
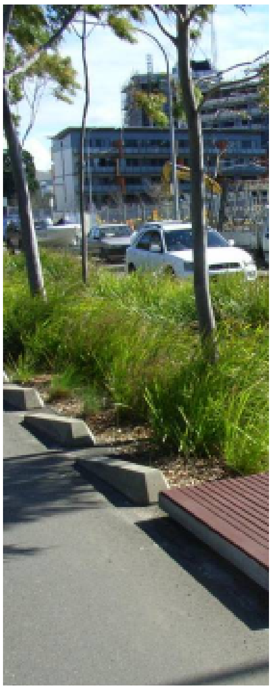


SPRING COVE ESTATE, MANLY

STORMWATER REPORT

December 2011

Spring Cove Developments Pty Ltd

Mott MacDonald
Hughes Trueman

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Issue and revision record

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1	30/06/2004	TE	RH	RH	Draft
2	05/05/2006	SG	RH	RH	Draft
3	05/12/2011	CB	RH	RH	Final

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Content

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Executive Summary

The stormwater drainage for Spring Cove Estate described within this report has been designed to satisfy the requirements of Manly Councils 'Specification for Stormwater Drainage 2003'.

As site constraints dictate that major system flows will surcharge across private property, the pipe system has been designed to convey 100 year ARI flows. This approach is in accordance with Section 7.2 of the above Council document. Modelling of the stormwater drainage system has been undertaken using the DRAINS software package to estimate design flows and pipes sizes, and to check freeboard at sag locations.

Substantial re-use of stormwater on the site will occur which will have the effect of reducing stormwater flows from the development. This stormwater reuse has not been considered in the sizing of the proposed stormwater system. The details of the stormwater re-use and associated stormwater quality management facilities are contained in the companion report *Stormwater Quality Assessment Report, November 2011*.

1. Introduction

1.1 Background

This report has been prepared by Mott MacDonald Hughes Trueman to address the stormwater drainage requirements of the Spring Cove Estate development in Manly.

The report should be read in conjunction with the Mott MacDonald Hughes Trueman engineering plans.

1.2 Site Description

St Patrick's Estate Manly currently houses St Pauls College, Archbishops residence and extends south from Darley Road to Spring Cove. Until recently, Gilroy House was also one of the constructed features of the site, and there are also a number of historically significant features of the site including steps and pathways. Spring Cove Estate comprises the southern portion of the Estate south of Darley Road.

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 quantity or quality resulting from the proposed development.

The existing flow paths and catchments for the site and the upstream catchment are shown on Drawing No. 291428C-SK02 in Appendix A. There are three (3) stormwater outlets to Spring Cove. The two (2) western outlets cater for a relatively small portion of the site while the eastern outlet caters for the majority of the site.

1.3 Scope

Previous drainage issues raised in the Land and Environment Court of NSW relate to both water quality and water quantity. Water quality issues are not addressed as part of this report. For details regarding water quality, reference should be made to the following report:

St Patrick's Estate, Spring Cove, Manly — Stormwater Quality Assessment Report November 2011.

2. Proposed Stormwater Drainage Infrastructure

The proposed stormwater system is shown on Drawing No. 291428C-CC231 – Stormwater Plan.

A piped stormwater collection system will be provided within the precincts to collect stormwater in accordance with Manly Council's document 'Specification for Stormwater Drainage 2003'. The layout of the site is constrained by existing trees that are to be retained and heritage features, particularly steps and pathway. The resulting site layout provides negligible opportunity to provide overland flowpaths along roads or drainage easements. Therefore the piped drainage system has been designed for a 100 year ARI.

Run-off from existing developed catchment above the site (i.e. St Paul's College and the Archbishop's Residence) flows in two directions. The majority (2.84 ha.) will be directed along the eastern boundary of the site to maintain the existing water regime to areas of significant vegetation. The remainder (1.1 ha.) is conveyed by Pipeline E along Road 1. Line E discharges just beyond the end of road 1 and the runoff is conveyed as overland flow along the heritage corridor. It is collected by Pit A8, just upstream of the lower section of Road 2.

Pit A8 is a bifurcation pit. Most flow from this pit will be conveyed by Line A to Outlet O3 at the south-eastern corner of the site, in order to maintain the existing flow distribution to the vegetation below the site and to Spring Cove. Flows exceeding the capacity of Line A will conveyed under Road 2 by a box culvert to Outlet O2.

Other stormwater management measures include:

- Bioretention swales and bioretention basins where run-off during minor storms from roads and hard surfaced areas are directed.
- Infiltration areas where run-off from minor storms from roads and hard surfaced areas are directed in order to replicate the existing water regime to areas of significant vegetation.
- Rainwater collection tanks will be provided at each house and for the apartments. These tanks will collect roof run-off in order to provide water for laundries and toilet flushing for the houses and apartments.
- 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 pits immediately before the outlets from the site (A.1 & G.1) are designed to surcharge. This is to allow large flows to leave the site as overland flow and to prevent high velocity flow being directed at vegetation below the site.

The above stormwater management measures are described in more detail in St Patrick’s Estate, Spring Cove, Manly — Stormwater Quality Assessment Report November 2011.

3. Stormwater Quantity Modelling

To demonstrate the peak site discharge for the above events in both the post developed site condition, Mott MacDonald Hughes Trueman has undertaken modelling using the “DRAINS” software package. DRAINS is a runoff routing program that converts rainfall patterns into runoff and routes flows through a drainage network.

DRAINS therefore offers a level of design superior to the rational method in that actual hydrographs for the 10 and 100 year storm events are produced rather than triangular hydrographs. Each catchment is analysed and hydrographs developed for the critical duration storm relating to the catchment characteristics.

