Appendix 2
Water Sensitive Urban Design Report

Cardno Willing

Shaping the Future

Integrated Water Cycle Management Plan

Stage 1 and 2 Salamander Waters Estate, Salamander Bay

Hill PDA

MAY 2007 JOB NO. 4681

HILL PDA

Integrated Water Cycle Management Plan for Stage 1 and 2 Salamander Waters Estate, Salamander Bay

Final Report

May 2007

Client	HIllPDA			
Document	Integrated Water Management Plan for Stage 1 and 2 Salamander Waters Estate, Salamander Bay			
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The aerial photo on the front page of this report is Salamander Waters Estate.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff (1999 edition)
ARQ	Australian Runoff Quality (2005 edition)
ML	Mega litre (one million litres)
MUSIC	Water Quality program
OSD	On-Site Detention
XPRAFTS	Rainfall/runoff program
XPSWMM	Unsteady one dimensional (1D) flood routing program

1. INTRODUCTION

Port Stephens Council is the owner of the proposed subdivision known as Salamander Waters Estate at Part Lot 59 DP 8312563, 360 Soldiers Point Road, Salamander Bay, NSW. The site is divided into Stage 1 and Stage 2 (see **Figure 1**).

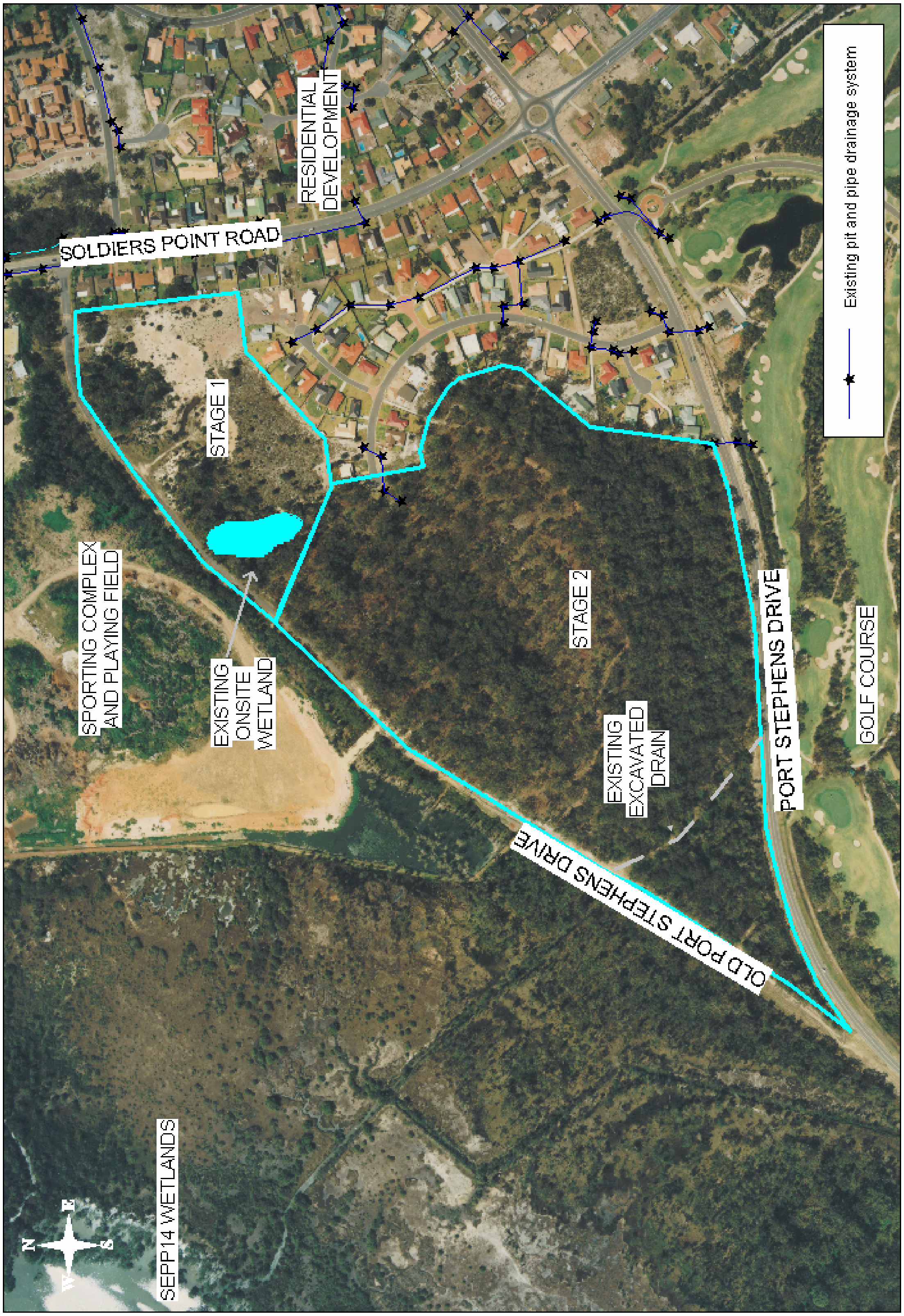
The site is surrounded by residential development to the east, a golf course and residential development to the south, a strip of woodlands and a newly established sporting complex and playing field to the north (former Salamander Bay Waste Disposal Centre), and wetlands listed under SEPP 14 to the north west.

The Director General's Requirements (dated 6/07/06) in relation to Water Cycle Management for Stage 1 and Stage 2 are detailed below:

- Assess direct and indirect impacts of the development on the adjoining SEPP 14 wetland areas. This must illustrate that no additional storm water runoff is to be directed to any SEPP 14 or unmapped wetland areas.
- Address the requirements of the relevant flooding data in relation to minimum floor levels.
- Provide an Integrated Water Cycle Management (IWCM) Plan based upon Water Sensitive Urban Design Principles.

This IWCM Plan has been prepared to ensure that the drainage, flooding and stormwater quality objectives are met as defined by Port Stephens Council and the Director Generals Requirements.

Figure 1
Site Location and Proposed Development Stages



2. AVAILABLE INFORMATION

2.1 Previous Study

In May 2005, Cardno Willing prepared a WSUD Concept Report for the Stage 1 and 2 of the development.

The treatment systems proposed in this study were designed to reduce post development pollutant loads to predevelopment levels. The predevelopment water quality and quantity levels were analysed using a MUSIC water quality model and XPRAFTS hydrological model to assess the scenarios.

Since the May 2005 report the development concept was modified and as such this report details revised modelling.

2.2 Rainfall

Rainfall Intensity-Frequency-Duration (IFD) data was generated based on the method outlined in Australian Rainfall and Runoff (Engineers Australia, 1999) (see **Table 1**).

Six minute rainfall data was obtained from the Bureau of Meteorology Office for the Williamtown rainfall gauge (Station No 061078) located approximately 30 km southwest of the site.

Table 1

IFD Data for Salamander Bay

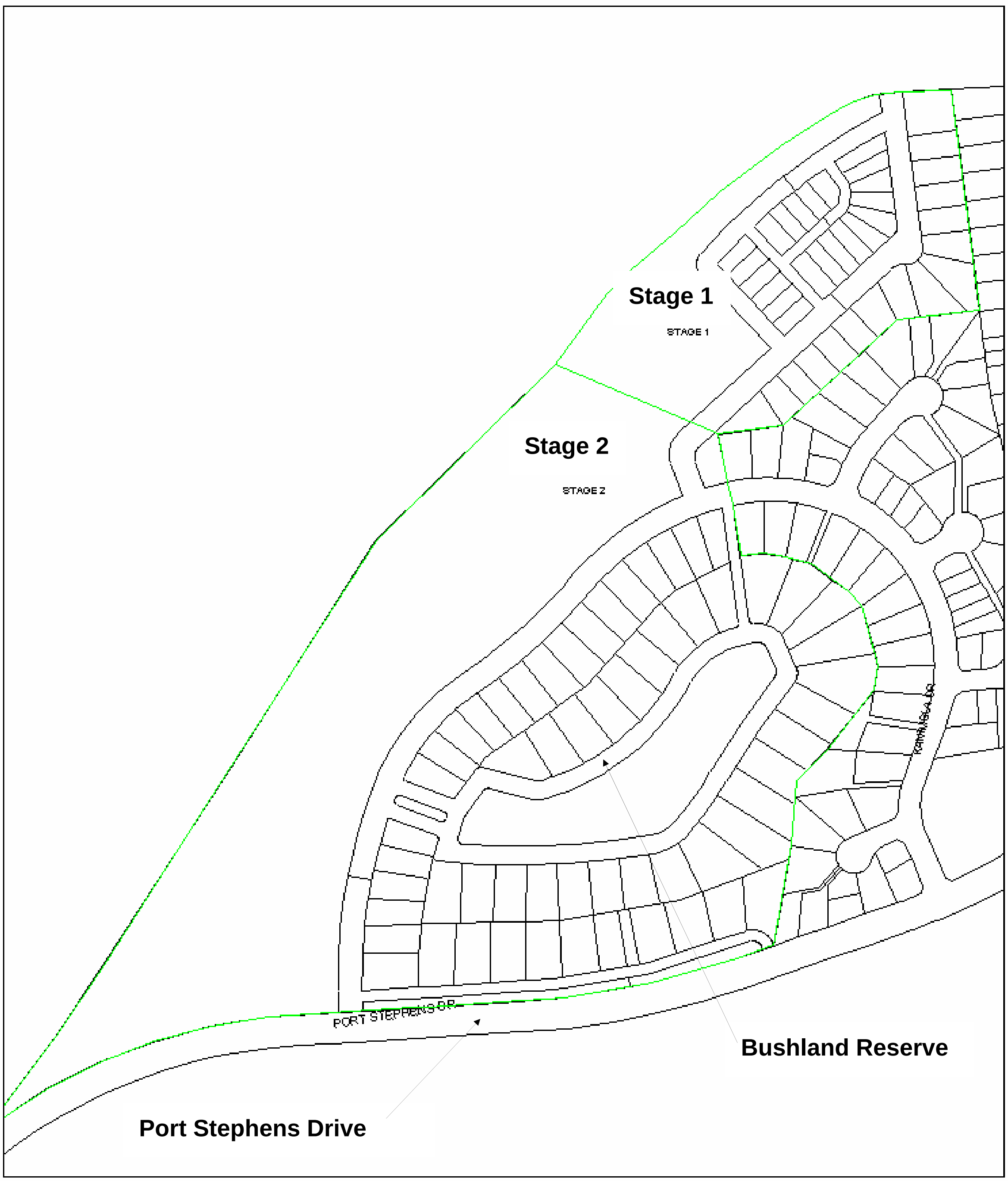
Duration	**ARI (years)**						
(mins)	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5	89	114	145	163	187	218	241
10	68	88	112	126	144	169	187
15	57	73	94	106	121	142	157
20	49.7	64	82	92	106	124	138
25	44.5	57	73	83	95	111	124
30	40.4	52	67	75	87	102	113
540	6.51	8.45	11.1	12.7	14.7	17.4	19.5
720	5.39	7.00	9.22	10.5	12.2	14.5	16.2

