ETS ENGINEERING

SITE BASED STORMWATER QUALITY MANAGEMENT REPORT

FOR PROPOSED DEVELOPMENT AT
813-843 RIPLEY RD, SOUTH RIPLEY 4306
FOR
AMEX CORPORATION PTY LTD

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EXECUTIVE SUMMARY

This Site Based Stormwater Quality Management Plan (SBSQMP) will outline the storm water quality treatment requirements to support the proposed MCU application for the integrated development at 813-843 Ripley Road, South Ripley 4306 (lot 196 on SP157517 and lot 370 on SP198119) for Amex Corporation Pty Ltd. The proposed development will consist of predominantly residential allotments typically ranging in size from 200m2 to greater than 800m2 but also include medium density residential, high school, commercial and extensive open space areas.

The SBSQMP discusses the environmental impacts likely to arise for stormwater quality from the proposed development. To alleviate the effects of stormwater flows downstream of the catchment, detailed modelling of the likely impacts was carried out, and mitigation measures were selected to reduce these impacts to a level that would be acceptable to the Urban Land Development Authority (ULDA) Guidelines and the Ipswich City Council (ICC) Design Guidelines.

The key aim of this SBSQMP was as follows:

- To model and employ stormwater quality treatment measures to ensure that the appropriate water quality objectives are achieved prior to stormwater runoff leaving the subject site;

Water Quality Modelling

Stormwater quality modelling was undertaken using the 'Model for Urban Stormwater Improvement Conceptualisation' (MUSIC) program. Stormwater Quality Improvement Devices (SQID's) proposed within the modelling analysis are bioretention systems. The modelling achieved the pollutant load Quality Objectives (WQO's) for the proposed development.

1.0 INTRODUCTION

ETS Group Pty Ltd was commissioned by Amex Corporation Pty Ltd to prepare a Site Based Stormwater Quality Management Plan (SBSQMP) for the proposed development at Ripley Road, Ripley. This report discusses the environmental impacts likely to arise for stormwater quality from the proposed development and details the treatment measures selected to reduce these impacts to a level that would be acceptable to the Urban Land Development Authority (ULDA) Development Guidelines and the Ipswich City Council (ICC) Design Guidelines. This report should be read in conjunction with the reports provided by RPS Group and Cardno Ltd. An aerial photo of the extents of the development area is shown below in Figure 1.

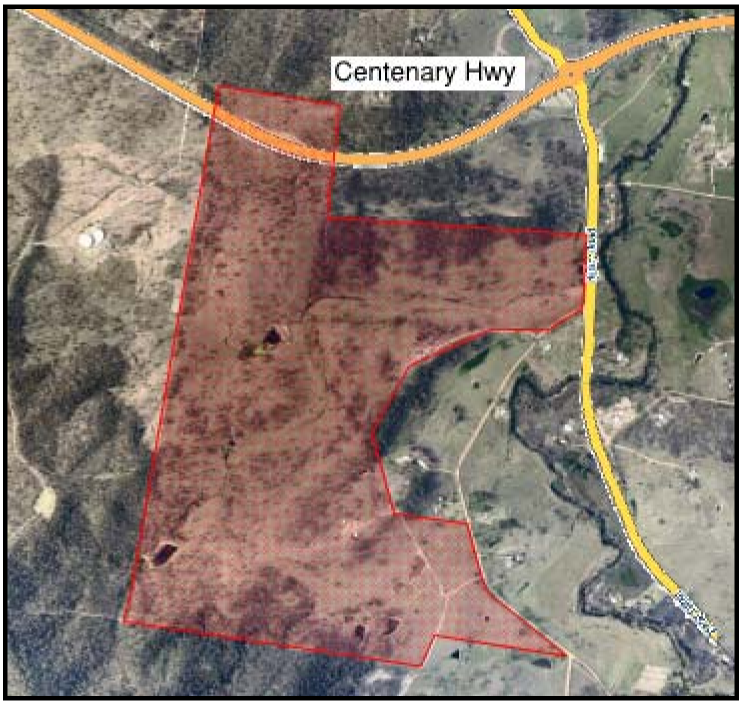

Figure 1. Aerial Photo of Site Location

2.0 SITE CHARACTERISTICS

The site adjoins the Centenary Highway to the north and Ripley Road to the east. The Ipswich City Council's PIP designates the proposed development site and the surrounding areas as a mixture of future urban, open space and parkland. The proposed overall layout for the site can be seen in Appendix A. The site is currently used for agricultural purposes. The elevation of the site ranges from approximately RL 45mAHD to RL 125mAHD. The site is gently graded, but a significant portion is hilly and exposed rock surfaces and scattered surface rocks were noted at a recent site inspection. The lower flatter areas are extensively cleared, and have a few scattered large trees such as eucalypts remaining. The hilly areas have higher tree density, especially is some of the steeper gullies.

The site is traversed by three major overland flow paths generally flowing west to east across the northern, central and southern areas of the site. The middle flow path splits into two smaller flow paths at approximately half way through the site. Some Geotechnical investigations have been undertaken however further investigations will be undertaken as required and the recommendations will be adopted at Operational Works.

3.0 DATA

In the preparation of this report, information about the site was gathered from the following sources:

- Ipswich City Council (For constructed services, hydrologic, and water quality parameters)
- Detailed Survey
- Site inspection
- Bureau of Meteorology (Meteorological Data from Amberley Rain Survey Station no. 040910)

4.0 STORMWATER QUALITY

Stormwater Quality Treatment (Construction Phase)

Erosion and sediment control measures used during the construction phase of the development will be designed and installed in accordance with International Erosion Control Association (Australasia) - "Best Practice Erosion & Sediment Control – for building and construction sites" November 2008.

During the construction phase various pollutants are generated which can find their way into the stormwater runoff. These pollutants can affect the quality of the stormwater runoff, and hence pollute both the site and the downstream receiving environment. Table 1 below outlines the major sources of pollutants.

Table 1: Major sources of pollutants during Construction Phase of Development

Construction Phase
Litter from construction packaging, paper, food packaging, off cuts, etc.
Sediment from erosion of exposed soils and stockpiles.
Hydrocarbons - from fuel and oil spills, leaks from construction equipment.
Toxic Materials - cement slurry, solvents, cleaning agents, wash waters.
pH altering substances - cement slurry, wash waters.

Temporary Sediment Basins

Due to the large scale of the proposed development it is likely that sediment basins will be constructed to cater for runoff from disturbed areas during construction. Sediment basins will be sized based on the maximum disturbed area within each basin's catchment at any one time during construction. The basins will be designed to retain sediment laden water for extended periods allowing adequate time for the gravitational settlement (or flocculation if required) of the fine particles. Table 2 below, details post-storm water quality criteria for dewatering of sediment basins.

Table 2: Major sources of pollutants during Construction Phase of Development

Site Conditions	Discharge Water Quality Standard
Post-storm de-watering of wet sediment basins	90 percentile total suspended solids (TSS) concentration not exceeding 50mg/L pH 6.5 to 8.5 Dissolved Oxygen >6mg/L Hydrocarbons – No visible sheen on receiving water Litter – No visible little washed from site.

Appropriate flocculation of the sediment basins may be required if collected water needs to be released more frequently than a typical 5 day settling cycle where the water does not met the required 50mg/L water quality standard for TSS.

Erosion and Sediment Control Management Plans will be generated at the detailed design phase of each stage of the development.

Stormwater Quality Treatment (Operational Phase)

For this development, several different stormwater quality treatment options were investigated. Table 2 below outlines these various options, as well as the reasons they were deemed suitable/unsuitable for use within the development. The chosen treatment system is detailed further in the stormwater modelling section of this report.

Table 3: Stormwater Treatment Options Investigated

Treatment Options	Feasibility for implementation
Permeable Pavement (Hydropave™)	Considered, but deemed unfeasible due to high maintenance costs and large quantities required.
Wetland	The use of a wetland was ruled out due to safety concerns as well as insufficient area available for use.
Underground Systems (eg.StormTech™ underground permeable chambers)	StormTech™ was contemplated but ruled out due it's high capital cost and concerns regarding their efficiency
Bioretention Systems	Deemed most suitable as they could fit within the site restrictions. Refer to Appendix A of this report for Bioretention system locations.

Bioretention Sytems

Figure 2- Typical Bioretention Basin

Bioretention systems operate by filtering stormwater runoff through densely planted surface vegetation and then percolating runoff through a prescribed filter media. During percolation, pollutants are retained through fine filtration, adsorption and some biological uptake. The vegetation in a bioretention system is a vital functional element of the system providing a substrate for bio-film growth within the upper layer of the filter media. Vegetation facilitates the transport of oxygen to the soil and enhances soil microbial communities which enhance biological transformation of pollutants (Source: Healthy Waterways).

Stormwater Quality Treatment Summary:

In terms of water quality treatment, the Ripley Road development will encompass 31 separate stormwater runoff catchments which originate from within the subject site. Bioretention systems and associated trash racks and sediment forebays will be modelled and designed for each catchment. Modelling of the 31 catchments determines the bioretention filter media area required to treat the stormwater runoff from each catchment in accordance with the State Planning Policy 4/10 for Healthy Waters Water Quality Objectives (WQO's). These WQO's satisfy both Ipswich City Council and the Urban Land Development Authority requirements for stormwater quality treatment.

Water Quality Objectives:

The load based Water Quality Objectives (WQO) adopted for the Operational Phase of the development are taken from the State Planning Policy 4/10 for Healthy Waters.

Table 4: Ipswich City Council's Water Quality Objectives

Pollutant	SPP 4/10 WQO's
Suspended Solids	80% (Removal)
Total Phosphorus	60%(Removal)
Total Nitrogen	45% (Removal)
Gross Pollutants	90% (Removal)

Stormwater Quality Modelling

Stormwater Pollutant modelling for the development has been generated using the modelling program 'Model for Urban Stormwater Improvement Conceptualisation' (MUSIC). A "Split Catchment" approach has been adopted for the MUSIC modelling in accordance with Healthy Waterways MUSIC Modelling Guidelines Version 1.0, 2010. This approach uses separate nodes for the following typical site areas:

- Roof Catchment;
- Road Catchment (which includes the verge);
- Ground Level (driveways, sheds, yards and general landscaped areas)

Surface Split Percentage and Imperviousness Fraction

The surface split percentage used within the MUSIC modelling has been adopted from Tables 3.3 and 3.5 in the Healthy Waterways MUSIC Modelling Guidelines Version 1.0, 2010:

Residential 15 dwellings / ha;

- Roads 25% of catchment area – 70% Impervious;
- Roofs (215m^2 area) 32.5% of catchment area – 100% Impervious; and
- Ground Level 42.5% of catchment area – 30% Impervious;

Figure 3 below details the typical "Split Catchment" Node layout for the MUSIC Modelling.

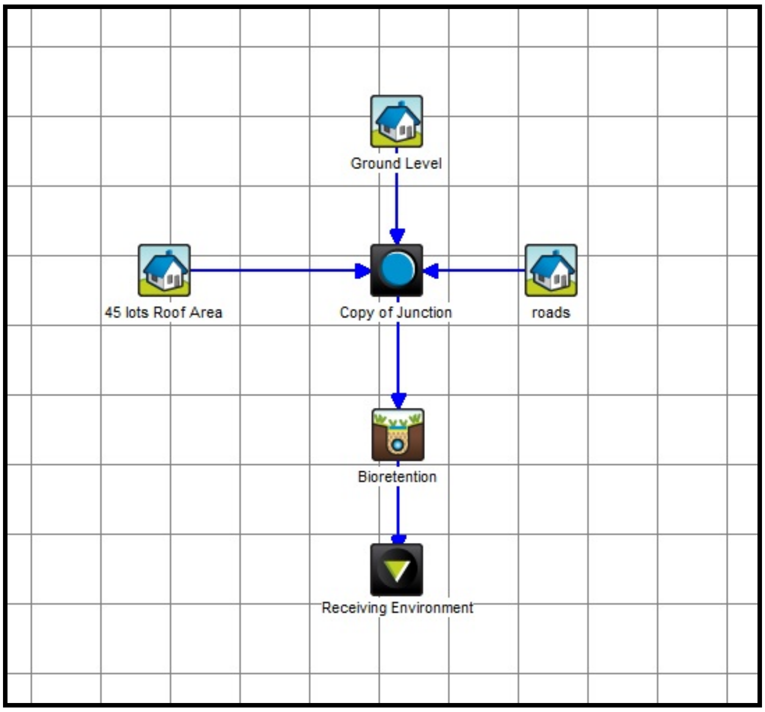

Figure 3 – Typical "Split Catchment" MUSIC Model

Modelling of Developed Site Conditions

The following parameters have been adopted within the MUSIC models:

Table 4: Soil Properties

(Adopted from Healthy Waterways MUSIC Modelling Guidelines Version 1.0, 2010.)

Catchment Characteristic	Urban Residential
IMPERVIOUS AREA PROPERTIES	
Impervious Area Rainfall Threshold (mm/day)	1
PERVIOUS AREA PROPERTIES	
Pervious Area Soil Storage Capacities	500
Pervious Area Soil Initial Storage (% of Capacity)	10
Field Capacity (mm)	200
Pervious Area Infiltration Capacity coefficient - a	211
Pervious Area Infiltration Capacity exponent - b	5.0
GROUNDWATER PROPERTIES	
Groundwater Initial Depth	50
Groundwater Daily Recharge Rate (%)	28
Groundwater Daily Baseflow Rate (%)	27
Groundwater Daily Deep Seepage Rate (%)	0

- Rainfall Data is taken from BOM Station Amberley 1990-1999 with a 6 minute time step;
- A seepage loss rate of 0mm/hr has been assumed in modelling;
- All other parameters used within the modelling were based on Healthy Waterways MUSIC Modelling Guidelines Version 1.0, 2010.

Bioretention Systems

The modelling parameters of the Bioretention basins are as follows:

- Extended Detention 0.3m for Bioretention basins;
- Filter Depth 0.7m for Basins as indicated in Chapter 5, Section 5.3 "Design Process" of the WSUD Technical Design Guidelines for South East Queensland 2006.
- Surface Area - Varies per basin;
- Filter area - Varies per basin;
- Filter Medium - Sandy loam particle size of 0.45mm, saturated hydraulic conductivity 180mm/hour;
- Transition layer 100mm thick course sand in accordance with WSUD TDG 2006.
- Drainage layer 200mm 2-5mm gravel in accordance with WSUD TDG 2006.
- Underdrain System An under drain system of slotted drainage pipes (100mm dia.) at 1.5m centers.
- Total Nitrogen content of Filter Media 800mg/kg
- Orthophosphate content of Filter Media 50mg/kg

MUSIC Model Stormwater Treatment Sizing Requirements

The stormwater treatment measure requirements by the MUSIC model are outlined in the following table arranged by treatment measure type with their characteristic dimensions provided. Table 5 below lists the requirements for bioretention basins.

Table 5: Bioretention Systems Conceptual Treatment Requirements

Catchment and Area	Foot Print Area (m^2)	Extended Detention Depth (m)	Filter Area (m^2)	Filter Depth (m)	Filter Median Particle Diameter (mm)	Saturated Hydraulic conductivity (mm/hr)
Catchment 1 (3.851Ha)	160	0.3	90	0.7	0.45	180
Catchment 2 (Medium Density Site)(1.132Ha)	283	0.3	283	0.7	0.45	180
Catchment 3 (2.959Ha)	950	0.3	600	0.7	0.45	180
Catchment 4 (4.460Ha)	900	0.3	600	0.7	0.45	180
Catchment 5 (3.150Ha)	700	0.3	550	0.7	0.45	180
Catchment 6 (14.180Ha)	1700	0.3	1250	0.7	0.45	180
Catchment 7 (5.131Ha)	750	0.3	460	0.7	0.45	180
Catchment 8 (2.599Ha)	420	0.3	230	0.7	0.45	180
Catchment 9 (3.689Ha)	550	0.3	340	0.7	0.45	180
Catchment 10 (4.5817Ha)	640	0.3	470	0.7	0.45	180
Catchment 11 (7.245Ha)	950	0.3	720	0.7	0.45	180
Catchment 12 (8.2126Ha)	1000	0.3	760	0.7	0.45	180
Catchment 13 (0.949Ha)	240	0.3	240	0.7	0.45	180
Catchment 14 (7.54Ha)	950	0.3	720	0.7	0.45	180

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Catchment 15 (Medium Density Site)(0.361Ha)	90	0.3 .	90	0.7	0.45	180
Catchment 16 (4.010Ha)	600	0.3	400	0.7	0.45	180
Catchment 17 (9.832Ha)	1500	0.3	900	0.7	0.45	180
Catchment 18 (2.995Ha)	500	0.3	260	0.7	0.45	180
Catchment 19 (1.358Ha)	190	0.3	130	0.7	0.45	180
Catchment 20 (6.358Ha)	900	0.3	600	0.7	0.45	180
Catchment 21 (2.388Ha)	340	0.3	220	0.7	0.45	180
Catchment 22 (7.499Ha)	1000	0.3	680	0.7	0.45	180
Catchment 23 (2.199Ha)	350	0.3	200	0.7	0.45	180
Catchment 24 (6.313Ha)	900	0.3	580	0.7	0.45	180
Catchment 25 (5.709Ha)	750	0.3	500	0.7	0.45	180
Catchment 26 (4.001Ha)	650	0.3	320	0.7	0.45	180
Catchment 27 (4.666Ha)	680	0.3	450	0.7	0.45	180
Catchment 28 (Medium Density Site)(0.450Ha)	112	0.3	112	0.7	0.45	180
Catchment 29 (7.938Ha)	1250	0.3	750	0.7	0.45	180
Catchment 30 (15.247Ha)	1950	0.3	1380	0.7	0.45	180
Catchment 31 (3.68Ha)	500	0.3	350	0.7	0.45	180

*Refers to Medium Density Sites where an allowance of 2.5% of the total catchment has been used for filter media as an interim measure until actual layouts are determined.

Refer to Appendix ‘A’ for Basin locations and Appendix ‘B’ for the model outputs results.

The Treatment Train Effectiveness

Table 6 outlines the effectiveness of the MUSIC Model Treatment Train in achieving the set Water Quality Objectives (WQO's) for pollutant reduction for the modelled catchments of the proposed Development. Note that Catchments 2, 15 and 28 are future Medium Density development sites and have not been modelled at this stage.

Table 6: Treatment Train Effectiveness for Catchment's 1 to 31

CATCHMENT 1	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	7.85	7.62	2.9%
Total Suspended Solids (kg/yr)	1.78E3	312.0	82.5%
Total Phosphorus (kg/yr)	3.39	1.29	61.9%
Total Nitrogen (kg/yr)	16.3	9.01	44.6%
Gross Pollutants (kg/yr)	188	0.00	100.0%

CATCHMENT 3	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	30.6	29.1	4.9%
Total Suspended Solids (kg/yr)	3.97E3	421.0	89.4%
Total Phosphorus (kg/yr)	9.08	3.58	60.5%
Total Nitrogen (kg/yr)	63.6	26.5	58.2%
Gross Pollutants (kg/yr)	717	0.00	100.0%

CATCHMENT 4	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	41.1	39.6	3.8%
Total Suspended Solids (kg/yr)	7.34E3	1.02E3	86.1%
Total Phosphorus (kg/yr)	14.2	5.54	61.1%
Total Nitrogen (kg/yr)	79.7	38.9	51.1%
Gross Pollutants (kg/yr)	874	0.00	100.0%

CATCHMENT 5	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	36.5	35.1	3.9%
Total Suspended Solids (kg/yr)	6.54E3	1.03E3	84.2%
Total Phosphorus (kg/yr)	12.9	5.07	60.7%
Total Nitrogen (kg/yr)	71.1	35.5	50.0%
Gross Pollutants (kg/yr)	786	0.00	100.0%

CATCHMENT 6	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	98.1	95.0	3.1%
Total Suspended Solids (kg/yr)	18.8E3	3.18E3	83.1%
Total Phosphorus (kg/yr)	36.9	14.6	60.4%
Total Nitrogen (kg/yr)	204	104	49.0%
Gross Pollutants (kg/yr)	2.33E3	0.00	100.0%

CATCHMENT 7	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	36.7	35.5	3.2%
Total Suspended Solids (kg/yr)	6.42E3	1.05E3	83.6%
Total Phosphorus (kg/yr)	13.0	5.22	59.9%
Total Nitrogen (kg/yr)	76.2	38.1	49.9%
Gross Pollutants (kg/yr)	868	0.00	100.0%

CATCHMENT 8	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	18.5	17.9	3.2%
Total Suspended Solids (kg/yr)	3.27E3	486	85.1%
Total Phosphorus (kg/yr)	6.56	2.55	61.1%
Total Nitrogen (kg/yr)	38.6	19.0	50.9%
Gross Pollutants (kg/yr)	438	0.00	100.0%

CATCHMENT 9	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	26.4	25.5	3.3%
Total Suspended Solids (kg/yr)	4.53E3	685	84.9%
Total Phosphorus (kg/yr)	9.51	3.75	60.5%
Total Nitrogen (kg/yr)	54.9	27.1	50.7%
Gross Pollutants (kg/yr)	624	0.00	100.0%

CATCHMENT 10	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	32.7	31.5	3.6%
Total Suspended Solids (kg/yr)	5.67E3	868	84.7%
Total Phosphorus (kg/yr)	11.7	4.62	60.6%
Total Nitrogen (kg/yr)	67.7	33.1	51.1%
Gross Pollutants (kg/yr)	772	0.00	100.0%

CATCHMENT 11	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	51.7	49.9	3.5%
Total Suspended Solids (kg/yr)	9.00E3	1.44E3	84.1%
Total Phosphorus (kg/yr)	18.5	7.46	59.6%
Total Nitrogen (kg/yr)	108	53.3	50.5%
Gross Pollutants (kg/yr)	1.22E3	0.00	100.0%

CATCHMENT 12	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	58.4	56.5	3.3%
Total Suspended Solids (kg/yr)	10.2E3	1.70E3	83.4%
Total Phosphorus (kg/yr)	20.6	8.34	59.5%
Total Nitrogen (kg/yr)	121	60.4	50.2%
Gross Pollutants (kg/yr)	1.38E3	0.00	100.0%

CATCHMENT 14	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	53.7	51.9	3.4%
Total Suspended Solids (kg/yr)	9.32E3	1.48E3	84.1%
Total Phosphorus (kg/yr)	19.5	7.86	59.8%
Total Nitrogen (kg/yr)	112	55.4	50.5%
Gross Pollutants (kg/yr)	1.27E3	0.00	100.0%

CATCHMENT 16	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	28.6	27.6	3.5%
Total Suspended Solids (kg/yr)	5.13E3	770	85.0%
Total Phosphorus (kg/yr)	10.2	4.00	60.8%
Total Nitrogen (kg/yr)	59.7	29.2	51.2%
Gross Pollutants (kg/yr)	676	0.00	100.0%

CATCHMENT 17	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	70.2	67.9	3.3%
Total Suspended Solids (kg/yr)	12.2E3	1.80E3	85.2%
Total Phosphorus (kg/yr)	25.0	9.76	61.0%
Total Nitrogen (kg/yr)	146	71.6	50.9%
Gross Pollutants (kg/yr)	1.66E3	0.00	100.0%

CATCHMENT 18	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	21.5	20.8	3.1%
Total Suspended Solids (kg/yr)	3.75E3	548	85.4%
Total Phosphorus (kg/yr)	7.62	3.00	60.7%
Total Nitrogen (kg/yr)	44.6	22.2	50.3%
Gross Pollutants (kg/yr)	507	0.00	100.0%

CATCHMENT 19	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	9.68	9.35	3.4%
Total Suspended Solids (kg/yr)	1.69E3	280	83.4%
Total Phosphorus (kg/yr)	3.46	1.39	59.8%
Total Nitrogen (kg/yr)	20.2	10.1	49.9%
Gross Pollutants (kg/yr)	229	0.00	100.0%

CATCHMENT 20	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	45.4	44.0	3.1%
Total Suspended Solids (kg/yr)	7.85E3	1.22E3	84.4%
Total Phosphorus (kg/yr)	16.2	6.39	60.6%
Total Nitrogen (kg/yr)	94.5	46.9	50.3%
Gross Pollutants (kg/yr)	1070	0.00	100.0%

CATCHMENT 21	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	17.0	16.5	3.3%
Total Suspended Solids (kg/yr)	3.00E3	481	84.0%
Total Phosphorus (kg/yr)	6.14	2.44	60.2%
Total Nitrogen (kg/yr)	35.3	17.7	49.9%
Gross Pollutants (kg/yr)	403	0.00	100.0%

CATCHMENT 22	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	53.7	52.0	3.2%
Total Suspended Solids (kg/yr)	9.39E3	1.58E3	83.2%
Total Phosphorus (kg/yr)	19.4	7.81	59.8%
Total Nitrogen (kg/yr)	111	55.9	49.6%
Gross Pollutants (kg/yr)	1.27E3	0.00	100.0%

CATCHMENT 23	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	15.7	15.2	3.2%
Total Suspended Solids (kg/yr)	2.72E3	394	85.5%
Total Phosphorus (kg/yr)	5.63	2.20	60.8%
Total Nitrogen (kg/yr)	32.6	16.0	50.9%
Gross Pollutants (kg/yr)	371	0.00	100.0%

CATCHMENT 24	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	45.4	43.9	3.2%
Total Suspended Solids (kg/yr)	8.14E3	1.34E3	83.5%
Total Phosphorus (kg/yr)	16.4	6.55	60.1%
Total Nitrogen (kg/yr)	93.7	46.7	50.2%
Gross Pollutants (kg/yr)	1070	0.00	100.0%

CATCHMENT 25	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	40.8	39.5	3.1%
Total Suspended Solids (kg/yr)	7.26E3	1.27E3	82.5%
Total Phosphorus (kg/yr)	14.6	5.91	59.6%
Total Nitrogen (kg/yr)	84.9	43.3	49.0%
Gross Pollutants (kg/yr)	964	0.00	100.0%

CATCHMENT 26	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	28.6	27.8	2.9%
Total Suspended Solids (kg/yr)	4.99E3	793	84.1%
Total Phosphorus (kg/yr)	10.1	4.02	60.3%
Total Nitrogen (kg/yr)	59.5	29.9	49.7%
Gross Pollutants (kg/yr)	676	0.00	100.0%

CATCHMENT 27	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	33.3	32.1	3.4%
Total Suspended Solids (kg/yr)	5.84E3	896	84.7%
Total Phosphorus (kg/yr)	12.0	4.76	60.3%
Total Nitrogen (kg/yr)	69.2	34.1	50.8%
Gross Pollutants (kg/yr)	787	0.00	100.0%

CATCHMENT 29	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	56.7	54.8	3.4%
Total Suspended Solids (kg/yr)	10.1E3	1.55E3	84.7%
Total Phosphorus (kg/yr)	20.1	7.82	61.0%
Total Nitrogen (kg/yr)	118	57.3	51.5%
Gross Pollutants (kg/yr)	1.34E3	0.00	100.0%

CATCHMENT 30	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	109	105	3.2%
Total Suspended Solids (kg/yr)	19.0E3	3.14E3	83.4%
Total Phosphorus (kg/yr)	39.4	15.9	59.8%
Total Nitrogen (kg/yr)	227	114	49.9%
Gross Pollutants (kg/yr)	2.57E3	0.00	100.0%

CATCHMENT 31	Unmitigated loads	Mitigated loads	Reduction
Flow (ML/yr)	26.4	25.5	3.4%
Total Suspended Solids (kg/yr)	4.54E3	751	83.4%
Total Phosphorus (kg/yr)	9.3	3.75	59.7%
Total Nitrogen (kg/yr)	55.1	27.5	50.1%
Gross Pollutants (kg/yr)	624	0.00	100.0%

Refer to Appendix C Drawings for details of Biorentention Systems.