3.1 Model Data

3.1.1 Hydrologic Parameters

The loss model in Drains represents hydrological processes such as interception, depression storage, evaporation and infiltration to determine runoff from a catchment. Losses are removed from the rainfall hyetograph to determine the rainfall excess, which is then converted to runoff.

3.1.1.1 Rainfall Data

The IFD data for Manly Council has been used as the initial input into drains for rainfall hyetographs. Storm temporal patterns, ranging in duration from 5 minutes to 2 hours, from *Australian Rainfall and Runoff (ARR)* (Institution of Engineers, Australia, 1987)

3.1.1.2 Depression Storage

Depression storage represents the initial losses from the catchment. The following inputs have been adopted:

- Grassed Areas – 5mm
- Paved Areas – 1mm

3.1.1.3 Soil Type

The infiltration capacity of grassed areas is partly dependent upon soil type. The four main soil types are as follows:

Table 3.1: Soil Classification

Classification	Description
1(A)	high infiltration – sand, gravels
2(B)	moderate infiltration
3(C)	slow infiltration
4(D)	very slow infiltration - clays

For Spring Cove Estate, the soil type adopted is Classification 3.

3.1.1.4 Antecedent Moisture Condition (AMC)

The infiltration capacity of grassed areas is also partly dependent upon AMC. The AMC is basically a measure of the wetness of the soil immediately prior to the storm event. The four main AMC conditions are as follows:

Table 3.2: AMC Conditions

Number	Description	Total Rainfall in 5 days preceding storm (mm)
1	completely dry	0
2	rather dry	0 - 12.5
3	rather wet	12.5 - 25
4	saturated	Over 25

For Spring Cove Estate, the AMC adopted is 3.

3.1.2 Other Data

The input data for the DRAINS model is listed in Appendix B. The adopted catchment boundaries are shown on Drawing No. 291428C-SK02.

Pit inlet capacities were determined using the relationships from *HEC22* (US Federal Highway Administration (FHWA), 2002) and *ARR* for on-grade and sag pits respectively. Where the majority of inflow to the pit is from house roofs, the pits were modelled as having unlimited inlet capacity. Building down pipes will be connected to the main drainage lines by interallotment pipes, however these have not been detailed at this stage.

The methods for estimating Pit losses listed in Manly Council's *Specification for Stormwater Drainage* (2003) do not cover drops or partially full pipes. The FHWA 'Composite Energy Loss Method' (*HEC22*, 2002) was used to estimate pit losses in these cases. Losses for all other pits were estimated using the Hare Equations.

Where overland flowpaths follow roads, the shape of the overland flowpath in DRAINS was determined from the from the road and swale cross-sections. However overland flow cross-sections in landscaped areas have not been determined at this stage.

For the purposes of sizing the piped stormwater system the effects of the rainwater collection tanks and infiltration areas were omitted from the DRAINS modelling. Likewise, bioretention swales and basins were assumed to be fully saturated at the start of the design storms. This is considered a more conservative approach.

3.2 Results

The outputs from the DRAINS model runs are at Appendix B. The model was run firstly run without any pit blockage factors in order to estimate pipe sizes. The results show that the proposed pipe system will convey the peak 100 year ARI flows.

A second model run was undertaken with pit blockage factors applied to estimate overland flows and to check ponding depths at sag locations. The adopted pit blockage are shown in Table 3.3 and derived from Manly Council's *Specification for Stormwater Drainage* (2003).

Table 3.3: Pit Blockage Factors

Pit Type	Blockage Factor
Sag, grate only	20%
On-grade, grate only	50%

3.2.1 Ponding Depths

As the proposed houses are located in close proximity to the road, there is a need to ensure that ponding at sag points does not cause flooding of houses and garages. Table 3.4 shows ponding levels in the 100 year ARI assuming the above pit blockage factors. The results show that Council's freeboard requirements are satisfied at these sag locations.

Table 3.4: Ponding Levels at Sag Locations

Pit No.	Ponding Level (mAHD)	House No.	Garage		Ground Floor	
			R.L.	Freeboard	R.L.	Freeboard
A.6	18.51	19	19.27	0.76	21.92	3.41
A.8	19.12	18	19.58	0.45	24.88	5.76
A.14	30.20	1	30.60	0.40	33.40	3.20
C.8	30.77	8, 9	31.00	0.23		

3.2.2 Flow Distribution from Pit A.8

Pit A.8 has significant impact on the distribution of flow between Outlet O2 and Outlet O3. Table 3.5 shows peak flows and the runoff volumes from Pit A.8 that are directed to outlets O2 and O3 respectively. The table shows that the majority of flow from Pit A.8 is directed to the eastern outlet, thus assisting to maintaining the existing flow regime to Spring Cove and the vegetation below the site.

Table 3.5: Flow Distribution from Pit A.8

ARI (years)	Peaks flows (L/s) in critical storm duration		Proportion of Runoff Volume in 2 hour duration storm	
	To O2	To O3	To O2	To O3
2	37	312	1%	99%
10	214	317	10%	90%
100	482	316	21%	79%

Appendices

Appendix A. Catchment Plans

A1 SHEET

Rev	Amendment / Reason For Issue	Date	Drawing Completed by	Designed & Checked by	Verified by X = Not verified	Issue Authorised (*)
A	ISSUED FOR INFORMATION	05.12.11	RAS	RPH		

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

NORTH

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Project
SPRING COVE ESTATE
MANLY