2.3 Concept Development Layout

The adopted lot layout for this report was provided by Hill PDA on 26/04/07. This layout is presented in **Figure 2.**

Figure 2

Development Layout



3. SITE CHARACTERISTICS

3.1 Site Details

The proposed subdivision applies to land that forms Stage 1 and 2 of Salamander Waters Estate located off Soldiers Point Road, Salamander Bay. The subject site is bounded by the old Port Stephens Drive to the north and Port Stephens Drive to the south (see **Figure 2**).

The proposed indicative development area for Stage 1 and Stage 2 is 4.3 ha and 16.4ha respectively. The site is surrounded by residential development to the east, a golf course and residential development to the south, a strip of woodlands and a newly established sporting complex and playing field to the north (former Salamander Bay Waste Disposal Centre), and wetlands listed under SEPP 14 to the north west.

Stage 1 has a mixture of native and exotic plants. Much of Stage 1 has been disturbed due to previous sand mining activities. A small wetland currently exists in Stage 1 (see **Figure 1**) known as a Lepironia Swamp, Sydney Freshwater Wetland. This wetland is likely to receive water from the groundwater.

The majority of Stage 2 is undisturbed moderately dense bushland.

The site is zoned 2(a) residential under Port Stephens Local Environmental Plan 2000.

The land in Stage 1 falls from the southern portion (12m AHD) of the site to the north western boundary (4m AHD). In Stage 2 the ground surface generally falls toward the north west with surface elevations ranging from 38m AHD on the central northern portion to 6m AHD on the north western boundary.

Geotechnical assessments were prepared for Stage 1 and Stage 2 by Douglas and Partners (Douglas and Partners, 2005a and 2005b). The following findings were reported:

> *"The ground conditions typically comprise of a thin silty sand topsoil layer, overlying loose sand.*
>
> *It appears that Stage 1 has been subject to uncontrolled filling subject to sand mining. Council suggested that the fill was material excavated during construction of the salamander shopping centre.*
>
> *The site is expected to be underlain by an unconfined sand aquifer. In Stage 2 groundwater flowing on the site would be expected to occur from the central crest of the site to the surrounding lower lying areas, including the adjacent former Salamander Bay Waste Disposal Centre.*

Shallow groundwater exists on the southern portions of the site in Stage 2. There is a drain running along the southern portion of the site which is expected to be hydraulically connected to the surrounding groundwater levels (see Figure 1).

A number of localised excavations near the drain indicated that the ground level is similar to the water level in the drain which is approximately 6m AHD.

From a geotechnical perspective the site is considered suitable for residential developments subject to appropriate engineering design and construction".

3.2 Site Opportunities and Constraints

The site opportunities and constraints to the implementation of WSUD are:

C*onstraints*:

- Offsite SEPP 14 Wetland;
- Limited opportunity for some lots to access drainage corridors;
- Steep surface grades that may lead to excessive erosion if not appropriately managed; and
- High groundwater table that may interact with potential water quality ponds. Detailed assessment of the depth to groundwater is recommended prior to construction.

Opportunities:

- Highly permeable sandy soils suitable for local disposal of excess runoff;
- Adequate area within the Asset Protection Zone for the construction of swales and water quality ponds;
- Sloping terrain that provides adequate grade for the design of stormwater drainage systems; and
- Many lots and roads border the APZ that can easily drain to proposed WSUD measures located within the APZ zone.

4. LEGISLATION

4.1 SEPP 14 Coastal Wetlands

The SEPP 14 Coastal Wetlands Policy has been made under the Environmental Planning and Assessment Act 1979 to ensure that wetlands are preserved and protected in the environmental and economic interest of the State.

Wetlands are ecologically, economically and socially important systems that provide many and varied services and functions. They are able to support plants and animals not found elsewhere and provide important breeding and nursery areas.

Wetlands listed under SEPP 14 (Wetland 766) are located to the north west of the site.

There are existing wetlands on the site, however, they are not classified under SEPP 14, and therefore the SEPP 14 provisions do not apply. The Ecological Assessment prepared by ERM concluded that although the larger of the wetlands on the site in Stage 1 appears to be natural, the smaller ponds on the site are likely to have been created during sandmining activities.

4.2 SEPP 71 Coastal Protection

SEPP 71 Coastal Protection Policy has been made under the Environmental Planning and Assessment Act 1979 to ensure that development in the NSW coastal zone is appropriate and suitably located. This Policy also provides a clear development assessment framework and a consistent strategic approach to coastal planning and management.

The 1997 Coastal Policy sets out the direction for management, planning and conservation of the coastal zone in NSW. It is required under SEPP 71 that consent not be granted for specific types of subdivision development in the coastal zone unless there is an adopted master plan or the Minister for Planning has waived the need for a master plan.

Part 3A of the Environmental Planning and Assessment Act was introduced to deal with matters of State development. Those areas designated as Coastal lands, covered by a State policy by definition, were of State significance.

Consequently, the subject development being of more than 25 lots and in the coastal lands area will be processed using Part 3A Provisions.

5. WATER MANAGEMENT OBJECTIVES

5.1 Drainage and Flooding

The objectives for drainage and flooding include:

- All building development is to be at least 0.5 m above the 100 Year ARI flood level;
- Nuisance flooding of roads and dwellings is to be avoided;
- Depths and velocities of overland flows are to be kept to safe levels in accordance with normally adopted industry/SES safety criteria; and
- Peak flows rates up to the 100 year ARI flood event to be no greater than existing conditions in order to protect the downstream ecosystem.
- The additional volume of runoff generated by the development and flowing onto neighbouring areas to be minimised were practical.

5.2 Water Quality

Stormwater treatment objectives were established by the NSW EPA in the 1997 Draft Managing Urban Stormwater: Council Handbook. These objectives include:

- 85% retention of the average annual load of TSS;
- 45% retention of the average annual load of TN;
- 45% retention of the average annual load of TP;

The stormwater quality objective for this site is to reduce post-development pollutant exports to levels no greater than existing conditions which is better than the above mentioned current best practise objectives.

5.3 Water Reuse

The objective for water re-use is to achieve significant savings of potable water in accordance with the BASIX requirements.

The NSW Government introduced BASIX in 2004 to ensure that designs for new dwellings meet targeted reductions in potable water and greenhouse emissions. A potable water savings of up to 40% (depending on the location in NSW) is required for all new developments. BASIX generally requires the inclusion of an alternative water supply source such as rainwater, stormwater or groundwater.

Potable water can be conserved by incorporating measures listed in **Section 8**.

6. PROPOSED DEVELOPMENT

The site is proposed to be redeveloped for residential use. Stage 1 development comprises:

- 34 residential dwellings;
- access roads;
- community spaces;
- wetland/ detention systems;
- grass areas; and
- preservation of the existing on-site wetland.

All building development is to be at least 0.5 m above the 100 Year ARI flood

Stage 2 development comprises:

- 60 residential dwellings;
- access roads;
- community spaces;
- wetland/ detention systems;
- grass areas; and
- preservation of existing bush in a reserve on the top of the hill.

The proposal provides a conventional internal road system to service the residential lots. The indicative layout of the proposed development is given in **Figure 2**.

7. WATER MANAGEMENT PLAN

A strategy has been developed to minimise impacts on the downstream receiving waters.

The strategy for Stage 1 was assessed using hydrological, hydraulic and water quality models. A concept strategy was developed for Stage 2 that was based on the results of the Stage 1 modelling.

The strategy includes incorporating measures to remove metals and pathogens as well as sediment. Removal of these pollutants are critical in protecting the downstream wetland ecosystem.

Both phosphorous and metals are largely in particulate form. Biofiltration and infiltration systems as well as wetlands are proposed to be incorporated at the site for both Stage 1 and 2. Biofilters contain a solid based filtering media, planted with vegetation and a collection pipe system. The media within biofilters can be modified to target specific pollutants. The vegetation improves sedimentation, protects the biofilters from erosion, increases evapotranspiration and maintains soil porosity. The surface of the root system is a highly biologically active zone that plays an important role in removing soluble pollutants.

Stormwater runoff from Stage 1 and 2 is proposed to be directed into a system of infiltration trenches and or bio retention swales which allow stormwater to recharge the underground aquifer and filter nutrients and organic mater from the storm water.