5.0 CONSTRUCTION AND ESTABLISHMENT OF THE BIORETENTION SYSTEMS

There are many risks during both the subdivision construction and the allotment building phase of the development which can affect the performance of bioretention systems. During the subdivision construction, typical civil works such as earthworks, road and services construction activities can generate large sediment loads which can smother vegetation and clog bioretention filter media. Likewise the allotment building phase, which is effectively an "uncontrolled" phase due to the number of contractors and subcontractors present on the house sites, represents a phase where bioretention system establishment can be at great risk. Due to the above risks, a staged establishment method will be adopted for the bioretention basins proposed for the development. The staged approach will be in accordance with Option 4 of the Healthy Waterways Construction and Establishment Guidelines 2010.

Stage 1 – Civil Construction

Stage 1 involves the civil works excavation of the full basin depth to create the form of the bioretention system following which the system operates as a temporary sediment basin.

Stage 2 – Building Phase Protection

The system continues to operate as a sediment basin until 90% of house building construction is completed within the catchment.

Stage 3 – Civil Construction and Landscape Establishment

Once the building phase is complete, the system is cleaned out of sediment. The various bioretention system treatment layers are constructed and landscaped in accordance with Healthy Waterways Construction and Establishment Guidelines 2010 Forms A – H.

Filter Media Specification

The filter media used within the proposed bioretention systems shall be selected and tested in accordance with the Facility for Advancing Water Biofiltration's (FAWB) "Guideline Specifications for Soil Media in Bioretention Systems Update March 2008" Refer to Appendix D for Details.

Landscaping

Landscaping to the bioretention basins and swales will be undertaken in accordance with the Landscape Architects drawings and Appendix A of WSUD Technical Design Guidelines for South East Queensland – Version 1 June 2006.

6.0 STORMWATER QUALITY IMPLEMENTATION AND STAGING

Purpose:	
Element	To maintain or enhance pre-development water quality and natural vegetation during the construction and operation of the development. Compliance with this objective is to meet requirements set out in the *Environmental Protection Act* (1994) the *Environmental Protection (Water) Policy* (1997) and Guideline on Identifying and Applying Water Quality Objectives.
Policy	The Principal Contractor is to be made aware of the requirements with respect to water quality within the *Environmental Protection Act* (1994) and the *Environmental Protection (Water) Policy* (1997) at the time of tendering. The Principal Contractor is to implement the measures for *Erosion and Sediment Control* to reduce contaminants entering the waterway system. Refer to the *Erosion and Sediment Control* section for full details.
Performance Indicators	Measured levels for water quality indicators shall fall within the value range as set out in the ICC guidelines. In addition the measured levels shall not exceed the baseline levels by more than 10% during the construction period and the measured levels shall not exceed the baseline levels during the maintenance period.
Monitoring	Monitoring frequency shall be in accordance with industry standards. In addition, visual inspections will be performed periodically, but at no less than fortnightly intervals, during the construction and maintenance period and during seasons of traditionally low rainfall (autumn, winter). Visual inspections performed periodically, but at no less than weekly intervals during the construction and maintenance period and during seasons of traditionally high rainfall (spring, summer). Undertake tests after any significant rainfall in any 24-hour period. A significant rainfall event is defined as rainfall of more than 20mm as measured by the Bureau of Meteorology at the nearest rain gauging station.
Reporting	The ETS Group shall receive the results of any testing and analysis conducted by the testing authority. Comparison of results with the baseline measurements shall be undertaken and the comparison results and recommendations reported on a monthly basis along with production of an annual report that will summarise the results for the year and identify any trends.
Corrective Action	Identify the reasons for the deterioration of water quality and determine if it is linked to construction activities. If construction activities are responsible, then isolate the specific cause and determine the best method to prevent the incident from occurring again. The work practice causing the pollution is to cease immediately and clean-up operations to commence immediately and to be completed within 5 working days. If other sources are responsible, then notify the Local Authority of the situation for their action.

Erosion and Sedimentation Management

<table>
<tr><th colspan="2">Purpose:</th></tr>
<tr><td>Element</td><td>To minimise the adverse impact on the quality of the environment by:
• Minimising the potential of on-site erosion; and
• Controlling the off-site deposition of sediment,
In accordance with the requirements of the Environmental Protection Policy (Water) 1997 and the Ipswich City Council’s Erosion and Sediment Control Standard.</td></tr>
<tr><td>Policy</td><td>These objectives will be achieved by the implementation of an Erosion and Sediment Control Program during the construction phase of the development.</td></tr>
<tr><td>Performance Requirements</td><td>The preparation of an Erosion and Sediment Control Program will be the responsibility of the ETS Group as consulting engineers for the development. The program will consist of the following elements:
• The characteristics of the site will be investigated including a soils investigation to determine soil characteristics as they apply to soil erosion and sediment control;
• The existing of proposed drainage patterns will be determined;
• Areas suitable for stockpiling soil and construction materials will be identified;
• The need for temporary erosion control devices will be assessed and suitable devices selected;
• Medium and long term measures to rehabilitate and stabilise the site will be formulated;
• Preparation of erosion and sediment control plans as required by Council’s Subdivision Approval. The control plans will be designed in accordance with:
o ESC Standard, Ipswich City Council
o Design of sediment basins, Brisbane City Council
o Soil Erosion and Control, Engineering Guidelines for Queensland Sites, Institute of Engineers
The control plans will incorporate the following:
• Design details of structures;
• A program for implementation and phasing of erosion control activities; and
• An on going program detailing maintenance and servicing requirements of control structures.

This document will be dynamic and as such will be subject to scrutiny and revision as the development progresses.</td></tr>
<tr><td>Performance Requirements</td><td>The following indicators are used to gauge the implementation and effectiveness of the Erosion and Sediment Control Plan (ESCP) process:
Construction Phase
• Installation of temporary erosion and sediment control devices in accordance with contract documentation and a council approved ESCP to this site;
• Maintenance of temporary erosion and sediment control devices;
• Minimal evidence of erosion after significant rainfall;
• Capture of sediment within devices after significant rainfall; and
• Measured levels for water quality in the area below the flood line within acceptable levels.
• Compliance with Ipswich City Council’s ESC standard.
Maintenance Phase
• Installation of temporary and permanent erosion and sediment control devices prior to the establishment of ground cover in accordance with the contract documentation and the approved ESCP;
• Maintenance of temporary and permanent erosion and sediment control devices;
• Minimal evidence of erosion after significant rainfall;
• Capture of sedimentation within devices after significant rainfall;</td></tr>
</table>

	• The presence and maintenance of grass strike and turfed areas; and • Measured levels for water quality in the area below the flood line within acceptable levels. • Compliance with Ipswich City Council's ESC standard. **Post Maintenance** • Maintenance of permanent sedimentation control devices; • Negligible erosion after significant rainfall; • Capture of sediment within devices after significant rainfall; • Maintenance of grass strike and turfed areas; and • Measured levels for water quality in the area below the flood line within acceptable levels.
Monitoring	The monitoring of erosion and sediment control processes will be a periodical visual inspection by ETS Group and/or the Principal Contractor but at no less than weekly intervals during the construction and maintenance periods.
Reporting	The ETS Group will: • During periodic site inspections ensure that all erosion and sediment controls are installed and maintained in accordance with the Contract Documents; Ipswich City Council's Erosion and Sediment Control Standard and the approved ESCP. • Instruct the Principal Contractor to install additional measures to prevent erosion as determined necessary during periodic site inspections; and • Liaise with Ipswich City Council's inspection officer during the construction and maintenance periods. • Liaise with Ipswich City Council's Erosion and Sediment Control Standard Officer.
Corrective Action	The superintendent in consultation with the Principal Contractor is to determine the source and the reason for the erosion and/or sedimentation and: • Implement measures to prevent further erosion occurring; and/or • Locate the source of the sediment entering the system and implement measures to prevent further ingress of sediment to the system; and • Where practicable remove the sediment deposited in the system.

Noise and Dust Management

<table>
<tr><th colspan="2">Purpose:</th></tr>
<tr><td>Element</td><td>To minimise the impact of noise and dust nuisance generated by earthworks and construction activities and maintain amenity for adjoining residents. Compliance with this objective is to meet the requirements set out in the Environmental Protection Reg. 1998 Part 2A Environmental Nuisance.</td></tr>
<tr><td>Policy</td><td>All works undertaken on site are to comply with the above documents.</td></tr>
<tr><td>Performance Requirements</td><td>Noise
ETS Group's Civil Engineering Works Specification Clause 9 included within the contract with the Principal Contractor nominates the following normal hours of on site work:
• 6.30am to 6.30pm Monday to Saturday or business days
• No work on Sundays or Public Holidays
Any construction or earthworks activities outside of the hours nominated above will only be permitted with the prior written approval of both the Principal and the relevant Local Authority delegate.
Dust
ETS Group's Civil Engineering Works Specification Clause 21 included within the Contract with the Principal Contractor specifies:
• Dust generated from the site and from earthworks is to be controlled so as not to adversely affect adjoining properties, and to meet the requirements of the Environmental Protection Act.
• No visible dust emissions must occur at the boundaries of the site during earthworks and construction activities on the site.
• If at any time during the earthworks and construction activities, dust emissions exceed the levels specified above, dust-generating activities must cease until sufficient corrective actions have been implemented to reduce dust emissions to acceptable levels or wind conditions are such that acceptable levels are achieved.
• In order to ensure minimal response times for implementation of corrective actions and continuity of the construction processes, watering equipment shall be available on site at all times during earthworks and construction activities to dampen down disturbed areas.</td></tr>
<tr><td>Monitoring</td><td>The monitoring and control of both noise and dust nuisance is to be a continuous process for the duration of the earthworks and construction activities at all times including non working days.</td></tr>
<tr><td>Reporting</td><td>The superintendent is to take note of noise and dust levels:
• During regular site inspections throughout the earthworks and construction activities; and
• Immediately following receipt of any complaints.</td></tr>
<tr><td>Corrective Action</td><td>The superintendent in consultation with the Principal Contractor is to determine the source of the unacceptable noise and dust emissions and;
• Devise a method to attenuate offending noise emissions either through maintenance of plant or revised work practices, and
• Reduce dust emissions through either:
    o Suspension of works until weather conditions are favourable;
    o Damping down of work areas; or
    o Revision of work practices.</td></tr>
</table>

7.0 LIFECYCLE COST ASSESSMENT

The developer will fund the initial capital cost of a system to convey and treat stormwater runoff. The lifecycle of the above management options can be stated as relatively long (approximately up to 20 years). This is due to the use of structural devices with long design life and natural systems that are self-regulating. Maintenance costs associated with such management options will be high in the early stages of the life cycle but as the developed area stabilises the costs will decrease.
A lifecycle cost assessment will be undertaken for each bioretention basin at the detailed design stage once final basin sizes are determined.

8.0 WATER QUALITY MONITORING PROGRAM

A water quality-monitoring program may be required for the site under the conditions imposed by the Development Permit. Below is a conceptual phase monitoring program that will be updated to a detailed design level for inclusion with the Operational Works Application. The site has no base flow of water during dry periods and as such the monitoring program will focus on stormwater discharge quality during construction and the quality of the ecological health during the maintenance period.

Objective / Target	To maintain or enhance pre-development water quality and natural vegetation during the construction and maintenance period. Compliance with this objective is to meet requirements set out in the *State Planning Policy 4/10 for Healthy Waters*, *Environmental Protection Act (1994)*, the *Environmental Protection (Water) Policy (1997)* and the *Ipswich City Council Planning Scheme Policy 3 – General Works Document.*
Management Strategy	During construction • To reduce the amount of contaminants entering the waterway system by using best practices. Refer to the Sediment and Erosion Control Plan. • Retention of existing vegetation along the waterway corridor (where applicable) with the early establishment of landscaping and rehabilitation work to minimise the potential mobilisation of contaminants. Post construction and during the Maintenance Period • Regular inspection of the works to ensure flora is establishing, contaminants are being removed and that the system's ecological health is of an acceptable quality.
Tasks / Actions	• During construction the Principal Contractor is to ➢ Be made aware of the requirements regarding the water quality issues on the site. ➢ Implement the measures and methodology detailed in the Erosion and Sediment Control Plan to reduce contaminants entering the waterway system. ➢ Perform monitoring of the quality of water based on rainfall events or discharge requirements using hand sampling and visual assessment techniques. • Landscape and rehabilitation works are to be completed as required during the construction phase to ensure protection of sensitive areas. • During the maintenance period perform monitoring of the quality of water based on rainfall events or periodic inspection, using hand sampling and visual assessment

	techniques.
Performance Indicators	• Capture of sediment and litter in the Sediment and Erosion control devices. • Visual indicators of the efficient removal of nutrients such as nitrogen and phosphorus. Such indicators include growth of flora, fauna within the area, an ecological health assessment, etc.
Frequency / Deadline	Visual inspections shall be performed periodically, but at no less than weekly intervals during the construction period, monthly during the maintenance period and after any significant rainfall in any 24-hour period.
Responsible Party	During the construction phase of the development the Principal Contractor is responsible for maintaining the quality improvement devices and strategies. The Superintendents for civil works and landscape works will be responsible for carrying out visual inspections and ordering any corrective action required. The Principal Contractor will notify the Superintendents if any changes occur in the conditions on site so that inspections can be carried out. During the maintenance period of the development the Superintendents will carry out inspections and order any corrective action required.
Reporting and Review	During construction • Site notes will be made of any inspections / tests carried out. A copy of these notes can be supplied to the Council Inspection Officer as requested. • All works will be inspected by Council Inspection Officer's prior to acceptance "On Maintenance" to ensure the Objective / Target is being achieved and that the Performance Indicators are in place. During the Maintenance Period • Site notes will be made of any inspections / tests carried out. A copy of these notes can be supplied to the Council Inspection Officer as requested at time of "Off Maintenance". • All works will be inspected by Council Inspection Officer's prior to acceptance "Off Maintenance" to ensure the Objective / Target has been achieved.

Corrective Action	• Identify the reasons for the deterioration of water quality and determine if it is linked to construction activities. • If construction activities are responsible, then isolate the specific cause and determine the best method to prevent the incident from occurring again. • The work practice causing the pollution is to cease immediately and clean-up operations to commence immediately and to be completed within 5 working days. • If other sources are responsible, then notify the Local Authority of the situation for their action.

9.0 MAINTENANCE PLANS AND ASSET HAND-OVER

A maintenance plan will be completed if required and submitted at acceptance of the works 'Off Maintenance' when the remainder of the stormwater drainage system and treatment devices become Council's responsibility.

10.0 STORMWATER QUALITY MAINTENANCE

Key stormwater quality treatment devices requiring maintenance during the operational works phase of the project are the specified bioretention systems.

Maintenance required for bioretention systems consists of:

- Regular and storm event inspections to insure:
  - Sufficient vegetation is still established.
  - No erosion has occurred: and
  - Any cleanup required is undertaken.
- Regular mowing/ harvesting to ensure vegetation is maintained at acceptable levels.
- Removal of litter.

MAINTENANCE PLAN DETAILS
BIO RETENTION SYSTEMS

SCHEDULE OF SITE VISITS													
Purpose of Visit	**Frequency**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Routine inspection	Monthly	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Annual inspection	1/year				✔								
Routine maintenance	2/year				✔						✔		
Routine clean out of sediment	1/2 year				✔								

The above schedule is a guideline only. Routine clean out and maintenance should be scheduled based on the outcome of routine inspection.

INSPECTION	
1.	**Routine Inspection**
1.1	Routine inspection should be carried out on a regular monthly basis. The purpose of the inspection is to indicate when maintenance of the Bio retention system is required.
1.2	Inspections should consider erosion, condition of vegetation, ponded water.
1.3	Complete appropriate Maintenance Form. Maintenance is required if failure of the above sediment.
2.	**Annual Inspection**
2.1	Once a year, the condition of the bio retention system should be closely inspected. Any damage or problems should be noted on the Maintenance Form for action.

ROUTINE MAINTENANCE	
1.	**Purpose**
1.1	Routine maintenance of the bio retention system involves weed control and the collection of any litter, removal of dead or diseased vegetation, and mulch replacement.

2.	**Weed Management**
2.1	If weeds have been observed during routine inspection, these weeds should be removed from the bio retention system. Weeding generally involves manual removal of perennial species.
2.2	The aim is to remove the weed including the roots when the weeds are less than 3 months old; otherwise weeds infestation rapidly occurs and is difficult to control.
2.3	Herbicides should not be used, as they would contaminate the water in the creek.
2.4	The weed should be disposed offsite at appropriate waste management facility.
2.5	Replant appropriate plant species, where necessary, in areas that have been extensively weeded.
3.	**Litter Management**
3.1	Remove and dispose of litter that may be visible around the bio retention system.
4.	**Dead or Diseased Vegetation**
4.1	Remove or dispose of any dead or diseased vegetation within system
5.	**Mulch Replacement**
5.1	Mulch replacement is recommended when erosion is evident or system looks unattractive.

CLEANOUT OF SEDIMENT	
1.	**Setup and Prepare site for Cleanout**
1.1	Notify adjacent residents at least three days prior to date of cleanout.
1.2	Setup equipment onsite
2.	**Cleanout of Sediment – Bioretention basin**
2.1	The preferred method of cleanout of the bio retention system is replacing the clogged medium.
2.2	Position the equipment on the side of the system to allow easy access into the bio retention system and transfer of material into adjacent tipper truck. The truck should be positioned so that water from the truck body drains into the bio retention systems.
2.3	Drain waste in the truck thoroughly before proceeding to the disposals point.
3.	**Cleanout of Sediment – Sediment Forebays**
3.1	Cleanout of forebays should be undertaken periodically by shovelling out accumulated sediment and conveying to maintenance truck via wheel barrow or by similar means.

Bioretention Construction and Maintenance should also be undertaken in accordance with Healthy Waterway's Bioretention Construction and Maintenance Checklists which are located in Appendix D.

11.0 CONCLUSION

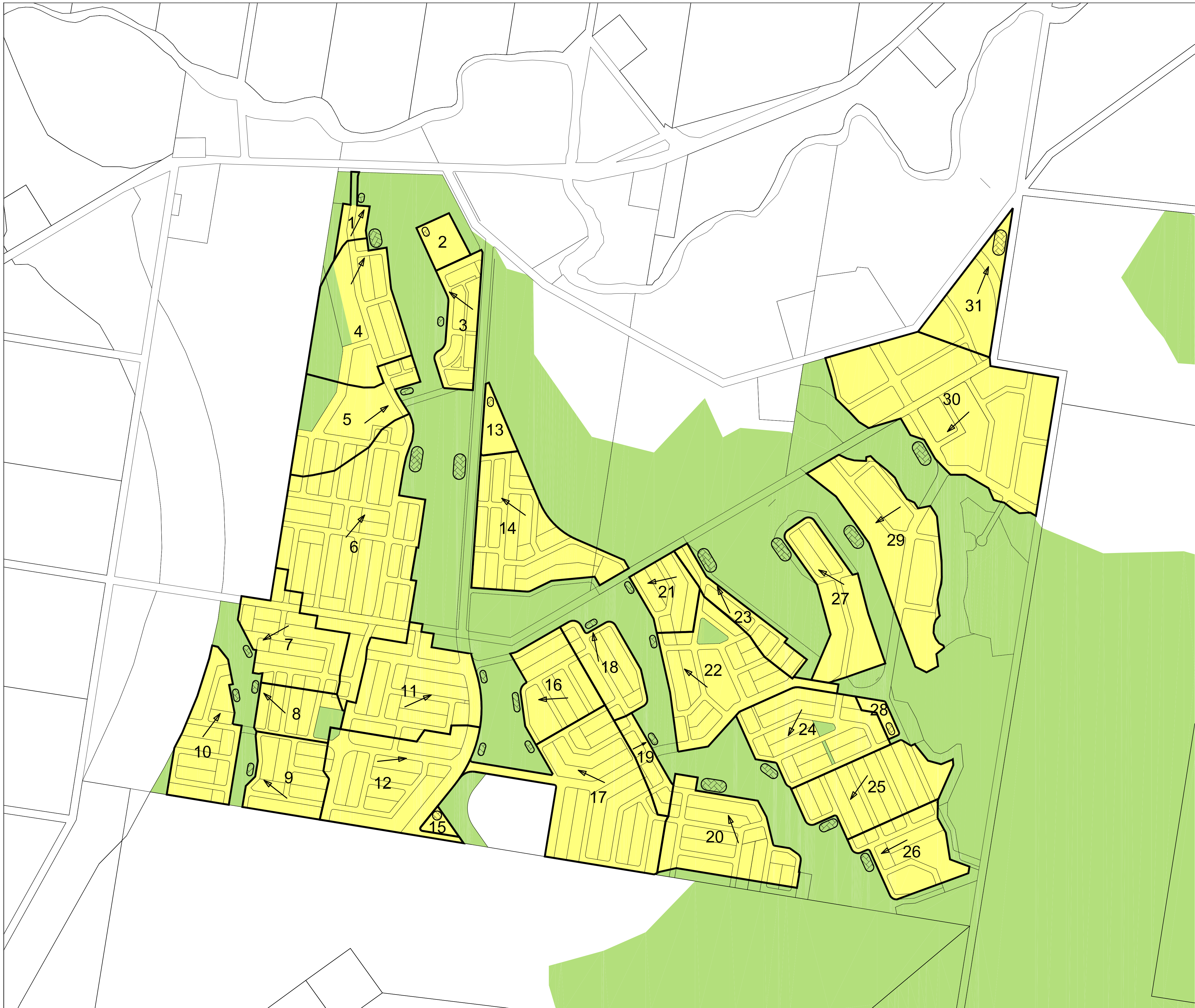
The Stormwater Quality Improvement Devices (SQID's) proposed for the development include bioretention basins with associated trash racks and sediment forebays for each catchment as detailed in Section 4.0 of this report.

The modelling of the proposed SQID's achieved the pollutant load Quality Objectives (WQO's) for each catchment in the development. As such, by implementing the above SQID's into the proposed development, stormwater runoff from the site will be treated in accordance with Urban Land Development Authority (ULDA) Development Guidelines and the Ipswich City Council (ICC) Design Guidelines.

