SEEC

Strategic Environmental & Engineering Consulting

Water Quality Management

for Major Project 05-0113
Seniors Living Resort, Frenchs Forest.
Proposed Concept Plan

Lots 1110, 1111, 1113, 1336, DP 752038;
Lot 20, DP 842523; Lot 80, DP 846099
Oxford Falls Road, FRENCHS FOREST

Prepared by:

Mark Passfield
12 May, 2010
SEEC Reference 10000056-WQMP-01

Strategic Environmental and Engineering Consulting

PO Box 1098, Bowral NSW 2576
phone: (02) 4862 1633 • fax: (02) 4862 3088 • email: reception@seec.com.au

Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects.

Any recommendations contained in this report are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, subject to the limited scope and resources available. Within the confines of the above statements and to the best of my knowledge, this report does not contain any incomplete or misleading information.

Mark Passfield
Director
SEEC

12 May 2010

Contents

1 Introduction

Tiffany Developments have commissioned SEEC to address stormwater quality management issues associated with a proposed seniors living resort on Oxford Falls Rd, Frenchs Forest (Major Project 05-0113, Seniors Living Resort - Proposed Concept Plan).

This plan identifies a series of commitments that will be implemented for stormwater quality management, although further engineering detail will be provided at a later stage in the development process. Stormwater quality modelling using software known as MUSIC has been used to demonstrate the effectiveness of the stormwater management plan.

A range of requirements for the Environmental Assessment of this project were provided by the Director General of the Department of Planning. The goals of this stormwater management plan are to use water resources wisely and to improve the current catchment conditions of Narrabeen Lakes. The aims of this plan are:

(i) To demonstrate a neutral or beneficial effect (NorBE) on stormwater quality leaving the site compared to existing conditions.

(ii) To demonstrate that the proposed stormwater quality treatment train meets the requirements of DECCW's draft environmental targets.

(iii) To provide measures onsite that will treat two offsite urbanised catchments and, by doing so, improve the water quality of the total catchment to Narrabeen Lakes.

(iv) To embrace opportunities for onsite re-use and reduce long-term reliance on mains water supply.

(v) To integrate water quality management with the proposed flood management and mitigation measures proposed by others.

(vi) To manage stormwater in a way that improves the development's appeal but does not compromise safety nor create a logistical/management problem.

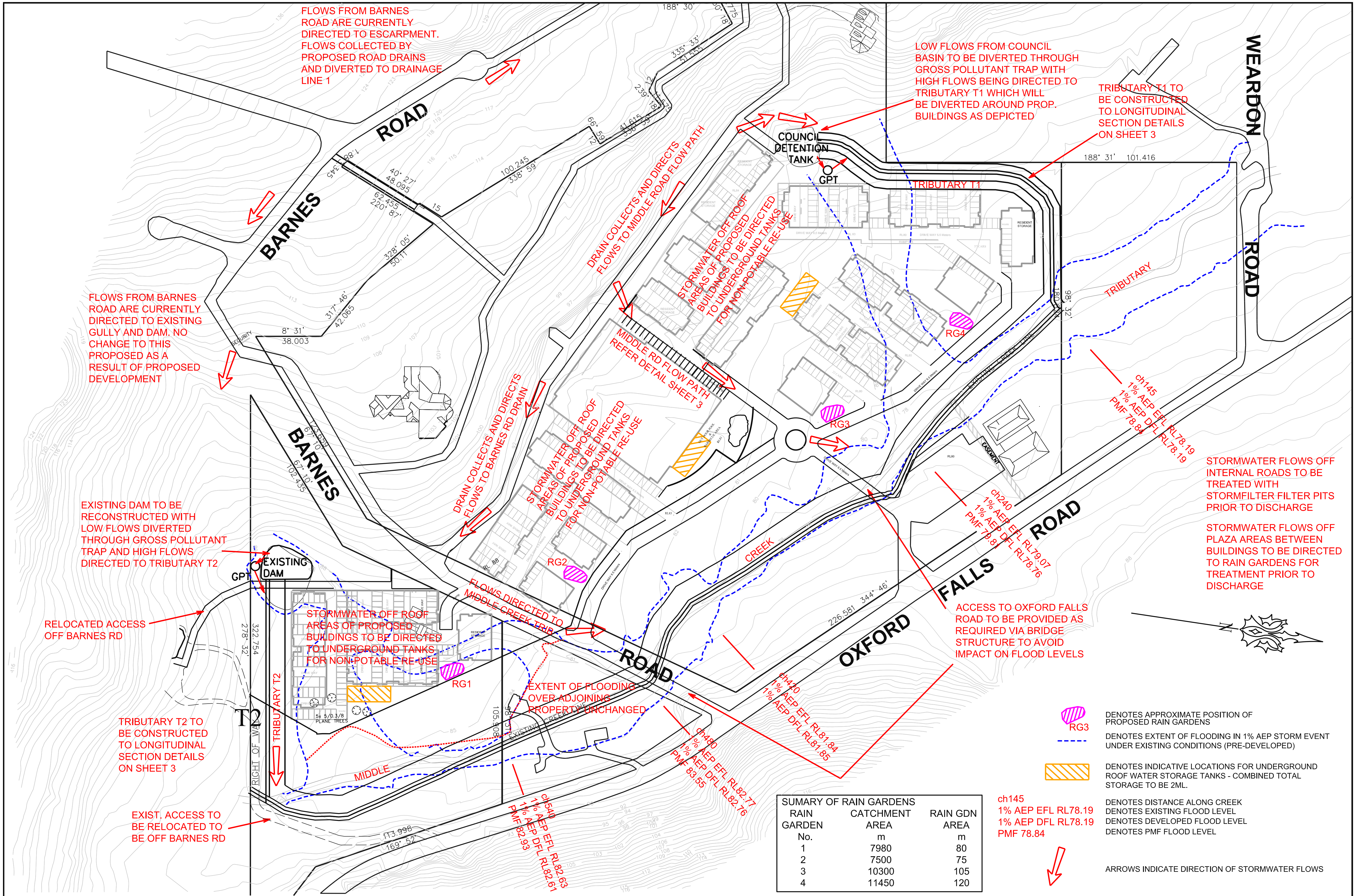
2 Proposed Development

The proposed development is a seniors living resort. The conceptual layout of the proposed development is provided by others and reproduced here in Figure 1. We note that the exact scale and layout of various structures might change as a result of the ongoing development process and following feedback from various government departments and authorities.

Earthworks are proposed to establish site levels. In general, the proposed development includes a series of low-rise apartment blocks, each with underground car parking. Unit blocks are connected by an internal road system. There will be extensive landscaping, pathways and recreational facilities. Several community buildings are also included.

The entire development lies within a small valley, below a low scarp. A tributary of Middle Creek passes through the site, as do two other, smaller depressions that appear to have been significantly modified as a result of past development. Modifications are proposed to two drainage lines through the site known as T1 and T2 (Figure 1 [1]), the details are provided by others.

1 Figure 1 is the conceptual stormwater plan prepared by JM Daley and Ass P/L



SUMARY OF RAIN GARDENS

RAIN GARDEN No.	CATCHMENT AREA m	RAIN GDN AREA m
1	7980	80
2	7500	75
3	10300	105
4	11450	120

Revision	Date	Remarks
C	10-05-10	ACCESS ROADS AMENDED
B	30-04-10	GPT'S ADDED
A	9-04-10	INITIAL ISSUE

Client: TIFFANY DEVELOPMENTS
Origin of Levels: N/A
Date of Survey : VARIOUS
Ratio (A1) : 1:1000

Datum : AHD
Designed by : N/A
Drawn by : N/A
Approved for issue : TH 29-03-2006

JMD Development Consultants

John M Daly & Associates PTY LTD
ABN 88051977989
Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
PO BOX 25 DX 5112
CAMPBELLTOWN NSW 2560
PH (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project :
PLAN DETAILING PROPOSED STORMWATER CONCEPTS FOR PROPOSED RETIREMENT RESORT DEVELOPMENT OVER LOTS 1110, 1111, 1113 & 1336 IN D.P.752038, LOT 20 IN D.P.842523 & LOT 80 D.P.846099 OXFORD FALLS ROAD, FRENCHS FOREST

Locality : FRENCHS FOREST
L.G.A. : WARRINGAH

Sheet 2 of 3 sheets
Ref: 10040E2
CAD Ref: S:\DATA\OXFORD FALLS\ENG\CAD\FLOOD-2010.DGN

3 The Site

3.1 General

The site lies in a narrow valley in Frenchs Forest on Sydney's northern beaches peninsula. Access is from Oxford Falls Road and Barnes Road. The site consists of six individual lots and covers an area of approximately 14.8 hectares, most of which lies west of a tributary of Middle Creek.

