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ENVIRONMENTAL ENGINEERING
AND PLANNING CONSULTANTS

STORMWATER QUALITY MANAGEMENT REPORT

OCEAN DRIVE, LAKE CATHIE

Prepared for: **Seawide Pty Ltd and Milland Pty Ltd**

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EXECUTIVE SUMMARY

This document is a report on Stormwater Quality Management for the proposed subdivision development at Ocean Drive, Lake Cathie. The report was prepared for Seawide Pty Ltd and Milland Pty Ltd by Jelliffe Environmental Pty Ltd, Environmental Engineering and Planning Consultants. The report is part of the Ocean Drive, Lake Cathie Planning Study undertaken for the clients by King and Campbell Pty Ltd.

The study area is described as Lot 4 DP 613261 and Lot 1 DP 374315, Ocean Drive, Lake Cathie, in the Hastings Shire. The report addresses issues relating to the management of stormwater from the site when developed as a residential sub-division. The site has an overall area of approximately 41 hectares of which less than 25 ha is available for actual residential development. The remainder would be in buffer areas and stormwater management.

The site comprises five sub-catchments and is formed by an undulating ridge running parallel to the beach. Two of the catchments comprising approximately 43% of the site flow to a creek to the south west. Two of the catchments comprising approximately 27% of the developable site flow through the SEPP 26 land to the east. The remaining 30% is in a single catchment which flows north to a creek which crosses Ocean Rive. The site slopes gently east and west of the ridge with elevation ranging from approximately 5 m AHD to approximately 25 m AHD.

The site soils range from fine/medium grained grey brown sands over pale grey sand and indurated sands in the low lying area to the south, through a light brown silty Loam clay, to silty Clay over mottled clay at between 150 mm and 900 mm depth. If acid sulphate soils exist on the site they would be limited to the low lying areas along the south western edge of the site.

Site constraints to development include some minor flood prone areas along the creek line at the south western end of the site and a small area which is identified by DLWC as having a "low probability" of acid sulphate soils. SEPP 26 littoral forest is located along the eastern perimeter of the site. The remainder of the site is open grazing land.

The site falls within the Coastal Zone as defined by the NSW Coastal Policy (1997). Objectives for stormwater management reflect the requirements of the Coastal Management Manual and the NSW Coastal Policy (1997) which require that the ecological and environmental values of the adjacent SEPP 26 littoral forest be protected and preserved. Drainage flows to the south western creek, while not impacting directly on the littoral SEPP 26 forest, were also considered as being important in terms of water quality. The objectives of the NSW Coastal Policy which are considered particularly relevant to the proposed development are:

Objective 1.2 *To conserve the diversity of all native plant and animal species and to protect and assist the recovery of threatened and endangered species, and*

Objective 1.3 *To improve water quality and estuarine waters and coastal rivers* *where it is currently unsatisfactory and maintain water quality where it is satisfactory.*

Action 1.3.8 states:

The discharge of contaminated stormwater to coastal waters will be minimised, with the aim being to ensure environmentally sound management of stormwater to prevent contamination in the future.

SEPP 26 requires that the likely effects of developments proposed within 100 m of the SEPP 26 Littoral Rainforests be considered in an environmental impact statement.

The following stormwater quality objective was established to ensure the objectives listed above would be complied with by the development.

Stormwater quality management measures within the proposed Ocean Drive, Lake Cathie development site shall achieve the objective of no deterioration in the overall quality of stormwater from the site following the development. Water shall be measured as using the following parameters: nutrients (Nitrogen and Phosphorus) and suspended solids.

The management of stormwater from the site shall minimise impacts on groundwater levels and quality both within the proposed development site and in adjacent land.

The report makes recommendations regarding stormwater management within the Ocean Drive, Lake Cathie study area. The following conclusions were drawn from the study:

- The development of residential land within the study area would result in an increase in the export of pollutants from the site unless stormwater quality control measures are implemented. The reduction in nutrients and particulates required to meet the stormwater management objectives is within the range of stormwater management measures applicable to the site.

- The potential presence of acid sulfate soils below the water table in areas to the south west of the site imposes the low risk of acid sulfate release if the water table is significantly lowered. It is concluded that the development proposed will not have the potential to significantly lower the water table in these areas provided spear point extraction is controlled.

- A range of stormwater quality management options were assessed. The following configuration was considered the most practical and effective for the site.

  - On Site Detention using household water tanks combined with domestic reuse, lawn watering and local infiltration measures at the allotment level. The OSD tanks operate by capturing and storing runoff from smaller storms and the first flush from larger events. A minimum storage volume is required which drains via a controlled small diameter pipe to a seepage area in the garden over a period of 1 to 2 days from full. Tanks may be larger allowing for storage for other purposes. Rainwater may be used for lawn watering or, subject to Council approval, use within the household as part of a separate pipe system for toilet flushing. There would be no cross connection with the town water supply without backflow prevention valves. It is noted that Sydney Water is now installing water meters incorporating backflow prevention which will allow tank water to be connected into the household water supply pipework.

- Grass Swale drainage with infiltration trenches and bottomless pits for the roadside drainage from roads in areas less than 5% gradient over sandy soils. Swale drainage and road side infiltration will have limited application and is not proposed in areas of silty loam, silty clay or clay.

- Dry storage litter and particulate collection devices (eg Nicholas Ski Jump, Pratten Trap or Ecosol RSF 1000) on all major sub-catchment drainage outlets upstream of wetlands. All surface stormwater from the developed site shall pass through the litter collection devices.

- Off stream macrophytic wetlands designed to capture and treat all of a design storm being 50% of the 1 year event for the catchment (equivalent to a 3month event). This equates to an area requirement of approximately 1.25% of the upstream catchment area. All surface stormwater from the developed site except peaks from extreme storm events, which will bypass the wetlands, to pass through the wetlands. Discharge from the eastern sub-catchment wetlands would be directed to seepage areas within the SEPP 26 forest to recharge the aquifer (discussed below).

- Direct bypass of the off-stream wetlands shall be limited to events in excess of the design storm. The wetlands will capture an estimated 85% of the stormwaters including all smaller events and the first flush from all storm events. The wetlands shall be designed such that flow velocities through the wetland do not exceed 0.2 m/s, to avoid scouring and resuspension of previously settled material.

- An education pamphlet shall be prepared and provided to potential owners informing them that they live in the catchment of a sensitive SEPP 26 area, and providing advice on minimising the potential for pollution of stormwater by household activities.

- The recommended management measures are predicted to achieve the reductions required by the water quality performance objective set out above.

- The site soils and topography indicate that an unconfined aquifer is likely to be present under the sandy soils of the SEPP 26 forest to the east and also in the sandy soils at the southern end of the site. The limited area of this sand suggest that the aquifer would not have the volume to be supply more than minor uses such as lawn watering. Coastal unconfined aquifers are generally characterised by low pH, low carbonate alkalinity and moderate iron content rendering them unsuitable for potable supply without costly treatment. The potential presence of acid sulfate soils on the south western side of the site (low probability), and the proximity of saline seawater to the east significantly reduces the volume of the reserve available for sustainable supply without risking exposure of the acid soils or salt water ingress. It is concluded that an unconfined aquifer under the eastern and southern parts of the site would not be significant as a potable water supply reserve, but may be suitable for controlled spear points for limited garden watering. If spear points are permitted groundwater levels and conductivity, iron content and pH should also be monitored to avoid deterioration of the reserve or incursion of saltwater.

