9 WATER CYCLE MANAGEMENT

9.1 Introduction

Water Cycle Management for the site is based on WSUD principles. The development plan provides for treatment of stormwater through a site specific water treatment train incorporating at source treatment as well as subsequent pollutant and nutrient removal along a treatment train with tertiary treatment in an environmental lake. Stormwater is retained on site for recycling via the existing lake whilst individual retention via rainwater tanks is to be encouraged. Ballina Council's policy to eventually supply treated effluent for non potable water supply is to be accommodated by construction of a dual reticulation water pipe system. The following sections discuss WSUD principles and the selection process used to design the Pacific Pines water cycle management system. Issues relating to Healthy Rivers Commission's Statement of Joint Intent is discussed overleaf. Stormwater Treatment is described in Section 9 while Water Recycling is described in Section 10.

9.2 Summary of Management Systems

In summary the water cycle management system provides for:

1. Continued use of the existing environmental lake (WQCP) as a tertiary treatment system and main detention dam / recycling source for the subdivision.

2. Provision of small dry detention systems upstream of the WQCP.

3. Provision of numerous primary small litter traps in stormwater collection pits.

4. Provision of a Stormwater Community Education Program (CEP) by the developer describing why the strategy has been adopted and how it works.

5. Ongoing monitoring of stormwater quality and comparison to baseline data is proposed together with maintenance of the stormwater treatment train. Management of the lake passes to Council in 2010 whilst management of the main stormwater conveyance systems will be split between Council and landowners depending on specific land uses and future titling. Training of Council staff in management of the systems is proposed. These proposals are already captured in part as development consent conditions for the WQCP with the intent of the conditions being passed to other components of the stormwater management system. Monitoring during and after construction of the WQCP has shown the facility to be achieving targets of no net increase in pollutant load.

6. Provision of swales, infiltration and bioretention systems in flatter areas.

7. Provision of recycled effluent and stormwater for irrigation and toilets. Theoretical modelling of the stormwater treatment train for the development footprint by Gilbert and Sutherland concluded that the lake will provide the no pollutant increase criteria required by Council. Full report available on request. Details of model results are provided in Table 9.4. Existing draining paths are shown on Figure 9.3 whilst the proposed stormwater treatment train is shown on Figures 9.1 and 9.2. Gilbert and Sutherland wrote Council's Stormwater Management Policy (Combined DCP Part13) and the modelling completed by them demonstrates compliance with the stated policy. To date Gilbert and Sutherland's conclusions have been supported by water quality monitoring results.

Development conditions for the construction of the WQCP required pre and post construction monitoring of water and habitat areas to determine whether any impacts occurred on these areas. Monitoring of the adjacent North Creek before, during and after construction of the WQCP confirms water quality upstream and downstream of the lake to be superior to that in North Creek. Results have been provided to Council from January 2005 to June 2007 in accordance with Development Consent conditions. Monitoring is ongoing. The additional at source treatment systems will further improve the water quality outcomes. The impact of this strategy is considered to produce a lower pollutant load from the site than currently exists. The theoretical modelling and subsequent ongoing monitoring demonstrates that the WQCP is achieving the desired environmental outcomes. Details of modelling results are provided in Table 9.4.

During approval for and construction of the WQCP the impact of the lake on groundwater hydrology was raised by Government Agencies. Subsequent to these enquiries and site meetings the lake was clay lined as agreed with Government Agencies where highly porous soils were encountered to prevent contamination of the groundwater by direct contact with stormwater runoff. Elsewhere on-site infiltration through natural soils is encouraged in accordance with WSUD. Where further detention ponds are required they are either sited above existing ground levels and mimic the existing ground topography or are located above ground water levels. Impacts on groundwater hydrology are therefore considered negligible**.** Detention ponds, sediment basins and Gross Pollutant Traps (GPT) have been strategically located to capture silts, gross pollutants and slow water discharge. One sediment basin already constructed to the north west of the WQCP is to be relocated to provide clearance around proposed buildings for maintenance access to the pond.. Conveyance of stormwater flow behaviour across the site is reproduced from existing to developed conditions by retention of site drainage lines and floodways.

Buffers to environmentally sensitive areas have been created in accordance with the consent conditions determined by the Environmental Impact Statement for the WQCP. When added to the additional buffer provided by the lake and approved sports fields buffers generally exceed 100 metres.