12.0 REFERENCES

1. Department of Primary Industries, et al, 1992. *Queensland Urban Drainage Manual (QUDM)*. Brisbane.
2. CRC for Catchment Hydrology, 2002. *Model for Urban Stormwater Improvement Conceptualisation (MUSIC)*. CRC for Catchment Hydrology, Melbourne.
3. Engineers Australia *Australian runoff Quality* Riverwood New South Wales
4. Bureau of Meteorology, *Meteorological data Amberley IFD 1990 - 1999,* Bureau of Meteorology
5. WSUD Technical Design Guidelines for South East Queensland – Version 1 June 2006.
6. Healthy Waterways MUSIC Modeling Guidelines 2010.

APPENDIX A - Site Layout



Catchment and Area	Foot Print Area (m^2)	Extended Detention Depth (m)	Filter Area (m^2)	Filter Depth (m)	Filter Median Particle Diameter (mm)	Saturated Hydraulic conductivity (mm/hr)
Catchment 1 (3.851Ha)	160	0.3	90	0.7	0.45	180
Catchment 2 (Medium Density Site)(1.132Ha)	283	0.3	283	0.7	0.45	180
Catchment 3 (2.959Ha)	950	0.3	600	0.7	0.45	180
Catchment 4 (4.460Ha)	900	0.3	600	0.7	0.45	180
Catchment 5 (3.150Ha)	700	0.3	550	0.7	0.45	180
Catchment 6 (14.180Ha)	1700	0.3	1250	0.7	0.45	180
Catchment 7 (5.131Ha)	750	0.3	460	0.7	0.45	180
Catchment 8 (2.599Ha)	420	0.3	230	0.7	0.45	180
Catchment 9 (3.689Ha)	550	0.3	340	0.7	0.45	180
Catchment 10 (4.5817Ha)	640	0.3	470	0.7	0.45	180
Catchment 11 (7.245Ha)	950	0.3	720	0.7	0.45	180
Catchment 12 (8.2126Ha)	1000	0.3	760	0.7	0.45	180
Catchment 13 (0.949Ha)	240	0.3	240	0.7	0.45	180
Catchment 14 (7.54Ha)	950	0.3	720	0.7	0.45	180
Catchment 15 (Medium Density Site)(0.361Ha)	90	0.3	90	0.7	0.45	180
Catchment 16 (4.010Ha)	600	0.3	400	0.7	0.45	180
Catchment 17 (9.832Ha)	1500	0.3	900	0.7	0.45	180
Catchment 18 (2.995Ha)	500	0.3	260	0.7	0.45	180
Catchment 19 (1.358Ha)	190	0.3	130	0.7	0.45	180
Catchment 20 (6.358Ha)	900	0.3	600	0.7	0.45	180
Catchment 21 (2.388Ha)	340	0.3	220	0.7	0.45	180
Catchment 22 (7.499Ha)	1000	0.3	680	0.7	0.45	180
Catchment 23 (2.199Ha)	350	0.3	200	0.7	0.45	180
Catchment 24 (6.313Ha)	900	0.3	580	0.7	0.45	180
Catchment 25 (5.709Ha)	750	0.3	500	0.7	0.45	180
Catchment 26 (4.001Ha)	650	0.3	320	0.7	0.45	180
Catchment 27 (4.666Ha)	680	0.3	450	0.7	0.45	180
Catchment 28 (Medium Density Site)(0.450Ha)	112	0.3	112	0.7	0.45	180
Catchment 29 (7.938Ha)	1250	0.3	750	0.7	0.45	180
Catchment 30 (15.247Ha)	1950	0.3	1380	0.7	0.45	180
Catchment 31 (3.68Ha)	500	0.3	350	0.7	0.45	180

LEGEND

STORMWATER CATCHMENT BOUNDARY

CONSERVATION/OPEN SPACE AREA

DIRECTION OF FLOW

PROPOSED BIO RETENTION BASIN

ASSOCIATED CONSULTANTS

-

DATE	REV	DESCRIPTION	APPROVED
	P2	CATCHMENTS AMENDED	
	P1	ORIGINAL ISSUE	KPH

REVISIONS

CLIENT AMEX CORPORATION LIMITED

PROJECT AMEX RIPLEY VALLEY WEST

LOCATION RIPLEY VALLEY

SHEET TITLE MASTER STORMWATER CATCHMENT PLAN

DESIGNED CH

DRAWN JW

CHECKED DATE

DATE APRIL 2012

APPROVED DATE

KEITH HOWELLS RPEQ 7295

ALAN SVILICIC RPEQ 8369

SCALE 0 300 600m

SCALE 1:10,000 (A3)

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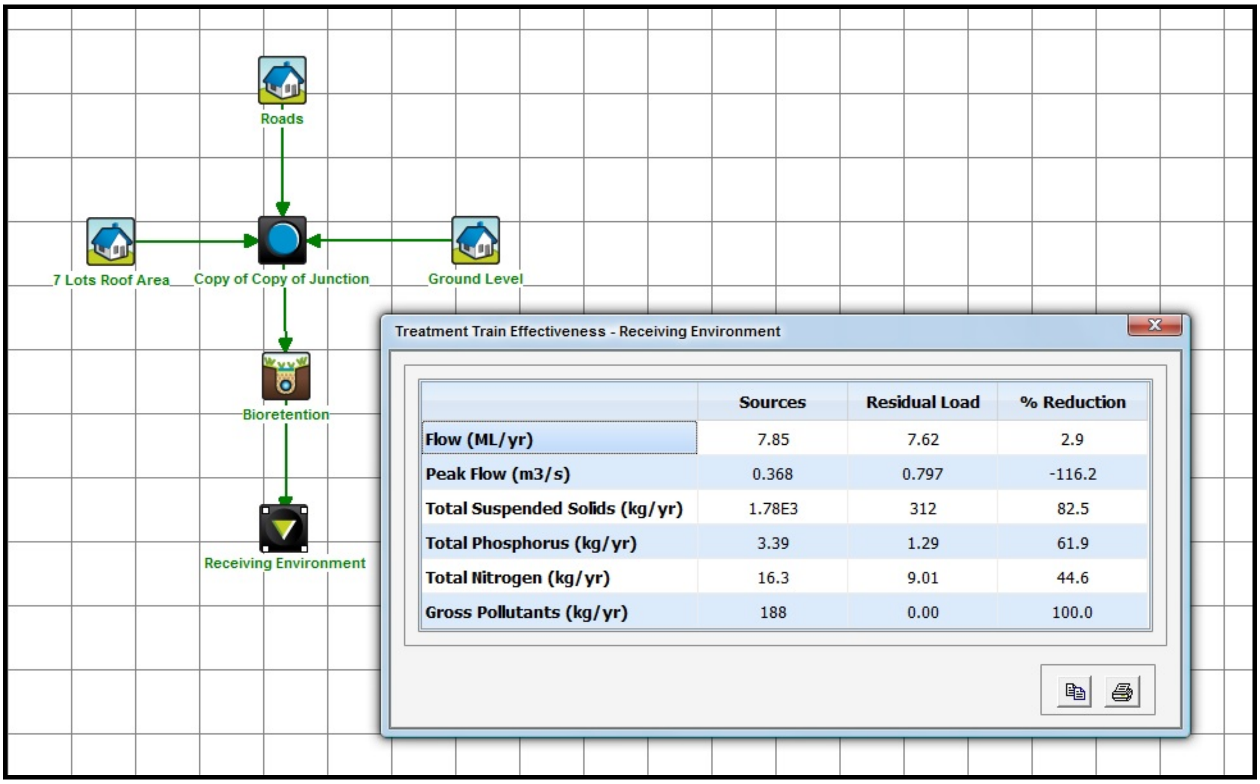
SHEET NUMBER: SK03 REV: P2

 FORM E027 10 AUG 2006

APPENDIX B- Music Modelling Results

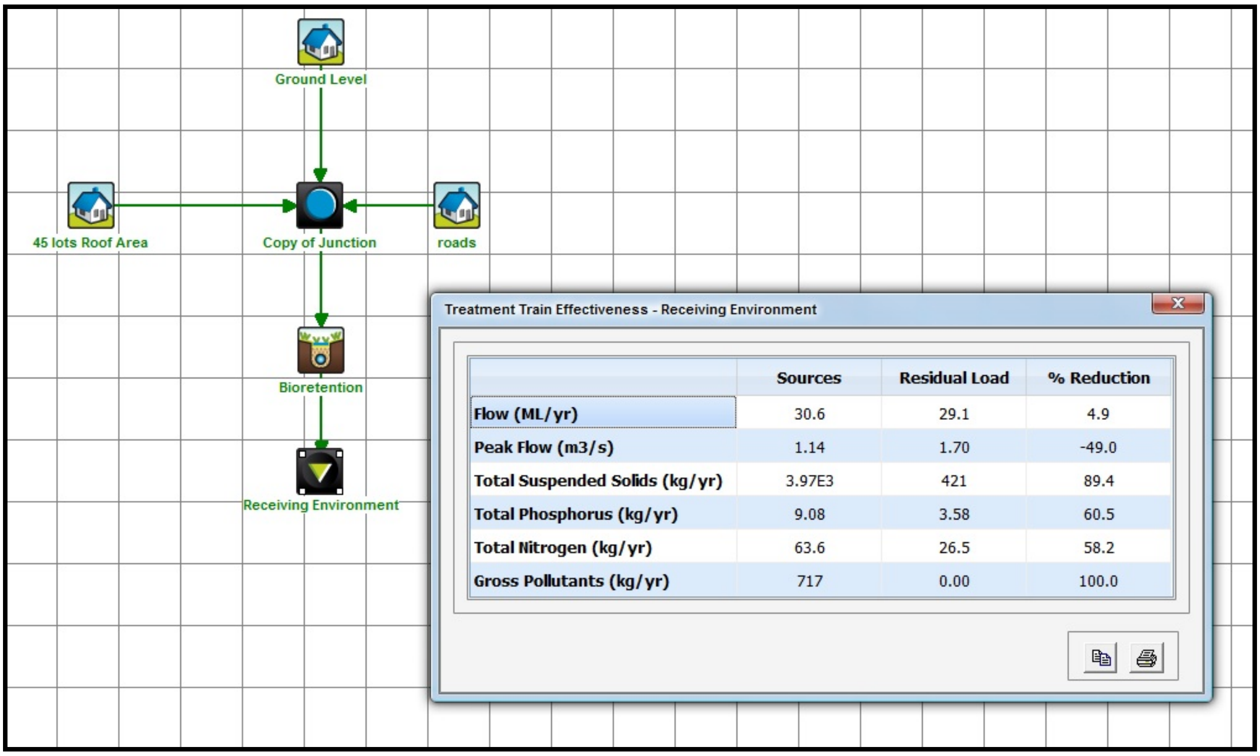
MUSIC Modelling Results

Catchment 1



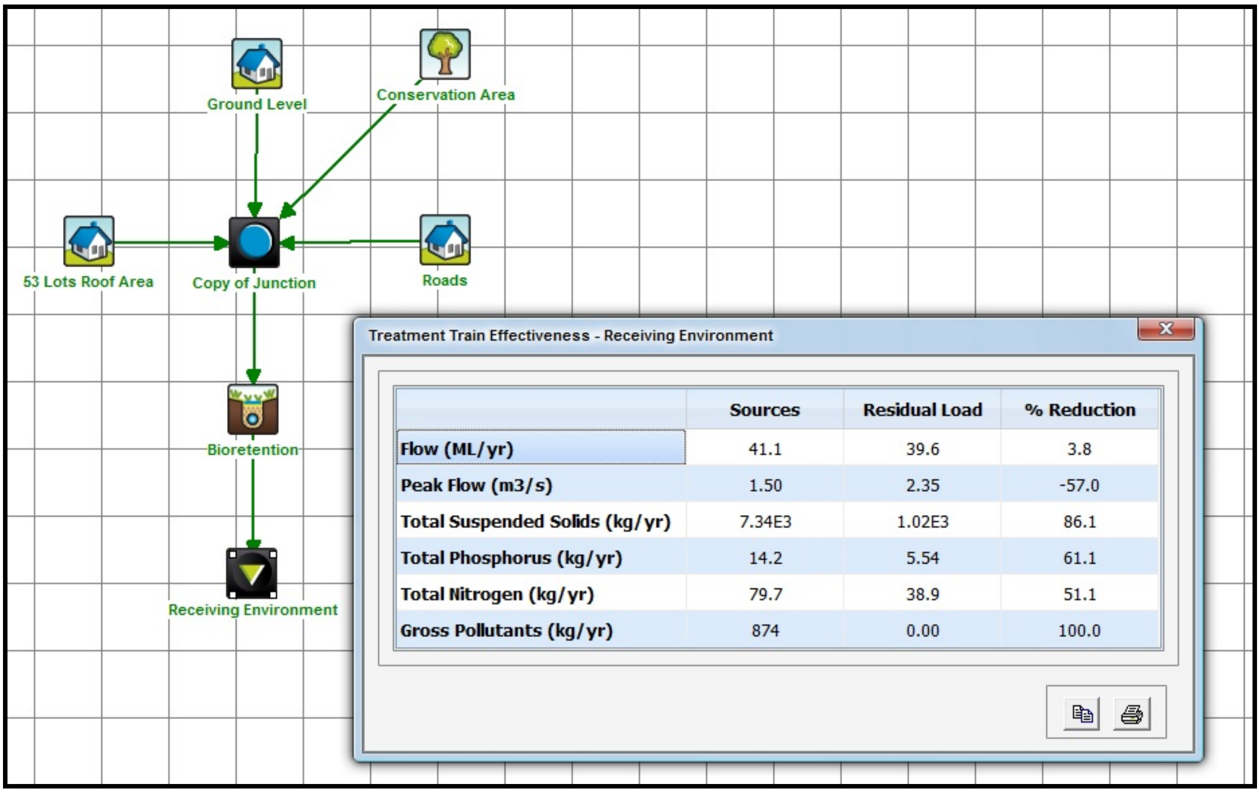
	Sources	Residual Load	% Reduction
Flow (ML/yr)	7.85	7.62	2.9
Peak Flow (m3/s)	0.368	0.797	-116.2
Total Suspended Solids (kg/yr)	1.78E3	312	82.5
Total Phosphorus (kg/yr)	3.39	1.29	61.9
Total Nitrogen (kg/yr)	16.3	9.01	44.6
Gross Pollutants (kg/yr)	188	0.00	100.0

Catchment 3



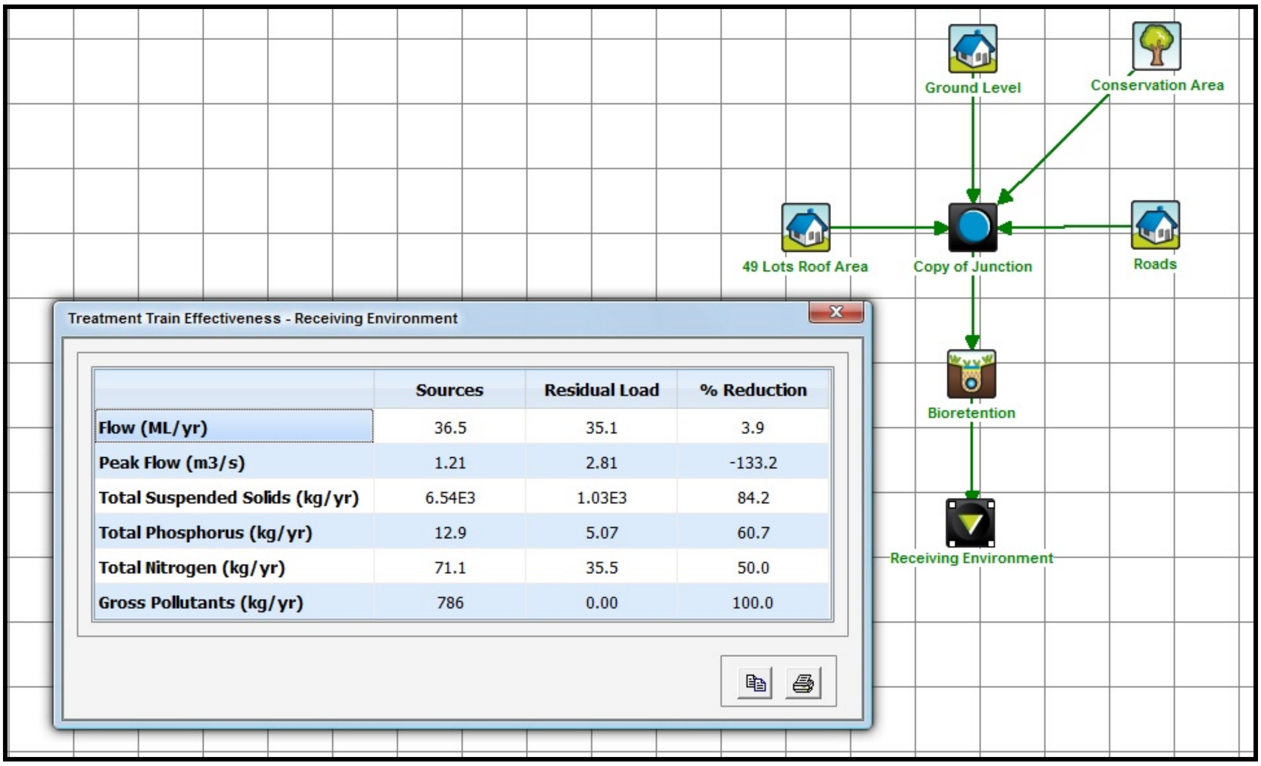
	Sources	Residual Load	% Reduction
Flow (ML/yr)	30.6	29.1	4.9
Peak Flow (m3/s)	1.14	1.70	-49.0
Total Suspended Solids (kg/yr)	3.97E3	421	89.4
Total Phosphorus (kg/yr)	9.08	3.58	60.5
Total Nitrogen (kg/yr)	63.6	26.5	58.2
Gross Pollutants (kg/yr)	717	0.00	100.0

Catchment 4



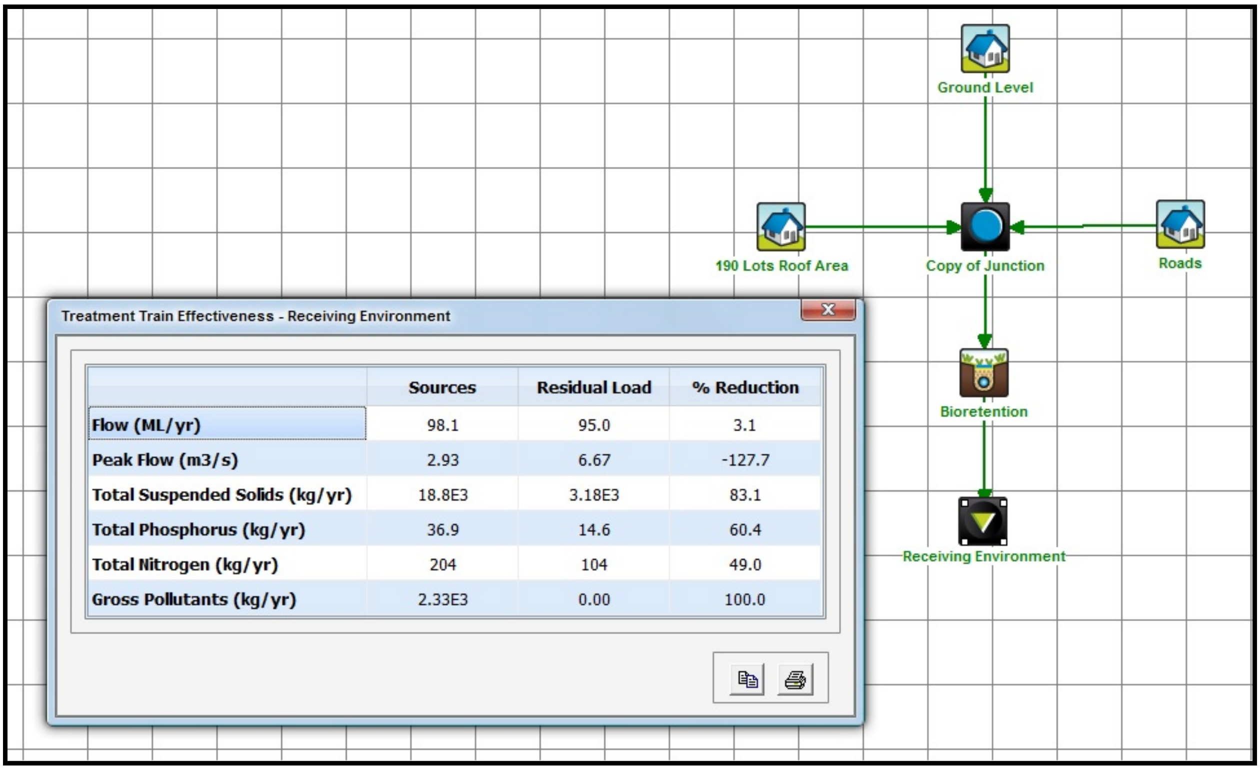
	Sources	Residual Load	% Reduction
Flow (ML/yr)	41.1	39.6	3.8
Peak Flow (m3/s)	1.50	2.35	-57.0
Total Suspended Solids (kg/yr)	7.34E3	1.02E3	86.1
Total Phosphorus (kg/yr)	14.2	5.54	61.1
Total Nitrogen (kg/yr)	79.7	38.9	51.1
Gross Pollutants (kg/yr)	874	0.00	100.0

Catchment 5



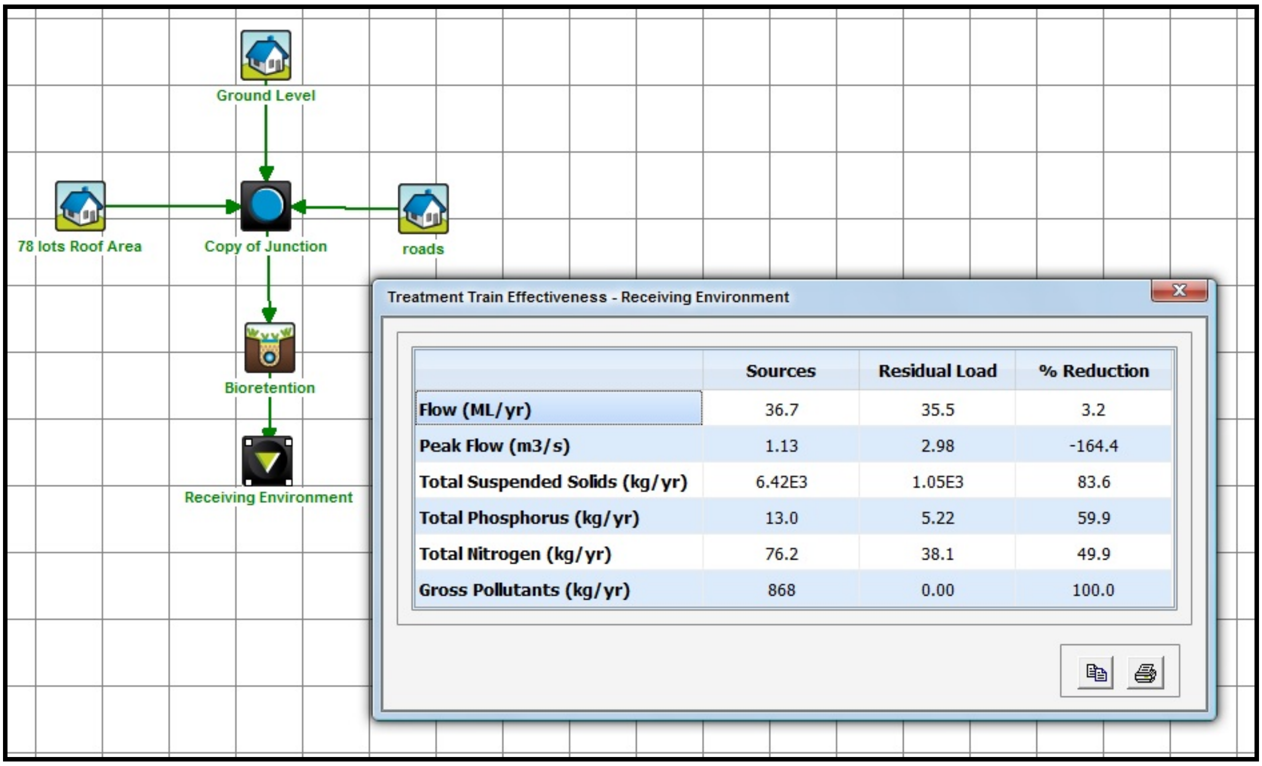
	Sources	Residual Load	% Reduction
Flow (ML/yr)	36.5	35.1	3.9
Peak Flow (m3/s)	1.21	2.81	-133.2
Total Suspended Solids (kg/yr)	6.54E3	1.03E3	84.2
Total Phosphorus (kg/yr)	12.9	5.07	60.7
Total Nitrogen (kg/yr)	71.1	35.5	50.0
Gross Pollutants (kg/yr)	786	0.00	100.0

