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Stormwater Concept Plan
Cobaki Lakes

Prepared for
LEDA Manorstead Pty Ltd

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Document control

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Title:	**Stormwater Concept Plan, Cobaki Lakes**	
Project Manager:	Neil Sutherland	
Author(s):	Alison Fullagar	
Client:	LEDA Manorstead Pty Ltd	
Client Contact:	Reg van Rij	
Client Reference:	**Cobaki Lakes Concept Plan**	
Synopsis:	This report addresses Environmental Assessment Requirements specified by the Director General of the NSW Department of Planning (DGRs) in relation to the proposed Cobaki Lakes development, Cobaki. Specifically, this report provides conceptual advice and assessments of stormwater management measures required to ensure that the stormwater runoff meets Tweed Shire Council's water quality objectives and is in accordance with the recommendations of the framework for coastal lake sustainability assessment. This report also includes an overview of an integrated water cycle management approach for the Cobaki Lakes Concept Plan.	

Revision History

Revision #	Date	Edition By		Approved By	
1	11/04/08	AJF		NMS	LJV
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Distribution

	Revision Number									
Distribution	1	2	3	4	5	6	7	8	9	10
LEDA Manorstead Pty Ltd	2	1	1							
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Summary

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by LEDA Manorstead Pty Ltd (LEDA) to undertake specialist studies and assessments in support of a concept plan of development for the Cobaki Lakes site at Cobaki, New South Wales.

Lodgement of a concept plan for the proposed Cobaki Lakes Development was authorised by the New South Wales Minister for Planning on January 24, 2007. The Director General of the Department of Planning issued Environmental Assessment Requirements (DGRs) for the concept plan on March 5, 2007.

This report describes assessments of the stormwater quality treatment devices specified in Tweed Shire Council's Development Design Specification D7, Stormwater Quality that would be required to meet Council's water quality objectives. A number of treatment train options were examined for use under a range of development densities. Each treatment train option comprises a combination of constructed wetlands, lot-based rainwater tanks or infiltration systems, and vegetated swales or bioretention trenches. The performance of each 'deemed to comply' treatment train was then compared using the MUSIC computer model.

A comparison of the estimated present water quality and the estimated water quality after completion of the development was also carried out. This comparison indicated that provided the recommended water quality management measures are properly installed and maintained, the water quality of runoff from the proposed development would achieve Council's desired objectives. The conceptual stormwater management measures proposed by the concept plan, together with habitat protection and rehabilitation works, are in accordance with the Cobaki Broadwater Management Plan.

Section four of this report considers the relationship between the conceptual stormwater management measures proposed under the Concept Plan and the findings of the Preliminary Flood Impacts Assessment prepared by BMT WBM Pty Ltd. Gilbert & Sutherland and WBM agree that onsite stormwater detention would not be required for peak flood level management. Further, whilst the proposed stormwater management regime takes into account the impacts of sea level rise and regional flooding, more detailed flood studies are to be undertaken as part of the development application process.

This report also examines options for Integrated Water Cycle Management (IWCM) for the proposed development. The IWCM approach aims to provide feasible integrated solutions for the management of water supply, wastewater, stormwater and groundwater throughout the site. A number of potential water management measures (including use of water efficient appliances and fittings, rainwater collection and reuse, greywater systems and wastewater treatment and reuse) have been identified for further investigation prior to the development of a detailed IWCMP for the site following approval of the concept plan.

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Glossary

Australian Height Datum (AHD)	National reference for relative height measurement in Australia.
Average Recurrence Interval (ARI)	The average or expected length of time between exceedances of a given variable, such as rainfall.
Bund	An embankment constructed around an area to prevent the inflow or outflow of liquids. Also called Bunding.
Catchment	The area above a given point which contributes to the runoff.
Clay	Very fine-grained sediment or soil (often defined as having a particle size less than 0.002 mm, or 2 microns, in diameter).
Ephemeral	A stream that flows briefly only in direct response to precipitation in the immediate locality and the channel of which is at all times above the watertable.
Erosion	The process by which material (such as rock or soil) is worn away or removed (as by wind or water).
Groundwater	The water contained in interconnected pores located below the watertable in an unconfined aquifer or located in a confined aquifer.
Intermittent	A stream in which the flow is seasonal, usually in response to rainfall in the immediate area (see ephemeral).
Loam	Medium-textured soil composed of approximately 10% to 25% clay, 25% to 50% silt and less than 50% sand.
pH	The degree of acidity or alkalinity measured on a scale of 1 to 14 with 7 as neutral. From 0 to 7 is acidic; from 7 to 14 is alkaline.
Sand	Sediment composed of particles within the size range 63 microns to 2 millimetres.
Scouring	The action of removing sediment from stream banks, particle by particle. This is a more destructive process than collapse when viewed over time due to incremental effects.
Sediment	Unconsolidated, fine-grained material (typically derived from the weathering of rocks), that is transported by water and settles on the floor of seas, rivers streams and other bodies of water.
Silt	Sediment having particles finer than sand and coarser than clay (i.e. 2 to 63 microns).
Sub-catchment	A smaller area within a catchment drained by one or more tributaries of the main water body.
Suspended Solids (SS)	The concentration of filterable particles in water (retained on a 0.45mm filter) and reported by volume (mg/L).
Total Nitrogen (TN)	Total nitrogen is the sum of the nitrogen present in all nitrogen-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Total Phosphorus (TP)	Total phosphorus is the sum of the phosphorus present in all phosphorus-containing components in the water column. The nutrients, nitrogen and phosphorus are essential for plant growth. High concentrations indicate potential for excessive weed and algal growth.
Turbidity	A measure of the cloudiness of water which is determined by the amount of light scattered by suspended particles.

List of drawings

GJ0640.5.1	Concept Plan
GJ0640.5.2	Site Location
GJ0640.5.3	Catchment Plan
GJ0640.5.4	Stormwater Management Concept

1) Introduction

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by LEDA Manorstead Pty Ltd to undertake specialist studies and assessments in support of a concept plan of development for the Cobaki Lakes site at Cobaki, New South Wales.

1.1 Scope of report

The Director General of the Department of Planning issued Environmental Assessment Requirements (DGRs) for the Cobaki Lakes Concept Plan on March 5, 2007.

This report provides advice on Integrated Water Cycle Management as part of the Cobaki Lakes Concept Plan. As such it addresses the following DGRs:

5.6 Address concept drainage and stormwater management issues arising from the development. This should include:
(a) Demonstrating that drainage and stormwater runoff will not have a significant impact on the surrounding environments downstream of the development (especially water, wetlands, and important habitat areas);
(b) demonstrating consistency with the Tweed Integrated Water Cycle Management – Context and Strategy Study (March 2006); and
(c) the identification of any on-site treatment of stormwater and waste water, including recycling, Water Sensitive Urban Design, the need to incorporate dual use reticulation, and drainage infrastructure.

14.1 Demonstrate that the development will not have any adverse impacts on adjoining lands. This is to include consideration of adjacent land uses, water quality, water quantity, erosion, sedimentation, fire management, fencing, and access.

This report also addresses the following items, identified in Attachment 2 to the DGRs:

8. Other plans including (where relevant):

- *Stormwater Concept Plan – illustrating the concept for stormwater management from the site and must include details of any major overland flow paths through the site and any discharge points to the street drainage system. Where an on-site detention system is required, the type and location must be shown and must be integrated with the proposed landscape design. Site discharge calculations should be provided.*

1.2 Development concept

Appropriate zoning and other development controls for the entire site are outlined in *Tweed Shire Development Control Plan: Section B7 – Cobaki Lakes* (DCP B7).

The Cobaki Lakes Concept Plan proposes the creation of a master planned residential community integrating residential development and supporting commercial, retail, recreational and educational facilities. Large areas of open space will be provided for environmental enhancement and for recreational purposes.

The development concept is shown on Drawing No. GJ0640.5.1.

1.3 Aims and objectives

The information herein is provided to meet the DGRs described above. Accordingly, this report provides conceptual details for the stormwater management measures to be installed in the whole of the development.

This report addresses those issues related to soil and water management with particular emphasis on stormwater quality control.

The report is divided into sections dealing with the proposal, a description of the physical characteristics of the site, an assessment of the likely stormwater runoff quality and management of the potential stormwater impacts during the construction and operational phases. It is these latter management sections that form the SWMP, which is included as Attachment 1.

This report, prepared by qualified Gilbert & Sutherland staff, is based on Tweed Shire Council's 'deemed to comply' solutions and MUSIC Version 3.01 computer modelling (prepared by Allan Genn) of likely changes to annual stormwater sediment and nutrient loads due to the proposed development.

1.4 Water management overview

The conceptual planning of the urban development proposed for Leda Manorstead's land at Cobaki has followed a constraints-based approach, which recognises:

a) The sensitivity of the receiving environment within the Cobaki Broadwater.
b) The large mosquito breeding areas currently on site.
c) The major opportunity that the careful rehabilitation of the southern areas could provide by way of an ongoing fisheries contribution to the Broadwater.

The main site constraints associated with the development, which this concept plan accommodates and subsequently solves, are as follows:

a) Existing agricultural drainage.
b) Mosquito breeding habitat from cattle movements.
c) Exposed acid sulfate soils.
d) Low contribution of salt-water couch to the fishery habitat of the Cobaki Broadwater.

The stormwater treatment train for each sub-catchment will involve the following measures:

a) Compliance with BASIX.
b) Bioretention devices within constructed swales where slope <5%.
c) Gross Pollutant traps (GPTs).
d) Sedimentation basins at the inlet zone for the constructed wetlands.
e) Constructed wetlands with a minimum 30% soft-edge treatment.
f) Diffuse low-flow discharge (<Q3month) and stormwater treatment within the rehabilitation areas.
g) High-flow bypass channels to protect the rehabilitation areas
h) Discharge of fully treated water to the Cobaki Broadwater.

Section 2 of this report provides further details on specific components of the stormwater treatment train and modelling results estimating the expected performance of the treatment measures.

A conceptual discussion of Integrated Water Cycle Management (IWCM) for the development is provided in Section 3. This section describes how the stormwater quality treatment measures will complement other aspects of water management within the development.

RIDGETOP ROAD

PLATEAU ROAD

SANDY LANE

COBAKI PARKWAY

To Boyd Street

Environmental Reserve

WATER RESERVOIR

SPORTS OVALS

To Piggabeen Road

Piggabeen Road

Cobaki Creek

Piggabeen Road

LEGEND

- Town Centre / Village Centre
- Residential
- Community Facilities / Education / Infrastructure
- Open Space
- Environmental Protection Area
- Lake
- Proposed School
- Proposed Community Facilities
- Proposed Restaurant

N

0 100 200 300 400 500 600 700 800 900 1000

Scale of metres

Base Plan supplied by LEDA Manorstead Pty Ltd

GILBERT+SUTHERLAND
agriculture · water · environment

Eastside
5/232 Robina Town Centre Drive, Robina, Qld. 4230
Phone 55789944 Mobile 0418 760919 Fax 55789945

FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING.

APPROVED . . . . . .

PROJECT

LEDA MANORSTEAD PTY LTD

COBAKI LAKES

CONCEPT PLAN

SCALE AS SHOWN	DRAWN A.J.F.	DRAWING No.
DATE 22/08/08	CHECKED	GJ0640.5.1

2) Stormwater quality assessment

2.1 Methods

2.1.1 Prescriptive approach

Tweed Shire Council (TSC) has provided detailed guidance on the methods to be adopted in assessing and designing water quality management measures in its 'Tweed Urban Stormwater Quality Management Plan' (TUSQMP) and its 'Development Design Specification, D7, Stormwater Quality' (D7).

Water quality objectives for urban development are specified in TUSQMP, Table 5.4. These objective are reproduced in Table 2.1.1.

Table 2.1.1 Maximum permissible discharge loads kg/ha/year

Pollutant	Dry Year	Average Year	Wet Year
Suspended Solids	120	300	400
Total Nitrogen	1.5	4.5	6
Total Phosphorus	0.35	0.8	1.1

Development applications must demonstrate that these objectives will be achieved. This may be done by modelling the likely runoff and pollutant loads using parameters detailed in D7 or by using 'deemed to comply' solutions also provided in D7.

Details of the level of modelling required depending on the size of the project are specified in TUSQMP. As this project is larger than 50ha, Level 2 or Level 3 modelling is required.

Alternatively, D7 Table 7.11-WS provides 'deemed to comply' solutions based on the area of urban catchment development. These solutions generally include the installation of a constructed wetland that has an area equal to 5% of the total catchment area. However, D7 Table 7.11-WS provides for a reduction in the size of the wetland (using the parameters provided) if infiltration systems, rainwater storage tanks, porous paving, vegetated buffers or grassed swales which comply with TSC's guidelines are installed in the catchment.

2.1.2 Modelling approach

To assess the likely impacts of the proposed development on water quality, we have used the CRC for Catchment Hydrology Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 3.01 computer model.

MUSIC is a water resources package with components for generating surface and subsurface runoff, non-point source pollutant export and pollutant transporting and routing. It is specifically designed for the analysis of the effects of planned land use changes and for the evaluation of best management practice stormwater quality improvement devices. The input data requirements are described below.

2.1.3 Model input data

This model requires the input of rainfall and evapotranspiration data. The rainfall data must be in the form of 6 minute time-step pluviometer records. This information was obtained from Tweed Shire Council's web site for Murwillumbah.

Suitable records were provided for the period from 01/01/1978 to 31/12/1978. The total rainfall for this period was 1693mm.

An analysis of a daily time-step rainfall data set for the Tweed Heads weather station (which is considered appropriate for this study in terms of proximity and relief) spanning the period from 1890 to 1994 provided the following annual rainfall data:

- Driest Year 693mm
- 10th percentile year 1,199mm
- Average year 1,699mm
- Median year 1,672mm
- 90th percentile year 2,236mm
- Wettest year 3,194mm

It should be noted that in the above analysis the results are statistical annual totals and may not necessarily refer to an actual historical year.

A continuous model run using the MUSIC dataset provided would therefore be expected to yield satisfactory results. This is because the average rainfall (1,693mm) of

the dataset is similar to the long term average (1,699mm).

Average monthly potential areal evapotranspiration values were obtained from the Tweed Shire Council's D7, Table 3. These values are presented in Table 2.1.3.1.

Table 2.1.3.1 Evapotranspiration data

Month	Evapotranspiration (mm)
Jan	165
Feb	135
Mar	135
Apr	100
May	70
Jun	60
Jul	60
Aug	75
Sep	105
Oct	135
Nov	150
Dec	165

2.1.4 Runoff parameters

Relevant parameters for the land uses were sourced from Tweed Shire Council's D7, Table 1 and are presented in Table 2.1.4.

Table 2.1.4 Runoff Parameters

Parameter	Forest Land Use	Rural Land Use	Urban Land Use
Field capacity (mm)	50	50	50
Infiltration coefficient	50	50	50
Infiltration exponent	2	2	2
Rainfall threshold (mm)	1	1	1
Soil capacity (mm)	150	150	150
Initial storage (%)	25	25	25
Daily recharge rate (%)	0.65	0.65	0.65
Daily drainage rate (%)	0.85	0.85	0.85

Note. The Forest land use above is the Undeveloped land use described in D7.

2.1.5 Water quality parameters

The water quality parameters modelled were:

- Suspended Sediment
- Total Nitrogen
- Total Phosphorus

The sediment and nutrient export parameters were adopted from the Tweed Shire Council's D7, Table 1 and are reproduced in Table 2.1.4.