9.3 Healthy Rivers Commission

Established in 1995 under the State's pollution control legislation the (Healthy Rivers) Commission conducted public enquiries into particular river systems referred by the government. It carried out investigations into the Hawkesbury Nepean, Shoalhaven, Georges – Botany Bay, the Hunter and Williams rivers, the predominantly rural catchments of the Clarence and the Bega Rivers, and the coastal lakes (over 90) along the NSW Coast. The HRC did not investigate North Creek.[7]

In response to these inquiries Government created an instrument which eventually became known as a joint Statement of Intent. The role of a Statement of Intent is to express whole of government policy for management of the particular river systems.

[7] Coast to Coast Conference 2002. New Accountability for Integrated Governance – The NSW Experience

In 2004 the Healthy River Commission was discontinued and the Natural Resources Commission (NRC) established. The HRC's reports and the Statements of Intent are available from the NRC. Government has asked the Natural Resources Commission to consider the incorporation of any outstanding Healthy River Commission recommendations into Catchment Action Plans and Government programs.

The former Healthy Rivers Commission made recommendations to Government in relation to various catchments on:

- suitable objectives for water quality, flows and other goals central to achieving ecologically sustainable development, as well as
- the known or likely views of stakeholder groups;
- the economic and environmental consequences of recommendations;
- and strategies, instruments and changes in management practices needed to implement the recommended objectives.

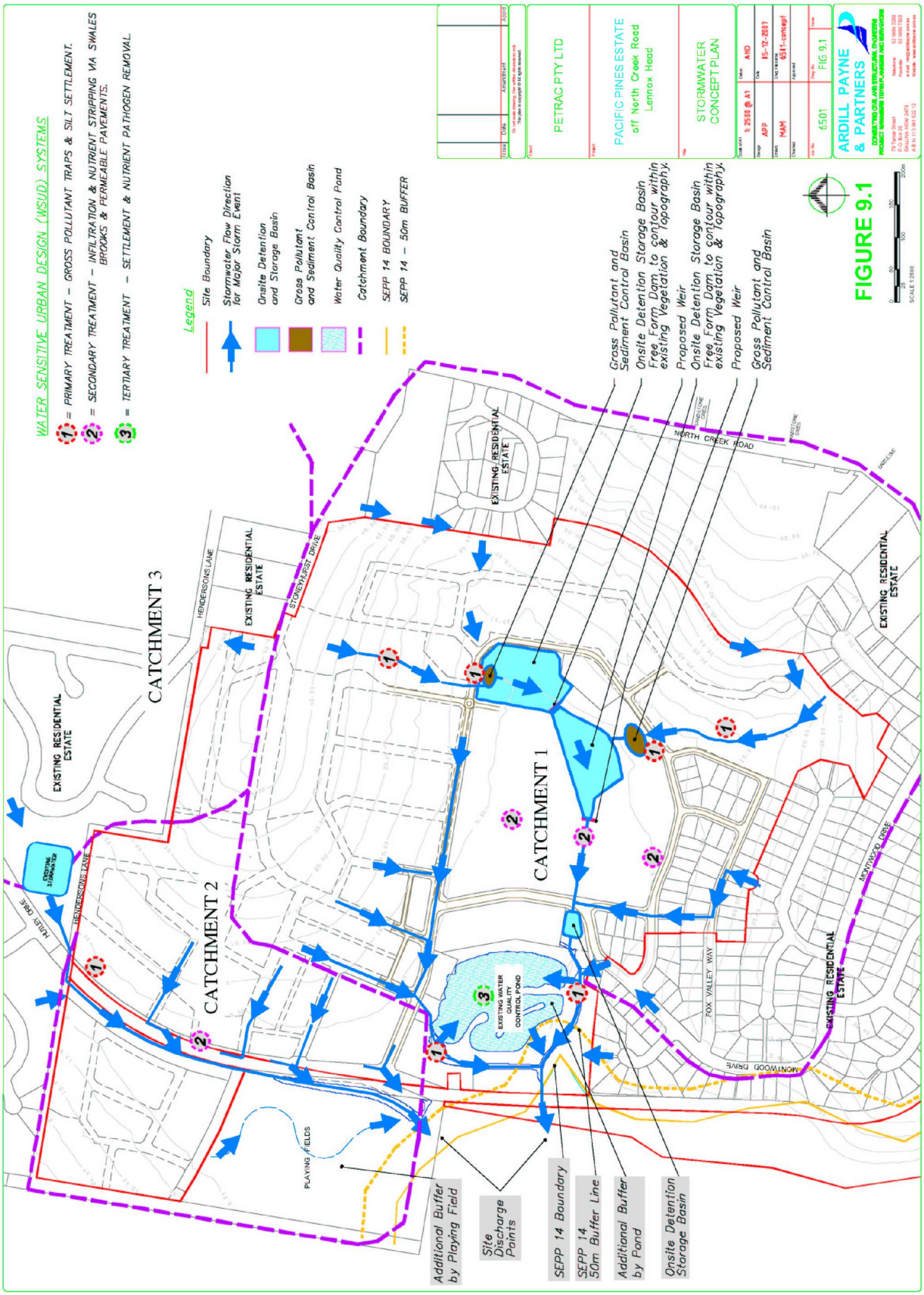
The NRC has listed thirteen targets for natural resource management. The targets were determined following recommendations from the Healthy Rivers Commission and other government and private submissions to the working papers distributed between 2005 and 2006 by NRC. The targets were adopted in 2007 and cover biodiversity, water, land and community.