Catchment 6



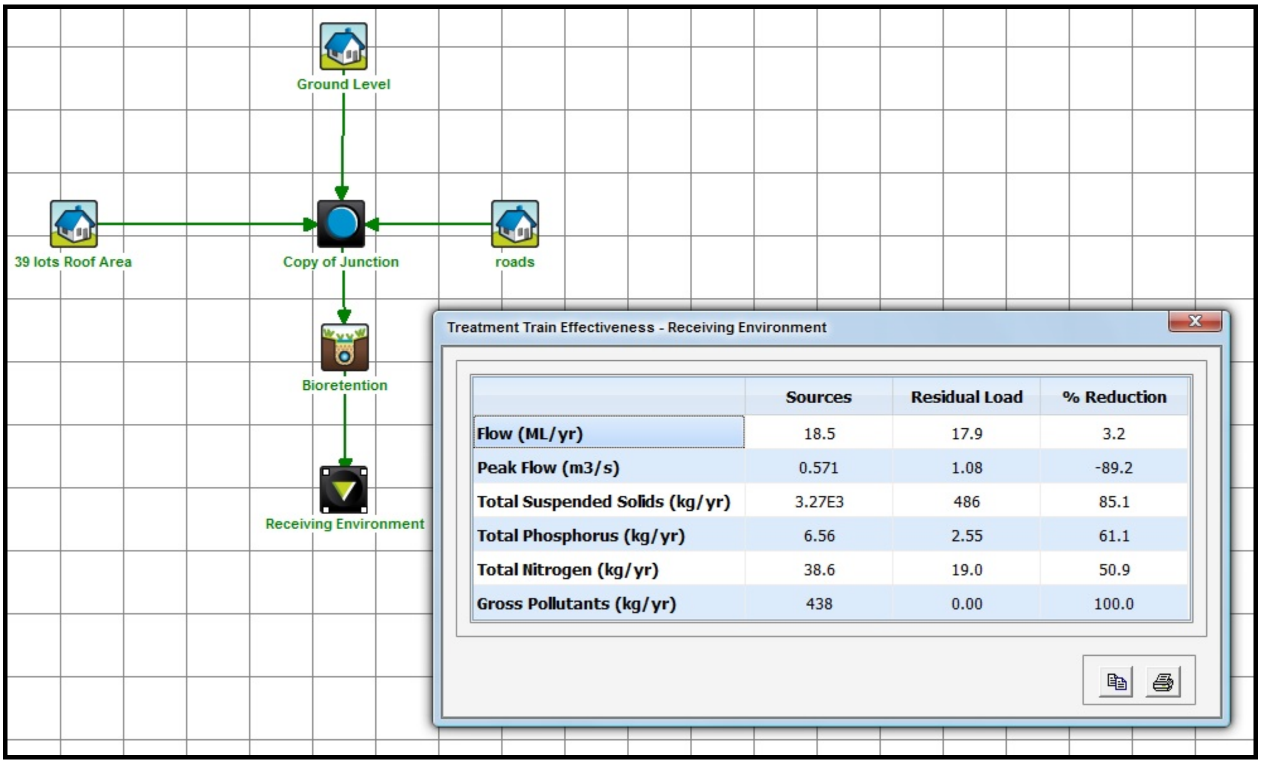
	Sources	Residual Load	% Reduction
Flow (ML/yr)	98.1	95.0	3.1
Peak Flow (m3/s)	2.93	6.67	-127.7
Total Suspended Solids (kg/yr)	18.8E3	3.18E3	83.1
Total Phosphorus (kg/yr)	36.9	14.6	60.4
Total Nitrogen (kg/yr)	204	104	49.0
Gross Pollutants (kg/yr)	2.33E3	0.00	100.0

Catchment 7



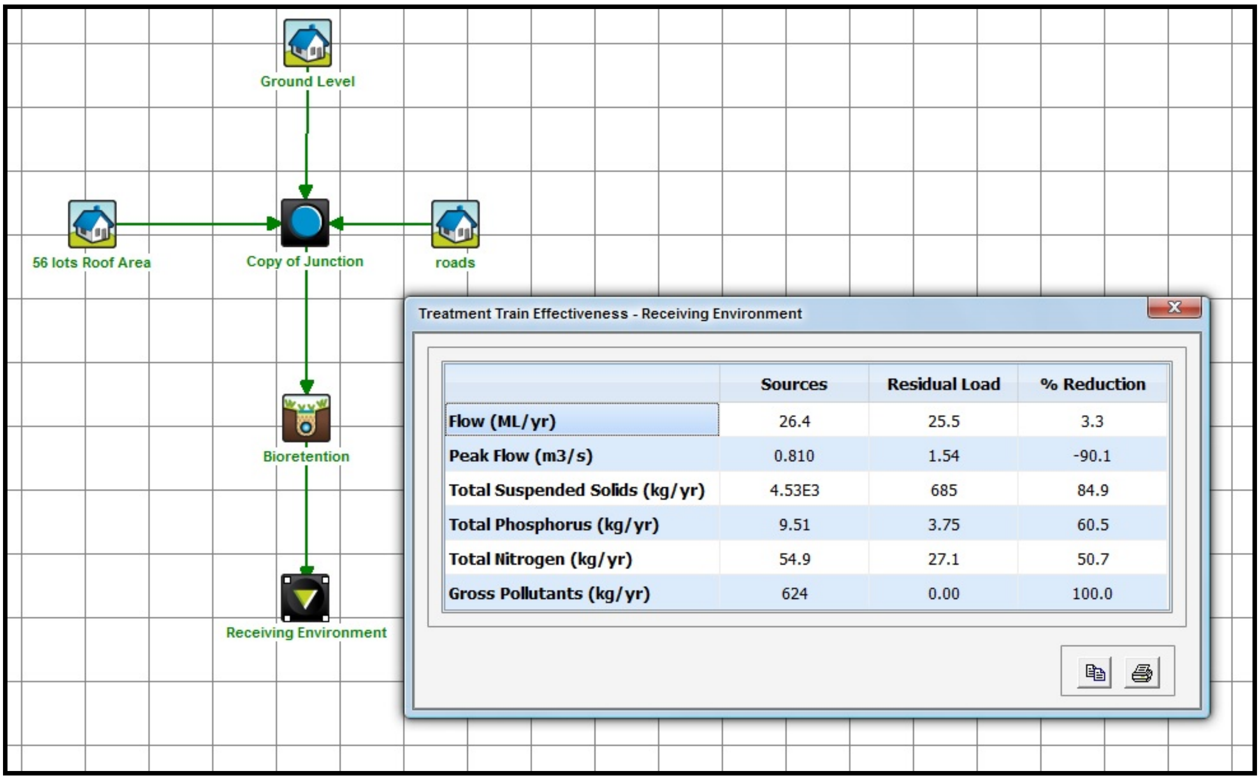
	Sources	Residual Load	% Reduction
Flow (ML/yr)	36.7	35.5	3.2
Peak Flow (m3/s)	1.13	2.98	-164.4
Total Suspended Solids (kg/yr)	6.42E3	1.05E3	83.6
Total Phosphorus (kg/yr)	13.0	5.22	59.9
Total Nitrogen (kg/yr)	76.2	38.1	49.9
Gross Pollutants (kg/yr)	868	0.00	100.0

Catchment 8



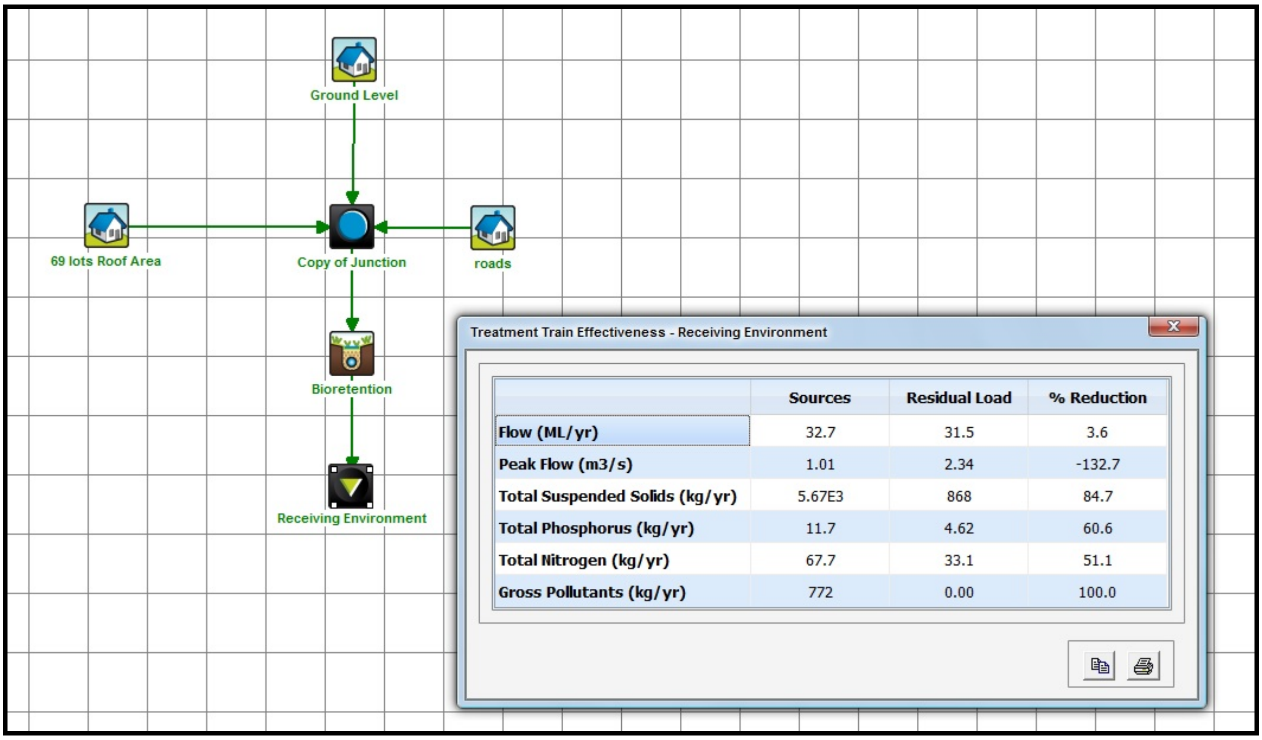
	Sources	Residual Load	% Reduction
Flow (ML/yr)	18.5	17.9	3.2
Peak Flow (m3/s)	0.571	1.08	-89.2
Total Suspended Solids (kg/yr)	3.27E3	486	85.1
Total Phosphorus (kg/yr)	6.56	2.55	61.1
Total Nitrogen (kg/yr)	38.6	19.0	50.9
Gross Pollutants (kg/yr)	438	0.00	100.0

Catchment 9



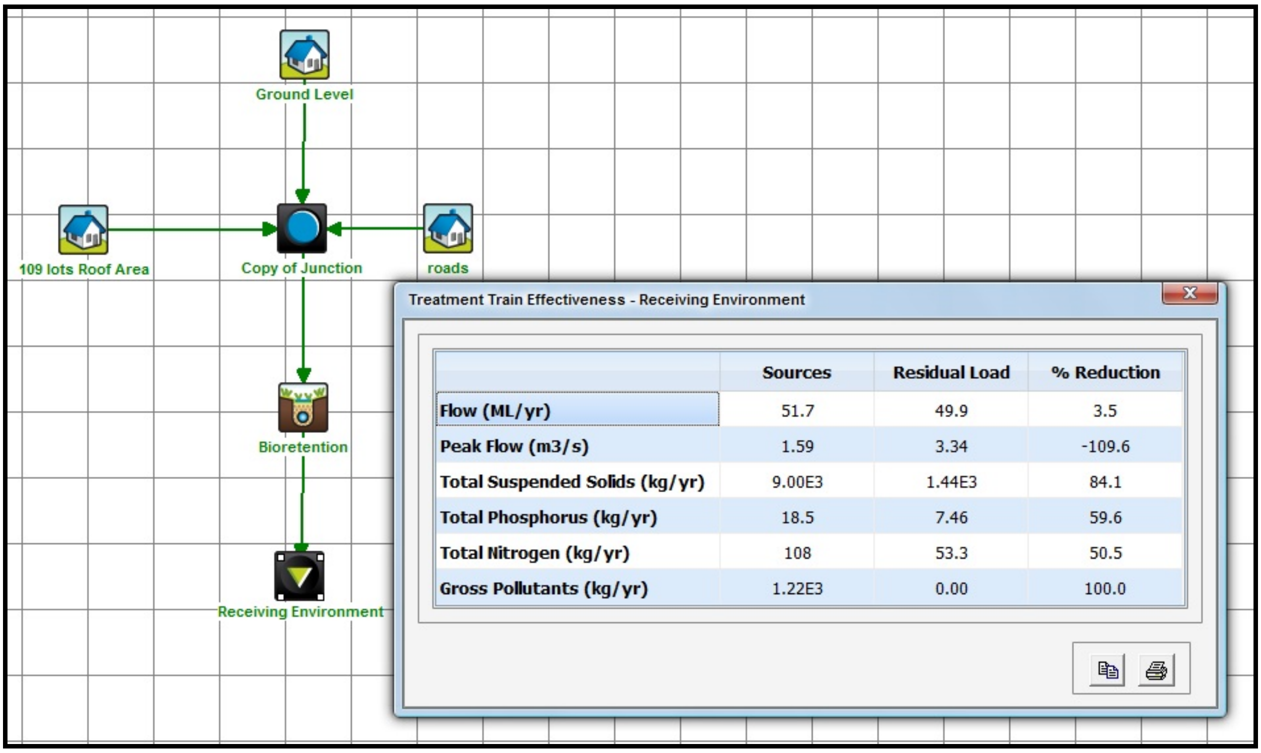
	Sources	Residual Load	% Reduction
Flow (ML/yr)	26.4	25.5	3.3
Peak Flow (m3/s)	0.810	1.54	-90.1
Total Suspended Solids (kg/yr)	4.53E3	685	84.9
Total Phosphorus (kg/yr)	9.51	3.75	60.5
Total Nitrogen (kg/yr)	54.9	27.1	50.7
Gross Pollutants (kg/yr)	624	0.00	100.0

Catchment 10



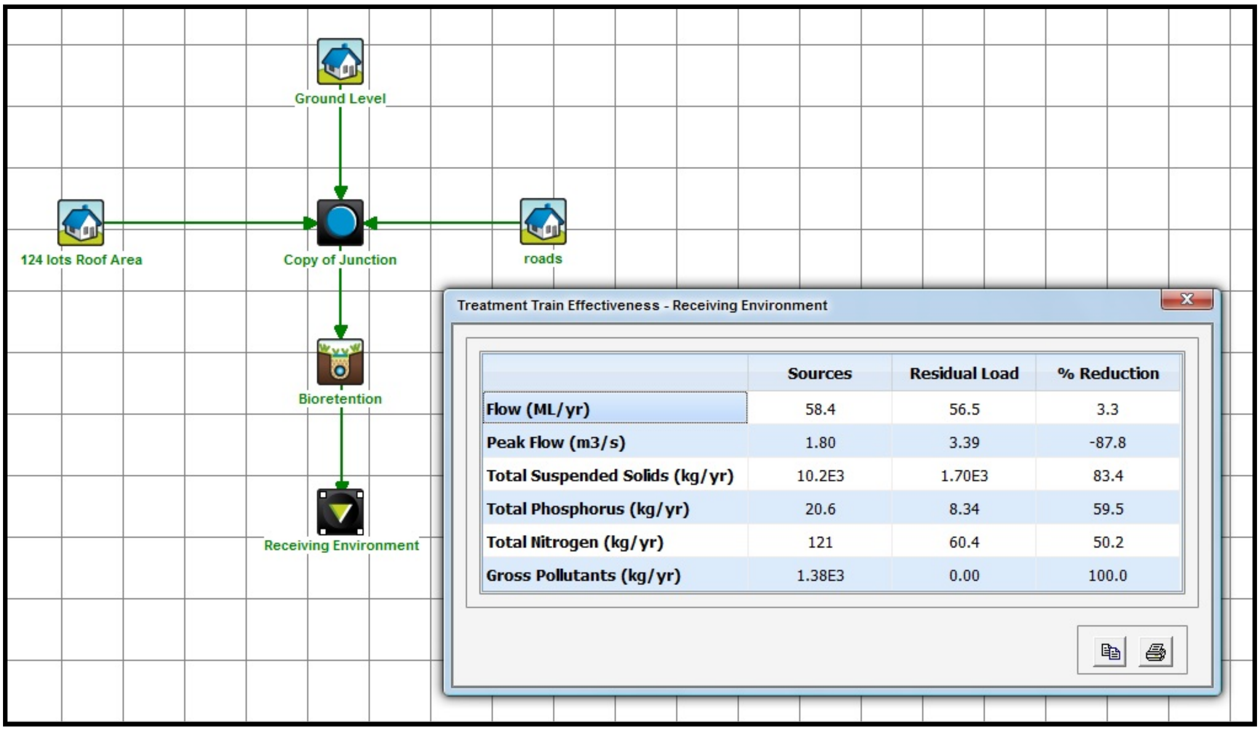
	Sources	Residual Load	% Reduction
Flow (ML/yr)	32.7	31.5	3.6
Peak Flow (m3/s)	1.01	2.34	-132.7
Total Suspended Solids (kg/yr)	5.67E3	868	84.7
Total Phosphorus (kg/yr)	11.7	4.62	60.6
Total Nitrogen (kg/yr)	67.7	33.1	51.1
Gross Pollutants (kg/yr)	772	0.00	100.0

Catchment 11



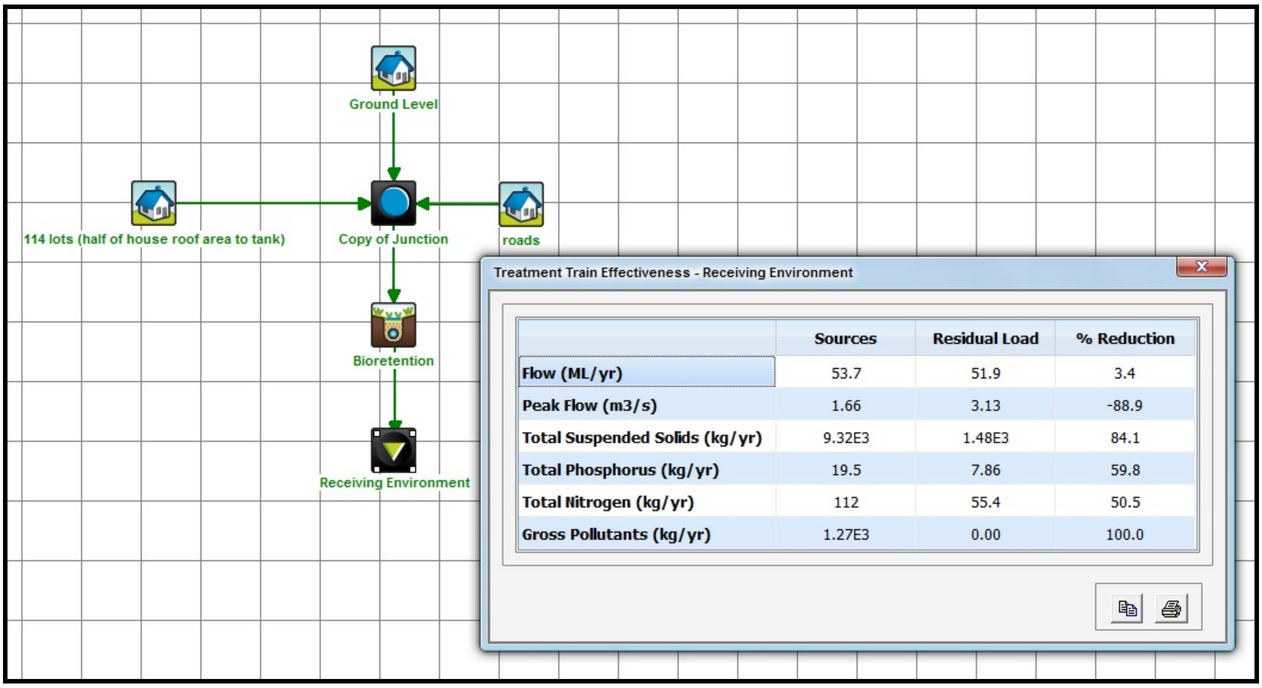
	Sources	Residual Load	% Reduction
Flow (ML/yr)	51.7	49.9	3.5
Peak Flow (m3/s)	1.59	3.34	-109.6
Total Suspended Solids (kg/yr)	9.00E3	1.44E3	84.1
Total Phosphorus (kg/yr)	18.5	7.46	59.6
Total Nitrogen (kg/yr)	108	53.3	50.5
Gross Pollutants (kg/yr)	1.22E3	0.00	100.0

Catchment 12



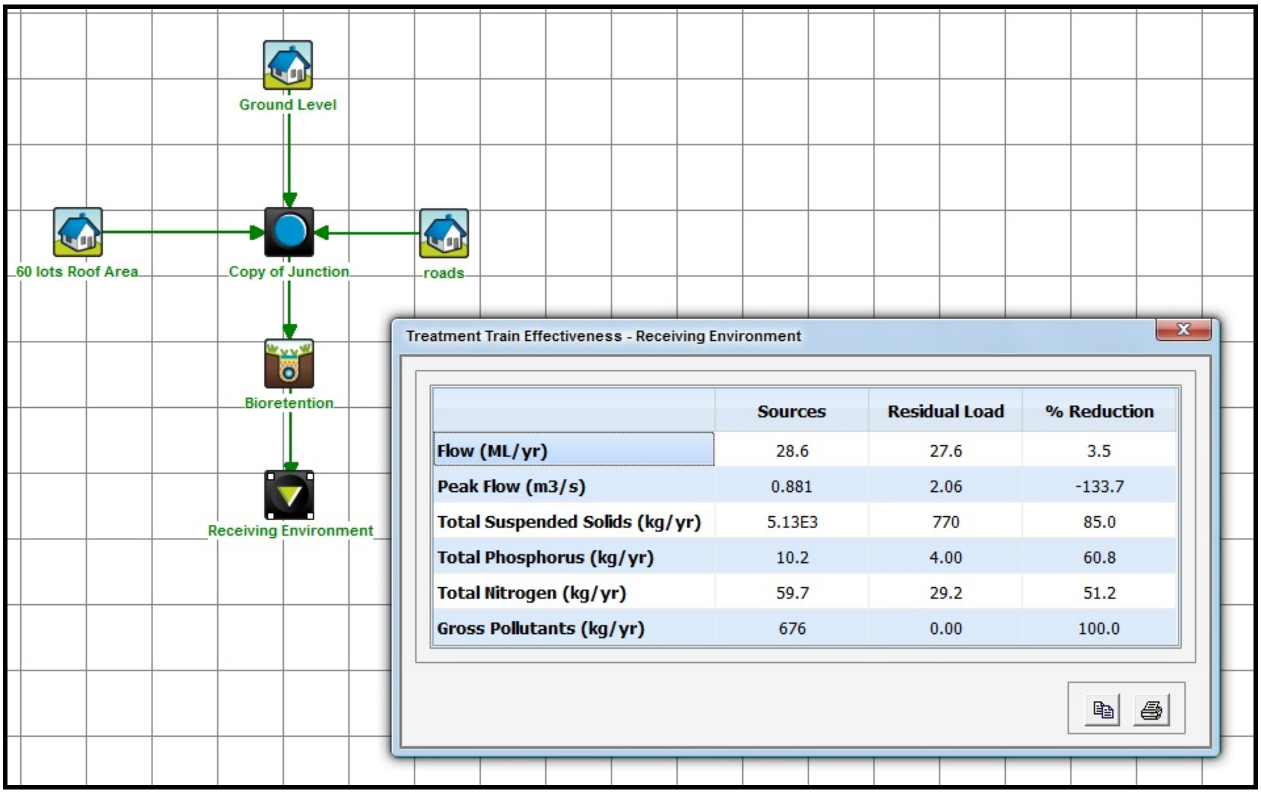
	Sources	Residual Load	% Reduction
Flow (ML/yr)	58.4	56.5	3.3
Peak Flow (m3/s)	1.80	3.39	-87.8
Total Suspended Solids (kg/yr)	10.2E3	1.70E3	83.4
Total Phosphorus (kg/yr)	20.6	8.34	59.5
Total Nitrogen (kg/yr)	121	60.4	50.2
Gross Pollutants (kg/yr)	1.38E3	0.00	100.0

