

Appendix F

Water Quality Amendment and Report 30 June 2009

**RESPONSE TO INFORMATION REQUEST
FROM THE NSW DEPARTMENT OF
PLANNING - SANDY BEACH MILL, SANDY
BEACH**

**Lot 260 DP1110719 Graham Drive, Sandy Beach
NSW**

Petersen Consulting Group
GEOTCOFH01296AD-AU
30 June 2009

30 June 2009

Petersen Consulting Group
1/41 Howard Street
Coffs Harbour NSW 2450

Attention: Mark Petersen

Dear Mark

RE: Coffey Geotechnics response to an information request from the NSW Department of Planning – Sandy Beach Mill, Sandy Beach

Coffey Geotechnics Pty Ltd (Coffey) is pleased to present our responses to the information request from the NSW Department of Planning and the NSW Department of Water and Energy for the Sandy Beach Mill Project, Sandy Beach.

We draw your attention to the attached sheet entitled "Important Information About Your Coffey Report" which should be read in conjunction with this report.

We trust that this report meets with your requirements. If you require further information please contact the undersigned in our Coffs Harbour office.

For and on behalf of Coffey Geotechnics Pty Ltd



Andrew Ballard
Associate Environmental Scientist
Environmental Team Leader – Coffs Harbour

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	1 Copy	Coffey (Coffs Harbour library)
	1 electronic copy	Petersen Consulting Group

CONTENTS

1	INTRODUCTION	2
1.1	General	2
1.2	Background Information	2
2	GROUNDWATER	3
3	ACID SULFATE SOILS / ACIDIC SOILS	5
4	DETAILED RESPONSE	6
5	LIMITATIONS	8

Important Information About Your Coffey Report

Figures

Figure 1: Groundwater Monitoring Well locations at Sandy Beach Mill

Tables

Table 1: Summary of Groundwater Bore Information

Table 2: Results of Physico-chemical Water Quality of Groundwater Monitoring Wells recorded on 10 July 2008

Table LR1: Summary of Laboratory Results for Groundwater Samples

Laboratory Certificate of Analysis

1 INTRODUCTION

1.1 General

I refer to your recent request seeking assistance with the preparation of advice on Groundwater matters. The following information is provided to assist in the preparation of a combined response to the NSW Department of Planning Director General's Environmental Assessment Requirements (DGRs) and the Department of Water & Energy (DWE) requirements prepared for proposed 43 lot residential subdivision (Lot 260 DP1110719) at the Sandy Beach Mill (SBM) site. Coffey Geotechnics advice is provided to assist in the preparation of an Environmental Assessment (EA) for Stage II of the SBM Project.

Specifically our advice provides additional information to assist in preparing a response to DGRs for the following:

- Section 7.4, which considers the nature and profile of the groundwater regime under the site, including any hydrologic impacts which would affect its depth or water quality, result in increased groundwater discharge, impact on the stability of potential acid sulfate soils in the vicinity, or affect groundwater dependent native vegetation.

The DWE requested information requirements include:

- The EA should provide a comprehensive description of proposed water management and drainage across the site, including any reliance on local stormwater or groundwater, and measures to minimise adverse impacts on water quality in receiving waters, such as through erosion and sediment control, stormwater management and buffer zones.
- The EA should provide a description of the groundwater regime underlying the site, including its general quality, any use by surrounding landholders, and the prevailing depth to water tables, and identify any potential adverse impacts due to the proposal.
- The EA should clarify, in accordance with procedures in the Acid Sulfate Soils Manual, the presence, distribution and potential hazard of any acid sulfate soil material beneath the site, and any likely development interactions and management procedures. Similarly if non-sulfate soil acidity only is confirmed, the EA should outline the risk of acid mobilisation due to the proposal and any management actions to minimise impacts on surface or ground water quality.

1.2 Background Information

Coffey has previously carried out several investigations on the SBM site including environmental investigations, geotechnical investigations, and acid sulfate soils assessments and has issued the following reports to Sandy Beach Mill Pty Ltd:

- CH1296/1-AG, dated 24 November 2005 – This report presented a Phase 1 Environmental Site Assessment (ESA) of SBM site including the then Lot 260 DP 752853. The site history found that the site had been owned previously by sawmillers from about 1938 to 2005. A sawmill had operated on Lot 260 on the southern side of Double Crossing Creek since about 1947. A total of seventeen testpits were excavated on this site and soil samples collected for preliminary screening purposes. The laboratory results identified areas of soil contamination and the Phase 1 ESA recommended that a more detailed Phase 2 ESA be undertaken.
- GEOTCOFH01296AA-AK, dated 11 August 2006 – This report presented the results of the Phase 2 ESA carried out for the Stage 1 area of the proposed residential subdivision. The

report included sampling and analysis of the site soils within the areas of environmental concern (AECs) identified in the Phase 1 ESA, see below. A preliminary geotechnical and acid sulfate soils assessment was also carried out at the same time and involved collecting soil samples for geotechnical assessment and acid sulfate soils samples from test pits.

