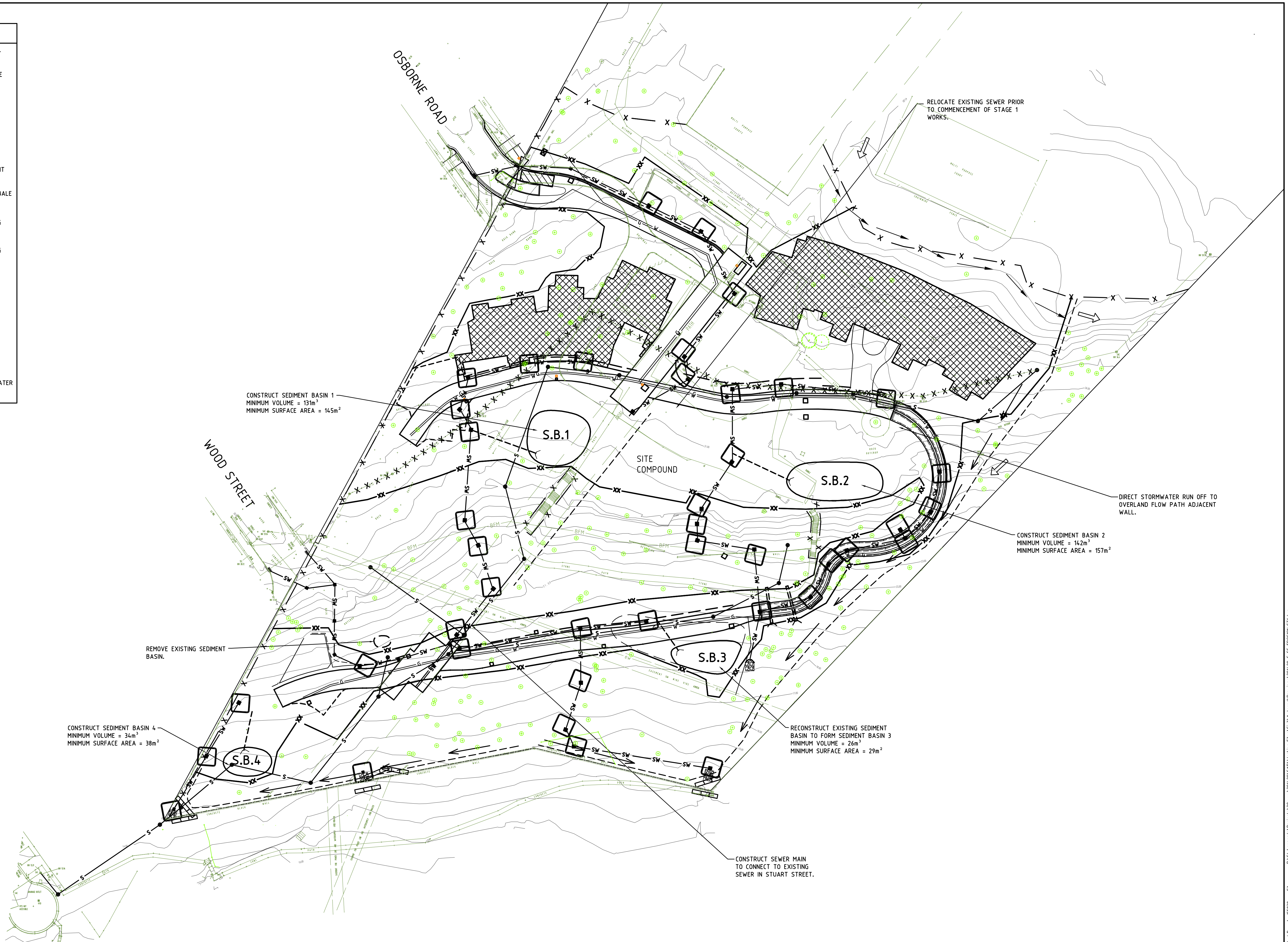
Appendix D. Sediment & Erosion Control Plans

- 291428C-CC301
- 291428C-CC302
- 291428C-CC303
- 291428C-CC304
- 291428C-CC305

LEGEND PROPOSED

- CONSTRUCT TEMPORARY SEDIMENT FENCE.
- MAINTAIN EXISTING BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
- CONSTRUCT BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
- OVERLAND FLOW PATH
- DIVERSION SWALE
- CONSTRUCT STRAW BALE SEDIMENT FILTER
- CONSTRUCT TEMPORARY STRAW BALE DROP INLET SEDIMENT TRAP
- CONSTRUCT TEMPORARY SANDBAG SEDIMENT TRAP AT LOWPOINT
- CONSTRUCT TEMPORARY SANDBAG KERB INLET SEDIMENT TRAP
- CONSTRUCT TEMPORARY STABILISED SITE ACCESS
- CONSTRUCT BULK EARTHWORKS PLATFORM FOR FUTURE BUILDING
- S.B.# CONSTRUCT SEDIMENT BASIN
- CONSTRUCT TEMPORARY STORMWATER CONNECTION TO SEDIMENT BASIN

NOTE: REFER TO DWG 291428C-CC305 FOR DETAILS.