Drawing Title
PROPOSED CATCHMENTS
PLAN

Client
SPRING COVE DEVELOPMENT PTY LTD

Architect/Project Manager
OAKSTAND PROPERTY GROUP

Drawing No.
291428C-SK02

Sheet 01 Of 01

Rev A

Date : 06-12-11 Time : 9:03am Plotted By : bud55938

Appendix B. Drains Model Input / Output

INPUT DATA

PIT / NODE DETAILS Version 10

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor
B.1	OnGrade	Bio-Swale	BS225 - 600x900		4	19.675		0	0.2
A.5	Sag	Bio-Swale	BS225 - 6C	5.1	2.6	19.331	0.25	0	0.5
A.4	OnGrade	Dummy	UNLIMITED		0.3	17.192		0	0.2
A.3	OnGrade	Dummy	UNLIMITED		0.8	15.454		0	0.2
A.2	OnGrade	Dummy	UNLIMITED		1.2	14.729		0	0.2
A.1	OnGrade	Dummy	UNLIMITED		2	13.578		0	0.2
3	Node					13.124		0	
C.10	OnGrade	Dummy	UNLIMITED		4	34.086		0	0.2
C.9	OnGrade	Dummy	UNLIMITED		1.6	33.06		0	0.2
C.8	Sag	Bio-Swale	BS225 - 6C	4.08	2.3	32.33	0.26	0	0.5
C.7	OnGrade	Junction	JP		0.5	30.693		0	0.2
C.6	OnGrade	Junction	JP		1.4	29.481		0	0.2
C.5	OnGrade	Dummy	UNLIMITED		2	26.366		0	0.2
C.4	OnGrade	Junction	JP		1.7	24.148		0	0.2
C.3	OnGrade	Junction	JP		2.4	24.083		0	0.2
C.2	OnGrade	Dish Drain	AWY_DDG		1	20.563		0	0.2
C.1	Node					18.801		0	
F.1	OnGrade	Dummy	UNLIMITED		4	25.285		0	0.2
D.4	OnGrade	Dish Drain	AWY_DDG		2.5	25.796		0	0.2
D.3	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	23.602		0	0.2
D.2	OnGrade	Dish Drain	AWY_DDG		1.5	23.093		0	0.2
D.1	OnGrade	Dish Drain	AWY_DDG		1.2	21.97		0	0.2
G.3	OnGrade	Bio-Swale	BS225 - 600x900		1.5	19.018		0	0.2
G.2	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	16.112		0	0.2
1	Node					15.025		0	
House 15	OnGrade	Dummy	UNLIMITED		0	19		0	0.2
H.1	OnGrade	Bio-Swale	BS225 - 600x900		2.5	18.55		0	0.2
A.7	OnGrade	Dish Drain	AWY_DDG		2	19.372		0	0.2
A.6	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	19.198		0	0.2
DP 19	OnGrade	Dummy	UNLIMITED		0	19.27		0	0.2
DP 2	OnGrade	Dummy	UNLIMITED		0	30.6		0	0.2
A.15	OnGrade	Bio-Swale	BS225 - 600x900		0.5	32.228		0	0.2
A.14	Sag	Bio-Swale	BS225 - 6C	0.6	2	32.924	0.1	0	0.5
A.13	Sag	Dish Drain	DDG	2	1.2	30.175	0.15	0	0.5
A.12	OnGrade	Dummy	UNLIMITED		1.5	30.417		0	0.2
A.11	OnGrade	Dummy	UNLIMITED		1.5	26.165		0	0.2
A.10	OnGrade	Junction	JP		1.5	22.954		0	0.2
A.9	OnGrade	Dummy	UNLIMITED		1.5	21.28		0	0.2
A.8	Sag	Surface Inl	900 x 900	3	1.5	19.643	0.5	0	0.5
DP 3	OnGrade	Dummy	UNLIMITED		0	31.75		0	0.2
A.16	OnGrade	Bio-Swale	BS225 - 600x900		4	31.114		0	0.2
DP 1	OnGrade	Dummy	UNLIMITED		0	33.4		0	0.2
J.2	OnGrade	NSW Dept	1.8 m lintel (all grades		4	29.416		0	0.2
J.1	OnGrade	Dummy	UNLIMITED		2.5	26.884		0	0.2
M.1	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	28.395		0	0.2
H.2	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	18.15		0	0.2
E.9	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	40.4		0	0.2
E.8	OnGrade	NSW Dept	1.8 m lintel (all grades		4	40.1		0	0.2
E.7	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	38.2		0	0.2
E.6	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	35.7		0	0.2
E.4	OnGrade	Junction	JP		0.9	34.341		0	0.2
E.3	OnGrade	Bio-Swale	BS225 - 600x900		1	32.834		0	0.2
E.2	OnGrade	Bio-Swale	BS225 - 600x900		1.2	31.993		0	0.2
D.7	OnGrade	NSW Dept	1.8 m lintel (all grades		1.5	30.59		0	0.2
D.6	OnGrade	Dish Drain	AWY_DDG		4	28.864		0	0.2
D.5	OnGrade	Dish Drain	AWY_DDG		1.4	27.26		0	0.2
2	Node					19.1		0	

DETENTION BASIN DETAILS

Name	Elev	Volume	Init Vol. (cu	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type
E.5	36	0	0	Culvert		1			
	36.2	35.4							
	36.4	70.8							
	36.6	105							
E.1	29	0	0	None					
	29.2	30							
	29.4	60							
	29.6	90							
	29.8	120							