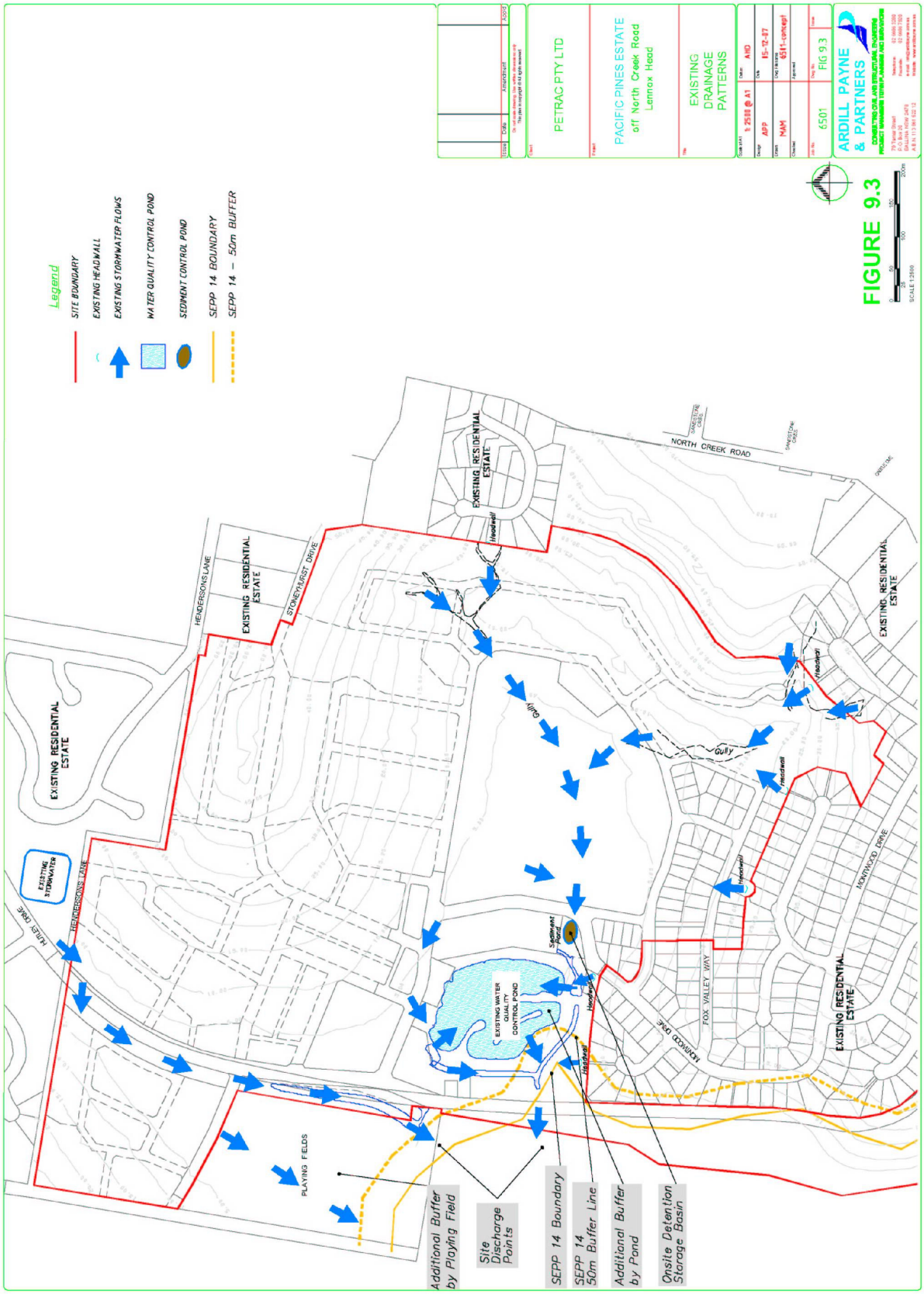
The water targets specific to water Cycle Management in the Pacific Pines Part 3A Application are numbers 5 to 9 of the NRC targets. These are described below:

5. By 2015 there is an improvement in the condition of riverine ecosystems
6. By 2015 there is an improvement in the ability of groundwater systems to support groundwater-dependent ecosystems and designated beneficial uses.
7. By 2015 there is no decline in the condition of marine waters and ecosystems
8. By 2015 there is an improvement in the condition of important wetlands and the extent of those wetlands is maintained

9. By 2015 there is an improvement in the condition of estuaries and coastal lake ecosystems.

The targets for water are primarily directed at Catchment Management Authorities who co-ordinate all relevant local and state government agencies in implementing catchment specific actions and policies to achieve the targets. Ballina Council has prepared a Control Plan for Stormwater Management which requires that there be no net increase in pollutant load from urban catchments similar to those proposed at Pacific Pines. The response to these objectives at Pacific Pines has been to match Council's and local government authorities requirements to ensure there is no net increase in pollutant load from the site to North Creek. Data collection to date has shown the discharges through the constructed wetland to be superior to the background water quality levels in North Creek. This being the case the development is on track to meet objectives 5-9 of NRC targets which relate to water quality.


WATER SENSITIVE URBAN DESIGN (WSUD) SYSTEMS
1 = PRIMARY TREATMENT – GROSS POLLUTANT TRAPS & SILT SETTLEMENT.
2 = SECONDARY TREATMENT – INFILTRATION & NUTRIENT STRIPPING VIA SWALES BROOKS & PERMEABLE PAVEMENTS.
3 = TERTIARY TREATMENT – SETTLEMENT & NUTRIENT PATHOGEN REMOVAL.
Legend
Site Boundary
Stormwater Flow Direction for Major Storm Event
Onsite Detention and Storage Basin
Gross Pollutant and Sediment Control Basin
Water Quality Control Pond
Catchment Boundary
SEPP 14 BOUNDARY
SEPP 14 – 50m BUFFER
PETRAC PTY LTD
PACIFIC PINES ESTATE
off North Creek Road
Lennox Head
STORMWATER CONCEPT PLAN
ARDILL PAYNE & PARTNERS
FIGURE 9.1
SCALE 1:2500
CATCHMENT 1
CATCHMENT 2
CATCHMENT 3
EXISTING RESIDENTIAL ESTATE
NORTH CREEK ROAD
HENDERSONS LANE
STONEYHURST DRIVE
HUNTER DRIVE
FOX VALLEY WAY
MONTWOOD DRIVE
EXISTING WATER QUALITY CONTROL POND
PLAYING FIELDS
Gross Pollutant and Sediment Control Basin
Onsite Detention Storage Basin Free Form Dam to contour within existing Vegetation & Topography.
Proposed Weir
Additional Buffer by Playing Field
Site Discharge Points
SEPP 14 Boundary
SEPP 14 50m Buffer Line
Additional Buffer by Pond
Onsite Detention Storage Basin