A1 SHEET

Rev	Amendment / Reason For Issue	Date	Drawing Completed by	Designed & Checked by	Verified by X = Not verified	Issue Authorised (*)
A	ISSUED FOR CONSTRUCTION	27.09.11	RAS	RPH		

10 5 0 10 20 30
PLAN Scale 1:500 @A1

NORTH

Mott MacDonald
Hughes Trueman
ABN 53 831 529 091
Level 2, 60 Pacific Hwy, PO Box 151, ST LEONARDS NSW 2065
T +61 2 9439 2633 F +61 2 9438 4505 stleonards@hughestrueman.com.au

Project: ST PATRICKS ESTATE SPRING COVE, MANLY

Client: OAKSTAND

Architect/Project Manager: TRUSTEES OF THE ROMAN CATHOLIC CHURCH

Drawing Title: EROSION AND SEDIMENT CONTROL CONCEPT PLAN STAGE 1

Drawing No. 291428C-CC301

Sheet ?? Rev A

Plotted By : bud55938 Date : 27-9-11 Time : 5:14pm

Rev	Amendment / Reason For Issue	Date	Drawing Completed by	Designed & Checked by	Verified by X = Not verified	Issue Authorised (*)
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ABN 53 831 529 091
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T +61 2 9439 2633 F +61 2 9438 4505 stleonards@hughestrueman.com.au

Project: ST PATRICKS ESTATE SPRING COVE, MANLY

Client: OAKSTAND

Architect/Project Manager: TRUSTEES OF THE ROMAN CATHOLIC CHURCH

Drawing Title: EROSION AND SEDIMENT CONTROL CONCEPT PLAN STAGE 2

Drawing No.: 291428C-CC302

Sheet: of ??