- The mean dry season water level in the unconfined aquifer underlying the SEPP 26 forest will be determined by mean sea level. However, the extent and depth of the freshwater lens and the incursion of the saline "wedge" will depend on the volume of fresh water in the lens above sea level. Sources of freshwater for the lens are: rain falling directly onto the SEPP 26 forest; runoff from the predominantly clay catchment to the west which infiltrates into the sandy soil at the base of the slope; and, groundwater infiltration from the higher ground. A conventional stormwater drainage scheme would convey stormwater from the development directly to the sea or western creek, bypassing the SEPP 26 forest area and starving the aquifer of a significant part of its freshwater supply. This would result in a reduction in the volume of freshwater in the lens and the western ingress of the salt water wedge. While such conditions are likely to occur naturally during periods of extended drought, a permanent reduction in recharge could be expected eventually altering the species diversity within the Littoral Rainforest. Changes would be expected to occur on the eastern (seaward) side first. To avoid this outcome it is recommended that runoff collected in the wetlands on the eastern side of the site discharge to seepage lines constructed into the sandy soil along the western edge of the SEPP 26 forest. A variety of seepage lines exist on the market ranging from "Atlantis" products to perforated Ag pipe "Megaflo" profiles. Conventional geotextile wrapped gravel or pipe and sand filled trenches would also be appropriate. During major storm events flow would bypass the wetlands and travel down established channels through the forest to discharge to the beach as presently occurs.

- The existing channels to the beach have eroded to a gravel level slightly above sea level. While further erosion downwards is unlikely lateral scouring is likely to occur. It is recommended that armouring protection of these channels be carried out. The most suitable material would appear to be rock gabions or Reno mattresses at exposed locations. These can be designed to have minimal visual impact if appropriately vegetated on the flanks of the channel. Any works rehabilitating the channels within the SEPP 26 area would need to be assessed as part of the EIS process.

The study concludes that the stormwater quality management scheme proposed in this report has the potential to achieve the objectives for stormwater quality management if implemented in its entirety.

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1 INTRODUCTION

1.1 Introduction

The report was prepared for Seawide Pty Ltd and Milland Pty Ltd by Jelliffe Environmental Pty Ltd, Environmental Engineering and Planning Consultants. The report is part of the Ocean Drive, Lake Cathie Planning Study undertaken for the clients by King and Campbell Pty Ltd.

1.2 Scope of the Report

The report addresses issues relating to stormwater quality management within the proposed subdivision site and management of changes to the site hydrology and hydro-geology.

Stormwater Quality

- Establishment of water quality objectives for the site with consideration of the adjacent SEPP 26 land.
- Design of a conceptual stormwater drainage system, including parameters for the collection, transportation, water quality treatment and disposal systems, and the location of major components of the system.
- Best management practises and techniques for the operation and long term maintenance of the stormwater drainage system.
- Comments on soil suitability ie acid sulfate soils.

Hydro-geological issues investigated are:

- Identifying the extent, likely size and ecological importance of any unconfined aquifers which affect the SEPP 26 land
- Potential pollution of any unconfined aquifers, particularly in sandy soils by the proposed development.
- Reduction in groundwater levels during dry periods from reduced infiltration in developed areas.
- Possible effects on acid sulfate soils from lowered water tables.

Methodology applied is:

- Establishment of water quality objectives for stormwater leaving the site.
- Quantification of the potential impacts of nutrient and sediment export from the development site in stormwater using a mass balance modelling approach.
- Review of Councils Sub-division Code as it relates to urban runoff and water quality.
- Identification of best management practice stormwater quality management strategies suitable for the site. Including the selection of cost effective and ecologically sustainable stormwater management systems.
- Detailed identification of best management practices and techniques for the design, operation and long term maintenance of the stormwater drainage system .
- Interaction between site hydrology, and hydro-geology and acid sulphate soils.

1.3 Background

The Ocean Drive, Lake Cathie Planning Study has been prepared to identify the constraints and opportunities for the proposed residential development of land described as Lot 4 DP 613261 and Lot 1 DP 374315, Ocean Drive, Lake Cathie. The site falls within the Coastal Zone defined in the NSW Coastal Policy 1997 and is the subject of a rezoning proposal. The major constraint to development of the site is the SEPP 26 land to the east which has high conservation value. Acid sulphate soils, if present, are likely to be limited to the low lying areas to the south west of the site. The final lot configuration is likely to be subject to further negotiation. This report therefore provides concept guidelines for the final design of stormwater management structures, allowing flexibility in adjusting sizes when the final configuration has been completed.

1.4 Report Structure and Sources of Information

This report is divided into 4 sections:

- Section 2 describes the study area and establishes appropriate water quality objectives for stormwater leaving the site
- Section 3 describes the results of stormwater quality modelling. Impacts on groundwater are also evaluated.
- Section 4 identifies and evaluates the options for stormwater management. Final management options area recommended.

Sources of information for the study included :

- Hastings Shire Council Subdivision Code
- Australian Rainfall and Runoff - Vol 1 & 2 (IEAust,1987)
- Site Plans by GeoLink and King and Campbell Pty Ltd.
- 1:6000 Orthophoto map of site
- 1:25,000 Cadastral plans
- NSW Coastal Policy (1997), Coastal Management Manual.
- Managing Urban Stormwater Series (NSW Government)
- Geotechnical survey of the site by Hackett Laboratory Services Pty Ltd

1.5 Study Team

Principal: Peter A Jelliffe (BSc, Grad. Dip. Environment. & Muncip. Eng., Grad. Dip. Urb. & Reg. Planning, Dip. Ed.) MAWWA

2 WATER QUALITY OBJECTIVES

2.1 Introduction and Site Description

The site has been described in detail in the body of the Planning Report. Following is a summary of the catchment characteristics.

The study area is described as Lot 4 DP 613261 and Lot 1 DP 374315, Ocean Drive, Lake Cathie, in the Hastings Shire. The report addresses issues relating to the management of stormwater from the site when developed as a residential sub-division. The site has an overall area of approximately 41 hectares of which less than 25 ha is available for actual residential development. The remainder would be in buffer areas and stormwater management.

The site comprises five sub-catchments and is formed by an undulating ridge running parallel to the beach. Two of the catchments comprising approximately 43% of the site flow to a creek to the south west. Two of the catchments comprising approximately 27% of the developable site flow through the SEPP 26 land to the east. The remaining 30% is in a single catchment which flows north to a creek which crosses Ocean Rive. The site slopes gently east and west of the ridge with elevation ranging from approximately 5 m AHD to approximately 25 m AHD.

The site soils range from fine/medium grained grey brown sands over pale grey sand and indurated sands in the low lying area to the south, through a light brown silty Loam clay, to silty Clay over mottled clay at between 150 mm and 900 mm depth. If acid sulphate soils exist on the site they would be limited to the low lying areas along the south western edge of the site.

Site constraints to development include some minor flood prone areas along the creek line at the south western end of the site and a small area which is identified by DLWC as having a "low probability" of acid sulphate soils. SEPP 26 littoral forest is located along the eastern perimeter of the site. The remainder of the site is open grazing land.

The site is bounded to the north by Ocean Drive, to the west and south by a creek and rural land, to the east by the SEPP 26 littoral forest and Rainbow Beach.

Land-use zoning of the site is currently Rural 1(a1) under the Hastings Local Environmental Plan 2001. It is proposed to seek a rezoning of the land to Residential 2(a1) to allow for residential subdivision. Much of the land to the east has been subdivided as Low Density Residential 2(a). There are no permanent watercourses flowing through the site. The site presently comprises both cleared and vegetated areas.

2.2 Site Drainage

Slopes over the majority of the site are between 5% and 12% with steepest slopes on the south eastern flanks of the ridges. Soils range from sands in the low lying southern area of Lot1 through silty loams on the south eastern slopes, to silty clay on the ridge tops and grey clay on the gently sloping northern land of Lot 4. The littoral forest is situated on sandy soil with underlying layers of pebbles and potentially coffee rock strata. Land above approximately 9m AHD is either silty loam, silty clay or clay B horizon over medium to heavy clays. Upper horizons have medium to low permeability with clays having low permeability. Infiltration in these area will be poor. No evidence of groundwater or water table was evident in sites above 9 m AHD from the Hackett Laboratory Services Pty Ltd field assessment.