Table 2.1.4 Pollutant Export Parameters (Log_{10}mg/L)

Parameter	Forest Land Use	Rural Land Use	Urban Land Use
Total Suspended Solids (SS)			
Storm flow mean	1.200	1.627	2.000
Storm flow Std dev	0.145	0.200	0.145
Base flow mean	0.800	0.600	0.800
Base flow Std dev	0.200	0.200	0.200
Total Nitrogen (TN)			
Storm flow mean	-0.900	-0.250	0.193
Storm flow Std dev	0.100	0.197	0.050
Base flow mean	-0.100	-0.150	-0.100
Base flow Std dev	0.050	0.400	0.050
Total phosphorus (TP)			
Storm flow mean	-1.470	-0.950	-0.680
Storm flow Std dev	0.300	0.100	0.280
Base flow mean	-1.000	-1.400	-1.000
Base flow Std dev	0.340	0.400	0.340

It should be noted that the rainfall to runoff model and the pollutant export expressions have not been calibrated for local catchments. This means the modelling results can not be expected to produce accurate assessments of the amount of pollutants likely to be exported from the proposed development. However, the results do provide useful assessments which enable comparisons of the effectiveness of various stormwater management strategies.

An assessment of the pervious and impervious proportions for the urban areas in each catchment was carried out to provide input for the model.

2.1.6 Modelling undertaken

The MUSIC model was used to form a basic model for the stormwater treatment system simulating the existing environment (Base Case) for comparison with models representing the anticipated environment subsequent to the change in land use (Developed Case after completion of the construction phase).

The modelled scenarios were as follows:

- Base Case.
- Developed Case WITHOUT treatment measures.
- Developed Case WITH treatment measures.

Descriptions of the catchments before and after completion of the development are included in Section 2.2.5. Details of the stormwater treatment methods recommended and the results of the MUSIC modelling are provided in Section 2.3.4.

2.2 Site description and proposal

2.2.1 Site location

The site location is shown on Drawing No GJ0640.5.2. The Concept Plan for the proposed development is shown in Drawing No. GJ0640.5.1 included in Section 1.

The site covers approximately 596 hectares and is located in Cobaki, immediately south of the Queensland/NSW border and approximately 2km west of the coastal township of Kirra.

2.2.2 Receiving environment

The land ranges in elevation from approximately RL0m Australian Height Datum (AHD) to approximately RL100m AHD.

Runoff from this development flows in a south-easterly direction via a number of unnamed ephemeral gullies towards Cobaki Creek, which runs along the south-eastern site boundary, and directly into Cobaki Broadwater. Cobaki Broadwater adjoins the Tweed River which discharges into the Pacific Ocean at Tweed Heads.

2.2.3 Existing surface water quality data

Monitoring of surface water quality in Cobaki Creek has been carried out by WBM (1989-1991) and Gilbert & Sutherland (commenced November 2007 and ongoing). Although the available data is limited, in the absence of a more complete data set it can be used to help establish background levels for the site. A summary of the available surface water quality data is provided in Appendix 1.

Water quality objectives for site runoff entering Cobaki Creek are outlined in Section B7.3.5 of DCP B7. Ongoing surface water monitoring being undertaken by Gilbert & Sutherland aims to build a more comprehensive data set to establish more reliable background data across the site prior to the commencement of construction works.

Site specific water quality criteria should be determined from the results of this monitoring.

Care should be taken to ensure that there is no worsening of the water quality in the receiving waters resulting from this development, during the construction or operational phases.

2.2.4 Existing development

The majority of the site is an extensively cleared closed-swamp complex with areas of grass, sedge and rushland. Some open Eucalyptus forest is concentrated around sections of the south-west edge and northern ridge and there is a scattering of scribbly gums around the natural low sand ridge in the middle and lower eastern parts of the site.

There are a number of dwellings and farm sheds on the subject land.

2.2.5 Proposed development

The proposed development involves the construction of a system of roads to provide access to approximately 3500 residential lots. The balance of the site would be dedicated to open space, a lake and land zoned environmental protection.

Given that the present application is for approval of a concept plan, detailed road and allotment layouts have not been

completed for the whole of the project. However, to demonstrate that stormwater can be managed satisfactorily on the site, three scenarios that consider a range of urban development densities have been assessed. Further details are provided in Section 2.2.6.

The total area of the proposed development, as shown on Drawing No. GJ0640.5.2, is approximately 596ha. The Cobaki Lakes Concept Plan proposes the creation of a residential community inclusive of associated educational, social, commercial, sporting and recreational amenities. The development would be completed in stages and would include substantial areas of open space, providing a riparian buffer to Cobaki Creek.

The proposed development would comprise the construction and/or installation of the following components:

- site earthworks
- roads
- stormwater drains
- sewer reticulation mains
- water reticulation mains
- underground electricity distribution cables
- telecommunication cables
- other ancillary services
- dwellings
- landscaping.

Once the development has been completed, all disturbed portions of the site will be rehabilitated or covered by some form of improvement protecting the soils from erosion, hence minimising the transport of suspended solids from the site. These improvements will include structures, paved areas, lawns and landscaping.

2.2.6 Catchment description

A review of aerial photographs of the site, confirmed by site inspection, indicates the site has been severely disturbed by previous clearing.

The Base Case (representing the site in its present state) has therefore been represented in the MUSIC model by the rural land use.

A catchment plan for the site (adopted from Map 4 of TSC DCP B7 - Cobaki Lakes) is provided in Drawing No. GJ0640.5.3.

To assess the conceptual stormwater management requirements, a one (1) hectare area has been considered and modelled. Using the modelled outputs for one hectare, it is then possible to assess and describe the management measures required per hectare of development.

The areas of the land uses included in the base case model are shown in Table 2.2.6.1.

Table 2.2.6.1 Catchment Characteristics before development

Catchment No.	Forest Area (ha)	Rural Area (ha)	Urban Area (ha)	Totals Area (ha)
Total Areas (ha)	0.00	1.00	0.00	1.00

The areas of the various land uses included in the model to represent the site when fully developed, are shown in Table 2.2.6.2.

Table 2.2.6.2 Catchment Characteristics after development

Catchment No.	Forest Area (ha)	Rural Area (ha)	Urban Area (ha)	Totals Area (ha)
Total Areas (ha)	0.00	0.00	1.00	1.00

Generally the urban land use has been used to represent the roads and the allotments. The rural land use has been used to represent the balance of the site.

The impervious area for the rural land use has been set at zero. The estimated impervious fractions for the urban catchments have been calculated in accordance with the TSC Development Control Plan (DCP) Section A14.3.2.

A full dissection of the catchment areas, land uses and the impervious fractions is provided in Table 2.2.6.3.

Table 2.2.6.3 Developed catchment characteristics

Scenario	Medium density (Area%)	No. Lots	No. Units	FI
1	15%	8.5	3	0.38
2	25%	7.5	5	0.39
3	35%	6.5	7	0.40

2.3 Stormwater quality assessment prescriptive approach

Tweed Shire Council encourages developers to adopt the principles of Integrated Water Cycle Management (IWCM) where practical. Council also encourages implementation of Water Sensitive Urban Design (WSUD) and provides a range of options for managing stormwater quality in Table 7.11-WS of its 'Development Design Specification D7'. These options are further discussed below. Where possible, WSUD devices should be integrated into the development.

The proposed stormwater treatment areas for the site are shown on Drawing No. GJ040.5.4.

2.3.1 Constructed wetlands

The surface areas specified in D7 for constructed wetlands are:

- deep water zone 250m^2/ha and
- macrophyte zone 250m^2/ha.

These areas are for an end-of-line constructed wetland required for each hectare of urban catchment development. Importantly, this specification does not differentiate between urban development densities.

2.3.2 Rainwater tanks

Council encourages the installation of rainwater tanks and has adopted a 'Rainwater Tanks' policy which provides details of an eligible rainwater tank.

If eligible rainwater tanks are installed throughout the development on each and every allotment, the size of the constructed wetland could be reduced by up to 50%. The wetland areas in this case would be:

- deep water zone 125m^2/ha and
- macrophyte zone 125m^2/ha.

However a rainwater tank that meets the requirements of BASIX does not necessarily satisfy Council's requirements for an eligible rainwater tank and hence qualify for the reduction of the wetland area.

2.3.3 Infiltration systems

As an alternative to rainwater tanks, TSC allows a reduction in the areas of the deep water and macrophyte zones of 0.5% for each 1% of sites (by area) in the catchment with roofwater disposed of by infiltration.

This option refers to 'sites' and makes no mention of road areas (which might occupy up to 30% of the development area). Assuming the literal interpretation of this provision, the required wetland areas could be reduced by 35% if all lots were fitted with appropriately sized infiltration systems. The wetland areas in this case would be:

- deep water zone 162.5m^2/ha and
- macrophyte zone 162.5m^2/ha.

As considerable areas in the eastern portion of the site are underlain by sandy soils, the use of infiltration systems in these areas may be appropriate.

2.3.4 Porous paving

If impermeable paving is limited to 10m^2 or less per site and porous paving is used exclusively for driveways, other paths and hardstand areas, TSC will permit a reduction of the wetland deep water and macrophyte areas of 0.1% for each 1% of sites (by area) where this requirement is met. Assuming that the dedicated road areas remain impermeable and the balance of the development complies with this requirement, approximately 72.5% of the development area would be eligible for the reduction.

In this case, the wetland areas would be:

- deep water zone 232m^2/ha and
- macrophyte zone 232m^2/ha.

2.3.5 Grassed filter strips

As an alternative to the porous paving, TSC will permit a reduction of the wetland deep water and macrophyte areas by 0.1% for each 1% of sites (by area) where:

- paths and hardstand areas are sloped so that runoff is directed onto grass filter strips (which provide an average detention time of 9 minutes during a 3 month ARI storm event), and
- driveways are sloped so that runoff does not flow onto the street.

Assuming that the dedicated road areas remain impermeable and the balance of the development complies with this requirement, approximately 72.5% of the development area would be eligible for the reduction. The wetland areas in this case would be:

- deep water zone 232m^2/ha and
- macrophyte zone 232m^2/ha.

2.3.6 Vegetated swales

For each 1m^2 of swale (maximum width 2m) used instead of conventional kerb and gutter, the wetland deep water and macrophyte areas may be reduced by 0.5m^2.

Based on an estimated average road length of 180m per hectare, with one way cross-fall and a 1.0m wide vegetated swale on one side of the pavement, a reduction of 90m^2 would be permitted for the wetland deep water and macrophyte areas. The wetland areas in this case would be:

- deep water zone 160m^2/ha and
- macrophyte zone 160m^2/ha.

2.3.7 Bioretention trenches

For each 1m^2 of bioretention trench used to treat road runoff, the wetland deep water and macrophyte areas may be reduced by 0.5m^2.

Again, based on an estimated average road length of 180m per hectare, with one way cross-fall and a 1.0m wide bioretention trench on one side of the pavement, a reduction of 118m^2 would be permitted for the wetland deep water and macrophyte areas. The wetland areas in this case would be:

- deep water zone 132m^2/ha and
- macrophyte zone 132m^2/ha.

2.3.8 Treatment trains

The principles of Water Sensitive Urban Design (WSUD) encourage the use of a number of stormwater treatment devices in series to form what is known as a 'treatment train'.

As there is considerable variation in terrain and soils types across the site, there would be a number of combinations of treatment devices included in the treatment trains. The choice of devices would depend on the design and operating requirements of each management measure, and the constraints imposed by site conditions such as soil type and permeability and slopes.

Council specifies that the maximum reduction that can be allowed by using various combinations of the treatment devices in a treatment train is 75% and the resulting wetland area should be no less than 1250m^2.

It is envisaged that treatment trains such as those described below would be employed throughout the proposed development.

Treatment train type 1 (TTT1)
In areas where grades are less than 5% and the underlying soils are sandy the treatment train for each hectare of development might comprise:

- Infiltration systems in each lot
- Vegetated swales (180m^2)
- Constructed wetlands (total area 138.75m^2).

Treatment train type 2 (TTT2)
In areas where grades are less than 5% and the underlying soils are clayey the treatment train for each hectare of development might comprise:

- Complying rainwater tanks in each lot
- Vegetated swales (180m^2)
- Constructed wetlands (total area 125m^2)

The maximum reduction in wetland area of 75% applies in this instance.

Treatment train type 3 (TTT3)
In areas where grades are steeper than 5% and the underlying soils are clayey the treatment train for each hectare of development might comprise:

- Complying rainwater tanks in each lot
- Bioretention trenches (180m^2)
- Constructed wetlands (total area 125m^2).

The maximum reduction in wetland area of 75% applies in this instance.

Treatment train type 4 (TTT4)
In areas where grades are steeper than 10% and the underlying soils are clayey the treatment train for each hectare of development might comprise:

- Complying rainwater tanks in each lot
- Constructed wetlands (total area 250m^2).

As described above, there are a number of deemed to comply options that may be suitable for various portions of the development.

During the detailed design process other treatment train options would be considered and included where appropriate.

It is to be noted that the treatment trains described above would be applicable to each of the density scenarios described in Section 2.2.5 as TSC's D7 does not make recommendations regarding different levels

of treatment required for differing densities of urban development.

2.4 Stormwater quality assessment modelling approach

2.4.1 Water quality assessment results

Details of the MUSIC model and the catchments have been provided in sections 2.1 and 2.2 respectively.

2.4.2 Base Case

As described in Section 2.2.5, the Base Case has been represented by the 'Rural' land use in the model.

Table 2.4.2.1 presents the average annual runoff volumes and quantities of suspended sediment, nitrogen and phosphorus predicted to be exported from each hectare of the project in its undeveloped state.

Table 2.4.2.1 Base Case average annual loads/ha

Runoff (ML/year)	Suspended Sediment (kg/year)	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
9.1	405.0	5.79	1.03

2.4.3 Developed Untreated Case

The same areas as above were modelled under the same rainfall conditions in a developed state to allow a comparison with the Base Case. The results of the untreated case modelling are shown in Table 2.4.3.1.

Table 2.4.3.1 Developed untreated case average annual loads

Scenario	Runoff (ML/year)	Suspended Sediment (kg/year)	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
1	10.6	1090	16.2	2.81
2	10.7	1110	16.4	2.76
3	10.8	1080	16.6	2.64

Table 2.4.3.1 demonstrates the changes in runoff and pollutant loads that are likely to occur if the development was completed without any stormwater management or treatment measures. It is noted that the water quality objectives specified in TUSQMP as shown in Table 2.4.3.2 are considerably better than the existing Base Case.

Table 2.4.3.2 Maximum permissible average annual loads/ha released

Runoff (ML/year)	Suspended Sediment (kg/year)	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
N/A	300	4.5	0.8

2.4.4 Developed Treated Case

The same treatment trains and areas discussed in the prescriptive approach above were modelled under the same rainfall conditions to compare the deemed to comply solutions with the modelling approach.

Constructed wetlands

The sizes of the constructed wetlands estimated using the deemed to comply solutions have been included in the MUSIC model. Typical properties are shown in Table 2.4.4.1.

Table 2.4.4.1 Wetland details

Parameter	Value
Inlet Properties	
Low Flow Bypass (m^3/s)	0.0
High Flow Bypass (m^3/s)	100.0
Inlet pond volume (m^3)	50
Storage Properties	
Surface Area (m^2)	500.0
Extended Detention Depth (m)	0.4
Permanent pool Volume (m^3)	500.0
Seepage loss (mm/hr)	0.5
Evaporative loss %of PET	125
Outlet properties	
Equivalent pipe dia (mm)	30
Overflow weir width (m)	4.0

Rainwater tanks

We have assumed that one or more rainwater storage tanks would be installed on each lot to capture runoff from the roof areas. These would be installed by the land owners or builders during the house construction phase in accordance with Council's 'Rainwater Tanks' Policy and the usual plumbing requirements.

It is expected that the tank would be connected to the reticulated drinking water supply system to ensure that the tank would be continuously replenished to 15% of capacity and that the water would be used for flushing toilets, laundry cold water and all outdoor uses. A first flush diversion device or filtration unit should be installed in accordance with Council's policy.