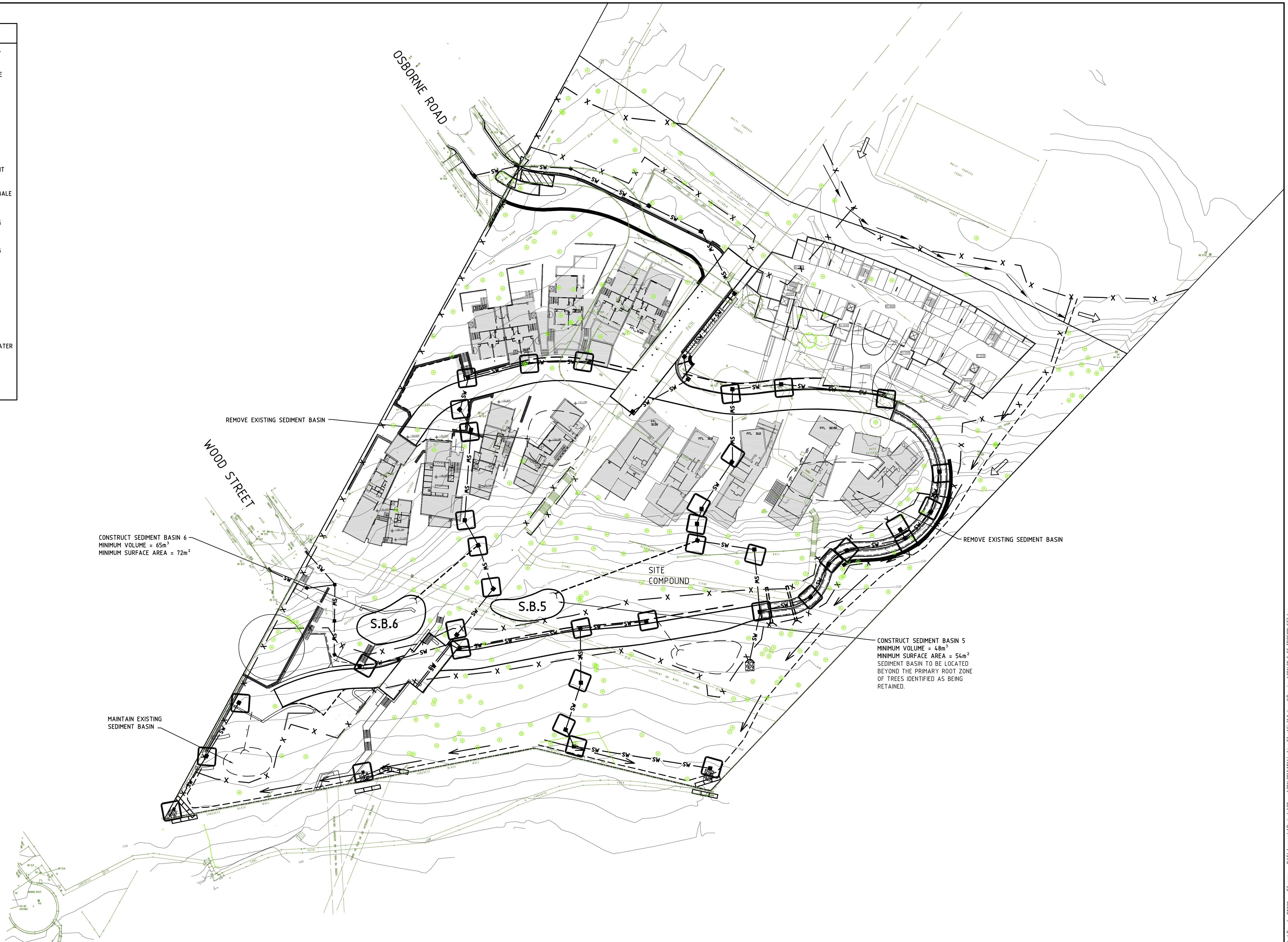
Rev: A

LEGEND PROPOSED

— — — —	CONSTRUCT TEMPORARY SEDIMENT FENCE.
—— x ——	MAINTAIN EXISTING BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
——xx——	CONSTRUCT BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
⇨ ⇨	OVERLAND FLOW PATH
←	DIVERSION SWALE
	CONSTRUCT STRAW BALE SEDIMENT FILTER
	CONSTRUCT TEMPORARY STRAW BALE DROP INLET SEDIMENT TRAP
	CONSTRUCT TEMPORARY SANDBAG SEDIMENT TRAP AT LOWPOINT
	CONSTRUCT TEMPORARY SANDBAG KERB INLET SEDIMENT TRAP
	CONSTRUCT TEMPORARY STABILISED SITE ACCESS
S.B.#	CONSTRUCT SEDIMENT BASIN
- - - -<	CONSTRUCT TEMPORARY STORMWATER CONNECTION TO SEDIMENT BASIN
	CONSTRUCT BUILDING

NOTE: REFER TO DWG 291428C-CC305 FOR DETAILS.

A1 SHEET



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Hughes Trueman
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Level 2, 60 Pacific Hwy, PO Box 151, ST LEONARDS NSW 2065
T +61 2 9439 2633 F +61 2 9438 4505 stleonards@hughestrueman.com.au

Project: ST PATRICKS ESTATE SPRING COVE, MANLY

Client: OAKSTAND

Architect/Project Manager: TRUSTEES OF THE ROMAN CATHOLIC CHURCH

Drawing Title: EROSION AND SEDIMENT CONTROL CONCEPT PLAN STAGE 3

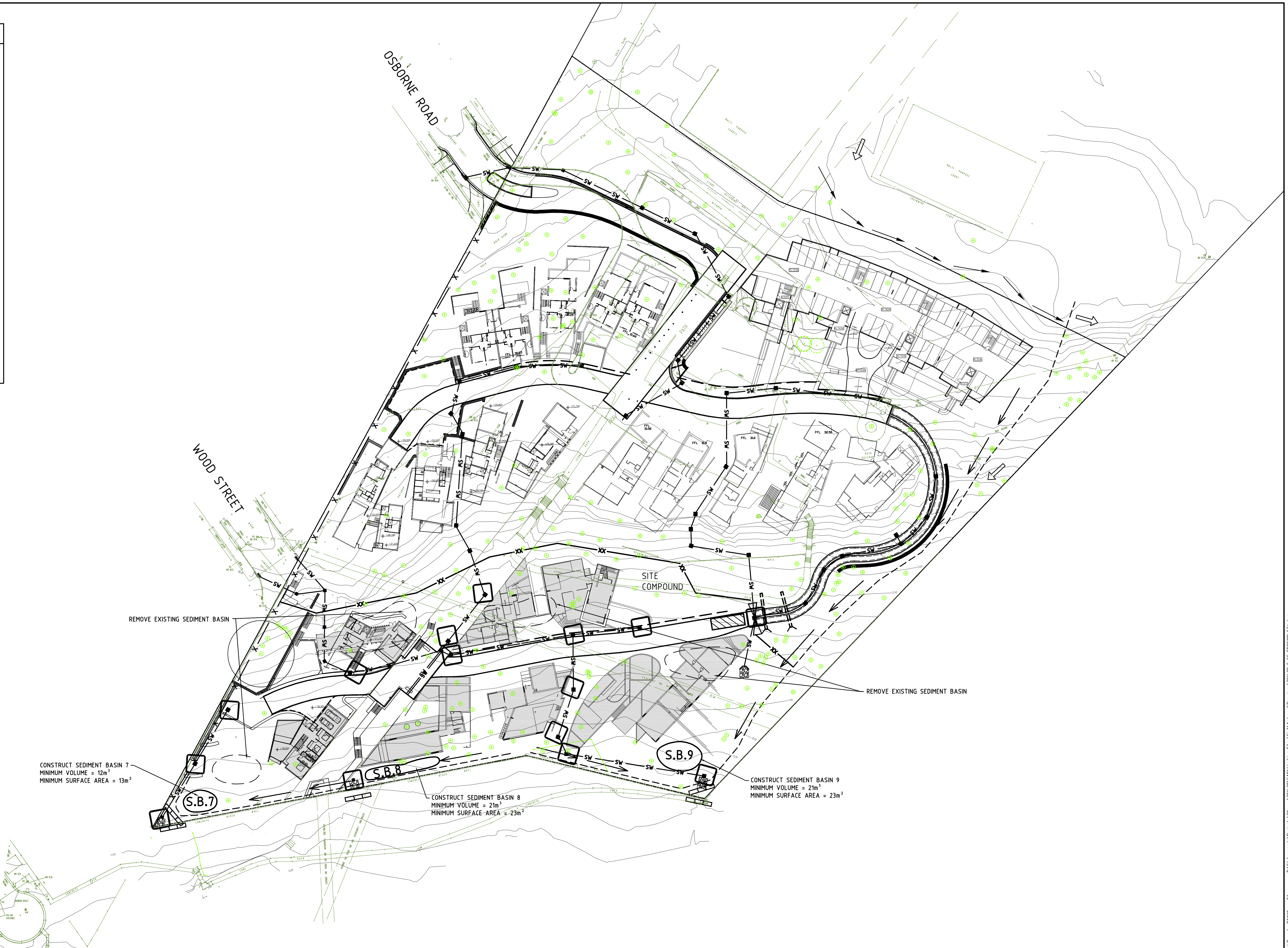
Drawing No. 291428C-CC303 | Sheet Of ?? | Rev A