Catchment 14



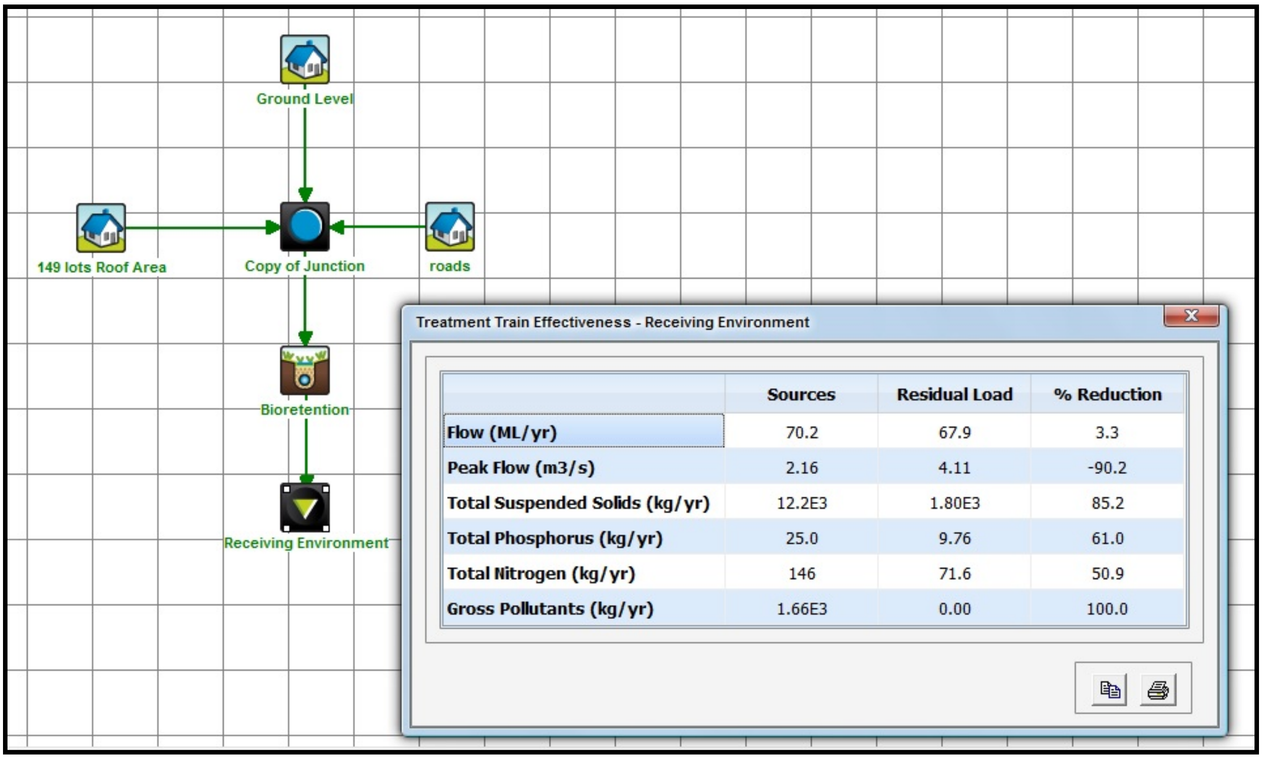
	Sources	Residual Load	% Reduction
Flow (ML/yr)	53.7	51.9	3.4
Peak Flow (m3/s)	1.66	3.13	-88.9
Total Suspended Solids (kg/yr)	9.32E3	1.48E3	84.1
Total Phosphorus (kg/yr)	19.5	7.86	59.8
Total Nitrogen (kg/yr)	112	55.4	50.5
Gross Pollutants (kg/yr)	1.27E3	0.00	100.0

Catchment 16



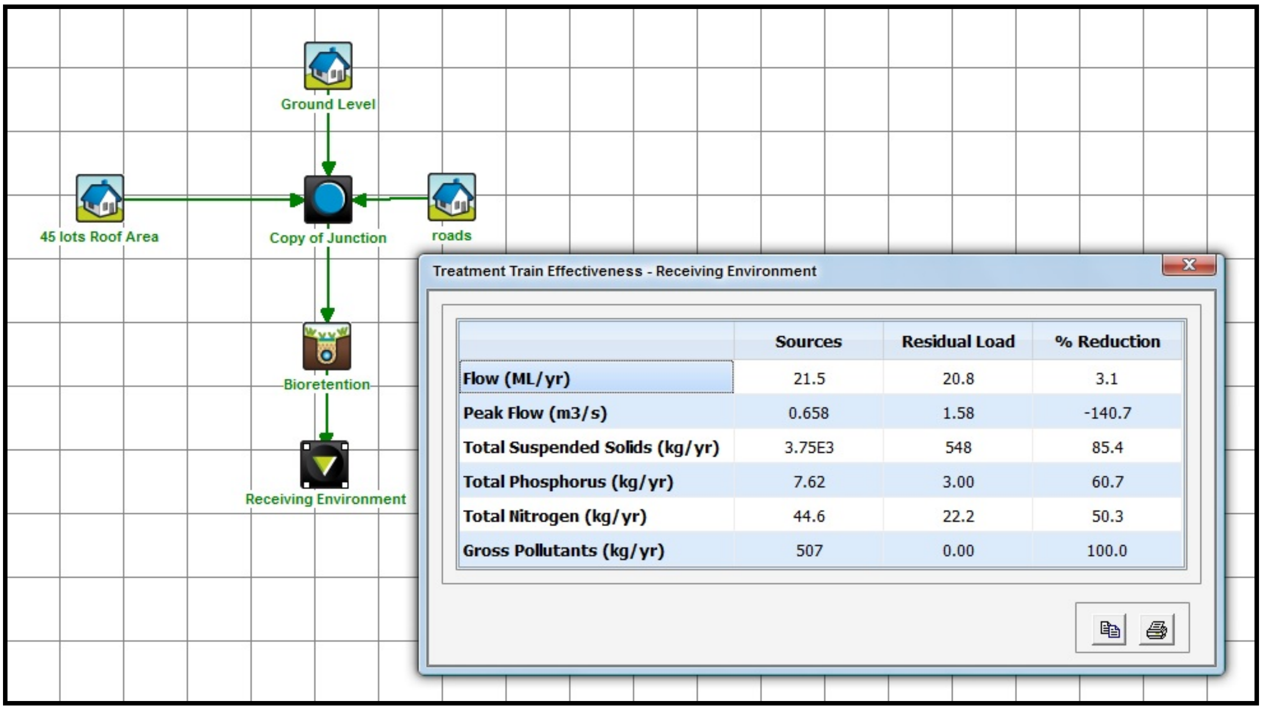
	Sources	Residual Load	% Reduction
Flow (ML/yr)	28.6	27.6	3.5
Peak Flow (m3/s)	0.881	2.06	-133.7
Total Suspended Solids (kg/yr)	5.13E3	770	85.0
Total Phosphorus (kg/yr)	10.2	4.00	60.8
Total Nitrogen (kg/yr)	59.7	29.2	51.2
Gross Pollutants (kg/yr)	676	0.00	100.0

Catchment 17



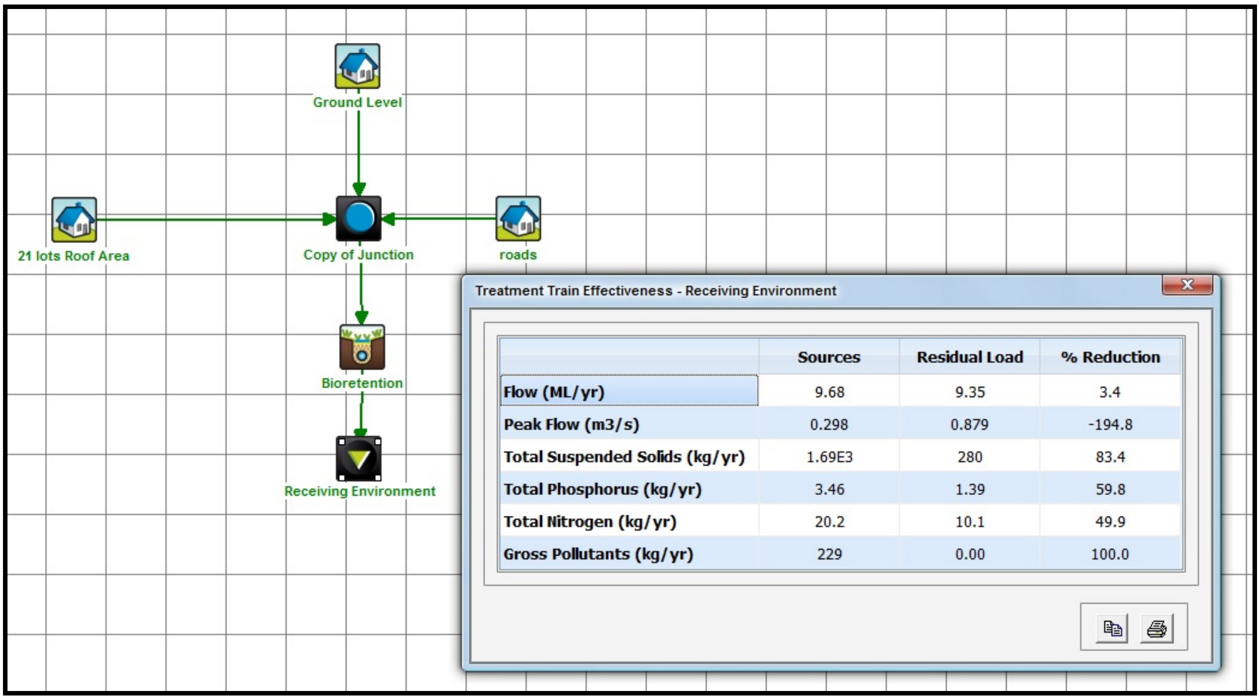
	Sources	Residual Load	% Reduction
Flow (ML/yr)	70.2	67.9	3.3
Peak Flow (m3/s)	2.16	4.11	-90.2
Total Suspended Solids (kg/yr)	12.2E3	1.80E3	85.2
Total Phosphorus (kg/yr)	25.0	9.76	61.0
Total Nitrogen (kg/yr)	146	71.6	50.9
Gross Pollutants (kg/yr)	1.66E3	0.00	100.0

Catchment 18



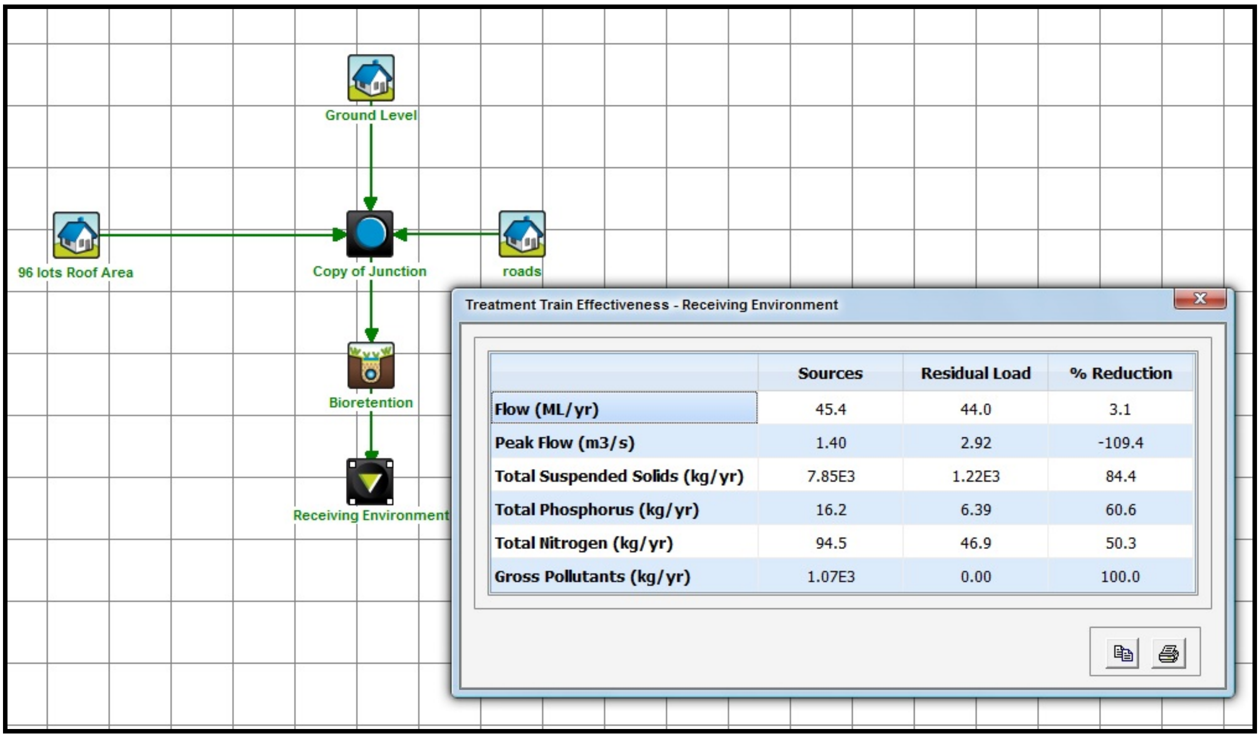
	Sources	Residual Load	% Reduction
Flow (ML/yr)	21.5	20.8	3.1
Peak Flow (m3/s)	0.658	1.58	-140.7
Total Suspended Solids (kg/yr)	3.75E3	548	85.4
Total Phosphorus (kg/yr)	7.62	3.00	60.7
Total Nitrogen (kg/yr)	44.6	22.2	50.3
Gross Pollutants (kg/yr)	507	0.00	100.0

Catchment 19



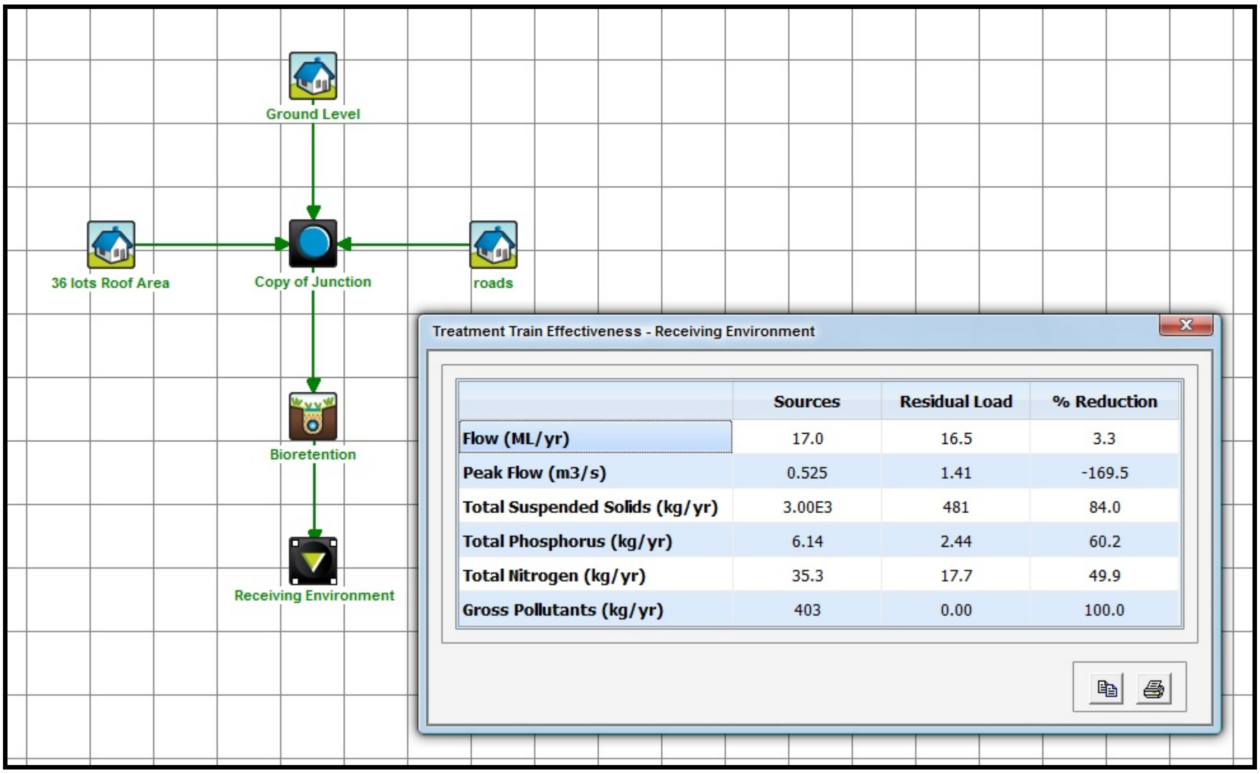
	Sources	Residual Load	% Reduction
Flow (ML/yr)	9.68	9.35	3.4
Peak Flow (m3/s)	0.298	0.879	-194.8
Total Suspended Solids (kg/yr)	1.69E3	280	83.4
Total Phosphorus (kg/yr)	3.46	1.39	59.8
Total Nitrogen (kg/yr)	20.2	10.1	49.9
Gross Pollutants (kg/yr)	229	0.00	100.0

Catchment 20



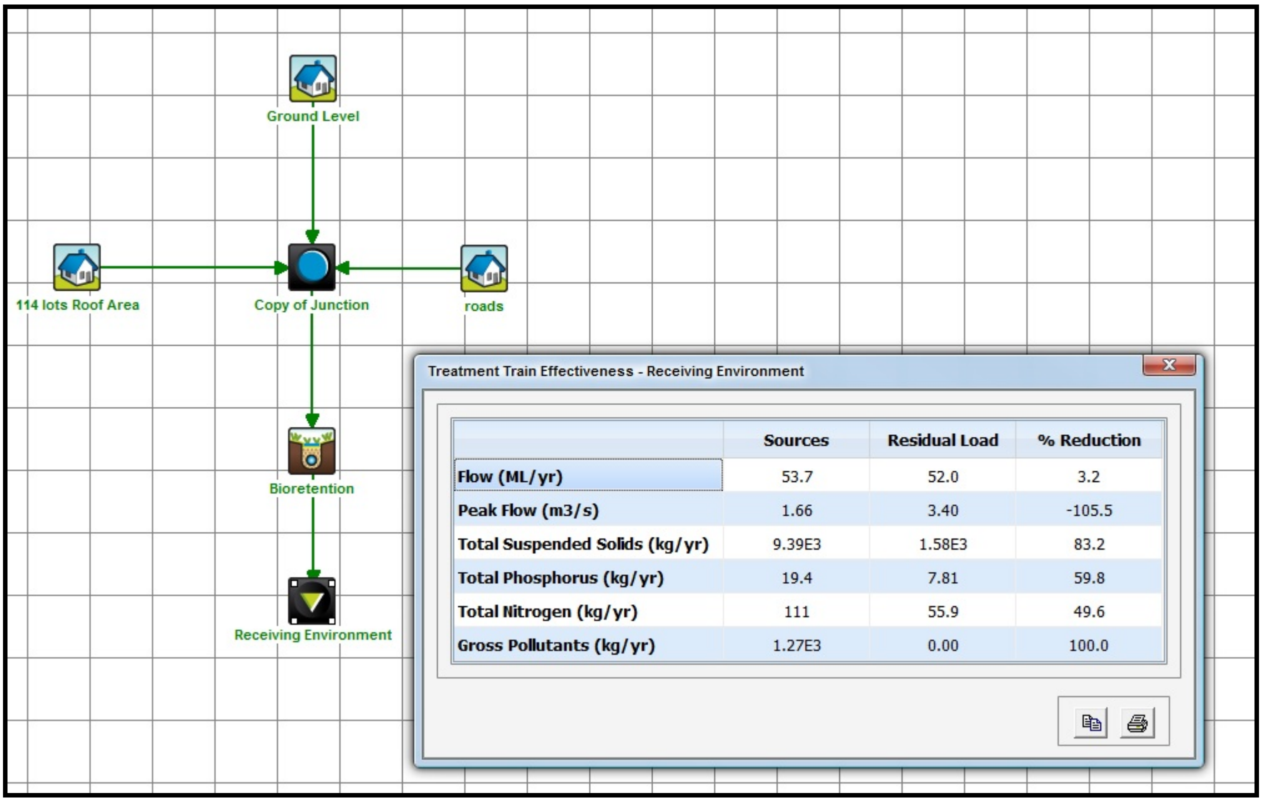
	Sources	Residual Load	% Reduction
Flow (ML/yr)	45.4	44.0	3.1
Peak Flow (m3/s)	1.40	2.92	-109.4
Total Suspended Solids (kg/yr)	7.85E3	1.22E3	84.4
Total Phosphorus (kg/yr)	16.2	6.39	60.6
Total Nitrogen (kg/yr)	94.5	46.9	50.3
Gross Pollutants (kg/yr)	1.07E3	0.00	100.0

Catchment 21



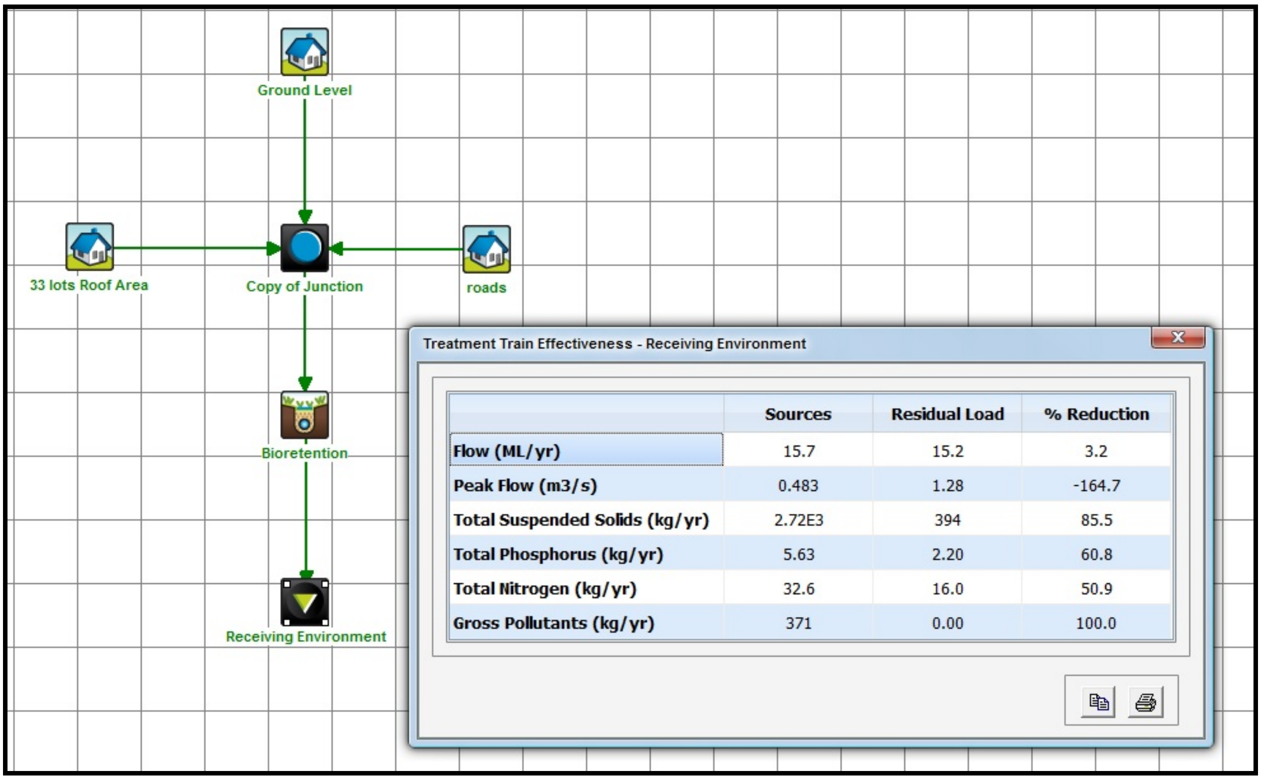
	Sources	Residual Load	% Reduction
Flow (ML/yr)	17.0	16.5	3.3
Peak Flow (m3/s)	0.525	1.41	-169.5
Total Suspended Solids (kg/yr)	3.00E3	481	84.0
Total Phosphorus (kg/yr)	6.14	2.44	60.2
Total Nitrogen (kg/yr)	35.3	17.7	49.9
Gross Pollutants (kg/yr)	403	0.00	100.0