The tributary of Middle Creek flows in a roughly northerly direction. The site is also drained by a number of other small depressions and vague drainage lines, all of which direct runoff into the main watercourse. The entire site eventually drains to Middle Creek and on to Narrabeen Lake. For the purposes of this report, the main watercourse is referred to as the Middle Creek Tributary. The total catchment area upstream of this development is approximately 110 hectares (JMD & Associates, 2004).

A low sandstone scarp traverses the site in a roughly north-south direction, defining the edge of the valley. Figure 1 shows the scarp (which is vegetated) and the more gently inclined valley below it on which the built component of the development will occur.

3.2 Geology and Soils

The site lies on a mixture of colluvial and depositional sediments overlying Hawkesbury Sandstone. Soils have a mixture of coarse and fine sandy to clayey sediments and are relatively high in organic material. Near-surface soils are generally sandy loam.

A short sandstone scarp approximately 10 to 20 metres high extends from NW to SE along the edge of the subject site. Minor cliffs exist along this scarp and maximal slopes are generally steep (approximately 25%) and short (< 30 m long). Soils in this scarp area are shallow, sandy and highly susceptible to erosion.

3.3 Topography

The subject site lies in a narrow valley in Frenchs Forest on Sydney's northern suburbs. As previously described, the Middle Creek Tributary traverses the site in a roughly south to north direction. A narrow, gently undulating valley infill adjoins the creek, mainly on its western side. This valley infill is surrounded by sandstone hills and scarps with short, steep (> 25%) slopes. A prominent low scarp runs through the site as shown in Figure 1, where sandstone outcropping is common and slopes are approximately 25 to 30%.

3.4 Drainage

The Middle Creek Tributary flows through the subject site near its eastern boundary and in a roughly northward direction. It eventually drains into Middle Creek and Narrabeen Lakes. The entire site lies within the catchment of this watercourse.

Drainage from the site is mostly via sheet flow, with only small depressions present. These appear to have been modified since European occupation in both form and location.

Middle Creek Tributary is in a highly modified but mostly stable condition, although it lacks a defined riparian corridor in some areas. Small portions of the valley associated with this creek are susceptible to localised flooding or waterlogging. No flood history is recorded for this site according to Warringah Council, but geomorphic conditions along sections of the creek indicate a history of minor overbank events.

There are two off-site catchments that drain onto the site from the west (Figure 1):

(i) T1 – that drains an urbanised area of 16.37 ha to a Council detention basin located near the far northwest corner of the site; and

(ii) T2 – that drains an urbanised area of 38.8 ha to a dam located near the southern boundary of the site.

Both the detention basin and the dam provide some settling of sediment but their relatively small size means their value for water treatment is limited. The dam in particular has no current maintenance strategy.

3.5 Acid Sulfate Soils

The site contains no lands below 10 m AHD so is unaffected by acid sulfate soils.

3.6 Climate

Climate data from the Bureau of Meteorology indicate that this area receives approximately 1,350 mm of rain annually (Frenchs Forest Road, Frenchs Forest). Rainfall is summer/autumn dominant.

3.7 Existing Land Use

The existing site has a mixed land use estimated as follows:

(i) 2.3 ha of commercial land, being the tennis complex in the northeast corner of the site;

(ii) 7.5 ha of rural residential land being existing houses to the west of the watercourse with their associated gardens and paddocks;

(iii) 1.5 ha of agricultural land being part of one property that has a large outdoor horse arena and a relatively high concentration of horses; and

(iv) 3.5 ha of native vegetation – mostly on the scarp through the site and east of the watercourse, but some patches just west of the watercourse too.

4 Water Quality Goals

4.1 Relevant Documentation

4.1.1 Healthy Rivers Commission, 2002

The site is within the Narrabeen Lakes catchment, which is recognised as being in "Healthy Modified Condition" according to the Independent Inquiry into Coastal Lakes (Healthy Rivers Commission, 2002). Nevertheless, it is still considered a sensitive catchment due to the level of urban development within the catchment area.

4.1.2 Narrabeen Lakes Estuary Management Plan, 2002

The Narrabeen Lakes Estuary Management Plan (2002) identified specific management options for the entire catchment. Relevant aspects of this Plan for the site in question include:

- The need to manage water quality, sediment loads and flood levels, particularly in Middle Creek.
- The creeks on this site were not identified as being in need of rehabilitation.
- The installation of a Gross Pollutant Trap or similar structure was recommended for the Middle Creek Tributary.
- The need for flood management in Middle Creek, which includes installing wetlands along it and its tributaries to enhance water quality and regulate flows.

4.1.3 Warringah Creek Management Study, 2004

The Warringah Creek Management Study from March 2004 refers to Middle Creek and its tributaries. In this study, Middle Creek is classified under Group C. Key features of Group C creeks in this study include:

- Catchments are well above catchment development thresholds.
- Ecosystems are already substantially modified.
- Weed growth is a threat to remnant and replanted native vegetation.
- Water quality is at or above acceptable limits, resulting in periodic stress symptoms such as fish kills, nuisance algal growth and high turbidity.

In light of the above, the Warringah Creek Management Study, March 2004 recommends that creek planning and management aim to protect or enhance existing creek values and maintain healthy ecosystems. The principles therein include the following:

- Support the health of target species and communities.
- Protect rare or threatened species and natural features.

- Prevent serious loss of natural diversity.
- Minimise damage to public and private property through creek processes.
- Maintain and enhance creek landscapes.
- Create opportunities for public access and recreation in waterway corridors.
- Ensure that people are safe in and around waterways.
- Preserve cultural heritage values.

4.1.4 Northern Beaches Stormwater Management Plan, 1999

For new urban developments, the Northern Beaches Stormwater Management Plan 1999 presents a series of targets:

(i) Short Term:

- Investigate impacts of urban consolidation on stormwater quality.
- Reduce nutrient loads discharged to creeks and streams by 45%.
- 50% retention of average annual load for suspended solids.
- Retention of sediment coarser than 0.125 mm for the 3-month ARI peak flow.
- Retention of litter greater than 50 mm for flows to the 3-month ARI peak flow.
- No visible oils for flows up to the 3 month ARI peak flow.
- During construction, meet the requirements of Department of Housing 1998 (now superseded by Landcom, 2004 - The Blue Book).
- During construction, limit the application, generation and migration of toxic substances to the maximum extent practicable.

(ii) Long Term:

- Reduce nutrient loads discharged to creeks and streams by 30%.
- Achieve suspended sediment loads which protect aquatic ecosystems and maintain natural creek bed regimes.
- Reduce gross solid loads in creeks and streams by 70%.
- Have improved, where possible, public access to riparian areas.
- Have maximised stormwater reuse within ecological, social and economic value constraints.

Note that the above lists are summaries of the items most relevant to water quality targets.

4.1.5 DECC Managing Urban Stormwater: Environmental Targets, 2007a

In their consultation draft (October 2007a) titled *Managing Urban Stormwater: Environmental Targets*, DECC and the Sydney Metropolitan CMA state that developments should include stormwater treatment measures that aim to achieve:

- 90% reduction in the average annual gross pollutant (> 5mm) load.
- 85% reduction in the average annual total suspended solids (TSS) load.
- 65% reduction in the average annual total phosphorus (TP) load.
- 45% reduction in the average annual total nitrogen (TN) load.

4.1.6 Managing Urban Stormwater: Soils and Construction (Landcom, 2004)

This document, known as the "Blue Book," provides recommendations and design criteria for erosion and sediment control during the construction stage. Warringah Council have adopted this as their standard requirement for construction-phase erosion and sediment control.

A Construction-Phase Soil and Water Management Plan (SWMP) will be required to address issues of erosion and sediment control for each stage of the proposed development.

4.1.7 ANZECC 2000

In Australia, the national guidelines for managing water quality in ambient waterways are known as the 'ANZECC guidelines' published by ANZECC (the Australian and New Zealand Environment Conservation Council) in 2000. The numerical trigger values in the ANZECC guidelines are derived and designed for assessing ambient waters only - they are not meant as regulatory design or discharge standards.