Plotted By : bud55938 Time : 5:16pm Date : 27-9-11

LEGEND PROPOSED

— — — —	CONSTRUCT TEMPORARY SEDIMENT FENCE.
— x —	MAINTAIN EXISTING BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
—xx—	CONSTRUCT BARRIER FENCE (1800mm HIGH TEMPORARY CONSTRUCTION FENCE).
⇨ ⇨	OVERLAND FLOW PATH
←	DIVERSION SWALE
	CONSTRUCT STRAW BALE SEDIMENT FILTER
	CONSTRUCT TEMPORARY STRAW BALE DROP INLET SEDIMENT TRAP
	CONSTRUCT TEMPORARY SANDBAG SEDIMENT TRAP AT LOWPOINT
	CONSTRUCT TEMPORARY SANDBAG KERB INLET SEDIMENT TRAP
	CONSTRUCT TEMPORARY STABILISED SITE ACCESS
S.B.#	CONSTRUCT SEDIMENT BASIN
	CONSTRUCT BUILDING

NOTE: REFER TO DWG 291428C-CC305 FOR DETAILS.



A1 SHEET

Rev	Amendment / Reason For Issue	Date	Drawing Completed by	Designed & Checked by	Verified by X = Not verified	Issue Authorised (*)
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NORTH

Mott MacDonald
Hughes Trueman
ABN 53 831 529 091
Level 2, 60 Pacific Hwy, PO Box 151, ST LEONARDS NSW 2065
T +61 2 9439 2633 F +61 2 9438 4505 stleonards@hughestrueman.com.au

Project: ST PATRICKS ESTATE SPRING COVE, MANLY

Drawing Title: EROSION AND SEDIMENT CONTROL CONCEPT PLAN STAGE 4

Client: OAKSTAND

Architect/Project Manager: TRUSTEES OF THE ROMAN CATHOLIC CHURCH

Drawing No.: 291428C-CC304

Sheet Of ??

Rev: A

Date : 27-9-11 Time : 5:17pm Plotted By : bud55938

SOIL AND WATER MANAGEMENT NOTES

INTRODUCTORY NOTES
1. THIS IS A CONCEPTUAL SOIL AND WATER MANAGEMENT PLAN (SWMP). IT IS INTENDED TO INDICATE THAT THE CIVIL WORKS REQUIRED FOR THE DEVELOPMENT OF THE SITE CAN BE UNDERTAKEN WITHOUT POLLUTION TO RECEIVING WATERS DURING THE CONSTRUCTION PHASE. THE LOCATIONS, SIZES AND TYPES OF CONTROL MEASURES SHOWN ARE SUGGESTED OPTIONS ONLY.

2. ALL REFERENCES OF DETAILS, TESTING AND PROCEDURES ARE TO BE FOLLOWED AS SPECIFIED IN THE DEPARTMENT OF HOUSING "MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION" MANUAL, MARCH 2004, HERE IN REFERRED TO AS THE "BLUE BOOK".

3. THESE CONCEPT PLANS ARE TO BE READ IN CONJUNCTION WITH THE ENGINEERING PLANS AND OTHER PLANS OR WRITTEN INSTRUCTIONS THAT MAY BE ISSUED AND RELATING TO THE DEVELOPMENT OF THE SITE.

4. ALL CONTRACTORS SHALL FULLY RESEARCH AND UNDERSTAND THEIR RESPONSIBILITIES IN MINIMISING THE POTENTIAL FOR SOIL EROSION AND POLLUTION TO DOWNSTREAM LANDS AND WATERWAYS.

AUTHORITY APPROVALS
1. THESE PLANS PRESENT CONCEPT OPTIONS ONLY, AND ARE INTENDED TO ASSIST THE CONTRACTOR IN THE DEVELOPMENT AND PRICING OF A SUITABLE EROSION CONTROL PHILOSOPHY.

2. IT IS THE CONTRACTORS RESPONSIBILITY TO PRODUCE SOIL AND WATER MANAGEMENT PLANS AND OTHER SUPPORTING DOCUMENTATION REQUIRED TO GAIN THE APPROVAL OF COUNCIL AND THE ENVIRONMENTAL PROTECTION AUTHORITY (NSW EPA) AS REQUIRED.

3. PRIOR TO COMMENCING WORK ON THE SITE, THE CONTRACTOR SHALL ENSURE THAT A CONTROLLED ACTIVITY APPROVAL HAS BEEN OBTAINED FROM THE NSW OFFICE OF WATER.