Each tank's performance has been assessed using a model which calculates the amount of rainfall captured from the roof area, the amount of runoff and the amount of water to be drawn from the mains water supply. Typical properties used in the modelling are shown in Table 2.4.4.2.

Table 2.4.4.2 House rainwater tank properties per house

Parameter	Value
Inlet Properties	
Low Flow By-pass (m^3/s)	0.00
High Flow By-pass (m^3/s)	100.00
Storage Properties	
Volume below overflow pipe (kL)	5
Depth above overflow (m)	0.2
Surface area (m^2)	2.5
Outlet properties	
Overflow pipe diameter (mm)	90
Re-use Properties	
Use stored water for irrigation or other purpose	✓
Annual demand (kL/yr) scaled by daily PET	75.00
Daily demand (kL/day)	0.00
Monthly distribution of annual demand (kL/year)	0.00

Average values were calculated using 30 years of daily time-step rainfall data for the period from 1961 to 1990 at Tweed Heads. This period is considered representative of current climatic conditions as the average annual rainfall for the period is 1760mm, which compares with the long-term average of 1700mm. In addition, the period contains the second highest rainfall year (1974) on record.

It has been assumed that the roof area contributing to the tank would be $180m^2$ (although the total roof area may be larger than this), the average daily water usage from the tank would be 680L/day, the area of garden/lawn to be watered would be $200m^2$ and size of the tank required would be 5,000L.

These estimates indicate that the volume of water used from the tank would be in excess of 75,000L per household per year. The impact of the tank on the volume of runoff and pollutant loads has been assessed using the MUSIC model.

Infiltration systems

In the areas where sandy soils are present infiltration trenches may be appropriate. Where these are installed, they should be installed by the developer in each allotment to collect and dissipate roof runoff.
It is estimated that approximately $3.3m^3$ of infiltration trench storage is required for each $180m^2$ of roof area, when the soil's hydraulic conductivity is at least 3m/day.

It is envisaged that this form of treatment could be constructed using milk crate type devices (e.g. Atlantis, Ausdrain or similar cells) wrapped in permeable geofabric.

The parameters used in the modelling are shown in Table 2.4.4.3.

Table 2.4.4.3 Infiltration system characteristics

Parameter	Value
Inlet Properties	
Low Flow Bypass (m^3/s)	0
High Flow Bypass (m^3/s)	100
Storage Properties	
Surface Area (m^2)	42.0
Depth to overflow weir (m)	0.9
Infiltration rate (mm/hr)	125
Evaporative loss as a % of PET	0.00
Outlet properties	
Overflow weir width (m)	1.0

Porous paving

Porous paving should be used where possible to maximise infiltration. This type of paving could be used in areas where the underlying soils have moderate infiltration rates. These have not been modelled in any of the treatment trains proposed.

Grassed filter strips
These have not been modelled in any of the treatment trains proposed.

Vegetated swales
Vegetated swales may be used as a substitute for kerb and channel where consistent with the proposed land uses and where grades are less than 5%.

Generally care would be required during detailed design to ensure;
- swales are designed in accordance with TSC's guidelines
- roadway trafficability (as defined in QUDM) is not impaired
- allotment amenity is maintained
- erosion and sediment control is adequate
- footway amenity is maintained
- driveway crossovers are carefully designed in accordance with TSC's guidelines.

Typical properties of swales are shown in Table 2.4.4.5.

Table 2.4.4.5 Swale characteristics

Parameter	Value
Inlet Properties	
Low Flow Bypass (m^3/s)	100
Storage Properties	
Length (m)	180.0
Bed slope (%)	2.00
Base width (m)	1.00
Top width (m)	2.20
Depth (m)	0.15
Vegetation height (m)	0.05
Seepage loss (mm/hr)	0.50

Bioretention trenches
The bioretention trenches may be used in in lieu of vegetated swales where required to achieve a higher level of treatment than swales. These would be designed in accordance with QUDM and TSC's Guidelines replace kerb and channel.

Operating characteristics of the trenches are set out in Table 2.4.4.6.

It should be noted that the final choice of management measures used, their location and size will be subject to detailed survey and design. These details would be submitted to TSC with applications for approval to a construction certificate.

Table 2.4.4.6 Bioretention trench characteristics

Parameter	Value
Inlet Properties	
Low Flow Bypass (m^3/s)	0
High Flow Bypass (m^3/s)	100
Storage Properties	
Extended detention depth (m)	0.2
Surface Area (m^2)	400.0
Seepage loss (mm/hr)	0.5
Infiltration Properties	
Filter area (m^2)	180.0
Filter depth (m)	0.5
Filter particle effective diameter (mm)	0.47
Saturated hydraulic conductivity (mm/hr)	180
Outlet properties	
Overflow weir width (m)	2.0

The retention of suspended sediment and nutrients is generally calculated by MUSIC using the default parameters of the exponential decay functions for each pollutant. The modelling results for the development are shown in Table 2.4.4.7.

Table 2.4.4.7 Developed treated case average annual loads

Scenario	Runoff (ML/year)	Suspended Sediment (kg/year)	Total Nitrogen (kg/year)	Total Phosphorus (kg/year)
Treatment train type 1				
1	8.45	190	11.8	1.21
2	8.57	194	11.9	1.21
3	8.59	184	11.9	1.18
Treatment train type 2				
1	9.25	206	13.1	1.33
2	9.29	214	13.1	1.36
3	9.33	202	13.2	1.28
Treatment train type 3				
1	9.29	284	10.6	1.21
2	9.34	274	10.6	1.20
3	9.38	291	10.7	1.41
Treatment train type 4				
1	9.44	438	12.2	1.56
2	9.48	446	12.3	1.55
3	9.52	464	12.3	1.61
Target loads kg/ha/year				
Total	N/A	300	4.5	0.8

The modelling demonstrates the relative efficiencies of the 'deemed to comply' solutions under a range of development scenarios. It also demonstrates that there is an inconsistency between the 'deemed to comply' solutions and Council's average annual pollutant load per hectare targets.

2.5 Summary of MUSIC modelling

A comparison of the estimated average annual pollutant loads in the stormwater runoff before and after completion of the proposed development, including the proposed treatment measures as shown in the tables above, indicates the proposed treatment measures have the capacity to substantially reduce the average annual suspended sediment and nutrient loads.

Based on the modelling described above, the total wetland area required to achieve TSC's 'deemed to comply' solution ranges from 125m² to 250m² per hectare of urban catchment development, dependant on the treatment train adopted.

Based on the Concept Plan provided, the total area of urban development within the Cobaki Lakes Site is approximately 330ha, thus requiring up to 8.25ha of constructed wetlands for stormwater quality treatment.

The stormwater management concept, shown in Drawing No. GJ0640.5.4 indicates proposed wetland areas of approximately 16ha (preliminary estimate), thus substantially exceeding the minimum area required for stormwater treatment.

Final polishing of stormwater runoff will occur by diffuse discharge through the rehabilitation areas in the southern portion of the site (both in the freshwater wetland and saltwater couch areas) prior to discharge in the receiving environment of the Cobaki Broadwater.

Stormwater management measures should be installed as described in Section 2.3. Provided these are properly installed and maintained, the estimates detailed in Section 2.4 indicate that the quality of the stormwater runoff from the site during the operational phase will be acceptable.

Careful management will be required to ensure that the projected quality levels are achieved and maintained particularly during the construction phases. These details are considered in the stormwater management plan, which is included as Attachment 1.

2.6 Assessment against Coastal Lake Management Framework

2.6.1 Coastal lake management framework

Stormwater quality is an important contributing factor to the health of the receiving environment. Accordingly the conceptual results described above have been considered in the context of the recommendations of the following reports:

- The Independent Public Inquiry into Coastal Lakes: Final Report (April 2002) – the 'inquiry report'.
- The Healthy Rivers Commission Report into Coastal Lakes and Statement of Joint Intent – 'the HRCCL report' and 'the HRCSJI'.
- The Northern Rivers Catchment Action Plan – 'the NRCAP'.
- The Cobaki Broadwater Management Plan' – 'the CBMP'.

2.6.2 Context of reports

Three of the four documents referenced above (the inquiry report, the HRCCL & HRCSJI and the NRCAP) collectively describe a process by which coastal lakes, the northern rivers and the catchments in which they exist need to be assessed for their current environmental condition and carefully managed to ensure potentially detrimental impacts are avoided and ongoing improvements are realised. To meet these goals, Coastal Lake Sustainability Assessment and Management Plans (SAMPs) are to be prepared. Responsibility for this process, which is currently in train, lies with the New South Wales State Government, statutory authorities and local councils, however input is required from a diverse range of stakeholders.

The three referenced documents do not, of themselves, establish assessment criteria against which proponents must assess their proposals. As at the date of this report a SAMP had not been prepared for the Cobaki Broadwater.

The fourth document – the January 1998 Cobaki Broadwater Management Plan

(CBMP) – was prepared by TSC and the Tweed River Management Plan Advisory Committee following the recognition of the Cobaki Broadwater as an area of high scenic and ecological value. The CBMP aims primarily to preserve all valuable habitats in the vicinity of the Broadwater and identifies opportunities for the enhancement of these habitats.

2.6.3 Assessment of stormwater proposals

The CBMP identifies extensive low lying areas of saltmarsh on the Cobaki Lakes site as an area which could be adversely impacted by the development of the site. Simultaneously, the CBMP identifies this area as an opportunity to enhance the habitat value of the Cobaki Broadwater and provide a buffer for nutrient and sediment in runoff from future development.

The Cobaki Lakes Concept Plan proposes to preserve and regenerate the saltmarsh areas through a combination of open space buffering and active rehabilitation works. These proposals, combined with the cessation of impacts from grazing, directly meets the objectives of the CBMP.

Similarly, the proposed integrated management of stormwater runoff from the site meets the CBMP's objectives for reduced nutrient and sediment input from the catchment.

The proponent and its consultants, including Gilbert & Sutherland, have met with Tweed Shire Council's representatives on the Northern Rivers Catchment Management Authority (NRCMA) during the Concept Plan development process. TSC and the NRCMA are familiar with and generally supportive of the various measures proposed in the Concept Plan to protect against adverse impacts on the Cobaki Broadwater and to enhance the contribution of the site to the Broadwater's fishery, in an ongoing effort to re-establish conditions closer to those that existed before agricultural use of the site.

Table A2 – 'Classification of Coastal Lakes: Summary of Data' contained within the Independent Public Inquiry into Coastal Lakes: Final Report (April 2002) classifies the Natural Sensitivity (Risk) of coastal lakes in NSW on a scale starting at 'High' and progressing to 'Very High' and then 'Extreme'. The table also summarises the overall condition of coastal lakes.

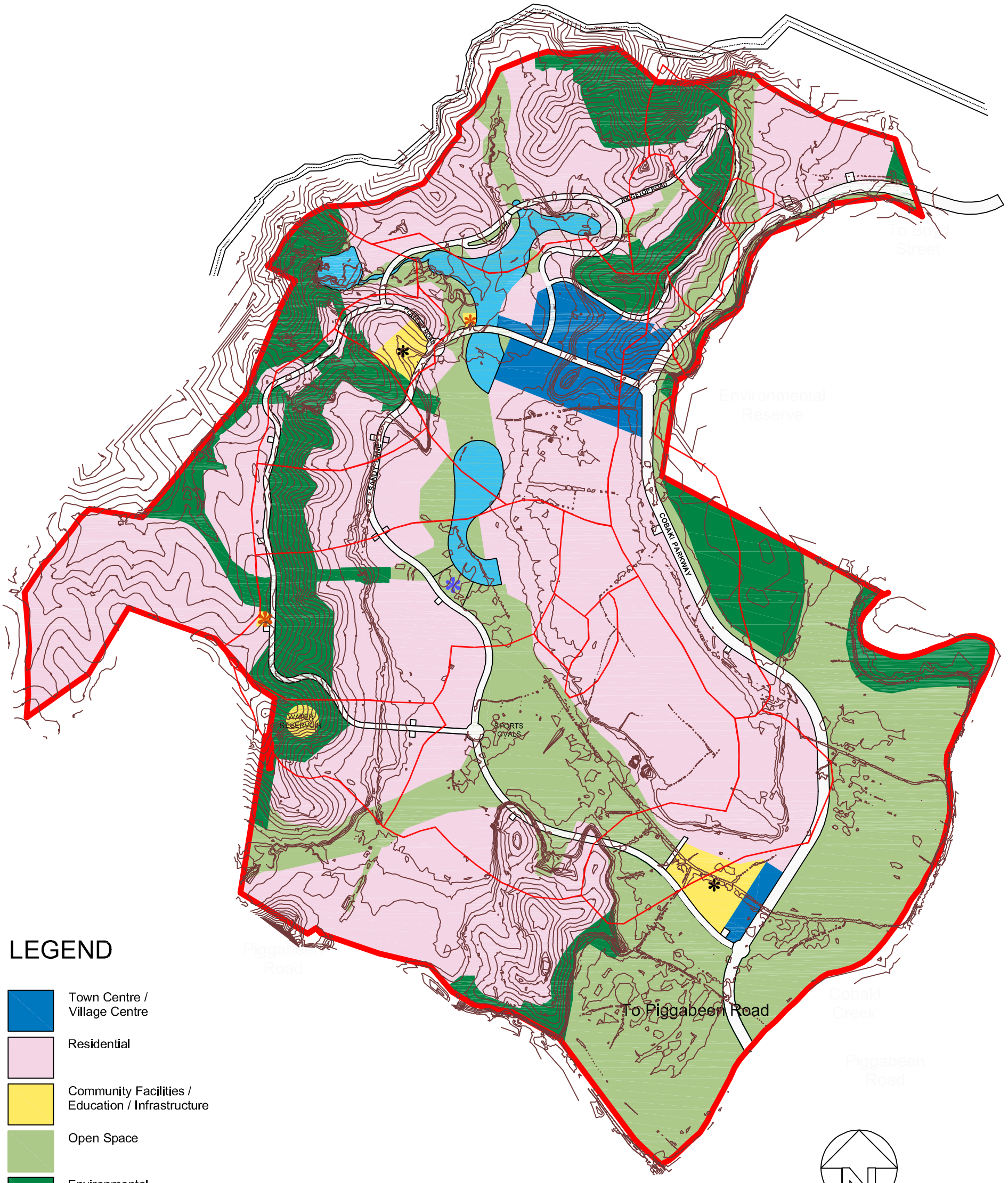
The 'Cobaki-Terranora' coastal lake Natural Sensitivity is classified as 'High' and the environmental status of the system is categorised as 'Healthy Modified Condition'. The proponent's proposals to cease grazing activities, regenerate saltmarsh vegetation and rehabilitate the degraded areas without adversely impacting the Cobaki Broadwater are not contrary to the recommendations of the inquiry report, the HRCCL report & HRCSJI and the NRCAP report.