Legend
SITE BOUNDARY
EXISTING HEADWALL
EXISTING STORMWATER FLOWS
WATER QUALITY CONTROL POND
SEDIMENT CONTROL POND
SEPP 14 BOUNDARY
SEPP 14 – 50m BUFFER
PETRAC PTY LTD
PACIFIC PINES ESTATE
off North Creek Road
Lennox Head
EXISTING DRAINAGE PATTERNS
ARDILL PAYNE & PARTNERS
FIGURE 9.3
NORTH CREEK ROAD
EXISTING RESIDENTIAL ESTATE
HENDERSONS LANE
STONEHURST DRIVE
EXISTING STORMWATER
HEALEY CLOSE
EXISTING WATER QUALITY CONTROL POND
Sediment Pond
Headwall
Gully
MONTWOOD DRIVE
FOX VALLEY WAY
HOWOOD CLOSE
PLAYING FIELDS
Additional Buffer by Playing Field
Site Discharge Points
SEPP 14 Boundary
SEPP 14 50m Buffer Line
Additional Buffer by Pond
Onsite Detention Storage Basin

9.4 Stormwater Treatment

Water Sensitive Urban Design (WSUD) has been incorporated in the Concept Plan layout of the subdivision. The WQCP was initially designed to treat all the subdivision with detention ponds, Gross Pollutant Traps (GPT) and sediment basins provided upstream of the lake. The current proposal adds to that by including contemporary WSUD principles of at source treatment and permeable surfaces. The WQCP is a constructed wetlands and is required to provide tertiary treatment for stormwater leaving the site prior to discharge into sensitive downstream waters. The WQCP has already been approved under a previous Development Consent and has been constructed. Although approval is not being sought for the WQCP as part of this application, the Concept Plan has been designed to ensure that the WQCP continues to operate as the main tertiary stormwater treatment system for the previously constructed parts of the Pacific Pines Estate whilst capturing, retaining and treating stormwater generated from what is being proposed as part of this Concept Plan.

A treatment train approach has been adopted in the WSUD.

The treatment train approach is particularly important when a treatment measure requires pre-treatments to remove pollutants that may affect the performance of the treatment measure. For example, wetland systems are often employed to protect receiving environments from the impact of excessive level of nutrients and heavy metals. However, wetlands will perform poorly if gross pollutants (eg. Litter) and coarse sediments are not removed prior to the wetland treatment. It is therefore important to select and order treatment measures appropriately to ensure that wetland systems are protected from gross pollutants and coarse sediments. By taking this ‘treatment train approach’, the most effective sequence of the treatments can be determined.

Many treatment measures can be ‘sized’ to suit the land area available. Table 9.1 describes the applicability of various treatment systems to different parts of a subdivision.

Table 9.1 Treatment Measures

Site Elements	Precinct Elements	Regional Elements
• Allotment density and layout	• street layout & streetscape	• public open space • multiple use corridors
• on-site retention (infiltration) • porous pavement • sand filter· buffer strip • grassed or vegetated swales • bio-retention system • rain garden	• precinct retention (infiltration) • porous pavement • sand filter • buffer strip • grassed or vegetated swales • bio-retention system • urban forest	• swales • bio-retention
• on-site detention • rainwater tank for stormwater reuse	• retarding basins • constructed wetlands & treatment ponds • stormwater reuse	• retarding basins • constructed wetlands & treatment ponds • stormwater reuse