ENVIRONMENTAL BOND
1. AN ENVIRONMENTAL BOND MAY BE REQUIRED. IT MUST BE LODGED AS AN ASSURANCE THAT ANY EROSION, SEDIMENT AND POLLUTION CONTROL STRATEGY DESCRIBED IN THE SWMP WILL BE DILIGENTLY ESTABLISHED, IMPLEMENTED AND MAINTAINED AS SPECIFIED BY THE APPROVAL.

2. THE AMOUNT OF BOND RELATES TO AREA OF LANDS TO BE DISTURBED. THE CONTRACTORS ATTENTION IS DRAWN TO THE FACT THAT THIS IS NOT NECESSARILY THE SAME AS THE ASSUMPTION USED IN DESIGN OF EROSION CONTROL MEASURES.

3. THE NSW EPA SHOULD BE CONSULTED TO DETERMINE THE BOND PAYABLE. HOWEVER, AS A GUIDE THE BOND IS TYPICALLY:
- NIL FOR LESS THAT 999SQm LAND DISTURBED.
- $2,000 PLUS $1 FOR EACH SQM OF DISTURBED LAND IN EXCESS 1,000SQm TO A MAXIMUM TOTAL PAYMENT OF $20,000.

5. THE CONTRACTOR, SHOULD REFER TO APPENDIX N, DEPARTMENT OF HOUSING BLUE BOOK FOR STANDARD CONDITIONS OF CONSENT.

SUGGESTED WORK SCHEDULE

STAGE 1
* EXISTING EROSION CONTROL FACILITIES AS SHOWN ON DWG NO. 291428C-CC301 TO BE RETAINED.
* ESTABLISH BARRIER FENCING AROUND VEGETATION IDENTIFIED TO BE RETAINED AND AS SHOWN ON DWG NO. 291428C-CC301.
* CONSTRUCT DRAINS ABOVE THE DEVELOPMENT SITE TO DIVERT "CLEAN" RUNOFF FROM ST PAULS COLLEGE AND THE ARCHBISHOP'S RESIDENCE AREAS AROUND THE CONSTRUCTION AREA.
* CONSTRUCT STABILISED CONSTRUCTION ENTRANCE.
* ERECT SEDIMENT FENCE DOWNSTREAM OF PROPOSED SEWER MAIN.
* CONSTRUCT PROPOSED SEWER MAIN IN ACCORDANCE WITH THE DRAWINGS. DISCRETE SECTIONS OF THE PROPOSED MAIN ARE TO BE EXCAVATED, THE PIPES LAID AND BACKFILLED, AND THE DISTURBED AREAS REHABILITATED PRIOR TO COMMENCEMENT OF THE NEXT SECTION OF SEWER MAIN.
* PLACE SILT FENCES DOWNSTREAM OF SEDIMENT BASIN AREAS, AS REQUIRED.
* CONSTRUCT NEW SEDIMENT BASINS AS SHOWN ON DWG 291428C-CC301.
* INSTALL SEDIMENT FENCES AS SHOWN ON DWG NO. 291428C-CC301.
* INSTALL THE PIPED STORMWATER DRAINAGE SYSTEM THROUGH THE SITE. ENSURE THE STORMWATER PIPES
1. DRAIN TO THE SEDIMENT BASINS. PROVIDE TEMPORARY CONNECTIONS WHERE REQUIRED.
2. * CONSTRUCT THE ROADWORKS AND SERVICES INSTALLATION AND BULK EARTHWORKS FOR APARTMENTS AND LOT 1.
3. * STABILISE ALL DISTURBED SURFACES WHEN POSSIBLE AFTER THE COMPLETION OF THE CONSTRUCTION WORKS.
* PROVIDE ONGOING MONITORING AND MAINTENANCE OF THE VARIOUS EROSION CONTROL MEASURES DURING THE
4. INFRASTRUCTURE AND BUILDING CONSTRUCTION PHASES.
5.

STAGE 2
6. * CONSTRUCT BARRIER FENCES ACROSS ACCESS ROADS AS SHOWN ON DWG 291428C-CC302.
2. * UNDERTAKE CONSTRUCTION OF APARTMENTS.
3. * STABILISE ALL DISTURBED AREAS WHERE POSSIBLE ON COMPLETION OF CONSTRUCTION WORKS.
4. * PROVIDE ONGOING MONITORING AND MAINTENANCE OF
7. THE VARIOUS EROSION CONTROL MEASURES DURING THE INFRASTRUCTURE AND BUILDING CONSTRUCTION PHASES.
8. * REMOVE SOIL AND WATER MANAGEMENT FACILITIES AROUND THE APARTMENTS ON COMPLETION OF WORKS.
9.

STAGE 3
10. 1. * REMOVE EXISTING SEDIMENT BASINS 1 & 2.
2. * CONSTRUCT SEDIMENT BASINS 5 & 6.
3. * UNDERTAKE CONSTRUCTION OF HOUSES LOT 1 AND 3-11.
4. * STABILISE ALL DISTURBED AREAS WHERE POSSIBLE ON
11. COMPLETION OF CONSTRUCTION WORKS.
5. * PROVIDE ONGOING MONITORING AND MAINTENANCE OF THE VARIOUS EROSION CONTROL MEASURES DURING THE
12. INFRASTRUCTURE AND BUILDING CONSTRUCTION PHASES.
6. * REMOVE SOIL AND WATER MANAGEMENT FACILITIES
13. AROUND THE HOUSES LOT 1 AND 3-11 ON COMPLETION OF WORKS.