Sustainable strategies for Stage 1 and 2 include:

- Incorporation of a stormwater system which recharges the local aquifer.
- Design of swale/bioswale systems that divert stormwater to a central location and remove run-off pollutants prior to leaving the site (see **Figure C.3** in **Appendix C**). Tree biofilters in the roads to treat runoff (see **Figure C.4 and C.5** in **Appendix C**).
- Incorporation of wetlands to treat the stormwater runoff (see **Figure C.6 and C.7** in **Appendix C**).
- Rainwater tanks to capture and reuse rainwater for each lot.
- For Stage 2 the establishment of an infiltration system for each dwelling based on the “Atlantis” cell system or similar (see **Figure C.1 and C.2** in **Appendix C**). These cells operate similar to the inter allotment pits for the residential allotments. They collected the roof water runoff from the dwellings and recharge the freshwater aquifer beneath the surface.
- Incorporation of native plant species which due to their suitability for the coastal environment have minimal water requirements.

8. WATER QUALITY ASSESSMENT FOR STAGE 1

8.1 Objectives for Stage 1

For Stage 1 the water quality was assessed using MUSIC water quality modelling software.

The aims of the modelling were to assess the:

- impacts of the proposed Stage 1 development on stormwater quality; and
- estimate the size of water quality treatment measures to reduce post-development pollutant loads to levels no greater than existing conditions.

The various adopted MUSIC and model parameters are outlined in **Appendix B**. **Figure 3** shows the subcatchments and subcatchments ID used in the MUSIC modelling.

The assessment undertaken in the Stage 1 study forms the basis for the sizing of the water quality treatment systems in Stage 2.

8.1.1 Water Quality elements for Stage 1

WSUD elements for Stage 1 is summarised in **Table 2** and consists of the following design elements (see **Figure 4**):

1. Constructed water quality wetland comprising a permanent water body (540m^3) and an extended detention capacity (882m^3) via a higher flow capacity outlet. This element provides:
    - incorporation of surrounding naturally occurring features;
    - bio-diversity of the environmental corridor;
    - treatment of runoff reaching the offsite SEPP 14 wetlands;
    - treatment of captured runoff prior to it reaching the groundwater table;
    - recharging groundwater to counteract the impervious effects on the local groundwater regime:
    - flood detention limiting the effects of high flows;
    - additional habitat for local wetland flora and fauna species;
    - a low maintenance solution utilising the existing water table level to maintain plant health and diversity; and
    - an excellent entry statement to the development, creating an aesthetically pleasing, contiguous connection to the surrounding environment.

2. Vegetated biofiltration swales (700m^2) and infiltration trenches (70m^2) that promote stormwater infiltration. This element provides:

- improved water quality by filtering out sediments and a reduction in dissolved nutrients via plant uptake;
- reduced overland flows by allowing infiltration. Low flows are encouraged to seep into the surrounding soils; and
- low maintenance planting regime.

3. Self watering tree biofiltration for every second lot not facing the APZ. This element provides:
   - part treatment of frequent low flows;
   - positive visual impact;
   - aesthetic community appeal;
   - reduces watering requirements for trees; and
   - high flow bypass into stormwater pipes.

4. Rainwater Tanks with a volume of 5000L for outdoor, toilet and laundry use. Assumed water usage rates were approximately 400L/lot/day. Rainwater tanks:
   - reduce total potable water demand and should be used in conjunction with water efficient appliances and fixtures. Typically the tank supply is for outdoor, toilet and laundry use. Captured stormwater can also be use for hot water systems.
   - assist in reducing the volume of stormwater runoff leaving the site; and
   - comply with BASIX requirements.

Table 2

WSUD Elements

WSUD Element	Sub-Catchment*	Details
Bioswale	C9	Filtration Area 500m^2, Depth 0.6m.
Wetland	C1	Area 300m^2, Depth 0.6m
Infiltration Trench	C1	Area 10m^2 , Infiltration rate 20mm/hr
Wetland	C8	Wetland 600m^2, Depth 0.3m
Bioswale	C8	Filtration area 200m^2
Infiltration Trench	C7	Area 60m^2, Infiltration rate 20mm/hr
Wetland	C7	Area 600m^2, depth 0.3m, invert level 2.5m AHD, 0.75m pipe outlet

*See **Figure 3** for subcatchment locations and subcatchment names

8.1.2 Assessment of Measures for Stage 1

Water quality treatment systems have been designed to minimise pollutant loads leaving the site to below estimated pre-development levels. The proposed water quality elements are detailed in **Section 8.1.1** and include wetlands with extended detention, tree bio-filters, a bioswales and infiltration systems. The treatment system was modelled using a MUSIC water quality model. The average annual loading at the existing natural wetland and the remaining flow at the outlet of the site for pre and post development scenarios are shown in **Table 3.**

Table 3
Average Annual Pollutant Exports to the Existing Onsite Wetland and Site Outlet for Existing and Proposed Scenarios

Parameter	Existing to Wetland	Future to Wetland	% Diff	Existing Outlet	Future Outlet	% Diff
Runoff (ML/yr)	1.90	1.92	1%	4.31	4.28	-1%
TSS (kg/yr)	178	14.7	-92%	982	35.4	-96%
TP (kg/yr)	0.18	0.181	-1%	0.397	0.225	-43%
TN (kg/yr)	1.54	2.67	73%	5.2	4.08	-22%
Gross Pollutants (kg/yr)	26.8	0	-100%	42.1	0	-100%

The results of the modelling indicate that the post development export loads are better than pre development levels at the outlet of the site. As such the proposed development for Stage 1 was found to not deprive or flood the downstream groundwater dependent SEPP 14 wetlands.

The existing on site wetland is not classified under SEPP 14, and therefore the SEPP 14 provisions do not apply. A 1% increase in runoff to the on site wetland is within the limitations of modelling accuracy and is considered as effectively the same as under existing conditions. The concept ensures similar flows are reaching the on site wetland to maintain the hydrological balance.

9. STAGE 1 FLOOD BEHAVIOUR

9.1 Hydrological and Hydraulic Modelling

Estimates of runoff from Stage 1 of the site under design storms were obtained using XPRAFTS rainfall/runoff model. Estimates of peak flood levels and peak flows were obtained using the XPSWMM flood routing program.

9.1.1 Hydrology

The aims of the current hydrological analysis were to:

- Determine the 1, 5 and 100 year ARI event flood hydrographs under existing and future conditions (without controls);

9.1.2 Hydraulics

The aims of the hydraulic analyses were to:

- Construct an XPSWMM model of the proposed Stage 1 detention basins
- Estimate flows for the 1, 5, and 100 year ARI under existing and future conditions.

9.1.3 Stage 1 Results

Future detention systems are proposed above the water quality pond in subcatchment C7 and subcatchment C1 as well as within the natural depression in subcatchment C8. The subcatchment delineation for Stage 1 is provided in **Figure 3**.

The stage storage relationship for subcatcment C8 was extracted from recent survey and is shown in **Table A.4.**

Figure A.3 shows the layout of the proposed stormwater drainage system. A summary of the estimated peak discharges for the 1, 5 and 100 year ARI event at the outlet to the natural wetland (Nout) and the remaining site (Wout) under existing and developed conditions is shown in **Table 4**.

Table 4
Summary of Peak Discharges for Stage 1

100 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node*	Existing (m^3/s)	Dur.** (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.80	1.5hr	1.37	1.5hr	0.51	2hr
Wout	0.90	2hr	0.68	1.5hr	0.13	9hr
5 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node	Existing (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.31	2hr	0.71	1.5hr	0.30	2hr
Wout	0.36	2hr	0.27	1.5hr	0.07	2hr
1 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node	Existing (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.11	9hr	0.33	1.5hr	0.04	9hr
Wout	0.13	9hr	0.09	9hr	0.13	2hr

*Nout – northern site outlet
*Wout – western outlet from natural onsite wetland
**Dur. – critical duration in hours

The results indicate that the peak flows downstream of the site are less than existing conditions.

Table 5 shows the volume of proposed detention storages and the estimated 100 year ARI water level.