In this case we understand the water quality of the Middle Creek Tributary fails the trigger values, probably as a result of the heavily urbanised catchment upstream of this site. This is why strict water quality goals will be adopted (Section 4.2) and the proponent will also be providing treatment to two of the offsite catchments that come onto this site (Section 5.3).

DECCW have a list of water quality objectives for Sydney's Northern Beaches Lagoons, including Narrabeen Lakes. Many of these mirror those given in the Warringah Creek Management Study, 2004 (or vice-versa).

4.2 Adopted Water Quality Goals

Issues of riparian management and revegetation are discussed elsewhere by Travers Bushfire and Ecology P/L. Issues of onsite detention and flow volume control are addressed by the stormwater engineer (John M Daly and Associates P/L).

This report addresses issues of surface stormwater quality only and, based on the above, the following water quality goals will be adopted for the site. They form the foundation of the MUSIC modelling presented in Section 6.

(i) Achieve a neutral or beneficial effect on water quality in the pre versus post development scenarios;

(ii) Adopt the water quality targets for reductions in TSS, TP, TN and gross pollutants as specified in DECC, 2007a (these exceed those in the Northern Beaches Stormwater Management Plan 1999) (Clause 4.1.5 above)

In addition, the proponent will improve the overall catchment to Narrabeen Lakes by installing gross pollutant traps on T1 and T2, to treat flows up to the 3-month ARI storm event. The benefit of doing this is shown in Section 6.3 and is driven by the Narrabeen Lakes estuary Management Plan, 2002 (Clause 4.1.2, item 3 above).

5 Proposed Water Quality Measures

A series of water quality measures will be adopted as part of the development:

5.1 Construction-Phase Soil and Water Management

A Construction-Phase Soil and Water Management Plan (SWMP) will be required to address issues of erosion and sediment control for each stage of the proposed development. It will be prepared by a certified professional in erosion and sediment control (CPESC) and to the requirements of Landcom (2004) (The Blue Book).

5.2 Rainwater Re-Use

There is a clear opportunity to collect and re-use rainwater derived from new roofs without roof gardens. The proposed development will be home to about 1,300 persons and staff. Their total water demand would be approximately 190 kL/day (based on 145 L/day/person (AS/NZS 1547:2000). About 25-30 percent of that would be used for toilet flushing, i.e. about 50 kL/day.

The proposed total roof area without roof gardens is 21,600 m^2. Using an in-house rainwater tank simulation known as "Tank-Sim" which uses daily rainfall data from the BOM (here for Frenchs Forest), we have identified the optimum tank volume to serve a demand of 50 kL/day (Appendix 1). That volume is about 2 ML.

Therefore, 2 ML of rainwater tanks will be installed at the site to collect and store rainwater for use in all toilets. The tank overflows will drain to the trunk drainage system.

5.3 Bioretention Basins (Raingardens)

Bioretention basins (raingardens) will be used to collect and treat all runoff from landscaped areas around the buildings. They will be built to the requirements of DECC , 2007b and their area will be 1 percent of the total area they drain. The raingardens will be built in areas of fill (i.e. not on roofs) so that their required depth can be achieved.

Runoff from all the landscaped areas around the buildings will be directed into the bioretention basins. This includes water percolated through the roof gardens and collected by the under-drainage system.

A typical example of a bioretention basin is shown in Figure 2. Raingardens are very efficient at treating urban runoff and they are recognised as one of the best measures for reducing pollutants. They also form an important part of the landscape design.

Figure 2 –Typical Bioretention Basin (Melbourne Docklands) © Melbourne Water.

5.4 Trunk Drainage

Conventional trunk drainage will be built as part of the site's road infrastructure. The engineer will incorporate several sets of Gross Pollutant Traps (GPTs) followed by Stormwater 360's Stormfilter® system directly downstream. Information on the Stormfilter® product is given in Appendix 2. The proposed recreation area and nearby lands in the west (3.25 ha) will drain to the road drainage and be treated in this way too.

The above measures will collect and treat runoff from most of the site. The only exception is land east of Middle Creek Tributary and land within the asset protection zone that is west of, and parallel, to Middle Creek Tributary. These lands will be essentially unchanged or subject to re-vegetation as part of the core riparian works. The re-vegetation will improve the water quality in runoff from this land without the need for physical treatment.

5.5 Off Site Drainage, T1 and T2

The proponent will further improve the overall catchment to Narrabeen Lakes by installing and maintaining large gross pollutant traps on T1 and T2. They will be designed to treat flows up to the 3-month ARI storm event. An example of such a GPT is Hume's "Humegard" product (Appendix 2). The GPTs will effectively trap sediment in minor flows (which are generally the most dirty). Refer to Section 6.3.

5.6 Maintenance

The proposed water quality measures are readily available and readily constructable. The site will have a management structure in place with dedicated staff who will be able to look after them. A site management plan will be prepared for the site and will incorporate details of inspections and maintenance procedures for many aspects of the development, including the stormwater quality measures. Maintenance procedures for the Stormfilter® and the GPTs would be defined by the manufacturers. Ongoing maintenance is important to the continued success of the stormwater management plan.

6 Water Quality Modelling

6.1 Introduction

Water Quality Modelling was undertaken to demonstrate the effectiveness of the Stormwater Management Plan. Calculations are derived using a computer model called MUSIC (Model for Urban Stormwater Improvement Conceptualisation) developed by the CRC for Catchment Hydrology (now part of eWater). MUSIC contains algorithms based on the known performance characteristics of common stormwater quality improvement structures used in Australia. These data are derived from research undertaken by eWater and others. Proprietary treatment systems can also be modelled, as long as their performance has been independently verified by third party research.

MUSIC uses a series of source nodes, one for each type of land use. The nodes are calibrated as in Table 5, Appendix 3. The calibrations are obtained from SCA (2009), as this document represents the latest NSW-specific modelling recommendations and adopts a conservative approach [2].

6.2 Modelling Inputs

6.2.1 Climate Data

Creation of a MUSIC catchment file requires an associated meteorological data file using 6-minute pluviograph data from the Bureau of Meteorology. The data used here is that for Sydney for 1976 to 1980 in 6 minute time steps. Data for this period and location were chosen because:

- they have an annual average that is close to the long-term average for Frenchs Forest;
- they have a very similar seasonal load and pattern; and
- they contain two relatively dry years and two relatively wet years.

Basic rainfall and evapotranspiration statistics are in Table 1 and the time-series graph is in Figure 3.

Table 1 Summary rainfall and evapotranspiration statistics for Sydney for 1976 to 1980

Measure	Statistics						
	mean	median	maximum	minimum	10%ile	90%ile	mean annual (mm)
Rainfall (mm/6 minute steps)	0.013	0.000	14.27	0.000	0.000	0.000	1,147
Evapotranspiration (mm/day)	3.452	2.930	5.810	1.390	1.430	5.260	1260

2 It is appreciated that the site is not an area administered by the Sydney Catchment Authority (SCA) but we (and SCA) believe there is no reason why their work cannot be adopted elsewhere in NSW. SCA require all developments in their catchments to show NorBE.