STAGE 4
1. * REMOVE EXISTING SEDIMENT BASINS 3, 4, 5 & 6.
2. * CONSTRUCT SEDIMENT BASINS 7, 8, & 9.
3. * UNDERTAKE CONSTRUCTION OF HOUSES LOT 12-19.
4. * STABILISE ALL DISTURBED AREAS WHERE POSSIBLE ON COMPLETION OF CONSTRUCTION WORKS.
5. * PROVIDE ONGOING MONITORING AND MAINTENANCE OF THE VARIOUS EROSION CONTROL MEASURES DURING THE INFRASTRUCTURE AND BUILDING CONSTRUCTION PHASES.
6. * REMOVE ALL SOIL AND WATER MANAGEMENT FACILITIES ON COMPLETION OF CONSTRUCTION.

EROSION CONTROL
1. CLEARLY VISIBLE BARRIER FENCING SHALL BE INSTALLED AT THE DISCRETION OF THE SITE SUPERINTENDENT TO SURE TRAFFIC CONTROL AND PROHIBIT UNNECESSARY SITE DISTURBANCE. VEHICULAR ACCESS TO THE SITE SHALL BE LIMITED TO ONLY THOSE ESSENTIAL FOR CONSTRUCTION WORK AND THEY SHALL ENTER SITE ONLY THROUGH THE STABILISED ACCESS POINTS.

2. ALL EARTHWORKS, INCLUDING WATERWAYS / DRAINS / SPILLWAYS AND THEIR OUTLETS WILL BE CONSTRUCTED TO BE STABLE IN AT LEAST THE DESIGN STORM EVENT, OR 1 YEAR ARI, WHICHEVER CAUSES THE GREATER FLOW.

3. WHERE PRACTICAL, FOOT AND VEHICULAR TRAFFIC WILL BE KEPT AWAY FROM ALL RECENTLY STABILISED AREAS.

4. AT ALL TIMES, AND IN PARTICULAR DURING WINDY AND DRY WEATHER, LARGE, UNPROTECTED AREAS WILL BE KEPT MOIST (NOT WET) BY SPRINKLING WITH WATER TO KEEP DUST UNDER CONTROL.

SEDIMENT CONTROL
1. ANY SAND USED IN THE CONCRETE CURING PROCESS (SPREAD OVER THE SURFACE) WILL BE REMOVED AS SOON AS POSSIBLE AND WITHIN 10 WORKING DAYS OF PLACEMENT.

2. WATER WILL BE PREVENTED FROM ENTERING THE PERMANENT DRAINAGE SYSTEM UNLESS IT IS RELATIVELY SEDIMENT FREE, I.E. THE CATCHMENT AREA HAS BEEN PERMANENTLY LANDSCAPED/STABILISED AND/OR ANY LIKELY SEDIMENT HAS BEEN FILTERED THROUGH AN APPROVED STRUCTURE.

3. TEMPORARY SOIL AND WATER MANAGEMENT STRUCTURES WILL BE REMOVED ONLY AFTER THE LANDS THEY ARE PROTECTING ARE STABILISED/REHABILITATED.

WASTE MANAGEMENT
1. ACCEPTABLE BINS WILL BE PROVIDED FOR ANY CONCRETE AND MORTAR SLURRIES, PAINTS, ACID WASHINGS, LIGHTWEIGHT WASTE MATERIALS AND LITTER. CLEARANCE SERVICES WILL BE PROVIDED AT LEAST WEEKLY, IN A MANNER AS APPROVED BY THE SITE SUPERINTENDENT.

OTHER MATTERS
1. ANY EXISTING TREES WHICH FORM PART OF THE FINAL LANDSCAPING PLAN WILL BE PROTECTED FROM CONSTRUCTION ACTIVITIES BY:
(A) PROTECTING THEM WITH BARRIER FENCING OR SIMILAR MATERIALS INSTALLED OUTSIDE THE DRIP LINE.
(B) ENSURING THAT NOTHING IS NAILED TO THEM.
(C) PROHIBITING PAVING, GRADING, SEDIMENT WASH OR PLACING OF STOCKPILES WITHIN THE DRIP LINE EXCEPT UNDER THE FOLLOWING CONDITIONS:

(I) ENCROACHMENT ONLY OCCURS ON ONE SIDE AND NO CLOSER TO THE TRUNK THAN EITHER 1.5 METRES OR HALF THE DISTANCE BETWEEN THE OUTER EDGE OF THE DRIP LINE AND THE TRUNK, WHICH EVER IS THE GREATER.

(II) A DRAINAGE SYSTEM THAT ALLOWS AIR AND WATER TO CIRCULATE THROUGH THE ROOT ZONE (E.G. A GRAVEL BED) IS PLACED UNDER ALL FILL LAYERS OF MORE THAN 300 MILLIMETRES DEPTH

(III) CARE IS TAKEN NOT TO CUT ROOTS UNNECESSARILY NOR TO COMPACT THE SOIL AROUND THEM.