Table 5
Proposed Detention Storage During a 100 year ARI Storm Event

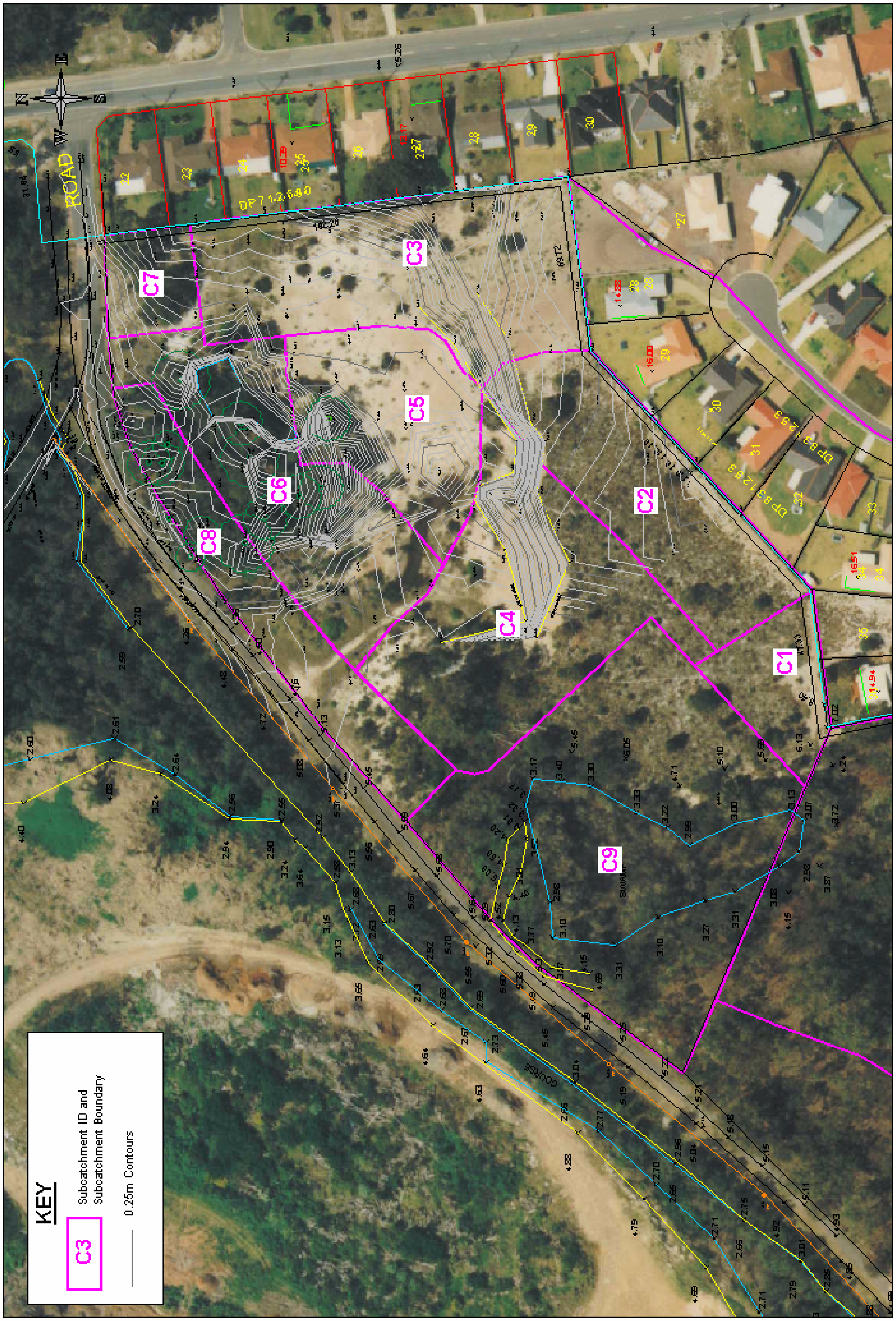
Sub catchment	Wetland Area (m^2)	Proposed Depth for Detention (m)	100yr ARI Water Level (m AHD)	Proposed Volume of Detention (m^3)
C1	300	0.04	7.54	12
C7	600	0.74	3.54*	444
C8	-	0.83	3.50*	Approx. 426
	Total			**882**

*Note in order to contain this flood level a slight bund maybe needed on the northern side of subcatchment C7 and C8.

Due to the identical nature of development for both Stage 1 and 2 the assessment undertaken in the Stage 1 study forms the basis for the sizing of the water quantity systems in Stage 2.

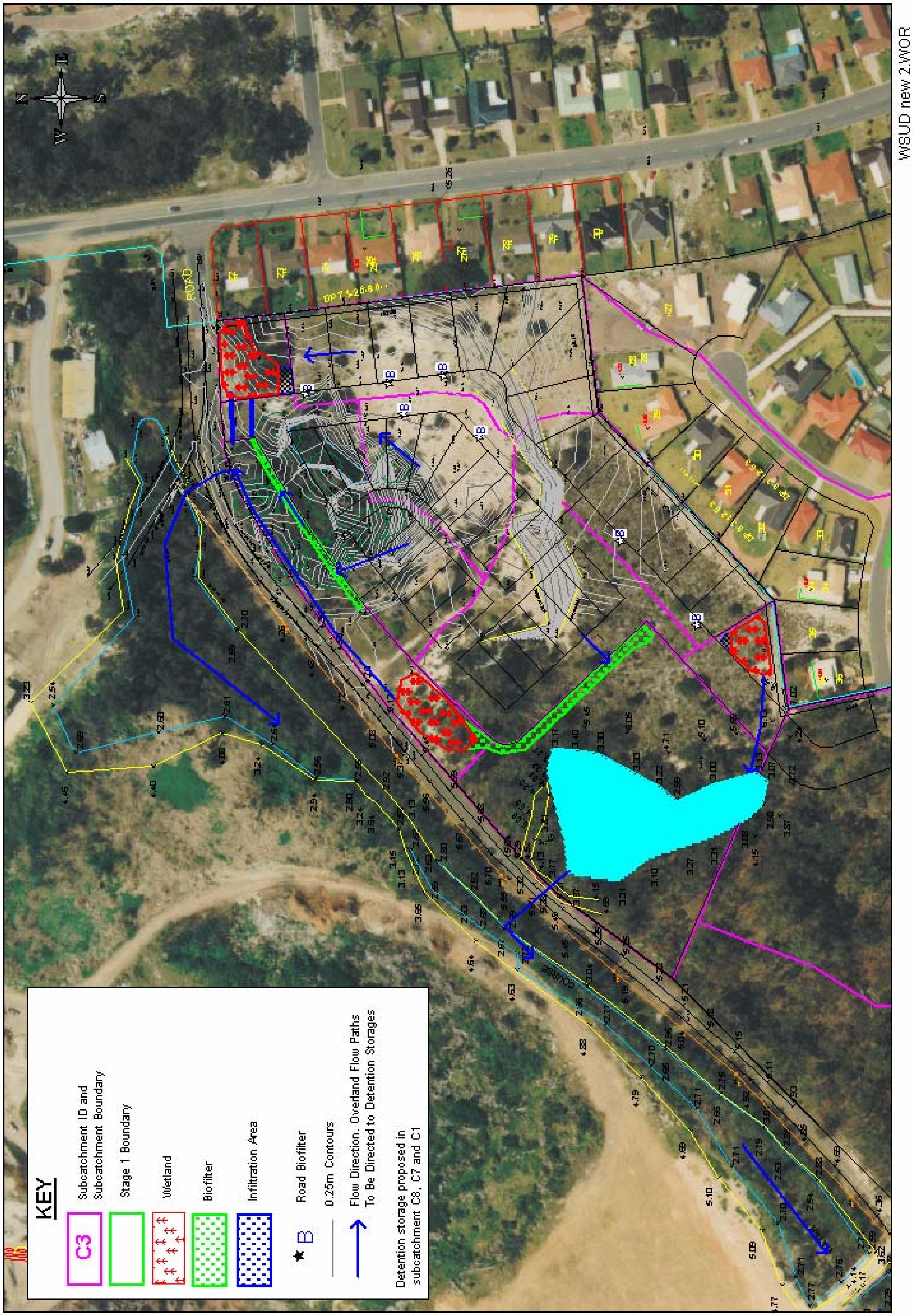
All buildings should have a freeboard of 0.5m above the 100 year ARI flood level, consistent with the NSW Floodplain Development Manual.

Figure 3
Subcatchment Delineation



Rafts Subcatchments.WOR

Figure 4
Proposed Stage 1 W SUD Elements



10. CONCEPT DESIGN FOR STAGE 2

The proposed treatment systems for Stage 2 were based on the detailed analysis undertaken for Stage 1 and modified in proportion to the increased urban development (see **Table 5**). This procedure is considered to be adequate for this concept plan and a more rigorous sizing will be undertaken at the detailed design stage.

Table 6
Water Quality and Quantity Concepts Proposed for Stage 2

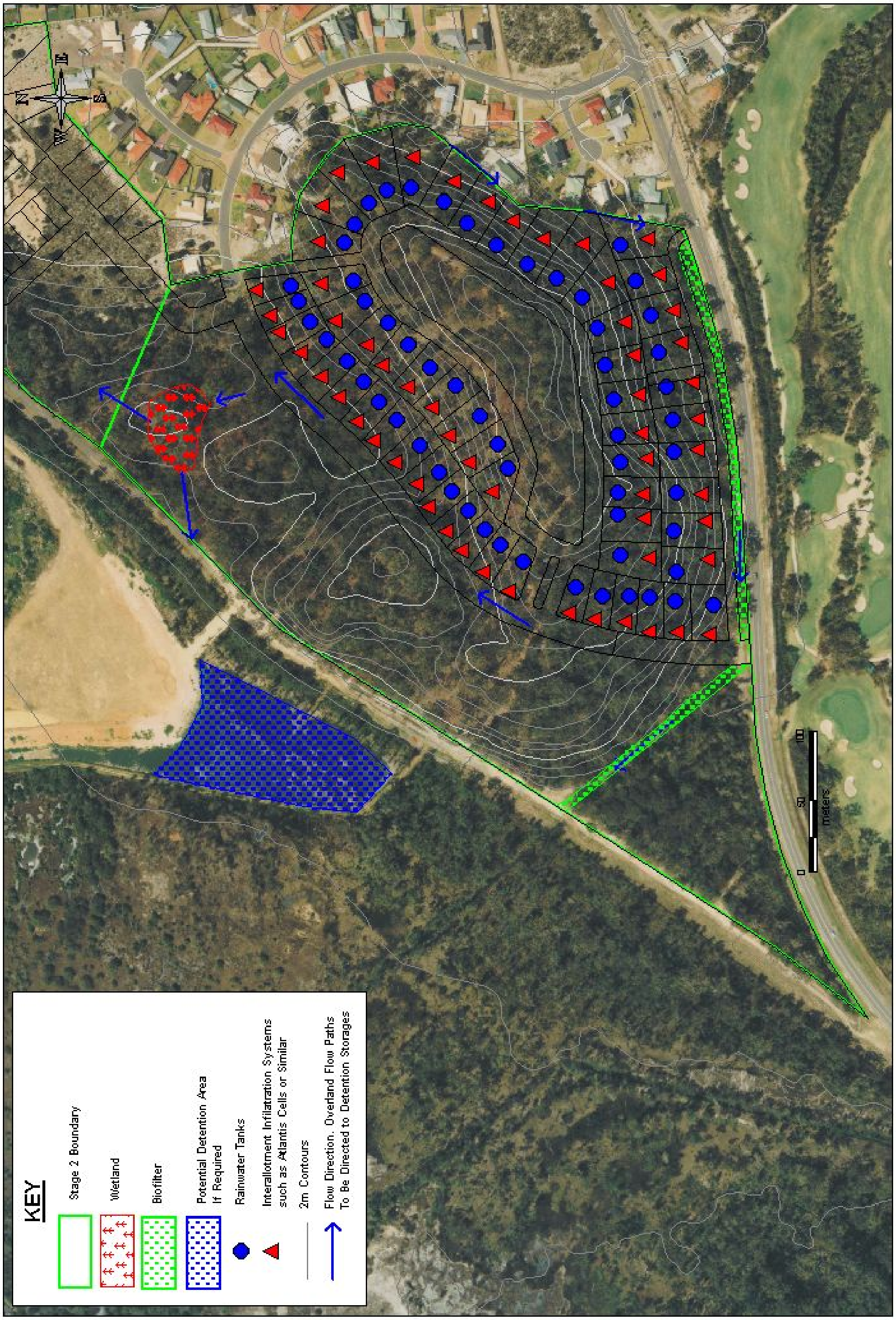
		Stage 1	Stage 2	Increased Multiplication Factor
Area of Proposed Dwellings	ha	2.03	6.4	3.16
Constructed Wetland - Permanent Capacity	m^3	540	1710	3.16
Constructed Wetland - Extended Capacity	m^3	882	2790	3.16
Vegetated Biofiltration / Swales	m^3 (total)	770	2435	3.16
Rainwater Tanks	L per lot	5000	5000	3.16