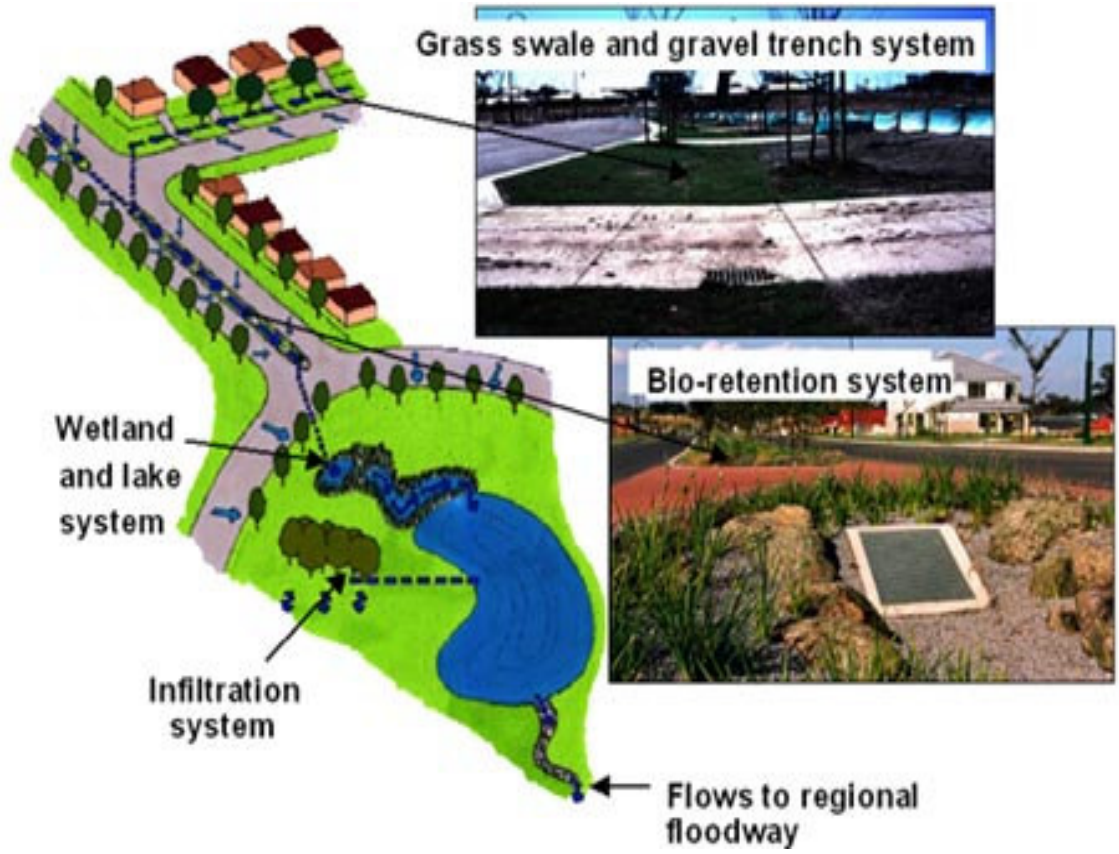
Figure 9.2 below is an example of the stormwater treatment train with pre-treatment measures for the protection of a downstream wetland system similar to that proposed for Pacific Pines.

The diagram illustrates a stormwater treatment train for the flatter part of the site. Local collection systems on flatter portions of the site consist of swales and bio-retention channels and wetlands. The swales and litter traps act as the primary treatment measure removing gross pollutants eg. litter and coarse sediments. The main stormwater conveyance channel follows the existing creek for part of its length and will provided a natural bio-retention facility. This treatment measure or Bio-retention system removes fine sediments and filters adsorbed pollutants (eg. Nitrogen and Phosphorous).

The final component of this treatment train is the tertiary treatment wetland system, which removes very fine particulate matter, in addition to biological uptake of pollutants (eg. Heavy metals and Nutrients). Stormwater collection and treatment on the steeper parts of the Pacific Pines site incorporate the use of litter traps and conventional stormwater collection systems discharging to bio-filtration channels and wetland systems on the flat parts of the site.

The treatment train selection process is described in sections 9.2 to 9.4. The adopted treatment train has been modelled to check compliance with the requirements of Council's Stormwater policy Combined DCP No.1 – Part 13. Modelling method and results are described in section 9.5. Results show compliance with Council requirements.

Figure 9.2 Typical Stormwater Train in Flat Areas



9.5 Site Identification

Type of treatment train

When determining the location for stormwater treatment measures, many factors must be considered. One fundamental question is whether to adopt an 'outlet' or a 'distributed' approach.

The traditional outlet approach involves constructing a single large treatment at the catchment's outlet. Although this 'single site' approach offers obvious maintenance advantages, it has the disadvantage of needing to treat very large volumes of water at a location sometimes far from the pollutant's source. The process proposed at Pacific Pines involves a distributed approach with an outlet control to buffer sensitive waterways below the site.

A distributed approach to stormwater pollution treatment has many advantages over the outlet approach. These include:

- improved protection: water quality protection may be distributed along a greater length of the waterway, thus protecting immediate downstream waterway reaches;
- localised treatment: specific targeting of treatments may be directed at highly polluted sites;
- distributed risk: the distributed approach has a lower risk of overall system failure, as the failure of any single treatment will not usually significantly impact on the total treatment system performance;
- improved removal efficiencies: distributed treatments are typically located in areas of lower flow. Lower flow velocities, volumes and higher pollutant concentrations in the stormwater at these sites, leads to higher operating efficiencies; and
- staged implementation: individual sites may be brought into operation in stages.