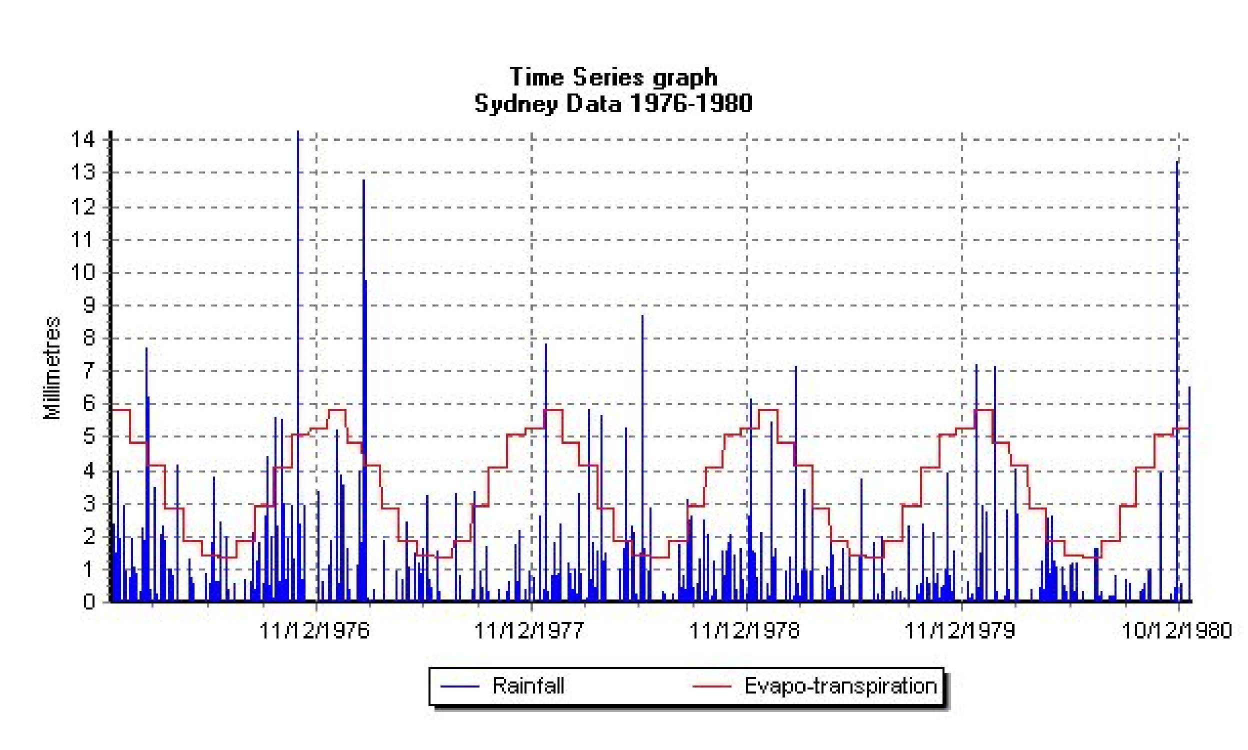


Figure 3 – Time Series graph of Rainfall Data used in MUSIC modelling.

6.2.2 *Pre Development*

The pre-existing model (Figure 4) uses source nodes calibrated as in Tables 4 and 5, Appendix 3 to model the land surfaces identified in Section 3.7. The total area modelled is 14.8 ha. The source nodes reflect the fractions of effective [3] imperviousness as follows:

- 60 percent in the tennis centre;
- 9 percent in the rural residential areas;
- 6 percent in the agricultural area;
- 0 percent in the forested areas.

6.2.3 *Post Development Conditions*

Post development modelling (Figure 5) assumes:

(i) The water quality measures described in Section 5 are implemented.

(ii) The site area remains at 14.8 ha but now consists of:

- 21,600 m^2 roof, 100 percent impervious with a rainfall threshold of 0.3 mm. Modelled with a roof source node (Appendix 3, Table 4);

3 Note that effective imperviousness is not necessarily the same as actual imperviousness (SCA, 2009).

- 37,230 m^2 urban landscaping between the buildings. This is modelled with an urban source node (Appendix 3, Table 4) set to 100 percent impervious but with a rainfall threshold of 7.5 mm (i.e. 7.5 mm of rain can fall before runoff occurs [4] [5]);
- 13,000 m^2 road pavements, 100 percent impervious with a rainfall threshold of 1.5 mm. Modelled with a sealed road source node (Appendix 3, Table 4);
- Approx 28,000 m^2 of sparsely developed land in the west including:
  - the sports playing area;
  - some remnant native vegetation above the scarp;
  - three existing dwellings and their landscaping.

  This area drains to the road network below the scarp. It is 2 percent effective impervious and modelled with an urban source node (Appendix 3, Table 4);
- Approx 28,000 m^2 of sparsely developed land east of the eastern-most road and along Middle Creek Tributary. This will be mostly undeveloped but it will contain the existing tennis centre buildings/car park and a road crossing. 14 percent effective impervious and modelled with an urban source node (Appendix 3, Table 4); and
- 20,000 m^2 of native vegetation being the core riparian zone and vegetation east of the watercourse [6]. Modelled with a forest source node, all pervious.

6.3 Results of Modelling

6.3.1 The Actual Site

(i) Mean Annual Loads

Table 2 contains the results of the modelling, showing the comparisons between the pre and post development mean annual pollutant loads. Also included is the "Treatment Train Effectiveness," i.e. the proportion of sediment and pollutants removed through the use of physical stormwater management measures.

4 Recent data from Monash University shows roof garden have a rainfall threshold between 5 and 10 mm).

5 This is a conservative approach as some of this landscaping will actually be on filled soils, not roofs, and so some deep seepage would occur.

6 There will be some remnant forest left near the scarp too but that is incorporated in the 32,500 m^2 above it.

When compared against the water quality objectives in Section 4.2:

- The DECC requirements for treatment train effectiveness are achieved for all parameters.
- The requirements of the Northern Beaches Stormwater Management Plan are achieved.
- Water quality is improved when compared to the existing conditions (NorBE is met).
- There is a very small net increase in annual flow volume.

Table 2 Results of MUSIC modelling

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Pre Development	68.8	5770	13.8	113	847
Post Development including treatment measures	73.1	2920	10.2	104	189
Change (%)	+6	-49	-26	-8	-78
Treatment Train Effectiveness (%)	NA	88	67.3	50.5	99.3

The MUSIC model schematics are shown in Figures 4 and 5.