The site may be divided into five (5) catchments. Catchment areas shown refer to the area of developable land which would be in the catchment above any wetland located at the lowest point.

- Northern Catchment (Catchment 1) 6.6 ha.
- North eastern Catchment (Catchment 2) 3.2 ha
- South eastern Catchment (Catchment 3) 2.77 ha
- South western Catchment (Catchment 4) 5.95 ha
- Southern Catchment (Catchment 5) 3.1 ha

The northern catchment drains to a creek which crosses the Ocean Road. The southern and south western catchments drain to the creek which runs to the south of the site. The north eastern and south eastern catchments both drain into the sandy soil of the Littoral forest. Runoff to the east typically seeps into the sandy soil below approximately 9 m AHD. Higher flows result in flow down several small local gullies within the SEPP 26 area.

2.3 Hydrogeology

The Hackett Laboratory Services Pty Ltd field assessment did not find groundwater within the clay based soils above 9 m AHD. However, it is highly likely that an unconfined aquifer can be found within the sandy soils of the littoral forest to the east below approximately 9 m AHD. The aquifer would be confined on the eastern side by tidal seawater and on the western side by the clay soils of the higher land. The dry weather mean water table level would be expected to be slightly above the mean tide level down from the west. During prolonged dry periods it could be expected that the saltwater wedge would intrude further west into the littoral forest area but be forced eastwards during wet periods. This behaviour, while part of the natural cycle, could be expected to affect the natural selection of species positioned along the eastern edge of the littoral forest. The water table is likely to be an essential element of the littoral forest ecosystem. Peak water table levels will be significantly higher than the base level (potentially over 1 m +) due to runoff and infiltration from the clay based catchment to the west.

It has been assumed in the modelling that the catchment yield for the sandy undeveloped site is 50%, of which less than 10% is likely to be from overland flow. Remaining losses would be from evapotranspiration. The yield from the developed areas will be higher due to the proportion of impermeable area (assumed to be approximately 65% of the developed area as roof, road or driveway). The remaining 35% will be mainly as grassed soil. The decrease in overall permeability of the site will reduce the infiltration into the silty clay soils, however field testing suggests that relatively little water actually follows this path, with the majority of water shedding as overland flow. Infiltration into the silty clay soils is therefore of less importance than maintenance of flows to the sands of the littoral forest zone to the east. It is therefore a management objective for the site to maintain recharge of the water table within the littoral forest.

2.4 Discussion on Catchment Characteristics

The behaviour of runoff and the proportion of impervious surface within the catchment will have a significant effect on the catchment hydrology and on the opportunity for pollutants to be washed out of the catchment by rain. Flow from impervious surfaces will tend to have greater kinetic energy than stormwater from pervious surfaces, thereby having greater potential to cause scouring and to mobilise pollutants which may have been deposited as fallout during dry periods or previous minor storms. This characteristic accounts for much of the higher pollution loading usually carried by urban stormwater when compared to stormwater from non-urban areas. Activities which occur within the catchment will also be reflected in the pollutant loading in stormwater. For example, the overuse of fertilisers in urban areas may result in elevated levels of nutrients in stormwater from those catchments.

The creeks running to the south west and to the north eventually become intermittently opening lagoon systems. When these systems are closed to ocean flushing nutrient levels may build up causing eutrophication. It will be a management objective that all stormwater from the site is treated for the removal of nutrients as well as sediments and gross pollutants (eg litter).

2.5 Salinity and Nutrient Dynamics

Salinity changes and distance from the ocean affect the relative importance of nitrogen and phosphorus in the waterway. The growth of algae may be expected where there is an abundance of nutrients (both N & P) and light. Where one of the nutrients is lacking waters are termed "limited"for that nutrient. Estuarine waters are typically nitrogen limited due to the low natural background nitrogen levels in oceanic waters and the relative abundance of phosphorus which is slowly leached and cycled from the estuarine sediments. For estuarine or intermittently opening estuarine systems the nutrient of most concern for algal growth is nitrogen. For fresh waters above the tidal limit, and for pond systems, the nutrient of most concern is likely to be phosphorus. In the estuary algal blooms are unlikely to occur where tidal flushing is pronounced due to short residence time within the estuary and the extent of dilution which occurs with tidal mixing. During closest conditions any influx of nutrients will result in an increase in the trophic status of the waters (ie increased algal growth).

The potential for algal growth in coastal heath and wetland areas is affected by water colour, pH and an abundance of available iron, which are all characteristics of groundwater in coastal heath areas. Wrigley *et al* (1988) reported that the tannic colouration in coastal heath waters (gilvin) significantly reduces algal production by reducing photosynthesis. They also report that the organic compounds which cause the colouration bond with phosphate making it unavailable for uptake by most plants. The combination of low pH and an abundance of available iron significantly increases the potential for available ortho-phosphate to bond with iron to form insoluble iron phosphate which precipitates to the bottom. These mechanisms significantly reduce the potential for coastal swamp/lake waters to become eutrophic, Wrigley *et al* noted that coastal water bodies with noticeable gilvin levels within developed residential subdivisions in Perth did not turn eutrophic, while lakes with similar catchment characteristics without gilvin were often eutrophic. These characteristics may be employed in the design of wetland systems for stormwater in coastal areas.

2.6 Sensitivity of The Littoral Forest System and the Creeks

Waterways may be considered sensitive if their beneficial uses or ecological condition (trophic status and ecological diversity) are likely to be threatened or degraded by even minor changes to the water quality. Protection of Biodiversity is a principle objective of ecologically sustainable development. The Biodiversity Working Party (1991) suggested that protecting bio-diversity means ensuring that the affects of development do not threaten the integrity of ecosystems or the conservation of species. Key measures for water quality will depend on the beneficial use and on the characteristics of the water body. For the groundwater of the littoral forest key parameters associated with stormwater are identified as nutrients Nitrogen and phosphorus. The key parameters requiring protection for the creek systems are nutrients, suspended solids and gross pollutants (eg litter). Oils, detergents and metals are also important but are of limited concern given the proposal to develop the site as a residential area.

2.7 Water Quality Objectives

From the status of littoral forest as a SEPP 26 area it may be concluded that it is a pristine eco-system. The objectives for water entering the SEPP 26 groundwater system, are:

- To achieve reduction in water quality parameters in accordance with the following priority:

High Priority
- Nitrogen and phosphorus

Medium priority
- Litter

Low Priority
- Sediment

The south western and northern creek systems have been altered by human activity and are considered modified eco-systems. The objectives for water entering the northern and south western creek systems are:

- To achieve reduction in water quality parameters in accordance with the following priority:

High Priority
- Nitrogen and phosphorus
- Sediments
- Litter

Medium priority
- Pathogens

Table 2.1: Stormwater Management Objectives

Waterways Value	Long Term	Short Term
Ecological Values		
E1 Aquatic Ecosystems	- Water quality in all waterways meets ANZECC - Aquatic life diversity of natural species maintained - Wetlands, mangroves and sea grasses protected and enhanced	- Nitrogen and phosphorus concentrations in all waterways reduced. - Faecal coliform levels in creek and estuaries not increased. - Suspended solids load in all waterways not exceeding 10mg/l in dry weather. - Areas of bank erosion addressed along the estuary banks. - Stormwater velocity from urban areas reduced, to prevent erosion. - Flow requirements for maintenance of aquatic ecosystems - Weed growth in all creeks and channels controlled.
E2 Riparian Vegetation	- Indigenous riparian and foreshore vegetation protected and restored	- Wetlands in estuarine areas protected from removal or development through adequate buffer zone - Degraded indigenous riparian vegetation along tidal reaches of the creeks restored.
E3 Littoral Forest	-- Indigenous littoral forest vegetation protected and restored	-Groundwater flow regimes and quality be maintained
E4 Bushland	Impact of urban stormwater on weed growth and propagation within neighbouring bushland and channels minimised.	- Impact of urban stormwater on weed propagation within bushland or along stormwater channels educed. - Bushland protected from clearing for development.
E5 Water Associated Wildlife	Habitat within and along waterways protected and restored to encourage and improve diversity of water associated wildlife	-Impact of urban stormwater on weed propagation within bushland or along stormwater channels educed. - Bushland protected from clearing for development.
Social Values		
S1 Visual	Visual amenity of all waterways maximised.	- Areas of bank erosion addressed along the estuary banks. - Weed growth in all creeks and channels controlled. - Litter prevented from entering creeks. No anthropogenic litter greater than 50 cm for flows up to 25% of the 1 year AR1 peak flow to be visible.
S2 Primary Recreation	- Water quality in creeks to meet ANZECC requirements for primary contact recreation - Public safety of Estuary continually reviewed.	- Water quality in creeks to meet ANZECC requirements for primary contact recreation 90% of dry weather days.

The recommended stormwater quality management objective is:

Stormwater quality management measures within the proposed Ocean Drive, Lake Cathie development site shall achieve the objective of no deterioration in the overall quality of stormwater from the site following the development. Water shall be measured as using the following parameters: nutrients (Nitrogen and Phosphorus) and suspended solids.

3 STORM WATER QUALITY MODELLING AND GROUNDWATER IMPACTS

3.1 Introduction

The change in export of pollutants (nutrients and suspended solids) from the site in stormwater was modelled using a simple mass balance method. The method involved establishing the likely mass of pollutants exported from differing landuse types in the absence of stormwater management measures. Pollutant export rates recently compiled by Pine River Shire Council (SE QLD) were applied. The mass of pollutants is calculated by multiplying the annual export rate per hectare with the number of hectares. The performance of the recommended management measures was established from published data and reductions applied in the order of the recommended management measures in the treatment train. The calculations are set out in Tables 4.2, 4.3 and 4.4.

3.2 Pollutants in Stormwater

Estuarine ecosystems may be sensitive to pollutants found in urban stormwater. The range of pollutants may include metals (Cu, Pb, Cd, Zn etc), oils and greases, organic chemicals (pesticides), BOD, sediments, pathogens and nutrients. The pollutants in greatest concentration and of most concern for creek water quality are generally accepted as being the nutrients (nitrogen and phosphorus), suspended solids (sediment) and pathogens (Faecal coliforms), of which nutrients and suspended solids are usually the limiting pollutants.

The pollutant export calculations were undertaken for three configurations:

- The catchment under present landuse
- The catchment when fully developed but <u>without</u> any stormwater control measures.
- The catchment fully developed <u>with</u> stormwater quality measures

3.3 Stormwater and Pollutant Retention

The majority of the area proposed to be developed as residential is on silty clay to clay soils. Surface runoff yields used in the model are set out in Table 4.2. Approximately 50 % of rainfall water will leave the developed site as runoff, however rainfall falling on roofed areas will be collected by rain tanks, with approximately 85% retention for slow release to the ground. As roofed areas will equate to between 15% and 20% of the total area, assuming 85% retention of rainfall, the effective area removed from the catchment by the use of rainwater tanks is between (15% x 0.85 = 13%) and (20% x 0.85 = 17%). The modelling has therefore assumed that with water tanks the catchment contributing surface runoff is approximately15% less than the actual area with a corresponding reduction of 15% in the export of soluble nutrients.

The effectiveness of management measures trialed as part of the options evaluation process, was determined using performance data produced in Duncan (1995, 1995b & 1997) for wetlands; in various

NSW EPA publications in the *Managing Urban Stormwater Series* (1996-98); the US EPA *Urban Runoff Pollution Prevention and Control Planning* (1993); The Brisbane City Council *Design Guidelines for Stormwater Quality Improvement Devices* (1999); and, in the DLWC *The Constructed Wetlands Manual* (1998).

3.4 Impacts of Development on Water Tables and Acid Sulphate Soils

Any increase in the area of impervious surface within the development site will decrease the rate of infiltration into the ground, potentially affecting the water table during drier years. As discussed in section 2.3 changes in infiltration to the silty clay and clay soils is of limited importance. A method of off-setting the reduction in infiltration to residential areas is to capture rainwater in roof tanks for slow release back into the ground. This measure is examined further in this report. As stated in section 2.3 the most important water table is that within the littoral forest area to the east. Provided runoff running overland or seeping into the sandy soils at the western edge of this area remains similar to the present it can be expected that this water table will be maintained and protected.

The potential for acid sulphate soil has been identified as either "No Known Occurrence" or "Low Probability" in the DLWC Acid Sulphate Soil maps. In summary acid sulphate potential is limited to soils towards the south western end of the site below 5 m AHD which are identified as having a Low Probability. In order to expose the acid sulfate soil to the atmosphere groundwater levels would need to fall below the existing dry season base level. At the base level the hydraulic gradient would be flat. At that level natural losses from the system would therefore be limited to evapotranspiration. Exposure of acid sulfate soils could therefore be expected as a natural course of events during periods of prolonged drought. However, any significant reduction in recharge could reduce the length of time required for groundwater levels to reach the base level during drought, and for evapotranspiration to expose the acid sulfate soils. It is therefore recommended that all opportunities for maximising infiltration within the study area are capitalised on. The most important measure to avoid drawing down the water table in areas with acid sulphate soils is to control the use of spear point bores in this area.

3.5 Modelling Objectives

The objectives of the modelling are:

a) *To predict the export of nutrients Total Phosphorus (TP) and Total Nitrogen (TN), and sediment from the study area catchments in stormwater.*

b) *To predict the likely impact of various stormwater management measures in reducing pollutant export from the site when completed.*

Modelling calculations are shown in Tables 4.2, 4.3 and 4.4.

4 STORMWATER QUALITY MANAGEMENT OPTIONS

4.1 Introduction

A range of stormwater quality management measures were identified and assessed. The measures have been divided into four groupings:

- Minor Engineered Measures
- Major Engineered Measures
- Economic and Community Based Measures
- Infra-structure Measures

The minor engineered measures are measures which are generally applied at the top of the catchment, either within individual allotments, blocks or precincts. They are generally applied closest to the source of stormwater pollution. Examples are filter strips, On-Site Detention OSD, rainwater tanks and infiltration beds, and pervious driveways. Smaller "end of pipe" silt and litter traps, stormwater pit baskets and smaller "in line" devices also fall into the Minor engineered measures group.

Major engineered measures are larger "end of pipe", or "middle of pipe" solutions. They are often necessary to capture pollutants which may not be captured by other measures. Examples are wetlands, wet and dry detention pond, Gross Pollution Traps (GPTs) and sediment separation devices.

Economic and community based measures are programs which utilise regulations, economic instruments and education to achieve outcomes which may include reduced discharges of pollutants through behaviour change, or by technical measures. Examples are public education programs, specific and detailed guidance in Development Control Plans and pricing/rate based incentive schemes, water efficiency programs.

Infra-structure measures are measures associated with major infra-structure public health engineering works, such as sewers, sewage pump stations and water supplies.

Table 4.1 sets out the effectiveness in removing pollutants, relative costs, maintenance requirements, suitable catchment sizes, specific requirements and applications for stormwater quality control options.