Based on the calculation presented in **Table 5** the following concept measures are proposed. An illustration of these measures are presented in **Figure 5**:

- A wetland with a permanent storage of approximately $1710m^3$ and an extended detention storage of approximately $2790m^3$.
- Inter allotment roof water pits that reduce stormwater runoff and recharge the freshwater aquifer beneath the surface. “Atlantis” cells or a similar product could be used to collect roof water runoff and recharge the freshwater aquifer beneath the surface. The appropriateness of this system is subject to the depth of the underlying bedrock. The size of these cells will be confirmed during the detailed design stage.
- Infiltration trenches and bio filtration swales that promote infiltration with a surface area of approximately $2435m^2$. The area for infiltration trenches can be met with the “Atlantis cells” or similar product mentioned above.
- Biofiltration tree pits along proposed roads.
- 5000L rainwater tanks per dwelling to be used for toilet flushing, laundry and outdoor use.

Where possible the proposed development will retain and enhance the existing vegetation at the site.

Figure 5
Proposed Stage 2 WSUD Measures



11. POTABLE WATER

11.1 Potable Water Conservation

Potable water actions provided below are designed with the intent of creating a sustainable development to comply with the requirements of BASIX.

Reduction in potable water demand is encouraged through four mechanisms. The four major sources of reducing potable water demand include:

- Rainwater tanks utilised for;
  - Toilet flushing;
  - Laundry use;
  - Outdoor needs; and if acceptable
  - Hot water.

- Water reducing fixtures;
  - Shower heads and flow reducers in taps; and
  - Encouragement to install high quality water efficient appliances.

- Directing runoff across vegetated areas;
  - Stormwater across lawns;
  - Stormwater runoff into tree bioswales; and
  - Stormwater runoff across APZ to reduce watering requirements using discontinuous kerbing.

- Reduced outdoor use;
  - Best gardening practices;
  - Native landscaping; and
  - Appropriate irrigation measures can be incorporated to reduce the reliance on potable water.

12. EROSION AND SEDIMENT CONTROL

During the construction period, an Erosion and Sediment Control Plan would be required as part of the overall Environmental Management Plan prepared for the construction phase.

The erosion and sediment control plan for the site should be prepared in accordance with the NSW Department of Housing ‘Managing Urban Stormwater’ 4th ed (2004) manual, NSW EPA ‘Managing Urban Stormwater: Treatment Techniques’ (1998) and NSW EPA’s guidelines on ‘Bunding and Spill Management’.

A construction management plan has been prepared for Stage 1 and ensures protection of the natural wetland located on Stage 1.

13. QUALIFICATIONS

It is important to recognise that any modelling studies provide only an estimate of the predicted flood levels, flows and water quality. The estimates given in the report are based on the best data available at the time of writing and the level of analysis commissioned. New data obtained in the future and/or more vigorous modelling assessments may lead to a revision of the estimates.

14. REFERENCES

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15. GLOSSARY

Annual exceedance probability (AEP)

The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a peak flood discharge of 500 m^3/s or larger occurring in any one year (see average recurrence interval).

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Average recurrence interval (ARI)

The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.

Catchment

The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.

Discharge

The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).

Flood

Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.

Freeboard

A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted flood planning level and the flood used to determine the flood planning level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such and wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change. Freeboard is included in the flood planning level.

Hydraulics

Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

Hydrograph

A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.

Hydrology

Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

Local overland flooding

Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Local drainage

Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

Mainstream flooding

Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

Major drainage

Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of the 2005 NSW Floodplain Development Manual major drainage involves:

- the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or
- water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or
- major overland flowpaths through developed areas outside of defined drainage reserves; and/or
- the potential to affect a number of buildings along the major flow path.

Mathematical/computer models

The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

Peak discharge

The maximum discharge occurring during a flood event.

Runoff

The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.

Stage

Equivalent to "water level". Both are measured with reference to a specified datum.

Stage hydrograph

A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.

Survey plan

A plan prepared by a registered surveyor.

APPENDIX A

FLOOD BEHAVIOUR

A.1 Aims

The aims of the hydrological analyses were to estimate the:

- 1, 5 and 100 year ARI flood hydrographs at the outlets under existing conditions and future conditions (without controls);
- concept size and outlet configuration for retarding basins to limit peak flows after development to no greater than peak flows under existing conditions.

A.2 Rainfall Runoff Modelling

Estimates of runoff were obtained using the XPRAFTS rainfall/runoff model.

A.2.1 The XPRAFTS Model

The features offered by XPRAFTS which are particularly suited to this study included:

- A link-node approach based on subcatchments joined by flood conveying “links”;
- Global or catchment depended input of rainfall;
- Specific features for the modelling of urbanising and urban catchments;
- Subcatchment roughness factor to characterise the full range of catchment conditions;
- A range of rainfall loss models including initial and continuing rainfall losses, proportional rainfall losses and full ARBM soil water balance model;
- Direct import of gauged rainfall and/or gauged flow data from hydrometric data archiving systems including HYDSYS and PROPHET; and
- Direct export of hydrographs for use by a range of hydrodynamic models including **XPSWMM**

A.2.2 Model Description

Based upon the existing stormwater drainage network and the natural topography, a simple XPRAFTS network was established.

A split sub catchment approach was adopted where subcatchments were divided into estimated pervious and impervious areas.

The subcatchment delineation for Stage 1 is provided in **Figure 3** and details of the subcatchments are presented in **Table A.1**.

Table A.1 Subcatchment Details
(C7, C8, C9 are non developable catchments)

ID	Comments	Total Impervious (m^2)	Total Impervious (ha)	Total Pervious (m^2)	Total Pervious (ha)	Total Area (ha)
C7	Proposed detention and wetland	600	0.06	483	0.05	0.11
C5		2492	0.25	1102	0.11	0.36
C4		4903	0.49	1603	0.16	0.65
C1	Proposed wetland	1080	0.11	505	0.05	0.16
C6		4194	0.42	1006	0.10	0.52
C3		2572	0.26	3862	0.39	0.64
C8	Proposed detention and wetland	600	0.06	2812	0.28	0.34
C2		2346	0.23	2133	0.21	0.45
C9	Natural wetland	0	0.00	10968	1.10	1.10
Total		18787	1.88	24474	2.45	4.33

Figure A.1
Existing XPRAFTS Layout

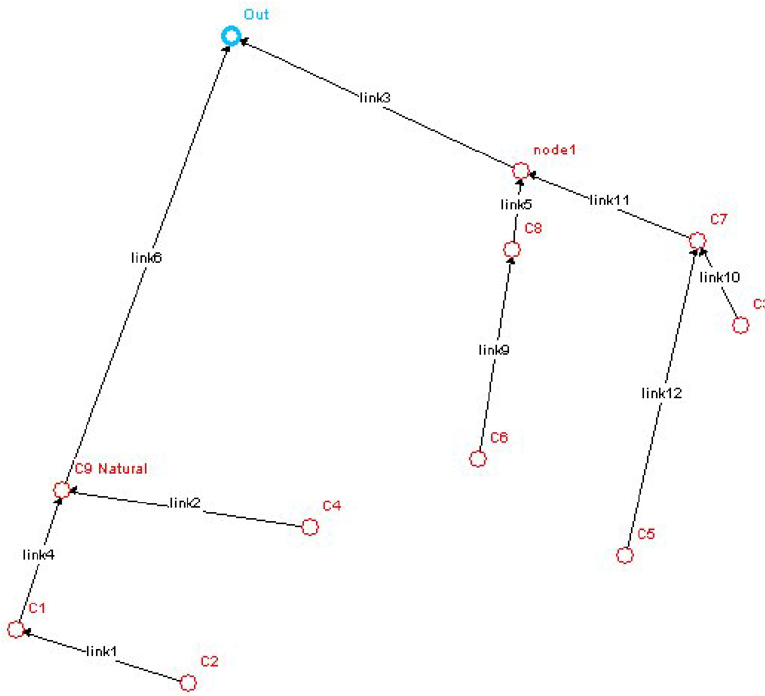
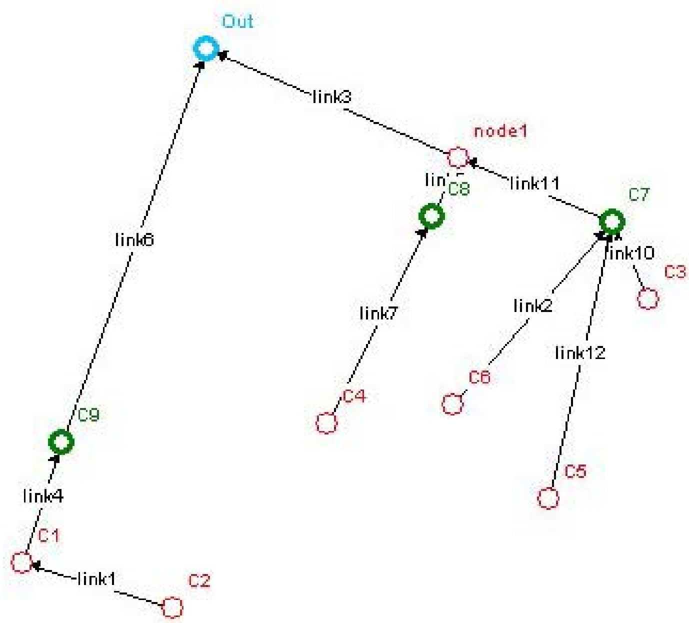