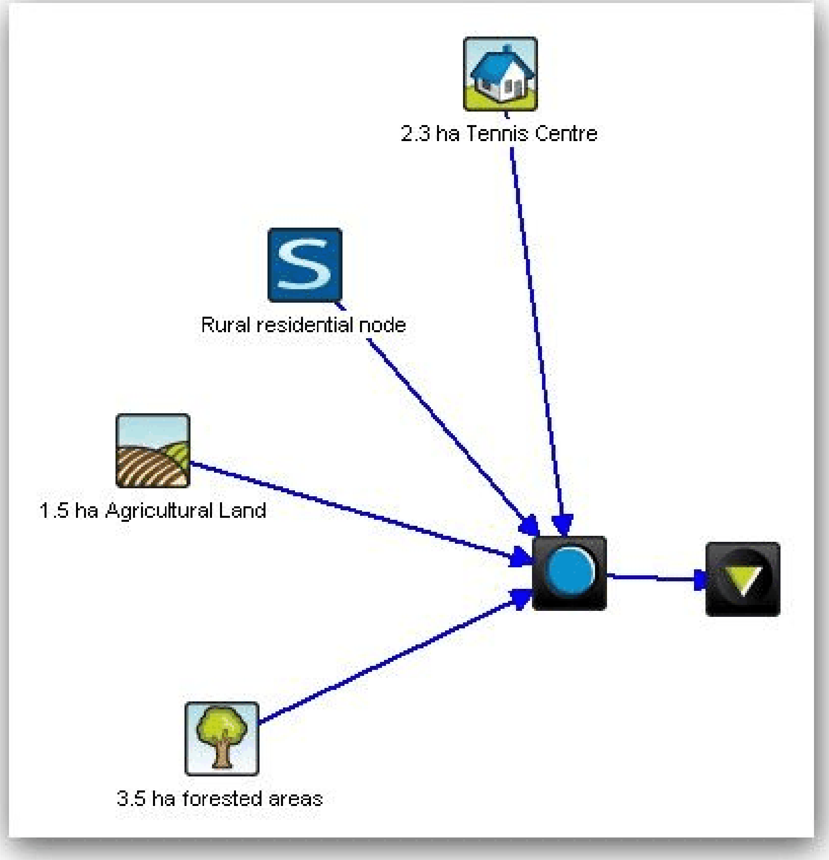


Figure 4 – MUSIC schematic - pre development

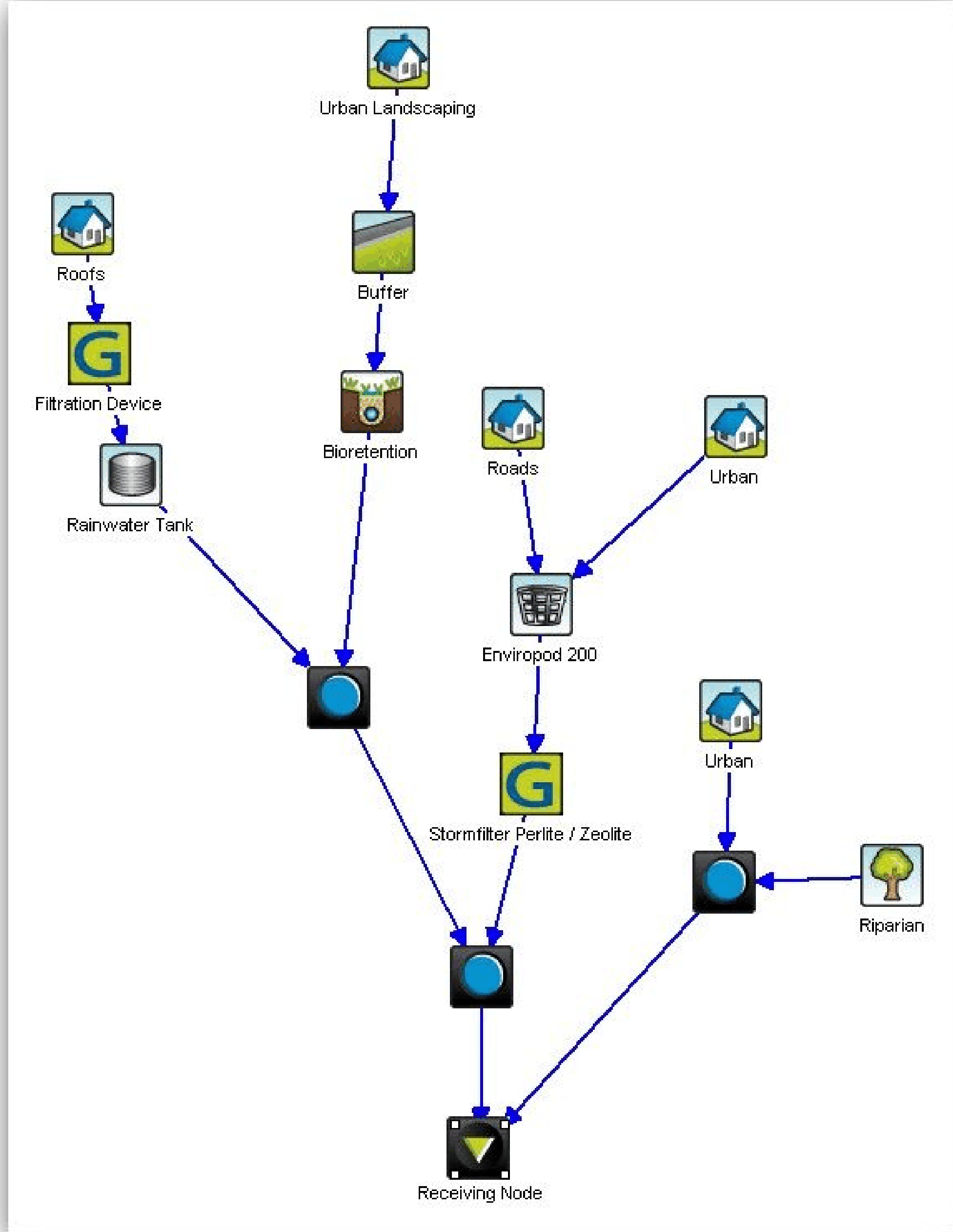


Figure 5 – MUSIC schematic, post development

(ii) Pollutant Concentrations

To further demonstrate neutral or beneficial effect (NorBE), the post-development pollutant concentrations should be no worse that pre-development concentrations. Figures 6 to 11 show the TSS, TP and TN graphs for pollutant concentrations in both pre and post development scenarios. They show either an improvement or minor change.