GILBERT+SUTHERLAND
agriculture · water · environment

Eastside
5/232 Robina Town Centre Drive, Robina, Qld. 4226
Phone 55789944 Mobile 0418 760919 Fax 55789945

PROJECT
LEDA MANORSTEAD PTY LTD
COBAKI LAKES
CONCEPT PLAN
SITE LOCATION

FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING.	APPROVED	SCALE AS SHOWN	DRAWN A.J.F.	DRAWING No.
		DATE 2804/08	CHECKED	GJ0640.5.2



LEGEND

- Town Centre / Village Centre
- Residential
- Community Facilities / Education / Infrastructure
- Open Space
- Environmental Protection Area
- Lake
- Catchment boundary

Base Plan supplied by LEDA Manorstead Pty Ltd
Catchment Plan adopted from Map 4 of Tweed Shire Council DCP Section B7 - Cobaki Lakes

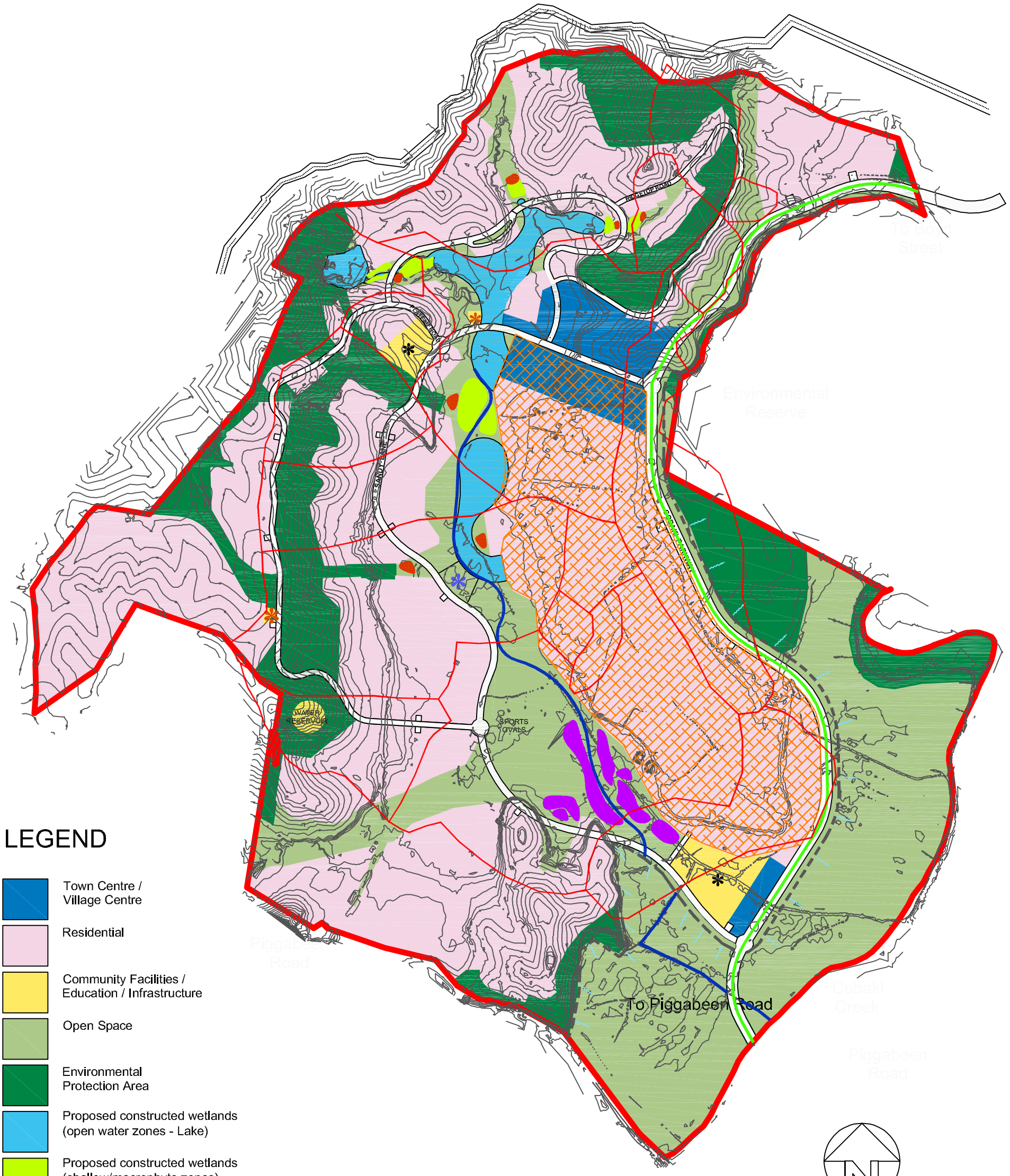
GILBERT+SUTHERLAND
agriculture · water · environment
Eastside
5/232 Robina Town Centre Drive, Robina, Qld. 4230
Phone 55789944 Mobile 0418 760919 Fax 55789945

FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING.

APPROVED . . . . . .

PROJECT
LEDA MANORSTEAD PTY LTD
COBAKI LAKES
CONCEPT PLAN
CATCHMENT PLAN

SCALE AS SHOWN	DRAWN A.J.F.	DRAWING No.
DATE 22/08/08	CHECKED	GJ0640.5.3



LEGEND

- Town Centre / Village Centre
- Residential
- Community Facilities / Education / Infrastructure
- Open Space
- Environmental Protection Area
- Proposed constructed wetlands (open water zones - Lake)
- Proposed constructed wetlands (shallow/macrophyte zones)
- Proposed constructed wetlands (sedimentation/inlet zones)
- Proposed Wallum Froglet Habitat rehabilitation area
- Area suitable for installation of infiltration systems
- Swale or bioretention swale
- Swale with spreader for diffuse discharge
- High flow bypass
- Diffuse discharge into final polishing zones
- Catchment boundary

Base Plan supplied by LEDA Manorstead Pty Ltd

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5/232 Robina Town Centre Drive, Robina, Qld. 4230
Phone 55789944 Mobile 0418 760919 Fax 55789945

FIGURED DIMENSIONS TO BE READ IN PREFERENCE TO SCALING.

APPROVED . . . . . .

PROJECT

LEDA MANORSTEAD PTY LTD

COBAKI LAKES

CONCEPT PLAN

STORMWATER MANAGEMENT CONCEPT

SCALE AS SHOWN	DRAWN A.J.F.	DRAWING No.
DATE 22/08/08	CHECKED	GJ0640.5.4

3) Integrated Water Cycle Management

3.1 IWCM Concept

Integrated Water Cycle Management (IWCM) describes a way of managing water in which all components of the water system (water supply, wastewater, stormwater and groundwater) are integrated to optimise the use of the resource. Sound IWCM means the community's water needs are met, whilst minimising environmental impacts and maximising the efficient use of this finite resource.

IWCM can involve the integration of a large number of concepts for re-use, reduction and recycling. These options may include (but are not limited to):

- demand management – use of water efficient appliances
- rainwater (roof runoff) collection and re-use (household or community scale)
- stormwater collection and reuse
- aquifer storage and recovery
- effluent recycling (sewer mining)
- WSUD measures for water quality improvement.

The optimum IWCM solution for any community will typically involve a combination of these options, based on existing infrastructure, local climate and site-based constraints. Economic and social factors may also contribute to the selection of appropriate IWCM options.

3.2 IWCM at Cobaki Lakes

A preliminary assessment of potential IWCM options for the Cobaki Lakes development was undertaken to identify individual components that may be appropriate to the site. However, the final IWCM strategy will not be limited to these options alone and should further strategies become apparent during the planning process, these may also be investigated and included in the final plan.

From the options identified, a conceptual IWCM strategy has been developed for further analysis and modelling. The elements to be investigated as part of the IWCM strategy for the Cobaki Lakes development are described herein.

Demand management solutions will include the development of a strategy to promote the use and installation of rainwater tanks will be investigated. Where tank use on individual lots is desirable, roof runoff from all such dwellings will be collected and stored in rainwater tanks for domestic re-use including toilet flushing, laundry cold water and outdoor uses in accordance with both BASIX requirements and Tweed Shire Council's Rainwater Tank Policy (adopted 2 November 2005). Compliance with BASIX (NSW Government Building Sustainability Index) should result in a minimum water savings of 40% of town water usage when compared to average NSW homes.[1]

Communal rainwater tanks will also be investigated as an option for collection and storage of runoff for use in landscape and open space irrigation.

Overflow from the rainwater tanks and runoff from the remainder of the development is intended to be treated by means of constructed wetlands in accordance with TSC guidelines. These wetlands may be augmented by the inclusion of infiltration systems, porous pavements, grassed filter strips, vegetated swales and bioretention systems into the treatment train.

A reticulated (town water) supply will be provided to households and businesses for kitchen and bathroom uses and laundry hot water. If required, this supply may also be utilised for top-up of domestic rainwater tanks when the tank level falls below 15%.

Investigations into the feasibility of demand management measures, in order to conserve water by reducing both town water usage and the volume of wastewater generated, will be undertaken. This will include the use of WELS Scheme rated water-efficient devices (including taps, showerheads, toilets, dishwashers and washing machines) to further reduce demand across the development.

The utilisation of treated water within the development remains an option under the concept plan. The feasibility of options for dual reticulation, such as use of purple pipe

[1] Tweed Shire Council, *Water Our Future – Integrated Water Cycle Management – June 2006,* TSC, June 2006.

The proposed rehabilitation works meet the objectives of the Cobaki Broadwater Management Plan as discussed in Section 2.6 of this report.

By adopting a first-principle approach during the development of the concept plan, runoff from the urban development would be treated in a number of ways, promoting the rehabilitation of both freshwater wetlands and significant areas of saltwater couch.

4) Stormwater management and flooding

4.1 Preliminary flood study history

In preparing this stormwater concept plan, Gilbert & Sutherland considered the summary findings of a preliminary flood impact assessment undertaken by BMT WBM Pty Ltd in March 2008[2] – 'the WBM summary report'.

The WBM summary report describes a 1995 flood study for a proposed development on the subject site using the 1D ESTRY computer model. The summary report indicates this model is to be upgraded and updated to consider Tweed Shire Council's 2005 Tweed Valley Flood Study (also by WBM) and the preliminary layout shown in the Concept Plan.

4.2 Consideration of preliminary flood study findings

Gilbert & Sutherland's review of WBM's preliminary flooding assessment indicates the report examined both Tweed catchment / storm tide flooding as well as Cobaki Creek flooding, but not local site flooding. The latter produces flood levels in the Cobaki Broadwater and Cobaki Creek which are not substantially above tidal variation and base creek flow level respectively.

The WBM preliminary flooding report does not model the effect of development in accordance with the Concept Plan on creek or river floods heights. WBM estimates that this impact would be very small – an opinion supported by our review. Gilbert & Sutherland and WBM agree that there is no need for on site detention for peak flood level management in the adjacent lake and creek, since regional creek and river floods dominate.

Whilst flood modelling at the detailed design stage will nonetheless be done, the Concept Plan demonstrates that there would be little point in providing on-site detention to manage local event runoff since discharge is into Cobaki Creek and the Cobaki Broadwater. Where discharge could occur to other landholdings, modelling and detention provisions (if required) would be provided.

Whilst WBM's preliminary flood modelling will be supplemented with detailed 3D flood modelling to support the DA process, minimum floor levels have been set by Tweed Shire Council and adopted by the proponent at 3.10m AHD. The basis for the selection of this height is a follows:

- TSC minimum floor level 3.10m – an assumed flood height of 2.60m AHD plus 0.50m to allow for a combination of an allowance for sea level rise (0.20m) and flood model inaccuracies (0.30m).
- Proponent's minimum floor level 3.10m – a modelled flood level of 2.10m AHD plus 1.00m to provide an allowance for both sea level rise and flood model inaccuracies.

4.2.1 Additional data collection

G&S has now collected tide data over a 20-week period adjacent to the site in Cobaki Creek. These data will form the basis of site tide predictions and the 3D flood modelling during the DA process. Together with further site survey, these data will allow for refined heights to be set for the saltmarsh area rehabilitation, tidal exchange and agricultural drain rehabilitation works. Whilst the assumed 1.00m allowance for modelling inaccuracies and climate change may seem excessive, it provides a wide safety margin to inform the concept plan.

4.2.2 Impacts of sea level rise

Assuming an allowance for modelling inaccuracies of 0.30m (before more accurate 3D modelling is completed) and adopting TSC's floor level of 3.10m AHD, a sea level rise of 0.70m has been allowed.

[2] Letter report dated March 7, 2008 by Sharon Wallace, Senior Flood Engineer, titled 'Cobaki Lakes Estate, Preliminary Flood Impact Assessment', BMT WBM Pty Ltd.

5) Conclusions

5.1 Erosion and sediment control

Conceptual erosion and sediment control plans will be prepared for submission in support of an application for a Part 3A approval. Detailed erosion and sediment control plans will be prepared and submitted for approval as part of an application for a Construction Certificate approval. Prior to commencement of construction in any stage, erosion and sediment controls should be installed in accordance with the stormwater management plan included as Attachment 1.

5.2 Water quality management

Stormwater management measures should be installed as described in Section 2.3. Provided these are properly installed and maintained, the estimates detailed in Section 2.4 indicate that the quality of the stormwater runoff from the site during the operational phase will be acceptable.

Careful management will be required to ensure that the projected quality levels are achieved and maintained particularly during the construction phases. These details are considered in the stormwater management plan, which is included as Attachment 1.

The developers of the structures on the individual allotments should also be encouraged to implement the principles of 'Water Sensitive Urban Design' in their developments to ensure a two phase treatment system is in place to complement the proposed stormwater management measures.

5.3 IWCM investigation strategy

Investigations will be undertaken into the feasibility of a number of different IWCM options as described in Section 3.2. Investigation into other IWCM options which become apparent throughout the planning process will also be undertaken.

The IWCM approach will aim to amalgamate a number of the techniques and options identified in order to achieve the most feasible solution for management of water supply, wastewater, stormwater and groundwater resources throughout the development.

(secondary supply), will be investigated, with potential to access and utilise a recycled water supply once the new Council treatment plant is constructed and online.

The option of installing spear pumps to access the near surface freshwater aquifer for landscape and open space irrigation will be investigated, as will options for groundwater recharge through infiltration of either stormwater runoff of treated water.

For any rural living areas, the feasibility of the installation of greywater recycling and on-site sewage treatment facilities to reduce wastewater loading on the municipal treatment plant will be investigated. This may also be complemented by an investigation into the potential for sewer mining for treatment and reuse on a larger scale throughout the development.

Water sensitive urban design features and the interaction between local freshwater and saltwater environments will be a focal point of the design. North of Sandy Lane would form a predominantly freshwater environment, south, a salt-water regime would be in effect. Engineering structures have been designed to maintain drainage, provide flood protection and allow for the effects of climate change.

Stormwater quality treatment will be provided for rainfall runoff by means of constructed wetlands within each sub-catchment in accordance with Tweed Shire Council's 'deemed to comply' requirements.

MUSIC modelling has been used to demonstrate the proposed development will have no adverse impacts on the quality of waters discharging from the site. A discussion of the proposed stormwater quality treatment options has been provided in Section 2.

Like the rehabilitation areas and the regional and district open spaces, the constructed wetlands would pass into public ownership. The wetlands have been elevated to minimise the disturbance of acid sulfate soils and the operational phase groundwater drawdown. This has the benefit of further reducing ongoing acid sulfate impacts.

To ensure that the water quality within the constructed wetlands can be maintained during long periods of drought, a pumped system allowing the introduction of salt water from south of Sandy Lane is proposed. A separate subsurface drainage system, bypassing the freshwater rehabilitation areas would ensure the brackish return water does not damage the freshwater wetlands before discharging into the salt-water couch treatment areas.

Diffuse stormwater discharge would be provided for both the freshwater and saltwater systems would be achieved through the construction of under-drained swales with level-spreader devices. Again, this presents a number of benefits from engineering, ecological and pest management perspectives.

The engineering benefit of combining freshwater and salt-water rehabilitation with stormwater treatment means less acid sulfate soils are disturbed, less valuable land is consumed for stormwater treatment and that the maintenance burden is reduced.

The ecological benefits centre on the health of rehabilitated areas and the ongoing fisheries habitat contribution to the Broadwater ecosystem. Additionally, by controlling, repairing and improving the surface water management within the rehabilitated areas, the mosquito and biting midge problem can be controlled.

Whilst proposed engineered controls on the culverts at each road crossing allow for effective separation of the tidally influenced and freshwater areas, tidal monitoring has been installed to ascertain whether additional drainage repair is necessary.

Previous agricultural drainage works, particularly along the banks of Cobaki Creek may require additional levelling, filling and limited excavation to ensure the highest ecological benefit from the rehabilitated areas. For this reason, the proposed rehabilitation takes a staged approach, allowing for adjustment, revision and ongoing consultation with stakeholders.