Figure A.2
Proposed XPRAFTS Layout



A.2.3 Model Parameters

Imperviousness

The area of impervious surfaces within each subcatchment was based on the surface types present in each subcatchment.

Vector Average Slope

The vector average slope for each subcatchment was estimated from the available information.

Surface Roughness

For each subcatchment, a surface roughness was entered for each surface type. The adopted surface roughness values were 0.025 for impervious surfaces and 0.06 for pervious surfaces.

Rainfall Losses

Rainfall losses were determined using an initial loss/continuing loss model. The adopted rainfall loss rates are summarised in **Table A.2**.

Table A.2
XPRAFTS Adopted Rainfall Losses for Design Floods

Surface Type	Initial Loss (mm)	Continuing Loss (mm/hr)
Impervious	1.0	1.0
Pervious	30	4.0

A.3 Design Floods

A.3.1 Design Rainfall

The IFD data was generated based on the method outlined in Australian Rainfall and Runoff (Engineers Australia, 1999). The IFD coefficients utilised are shown in **Table A.3**.

Table A.3
Design IFD parameters for the Site

Parameter	Value
2 Year ARI 1 hour Intensity	35.5 mm/hr
2 Year ARI 12 hour Intensity	7 mm/hr
2 Year ARI 72 hour Intensity	2.28 mm/hr
50 Year ARI 1 hour Intensity	70 mm/hr
50 Year ARI 12 hour Intensity	14.5 mm/hr
Parameter	**Value**
50 Year ARI 72 hour Intensity	4.55 mm/hr
Location Skew	0.0
F2	4.31
F50	16

A.4 Hydraulic Modelling

An **XPSWMM** model was constructed to assess the proposed detention system at the site. The hydrographs from XPRAFTS were imported as interface files into XPRAFTS. Analyses were undertaken for design flood events with rainfall durations ranging from 30 minutes to 36 hours. The estimated peak design flows for the 1, 5 and 100 year ARI design floods are summarised in **Table 4**.

Figure A.3 shows the layout of the proposed stormwater drainage system.

Future detention systems are proposed above the water quality pond in subcatchment C7 and subcatchment C1 as well as within the natural depression in subcatchment C.8.

The stage storage relationship for subcatcment C8 was extracted from recent survey and is presented in **Table A.4.**

Table A.4 Proposed Stage Storage in Subcatchment C8

RL (m AHD)	Area (m^2)	Volume (m^3)	Cumulative Volume (m^3)
2.8	24	0	
3	77.37	10.137	10.137
3.2	223.23	30.06	40.197
3.4	603.5	82.673	112.733
3.6	938.4	154.19	236.863
3.8	1184	212.24	366.43
4	3412	459.6	671.84
5	3412	3412	3871.6

An **XPSWMM** model was constructed for the proposed stormwater drainage at the site. The results are summarised in **Table 4**.

The model was run for the 100, 5 and 1 year ARI design storm events for a series of storm durations ranging from 1 to 9 hours. Peak discharges and water levels were estimated. The 100 and 5 year ARI design flood peak levels and discharges are shown in **Figure A.3** and **Figure A.4**.

Figure A.3
100 year ARI Design Flood Peak Levels and Discharges

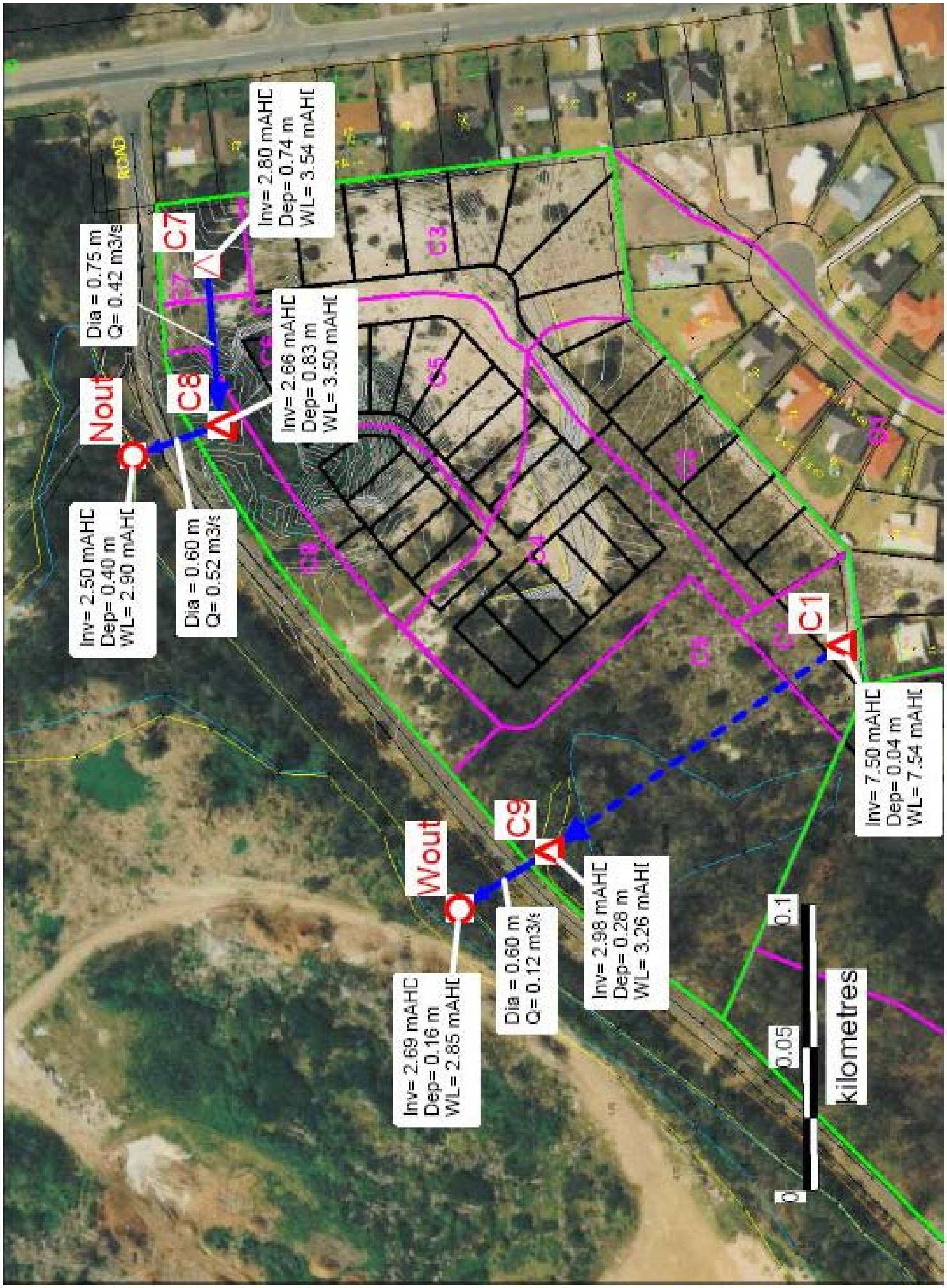
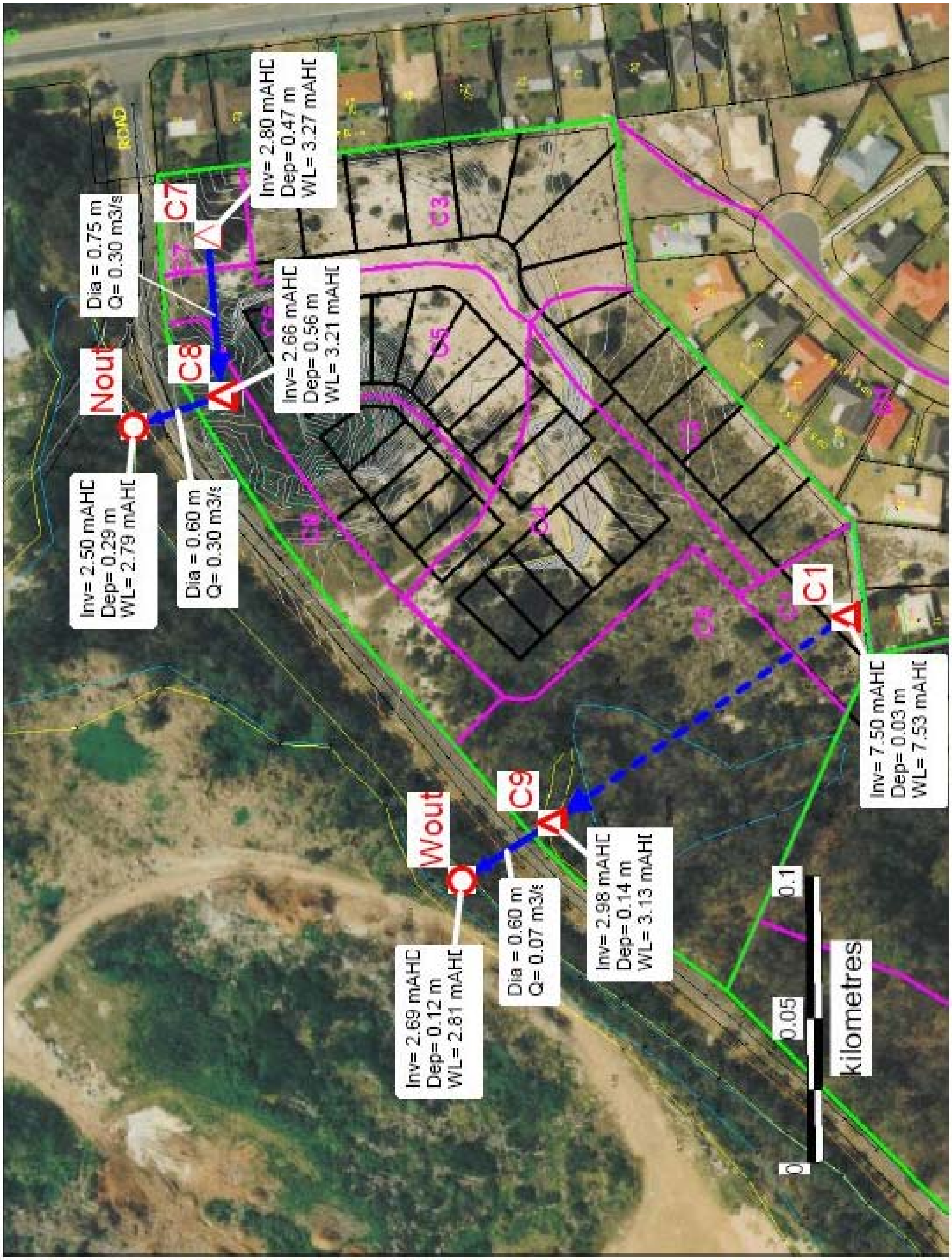