(IV) SIGNAGE IS TO BE DISPLAYED ON THE TREE PROTECTION FENCE ADVISING CONSTRUCTION WORKERS THAT ACCESS BEYOND THE PROTECTIVE FENCING IS PROHIBITED WITHOUT AUTHORISATION OF THE PROJECT SITE MANAGER.

2. EROSION AND SEDIMENT CONTROL MEASURES SHALL BE INSPECTED TO ENSURE THAT THEY OPERATE EFFECTIVELY. REPAIRS AND OR MAINTENANCE SHALL BE UNDERTAKEN REGULARLY AND AS REQUIRED, PARTICULARLY FOLLOWING STORM EVENTS.

3. THE CONTRACTOR SHALL PROVIDE ALL MONITORING CONTROLS & TESTING.

4. SITE REVEGETATION AND REHABILITATION SHALL BE UNDERTAKEN AS SOON AS PRACTICABLE THROUGHOUT CONSTRUCTION OPERATIONS.

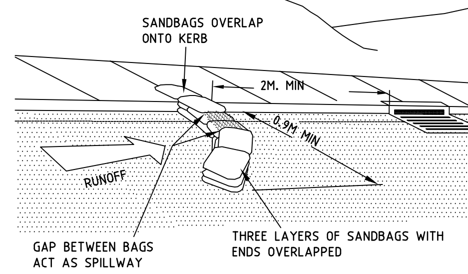
5. CONSTRUCTION SHALL BE PROGRAMMED SO THAT THE TIME OF EXPOSURE OF WORKING SURFACES IS MINIMISED.

6. ALL SPOIL DEPOSITED DURING CARTAGE OF MATERIALS FROM OR TO THE SITE SHALL BE REMOVED IMMEDIATELY TO THE SATISFACTION OF COUNCIL.

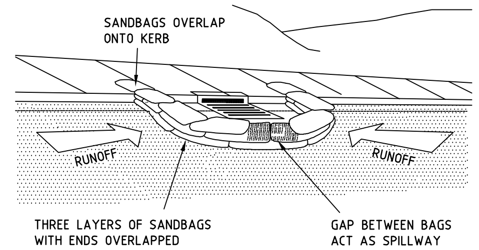
7. WHERE REQUIRED GUTTERS AND ROADWORKS SHALL BE SWEPT REGULARLY TO MAINTAIN THEM FREE FROM SEDIMENT.

CONSENT CONDITIONS
THE CONTRACTOR SHALL COMPLY WITH THE RELEVANT CONDITIONS OF THE DEVELOPMENT CONSENT IN PARTICULAR:

CONDITION No.	DESCRIPTION
196	SITE DEWATERING
198	MAINTENANCE OF SEDIMENT & EROSION CONTROL MEASURES
199	BUILDING OPERATIONS
200	INSTALLATION OF SEDIMENT & EROSION CONTROL MEASURES
275	SITE CLEARING METHODS
276	STABILISED CONSTRUCTION ACCESS
278	STOCKPILING OF MATERIALS
279	STABILISATION OF DISTURBED AREAS
280	RESPONSIBILITY FOR SEDIMENT CONTROL MEASURES
282	POLLUTION OF RECEIVING WATERS
283	WEEKLY REPORT ON SEDIMENT & EROSION CONTROL MEASURES
284	ON-SITE TRAINING

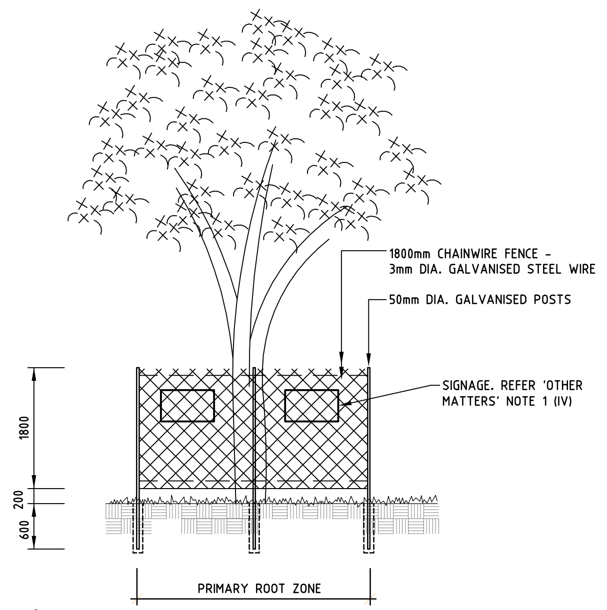


SANDBAG SEDIMENT TRAP FOR KERB INLET ON GRADE



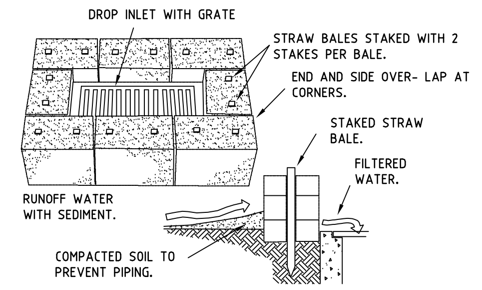
SANDBAG SEDIMENT TRAP FOR KERB INLET AT LOW POINT

DRAINAGE AREA 0.6HA. MAX. SLOPE GRADIENT 1:2 MAX. SLOPE LENGTH 60M MAX.