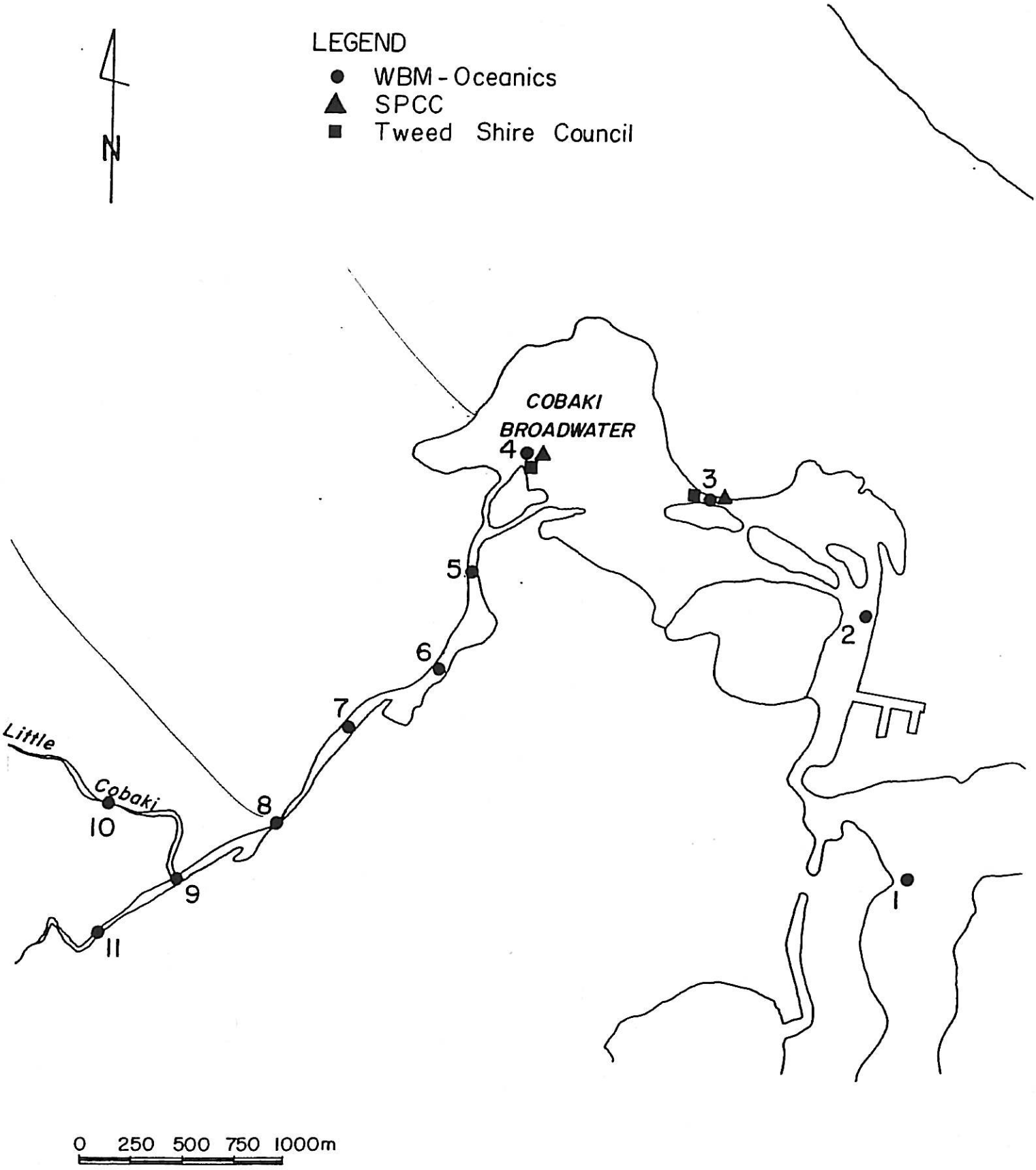
The effects of climate change have been accommodated by the protection of the freshwater habitat by the construction of Sandy Lane and the engineered culverts and the provision of defined retreat areas for the saltwater couch.

6) Appendix 1 – Water quality monitoring results

Job No: GJ0640-1
Client: Leda Manorstead Pty Ltd
Project: Cobaki Lakes
Date: 10/04/08
Description: Surface Water Quality Monitoring Summary

WBM Data					G&S Data				
Sampling commenced:			12/09/1991		**Sampling commenced:**			22/10/2007	
Sampling concluded:			13/12/1991		**Sampling concluded:**			ongoing	
Rounds conducted:			5		**Rounds conducted:**			5	
		median	**mean**	**std.dev.**			**median**	**mean**	**std.dev.**
SW1	TP (mg/L)	-	-	-	**SW1**	TP (mg/L)	0.05	0.05	0.04
	TN mg/L)	-	-	-		TN mg/L)	1.65	1.65	0.21
	TURB (NTU)	-	-	-		TURB (NTU)	40	40	-
SW2	TP (mg/L)	-	-	-	**SW2**	TP (mg/L)	0.02	0.02	-
	TN mg/L)	-	-	-		TN mg/L)	2.40	2.40	-
	TURB (NTU)	-	-	-		TURB (NTU)	-	-	-
SW3	TP (mg/L)	0.06	0.13	0.12	**SW3**	TP (mg/L)	-	-	-
	TN mg/L)	0.07	0.15	0.17		TN mg/L)	-	-	-
	TURB (NTU)	16	24	20		TURB (NTU)	-	-	-
SW4	TP (mg/L)	0.08	0.13	0.12	**SW4**	TP (mg/L)	-	-	-
	TN mg/L)	0.09	0.19	0.20		TN mg/L)	-	-	-
	TURB (NTU)	35	42	20		TURB (NTU)	-	-	-
SW5	TP (mg/L)	-	-	-	**SW5**	TP (mg/L)	0.15	0.12	0.09
	TN mg/L)	-	-	-		TN mg/L)	0.57	0.53	0.17
	TURB (NTU)	-	-	-		TURB (NTU)	30	30	12
SW6	TP (mg/L)	0.06	0.11	0.12	**SW6**	TP (mg/L)	0.08	0.10	0.08
	TN mg/L)	0.30	0.34	0.33		TN mg/L)	0.75	0.94	0.68
	TURB (NTU)	35	44	17		TURB (NTU)	10	22	16
SW8	TP (mg/L)	0.08	0.14	0.13	**SW8**	TP (mg/L)	0.07	0.08	0.07
	TN mg/L)	0.35	0.38	0.34		TN mg/L)	0.40	0.41	0.07
	TURB (NTU)	34	39	20		TURB (NTU)	10	16	9

For monitoring locations see attached map:
WBM Oceanics (1991) Cobaki Development Water Quality Study. Figure 3.1



FIGURE

WATER QUALITY DATA COLLECTION LOCATIONS 3.1

WBM

7) Attachment 1

7.1 Stormwater Management Plan

GILBERT+SUTHERLAND
agriculture · water · environment

Stormwater Management Plan
Cobaki Lakes Concept Plan

Prepared for
LEDA Manorstead Pty Ltd

May, 2008

Document control

Document:	**GJ0640-1_SWMP_RAF1F.doc**	Gilbert & Sutherland P/L ABN 56 077 310 840 Originating Office: Robina Eastside 5/232 Robina Town Centre Drive, Q4230 PO Box 4115, Robina Q4230 Telephone 07 5578 9944 Facsimile 07 5578 9945 gsrobina@bigpond.com Also at Kawana and Brisbane
Title:	**Stormwater Management Plan Cobaki Lakes Concept Plan**	
Project Manager:	Neil Sutherland	
Author:	Alison Fullagar	
Client:	LEDA Manorstead Pty Ltd	
Client Contact:	Reg van Rij	
Client Reference:	**Cobaki Lakes Concept Plan**	
Synopsis:	This management supports Stormwater Concept Plan for the Cobaki Lakes development. It establishes responsibilities and procedures for the management of erosion, sediment and stormwater during the construction and operational phases of this project.	

Revision History

Revision #	Date	Edition By		Approved By	
1	11/04/08	AJF		NMS	LJV
2	14/05/08	AJF		NTZ	LJV

Distribution

	Revision Number									
Distribution	1	2	3	4	5	6	7	8	9	10
LEDA Manorstead Pty Ltd	2	1								
G&S Library and File	2	1								
JBA Urban Planning		1								

Summary

Gilbert & Sutherland Pty Ltd (G&S) was commissioned by LEDA Manorstead Pty Ltd to prepare a Stormwater Concept Plan and Stormwater Management Plan (SWMP) for the Cobaki Lakes Concept Plan.

This Stormwater Management Plan provides procedures aimed at achieving site specific stormwater quality objectives during the construction and operational phases. Ideally it should be included in the contract documents for the earthworks, roadworks and drainage construction works in this project.

Table of contents

1) Stormwater management plan

1.1 Objectives and implementation

1.1.1 Objectives

The principle objective of this SWMP is to provide mitigation measures to minimise the potential impacts of the development.

Additionally, the SWMP provides information on specific site management issues relating to potential environmental impacts from the development during the construction and operational phases.

The control measures detailed in this SWMP have been developed to minimise impacts on the environment and achieve the following objectives:

- appropriate stewardship of natural resources,
- protection of downstream flora and fauna habitats,
- confirmation of the success of impact control measures by the means of monitoring during the construction of each stage,
- compliance with statutory requirements, and
- preservation of the existing groundwater conditions.

1.1.2 Implementation

The management plan requires the Proponent to mitigate the potential environmental impacts associated with the construction of the subdivision works.

It is intended that the SWMP will provide a set of performance criteria and guiding principles with which the engineering designs for the development will comply. The plans and specifications forming part of the construction contract for each stage should also include these performance criteria.

1.2 SWMP structure

This SWMP acknowledges the environmental impacts associated with the development and details strategies to mitigate them.

Each control strategy is based upon proven environmental management methods and is presented as a commitment. The commitments made within this document will form the basis of future assessments, which will be made available to the Tweed Shire Council for review.

1.2.1 Site-specific objectives

The stormwater quality objectives and environmental management strategies detailed in this SWMP are designed to comply with relevant laws and regulations while acknowledging the specific characteristics and localised environmental context of the site. The application of relevant legislation, guidelines and standards may necessitate specific consideration of unique or unusual natural and/or human factors in the local environment. Where necessary, variations to the relevant guidelines may be sought and, where approved, included in this SWMP.

This SWMP includes tables detailing objectives and management strategies for both the construction and operational phases of the development. The party responsible for the implementation of the measures detailed is written on the table itself. The tables then detail the issue, the performance criteria, the implementation strategy, monitoring, auditing, reporting, failure identification and the corrective action. The detachable pages within each section detail the provisions of the SWMP. The format is presented below for reference purposes.

#.# Title

Person responsible	This is the person or party who has accepted the responsibility of implementing the SWMP provisions detailed on this page

Issue	The issue with which the table deals.
Operational policy	The operational policy or management objective that applies to the element.
Performance criteria	Performance criteria (outcomes) for each element of the operation.
Implementation strategy	The strategies or tasks (to nominated operational design standards) that will be implemented to achieve the performance criteria
Monitoring	The monitoring requirements which will measure actual performance (i.e. specified limits to pre-selected indicators of change).
Auditing	The auditing requirements, which will verify implementation of, agreed construction and operation phase environmental management strategies and compliance with agreed performance criteria.
Reporting	Content, timing and responsibility for reporting and auditing of monitoring results.
Identification of incident or failure	The circumstances under which the agreed performance criteria are unlikely to be met and environmental harm is likely to result.
Corrective action	The action to be implemented in case a performance requirement is not reached and the party(s) responsible for action.

Commitment #
A promise made by management.

An objective of the tabular format is to allow for change and allow the management plan to be a working document. If items need altering, changes may be made (after the appropriate consultation with the statutory authorities) to the individual tables.

1.3 General commitments

Commitment 1
The Proponents undertake to comply with the environmental implementation strategy as contained within the approved Stormwater Management Plan (SWMP).

Commitment 2
The Proponents undertake to fulfil all commitments made in this SWMP and to carry out their activities on the project site in accordance with relevant current statutory requirements and approved amendments

1.4 Compliance

Compliance with the provisions of this SWMP requires the objectives and management strategies contained herein to be both reasonable and achievable within the context of the approval(s) to which they relate. Incidents and/or failures that involve factors beyond the control of the responsible party(s) and the response and/or corrective actions taken by the responsible party(s) should be considered in assessing compliance with this SWMP.

1.5 Definitions

In this SWMP the terms have the following meanings:
SWMP means the approved Stormwater Management Plan and includes any amendments that may be approved from time to time;
Development means the development of the site for the purposes of dwelling houses and other land uses;
TSC means Tweed Shire Council;
Proponent means the person undertaking the development of the land and includes the person nominated by the Proponent as having the responsibility for implementing the provisions of the SWMP;
EPA means New South Wales Environment Protection Authority.

1.6 Contact details

The following persons are responsible for the implementation of the management measures described in the individual tables of the SWMP.

Contractor's Site Manager
The name and address of the Contractor and its representative will be notified to Council by the Consulting Engineer prior to the commencement of each contract/stage of the project.

Consulting Engineer
Unless advised otherwise the Consulting Engineer is:
Company: To be advised
Address:

Contact Details:
Phone:
Facsimile:

Environmental Consultant
Unless advised otherwise the Environmental Consultant is:
Company Gilbert & Sutherland Pty Ltd
Address: Eastside 5/232 Robina Town Centre Drive
PO Box 4115
Robina Q 4230
Contact Details: Mr Neil Sutherland
Phone: 55789944
Facsimile: 55789945

2) Management of potential impacts – background and construction phase

The SWMP requires the Proponent to mitigate the potential environmental impacts associated with the construction of the subdivision works.

Prior to commencement of construction in any stage, detailed erosion and sediment control plans will be prepared, based on the requirements of this SWMP and the NSW Landcom, *Managing Urban Stormwater Soils and Construction*,[1] and submitted to and approved by Council.

The development should be built in stages to minimise the potential for soil erosion and water pollution. This would enable the site to be progressively rehabilitated as the development proceeds.

As soon as is practicable after the completion of the earthworks, the disturbed areas will be reseeded to establish a fast-growing cover crop which will minimise erosion and movement of sediment across and off the site. On steeper slopes and the road cuttings, it is likely that hydromulching and/or placing of hoop pine mulch will be required.

Wherever possible the site will remain grassed and otherwise undisturbed until construction commences.

Although no MUSIC modelling has been completed for the construction phase, it is evident that temporary sedimentation ponds and other sediment control measures should be installed during this phase.

Prior to commencement of earthworks in any stage, temporary sedimentation ponds should be installed. The exact number, location and size will be determined at the detailed design stage concurrently with the development of the staging plan. All runoff from disturbed areas is to be collected by means of surface drains and diverted to a sedimentation pond. Where practicable, runoff from undisturbed areas should be diverted around disturbed areas and away from the sedimentation pond. The temporary sedimentation ponds may be removed when the site has been revegetated, after completion of the bulk earthworks.

Other control measures such as (but not limited to) temporary sedimentation basins, silt fences and contour drains should be installed and maintained in accordance with recommendations contained in the NSW Landcom, *Managing Urban Stormwater Soils and Construction*.

Erosion and sediment control measures must be installed in disturbed areas during the building construction phase in accordance with the requirements of Council's *Sediment and Erosion and Control Guidelines for Builders and Developers*. These measures should be maintained until landscaping has been completed and becomes established.

The soils identified on the site are assessed as low to very low fertility soils. Nevertheless, it is considered that nutrient transport from the site during the construction phase should be minimised by implementation of appropriate control measures.

The following detachable pages detail the provisions of this SWMP for the construction phase.