Catchment 22



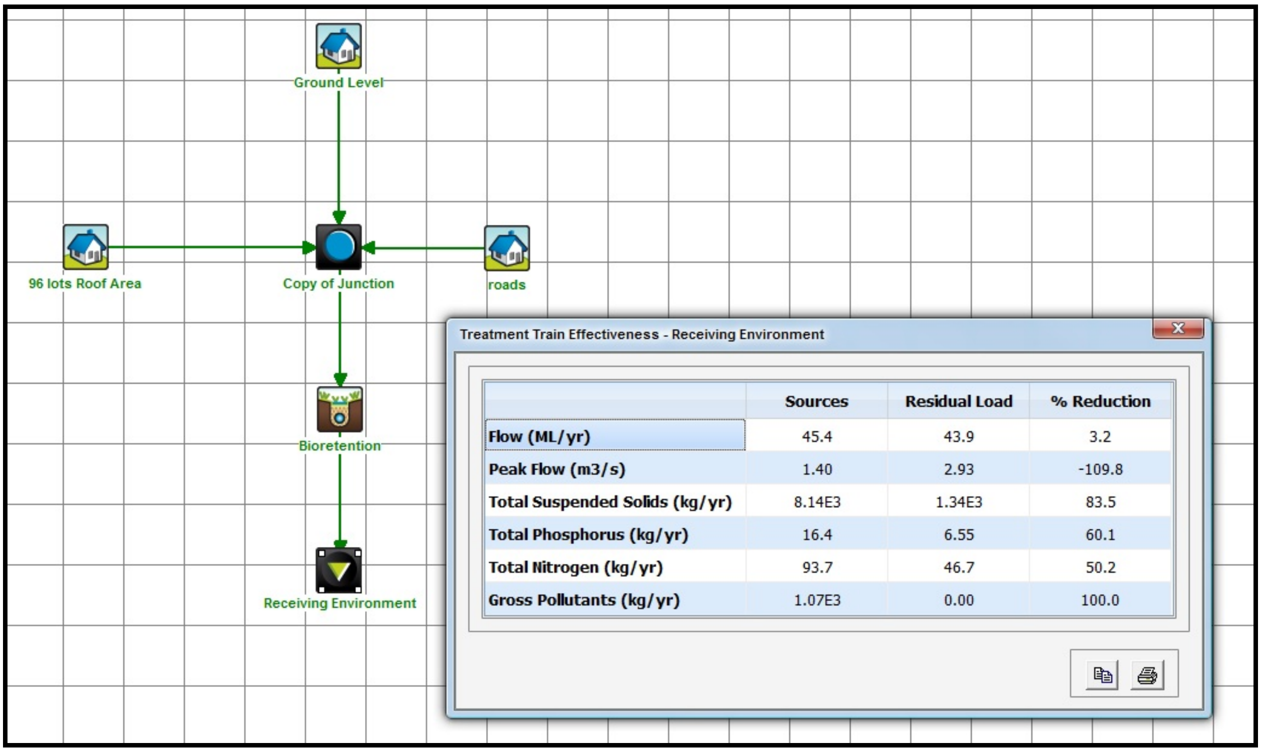
	Sources	Residual Load	% Reduction
Flow (ML/yr)	53.7	52.0	3.2
Peak Flow (m3/s)	1.66	3.40	-105.5
Total Suspended Solids (kg/yr)	9.39E3	1.58E3	83.2
Total Phosphorus (kg/yr)	19.4	7.81	59.8
Total Nitrogen (kg/yr)	111	55.9	49.6
Gross Pollutants (kg/yr)	1.27E3	0.00	100.0

Catchment 23



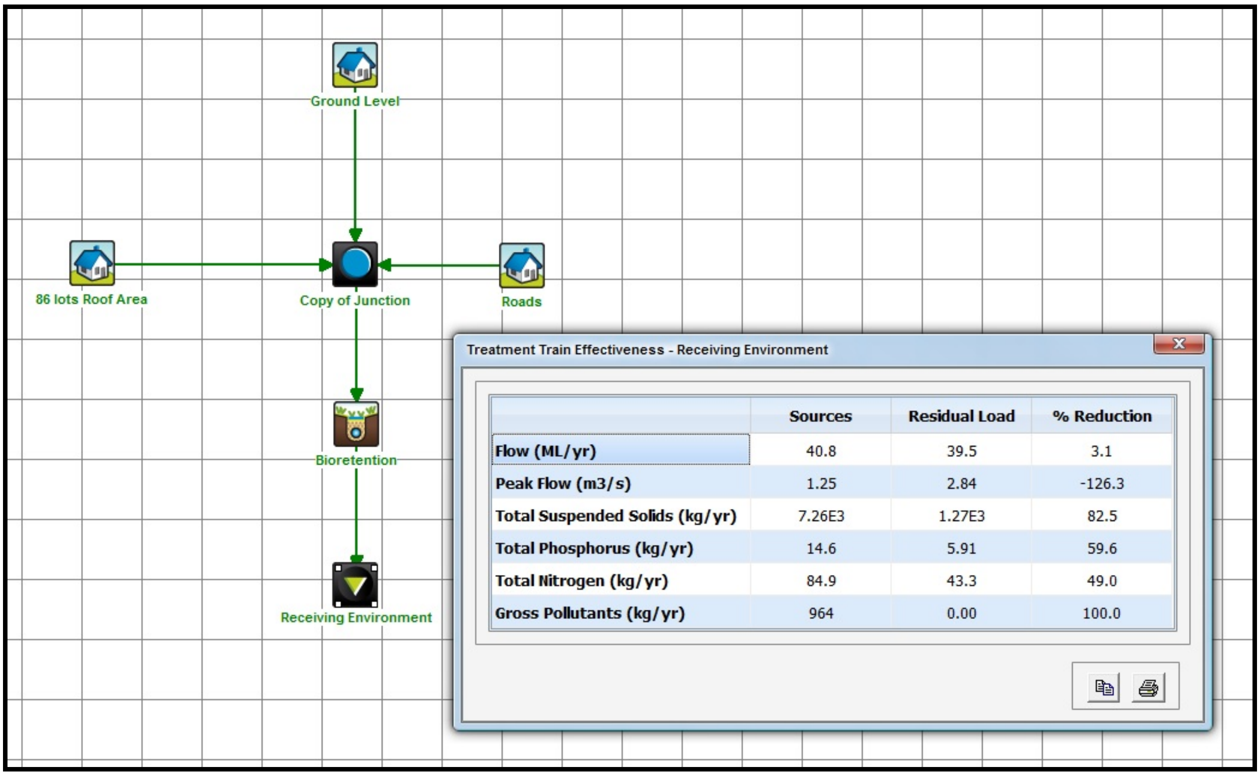
	Sources	Residual Load	% Reduction
Flow (ML/yr)	15.7	15.2	3.2
Peak Flow (m3/s)	0.483	1.28	-164.7
Total Suspended Solids (kg/yr)	2.72E3	394	85.5
Total Phosphorus (kg/yr)	5.63	2.20	60.8
Total Nitrogen (kg/yr)	32.6	16.0	50.9
Gross Pollutants (kg/yr)	371	0.00	100.0

Catchment 24



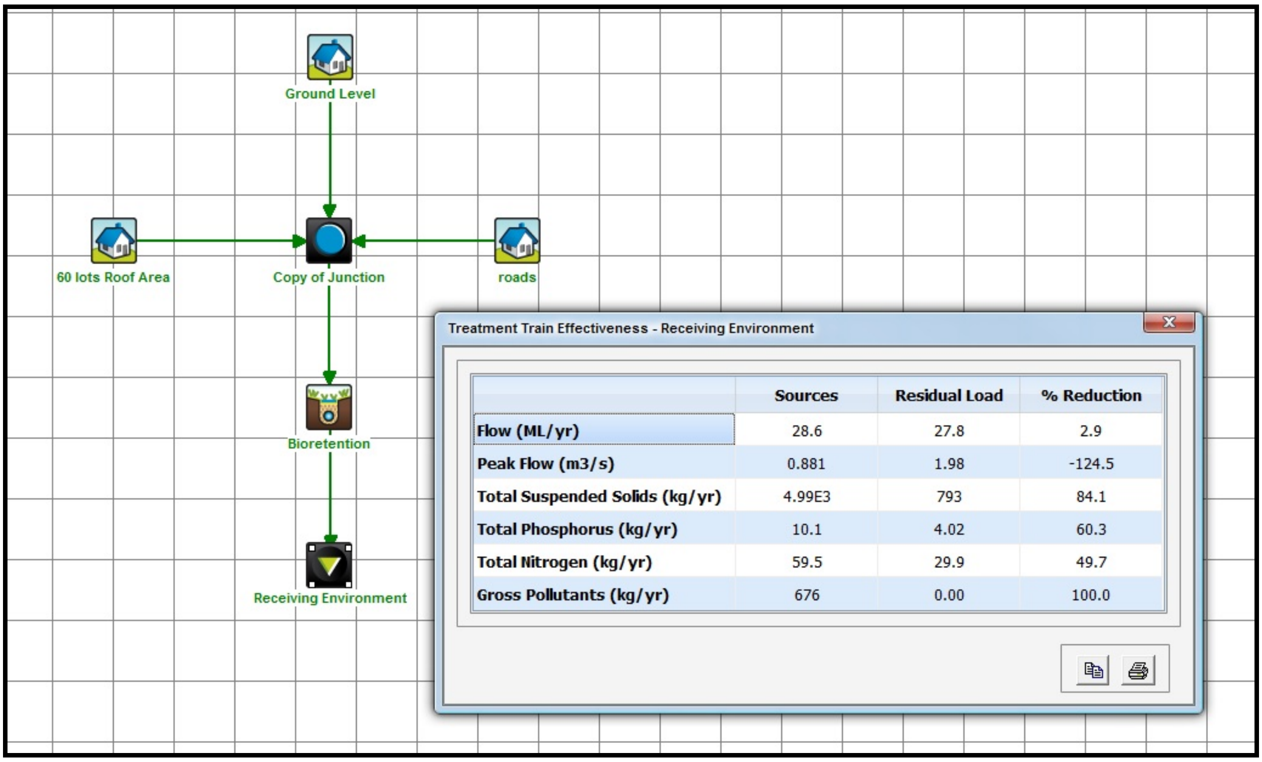
	Sources	Residual Load	% Reduction
Flow (ML/yr)	45.4	43.9	3.2
Peak Flow (m3/s)	1.40	2.93	-109.8
Total Suspended Solids (kg/yr)	8.14E3	1.34E3	83.5
Total Phosphorus (kg/yr)	16.4	6.55	60.1
Total Nitrogen (kg/yr)	93.7	46.7	50.2
Gross Pollutants (kg/yr)	1.07E3	0.00	100.0

Catchment 25



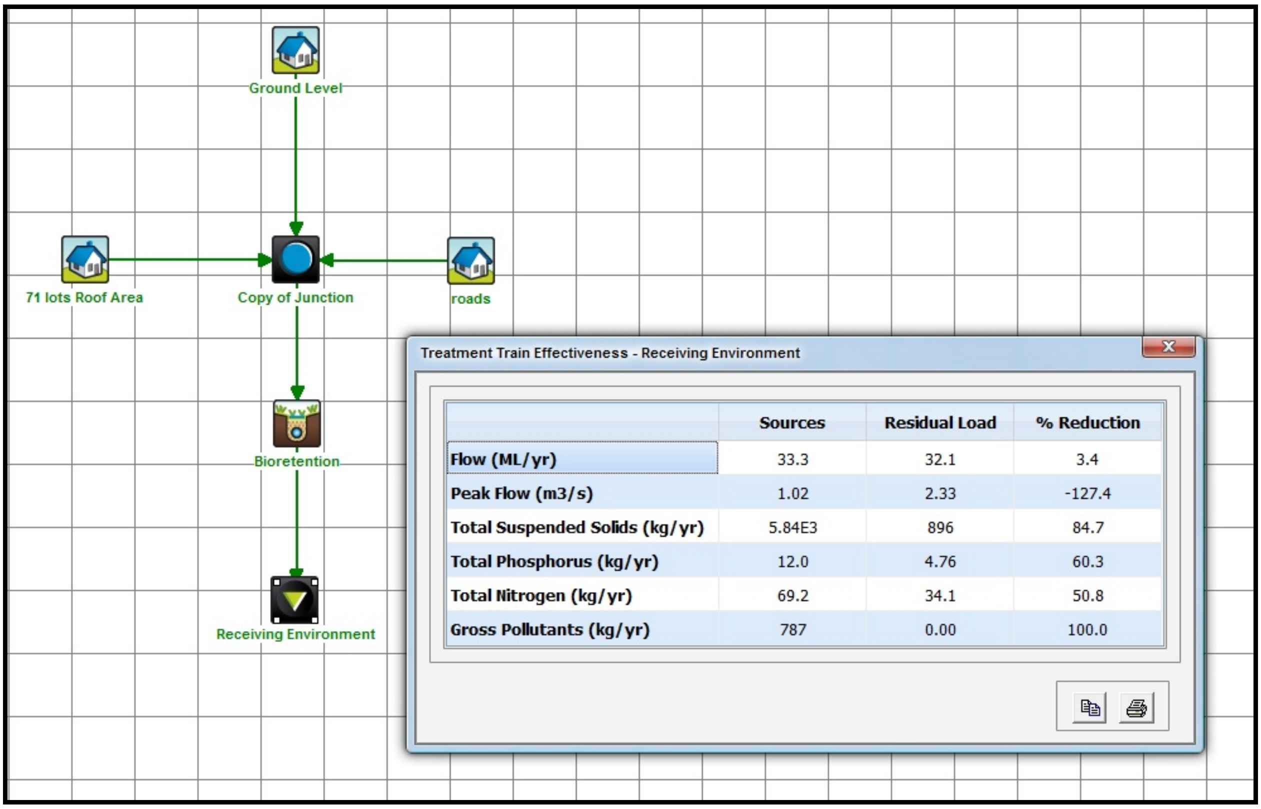
	Sources	Residual Load	% Reduction
Flow (ML/yr)	40.8	39.5	3.1
Peak Flow (m3/s)	1.25	2.84	-126.3
Total Suspended Solids (kg/yr)	7.26E3	1.27E3	82.5
Total Phosphorus (kg/yr)	14.6	5.91	59.6
Total Nitrogen (kg/yr)	84.9	43.3	49.0
Gross Pollutants (kg/yr)	964	0.00	100.0

Catchment 26



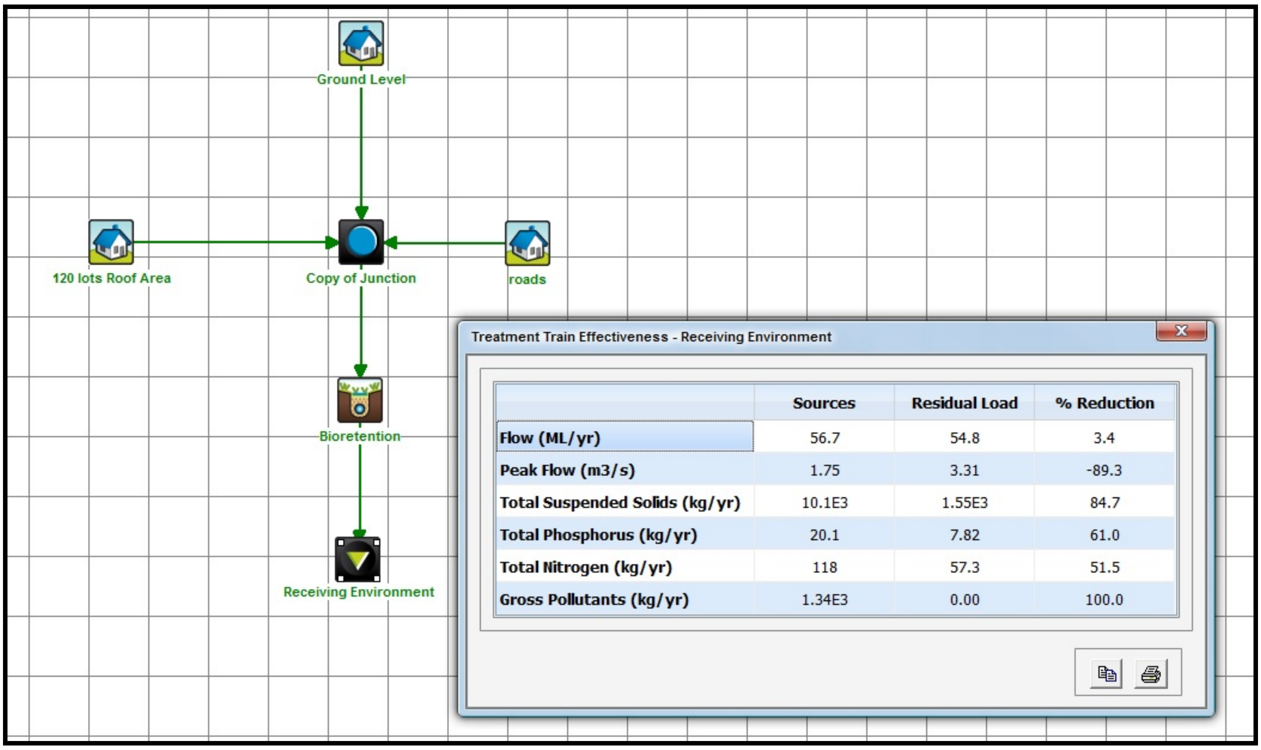
	Sources	Residual Load	% Reduction
Flow (ML/yr)	28.6	27.8	2.9
Peak Flow (m3/s)	0.881	1.98	-124.5
Total Suspended Solids (kg/yr)	4.99E3	793	84.1
Total Phosphorus (kg/yr)	10.1	4.02	60.3
Total Nitrogen (kg/yr)	59.5	29.9	49.7
Gross Pollutants (kg/yr)	676	0.00	100.0

Catchment 27



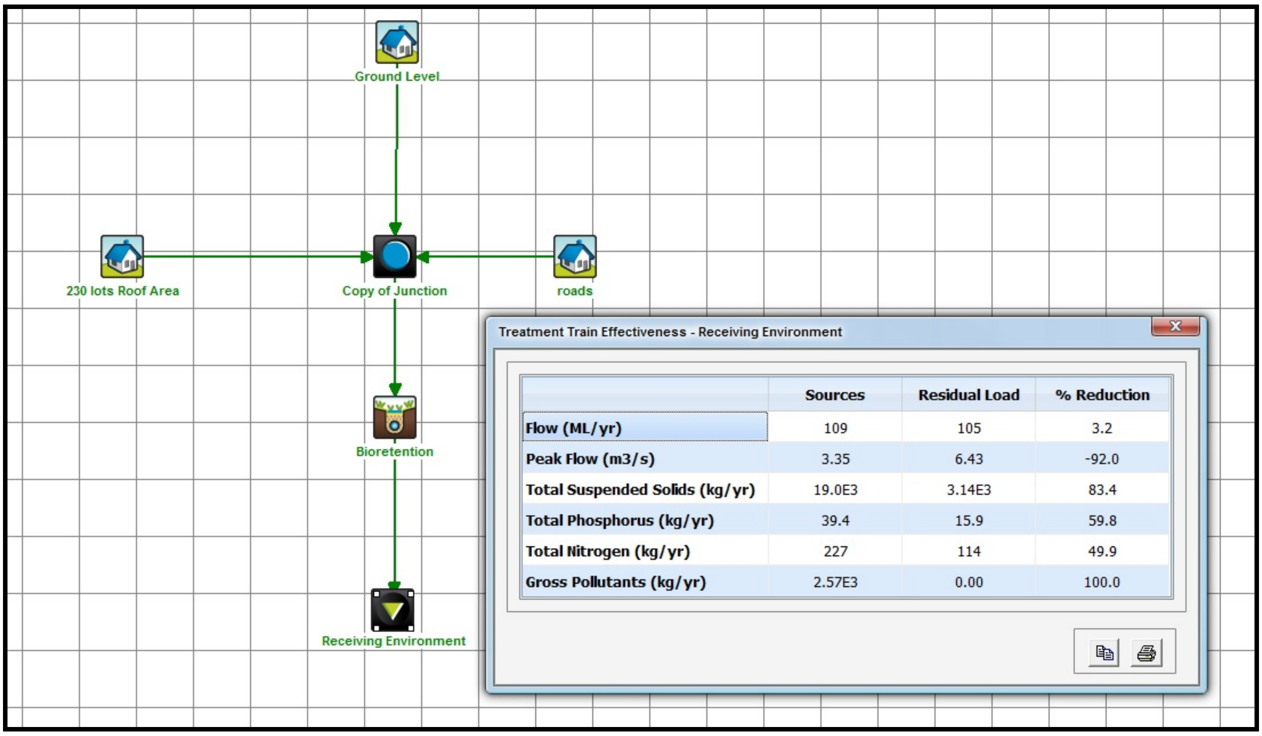
	Sources	Residual Load	% Reduction
Flow (ML/yr)	33.3	32.1	3.4
Peak Flow (m3/s)	1.02	2.33	-127.4
Total Suspended Solids (kg/yr)	5.84E3	896	84.7
Total Phosphorus (kg/yr)	12.0	4.76	60.3
Total Nitrogen (kg/yr)	69.2	34.1	50.8
Gross Pollutants (kg/yr)	787	0.00	100.0

Catchment 29



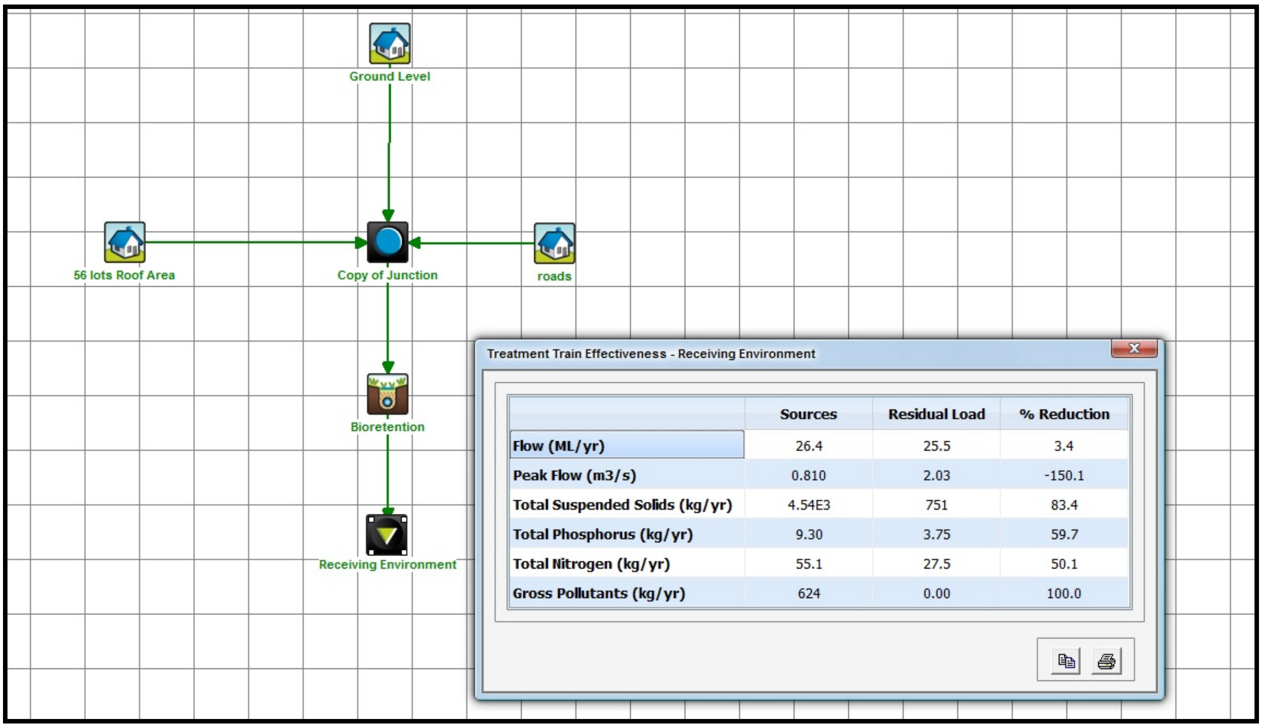
	Sources	Residual Load	% Reduction
Flow (ML/yr)	56.7	54.8	3.4
Peak Flow (m3/s)	1.75	3.31	-89.3
Total Suspended Solids (kg/yr)	10.1E3	1.55E3	84.7
Total Phosphorus (kg/yr)	20.1	7.82	61.0
Total Nitrogen (kg/yr)	118	57.3	51.5
Gross Pollutants (kg/yr)	1.34E3	0.00	100.0

Catchment 30



	Sources	Residual Load	% Reduction
Flow (ML/yr)	109	105	3.2
Peak Flow (m3/s)	3.35	6.43	-92.0
Total Suspended Solids (kg/yr)	19.0E3	3.14E3	83.4
Total Phosphorus (kg/yr)	39.4	15.9	59.8
Total Nitrogen (kg/yr)	227	114	49.9
Gross Pollutants (kg/yr)	2.57E3	0.00	100.0