Table 4.1 **Stormwater Management Options Performance Data Sheet**

Management Option	Effectiveness				Catchment Area	Maintenance	Cost	Required Soil Conditions	Specific Considerations	Application
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments						
Minor Engineered Measures										
Filter strips	Moderate	Moderate	High	High	<2 ha	Low	Low	Most soils	Maintained to avoid channelisation	Drain edges - lower edges of lots - parks
Porous pavements	Moderate	Low	High	High	Local	Low - occasional Cleaning	Moderate	Permeable	Must be kept clean	Low use roadways, parking areas, paths
Infiltration of Roof Runoff	Moderate	Moderate	High	High	Roof Areas	Low	Low to moderate	Highly permeable	Designed to avoid local flooding	Range of buildings in sandy areas
Grass Swales	Moderate	Moderate	High	High	< 2ha	Low to moderate mowing and cleaning	Low	Moderately permeable	Slope constraints unless terraced or using reinforced turf.	Lower density developments, & low flow channels
Infiltration beds/trenches	Moderate	Moderate	High	High	<2 ha	Moderate - regular inspection and periodic cleaning	Moderate	Moderate to highly permeable	High risk of failure if allowed to trap sediment - require pre-treatment	Suitable for established areas with low sediment load.
Rainwater Tanks and infiltration	Moderate	Moderate	High	High	Roof Areas	Moderate	Moderate to high	Most soils	Tanks must be empty to catch and store water	Small to moderate sized buildings

For effectiveness, High is 75% to 100%, Moderate is 50% to 70%, Low is 10% to 50%, Negligible is <10%, * is estimated value.

Table 4.1 Continued..

Management Option	Effectiveness				Catchment Area	Maintenance	Cost	Required Soil Conditions	Specific Considerations	Application
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments						
Reduced Impervious Area for New Development	Variable depending on reduction - may be significant				N/A	Low - mowing or maintenance of vegetation	Low to moderate	Best in moderate to permeable soils	Serviceability of permeable surfaces	Low use parking areas, paths, low use roads
Pet Waste Collection and Disposal	Low*	Low*	High*	Negligible*	N/A	Moderate cleaning of pet waste bins	Low	No constraints	Requires behavioural change in both animals and owners	Parks, suburban footpaths, areas used to walk dogs
Smaller Silt and Litter Traps (eg Nicholas Ski Jump, ECOSOL RSF 1000)	Low	Low-moderate (Organic N Only)	Low-moderate	High	generally < 8ha	Regular cleaning, low technology	Low	No constraints	Nicholas Ski Jump units may be cleaned by locals using wheelie bins	Small to moderate subdivisions upstream of wetlands or riparian buffers
On Site Detention OSD	Moderate	Moderate	Low	Moderate	<1 ha	Mod to high. Maintenance of system	Moderate	All soils	OSD must not cause local flooding problems.	Small to moderate sized buildings and lots

* Estimates Only

Table 4.1 Continued..

Management Option	Effectiveness				Catchment Area	Maintenance	Cost	Required Soil Conditions	Specific Considerations	Application
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments						
Protection and Re-vegetation of Riparian Areas	Moderate	Moderate	High	High	unlimited	Low after establishment . Removal of exotic weeds	Low	All soils	Maintained to avoid colonisation by exotics. Use endemic local species.	Edges of water courses and drains.
Major Engineered Measures										
Dry Detention Ponds	Low - Moderate	Low-Moderate	Low	Moderate	> 2ha	Moderate. Mowing and removal of debris.	Moderate	Effectiveness increases with increasing soil permeability	Ponds need to be landscaped to serve as a useful secondary open space function.	New urban areas.
On-stream Constructed wetlands	Moderate	Low	High	High	> 2ha, best >4 ha	Low to moderate. Removal of debris and weeds. Weirs and outlets	Moderate to high	Impermeable clay liner may be required for permeable soils.	Wetlands must be large enough & properly designed Mosquito problems.	New urban areas and existing areas with available land.
Off-stream Constructed Wetlands	Moderate	Low	High	High	>4 ha	Low to moderate. Removal of debris and weeds. Weirs and outlets	Moderate to high	Clay liner may be required for permeable soils.	Designed to trap the first flush for a design event. Use small area Avoids pollutant remobilisation.	New urban areas and existing areas with available land.

Table 4.1 Continued..

Management Option	Effectiveness				Catchment Area	Maintenance	Cost	Required Soil Condition	Specific Considerations	Application
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments						
Sediment Traps	Negligible	Negligible	Low	Negligible	> 2ha	Moderate. Require regular inspection and cleaning	Moderate to high	All soils	-	New development or where there is adequate space.
Gross Pollution Traps	Negligible	Negligible	Low	Low	> 2 ha	Moderate cleaning costs	High	All soils	Must be designed to be landscaped with surrounding area	Medium to larger urban catchments
Sand Filters	Moderate	Moderate	Moderate to high	High	< 1 ha	High cleaning costs	High	All soils	Suitable for small sites with particular problems	Small sites requiring a high level of treatment
Infiltration ponds	Moderate	Moderate	High	High	1 ha to 8 ha	Moderate cleaning costs	Moderate to High	Permeable soils	Not suitable for construction sites. Require large area.	New sites or retro fit where there is sufficient space

Table 4.1 Continued..

Management Option	Effectiveness				Catchment Area	Maintenance	Cost	Required Soil Conditions	Specific Considerations	Applications
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments						
Economic and Community Based Measures										
Oil and Sediment Separation Devices GPT's eg CDS, Ecosol, Humeceptor,	Negligible to low	Negligible to low	Negligible	High	1 ha to 20 ha+	High. Requires a suction truck or hydraulic basket lifter.	High	All soils	These systems remove litter, oils and suspended solids. Rely on regular cleaning.	New urban situations. Also suitable for retro-fitting in old systems.
Litter racks/booms	Negligible	Negligible	Negligible	Low	Generally greater than 2 ha.	Moderate to high cost associated with cleaning. Very effective at litter removal.	Low to Moderate	All soils	Must be carefully designed for ease of cleaning and for headloss constraints.	Suitable for New development and some existing drains & creeks.

Table 4.1 Continued..

Management Option	Effectiveness				Catchment Area	Mainten ance	Cost	Required Soil Conditions	Specific Considerations
	Phosphorus	Nitrogen	Pathogens	Suspended Sediments					
Economic and Community Based Measures									
Community Education	Potential moderate improvement from improved household practises	Potential low to moderate improvement from pet waste handling	Potential moderate to high reduction	Potential Moderate to Low	Low cost	Low	N/A	Requires on-going educational advertising campaign combined with incentives and feedback. Feedback must be provided to community.	Existing areas where improvements may result. Areas where human practices are a major pollutant source

For effectiveness, High is 75% to 100%, Moderate is 50% to 70%, Low is 10% to 50%, Negligible is <10%, * is estimated value.
For Cost Low is < $1,000 per ha, Moderate is < $10,000/ha , High is > $10,000 per ha.

Reference: US EPA (1993) & NSW EPA (1996-98)

4.2 Stormwater Management Issues and Objectives

The main environmental issues relating to stormwater management within the study area are:

- Potential export of pollutants from the development area to the SEPP 26 area or the two creeks to the north and south west.

- Change in groundwater recharge behaviour in the SEPP 26 area.

The design objectives for stormwater management within the Ocean Drive, Lake Cathie site are:

- *Minimise the discharge of contaminated stormwater from the site into the SEPP 26 forest and the two creeks*

This objective can be achieved by a combination of stormwater treatment and infiltration measures.

- *Retain as much as possible the pre-development SEPP 26 groundwater recharge characteristics*

This objective requires that runoff from the site not be diverted from the original drainage pathways and that runoff be directed to infiltrate into the sandy soils of the SEPP 26 area.

- *Utilise the infiltration, hydraulic conductivity and pollutant removal characteristics of the soils to treat stormwater where practical*

Utilisation of the soil for treatment is only an option in sandy areas. However seepage areas can be established in silty loam and silty clay soils to infiltrate and treat captured roof water.