[1] Landcom, 2004, 'Managing Urban Stormwater, Soils and Construction' 4th Edition, March 2004.

2.1 Construction phase dust management.

Person responsible	Contractor's Site Manager.

Issue	Minimisation of movement of dust offsite.
Operational policy	To achieve acceptable air quality standards through the control of the movement of dust offsite from site works.
Performance criteria	The target level for complaints by nearby residents is no more than one in any seven day period. Ambient air quality should not deteriorate by more than 30% over a period of seven consecutive days. Dust deposition at any nearby residence should not exceed 100mg/m^2/day.
Implementation strategy	The minimisation of the movement of dust offsite will be achieved through the following onsite practices: • All permanent bunds and reshaped areas will be revegetated within 10 days after completion of earthworks (including excavation and backfilling of services trenches). • Stockpiling onsite will be minimised where possible. • An onsite water cart will be available at all times. The site will be watered daily and additional watering will be conducted during high-risk times such as high winds and low rainfall and after receipt of complaints. • All dust creating activities to cease if wind speed exceeds 10m/sec. • Contractors' staff to be trained to implement dust minimisation measures.
Monitoring	Daily inspections will be carried out to verify that dust mitigation measures are being implemented. Dust monitoring will be conducted upon receipt of complaints by residents. If dust monitoring is to take place, the following will occur: • Temporary dust deposition gauges will monitor the movement of dust offsite at the nearest residences adjacent to the proposed stages and within the predominant wind directions. • Monitoring will be undertaken in accordance with AS 3580.10.1(1991).
Auditing	Management to examine the complaints register weekly and review corrective action taken.
Reporting	• The contractor to notify EPA of a possible environmental nuisance on receipt of 3 or more dust complaints in any 24 hour period. • Receipts will be provided to TSC upon request. • Complaints by residents are to be recorded in a Complaints Register and notified to TSC.
Identification of incident or failure	Any dust-related complaints by residents will indicate a failure of the dust control measures.
Corrective action	Locate the source of the dust and implement the following measures: • Apply water sprays to vegetation • Cover or water exposed areas • If dust persists, cease the dust creating activities. All dust complaints to be addressed in consultation with council officers.

Commitment 3
Dust generated during the construction of the subdivision works will be managed to ensure that dust movement offsite is controlled.

2.2 Construction phase sediment and erosion controls

Person responsible	Contractor's Site Manager, Consulting Engineer

Issue	Sediment and Erosion Controls.
Operational policy	To prevent the displacement of sediment and soil across and offsite.
Performance criteria	Offsite discharges to comply with requirements for suspended sediments as detailed in Section 2.5 of the SWMP. No visual indication of erosion on stages under construction, including evidence of rilling (an indicator of sheet erosion).
Implementation strategy	• Detailed erosion and sediment control plans shall be prepared in accordance with the provisions outlined in Annexure A of Tweed Shire Council's Development Design Specification D7 Stormwater Quality. These plans shall be submitted to and approved by TSC Prior to commencement of construction in any stage. • Erosion and sediment control devices shall be installed prior to commencement of work in each stage in accordance with the approved plans and to the reasonable satisfaction of TSC. • Temporary erosion measures (eg. silt fences) are to be employed onsite during construction where reasonably deemed necessary by TSC from an assessment of slope and soil type. Such measures should be in accordance with the recommendations in the IE Aust. Qld. Soil Erosion and Sediment Control Guidelines. • Stockpiled soil should be stored/bunded in a manner to prevent soil being washed offsite (i.e. bunding where necessary.) • Outside the construction area of each stage existing surface water conditions should be maintained wherever possible.
Monitoring	• Carry out visual inspections weekly and after rainfall events to ensure that erosion measures are in place and operational to suit the activities taking place at the time. • Surface water quality to be monitored monthly (refer to the Section titled 'Surface Water Monitoring' which details monitoring of surface water and stormwater quality).
Auditing	Visual inspections to be carried out monthly and after rainfall events to verify that control measures are in place and properly maintained.
Reporting	Reporting only required if insufficient sediment and erosion measures are identified.
Identification of incident or failure	• Signs of erosion on site. • Damaged or failed erosion control devices. • Falling stormwater quality as identified by Environmental Contractor. • Build-up of sediment.
Corrective action	Apply remedial measures to improve sediment and erosion measures, for example: silt fences, shake down areas.

Commitment 4
Best management practices will be implemented into work practices throughout the construction of the subdivision works to minimise erosion and sediment transport offsite.

2.3 Construction phase surface water monitoring on site

Person responsible	Contractor's Site Manager, Environmental Consultant

Issue	Surface water controls on site – temporary sedimentation ponds.
Operational policy	To maintain stormwater quality conditions of runoff during the construction phase.
Performance criteria	All water discharged from the site during the construction phase should comply with the following criteria:

Water Quality Parameter	Release Criteria	Criteria Type
pH	>5.0[+]	Minimum
Turbidity	50NTU	Maximum

[+] adopted from TSC DCP B7 – Cobaki Lakes

Implementation strategy	• Stormwater control should be achieved by directing as much runoff as practicable from disturbed areas to temporary sedimentation ponds. 'Clean' runoff from undisturbed areas should be diverted around disturbed areas if possible. • All samples must be analysed at a NATA registered laboratory for the indicators listed in 'Monitoring' below.
Monitoring	• Surface water monitoring during construction should be conducted in all temporary sedimentation basins for the parameters listed above. Flow rates are to be estimated and recorded at the time of sampling. • Sampling frequency is to be monthly and during the first rainfall event (>25mm in any 24hr period) each month. • Daily visual surveillance of water bodies for changes in conditions.
Auditing	The Consulting Engineer to audit stormwater quality results to verify that all discharges comply with the performance criteria above.
Reporting	• Result sheets to be compiled for monitoring results. All results to be kept on site for inspection by local and state government officers at all times. • Monthly reports to TSC including raw data, a results summary and a discussion comparing results with baseline values and ANZECC guidelines.
Identification of incident or failure	• Degradation of surface water quality (i.e. Suspended Solids) at the monitoring points to below the levels specified in 'Performance Criteria' above prior to discharge. • Visible changes in water body conditions.
Corrective action	• If the test result for any parameter fails to meet the performance criteria, then weekly monitoring shall commence and continue until the recorded value/s meet the performance criteria. • If a pH is detected outside the criteria range, then such waters should be contained, and the pH adjusted to within the range of 6.5 to 9.0 prior to release.

[redacted]	• If total suspended solids exceed the water quality criteria for this parameter, then water may need to be contained on site for a period sufficient to allow suspended solids to settle out prior to release, or settling should be aided by dosing with flocculation agents at the rate recommended by the manufacturer (for example Gypsum at dose rate of 30kg/100m^3). • Erosion control devices should be immediately inspected and cleaned if necessary. • Additional devices should be installed if a need is detected to prevent future breaches of the suspended solids criteria. The placement of stockpiles and management of disturbed areas should be reviewed with regard to sediment and silt control.

Commitment 5

The Proponent will take all reasonable steps to ensure that all waters discharged from the site meet the performance criteria set out above.

2.4 Construction phase surface water monitoring – permanent treatment measures

Person responsible	Contractor's Site Manager, Consulting Engineer, Environmental Consultant

Issue	Surface water controls, permanent treatment measures.
Operational policy	To maintain water quality condition of receiving waters during the construction phase.
Performance criteria	All water discharged from the site during the construction phase should comply with the following criteria:

Water Quality Parameter	Release Criteria[+]	Criteria type
pH	>5.0	Minimum
Suspended Solids	<50mg/L	Maximum
Dissolved Oxygen (field measured)	>80% saturation	Minimum
Total N	<0.50mg/L	Maximum
Total P	<0.20mg/L	Maximum
Salinity	<5g/L	Maximum
Oil and Grease	None visible	Maximum

[+] adopted from TSC DCP B7 – Cobaki Lakes

These performance criteria may be adjusted upon submission of suitable background data and calculation of revised site specific objectives derived in accordance with ANZECC guidelines. Any amendment to the performance criteria must receive written approval by TSC prior to alteration of the approved SWMP.

Implementation strategy	• Surface water samples to be collected during the first rainfall event (>25mm in 24 hours) each month from the monitoring points and analysed at a NATA registered laboratory. • Monitoring results should be reviewed after 6 months and sampling frequency revised in consultation with Council Officers. • Stormwater control should be achieved by directing as much runoff as practicable from disturbed areas to the temporary control measures. 'Clean' runoff from undisturbed areas should be diverted around disturbed areas if possible.
Monitoring	• Surface water monitoring during construction should be conducted at the monitoring points for the parameters shown above. Flow rates are to be estimated and recorded at the time of sampling. • Sampling frequency is to be after the first rainfall event (>25mm in 24hours) each month. • Daily visual surveillance of water bodies for changes in conditions.
Auditing	The consulting engineer to audit stormwater quality results to verify all discharges comply with the performance criteria.

Reporting	Results sheets to be compiled for monitoring results relating to water quality of water bodies. All results to be kept on site for inspection by local and state government officers at all times. Monthly reports to TSC including raw data, a results summary and a discussion comparing results with baseline values and ANZECC guidelines.
Identification of incident or failure	Degradation of surface water quality at the monitoring points to below the levels specified in 'Performance Criteria' above prior to discharge. Apparent visual changes in water body conditions.
Corrective action	Locate the source of the contaminant. Take all possible actions to contain and control the contaminant. Investigate the cause of the contamination and take action to prevent a recurrence. If the test result for any parameter fails to meet the performance criteria, then weekly monitoring shall commence and continue until the recorded value/s meets the performance criteria. For example: • If total suspended solids exceed the stormwater quality criteria for this parameter, then water may need to be contained on site for a period sufficient to allow suspended solids to settle out prior to release, or settling shall be aided by dosing with flocculation agents at the rate recommended by the manufacturer. Erosion control devices should be immediately inspected and cleaned if necessary. Additional devices should be installed if a need is detected to prevent future breaches of the suspended solids criteria. The placement of stockpiles and management of disturbed areas should be reviewed with regard to sediment and silt control. • If Total N levels are high, check upstream stormwater quality. Check fertiliser application rates on landscaping work on site and adjust as required. • If Total P levels are high, check effluent disposal practices upstream. Check fertiliser rates on landscaping work on site and adjust as required. • If Oil and Grease levels are high, locate the source of the contamination and clean up source and contaminated waters in consultation with Council officers.

Commitment 6

Surface water quality should be maintained during the construction of the subdivision works in accordance with the criteria detailed above.

2.5 Construction phase contractor management

Person responsible	Consulting Engineer

Issue	Contractor management.
Operational policy	To ensure the proponent's duty of care is met by ensuring the Contractor is aware of his responsibilities under the terms of the SWMP and the EPA.
Performance criteria	Contractor is fully aware of their responsibilities under the terms of the SWMP.
Implementation strategy	• Review of the SWMP and the construction phase contracts by the proponent. • Periodic checks to be made by an independent Environmental Consultant. • Training for construction staff in implementation of SWMP provisions.
Monitoring	Weekly site inspections to be carried out.
Auditing	Inspections will be carried out monthly during the construction phase by an Environmental Consultant for every stage of development.
Reporting	Full details to be available to the contractor together with suggested corrective actions if required.
Corrective action	To be detailed at the time.

Commitment 7

A proactive program of contractor management will be implemented.

3) Management of potential impacts – on maintenance phase

3.1 Intent

This part of the SWMP specifies those matters which must be complied with by the Proponent during the 6 months 'on-maintenance period', being the period after construction but before Tweed Shire Council assumes responsibility for the subdivision works. The Proponents' obligations in this Section of the SWMP conclude at the end of the maintenance period for each stage.

3.2 Implementation

At the completion of the construction of the development's civil works, the GPT's (if any have been installed) should be cleaned out to become part of the permanent stormwater quality control treatment train.

3.3 On maintenance phase sediment and erosion controls

Person responsible	Contractor's site manager, consulting engineer.

Issue	Sediment and erosion controls.
Operational policy	To prevent the displacement of sediment and soil across and offsite.
Performance criteria	Offsite discharges to comply with requirements for suspended sediments as detailed in Section 3.4 of the SWMP.
Implementation strategy	Temporary erosion and sediment control devices shall be maintained in an operational state during the maintenance period.
Monitoring	• Temporary erosion control measures are to be inspected monthly and after rainfall events. • Permanent stormwater quality control structures (GPT's, basins etc.) are to be inspected monthly and after rainfall events.
Auditing	Quarterly inspections to be carried out by an independent Environmental Consultant.
Reporting	Reporting only required in the event of failure of the sediment and erosion control measures.
Identification of incident or failure	• Signs of erosion on site • Build up of sediment • Falling stormwater quality
Corrective action	Repair temporary sediment and erosion control measures. Check permanent measures for build up of sediment and clean out as necessary.

Commitment 8

Erosion and sediment control devices will be maintained during the on-maintenance period until the risk of soil erosion and sediment transport is considered negligible.

3.4 On maintenance phase surface water monitoring

Person responsible	Contractor's Site Manager, Environmental Consultant.

Issue	Surface water monitoring in new permanent water bodies.
Operational policy	To establish stable surface water conditions and verify that development management is appropriate.
Performance criteria	All water discharged from the site should comply with the following criteria:

Water Quality Parameter	Release Criteria[+]	Criteria type
pH	>5.0	Range
Suspended Solids	<50mg/L	Maximum
Dissolved Oxygen (field measured)	>80% saturation	Minimum
Total N	<0.50mg/L	Maximum
Total P	<0.20mg/L	Maximum
Salinity	<5g/L	Maximum
Oil and Grease	None visible	Maximum

[+] adopted from TSC DCP B7 – Cobaki Lakes

These performance criteria may be adjusted upon submission of suitable background data and calculation of revised site specific objectives derived in accordance with ANZECC guidelines. Any amendment to the performance criteria must receive written approval by TSC prior to alteration of the approved SWMP.

Implementation strategy	• Surface water entering and exiting the development shall be monitored at the environmental monitoring points during the 'On-maintenance' period. • Surface water monitoring shall be undertaken at the discharge points from the development stages until stable water quality criteria have been established. • Monitoring will also be undertaken during flood events where practicable. This monitoring will allow water quality comparisons to be made.
Monitoring	• Surface water monitoring for all parameters will be conducted monthly at all monitoring points. • To revert to construction phase provisions if problems are identified. • If problems are identified, laboratory analysis at a NATA registered laboratory for the parameters listed above until such a time as TSC is satisfied that the Proponent's duty of care under the EPA has been discharged. • These provisions will conclude at the end of the 'on maintenance' period.
Auditing	The Proponent to audit water quality results quarterly to verify that discharges comply with the performance criteria.

Reporting of monitoring results	• Monitoring test results are to be compiled on monthly result sheets. Monthly reports containing raw data and an interpolation sheet to be sent to TSC. • Results to be available at all times.
Identification of incident or failure	Fall in surface water quality at the environmental monitoring points.
Corrective action	• Identify reason for deterioration in surface water quality to identify if it is linked to the development. • Take necessary steps to address the problem such as improved temporary sediment and erosion controls.

Commitment 9

Subdivision works will be maintained during the maintenance period to ensure surface water quality complies with the water quality criteria detailed above.

3.5 On maintenance phase maintenance

Person responsible	Contractor's Site Manager, Consulting Engineer.