9.6 Site Constraints

The characteristics of a particular site can limit the choice of treatment measures suited to the area. These constraints fall broadly into two categories - physical and social.

Physical site constraints can make construction difficult or impossible and maintenance expensive if not addressed adequately. Factors to consider include:

- topography - e.g. steep slopes
- soils and geology - e.g. erosivity, porosity, depth to bedrock or instability
- groundwater - e.g. geochemistry and water table depth
- space - limited open space, proximity to underground services. (e.g. gas, power).

Social constraints include issues of health and safety, aesthetics and impacts on recreational facilities. Factors to consider include:

- odour problems
- visual impacts
- noise
- physical injury - resulting from unauthorised access to structures;
- contamination - infection, poisoning or injury caused by trapped pollutants or algal blooms
- vermin - e.g. mosquitoes, rats.

At Pacific Pines the physical constraints consist of:

- Steep slopes. Slopes greater than 5% prevent swales from operating properly as insufficient detention is available. This is applicable to much of the site at Pacific Pines.
- Impermeable soils and high water table. Pacific Pines has relatively impermeable soils in the moderate to steep slopes and a high water table in the lower slopes and flatter portions of the site. This constraint reduces the ability of infiltration systems to work properly and limits infiltration areas to the lower slopes and flat areas.
- Downstream sensitive water areas. From prior studies the WQCP wetland system has been incorporated to protect sensitive downstream waters.
- The wetland attracts public safety, health and maintenance issues which have been addressed in the Development Approval process for this facility.

9.7 Potential Treatment Options:

Based on the major site constraints and proposed subdivision design, the following treatment options were short listed for evaluation. Table 9.3 summaries the rating of these options in terms of their treatment performance, maintenance requirements, cost and site constraints.

Primary Treatment Options

Gross pollutant Traps
Litter traps
Swales

Secondary Treatment Options

Swales
Infiltration Trenches
Porous Paving
Bio-retention systems

Tertiary Treatment options

Bio-retention
Wetlands

The stormwater treatment train is also constrained by the site's topography and drainage paths. There are three drainage catchments which control the treatment process. The main catchment is to the east and south of the WQCP. This catchment drains to the WQCP and all options above are applicable.

The second catchment is to the west of Hutley Drive and drains to the playing fields. All options except the wetlands are available for the western catchment.

The third catchment is to the north and outside of Pacific Pines. This catchment consists of existing subdivisions with their own treatment systems. Water from the northerly catchment passes through Pacific Pines via the drainage paths along Hutley Drive.

Table 9.3 Comparison of Treatment Options

	GPT	Litter Baskets	Swales	Porous Paving	Infiltration	Bio-retention	Wetlands (WQCP)
Maintenance by Council	Regular cleaning	Regular removal and cleaning	Mowing and cleaning	Sweeping and silt removal	Remove and replace when clogged	Remove and replace when clogged	Silt removal and reed harvesting
Maintenance frequency	Monthly or after storms	Monthly or after storms	Monthly	Weekly & after storms	5 years	5 years	2-5 years
Impact on water quality of failed maintenance	High	High	Minor	Moderate	Moderate	Moderate	High
Pollution Retention	Large particles and litter	Litter and range of particles	Small coarse particles	Small coarse particles	Small fine particles, nutrients and soil attachments	Small fine particles, nutrients and soil attachments	Small fine particles, nutrients and soil attachments
Head Requirement	Minor	Minor	Minor	Minor	Minor	Minor	Minor
Cost	Moderate	Low	Low	Moderate	Moderate	Moderate	High
Secondary Benefits	Low	Moderate	Low	Low	Moderate	Moderate	High
Relative ease of maintenance	Difficult to maintain. Suitable in limited situations eg detention basins	Small baskets easy to maintain regularly with small crew. Preferred by Council.	Easy	Difficult to maintain as clogs easily. Requires specialised cleaning equipment	Low maintenance until removal and replacement required.	Low maintenance until removal and replacement required	Reed harvester relatively low maintenance. Silt removal difficult.
Site Constraints Limits	Suitable at Detention Basins.	Not constrained	Flatter slopes. Low pedestrian and vehicular crossing areas.	Limited to flatter parts of site.	Limited to low slopes due to impermeable soils elsewhere & water table.	Limited to flat parts of site	Limited to flat parts of site

9.8 Water Quality Outcomes

Table 9.4 below provides details of water quality at pre and post development stages with and without the impact of different treatment systems along the treatment train.