4.3 Stormwater Management Options

The treatment train should serve to minimise the export of pollutants from individual allotments, capture silt and litter using physical means which are small footprint and easy to clean, and utilise biological systems to remove fine particulates and soluble pollutants (including nutrients).

Stormwater management for the site may therefore combine the following elements.

- Source control of stormwater from roofs and driveways. Options include:

    - On Site Detention using water tanks or high volume guttering
    - Direction of captured roofwater into the ground by drip irrigation of gardens, seepage trenches or leaky pipe drainage systems. Captured rainwater may also be used to irrigate garden beds during dry times or as internal household supply for toilet flushing and laundry water.

- Community education into the responsible application of fertilisers and the disposal of garden wastes and lawn clippings.

- Infiltration of stormwater from roads via swale drains and infiltration trenches where soils are sandy. This option is applicable only to areas along the eastern edge of the site and in the southern end where slopes are < 5% and soils are sandy.

- Capture of silt and litter from all road drains by end of pipe silt and litter trap devices (eg Nicholas Ski Jump, Pratten Trap or ECOSOL RSF 1000 units). The type of system selected should be capable of storing captured material in a dry condition and be cost effective to clean out.

- Final treatment of all stormwater through off stream constructed macrophyte wetlands.

- Education pamphlet providing advice to owners on minimising the potential for pollution of stormwater by household activities.

The measures described above were assessed in terms of expected performance in removing pollutants. The effectiveness of the education pamphlet was not modelled as it is uncertain as to the impact of this measure. The wetlands were assumed to be off-stream devices capable of capturing and storing flows from a 3 month storm event taken as 50% of the 1 year catchment storm event. This is achieved by a wetland of between 1 and 2% of the catchment area.

4.4 Details of the Stormwater Management Measures

- **Roof water Capture by Rainwater Tanks with slow release into the ground**

This measure will have the same effect as removing 15% of the pollutant load from the residential catchment (refer section 3.3). The collected roofwater will not re-enter the surface flow system as it will be disposed of by slow release into the ground. The measure was modelled by reducing the effective residential area by 15%.

- **Silt and Litter Capture Devices**

Silt and litter capture devices are located on all drainage outlets discharging to the wetlands (ie the ends of all drains). These devices will remove gross litter and medium sediments, but do not remove fine sediments or soluble nutrients. Silt and litter control devices are significantly cheaper and smaller than Gross Pollutant Traps. An advantage of many of these systems is that they store the captured material dry and are relatively easy to clean, not requiring suction trucks. Dry litter does not release nutrients at the same rate as material kept wet and potentially anaerobic.

- **Off-stream Wetlands**

Off-stream wetlands allow the capture of initial flows from the catchment and all storm events up to the design size (a 3 month storm event). Larger flows with high velocities which would potentially resuspend captured material are bypassed down a grassed side channel over a weir. The advantages of the off stream wetland are a smaller footprint and greater effectiveness in capture. The requirement to understand the hydraulic behaviour of the wetland bypass system results in tighter design control over velocities within the wetland during extreme events. Design modelling by this consultant has found that the advantages of off-stream wetlands over in-stream wetlands are appear to diminish when wetlands reach around 3% of the catchment area. A 3 month RI design storm can be contained within a wetland of around 1.25% of the catchment. It is proposed that off stream wetlands within the site be between 1% and 2% in area.

- **Roadside Drainage Measures**

Grassed swale drainage is only effective in soils of higher permeability (ie loams or sands) and serves to remove sediments and pollutants associated with particulates. Infiltration may be enhanced by the use of gravel filled trenches or leaky pipe located in a trench along the invert of the swale. Other measures include bottomless drainage pits and leaky pipe connections in conventional road drainage pipeworks. These measures are only effective in loam or sandy soils and are therefore limited on this site.

- **OSD and Infiltration of Roofwater**

On Site Detention (OSD) involves the capture and holding of roof water in rainwater tanks for slow release into the ground or for reuse by garden irrigation or internal household uses such as toilet flush water. Roofwater contains a range of pollutants dissolved from the air or entrained as particulates. These pollutants are often removed when rainwater lands on soil or vegetation. However, where rainwater lands on impervious surfaces the pollutants may be carried directly into drains and ultimately a natural watercourse. Detaining roofwater in rainwater tanks for later watering of lawns and gardens, or slow release into pits, trenches or sumps near the source reduces the potential for pollutants washed out of the air to reach a water course, and also helps reduce the impact of development on the local water table. Measures such as OSD and road runoff infiltration. reduce the effective impervious area as well as removing pollutants.

The tank and infiltration area design should be sized to enable a design storm to be disposed of. The following design guide is recommended:

- Rain tank to hold as a minimum the volume from the first 25% a 3 month 24 hour design storm above any long term storage requirements for the allotment. The 3 month event is taken as 50% of the 1 year ARI event. AR & R (1987) gives the 1 year 24 hour event as 4.44 mm/hr. The design storm rainfall is approximately 4.44 mm/hr x 24 hrs x 50% = 53.3 mm. The first 25% of the event is 53.3 mm x 0.25 = 13.35 mm. For a house with a typical 150 m^2 of roof area the design storm will be approximately 150 m^2 x 0.01335 m = 2.0 m^3. By allowing a small flow from the tank to a trickle disposal area the effective volume of the tank is increased. A

1 hr time step mass balance model was used to find the optimum size tank. A tank with a minimum volume of 1.8 m^3 was found to be effective in intercepting the initial 25% of the 3 month 24 yr storm event as well as directing approximately 53% of overall rainwater to the infiltration bed. A 1.8 m^3 tank volume also reduce the peak loading on stormwater infrastructure during intense events.

- The outflow from the rain tank to the infiltration area should allow the controlled slow release of collected water to the infiltration area such that infiltration from a design storm occurred over a period of say 24 hours. The model found that an outflow rate of between 0.02 L/s and 0.04 L/s would be adequate. Rainfall exceeding the design rate of discharge will result in filling of the tank and eventual overflow to the normal drainage system. Minimum design size calculations are shown in section 4.10. Drip irrigation of garden beds or shallow subsurface leaky pipe technology would also be appropriate.

- Design of overflow pipes from the top of the tank in accordance with normal design criteria for peak flows.

- Design of the seepage area to accommodate the flow rate which would occur from the tank during and after the 24 hr design storm (refer section 4.10 for calculations).

4.5 Origin of Performance Data used in the Model

Performance data for litter traps was obtained from manufacturers' data (Nicholas Ski Jump). Performance data for filter strips and grass swales drains was obtained from the NSW EPA Managing Urban Stormwater Series: Treatment Techniques (1997). The effectiveness of OSD is based on a reduction in runoff from residential areas of approximately 15%. with the majority of nutrients exported from the study area being carried in surface water from impervious areas. Performance data for wetlands was obtained from Duncan (1997).

Table 4.2 Assumed Effectiveness of Stormwater Management Measures

Stormwater Quality Management Measure	Percentage Reduction in Total Phosphorus	Percentage Reduction in Total Nitrogen	Percentage Reduction in Sediment
1.OSD in urban areas[2]	15 %	15 %	-
2.Silt and Litter Traps[3]	5%	5%	60%
3.Wetlands 2% of clatchment[1]	44%	20%	70%
4.Grassed Swale Drains	30%	10%	15%
Combined reduction not including swale drains	55%	35%	88%

[1] Based on performance data by Duncan CRC for Catchment Hydrology (1997).
[2] Conservative estimate only
[3] Doug Nicholas - Nicholas Ski Jump

4.6 Predicted performance of the Recommended Stormwater Management Options

The stormwater quality management options introduced in section 4.2 were assessed for the residential areas within the study area.