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)
C B.1	B.1	0.1326	15	85	0	5	15	0	
C A.5	A.5	0.0642	69	31	0	3	10	0	
C A.2	A.2	0.0785	75	25	0	3	6	0	
C A.1	A.1	0.0001	99	1	0	1	5	0	
C C.10	C.10	0.1762	75	25	0	3	5	0	
C C.9	C.9	0.0515	58	42	0	3	5	0	
C C.8	C.8	0.0868	58	42	0	3	5	0	
C C.5	C.5	0.1903	75	25	0	2	5	0	
C C.2	C.2	0.033	25	75	0	5	10	0	
C F.1	F.1	0.0444	60	40	0	5	10	0	
C D.3	D.4	0.0063	95	5	0	2	2	0	
C D.2	D.2	0.0301	35	65	0	2	10	0	
C D.1	D.1	0.006	80	20	0	2	5	0	
C G.3	G.3	0.2961	60	40	0	3	10	0	
C House15	House 15	0.0225	100	0	0	2	0	0	
C H.1	H.1	0.0124	72	28	0	2	5	0	
C A.7	A.7	0.0089	100	0	0	2	5	0	
C Houses	DP 19	0.0702	100	0	0	2	0	0	
House 2	DP 2	0.02	100	0	0	2	0	0	
C A.15	A.15	0.0576	27	73	0	3	10	0	
C A.14	A.14	0.0858	33	67	0	3	10	0	
C A.13	A.13	0.0254	100	0	0	2	5	0	
C A.11	A.11	0.16	78	22	0	3	5	0	
C A.8	A.8	0.156	10	90	0	5	15	0	
House 3, 4	DP 3	0.04	100	0	0	2	0	0	
C A.16	A.16	0.0852	21	79	0	3	10	0	
House 1	DP 1	0.02	100	0	0	3	0	0	
C J.2	J.2	0.475	75	25	0	5	10	0	
C M.1	M.1	0.06	90	10	0	5	5	0	
C E8	E.8	0.085	75	25	0	5	10	0	
C E.5	E.5	1.1199	0	80	20	1	10	1	
C E.3	E.3	0.0885	81	19	0	2	5	5	
C E.2	E.2	0.0223	95	5	0	1	5	0	
C E.1	E.1	0.0244	100	0	0	1	5	0	
C D.7	D.7	0.0192	95	5	0	2	2	0	
C D.5	D.5	0.0054	95	5	0	2	2	0	

PIPE DETAILS

Name	From	To		Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)
P B.1	B.1	A.5		21.194	18.06	17.578	2.27	RCP	225	225
P A.5	A.5	A.4		14.874	15.99	15.75	1.61	RCP	525	525
P A.4	A.4	A.3		13.512	15.7	13.95	12.95	RCP	525	525
P A.3	A.3	A.2		5.08	13.9	13.38	10.24	RCP	525	525
P A.2	A.2	A.1		37.848	13.15	12.3	2.25	RCP	525	525
P A.1	A.1		3	4.678	12.25	12.2	1.07	uPVC HD	150	154
P C.10	C.10	C.9		27.98	31.2	30.41	2.82	RCP	375	375
P C.9	C.9	C.8		13.583	30.36	29.709	4.79	RCP	375	375
P C.8	C.8	C.7		19.632	29.57	29.35	1.12	RCP	450	450
P C.7	C.7	C.6		14.521	29.3	28.3	6.89	RCP	450	450
P C.6	C.6	C.5		5.293	26.381	25.5	16.64	RCP	450	450
P C.5	C.5	C.4		4.585	24.206	23.3	19.76	RCP	450	450
P C.4	C.4	C.3		15.68	23	22.4	3.83	RCP	450	450
P C.3	C.3	C.2		17.04	20.8	19.46	7.86	RCP	450	450
P C.2	C.2	C.1		11.978	19.4	18.8	5.01	RCP	450	450
P F.1	F.1	D.4		2.715	24.23	24.2	1.1	RCP	375	375
P D.4	D.4	D.3		11.68	24.15	22.574	13.49	RCP	300	300
P D.3	D.3	D.2		5.15	22.574	22	11.15	RCP	375	375
P D.2	D.2	D.1		11.54	21.92	20.8	9.71	RCP	375	375
P D.1	D.1	C.2		14.382	20.75	19.5	8.69	RCP	375	375
P G.2	G.3	G.2		25.399	17	14.65	9.25	RCP	375	375
P G.1	G.2		1	1.151	14.45	14.4	4.34	RCP	375	375
DP 15	House 15	H.1		1	18.4	18.2	20	uPVC HD	150	154
P H.1	H.1	A.7		14.935	17.16	17	1.07	RCP	525	525
P A.7	A.7	A.6		2.719	17	16.85	5.52	RCP	525	525
P A.6	A.6	A.5		33.674	16.8	16.31	1.46	RCP	525	525
P H18-19	DP 19	A.5		1	18.2	17.85	35	uPVC HD	100	105
P DP2	DP 2	A.15		1	30.3	30.25	5	uPVC HD	100	105
P A.15	A.15	A.14		16.955	29.52	29.15	2.18	RCP	375	375
P A.14	A.14	A.13		9.146	29.1	29.015	0.93	RCP	375	375
P A.13	A.13	A.12		6.256	28.96	28.897	1.01	RCP	375	375
P A.12	A.12	A.11		24.766	28.83	25.3	14.25	RCP	375	375
P A.11	A.11	A.10		7.789	23.658	22.1	20	RCP	375	375
P A.10	A.10	A.9		12.682	20.8	20	6.31	RCP	450	450
P A.9	A.9	A.8		16.186	19.334	18.8	3.3	RCP	450	450
P A.8	A.8	A.7		2.932	17.5	17.05	15.35	RCP	450	450
Box Culver	A.8		2	16.66	18.2	18.04	0.96	Box Culver	0.6W x 0.45H	
P DP3	DP 3	A.16		1	30.75	30.7	5	uPVC HD	150	154
P A.16	A.16	A.15		16.253	30.07	29.57	3.08	RCP	375	375
P DP1	DP 1	A.14		1	29.8	29.75	5	uPVC HD	100	105
P J.2	J.2	J.1		10.999	27.226	25.6	14.78	RCP	375	375
P J.1	J.1	A.10		40.652	25.62	21.8	9.4	RCP	450	450
P M.1	M.1	J.1		6.137	26.05	25.942	1.76	RCP	375	375
P H.2	H.2	H.1		10.646	17.3	17.18	1.13	RCP	450	450
Pipe572	E.9	E.8		12.164	39.2	38.55	5.34	RCP	375	375
P E.8	E.8	E.7		18.18	38.5	36.65	10.18	RCP	375	375
P E.7	E.7	E.6		20.065	36.6	34.85	8.72	RCP	375	375
P E.6	E.6	E.5		15.876	34.8	34.3	3.15	RCP	375	375
P E.5	E.5	E.4		19.097	34.25	33.8	2.36	RCP	450	450
P E.4	E.4	E.3		21.844	33.75	31.802	8.92	RCP	450	450
P E.3	E.3	E.2		6.679	31.73	30.37	20.36	RCP	450	450
P E.2	E.2	E.1		17.041	30.25	30.012	1.4	RCP	525	525
Pipe582	D.7	D.6		11.62	27.6	26.85	6.45	RCP	375	375
P D.6	D.6	D.5		11.62	26.85	26.1	6.45	RCP	300	300
P D.5	D.5	D.4		11.62	26.05	24.75	11.19	RCP	300	300