Issue	Maintenance
Operational policy	To maintain the stormwater quality control structures to ensure adequate performance during the maintenance period.
Performance criteria	The control measures are maintained and operational.
Implementation strategy	Ensure inlets and outlets are not blocked and are structurally stable. All waste to be disposed of at council approved waste facilities.
Monitoring	• Monthly inspection of control structures during the maintenance period. • Any recurring problems with the control structures to be rectified during the maintenance period. • Structures also to be inspected following major rainfall events.
Auditing	The Proponent to carry out quarterly inspections to verify that the stormwater quality control structures are properly maintained by the contractor.
Reporting of monitoring results	• Record inspection details. • Record details of all maintenance activities (including volume of silt removed from each GPT or other control structure) and include in monthly reports to TSC. • Results to be available to EPA at all times.
Identification of incident or failure	• Blockage of stormwater system. • Re-entrainment of trapped sediments. • Deterioration of water quality within or downstream of control structure.
Corrective action	• Clean or maintain stormwater control structure as appropriate. • Take necessary steps to address the problem to prevent a recurrence.

Commitment 10

Stormwater quality control structures will be adequately maintained during the maintenance period to ensure continued performance.

3.6 On-maintenance phase maintenance of lake system

Person responsible	Contractor's Site Manager, Consulting Engineer.

Issue	Water quality and surface level control in lakes during extended drought periods.
Operational policy	To ensure water quality and levels in the lakes can be maintained during extended periods of drought.
Performance criteria	Lake water quality and levels are maintained during extended periods of drought.
Implementation strategy	• Saltwater from Cobaki Creek (south of Sandy Lane) would be pumped into the lakes. • A subsurface drainage system would be provided to enable brackish return water to bypass the freshwater rehabilitation areas.
Monitoring	• Water quality monitoring to be carried out in accordance with Section 3.4. • Water levels at the weirs at the downstream end of each lake to be monitored monthly. • Establish complaints register and record details of all complaints. • Inspections to be carried out monthly, and following complaints, to ensure any deterioration in water quality (e.g. evidence of an algal outbreak) can be rectified promptly.
Auditing	• The proponent to carry out quarterly inspections of the lakes to verify that monitoring has been carried out and corrective action has been implemented if required. • The proponent to carry out quarterly inspections of the pump station infrastructure to ensure it is maintained in working order.
Reporting of monitoring results	• Monitoring results (water quality and lake levels) to be included in monthly reports to TSC. • Record details of all maintenance activities. • Results to be available to EPA at all times, upon request.
Identification of incident or failure	• Water quality of outflow fails to meet the release criteria. • Complaints from residents regarding odours, increased mosquito activity, reduced water levels or visible signs of pollution (e.g. algae, increased turbidity). • Water surface levels in the lakes fall greater than 300mm below the outlet weir.
Corrective action	Pumping of saltwater into the lake system for flushing or top-up as appropriate.

4) Management of potential impacts – operational phase

4.1 Intent

This part of the SWMP specifies those matters that must be complied with by TSC after it assumes responsibility for the subdivision works.

4.2 Implementation

Permanent stormwater quality control structures are to be monitored and maintained as detailed in the following tables.

4.3 Operational phase surface water monitoring

Person responsible	Tweed Shire Council

Issue	Surface water monitoring.
Operational policy	To verify that stable surface water conditions are maintained.
Performance criteria	All water discharged from the site should comply with the following criteria:

Water Quality Parameter	Release Criteria[+]	Criteria type
pH	>5.0	Range
Suspended Solids	<50mg/L	Maximum
Dissolved Oxygen (field measured)	>80% saturation	Minimum
Total N	<0.50mg/L	Maximum
Total P	<0.20mg/L	Maximum
Salinity	<5g/L	Maximum
Oil and Grease	None visible	Maximum

[+] adopted from TSC DCP B7 – Cobaki Lakes

These performance criteria may be adjusted upon submission of suitable background data and calculation of revised site specific objectives derived in accordance with ANZECC guidelines. Any amendment to the performance criteria must receive written approval by TSC prior to alteration of the approved SWMP.

Implementation strategy	• Surface water entering and exiting the development shall be monitored at the environmental monitoring points during the operational phase of the development. • Monitoring will also be undertaken during flood events where practicable. This monitoring will allow water quality comparisons to be made.
Monitoring	• Surface water monitoring will be conducted for all parameters quarterly for 12 months then half yearly. • To revert to construction phase provisions if problems are identified. • If problems are identified, laboratory analysis at a NATA registered laboratory for Suspended Solids, Total N, and Total P until such a time as TSC determines the cause of the problem and rectifies it.
Auditing	Council to audit water quality results quarterly to verify that discharges comply with the performance criteria.
Reporting of monitoring results	• Monitoring test results are to be compiled annually. Annual reports containing raw data and an interpretation to be made available to all persons on request. • Results to be available at all times.
Identification of incident or failure	Fall in surface water quality at the environmental monitoring points.
Corrective action	• Identify reason for deterioration in surface water quality to identify if it is linked to the development and/or the treatment structures. Take necessary steps to address the problem such as a public education program regarding fertilisers and other nutrients.

4.4 Operational phase maintenance of treatment measures

Person responsible	Tweed Shire Council

Issue	Operation and maintenance of the treatment measures.
Operational policy	To maintain the stormwater quality control structures to ensure adequate performance during the operational period.
Performance criteria	The control measures are maintained and operational. Pollutant concentration of stormwater released from the treatment system to satisfy the quality criteria set out in Section 4.3.
Implementation strategy	• Ensure inlets and outlets are not blocked. • Ensure that sediment accumulation does not impair operation of GPT.
Monitoring	• Water sampling to be carried out according to Section 4.3. • If elevated levels are found for any parameter, commence weekly sampling and testing for the parameter concerned and if possible examine the composition/constituents of the pollutant. • Establish complaints register and record details of complaints. • Inspect control structures after rainfall events. These inspections are to be recorded.
Auditing	TSC to carry out quarterly inspections to verify that monitoring has been carried out and that action has been implemented if required to correct any shortcomings.
Reporting of monitoring results	• Monthly reports to TSC. • Record details of all maintenance activities. • Results to be available to EPA at all times.
Identification of incident or failure	Water quality of outflow fails to meet the release criteria. Complaints from residents about odours or increased mosquito numbers.
Corrective action	Clean or maintain stormwater control structure as appropriate.

4.5 Operational phase maintenance of lake system

Person responsible	Tweed Shire Council

Issue	Water quality and surface level control in lakes during extended drought periods.
Operational policy	To ensure water quality and levels in the lakes can be maintained during extended periods of drought.
Performance criteria	Lake water quality and levels are maintained during extended periods of drought.
Implementation strategy	• Saltwater from Cobaki Creek (south of Sandy Lane) would be pumped into the lakes. • A subsurface drainage system would be provided to enable brackish return water to bypass the freshwater rehabilitation areas.
Monitoring	• Water quality monitoring to be carried out in accordance with Section 4.3. • Water levels at the weirs at the downstream end of each lake to be monitored quarterly. • Establish complaints register and record details of all complaints. • Inspections to be carried out quarterly, and following complaints to TSC, to ensure any deterioration in water quality (e.g. evidence of an algal outbreak) can be rectified.
Auditing	• TSC to carry out quarterly inspections of the lakes to verify that monitoring has been carried out and corrective action has been implemented if required. • TSC to carry out quarterly inspections of the pump station infrastructure to ensure it is maintained in working order.
Reporting of monitoring results	• Record details of all maintenance activities. • Results to be available to EPA at all times, upon request.
Identification of incident or failure	• Water quality of outflow fails to meet the release criteria. • Complaints from residents regarding odours, increased mosquito activity, reduced water levels or visible signs of pollution (e.g. algae, increased turbidity). • Water surface levels in the lakes fall greater than 300mm below the outlet weir.
Corrective action	Pumping of saltwater into the lake system for flushing or top-up as appropriate.

5) Administration of the SWMP

5.1 Amendment of the SWMP

The proponent may make application to TSC to amend the provisions of this SWMP. The application shall:

a. be in writing;
b. specify the provisions of the SWMP to which the application relates; and
c. state how the proposed amendment(s) achieve the objectives of the provisions to which the amendment(s) relate.

TSC shall approve the amendment(s) where TSC is satisfied acting reasonably that the proposed amendment(s) achieve the objective of the provisions to which the amendment(s) relates.

5.2 Incident management

The Proponent and any person appointed by the Proponent as having responsibility for a control strategy set out in this SWMP have clearly defined responsibilities under the Environmental Planning and Assessment Act 1979 to report any incidents likely to cause material or serious environmental harm.

BMT WBM Pty Ltd
Level 11, 490 Upper Edward Street
Brisbane 4000
Queensland Australia
PO Box 203 Spring Hill 4004

Tel: +61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.wbmpl.com.au

Our Ref: SAW: L.B15319.003.Preliminary FIA rev1.doc

7 March 2008

Leda Holdings Pty Ltd
Level 1, 46 Cavill Avenue
Surfers Paradise
QLD 4217

Attention: Franz Van Den Brink

Dear Franz

RE: COBAKI LAKES ESTATE, PRELIMINARY FLOOD IMPACT ASSESSMENT

Please find below a summary of the work undertaken on a preliminary flood impact assessment of the Cobaki Lakes Estate development.

Background

In 1995, BMT WBM (then trading as WBM Oceanics Australia) was commissioned by Leda Developments to carry out a flood study for a proposed development at Cobaki in Tweed Shire. The purpose of the study was to quantify the impacts of various filling scenarios and road immunity levels on existing flood levels. This assessment was undertaken using a 1D hydrodynamic ESTRY model of the Tweed River and its tributaries developed and calibrated in the preceding 10 years.

The impacts of the development were assessed for both longer duration Tweed River and shorter duration Cobaki Creek flood events. The Tweed River flood events produced the highest peak flood levels at the site and dictated fill levels. However, the greater impacts on existing flood levels were associated with Cobaki Creek flood events.

A number of short letter reports have also been issued since the original flood study to reflect additional scenarios and updates for the proposed development. All of these updates have been based on the original modelling undertaken using the 1D ESTRY model of the Tweed River and tributaries.

In 2005, BMT WBM upgraded the Tweed River model to a 2D TUFLOW model as part of the Tweed Valley Flood Study undertaken for Tweed Shire Council. Council's current design flood levels are based on this model, and it is accepted as the current standard for assessing the potential impacts of proposed developments in the catchment. BMT WBM is in the process of updating this model for Council to incorporate new ALS data obtained for the catchment. However, this version of the model is not yet complete.

Leda Holdings plan to update the previous flood impact assessment of the Cobaki Lakes development to be based on the 2005 TUFLOW model and latest development layout. Initially, a preliminary assessment has been commissioned to inform the Full Concept Plan. The scope of this preliminary stage is to update estimates of potential impacts for the 100 year ARI Cobaki Creek and Tweed River flood events. The scope has been extended to include preliminary sizing of waterway crossings for the main new roads associated with the development (Cobaki Parkway and Sandy Lane).

Note that the scope does not include consideration of drainage issues or flood events on the local watercourse through the development, or any landscaping of this waterway corridor. For the purposes of this initial assessment, it is assumed that the waterway corridor and areas designated as open space in the development (i.e. the green and blue areas on the concept plan) are at current ground levels.

Methodology

In summary, the following scope of works has been undertaken:

- The Cobaki Creek and Piggabeen Creek cross-sections from the 1995 ESTRY model were incorporated into the 2005 TUFLOW model to improve representation of these channels in the TUFLOW model;
- An amended version of the TUFLOW model was developed to simulate local Cobaki Creek flood events. This included cropping the boundaries to cover only Terranora Creek and its tributaries downstream as far as the Pacific Highway bridge, and amending the locations of inflow and direct rainfall boundaries to match the local Cobaki Creek flood events;
- The latest concept plan for the proposed development (drawing SK 01.01 E, received 18 December 2007) was translated into a projected co-ordinate system;
- The areas of proposed development were extracted from the plan and incorporated into the model as filled areas. This comprised approximately 260 ha of development of which approximately 65 ha was in the existing 100 year ARI floodplain;
- The main roads associated with the development were extracted from the plan and incorporated into the model as topographic 'breaklines'. Cobaki Parkway was set at the existing 100 year ARI design flood level for the area (2.6 mAHD) and Sandy Lane was set at the existing 20 year ARI level (2.35 mAHD);
- Preliminary sizing of the Cobaki Parkway floodplain crossing was undertaken (see section 'Cobaki Parkway Floodplain Crossing' below);
- The Cobaki Parkway and main Sandy Lane floodplain crossings were represented in the model as 'flow constriction' cells in the 2D domain with a nominal head loss. The other minor crossings of Sandy Lane were modelled as culverts in the 1D domain;[1]
- The three 100 year ARI flood scenarios were simulated for both the existing and developed case scenarios (see section 'Design Events' below);
- The magnitude and extent of impacts of the proposed development on peak flood levels was estimated for each design flood scenario;
- A letter report summarising the methodology and results of the preliminary flood impact assessment was prepared.

Cobaki Parkway Floodplain Crossing

The Cobaki Parkway crossing of the floodplain had been sized for previous studies based on the 1D ESTRY model for 5 and 20 year ARI flood immunity scenarios. This was resized based on the new 2D TUFLOW model and with a 100 year ARI flood immunity. Sizing of flow areas was based on existing floodplain flow in the 100 year ARI Cobaki Creek flood event, as the greatest impacts were associated with this event.

The existing peak flow along Cobaki Creek at the proposed Cobaki Parkway crossing is approximately 225 m^3/s, comprising approximately 75 m^3/s in the channel and 150 m^3/s across the floodplain at the lower end of the site. A preliminary flow area of approximately 175 m^2 was adopted for the floodplain crossing (corresponding to an opening approximately 110 m wide x 1.6 m high).

For this assessment, Cobaki Parkway has only been incorporated to the edge of the property boundary, i.e. the crossing of Cobaki Creek is not included.

[1] This approximation of the main floodplain crossings and Cobaki Parkway bridge in the model is considered adequate at this conceptual stage, however a more accurate assessment of the crossings is recommended at a later stage when the crossing configurations are designed.

Design Events

Table 1 summarises the combinations of design events that were simulated to represent the various 100 year ARI flood scenarios. All events were simulated for both the existing and developed case scenarios.

Table 1 100 Year ARI Flood Scenarios Simulated

Flood Scenario	Upstream Boundary	Downstream Boundary	Notes
Cobaki Creek catchment	Inflows for 100 year ARI, 12 hour storm	5 year ARI storm surge (peak level 0.8 mAHD)	Results in greatest impacts on existing flood levels
Tweed River catchment	Inflows for 100 year ARI, 36 hour storm	20 year ARI storm surge (peak level 2.2 mAHD)	Results in highest peak flood levels immediately upstream of the site
Tweed River storm surge	Inflows for 5 year ARI, 36 hour storm	100 year ARI storm surge (peak level 2.6 mAHD)	Results in highest peak flood levels at the site

Preliminary Results

The preliminary assessment of the proposed Cobaki Lakes development produced the following broad results for the 100 year ARI design events:

- As per the 2005 Tweed Valley Flood Study and previous Cobaki Lakes studies, the updated modelling indicates the Tweed River storm surge scenario produces the highest peak flood levels at the site (approximately 2.3 mAHD at Cobaki Parkway), whilst the greatest impacts on existing flood levels is associated with Cobaki Creek flood events (which produce lower peak flood levels at the site, i.e. approximately 1.65 mAHD).
- The modelling indicates that propagation of the design storm surge level (2.6 mAHD) at the river mouth produces a peak flood level of approximately 2.3 mAHD at the site under existing conditions. However, Tweed Shire Council has adopted the design storm surge level (2.6 mAHD) as the minimum design flood level, which will dictate fill levels at the site.
- For the post-development Cobaki Creek flood scenario (see Figure 1):
  - Peak flood levels downstream of the site will be within ±50 mm of existing peak flood levels (i.e. areas shaded pale yellow). The post-development peak flood level at Cobaki Lake will be approximately 1.5 mAHD.
  - Peak flood levels upstream of the site will increase by up to 140 mm, with the greatest increase at Piggabeen Road. The post-development peak flood level here will be approximately 1.75 mAHD.[2]
  - Peak flood levels on the opposite (southern) bank of Cobaki Creek will increase by up to 130 mm, with the greatest increase at Cobaki Road opposite Piggabeen Road. The post-development peak flood level here will be approximately 1.75 mAHD.[3]
  - Peak flood levels on the opposite (southern) bank of Cobaki Creek will increase by up to 100 mm at McAllisters Road opposite Cobaki Parkway. The post-development peak flood level here will be approximately 1.6 mAHD.[4]

[2] Note that the 1993 development conditions on the subdivision upstream of Piggabeen Road specify a minimum floor level of 2.8 mAHD which is between 0.8 and 1.1 m higher than the post-development peak flood levels in this location for the Cobaki Creek flood event.
[3] Levels at Cobaki Road adjacent to the nearest dwelling have increased by approximately 120 mm though modelling does not indicate the dwelling itself will be inundated.
[4] No dwellings have been identified in this area.