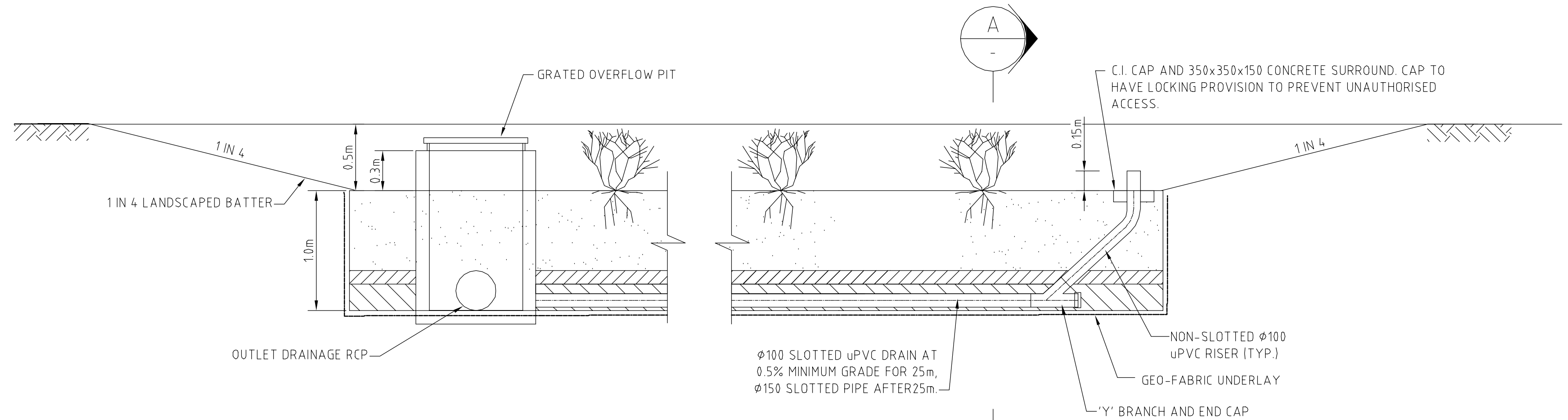
Catchment 31



Treatment Train Effectiveness - Receiving Environment

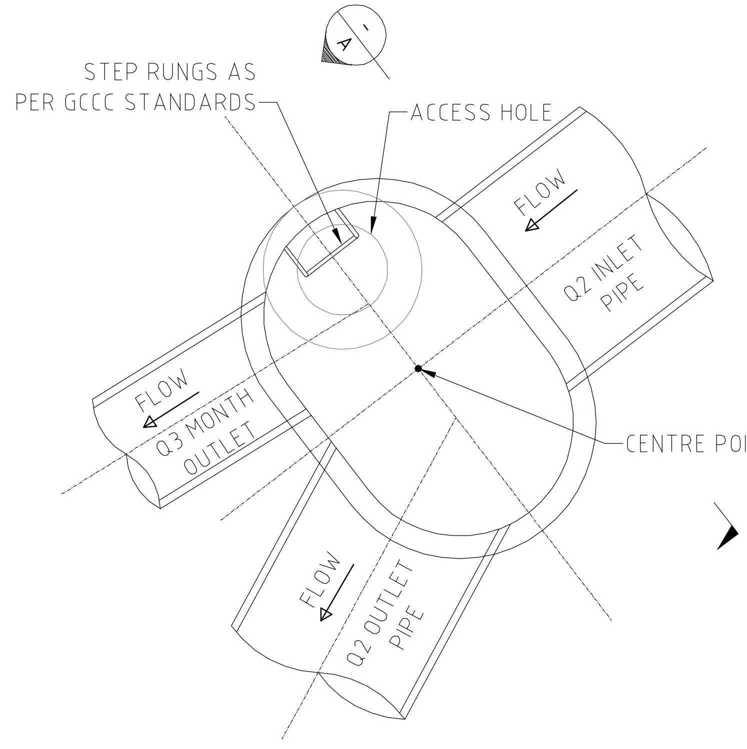
	Sources	Residual Load	% Reduction
Flow (ML/yr)	26.4	25.5	3.4
Peak Flow (m3/s)	0.810	2.03	-150.1
Total Suspended Solids (kg/yr)	4.54E3	751	83.4
Total Phosphorus (kg/yr)	9.30	3.75	59.7
Total Nitrogen (kg/yr)	55.1	27.5	50.1
Gross Pollutants (kg/yr)	624	0.00	100.0

APPENDIX C - Stormwater Design Drawings



LONGITUDINAL SECTION

TYPICAL BIO-RETENTION BASIN



SPLITTER MANHOLE

1500mmØ MANHOLE EXPANDED

900mm

1:40 @ A4

BIO-RETENTION BASIN STAGED CONSTRUCTION

BIORETENTION BASIN WILL BE CONSTRUCTED IN ACCORDANCE WITH OPTION 4 OF THE HEALTHY WATERWAYS CONSTRUCTION AND ESTABLISHMENT GUIDELINES

STAGE 1 - CIVIL CONSTRUCTION
STAGE 1 INVOLVES THE CIVIL WORKS TO CREATE THE FORM OF THE BIORETENTION SYSTEM AND INSTALL STRUCTURES FOLLOWING WHICH THE SYSTEM IS ALLOWED TO OPERATE AS A SEDIMENT BASIN.

STAGE 2 - BUILDING PHASE PROTECTION
THE BIORETENTION SYSTEM IS ALLOWED TO OPERATE AS THE SEDIMENT BASIN DURING THE BUILDING PHASE

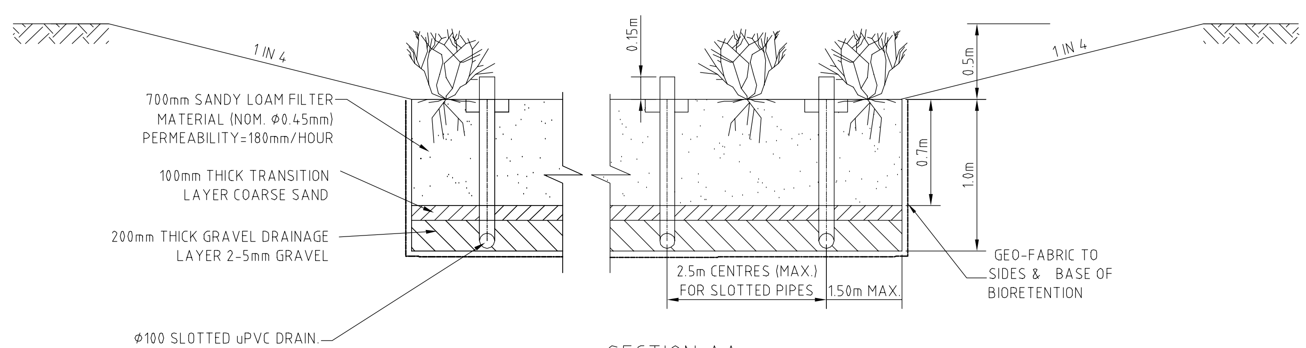
STAGE 3 - CIVIL CONSTRUCTION AND LANDSCAPE ESTABLISHMENT
ONCE THE BUILDING PHASE IS COMPLETE, THE BIORETENTION SYSTEM IS CLEANED OUT OF ACCUMULATED SEDIMENT.

A) THE BIORETENTION BASIN IS TO BE CONSTRUCTED IN ACCORDANCE WITH HEALTHY WATERWAYS "CONSTRUCTION AND ESTABLISHMENT GUIDELINES" SIGN OFF FORMS (INCLUDING THE PRE-START MEETING FORM AND FORMS A-G). COPIES OF THESE FORMS ARE LOCATED IN APPENDIX D OF THE SITE BASED STORMWATER QUALITY MANAGEMENT PLAN.

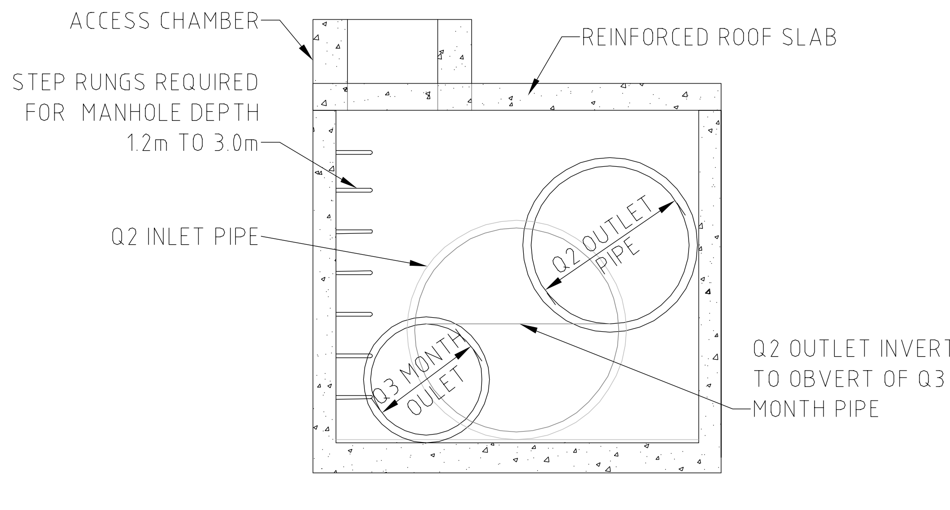
B) SLOTTED 100MM DIA. UPVC PIPES WITHIN THE DRAINAGE LAYER OF THE BIORETENTION BASIN MUST NOT BE SUBSTITUTED WITH AGGI PIPES NOR WRAPPED IN GEOFABRIC.

C) THE SOIL SPECIFICATIONS FOR FILTER MEDIA FOR THE BIORETENTION BASIN MUST BE IN ACCORDANCE WITH FAWB GUIDELINES VERSION 1 JUNE 2009.

D) LANDSCAPING OF THE BIORETENTION BASIN IS TO BE IN ACCORDANCE WITH APPENDIX A OF THE WATER SENSITIVE URBAN DESIGN TECHNICAL GUIDELINES (WSUD TDG).



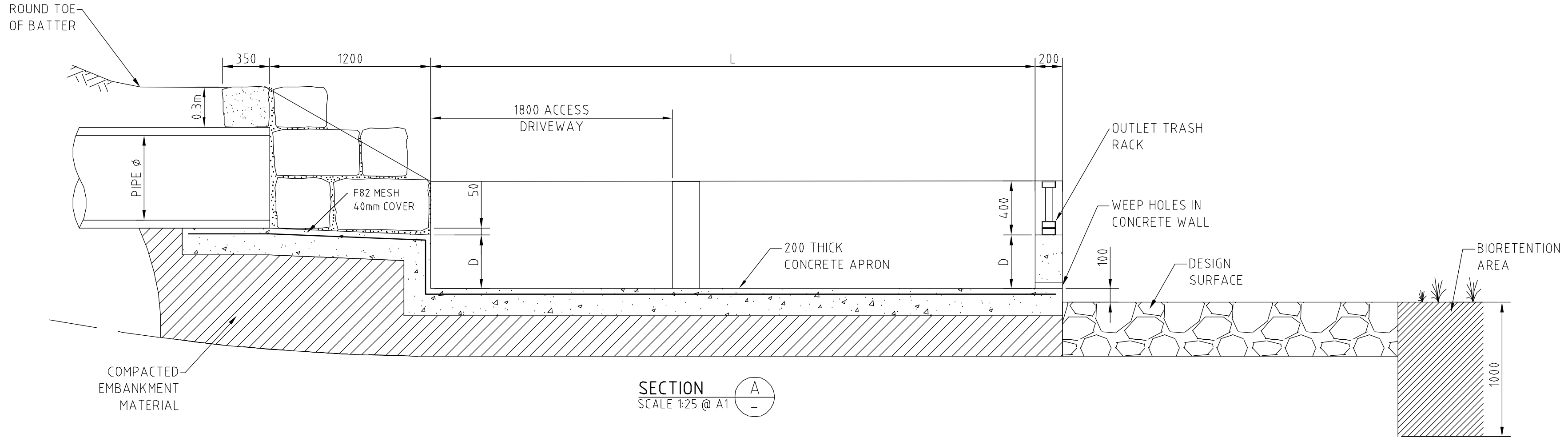
SECTION AA



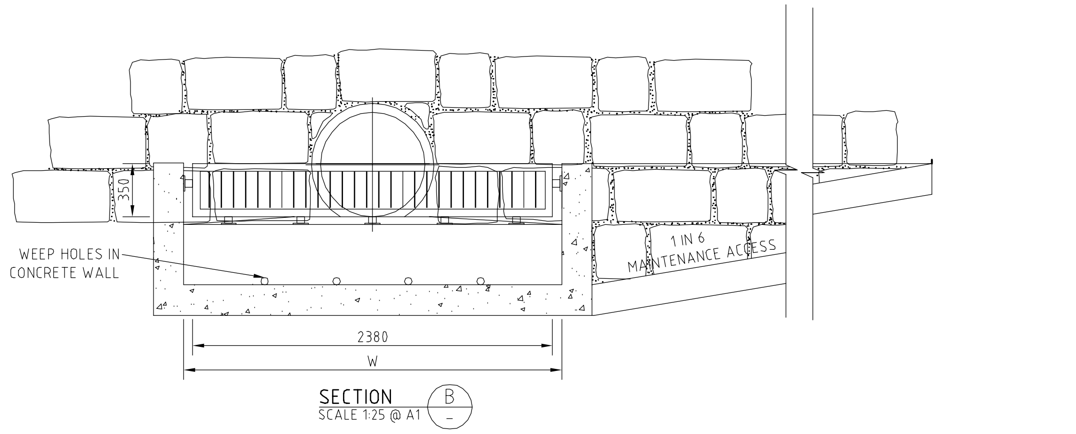
SECTION A -
SCALE 1:40 @ A1

ASSOCIATED CONSULTANTS	-
REVISIONS	P1 ORIGINAL ISSUE KPH (DATE / REV / DESCRIPTION / APPROVED)
CLIENT	AMEX
PROJECT	AMEX RIPLEY VALLEY WEST
LOCATION	RIPLEY VALLEY
SHEET TITLE	BIO RETENTION BASIN DETAILS - SHEET 2 OF 2
DESIGNED	CH
DRAWN	JW
CHECKED / DATE	
DATE	APRIL 2012
APPROVED	KEITH HOWELLS RPEQ 7295; ALAN SVILICIC RPEQ 8369
SCALE	0 0.25 0.5 0.75 1.0 1.25m; 1 : 25 (A1 SIZE) U.N.O.
JOB CODE	AMXSRV
SHEET NUMBER	SK05
REV	P

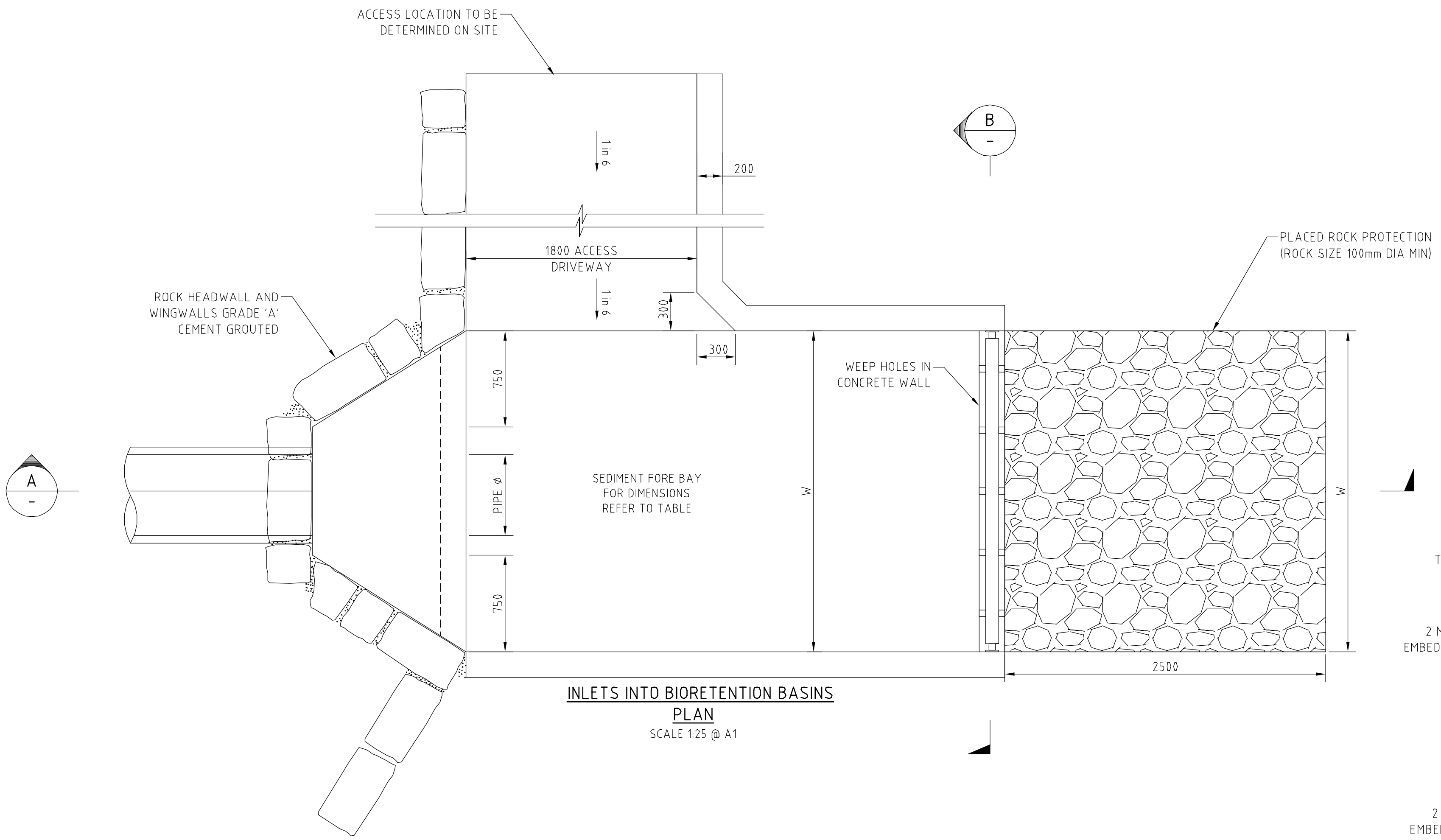
AUSTRALIA
BRISBANE
555 CORONATION DRIVE TOOWONG QLD 4066
PH: (07) 3371 7000 FAX: (07) 3371 5679
EMAIL - mail@etsgroup.net.au
SUNSHINE COAST
20 INNOVATION PARKWAY BIRTINYA QLD 4575
PH: (07) 5438 8100 FAX: (07) 5438 8200
EMAIL - mail.sc@etsgroup.net.au
PAPUA NEW GUINEA
PORT MORESBY
5TH FLOOR CUTHBERTSON HOUSE PO BOX 908
TELEPHONE (675) 321 1333 FACSIMILE (675) 321 7653
EMAIL - etspng@datec.net.pg
ETS GROUP
ARCHITECTS · CIVIL & STRUCTURAL ENGINEERS
www.etsgroup.net.au



SECTION A
SCALE 1:25 @ A1



SECTION B
SCALE 1:25 @ A1



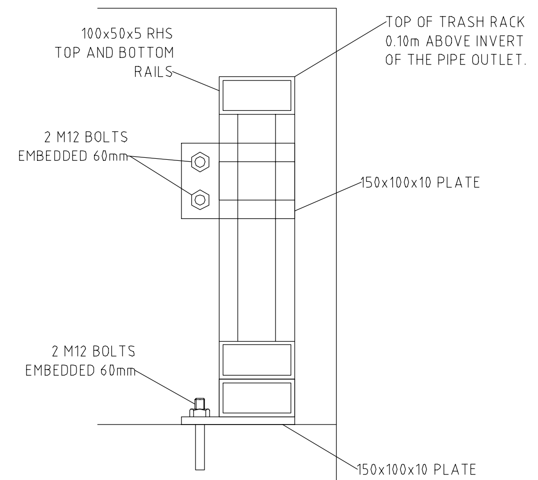
INLETS INTO BIORETENTION BASINS
PLAN
SCALE 1:25 @ A1

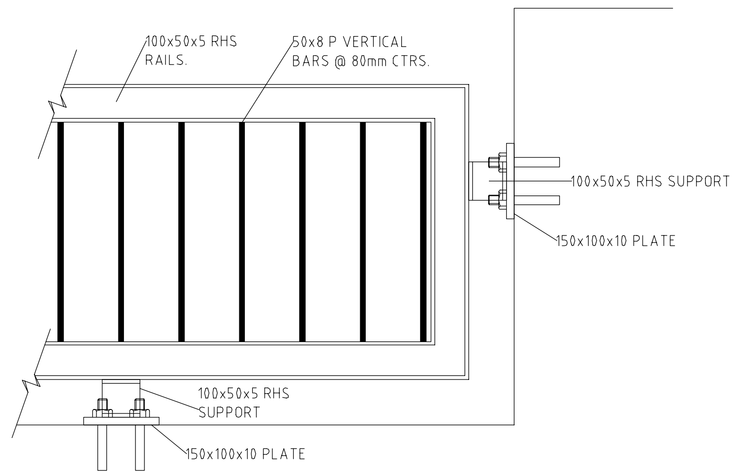
ROCK PROTECTION NOTES:

1. NOMINAL ROCK SIZE TO BE 300 DIAMETER.
2. SELECTED ROCKS TO BE DURABLE AND RESISTANT TO WEATHERING, AND SHOULD BE PROPORTIONED SO THAT NEITHER THE BREADTH NOR THE THICKNESS OF A SINGLE ROCK IS LESS THAN ONE-THIRD ITS LENGTH
3. ROCK SIZE INDICATED IS NOMINAL AND ASSUMES 50% OF THE ROCK IS SMALLER.
4. MAXIMUM ROCK SIZE SHALL NOT EXCEED 1.5 TIMES THE NOMINAL ROCK SIZE
5. SELECTED ROCKS SHOULD BE EVENLY GRADED
6. ROCKS SHOULD BE PLACED IN STABLE POSITIONS WITH SEVERAL POINT CONTACTS, GENERALLY BALANCED REARWARD.
7. ROCKS SHOULD FORM AN INTERLOCKING MASS WHEN COMPLETED WITH NO INDIVIDUAL ROCK FREE TO MOVE.

OUTLET TRASH RACK NOTES:

1. ALL METAL WORK TO BE HOT DIPPED GALVANISED AFTER FABRICATION
2. ALL FASTENERS AND BOLTS ARE TO BE GALVANISED OR STAINLESS STEEL
3. ALL METALWORK TO BE GRADE 250 STRUCTURAL STEEL TO AS 4100





ASSOCIATED CONSULTANTS	-
REVISIONS	P1 ORIGINAL ISSUE KPH
CLIENT	AMEX
PROJECT	AMEX RIPLEY VALLEY WEST
LOCATION	RIPLEY VALLEY
SHEET TITLE	BIO RETENTION BASIN DETAILS - SHEET 1 OF 2
DESIGNED	CH
DRAWN	JW
CHECKED	
DATE	APRIL 2012
APPROVED	KEITH HOWELLS RPEQ 7295; ALAN SVILICIC RPEQ 8369
SCALE	0 0.25 0.5 0.75 1.0 1.25m — 1 : 25 (A1 SIZE) U.N.O.
JOB CODE	AMXSRV
SHEET NUMBER	SK04
REV	P

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APPENDIX D - Healthy Waterways Guidelines and Checklists

GUIDELINES FOR FILTER MEDIA IN BIOFILTRATION SYSTEMS (Version 3.01) June 2009

The following guidelines for filter media in biofiltration systems have been prepared on behalf of the Facility for Advancing Water Biofiltration (FAWB) to assist in the development of biofiltration systems, including the planning, design, construction and operation of those systems.

NOTE: This is a revision of the previous FAWB guideline specifications (published in 2006 (Version 1.01), 2008 (Version 2.01)). It attempts to provide a simpler and more robust guideline for both soil-based and engineered filter media. FAWB acknowledges the contribution of EDAW Inc., Melbourne Water Corporation, Dr Nicholas Somes (Ecodynamics), Alan Hoban (South East Queensland Healthy Waterways Partnership), Shaun Leinster (DesignFlow) and STORM Consulting to the preparation of the revised guidelines.

1 GENERAL DESCRIPTION

The biofiltration filter media guidelines require three layers of media: the filter media itself (400-600 mm deep or as specified in the engineering design), a transition layer (100 mm deep), and a drainage layer (50 mm minimum cover over underdrainage pipe). The biofiltration system will operate so that water will infiltrate into the filter media and move vertically down through the profile.

The filter media is required to support a range of vegetation types (from groundcovers to trees) that are adapted to freely draining soils with occasional wetting. The material should be based on **natural or amended natural soils** or it can be **entirely engineered**; in either case, it can be of siliceous or calcareous origin. In general, the media should have an appropriately high permeability under compaction and should be free of rubbish, deleterious material, toxicants, declared plants and local weeds (as listed in local guidelines/Acts), and should not be hydrophobic. The filter media should contain some organic matter for increased water holding capacity but be low in nutrient content. In the case of natural or amended natural soils, the media should be a **loamy sand**.

Maintaining an adequate infiltration capacity is crucial in ensuring the long-term treatment efficiency of the system. The ability of a biofiltration system to detain and infiltrate incoming stormwater is a function of the filter surface area, extended detention (ponding) depth, and the hydraulic conductivity of the filter media (Figure 1). Most importantly, design of a biofiltration system should optimize the combination of these three design elements.

For a biofiltration system in a temperate climate with an extended detention depth of 100 – 300 mm and whose surface area is approximately 2% of the connected impervious area of the contributing catchment, the prescribed hydraulic conductivity will generally be between 100 – 300 mm/hr in order to meet best practice targets (Figure 2). This configuration supports plant growth without requiring too much land space. In warm, humid (sub- and dry- tropical) regions the hydraulic conductivity may need to be higher in order to achieve the required treatment performance using the same land space (i.e., ensuring that the proportion of water treated through the media meets requirements).