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Widt (m)	L.B. Slope (1:?)

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Dept Major Stor (m)	SafeDepth Minor Stor (m)
OF B.1	B.1	A.5	1				Bioswale	0.1	0.1
OF A.5	A.5	A.4	1				Dummy us	0.2	0.05
OF A.4	A.4	A.3	1				Dummy us	0.2	0.05
OF A.3	A.3	A.2	0.5				Dummy us	0.2	0.05
OF A.2	A.2	A.1	1				Dummy us	0.2	0.05
OF A.1	A.1	3	0.5				Dummy us	0.2	0.05
OF C10	C.10	D.7	2				Accessway	0.14	0.075
OF C.9	C.9	C.8	0.5				Bioswale	0.1	0.1
OF C.2	C.2	B.1	1				Bioswale	0.1	0.1
OF D.3	D.4	D.2	0.5				Accessway	0.14	0.075
OF D.2	D.2	D.1	0.5				Accessway	0.14	0.075
OF D.1	D.1	C.2	0.5				Accessway	0.14	0.075
OF G.2	G.3	G.2	3				Dummy us	0.2	0.05
OF H.1	H.1	A.7	1				Accessway	0.14	0.075
OF A.7	A.7	A.6	0.5				Bioswale	0.1	0.1
OF A.6	A.6	A.5	1				Dummy us	0.2	0.05
OF A.15	A.15	A.14	0.5				Bioswale	0.1	0.1
OF A.14	A.14	A.13	0.1				Dummy us	0.2	0.05
OF A.13	A.13	A.11	0.1				Dummy us	0.2	0.05
OF A.16	A.16	A.15	0.5				Bioswale	0.1	0.1
OF J2	J.2	J.1	0.5				Dummy us	0.2	0.05
OF H.2	H.2	H.1	0.5				Dummy us	0.2	0.05
OF E7	E.8	E.5	1				Dummy us	0.2	0.05
OF E.5	E.5	E.3	0.5	36.4	9.2	1.65	Dummy us	0.2	0.05
OF E.3	E.3	E.2	1				Dummy us	0.2	0.05
OF E.2	E.2	C.8	0.5				Bioswale	0.1	0.1
OF E.1	E.1	A.8	15	29.4	9.25	1.6	Dummy us	0.2	0.05
OF D.6	D.6	D.5	0.5				Accessway	0.14	0.075
OF D.5	D.5	D.4	0.5				Accessway	0.14	0.075
OF D.5	D.5	D.4	0.5				Accessway	0.14	0.075