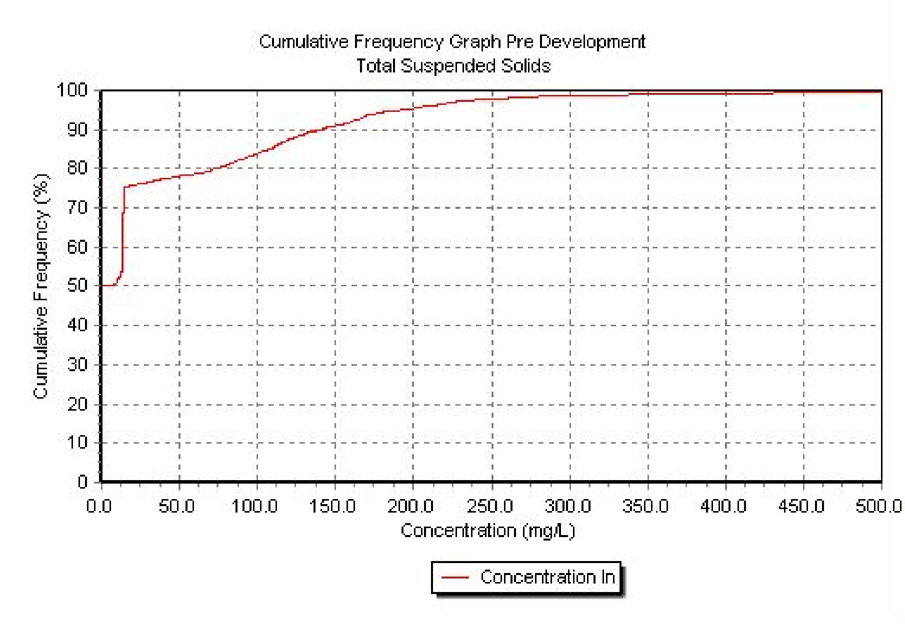


Figure 6

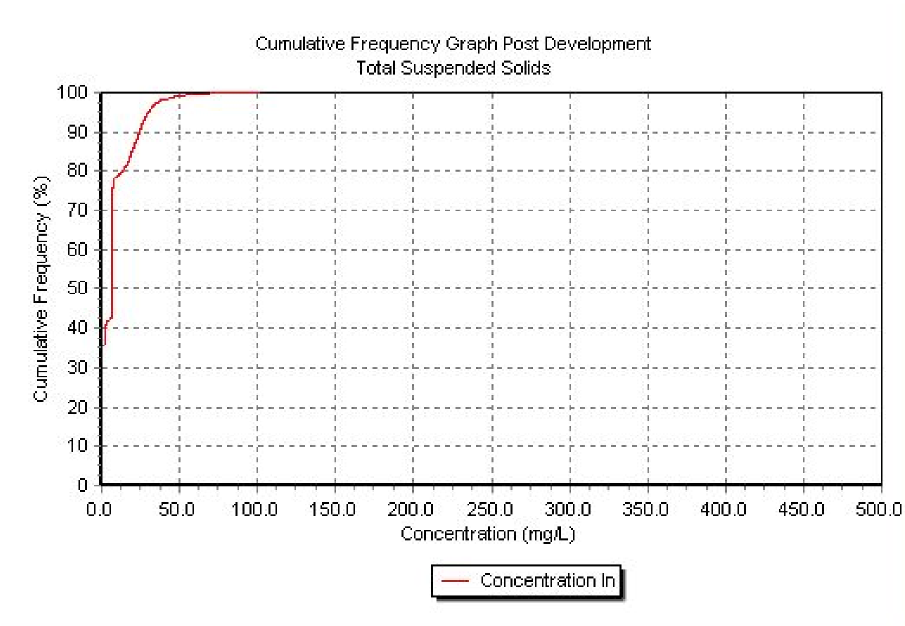


Figure 7

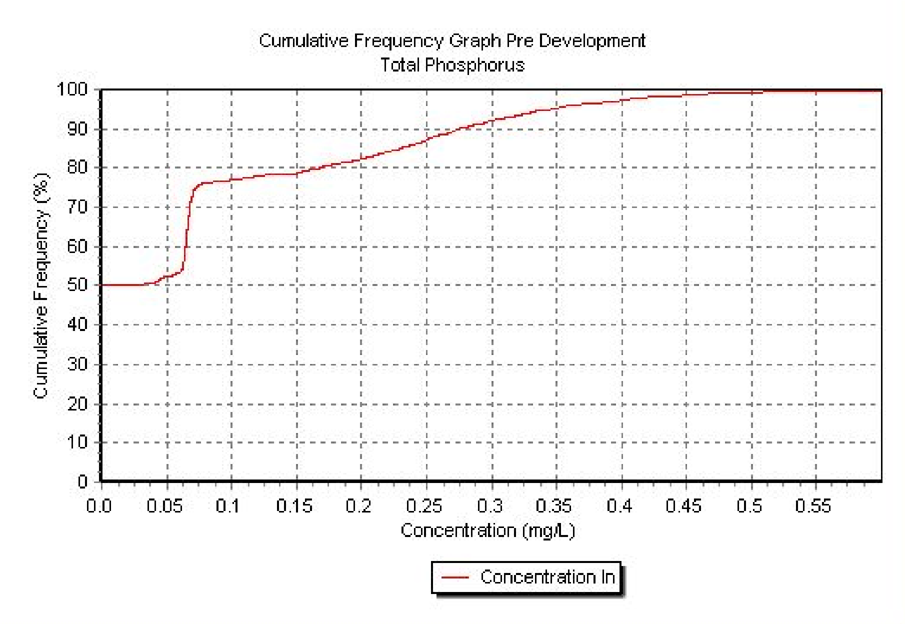


Figure 8

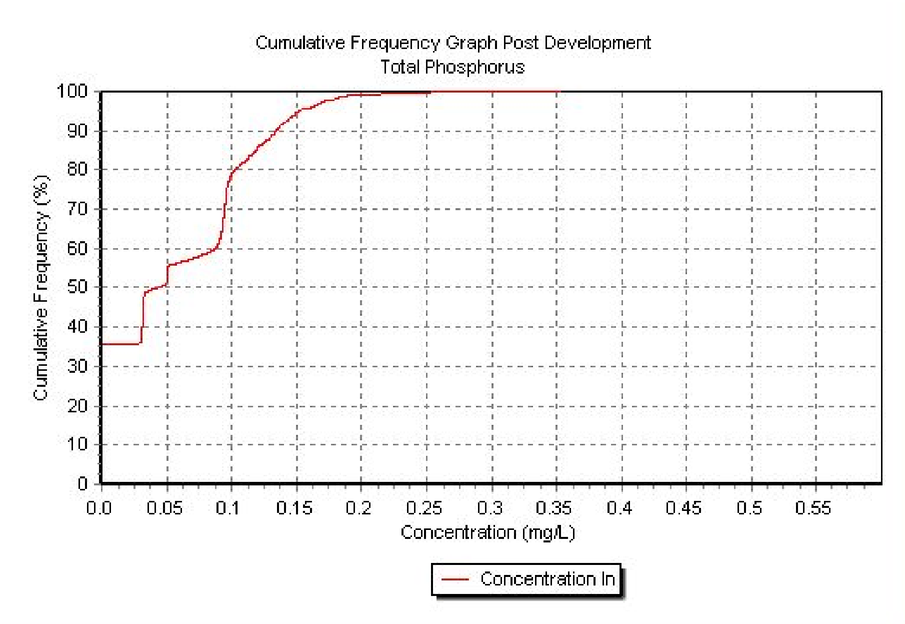


Figure 9

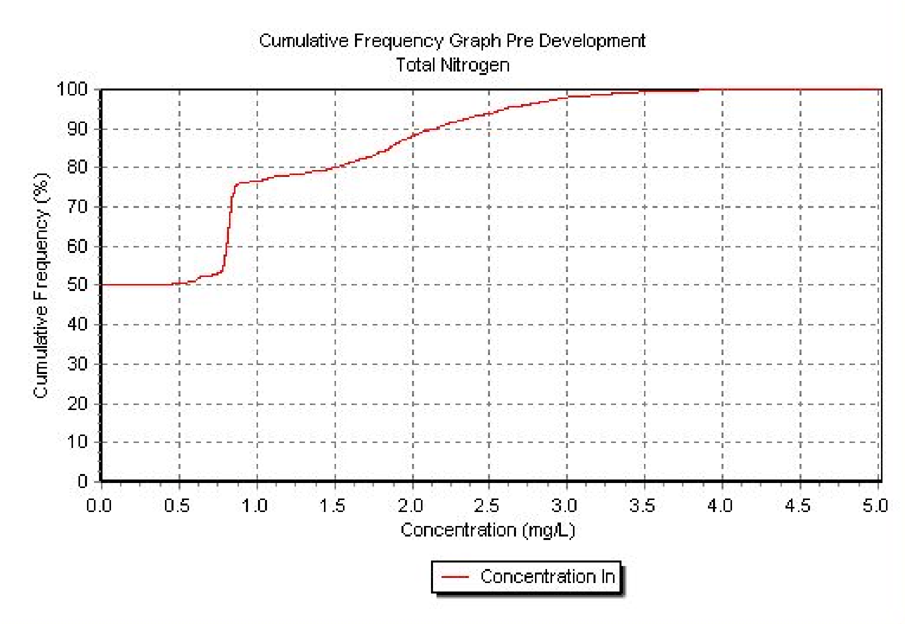


Figure 10

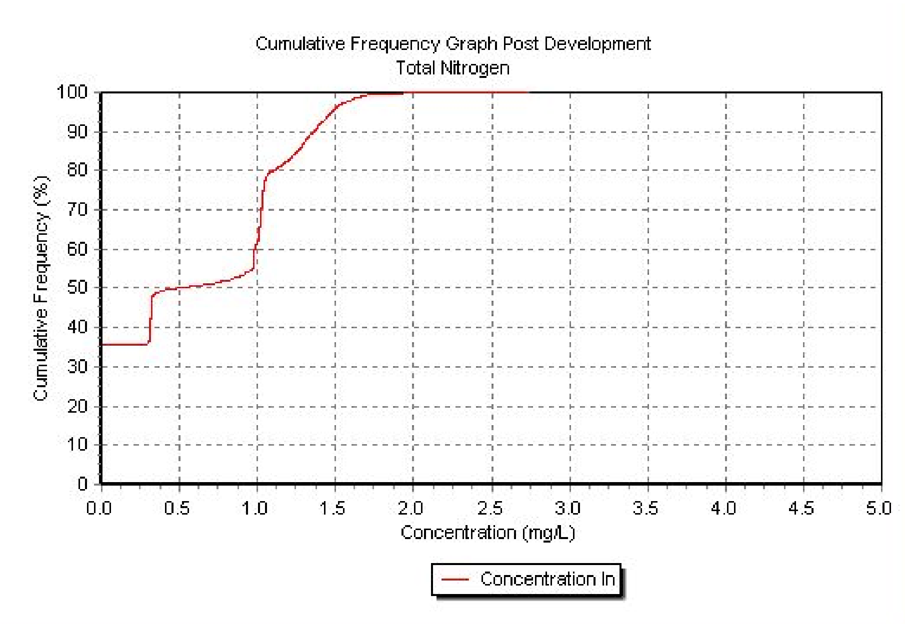


Figure 11

6.3.2 *Off-Site Catchments*

MUSIC was used to predict the improvement on the two offsite catchments that enter the site (T1 and T2). These will each have a large GPT installed to treat up to the 3 month ARI storm flow (Section 5.4 and Appendix 2).

GPTs target sediment and litter and so the result shows little change in nitrogen and phosphorous. However, there is a substantial change in total suspended solids (TSS). MUSIC predicts 16.4 tonnes less sediment will reach the Middle Creek Tributary per year.

Table 3 - Predicted Performance of GPT traps on watercourses T1 and T2

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	Gross Pollutants (kg/yr)
Pre Development	418	54,900	102	831	0
Post Development including GPTs	418	38,500	104	752	0
Change (%)	0	-30	0 [7]	-10	0

7 A GPT won't add phosphorous.

7 Conclusions and Commitments

Section 5 of this plan identifies a series of recommendations that, when incorporated appropriately, will achieve the adopted water quality goals from Section 4. MUSIC modelling in Section 6 demonstrates the effectiveness of the recommended measures.

Without integrated water quality management, the development could potentially have a negative impact on local watercourses. The proposed stormwater management plan embraces the principles of WSUD to improve water quality in the receiving waters. Other benefits of the plan include harvesting rainwater for indoor use and retro-fitting GPTs on two large offsite catchments that drain onto the site.

Providing the recommendations of this Plan are implemented the development satisfactorily addresses the required water quality goals.

Note that issues of riparian management and onsite detention are discussed by others.

8 References / Bibliography

ANZECC/ARMCANZ (2000). Australian Water Quality Guidelines for Fresh and Marine Waters.

Chapman, G.A. and Murphy, C.L. (1989). *Soil Landscapes of the Sydney 1:100,000 sheet.* Soil Conservation Service of N.S.W., Sydney.