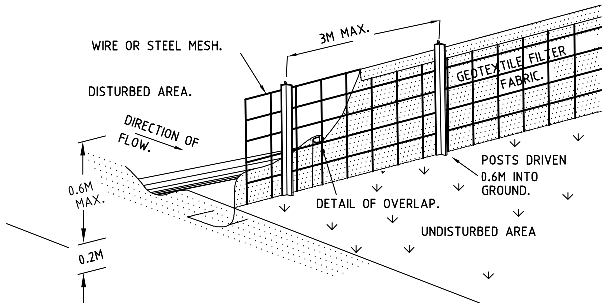
TREE PROTECTION DETAIL

NOTE: PROVDE SIGNAGE ON FENCE. REFER DA CONDITIONS FOR DETAILS.

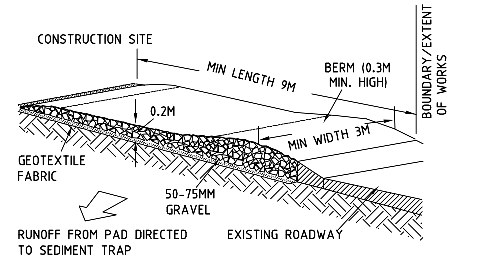


STRAW BALE DROP INLET SEDIMENT TRAP

N.T.S.



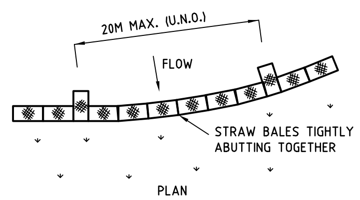
SEDIMENT FENCE



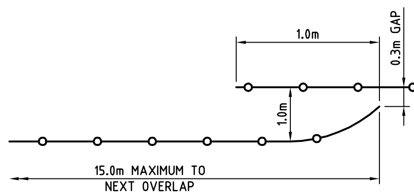
TEMPORARY SITE ACCESS

N.T.S.

MAINTENANCE
THE TEMPORARY ACCESS SHALL BE MAINTAINED IN A CONDITION THAT PREVENTS TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHTS OF WAY. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL GRAVEL AS CONDITIONS DEMAND AND REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT. ALL SEDIMENT SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC RIGHTS OF WAY MUST BE REMOVED IMMEDIATELY.

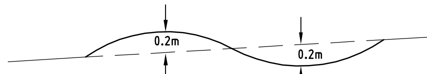


DRAINAGE AREA 0.4HA MAX. SLOPE GRADIENT 1:2 MAX. SLOPE LENGTH 40M MAX.



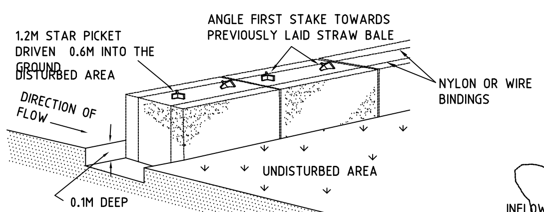
SEDIMENT FENCE OVERLAP DETAIL

N.T.S.



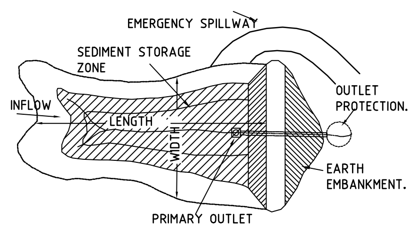
DIVERSION SWALE

N.T.S.



STRAW BALE SEDIMENT FILTER

N.T.S.



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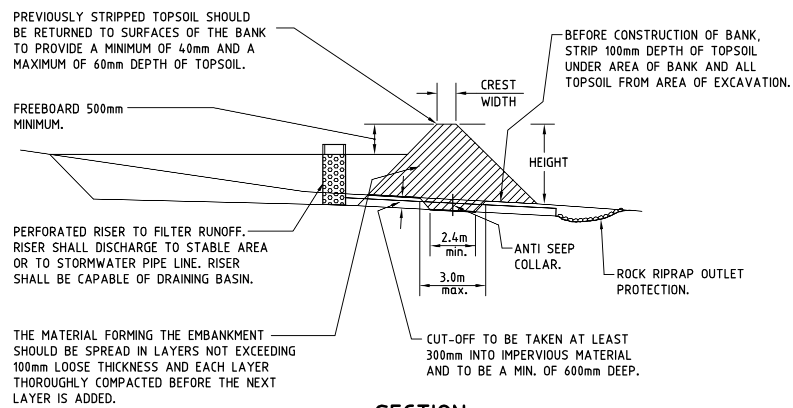

SECTION

TYPICAL SEDIMENT BASIN

A1 SHEET
300mm
200mm
100mm

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Scales
Not To Scale

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Level 2, 60 Pacific Hwy, PO Box 151, ST LEONARDS NSW 2065
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Drawing Title
EROSION AND SEDIMENT CONTROL CONCEPT NOTES AND DETAILS

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