Figures provided in Columns 1-3 are extracted from the EIS for the Water Quality Control Pond as calculated by Gilbert and Sutherland using AQUALM-XP for water quality modelling. Column 1 shows existing pollutant load. Column 2 shows pollutant load for a fully developed catchment without treatment. Column 3 shows pollutants removed by the treatment train used in the original stormwater treatment train. Column 5 shows pollutants removed by additional at source treatments. Column 6 shows pollutant load after all systems installed. By inspection the column 6 values are less than the column 1 (existing) pollutant loads and therefore demonstrates compliance with Council policy. The values provided in column 4 have been calculated by Ardill Payne and Partners using conservative capture rates recommended by Brisbane City Council.

The assumed area of the subdivision covered by column 4 is relatively small (approximately 7% of the urbanized catchment). This is because the area is calculated from land with gradients less than or equal to 5%. The area of land required for detention basins may be further reduced through the provision of roofwater tanks in the subdivision design rationale.

Table 9.4 Water Quality Results for Pacific Pines Catchment Stormwater Pollutant Load before and after Development Values are in kilograms per year.

	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
	Undeveloped Catchment	Fully Developed Catchment	Pollutants Captured by GPTs, Detention Ponds, Open Space and WQCP	Pollutant load after treatment by EIS systems Col 2-3	Capture by Swales and Bioretention #	Pollutant load after treatment by extra systems Col 4-5
Total Nitrogen	880	1285	(648)	637	(19)	618
Total Phosphorous	106	174	(127)	47	(3)	44
Total Suspended Solids	18,657	63,300	(54,000)	9,300	(1,266)	8,034

9.9 Erosion & Sediment Control

Erosion and sediment controls are required during construction and operation of the subdivision. The control mechanisms for the completed subdivision are the primary, secondary and tertiary treatment systems described above. During construction works on the site, a stormwater management plan (SMP) is required as detailed in Appendix No. 5 prepared by Gilbert & Sutherland.

The SMP has been prepared for the extremely sensitive works area associated with WQCP construction and it is proposed to extend these recommended practices to the rest of the subdivision.

Stormwater Management Plan

Stormwater management during construction of the subdivision will be required to control runoff from the site to minimise sediment and transport of other pollutants into downstream waters. Generally conventional control systems will be used in accordance with the Department of Housing recommendations. This will include the provision of silt fences, detention ponds, swales, re-grassing and bunding of fill and/or excavated areas.

10 WATER RECYCLING

The water recycling systems available for the subdivision consists of:

- Recycling of stormwater stored in the WQCP for irrigation of the playing fields and adjacent open space.
- Recycling of stored roofwater for irrigation in individual allotments.;
- Recycling of treated effluent from Ballina Shire Council's treated effluent plant for external irrigation and toilet flushing as per Council policy

The water recycling strategy cannot be finalised until Council's requirements for the volume of treated effluent it wishes to pump to Pacific Pines has been determined. Previous studies had shown that sufficient capacity existed in the WQCP to supply irrigation to the playing fields whilst roofwater storage tanks could supply household irrigation and toilet flushing demand.

Based on water quality monitoring of the WQCP Stormwater from the Lake could be pumped to the playing fields for irrigation purposes with only basic filtration required for pre treatment. Dispersal would be by spray irrigation.

Construction of systems for recycling of stored roofwater would follow Ballina Council's current policy on reticulation of treated effluent. This requires recycled water systems to be identified with lilac coloured pipe, special external taps and signage to identify the source as recycled water.

Similarly recycled treated effluent (non potable water) would follow the protocols described above with reticulated non potable mains constructed beside conventional potable water mains with identification of the non potable service by its lilac colour. Council has made provision in its Development Servicing Plan to construct headworks at The Lennox Head STP to create treated effluent and deliver it via a dedicated rising main to a reservoir installed in the Pacific Pines catchment area. Based on previous jobs it is envisaged that the non potable reticulation would be charged by potable water service until the treated effluent is available from the STP and reservoir. House connections would still be made with the consumer using the potable in lieu of non potable water until the treated effluent facility is commissioned.