100 YEAR ARI RESULTS

DRAINS results prepared 05 December, 2011 from Version 2011.12

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
B.1	18.58		0.069		1.09	0.021	Inlet Capacity
A.5	17.33	19.46	0.057	1.9	2	0	Inlet Capacity
A.4	16.12		0		1.07	0	None
A.3	14.93		0		0.52	0	None
A.2	14.62		0.054		0.11	0	None
A.1	13.58		0		0	0.537	Outlet System
3	12.35		0.537				
C.10	31.83		0.123		2.26	0	None
C.9	30.9		0.036		2.16	0	None
C.8	30	32.47	0.06	1.5	2.33		Inlet Capacity
C.7	29.58		0		1.12		None
C.6	26.75		0		2.73		None
C.5	25.14		0.133		1.23		None
C.4	23.86		0		0.29		None
C.3	21.83		0		2.25		None
C.2	20.21		0.02		0.35	0.005	Inlet Capacity
C.1	19.05		0				
F.1	24.52		0.028		0.77		None
D.4	24.51		0.005		1.29	0.001	Inlet Capacity
D.3	22.82		0		0.78		None
D.2	22.17		0.018		0.92	0.004	Inlet Capacity
D.1	21.02		0.008		0.95	0.001	Inlet Capacity
G.3	17.22		0.188		1.8	0.114	Inlet Capacity
G.2	14.91		0.114		1.2		None
1	14.55		0				
House 15	18.44		0.017		0.56		None
H.1	18.17		0.075		0.38	0.024	Inlet Capacity
A.7	18.19		0.026		1.18	0.007	Inlet Capacity
A.6	17.8		0.007		1.4	0	None
DP 19	18.28		0.052		0.99		None
DP 2	30.36		0.015		0.24		None
A.15	30.13		0.041		2.1	0.004	Inlet Capacity
A.14	30.04	33.02	0.054	0.6	2.88	0.017	Inlet Capacity
A.13	29.73	30.23	0.034	0.5	0.44	0	Inlet Capacity
A.12	29.46		0		0.96		None
A.11	24.63		0.112		1.53		None
A.10	22.89		0		0.06		None
A.9	21.1		0		0.18		None
A.8	18.87	20.09	0.646	2.5	0.78		Inlet Capacity
DP 3	30.83		0.03		0.92		None
A.16	30.52		0.049		0.59	0.008	Inlet Capacity
DP 1	30.04		0.015		3.36		None
J.2	27.59		0.313		1.83	0.212	Inlet Capacity
J.1	26.7		0.212		0.19		None
M.1	26.71		0.042		1.69		None
H.2	18.15		0		0	0.072	Outlet System
E.9	39.2		0		1.2		None
E.8	38.74		0.056		1.36	0.006	Inlet Capacity
E.7	36.85		0		1.35		None
E.6	35.7		0		0		Outlet System
E.4	34.66		0		-0.32		Outlet System
E.3	32.79		0.062		0.04	0.016	Inlet Capacity
E.2	31.26		0.031		0.74	0	None
D.7	27.73		0.014		2.86		None
D.6	26.98		0		1.89	0	None
D.5	26.19		0.004		1.07	0	None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
C B.1	0.066	0.014	0.052	5	15	0	AR&R 100 year, 1 hou
C A.5	0.042	0.031	0.011	3	10	0	AR&R 100 year, 25 mi
C A.2	0.054	0.042	0.012	3	6	0	AR&R 100 year, 1.5 hc
C A.1	0	0	0	1	5	0	AR&R 100 year, 5 min
C C.10	0.123	0.094	0.029	3	5	0	AR&R 100 year, 1.5 hc
C C.9	0.036	0.021	0.014	3	5	0	AR&R 100 year, 1.5 hc
C C.8	0.06	0.036	0.024	3	5	0	AR&R 100 year, 1.5 hc
C C.5	0.133	0.102	0.032	2	5	0	AR&R 100 year, 1.5 hc
C C.2	0.019	0.006	0.013	5	10	0	AR&R 100 year, 25 mi
C F.1	0.028	0.019	0.01	5	10	0	AR&R 100 year, 25 mi
C D.3	0.005	0.004	0	2	2	0	AR&R 100 year, 5 min
C D.2	0.018	0.007	0.011	2	10	0	AR&R 100 year, 25 mi
C D.1	0.004	0.003	0.001	2	5	0	AR&R 100 year, 1.5 hc
C G.3	0.188	0.124	0.064	3	10	0	AR&R 100 year, 25 mi
C House15	0.017	0.017	0	2	0	0	AR&R 100 year, 5 min
C H.1	0.009	0.006	0.002	2	5	0	AR&R 100 year, 1.5 hc
C A.7	0.007	0.007	0	2	5	0	AR&R 100 year, 5 min
C Houses	0.052	0.052	0	2	0	0	AR&R 100 year, 5 min
House 2	0.015	0.015	0	2	0	0	AR&R 100 year, 5 min
C A.15	0.034	0.011	0.023	3	10	0	AR&R 100 year, 25 mi
C A.14	0.051	0.02	0.031	3	10	0	AR&R 100 year, 25 mi
C A.13	0.019	0.019	0	2	5	0	AR&R 100 year, 5 min
C A.11	0.112	0.089	0.023	3	5	0	AR&R 100 year, 1.5 hc
C A.8	0.075	0.011	0.065	5	15	0	AR&R 100 year, 1 hou
House 3, 4	0.03	0.03	0	2	0	0	AR&R 100 year, 5 min
C A.16	0.049	0.013	0.036	3	10	0	AR&R 100 year, 25 mi
House 1	0.015	0.015	0	3	0	0	AR&R 100 year, 5 min
C J.2	0.313	0.249	0.064	5	10	0	AR&R 100 year, 25 mi
C M.1	0.042	0.038	0.004	5	5	0	AR&R 100 year, 1.5 hc
C E8	0.056	0.045	0.011	5	10	0	AR&R 100 year, 25 mi
C E.5	0.626	0	0.626	1	10	1	AR&R 100 year, 20 mi
C E.3	0.062	0.051	0.011	2	5	5	AR&R 100 year, 1.5 hc
C E.2	0.016	0.016	0.001	1	5	0	AR&R 100 year, 5 min
C E.1	0.018	0.018	0	1	5	0	AR&R 100 year, 5 min
C D.7	0.014	0.013	0.001	2	2	0	AR&R 100 year, 5 min
C D.5	0.004	0.004	0	2	2	0	AR&R 100 year, 5 min

Outflow Volumes for Total Catchment (1.97 impervious + 1.89 pervious = 3.86 total ha)