Figure A.4
5 year ARI Design Flood Peak Water Levels and Discharges



A.4.1 Results

The results presented in **Table A.5** show that the development limits the total flows leaving the site during the 1,5 and 100 year ARI event to predevelopment levels.

Table A.5
Summary of Peak Discharges for Stage 1

100 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node*	Existing (m^3/s)	Dur.** (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.80	1.5hr	1.37	1.5hr	0.51	2hr
Wout	0.90	2hr	0.68	1.5hr	0.13	9hr
5 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node	Existing (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.31	2hr	0.71	1.5hr	0.30	2hr
Wout	0.36	2hr	0.27	1.5hr	0.07	2hr
1 year ARI Design Flood			**No Treatment**		**With Treatment**	
Node	Existing (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)	Future (m^3/s)	Dur. (hr)
Nout	0.11	9hr	0.33	1.5hr	0.04	9hr
Wout	0.13	9hr	0.09	9hr	0.13	2hr

*Nout – northern site outlet
*Wout – western outlet from natural onsite wetland
**Dur. – critical duration in hours

WATER QUALITY MODELLING

B.1 Aims

The aims of the catchment based water quality modelling were to assess the:

- impacts of the proposed development on stormwater quality and pollutant exports from the site; and to
- estimate the size of water quality treatment measures to reduce post-development pollutant exports to levels no greater than under existing conditions.

B.2 Water Quality Modelling

The creation of the water quality model was undertaken in sequential steps as follows:

- pluviograph rainfall data was obtained for the Williamtown rainfall station;
- the catchment was divided into subcatchments;
- areas of each subcatchment land use were determined;
- representative baseflow and stormflow event mean concentrations (EMCs) were selected;
- the rainfall/runoff models were run and the model parameters were adjusted to give runoff rates similar to published gauged data for catchments with similar characteristics;
- various catchment models were assembled that represented both the site and the souring subcatchment that drained in to the site;
- the models were run to estimate pollutant exports under existing and future conditions (without any controls) and pollutant capture in the various measures that were considered.

B.2.1 Model Description

Classification of Surface Types

Three land use categories were adopted to represent developed urban lots including roads, roofs and community open space including natural bushland.

The existing land use categories were adopted to represent forest and disturbed areas.

Rainfall/ Runoff Modelling

Rainfall

Rainfall data was obtained from the Bureau of Meteorology Office. Six (6) minute rainfall was obtained from the Williamtown rainfall gauge (Station No 061078) located approximately 30 km South West from the site.

Evaporation
Evaporation was based on monthly pan evaporation rates recorded at Station 061078 at Williamtown were adopted, and are summarised in Table B.1.

Table B.1
Adopted Average Daily Average Pan Evaporation at Williamtown (mm)

Month	Evaporation (mm)	Month	Evaporation (mm)
January	213.9	July	80.6
February	173.6	August	108.5
March	148.8	September	138
April	114	October	173.6
May	80.6	November	189.0
June	75.0	December	226.3

Rainfall/runoff model

In the absence of direct calibration of the rainfall/runoff model against gauged runoff from the catchment, the rainfall/runoff model parameters were "calibrated" against representative annual volumetric runoff coefficients for each land use.

The adopted MUSIC treatment parameters and MUSIC parameters are summarised in **Table B.3 and B.4**.

Non Point Source Pollutant Modelling

Pollutant Exports

The adopted pollutant concentrations are shown in **Table B.2.**

Table B.2
Adopted EMCs

	Pollutant Concentrations (mg/L)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Developed Urban Lots (excluding roofs)	158	0.35	2.63
Roof	35	1.6	0.18
Natural Bushland	12.6	0.06	0.68
Disturbed Bushland	200	0.0794	1

Table B.3
Adopted MUSIC Parameters for Treatment Measures

USTM treatment nodes	Wetland Node	Infiltration Trench	Rainwater Tank Node	Road Biofilter and Biofilter
Number of CSTR cells	5	1	2	3
TSS k (m/yr)	5000	400	400	1000
TSS C* (mg/L)	6	12	12	12
TSS C** (mg/L)	6	12	-	-
TP k (m/yr)	2800	300	300	500
TP C* (mg/L)	0.09	0.090	0.13	0.13
TP C** (mg/L)	0.09	0.090		
TN k (m/yr)	500	40	40	50
TN C* (mg/L)	0.39	1	1.4	1.3
TN C** (mg/L)	1.3	1	-	-
Threshold hydraulic loading for C** (m/yr)	3500	3500	-	-
Extraction for Re-use	Off	Off	On	Off

Table B.4
Adopted MUSIC Parameters

Source nodes	**Developed Urban Lots**	**Natural Bushland**
Rainfall/Runoff Parameters		
Field Capacity (mm)	170	170
Pervious Area Infiltration Capacity coefficient - a	200	200
Pervious Area Infiltration Capacity exponent - b	1	1
Impervious Area Rainfall Threshold (mm/day)	1	1
Pervious Area Soil Storage Capacity (mm)	200	200
Pervious Area Soil Initial Storage (% of Capacity)	30	30
Groundwater Initial Depth (mm)	10	10
Groundwater Daily Recharge Rate (%)	25	25
Groundwater Daily Baseflow Rate (%)	5	5
Groundwater Daily Deep Seepage Rate (%)	0	0
Stormwater Pollutant Parameters		
Stormflow TSS Mean (log mg/L)	2.2	1.95
Stormflow TSS Standard Deviation (log mg/L)	0.32	0.31
Stormflow TSS Mean (mg/L)	158.489319	89.125094
Stormflow TSS Standard Deviation (mg/L)	2.08929613	2.0417379
Stormflow TSS Estimation Method	Stochastic	Stochastic
Stormflow TP Mean (log mg/L)	-0.45	-1.1
Stormflow TP Standard Deviation (log mg/L)	0.25	0.3
Stormflow TP Mean (mg/L)	0.35481339	0.0794328
Stormflow TP Standard Deviation (mg/L)	1.77827941	1.9952623
Stormflow TP Estimation Method	Stochastic	Stochastic
Stormflow TN Mean (log mg/L)	0.42	-0.16
Stormflow TN Standard Deviation (log mg/L)	0.19	0.26
Stormflow TN Mean (mg/L)	2.63026799	0.691831
Stormflow TN Standard Deviation (mg/L)	1.54881662	1.8197009
Stormflow TN Estimation Method	Stochastic	Stochastic
Baseflow TSS Mean (log mg/L)	1.1	1.4
Baseflow TSS Standard Deviation (log mg/L)	0.17	0.13
Baseflow TSS Mean (mg/L)	12.5892541	25.118864
Baseflow TSS Standard Deviation (mg/L)	1.47910839	1.3489629
Baseflow TSS Estimation Method	Stochastic	Stochastic
Baseflow TP Mean (log mg/L)	-0.82	-1.2
Baseflow TP Standard Deviation (log mg/L)	0.19	0.13
Baseflow TP Mean (mg/L)	0.15135612	0.0630957
Baseflow TP Standard Deviation (mg/L)	1.54881662	1.3489629

Source nodes	Developed Urban Lots	Natural Bushland
Baseflow TP Estimation Method	Stochastic	Stochastic
Baseflow TN Mean (log mg/L)	0.32	-0.17
Baseflow TN Standard Deviation (log mg/L)	0.12	0.13
Baseflow TN Mean (mg/L)	2.08929613	0.676083
Baseflow TN Standard Deviation (mg/L)	1.31825674	1.3489629
Baseflow TN Estimation Method	Stochastic	Stochastic

B.3 Results

The MUSIC models were run for the period January 2000 to December 2002, which includes a representative average rainfall year for the area, at 12 minute intervals to calculate to subcatchment runoff, pollutant exports and pollutant capture in the concept stormwater treatment measures.