Chapman, G.A., Murphy, C.L., Tille, P.J., Atkinson, G., and Morse, R.J. (1989). Soil Landscape Series Sheet 9130 Sydney. Soil Conservation Service of N.S.W.

Department of Environment and Climate Change (DECC) (2007a, draft). Managing Urban Stormwater: Environmental Targets (Consultation Draft, October, 2007).

Department of Environment and Climate Change (DECC) (2007b, draft). Managing Urban Stormwater: Treatment Techniques (2nd Edition, Consultation Draft, October, 2007).

Healthy Rivers Commission (2002). *Coastal Lakes; Independent Inquiry into Coastal Lakes* Final Report. Healthy Rivers Commission of New South Wales.

Institute of Engineers, Australia (2007). *Australian Rainfall and Runoff - A Guide to Flood Estimation.* September 2007.

J M Daley and Associates P/L (2004). *Oxford Falls retirement Resort. Stormwater Concept Plan*. September 2004.

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

Macleod, A.P. (2008). "Music Calibration Based on Soil Conditions." NSW and Qld SIA Stormwater 2008 Conference Proceedings.

Melbourne Water (2005). *WSUD Engineering Procedures: Stormwater.* CSIRO Publishing.

SCA (2009). *A Guide to the Use of Music in Sydney's Drinking Water Catchments*. DRAFT.

Warringah Council (2004). Warringah Creek Management Study, March 2004.

Water Services Association of Australia (WSAA) (1999). *Affordable Water Supply and Sewerage for Small Communities.* ARMCANZ, Crown Copyright.

9 Appendices

9.1 Appendix 1: Rainwater Tank Modelling

To determine the most economical rainwater tank volume we have used an in-house tank simulator knows as TANKSIM. TANKSIM uses daily rainfall data to model the performance of various tank volumes. Here we used daily rainfall data for Frenchs Forest for about 45 years. We assumed a daily load of 50 kL (Section 5.1) [8]. The results are given below and show a 2 ML tank would meet 90 percent of its demand.

TankSim Rainwater Tank Simulation

Page 1

TankSim built by: SEEC Morse McVey www.seec.com.au

PROJECT DETAILS

Client name:	Tiffany Developments	
Address:	Oxford Falls	
Select closest rainfall station:	Frenchs Forest	
Avg annual rainfall:	1394.4	mm/year
No of years of data:	44.6	years
Longest dry spell:	50	days
Roof area:	21500	square metres
Estimated daily demand 1:	50000	L per day
Reduce demand 1 by season:	N	Y or N
Apply demand 1 on wet days:	Y	Y or N
Estimated daily demand 2:	0	L per day
Reduce demand 2 by season:	N	Y or N
Apply demand 2 on wet days:	N	Y or N
Revert to mains:	N	Y or N
Mains reversion threshold:	10	%
Avg annual total demand on tank:	18255605	L/year

COMPARE THE FOLLOWING TANKS

Tank 1:	1000000	L
Tank 2:	2000000	L
Tank 3:	3000000	L
Tank 4:	4000000	L

MODELLING PROPERTIES

Initial loss (mm) per day:	0.3	mm/day
Runoff coefficient:	0.95	

DAILY DEMAND

Month	Month No	Factors	Demand 1	Demand 2	
January	1	1	50000	0	L per day
February	2	0.9	50000	0	L per day
March	3	0.8	50000	0	L per day
April	4	0.6	50000	0	L per day
May	5	0.3	50000	0	L per day
June	6	0.1	50000	0	L per day
July	7	0.1	50000	0	L per day
August	8	0.2	50000	0	L per day
September	9	0.4	50000	0	L per day
October	10	0.6	50000	0	L per day
November	11	0.8	50000	0	L per day
December	12	1	50000	0	L per day

TankSim built by SEEC (Strategic Environmental and Engineering Consulting). Tel. 02 4862 1633. www.seec.com.au

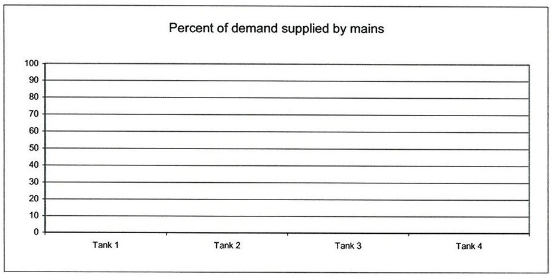
8 We also checked whether a larger tank would be able to supply a greater demand e.g. 76 kL/day (being 40 percent of demand). In this case a 5 ML volume would meet 81 percent of its demand.

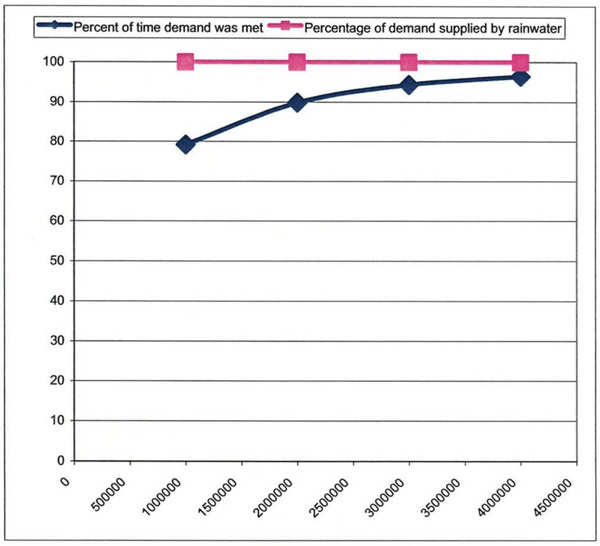
TankSim Rainwater Tank Simulation

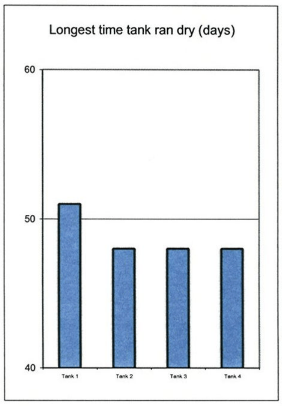
Page 2

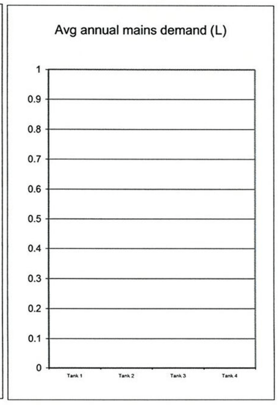
RESULTS

	Tank 1 1000000 L	Tank 2 2000000 L	Tank 3 3000000 L	Tank 4 4000000 L
% of time demand met:	79.14	89.76	94.27	96.39
% of demand from mains:	0	0	0	0
% of demand from rainwater:	100	100	100	100
Longest time tank ran dry:	51	48	48	48
Avg annual mains demand:	0	0	0	0