Storm	Total Rainf cu.m	Total Runo cu.m (Runc	Impervious cu.m (Runc	Pervious Runoff cu.m (Runoff %)
AR&R 100	855.59	652.05 (76	369.33 (84	282.73 (67.4%)
AR&R 100	1357.36	1115.74 (8	596.16 (86	519.58 (78.1%)
AR&R 100	1736.91	1463.10 (8	767.74 (86	695.36 (81.7%)
AR&R 100	2045.69	1743.85 (8	907.32 (87	836.54 (83.5%)
AR&R 100	2315.88	1984.70 (8	1029.47 (8	955.23 (84.2%)
AR&R 100	2566.77	2210.82 (8	1142.87 (8	1067.95 (84.9%)
AR&R 100	3155.39	2738.77 (8	1408.94 (8	1329.83 (86.0%)
AR&R 100	3666.81	3202.15 (8	1640.16 (8	1562.00 (87.0%)
AR&R 100	4226.48	3685.14 (8	1893.21 (8	1791.93 (86.5%)
AR&R 100	4708.96	4102.87 (8	2111.23 (8	1991.65 (86.3%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P B.1	0.048	2.11	18.186	17.704	AR&R 100 year, 1 hour storm, average 95 mr
P A.5	0.543	3.17	16.45	16.137	AR&R 100 year, 1 hour storm, average 95 mr
P A.4	0.543	7.04	15.903	14.933	AR&R 100 year, 1 hour storm, average 95 mr
P A.3	0.543	2.51	14.678	14.615	AR&R 100 year, 1 hour storm, average 95 mr
P A.2	0.595	2.75	14.152	13.578	AR&R 100 year, 1.5 hours storm, average 73
P A.1	0.058	3.13	12.587	12.354	AR&R 100 year, 1.5 hours storm, average 73
P C.10	0.123	2.8	31.357	30.899	AR&R 100 year, 1.5 hours storm, average 73
P C.9	0.159	3.64	30.516	30.002	AR&R 100 year, 1.5 hours storm, average 73
P C.8	0.218	2.32	29.828	29.608	AR&R 100 year, 1.5 hours storm, average 73
P C.7	0.218	4.48	29.455	28.455	AR&R 100 year, 1.5 hours storm, average 73
P C.6	0.218	6.47	26.5	25.619	AR&R 100 year, 1.5 hours storm, average 73
P C.5	0.35	7.52	24.356	23.856	AR&R 100 year, 1.5 hours storm, average 73
P C.4	0.35	4.13	23.237	22.637	AR&R 100 year, 1.5 hours storm, average 73
P C.3	0.35	5.34	20.994	20.209	AR&R 100 year, 1.5 hours storm, average 73
P C.2	0.433	4.85	19.647	19.047	AR&R 100 year, 1.5 hours storm, average 73
P F.1	0.028	0.32	24.511	24.511	AR&R 100 year, 25 minutes storm, average 1
P D.4	0.049	4.27	24.216	22.822	AR&R 100 year, 25 minutes storm, average 1
P D.3	0.049	4.01	22.637	22.172	AR&R 100 year, 25 minutes storm, average 1
P D.2	0.063	3.99	21.995	21.018	AR&R 100 year, 25 minutes storm, average 1
P D.1	0.07	3.93	20.832	20.209	AR&R 100 year, 25 minutes storm, average 1
P G.2	0.074	4.34	17.079	14.908	AR&R 100 year, 25 minutes storm, average 1
P G.1	0.143	3.6	14.78	14.546	AR&R 100 year, 25 minutes storm, average 1
DP 15	0.017	4.85	18.437	18.237	AR&R 100 year, 5 minutes storm, average 26
P H.1	0.053	0.25	18.172	18.189	AR&R 100 year, 1 hour storm, average 95 mr
P A.7	0.431	1.99	17.82	17.802	AR&R 100 year, 1 hour storm, average 95 mr
P A.6	0.434	2	17.553	17.331	AR&R 100 year, 45 minutes storm, average 1
P H18-19	0.052	7.51	18.278	17.928	AR&R 100 year, 5 minutes storm, average 26
P DP2	0.015	2.66	30.364	30.314	AR&R 100 year, 5 minutes storm, average 26
P A.15	0.12	1.09	30.103	30.041	AR&R 100 year, 25 minutes storm, average 1
P A.14	0.17	1.54	29.798	29.732	AR&R 100 year, 25 minutes storm, average 1
P A.13	0.204	1.85	29.523	29.458	AR&R 100 year, 25 minutes storm, average 1
P A.12	0.204	5.81	28.963	25.433	AR&R 100 year, 25 minutes storm, average 1
P A.11	0.314	7.38	23.812	22.89	AR&R 100 year, 25 minutes storm, average 1
P A.10	0.659	4.15	21.575	21.099	AR&R 100 year, 25 minutes storm, average 1
P A.9	0.659	4.15	19.784	19.25	AR&R 100 year, 25 minutes storm, average 1
P A.8	0.461	2.9	18.237	18.189	AR&R 100 year, 1 hour storm, average 95 mr
Box Culver	0.466	2.8	18.868	18.321	AR&R 100 year, 45 minutes storm, average 1
P DP3	0.03	3.13	30.828	30.778	AR&R 100 year, 5 minutes storm, average 26
P A.16	0.069	2.52	30.181	30.133	AR&R 100 year, 25 minutes storm, average 1
P DP1	0.015	1.71	30.042	30.041	AR&R 100 year, 5 minutes storm, average 26
P J.2	0.106	5.66	27.311	26.696	AR&R 100 year, 15 minutes storm, average 1
P J.1	0.356	5.71	25.807	22.89	AR&R 100 year, 25 minutes storm, average 1
P M.1	0.041	0.37	26.698	26.696	AR&R 100 year, 1.5 hours storm, average 73
P H.2	0	0	18.15	18.172	AR&R 100 year, 5 minutes storm, average 26
Pipe572	0	0	39.2	38.736	AR&R 100 year, 5 minutes storm, average 26
P E.8	0.05	4.15	38.563	36.851	AR&R 100 year, 25 minutes storm, average 1
P E.7	0.05	3.67	36.668	35.7	AR&R 100 year, 25 minutes storm, average 1
P E.6	0.032	0.29	35.704	36.012	AR&R 100 year, 10 minutes storm, average 2
P E.5	0.52	3.27	35.157	34.664	AR&R 100 year, 20 minutes storm, average 1
P E.4	0.52	6.25	33.983	32.793	AR&R 100 year, 20 minutes storm, average 1
P E.3	0.565	8.61	31.924	31.258	AR&R 100 year, 25 minutes storm, average 1
P E.2	0.596	2.75	30.794	30.537	AR&R 100 year, 1.5 hours storm, average 73
Pipe582	0.014	2.02	27.643	26.978	AR&R 100 year, 5 minutes storm, average 26
P D.6	0.014	2.34	26.892	26.188	AR&R 100 year, 5 minutes storm, average 26
P D.5	0.018	3.03	26.091	24.791	AR&R 100 year, 5 minutes storm, average 26