- **Wetland Sizing and Disposal System**

Recommended minimum off-stream wetland sizes are presented in Table 4.5. Wetlands should be designed to capture and detain all of the flow from a *design storm* being 50% of the volume of a 1 year event. This is usually assumed to equate to a 3 month event. Recent modelling by Evan Thomas (Gold Coast City Council, 2002) has shown that 85% of all rain event is captured by systems designed to capture 3 month events. Events of greater magnitude than the design storm will overtop the weir at the upstream end of the bypass channel allowing some water to bypass. As a general rule the design storm volume will be stored above the mean operating level of the wetland. The elevation of the bypass channel above the mean operating level (MOL) will determine the volume which can be stored before water bypasses via the channel. Bypass weirs are typically elevated approximately 500 mm above MOL. The area required for the wetland may be conservatively estimated by dividing the total volume of the design storm by 500 mm to give an area. The AR&R (1987) tables give the 1 year 1 hour rainfall event as 31.30 mm per hour for Lake Cathie. A *design storm* event of 50% of the 1 year event will be 15.65 mm/hr. Assuming runoff from the residential area in the design storm is approximately 55%, but 15% of the catchment area will be roofed with rainwater captured by tanks, the actual runoff coefficient will be approximately 55% - 15% = 40% of the rainfall over the catchment. This equates to approximately 0.0157 m x 10,000 m^2 x 0.4 = 63 m^3/ha. Assuming a depth of 500 mm the average area of wetland required is approximately 63 m^3 / 0.5 m = 126 m^2/ha of wetland. This may rounded to 125 m^2/ha which is 1.25% of the catchment. Off-stream wetlands should therefore be no less than 1.25% of the catchment area. Recommended minimum wetland areas are shown in table 4.5.

The design shall have a length to width ratio of between 3:1 and 4:1, have a maximum depth of 1.0 to 1.5 m occupying no more than 25% of the wetland volume with the remaining area in depths varying between 300mm and 800 mm. Edges should fall steeply to 300 mm with floor slopes designed to fall to the deepest point to minimise the potential for isolated shallow pools to develop if water levels drop. These measures are to encourage a diversity of habitat and to minimise mosquito breeding conditions.

The bypass weir and channel should be designed to bypass flows in excess of the design event or higher. The wetland and bypass systems should be designed such that velocities within the wetland do not exceed 0.2 m/s within the wetland during extreme events (ie > 20 yr event). Velocities in the bypass channel should not exceed 2.5 m/s in a 5 year event and 3 m/s during a 100 year event. Where bypass velocities exceed 2 m/s the channel will need to be grassed using a reinforced turf.

Discharge of water from the wetlands and bypass channels in the catchments of the south western and northern creeks shall be by direct overflow through an energy dissipation pad to the present seepage pathway. Discharge from the wetlands to the SEPP 26 area (eastern wetlands) shall be to low flow seepage trenches designed to infiltrate up to the 1 year storm event flows. The seepage trenches will be placed along the western edge of the SEPP 26 zone within the existing water supply easement. Events > approximately 1 year ARI will overflow this system by surcharging from the trenches and spreading downslope into the SEPP 26 area as presently occurs. Due to the sandy soils infiltration is likely to be rapid. The seepage trenches will be gravel filled with a suitably sized slotted pipe distributing water along the length. The trenches need only be 300 to 500 mm deep with a gentle grade. (Ie 1%).

4.7 Pollution Reduction Predicted for the Recommended Management Measures

Table 4.3 sets out the pollutant export rates for catchments with no stormwater management measures. Table 4.4 shows the predicted reduction in pollutants from the recommended management measures.

Table 4.3 Pollutant Export Rates for Differing Landuses With No Stormwater Quality Management and Predicted Percentage Reduction in Pollutant Export by Measures Recommended

Landuse and Residential Catchment Area (ha)		Runoff ML/yr	TN kg/yr	TP kg/yr	Sediments kg/yr
Export rates for existing landuse		35%	7.4 kg/ha/yr	0.7 kg/ha/yr	290 kg/ha/yr
Export rate for residential landuse		50%	10.3 kg/ha/yr	1.6 kg/ha/yr	950 kg/ha/yr
Predicted Pollutant Export from Existing Landuse					
Northern catchment 1	6.6	-	49	4.6	1914
North eastern catchment 2	3.2	-	24	2.2	928
South eastern catchment 3	2.79	-	21	2	809
North Western catchment 4	5.95	-	44	4.2	1726
Southern catchment 5	3.1		23	2.2	900
Total	21.64	-	160	15	6276

Table 3.4 Continued......

Predicted Pollutant Export For Residential Development Without Recommended Management Measures					
Landuse and Residential Catchment Area (ha)		Runoff ML/yr	TN kg/yr	TP kg/yr	Sediments kg/yr
Northern catchment 1	6.6	-	68	10.6	6270
North eastern catchment 2	3.2	-	33	5.12	3040
South eastern catchment 3	2.79	-	29	4.5	2650
North Western catchment 4	5.95	-	61.2	9.5	5653
Southern catchment 5	3.1	-	32	5	2945
Total	21.64	-	223	35	20558

Table 4.4 Predicted Pollutant Export with Recommended Management Measures

Landuse and Residential Catchment Area (ha)		TN kg/yr	TP kg/yr	Sediments kg/yr
% Reduction with Recommended Management Measures		35%	55%	88%
Predicted Pollutant Export From Proposed Residential Development With Recommended Management Measures				
Northern catchment 1	6.6	44	4.8	752
North eastern catchment 2	3.2	21.5	2.3	365
South eastern catchment 3	2.79	18.9	2	318
North Western catchment 4	5.95	40	4.3	678
Southern catchment 5	3.1	21	2.3	353
Total	21.64	145	15.7	2466

Table 4.5 Recommended Wetland Sizes (Surface Areas Not Including Bypass Channels)

Catchment	Developed catchment Above Wetland in Hectares	Recommended Wetland Surface Area[1] m^2
Northern Catchment 1	6.6	825
North Eastern Catchment 2	3.2	400
South Eastern Catchment 3	2.7	338
North Western Catchment 4	5.95	744
Southern Catchment 5	3.1	388

Note: the area required for the wetland plus bypass channel plus batter slopes etc will be result in the entire area required in the order of 2% of the catchment. The surface area of off-stream wetland alone is 1.25% of the catchment.

4.8 Discussion

Table 4.3 shows the predicted mass of nutrients (Nitrogen and Phosphorus) and sediments exported from the area proposed for development in its existing landuse configuration, and with the proposed residential development but without any of the recommended stormwater management measures. Table 4.4 shows the predicted export of pollutants from the developed site with the recommended stormwater quality management measures. The results show a reduction in nitrogen and suspended solids and a return to the same export rate for phosphorus.

4.9 Conclusions

The following conclusions can be drawn from the study:

- The development of residential land within the study area would result in a significant increase in the export of pollutants from the site unless additional stormwater quality control measures are implemented.

- A range of stormwater quality management options were assessed. The following stormwater treatment train was considered the most practical and cost effective for the site.

    - On Site Detention by household rainwater tanks or high volume guttering combined with on-site infiltration measures at the allotment level;

    - Silt and litter traps on the outlets of all drains immediately upstream of the off stream wetlands. The traps will remove silt and gross pollutants with the captured material retained in a dry condition. Recommended traps are the Nicholas Ski Jump and the ECOSOL RSF 1000 (the latter requiring greater elevation drop at the outlet)

- Grass swale drainage with infiltration trenches, bottomless pits and leaky pipes for the roadside drainage scheme only in areas where grades < 5% and soils are sand. In other areas conventional stormwater management should be applied.

- Education pamphlet instructing potential owners that they live in a sensitive catchment, and providing advice on minimising the potential for pollution of stormwater by household activities.