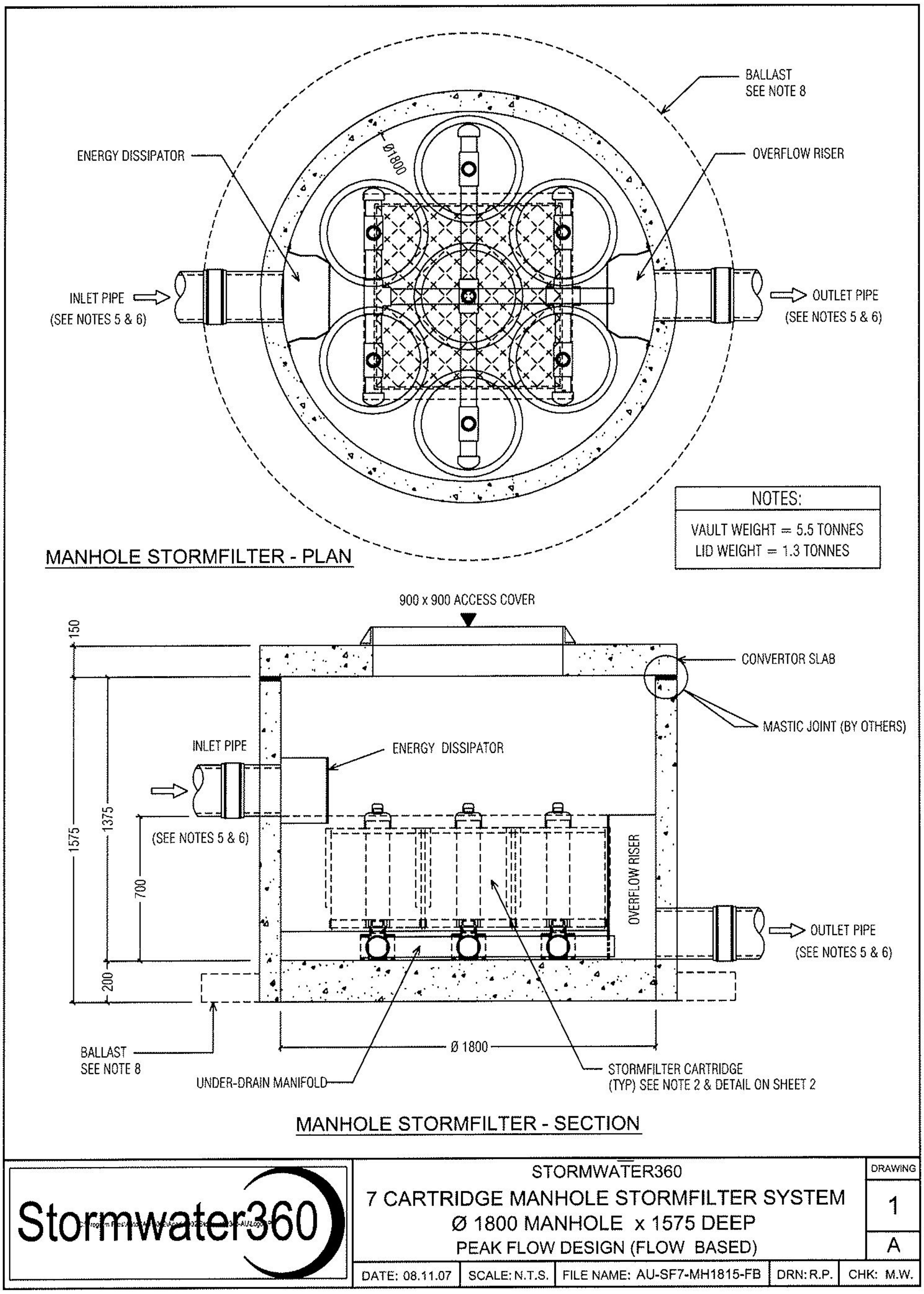


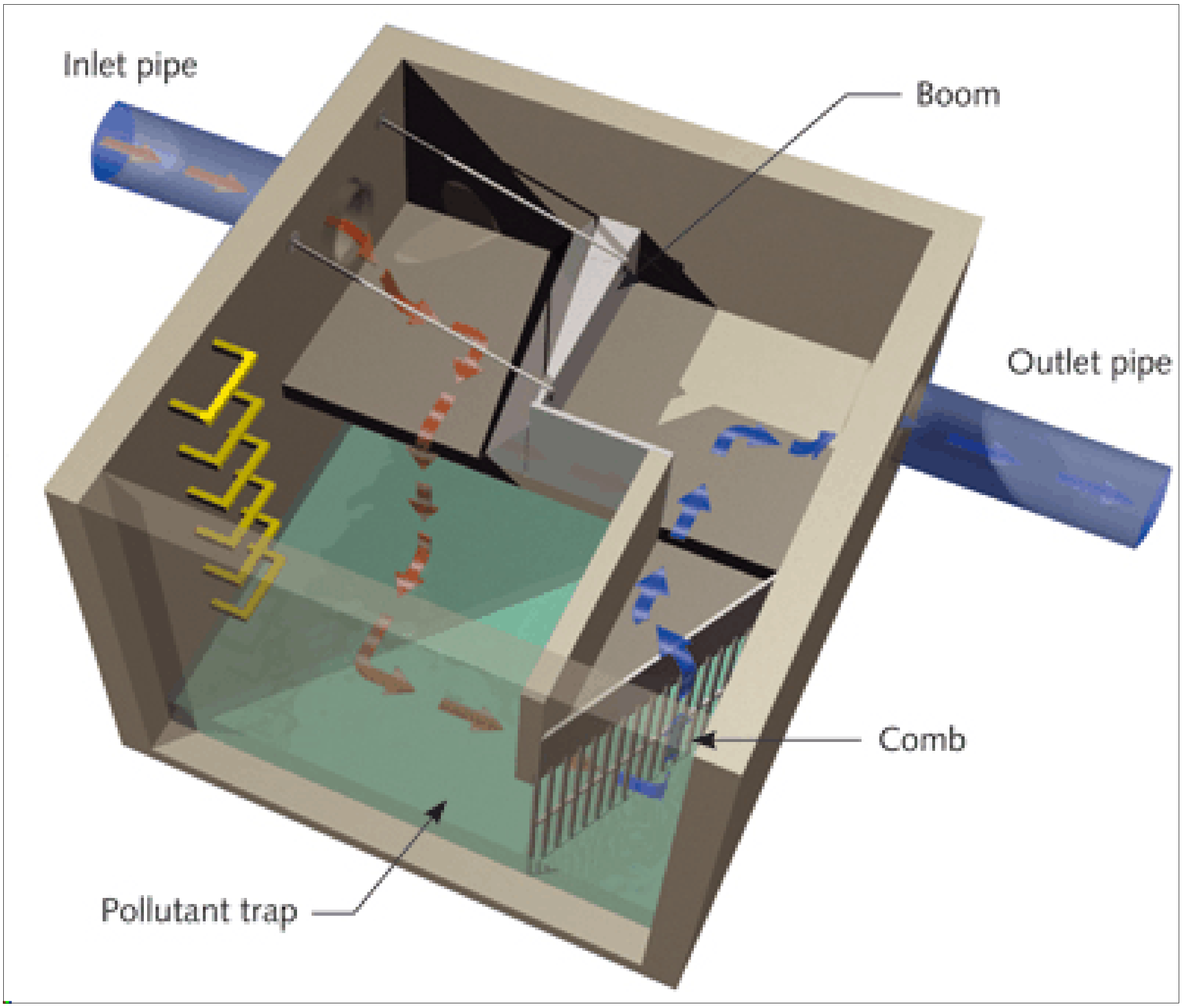




TankSim built by SEEC (Strategic Environmental and Engineering Consulting). Tel. 02 4862 1633. www.seec.com.au

9.2 Appendix 2 – Stormfilter (Stormwater 360) and Humeguard (Humes)





Schematic of Humes' Humegard GPT.

9.3 Appendix 3: Universal MUSIC Calibration

Table 4 presents the universal settings used for calibrating the event mean concentrations (EMCs) for roofs. They are derived from SCA, 2009.

Table 4 Stormflow concentration calibrations used in MUSIC at this site

	TSS mean (log mean)	TSS std dev (log std dev)	TP mean (log mean)	TP std dev (log std dev)	TN mean (log mean)	TN std dev (log std dev)
Roofs	20 (1.3)	2.1 (0.320)	7.8 (-0.89)	1.8 (0.25)	1.78 (0.25)	1.55 (0.19)
Road	269 (2.43)	2.1 (0.32)	0.5 (-0.30)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)
Agricultural land	141 (2.15)	2 (0.31)	0.6 (-0.22)	2 (0.3)	6.31 (0.48)	1.82 (0.26)
Commercial	141 (2.15)	2.09 (0.32)	0.251 (-0.6)	1.78 (0.25)	2 (0.3)	1.55 (0.19)
Urban	141 (2.15)	2.09 (0.32)	0.251 (-0.6)	1.78 (0.25)	2 (0.3)	1.55 (0.19)
Rural residential Land	89 (1.95)	2.1 (0.32)	0.22 (-0.66)	1.8 (0.25)	2.19 (0.34)	1.55 (0.19)

The pervious area characteristics for each source node are calibrated based on a sandy loam soil with a 500 mm rooting depth (SCA, 2009). Calibration is as shown in Table 5.

Table 5 Pervious area calibrations used in MUSIC

	Value
Soil storage capacity	98 mm
Initial storage	30 %
Field capacity	70 mm
Infiltration capacity coefficient	250
Infiltration capacity exponent	3
Groundwater initial depth	30 mm
Daily recharge rate	60%
Daily baseflow rate	45%
Daily deep seepage rate	0%