Where one of these design elements falls outside the recommended range, the infiltration capacity can still be maintained by offsetting another of the design elements. For example, a filter media with a lower hydraulic conductivity may be used, but the surface area or the extended detention depth would need to be increased in order to maintain the treatment capacity. Similarly, if the available land were the limiting design element, the system could still treat the same size storm if a filter media with a higher hydraulic conductivity were installed. Where a hydraulic conductivity greater than 300 mm/hr is prescribed, potential issues such as higher watering requirements during the establishment should be considered. Biofiltration systems with a hydraulic conductivity greater than 600 mm/hr are unlikely to support plant growth due to poor water retention, and may also result in leaching of pollutants. However plant survival might be possible if the outlet pipe were raised to create a permanently submerged zone.

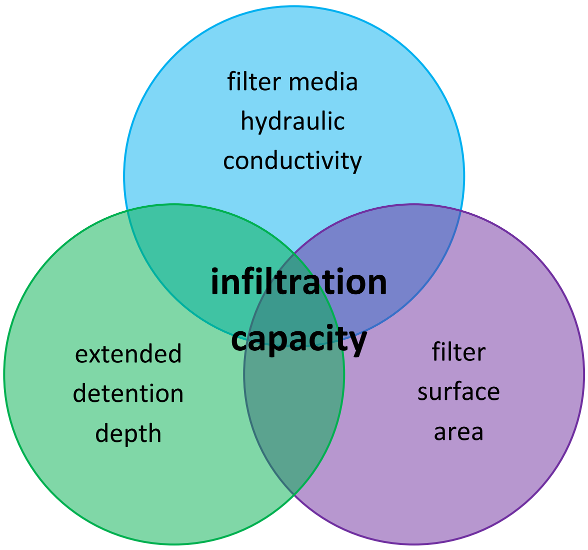

Figure 1. Design elements that influence infiltration capacity.

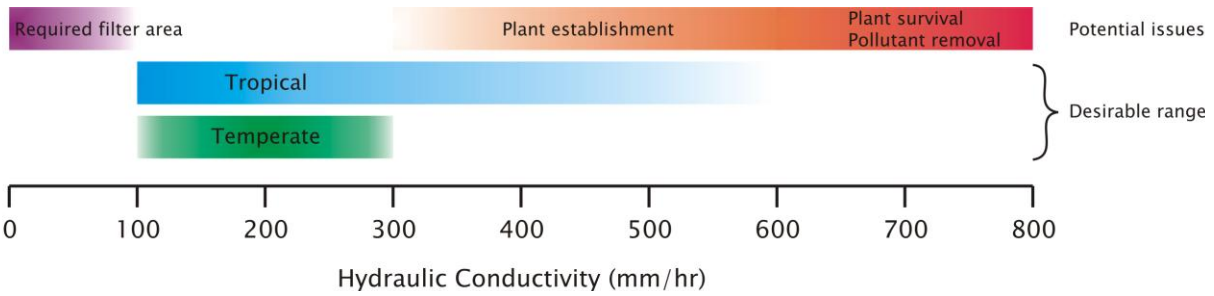

Figure 2. Recommended filter media hydraulic conductivity range and potential issues

The infiltration capacity of the biofiltration system will initially decline during the establishment phase as the filter media settles and compacts, but this will level out and then start to increase as the plant community establishes itself and the rooting depth increases (see Appendix A). In order to ensure that the system functions adequately at its eventual (minimum) hydraulic conductivity, a safety co-efficient of 2 should be used: i.e., **designs should be modelled using half the prescribed hydraulic conductivity**. If a system does not perform adequately with this hydraulic conductivity, then the area and/or ponding depth should be increased. It may also be desirable to report sensitivity to infiltration rate, rather than simply having expected rate. This is important when assessing compliance of constructed systems as systems should ideally meet best practice across a range of infiltration rates.

2 TESTING REQUIREMENTS

2.1 Determination of Hydraulic Conductivity

The hydraulic conductivity of potential filter media should be measured using the ASTM F1815-06 method. This test method uses a compaction method that best represents field conditions and so provides a more realistic assessment of hydraulic conductivity than other test methods.

Note: if a hydraulic conductivity lower than 100 mm/hr is prescribed, the level of compaction associated with this test method may be too severe and so underestimate the actual hydraulic conductivity of the filter media under field conditions. However, FAWB considers this to be an appropriately conservative test, and recommends its use even for low conductivity media.

2.2 Particle Size Distribution

Particle size distribution (PSD) is of secondary importance compared with hydraulic conductivity. A material whose PSD falls within the following recommended range does not preclude the need for hydraulic conductivity testing i.e., it does not guarantee that the material will have a suitable hydraulic conductivity. However, the following composition range (percentage w/w) provides a useful guide for selecting an appropriate material:

Clay & Silt	<3%	(<0.05 mm)
Very Fine Sand	5-30%	(0.05-0.15 mm)
Fine Sand	10-30%	(0.15-0.25 mm)
Medium to Coarse Sand	40-60%	(0.25-1.0 mm)
Coarse Sand	7-10%	(1.0-2.0 mm)
Fine Gravel	<3%	(2.0-3.4 mm)

Clay and silt are important for water retention and sorption of dissolved pollutants, however they substantially reduce the hydraulic conductivity of the filter media. This size fraction also influences the structural stability of the material (through migration of particles to block small pores and/or slump). It is essential that the total clay and silt mix is **less than 3% (w/w)** to reduce the likelihood of structural collapse of such soils.

The filter media should be well-graded i.e., it should have all particle size ranges present from the 0.075 mm to the 4.75 mm sieve (as defined by AS1289.3.6.1 - 1995). There should be no gap in the particle size grading, and the composition should not be dominated by a small particle size range. This is important for preventing structural collapse due to particle migration.

2.3 Soil-Based Filter Media: Properties

The following specifications are based on results of extensive treatment performance testing conducted by FAWB as well as recommendations made by AS4419 – 2003 (Soils for Landscaping and Garden Use). Filter media must be tested for the following; media that do not meet these specifications should be rejected or amended:

i. Total Nitrogen (TN) Content – <1000 mg/kg.

ii. Orthophosphate (PO_4^{3-}) Content – <80 mg/kg. Soils with total phosphorus concentrations >100 mg/kg should be tested for potential leaching. Where plants with moderate phosphorus sensitivity are to be used, total phosphorus concentrations should be <20 mg/kg.

iii. Organic Matter Content – at least 3% (w/w). An organic content lower than 3% is likely to have too low a water holding capacity to support healthy plant growth. In order to comply with both this and the TN and PO_4^{3-} content requirements, a low nutrient organic matter will be required.

iv. pH – as specified for 'natural soils and soil blends' 5.5 – 7.5 (pH 1:5 in water).

v. Electrical Conductivity (EC) – as specified for 'natural soils and soil blends' <1.2 dS/m.

Optional testing:

vi. Dispersibility – this should be carried out where it is suspected that the soil may be susceptible to structural collapse. If in doubt, then this testing should be undertaken.

Potential filter media should generally be assessed by a horticulturalist to ensure that they are capable of supporting a healthy vegetation community. This assessment should take into consideration delivery of nutrients to the system by stormwater. Any component or soil found to contain high levels of salt (as determined by EC measurements), high levels of clay or silt particles (exceeding the particle size limits set above), or any other extremes which may be considered retardant to plant growth should be rejected.

3 ENGINEERED FILTER MEDIA

Where there is not a locally available soil-based material that complies with the properties outlined in Sections 2.1 - 2.3, it is possible to construct an appropriate filter medium. A washed, well-graded sand with an appropriate hydraulic conductivity should be used as the filter medium. Suitable materials include those used for the construction of turf profiles (e.g. golf greens); these materials are processed by washing to remove clay and silt fractions. In large quantities (>20 m^3), they can be obtained directly from sand suppliers, while smaller quantities can be purchased from local garden yards. The **top 100 mm of the filter medium** should then be ameliorated with appropriate organic matter, fertiliser and trace elements (Table 1). This amelioration is required to aid plant establishment and is designed to last four weeks; the rationale being that, beyond this point, the plants receive adequate nutrients via incoming stormwater.

Table 1. Recipe for ameliorating the top 100 mm of sand filter media

Constituent	Quantity (kg/100 m^2 filter area)
Granulated poultry manure fines	50
Superphosphate	2
Magnesium sulphate	3
Potassium sulphate	2
Trace Element Mix	1
Fertilizer NPK (16.4.14)	4
Lime	20

Laboratory testing has shown that biofilters that contain an engineered filter medium will achieve essentially the same hydraulic and treatment performance as those containing a soil-based filter medium (Bratieres *et al.*, 2009). However, it is recommended that a submerged zone be included in biofiltration systems that utilise such a free draining filter medium to provide a water source for vegetation between rainfall events.

4 TRANSITION LAYER

The transition layer prevents filter media from washing into the drainage layer. Transition layer material shall be a clean, well-graded sand material containing <2% fines. To avoid migration of the filter media into the transition layer, the particle size distribution of the sand should be assessed to ensure it meets 'bridging criteria', that is, the smallest 15% of the sand particles bridge with the largest 15% of the filter media particles (Water by Design, 2009; VicRoads, 2004):

D_{15} (transition layer) ≤ 5 x D_{85} (filter media)

where: D_{15} (transition layer) is the 15^{th} percentile particle size in the transition layer material (i.e., 15% of the sand is smaller than D_{15} mm), and
D_{85} (filter media) is the 85^{th} percentile particle size in the filter media.

A dual-transition layer, where a fine sand overlays a medium-coarse sand, is also possible. While it is acknowledged that this can increase the complexity of the construction process, testing indicates that a dual-transition layer produces consistently lower levels of turbidity and concentrations of suspended solids in treated outflows than a single transition layer. Therefore, it is recommended that this design be specified for stormwater harvesting applications (to enable effective post-treatment disinfection) and where minimising the risk of washout during the establishment period is of particular importance.

The transition layer can be omitted from a biofiltration system provided the filter media and drainage layer meet the following criteria as defined by the Victorian Roads *Drainage of Subsurface Water from Roads - Technical Bulletin No 32* (VicRoads, 2004):

D_{15} (drainage layer) ≤ 5 x D_{85} (filter media)

D_{15} (drainage layer) = 5 to 20 x D_{15} (filter media)

D_{50} (drainage layer < 25 x D_{50} (filter media)

D_{60} (drainage layer) < 20 x D_{10} (drainage layer)

These comparisons are best made by plotting the particle size distributions for the filter media and gravel on the same soil grading graphs and extracting the relevant diameters (Water by Design, 2009).

5 DRAINAGE LAYER

The drainage layer collects treated water at the bottom of the system and converys it to the underdrain pipes. Drainage layer material is to be clean, fine gravel, such as a 2 – 5 mm washed screenings. Bridging criteria should be applied to avoid migration of the transition layer into the drainage layer (Water by Design, 2009; VicRoads, 2004):

D_{15} (drainage layer) ≤ 5 x D_{85} (transition layer)

where: D_{15} (drainage layer) is the 15th percentile particle size in the drainage layer material (i.e., 15% of the gravel is smaller than D_{15} mm), and
D_{85} (transition layer) is the 85th percentile particle size in the transition layer material.

Note: The perforations in the underdrain pipes should be small enough that the drainage layer cannot fall into the pipes. A useful guide is to check to that the D_{85} (drainage layer) is greater than the pipe perforation diameter.

Geotextile fabrics are **not recommended** for use in biofiltration systems due to the risk of clogging. An open-weave shade cloth can be placed between the transition layer and the drainage layer to help reduce the downward migration of smaller particles if required, however this should only be adopted where there is insufficient depth for transition and drainage layers.

6 INSTALLATION

It is recommended that filter media be lightly compacted during installation to prevent migration of fine particles. In small systems, a single pass with a vibrating plate should be used to compact the filter media, while in large systems, a single pass with roller machinery (e.g. a drum lawn roller) should be performed. Under no circumstance should heavy compaction or multiple-passes be made. Filter media should be installed in two lifts unless the depth is less than 500 mm.

7 FIELD TESTING

It is recommended that field testing of hydraulic conductivity be carried out at least twice: 1. one month following commencement of operation, and 2. in the second year of operation to assess the impact of vegetation on hydraulic conductivity.

The hydraulic conductivity of the filter media should be checked at a minimum of three points within the system. The single ring, constant head infiltration test method (shallow test), as described by Le Coustumer *et al.* (2007), should be used. Given the inherent variability in hydraulic conductivity testing and the heterogeneity of the filter media, the laboratory and field results are considered comparable if they are within 50% of each other. However, even if they differ by more than 50%, the system will still function if both the field and laboratory results are within the relevant recommended range of hydraulic conductivities.

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APPENDIX A

Figure A.1 illustrates the change in hydraulic conductivity during the establishment phase of a Melbourne biofiltration system containing a sandy loam filter media. The hydraulic conductivity initially declines as the filter media is compacted under hydraulic loading, but recovers back to the design value (as indicated by the dashed horizontal line) as plant growth and increased rooting depth counters the effects of compaction and clogging.

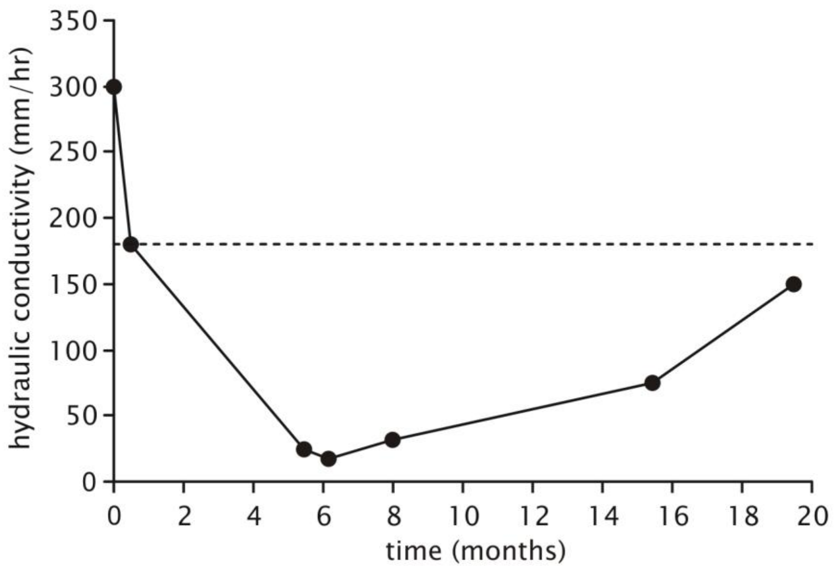

Figure A.1 Evolution of hydraulic conductivity during the first 20 months of a biofiltration system (after Hatt *et al.*, 2009)

Construction and Establishment Sign-off Forms: Bioretention Systems Version 1

The *Construction and Establishment Sign-Off Forms: Bioretention Systems* outline the key items to be reviewed when delivering and inspecting bioretention systems.

The Sign-Off Forms follow the construction methods provided in Sections 3.9 and 3.10 of the *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands* (Water by Design, 2009, accessible from www.waterbydesign.com.au).

The Sign-off Forms are to be used by contractors, construction site superintendents, designers and local authority compliance inspectors to ensure all the elements of the bioretention system have been constructed in accordance with the design. It is the responsibility of the site superintendent and contractor to ensure the most recent version of the forms are being used.

The Sign-Off Forms form the basis of the certification and compliance requirements for bioretention systems. They are designed for easy incorporation into asset databases managed by Councils or private organisations such as body corporates.

The following Construction and Establishment Sign-Off Forms are provided:

- Bioretention System Construction and Establishment
- Pre-Start Meeting Sign-Off Form
- FORM A — Earthworks and Functional Structures
- FORM B — Under-drainage
- FORM C — Bioretention Media
- FORM D — Finished Levels
- FORM E — Coarse Sediment Forebay
- FORM F — Protective Measures
- FORM G — Landscape Installation
- FORM H — Landscape Establishment

If an item receives an 'N' in the 'Satisfactory Criteria', indicating that an element is 'not satisfactory', appropriate actions must be specified to rectify the construction issue before final inspection sign-off is given.

Disclaimer

The material contained in this publication is produced for general information only. It is not intended as professional advice on specific applications. It is the responsibility of the user to determine the suitability and appropriateness of the material contained in this publication to specific applications. No person should act or fail to act on the basis of any material contained in this publication without first obtaining specific independent professional advice. The South East Queensland Healthy Waterways Partnership (SEQHWP) expressly disclaim all and any liability to any person in respect of anything done by any such person in reliance, whether in whole or in part, on this publication. The information contained in this publication does not necessarily represent those of the funding partners.

BIORETENTION SYSTEM CONSTRUCTION & ESTABLISHMENT SIGN-OFF FORMS			
Asset I.D.		DA No.	
System location:			
Area:	Catchment Area (ha):	Bioretention Area (ha):	
Civil drawing no.			
Landscape drawing no.			
Role/Stakeholder	Company	Contact Name	Contact Details
Developer			
Site superintendent (civil)			
Site superintendent (landscape)			
Bioretention designer			
Civil engineer			
Landscape architect			
Civil contractor			
Landscape contractor			
Council compliance officer			

Checklist of Sign-Off Forms			
Sign-Off Form	Date Completed	Name of Signatory & Role (e.g. Superintendent)	Signature
Pre-Start Meeting			
Form A — Earthworks & Functional Structures			
Form B — Under-Drainage			
Form C — Bioretention Media			
Form D — Finished Levels			
Form E — Coarse Sediment Forebay			
Form F — Protective Measures			
Form G — Landscape Installation			
Form H — Landscape Establishment			

Pre-Start Meeting List pre-start meeting attendees who are to sign indicating they have attended the meeting and understand the design intent, construction and establishment process.			
Location			
Date			
Role/Stakeholder	Company	Contact Name	Sign
Developer			
Site superintendent (civil)			
Site superintendent (landscape)			
Bioretention designer			
Civil engineer			
Landscape architect			
Civil contractor			
Landscape contractor			
Other			
Other			
Other			
Comments (attach and refer to additional pages if necessary)			
Actions (attach and refer to additional pages if necessary)			

FORM A — Earthworks and Functional (Hydraulic) Structures				
Purpose: To ensure earthworks bulking out, trimming and profiling and the key levels of functional (hydraulic) structures are in accordance with design drawings and specifications. The earthworks and structures dictate the movement of stormwater through the bioretention system and are a critical element in the function of the system.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
As constructed survey completed and attached to this form				
Photos taken and attached to this form				
Set-out of system is correct				
Base levels are at correct elevation (±50 mm)				
Base at correct grading (0.5%)				
Punch out holes in overflow pit are correct size, correct level and above invert level of outlet pipe (±25 mm)				
Overflow pit is correct size and crest and invert is at correct level (±25 mm)				
Outlet pipe invert levels are correct (upstream and downstream) (±25 mm)				
Outlet pipe is free draining				
Overflow weir (if required) is correct length and at correct level (±25 mm)				
Overflow weir (if required) is keyed into bund				
Bunds/embankments surrounding the system are at correct levels or above				
HOLD POINT: Superintendent and bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed survey and drawings and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM B — Under-drainage				
Purpose: To ensure under-drainage is installed correctly before the bioretention media is installed.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Base of system free from debris				
Liner (typically filter cloth) correctly installed				
There is no fabric 'sock' around the under-drainage				
Correct under-drainage has been supplied and slotted at 2 mm or smaller				
Under-drainage pipes are laid at the correct spacing (small bioretention system 1.5 m, large system 2 m) Required grade (verified using level or string line)				
Under-drainage pipes laid at required grade (verified using level or string line to achieve design level ±25 mm and 0.5% grade)				
All junctions and connections have been appropriately sealed				
Top of clean out points at design level (i.e. approximately 50–150 mm above filter media surface)				
HOLD POINT: Superintendent or bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed survey and drawings and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM C — Bioretention Media				
Purpose: To ensure that the media placed in the system meets the required specifications and that there is a record of the media being delivered to site. To ensure media layers are installed correctly and meet the design and specification requirements.				
SOURCING, TESTING AND SUPPLYING BIORETENTION MEDIA				
Drainage layer	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Meets the specifications				
Meets the required hydraulic conductivity (4,000 mm/hr)				
Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				
Transition layer supply				
Meets the specifications				
Supplier certification provided (certification attached)				
Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				
Filter media supply				
Meets the FAWB's *Guideline Specifications for Soil Media in Bioretention Systems* (2008)				
Meets the required hydraulic conductivity (100–500 mm/hr, 750 mm/hr maximum)				
Frequency of laboratory testing completed in accordance with Section 3.5 (results of testing attached)				
Supplier certification provided (certification attached)				
Delivery supply docket certifies that the material delivered is the material tested (delivery docket attached)				
HOLD POINT: Superintendent or bioretention designer inspection and review of test results and certifications before proceeding.				
Comments (attach and refer to additional pages if necessary)				

FORM C — Bioretention Media (cont.)				
INSTALLATION OF BIORETENTION MEDIA				
	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Base of system free from debris				
Drainage layer (fine gravel) installed to correct depth (± 25 mm)				
Transition layer (coarse sand) installed to correct depth (± 25 mm)				
Placement of filter media completed to avoid compaction of media and using at least two lifts				
Filter media installed to correct depth				
Light, even compaction applied to remove air gaps (e.g. light roller or single pass with a ‘pozitrack’ bobcat)				
Spreader bar used to flatten surface of filter media				
Sediment fences in place				
INSPECTION: Superintendent and bioretention designer inspection and sign-off to occur while installation of media is occurring. Photos must be taken by the superintendent, the bioretention designer or the contractor.				
Comments (attach and refer to additional pages if necessary)				

NB: Laboratory test results, certification, delivery dockets and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM D — Finished Levels				
Purpose: To ensure finished levels of system surface and bunds are correct and meet the design.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Landscaping topsoil applied to surrounding bunds to achieve design levels				
As-constructed survey of system surface and surrounding bunds completed				
Final constructed levels are consistent with design levels				
Under-drainage clean-outs extended 50–150 mm above filter media				
Under-drainage pipes flushed to remove initial ingress of material				
HOLD POINT: Superintendent and bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed survey and drawings and photos attached.

Signed by superintendent: ____________________

Print name: ____________________

Date: ____________________

AND

Signed by bioretention designer: ____________________

Print name: ____________________

Date: ____________________

FORM E — Coarse Sediment Forebay				
Purpose: To ensure the coarse sediment forebay is constructed correctly.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Extent of coarse sediment forebay correctly set out				
Rocks to be used to line base of forebay are correct size and shape				
Base of constructed forebay is flat and set at the correct level below the surface of the filter media				
Rocks placed for energy dissipation are of appropriate size and are in correct location				
Interface between forebay and filter media is structurally sound and not prone to collapse				
HOLD POINT: Superintendent or bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed survey and drawings and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM F — Protective Measures				
Purpose: To ensure protective measures are correctly installed to protect the bioretention system while building is occurring in the catchment.				
Protection option adopted (Option 1, 2 or 3)				
Option 1 — Surface protection during building phase	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Continuous sediment fences installed around perimeter of filter media and top of batter.				
Where landscape works are not to commence immediately then cover batters with filter cloth.				
Protective covering (filter cloth + 25 mm topsoil + turf) installed across entire filter media area of system.				
Option 2 — Bypass and early establishment	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Continuous sediment fences installed around perimeter of filter media and top of batter.				
Where landscape works are not to commence immediately then cover batters with filter cloth.				
Temporary bund installed (where required) to prevent stormwater runoff from entering bulk of system. Bund keyed into batters of bioretention and crest level higher than pits and weirs.				
Temporary protective covering (filter cloth + 25 mm topsoil + turf) installed within bunded area.				
HOLD POINT: Superintendent and bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: Photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM G — Landscape Installation				
Purpose: To ensure the correct plants are supplied, installed and established.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
Correct mulch has been supplied				
Mulch applied to correct depth and secured				
Supplied plants are correct species				
Supplied plants are in correct pot sizes and maturity (300 mm min)				
Plants have been installed at correct planting density (min 6 plants/m^2)				
As constructed drawings marked up with final plant species and densities				
Mulch is clear of plant stems by approximately 50 mm				
HOLD POINT: Superintendent AND bioretention designer inspection and sign-off before proceeding.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed drawings and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________

FORM H — Landscape Establishment				
Purpose: To ensure the correct plants are supplied, installed and established.				
Items	Checked	Satisfactory	Action (if unsatisfactory)	Initial
PLANT ESTABLISHMENT				
Weeds being removed as required				
Watering occurring as required				
Replanting occurred as required to replace failed plants				
Plants successfully established plants propagation is occurring. Measure of successful establishment 1. Survivorship greater than 90% 2. 80% coverage of system 3. Preferably more than one species per macrophyte zone 4. At least 5 plants/m^2 (preferably 6–10 plants/m^2) 5. Plant height of at least 50%. This can be measures through the use of marker or stakes through the bioretention 6. Propagation is occurring (more than 2–3 stems, seeding) 7. No weeds. Growth and maturity should be recorded through three-monthly photo logs every 500 m^2.				
HOLD POINT: Superintendent AND bioretention designer inspection and sign-off.				
Comments (attach and refer to additional pages if necessary)				

NB: As constructed drawings and photos attached.

Signed by superintendent: ______________________________

Print name: ______________________________

Date: ______________________________

AND

Signed by bioretention designer: ______________________________

Print name: ______________________________

Date: ______________________________