- For the post-development Tweed River catchment flood scenario (see Figure 2):
  - Peak flood levels downstream of the site will be within ±50 mm of existing peak flood levels. The post-development peak flood level at Cobaki Lake will be approximately 2.25 mAHD.
  - Peak flood levels upstream of the site will increase by up to 75 mm, with the greatest increase at Piggabeen Creek. The post-development peak flood level here will be approximately 2.35 mAHD.
- For the post-development Tweed River storm surge flood scenario (see Figure 3):
  - Peak flood levels both up- and downstream of the site will be within ±50 mm of existing peak flood levels. The post-development peak flood level will be approximately 2.3 mAHD from Piggabeen Creek down to Cobaki Lake.

Note that whilst there may be some increase in peak flood levels, this is not expected to have any significant effect on flood damages for existing and / or future development. Furthermore, post-development peak flood levels remain below Tweed Shire Council's adopted minimum design flood level of 2.6 mAHD for the area.

Flood Evacuation

All development will be filled to the minimum 100 year ARI design flood level of 2.6 mAHD. The 2005 Tweed Valley Flood Study indicates the PMF (probable maximum flood) level at the site is approximately 4.5 mAHD. In the event of a flood greater than a 100 year ARI, evacuation will be required to land above the PMF.

The western and northern development blocks have a direct connection to land above the PMF. The eastern development blocks will be connected to land above the PMF via Cobaki Parkway, which will be at or above the minimum 100 year ARI design flood level.

Climate Change

The flood modelling undertaken includes consideration of the impacts associated with potential sea level rise due to climate change. It does not include potential changes in rainfall patterns due to climate change. Note that it is the storm surge rather than the rainfall runoff scenario that results in the highest peak flood levels at the site.

The downstream ocean boundary conditions adopted in the 2005 TUFLOW model have been based on the Department of Infrastructure, Planning and Natural Resources' (DIPNR's) "Floodplain Management Guideline No. 5 Ocean Boundary Conditions" (2004). The guideline recommended two model scenarios:

- Design flood (i.e. 1 in 100 year ARI) with a normal (neap) tidal cycle, and
- Smaller flood (i.e. 1 in 5 year ARI) with elevated ocean levels (i.e. 2.6 mAHD).

The guideline acknowledged that climate change could result in a 0.2 m increase in ocean water levels over the next 20 years, however the elevated ocean level of 2.6mAHD was recognised to be conservative and therefore no additional allowance was recommended.

It is noted that the Department of Environment and Climate Change (DECC) recently issued a new Floodplain Risk Management Guideline "Practical Consideration of Climate Change" in October 2007 which recommends a range of scenarios for sea level rise from 0.18 to 0.91 m. The downstream ocean boundary in the 2005 TUFLOW incorporates the lower end of this range.

Further Work

Further scenarios can be modelled to identify the impacts of any amendments to the development layout and / or design, and any additional climate change scenarios required. Further refinement of the road crossings, and assessment of the proposals for the waterway corridor (including proposed lakes) is also recommended. This future work can be costed as and when required.

I trust the above meets your requirements in relation to a preliminary assessment of the latest Cobaki Lakes development using the 2005 TUFLOW model of the Tweed River and tributaries. Please do not hesitate to get in touch if you have any queries.

Yours faithfully

BMT WBM Pty Ltd

Sharon Wallace

Senior Flood Engineer

cc Jason Murdoch, BradLees Consulting

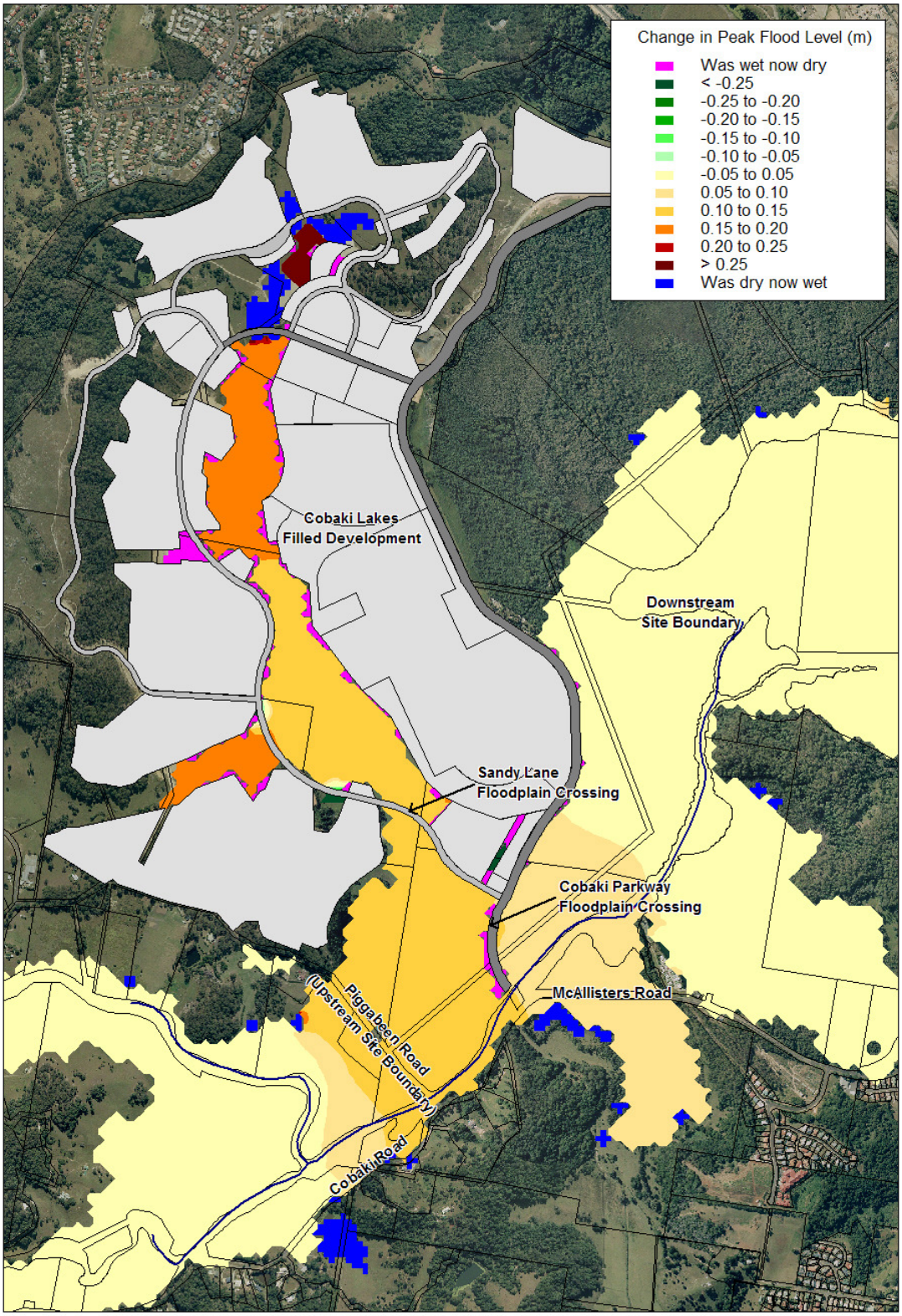


Figure 1 Post-Development 100 Year ARI Cobaki Creek Flood Event

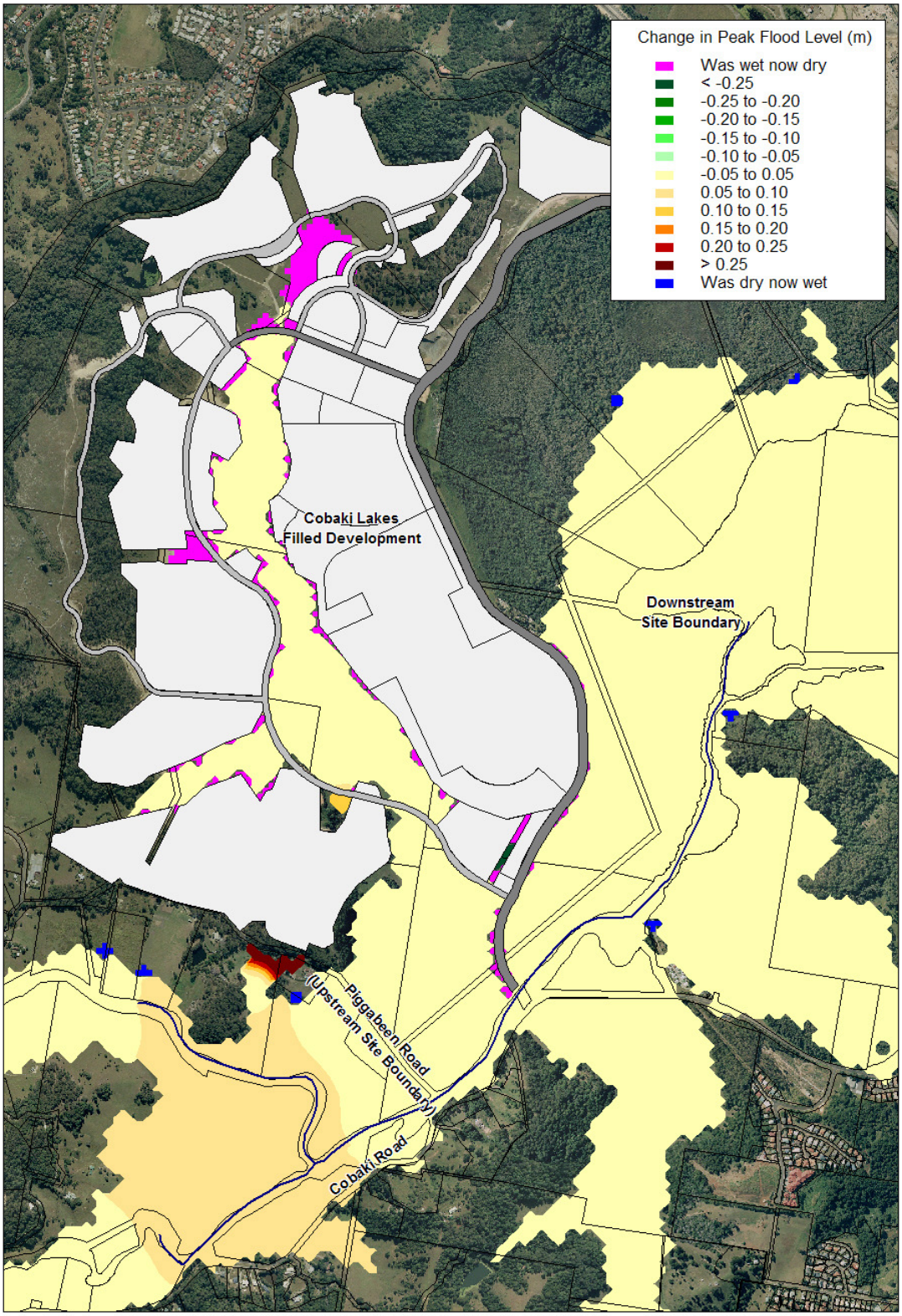


Figure 2 Post-Development 100 Year ARI Tweed River Catchment Flood Event

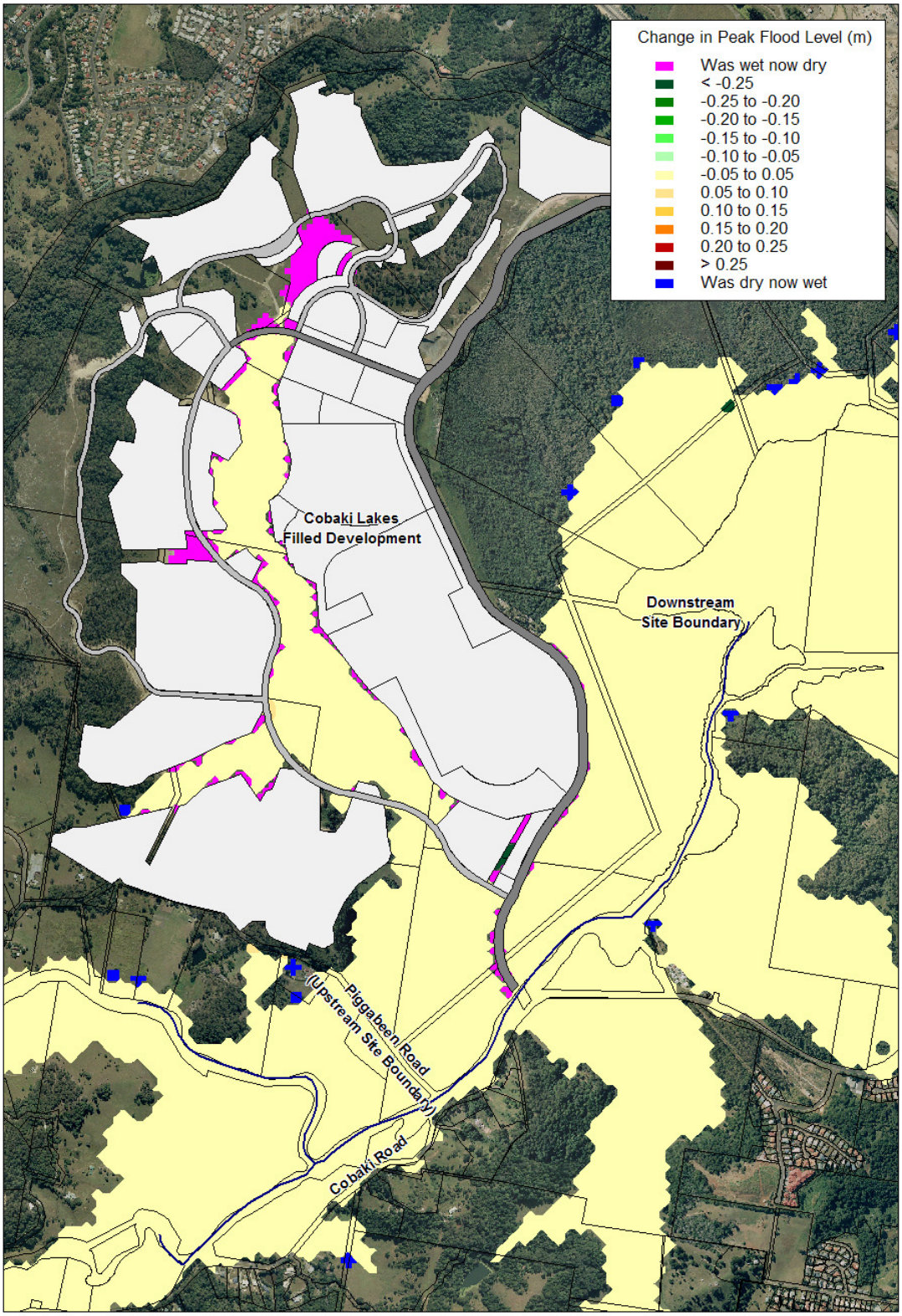


Figure 3 Post-Development 100 Year ARI Tweed River Storm Surge Flood Event