- Based on the model predictions, it is estimated that the mass of nitrogen exported from the developed site with the recommended management measures implemented, will be slightly less than is currently being exported. The mass of phosphorus will be approximately the same as at present, and the mass of sediments significantly less than at present.

- The recommended management measures are predicted to achieve the objectives for stormwater management set out in section 2.

4.10 Management of the Stormwater Management Measures

- **Off-stream Wetlands**

Wetlands occupy a significant area and as such must be appropriately located to gain the maximum benefit. This is achieved by locating wetlands below the source of the runoff which is to be treated. Locating wetlands at higher elevations will result in runoff from developed areas which cannot flow by gravity to the wetland effectively bypassing the treatment train. Collection of stormwater at a lower point and pumping back up to a higher wetland cannot be justified on either economic or environmental terms (relating to energy usage by pumps and consequent green house gas generation). The proposed off-stream wetlands are an essential component of the stormwater treatment train and will need to be located below residential areas.

Wetlands are most effective with a length to width ratio of between 3:1 and 4:1. Wetlands which have a larger ratio (ie long and thin) will tend to have problems with flow velocity potentially resulting in resuspension of captured material during larger events. Wetlands which have a lower ratio (ie short and wide) will tend to exhibit short circuiting, reducing their effectiveness.

The issue of risks of locating wetlands close to the SEPP 256 area has been raised. An assessment of hazards associated with locating wetlands close to the SEPP 26 area identifies the following potential hazards.

- Potential Hazard 1. Change in water table levels and water quality resulting from leakage from the wetlands

The wetland floors will be sealed to avoid leakage. This is essential to maintaining control over wetland water levels. Discharge from the wetlands will be into seepage trenches located along the western edge of the SEPP 26 area specifically to ensure that the SEPP 26 water table is replenished by clean stormwater, as presently occurs. If there is leakage from the wetlands the water will enter the same ground water system. Wetland leakage will never have the potential to approach or exceed the rate of throughflow. Any water leaking from the wetlands will have received treatment in the wetland and be of acceptable quality.

Hazard Impact : Low
Risk: Low

- Potential Hazard 2. Proximity of wetland adversely affecting littoral forest vegetation

The wetlands are proposed to be set back a minimum of 10 m from the edge of the littoral forest area as recommended by ecologist Peter Brennan. Dr Brennan has specialist experience in edge effects on vegetation and his advice has been taken into consideration. The area proposed for the wetlands is all presently cleared. The only potential damage to littoral plants would be if excavation caused root damage. While root systems may extend 10 m from individual trees, at this distance they are near the extent of their range and are therefore peripheral. Damage would be highly unlikely to cause individual plants to die. An assessment of the main threats to the SEPP 26 forest at this location show that the main threats are from the eastern (seaward) side in the form of wind and storm damage, tidal innundation, beach erosion and saline groundwater intrusion during prolonged dry periods. There is no justification on ecological grounds for locating the wetlands, which are vital for stormwater quality management, further than 10 m.
Hazard Impact: Low
Risk: Low

- Potential Hazard 3. Risk of wetland system "failing" resulting in water entering the SEPP 26 area.

This hazard relates to possible impacts on the SEPP 26 littoral forest in the event that the wetland "failed" and stormwater discharged directly to the SEPP 26 area. Wetlands, particularly off-stream wetlands are extremely robust systems hydraulically designed to cope with extreme storm events. They operate on the basic principal that detaining stormwater in a quiet pond with dense macrophytes results in removal of a wide range of pollutants through natural physical, biological and chemical processes. The effectiveness of wetland systems in cleaning stormwater has yet to be duplicated by any other affordable treatment process. If properly designed, once established the opportunity for wetlands to fail is very low. If there is a problem then it can generally be rectified by simple earthworks within a few days. The separation distance between a failing wetland and the SEPP 26 area will have no bearing at all on the level of impact from such an event on the SEPP 26 area. The risk of this hazard causing an impact on the SEPP 26 area would also be unaffected by locating the wetland further away from the SEPP 26 area than the 10 m minimum proposed. The low risk of wetland failure and the negligible benefits to be gained from greater separation distance in the event of failure do not warrant compromising the overall effectiveness of the stormwater scheme by locating the wetlands further up the slope.

Hazard Impact: Low
Risk: Low

Wetland Management Actions

Actions	Frequency
- Inspection of inlet and outlet structures and pipes to ensure they are clear and operational	Inspection before and after major rain events or at least every three months by Council
- Inspection and removal of any collected debris in wetland	Annual
- Inspection and removal of weed species	Annual
- Lowering of water level in wetland in early to mid September with level returned after first spring rains. Lowering the water level allows soil to be aerated.	September each year
- If mosquito complaints are received disrupt mosquito breeding cycle by raising the water level over a week period.	As required
- Monitoring of depth and dredging as required	Annual monitoring and dredging as required to ensure minimum depth of 300 mm is maintained across the wetland

- **Grassed Swale Drains**

Grassed swale drains have limited application on the site other than in flat sandy areas with slopes < 5%.

Actions	Frequency
- Inspect and keep well mown, all grassed swale drains.	Inspection at time of mowing.
- Remove areas where ponding may occur by filling and re-turfing depressions	As required

- Ensure driveways over grassed swale drains are properly constructed and do not impede stormflows	Inspection at time of construction
- Inspect for weeds and eradicate if found	Inspection at time of mowing

- **Silt and Litter Traps**

Silt and litter traps shall be located at the ends of all stormwater pipes prior to discharge into the wetlands.

Actions	**Frequency**
- Inspect for contents captured or physical damage	Every two months or after heavy rain
- Clean out when required but no longer than 3 months	Preferably 2 - 3 months or as required.
- Inspect components (screens, racks etc) are fully operational	Every three months and after major storms

- **Household Roof Water OSD Systems**

Tanks with a minimum effective storage volume for rainwater of 0.6 m^3 per 50 m^2 of roofed area shall be provided (ie for 150 m^2 roof area the minimum tank volume required is 1.8 m^3). Tanks shall be fitted with a low flow discharge to a seepage area designed to accept flows of around 0.04 L/s for sandy soils (discharge over 12 hours) and 0.02 l/s (ie discharge of full tank over 24 hours) for silty clay soils. The seepage area may be designed to have a volume of 2.7 m^3 per 50 m^2 of roofed area (ie for 150m^3 of roofed area the seepage area should be 2.66 x 150/50 = 8 m^3. This could be achieved by a gravel filled trench with minimum 600 mm depth and surface area of 12 m^2. The trench volume has been calculated as 4 times the required wetted volume to take account of space occupied by gravel (ie 1.8 m^3 x 4.0 = 7.2 m^3), plus a factor for rainfall actually percolating into the trench (0.053m x 33% x 4.0 x 12m^2 = 0.8 m^3).

Actions	**Frequency**
- Inspection of rainwater tanks. Cleaning out debris in filters, sumps and pits.	As required to maintain effectiveness - by householders

- **Roadside swales, sumps, infiltration trenches and pits.**

Actions	**Frequency**
- Inspection of systems for clogging during major storm events or as a result of complaint. Cleaning out pits or trenches when clogging occurs.	Inspection during major rain events by Council

- **Householder Education Pamphlet**

It is recommended that a Householder Education Pamphlet be presented to all initial land purchasers. The pamphlet should highlight that the land which they have purchased and are now custodians of, is in the catchment of the sensitive SEPP 26 land and coastal creeks. It should draw to the attention of the landowner that any activities within their lot which may result in the release of sediments, nutrients, exotic plants, pathogens or other potential contaminants in stormwater, has the potential to adversely affect the environment and is potentially illegal. The pamphlet shall emphasise that it is the individual responsibility of landowners to ensure that the subdivision does not result in a deterioration in stormwater quality, and shall list measures which can be applied by the landowner.

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