CHANNEL DETAILS

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

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Stor
OF B.1	0.021	0.034	0.03	0.11	0.05	1.03	0.44	AR&R 100
OF A.5	0	0	7.665	0	0	0	0	
OF A.4	0	0	7.665	0	0	0	0	
OF A.3	0	0	7.665	0	0	0	0	
OF A.2	0	0	7.665	0	0	0	0	
OF A.1	0.537	0.537	7.665	0.068	0.05	17.56	0.8	AR&R 100
OF C10	0	0.014	0.555	0.035	0.01	2.36	0.34	AR&R 100
OF C.9	0	0.042	0.066	0.075	0.06	0.7	0.8	AR&R 100
OF C.2	0.005	0.069	0.03	0.143	0.08	2.13	0.53	AR&R 100
OF D.3	0.001	0.018	1.719	0.025	0.02	1.7	0.83	AR&R 100
OF D.2	0.004	0.008	1.719	0.018	0.01	1.23	0.69	AR&R 100
OF D.1	0.001	0.02	1.719	0.026	0.02	1.74	0.88	AR&R 100
OF G.2	0.114	0.114	7.665	0.036	0.02	11.27	0.53	AR&R 100
OF H.1	0.024	0.026	0.961	0.036	0.02	2.4	0.6	AR&R 100
OF A.7	0.007	0.007	0.03	0.041	0.01	0.7	0.26	AR&R 100
OF A.6	0	0	7.665	0	0	0	0	
OF A.15	0.004	0.028	0.046	0.073	0.04	0.7	0.55	AR&R 100
OF A.14	0.017	0.017	7.665	0.018	0.01	6.14	0.3	AR&R 100
OF A.13	0	0	7.665	0	0	0	0	
OF A.16	0.008	0.024	0.06	0.055	0.03	0.7	0.62	AR&R 100
OF J2	0.212	0.212	7.665	0.046	0.03	13.25	0.63	AR&R 100
OF H.2	0.072	0.072	7.665	0.031	0.01	10.2	0.45	AR&R 100
OF E7	0.006	0.006	7.665	0.012	0	4.04	0.23	AR&R 100
OF E.5	0	0	7.665	0	0	0	0	
OF E.3	0.016	0.016	7.665	0.018	0.01	5.84	0.32	AR&R 100
OF E.2	0	0	0.03	0	0	0	0	
OF E.1	0.607	0.607	7.665	0.07	0.06	18.1	0.84	AR&R 100
OF D.6	0	0.004	2.075	0.013	0.01	0.88	0.69	AR&R 100
OF D.5	0	0.005	2.075	0.014	0.01	0.96	0.67	AR&R 100

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
E.5	36.01	1.7	0.52	0.52	0
E.1	29.52	77.8	0.607	0	0.607

CONTINUITY CHECK for AR&R 100 year, 1.5 hours storm, average 73 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Cł (cu.m)	Difference %
B.1	116.43	116.41	0	0
A.5	3580.2	3579.4	0	0
A.4	3579.4	3581.73	0	-0.1
A.3	3581.73	3580.39	0	0
A.2	3660.39	3659.05	0	0
A.1	3659.11	3658.26	0	0
3	3649.4	3649.4	0	0
C.10	179.56	179.56	0	0
C.9	229.73	229.74	0	0
C.8	314.31	314.3	0	0
C.7	314.3	314.3	0	0
C.6	314.3	314.3	0	0
C.5	508.24	508.23	0	0
C.4	508.23	508.26	0	0
C.3	508.26	508.28	0	0
C.2	647.46	647.25	0	0
C.1	644.55	644.55	0	0
E.1	43.46	43.46	0	0

D.3	76.4	76.4	0	0
D.2	103.96	103.81	0	0.2
D.1	110	109.94	0	0.1
G.3	289.81	289.81	0	0
G.2	289.81	279.39	0	3.6
1	279.39	279.39	0	0
House 15	24.41	24.41	0	0
H.1	36.94	36.93	0	0
A.7	3325.2	3324.26	0	0
A.6	3324.26	3323.24	0	0
DP 19	76.17	76.17	0	0
DP 2	21.7	21.7	0	0
A.15	190.98	190.96	0	0
A.14	290.49	290.46	0	0
A.13	318.02	318	0	0
A.12	318	318	0	0
A.11	482.32	482.33	0	0
A.10	1029.52	1029.55	0	0
A.9	1029.55	1029.56	0	0
A.8	4745.85	4737.67	0	0.2
DP 3	43.4	43.4	0	0
A.16	117.96	117.95	0	0
DP 1	21.7	21.7	0	0
J.2	483.84	483.82	0	0
J.1	547.22	547.2	0	0
M.1	63.52	63.4	0	0.2
H.2	0	-0.01	0	0
E.9	0	0	0	0
E.8	86.58	86.55	0	0
E.7	85.52	85.52	0	0
E.6	85.52	-1571.31	0	1937.4
E.5	-593.68	3833.03	0	0
E.4	3833.03	3928.64	0	-2.5
E.3	4020.24	4065.74	0	-1.1
E.2	4089.67	4100.17	0	-0.3
E.1	4126.65	4050.59	76.04	0
D.7	20.58	20.58	0	0
D.6	20.58	20.58	0	0
D.5	26.37	26.33	0	0.2
2	1459.07	1459.07	0	0