The pollutants analysed were suspended solids, total nitrogen and total phosphorous. The average annual runoff, pollutant loads and pollutant capture are summarised in **Table B.5.**

The modelling of the catchment revealed that the post-development pollutant exports can be reduced to levels no greater than existing conditions.

Table B.5
Average Annual Pollutant Exports to the Existing Onsite Wetland and Site Outlet for Existing and Proposed Scenarios

Parameter	Existing to Wetland	Future to Wetland	% Diff	Existing Outlet	Future Outlet	% Diff
Runoff (ML/yr)	1.90	1.92	1%	4.31	4.28	-1%
TSS (kg/yr)	178	14.7	-92%	982	35.4	-96%
TP (kg/yr)	0.18	0.181	-1%	0.397	0.225	-43%
TN (kg/yr)	1.54	2.67	73%	5.2	4.08	-22%
Gross Pollutants (kg/yr)	26.8	0	-100%	42.1	0	-100%

APPENDIX C

EXAMPLES OF WSUD TECHNIQUES THAT COULD BE APPLIED TO SALAMANDER WATERS

Figure C.1 Atlantis Infiltration Tank System that includes has a pre filtering system

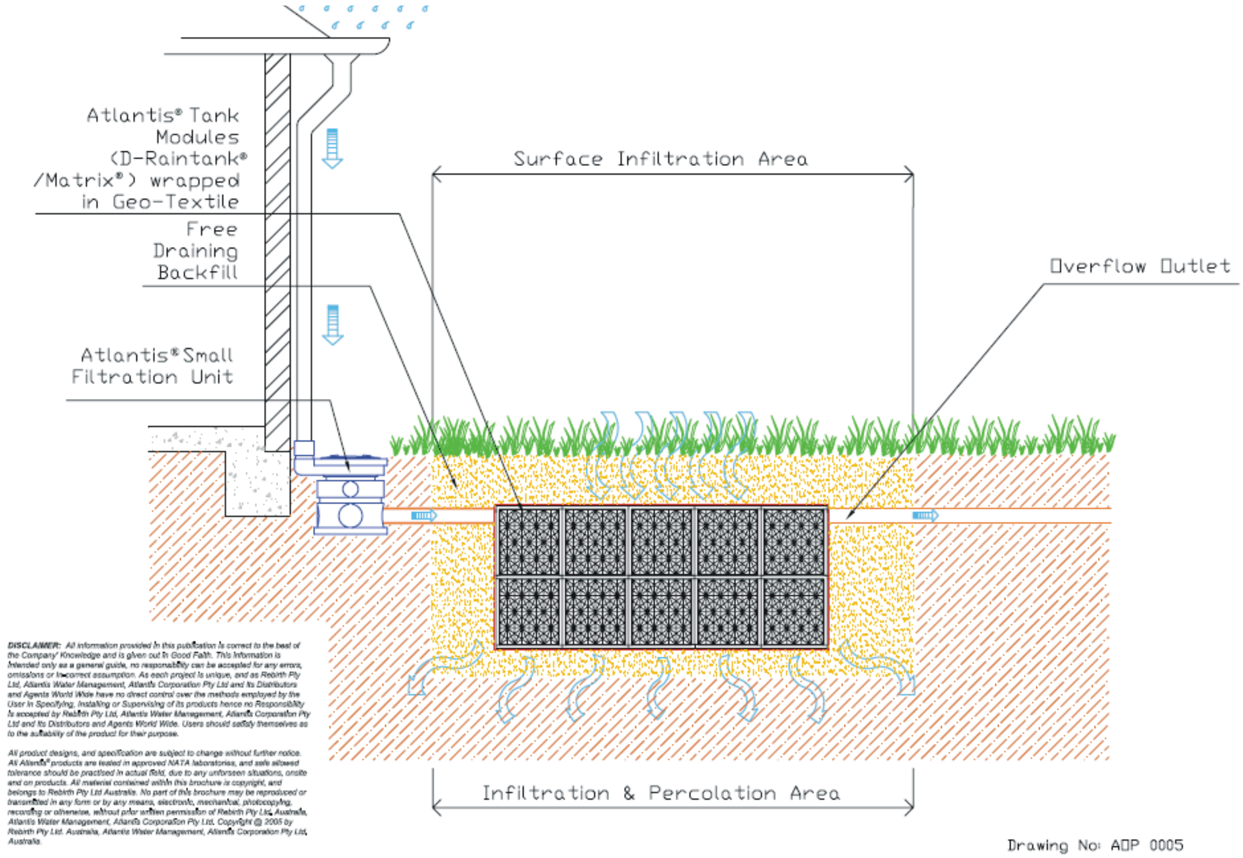


Figure C.2 Example of Atlantis Cells at SALT Development, Casurina. Designed by Cardno.

At the SALT development Atlantis Cells with a volume of 5000L were installed for each dwelling to ensure zero runoff at this site.

Figure C.3 Examples of Bioswales along a Road
(Warriewood, NSW)

Figure C.4 Example of Tree Biofiltration Pits
Docklands Victoria

Figure C.5 Typical Example of Tree Bifiltration Pits

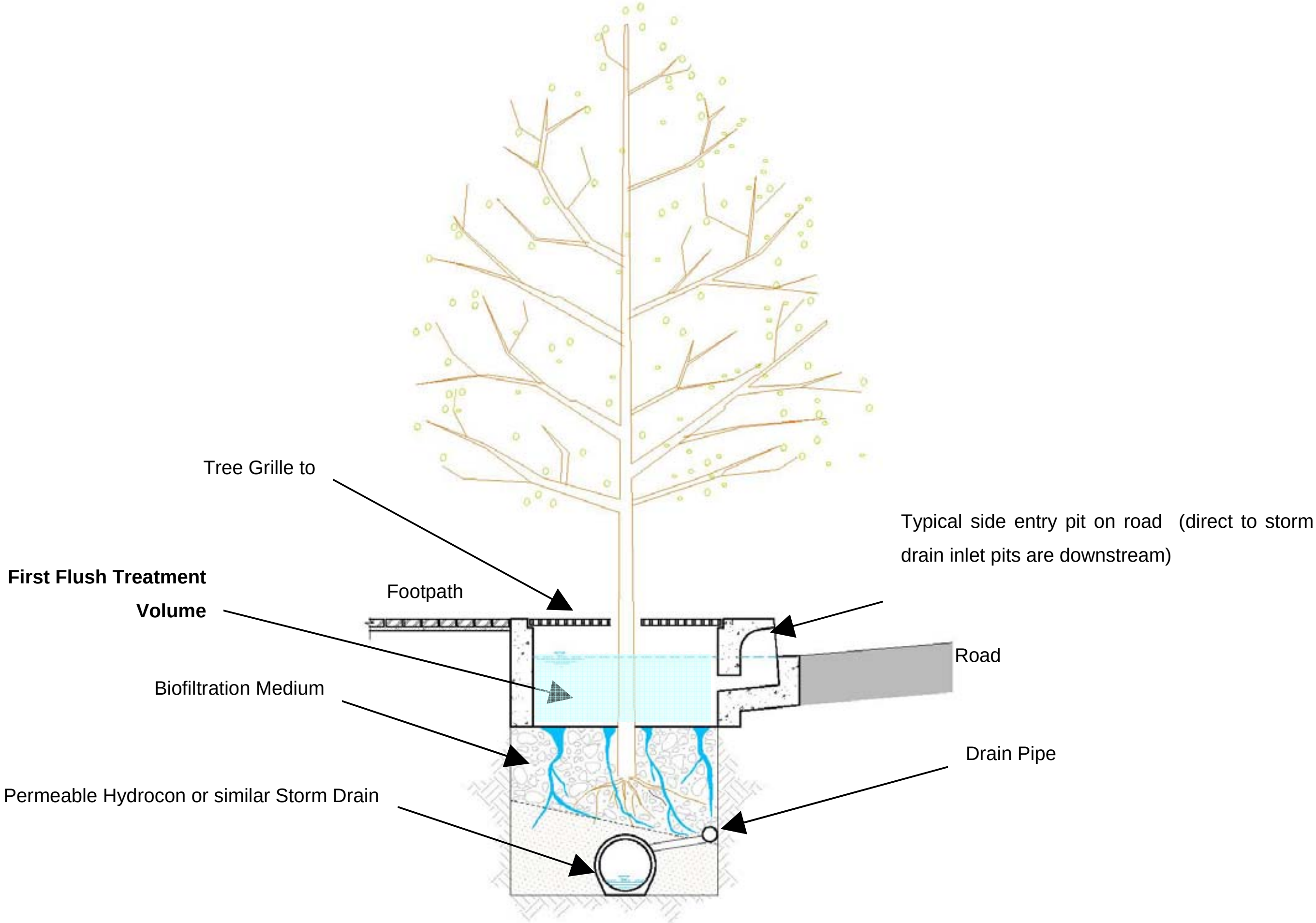


Figure C.6 Typical Example of a Constructed Wetland
Victoria Park NSW

Figure C.7 Typical Example of a Constructed Wetland at Coomera Waters, Designed by Cardno