- GEOTCOFH01296AA-AM dated 5 March 2007 – included a review of the previous Phase 1 ESA site history, assessment of potential Areas of Environmental Concern (AECs) and Chemicals of Concern (COCs) and limited sampling and analysis of site soils on both the Stage 1 and Stage 2 areas of the SBM site.
- GEOTCOFH01296AA-AO dated 5 March 2007 – This report presented the results of the Phase 2 ESA carried out for the Stage 2 area of the SBM subdivision. The report included sampling and analysis of the site soils within the AECs identified in the Phase 1 ESA. The Phase 2 ESA included the installation and monitoring of six groundwater monitoring wells on the northern and southern side of the Double Crossing Creek. A preliminary geotechnical and acid sulfate soils assessment was also carried out at the same time and involved collecting soil samples for geotechnical testing and acid sulfate samples from test pits.
- GEOTCOFH01296AC-AG dated 11 April 2007 – Coffey prepared a Remedial Action Plan (RAP) for the remediation of contaminated soils at the former Sandy Beach Sawmill site. The RAP covered remediation of TPH, PAH and metals contaminated soil AECs, including the removal of an underground storage tank (UST) and associated pipework.
- GEOTCOFH01296AD-AA dated 31 August 2007 – This report presented the results of the Validation Report carried out for the AEC's identified in previous investigations. The report included excavation, sampling and analysis of the site soils within the AECs and hotspots identified.

Copies of these correspondence and reports have been provided previously to Petersen Consulting.

A further round of groundwater sampling was undertaken of the 3 monitoring wells on the 10 July 2008, see Figure 1. The results from this groundwater monitoring event are attached to this report and will be included with the final validation report for the creek reserve area which is currently in preparation.

2 GROUNDWATER

A search on the 3 April 2009 of the NSW Department of Water Energy (DWE) groundwater bore information indicated that there were in the order of 25 bores within a 1km radius of the SBM site. Information was available on seven of the 25 bores, and indicates these bores were drilled to between 12.5m and 67m depth, with a water bearing zone typically below 16m depth. Standing water levels ranged from 5m to 58m below the ground surface. Double Crossing Creek is located along the northern boundary of the SBM site. The available information on seven of these bores is summarised in Table 1 below.

Table 1: Summary of Groundwater Bore Information

Bore Number	Authorised Use	Total Depth of Bore (m)	Distance, Direction & Gradient* from Site	Depth to Standing Water Level or Water Bearing Zones (m)
GW058044	Domestic	67.0	800m northwest Up-gradient	58m
GW070074	Domestic	24.0	600m west Up-gradient	5m
GW302970	Domestic	67	30m north Up-gradient	-
GW059394	Domestic Stock	17.10	600m northeast Up-gradient	9.5m
GW052135	Domestic	20.50	960m northeast Up-gradient	16m
GW063566	Domestic Stock	48	720m east-northeast Up-gradient	14m
GW050029	Domestic	12.50	360m northeast Up-gradient	9m

Based on the results of the groundwater bore search it appears that groundwater bores within the area are registered for domestic use, and are likely to be used for irrigation purposes. None of the bores were inferred to be located down gradient of the site. Based on the location of the site, and the electrical conductivity readings recorded during fieldwork (see table 1 below), the groundwater quality is described as brackish/marine water.

Based on these observations, it is considered that the principal beneficial reuse of the groundwater is for the maintenance of the integrity of aquatic ecosystems when it discharges to the nearby Double Crossing Creek.

Coffey carried out a groundwater investigation (provided in report no. GEOTCOFH01296AA-AO) which included the installation of three groundwater monitoring wells on Lot 260. The investigation undertaken included the sampling and subsequent laboratory testing of six groundwater samples to assess for groundwater contamination associated with previous activities undertaken within the Sandy Beach Sawmill.

The laboratory results for samples collected on the 23 October 2006 indicated concentrations of TPH (BH1, BH4, and BH6), toluene (BH4 and BH6) and total chromium (BH1, BH2, and BH3) exceeding the adopted criteria.

Coffey's most recent groundwater monitoring event was on the 10 July 2008. For the purposes of this investigation BH4, BH5 and BH6 were used as they are located on the southern side of Double

Crossing Creek within the investigation area. Standing water levels (SWL) were measured in the groundwater wells prior to sampling and they ranged in depths from 1.28 to 1.45m bgs. Laboratory results for samples collected from the groundwater monitoring wells did not identify any groundwater contamination which would restrict the proposed future use of the site, see attached Laboratory Certificate Analysis. The reported levels of copper (BH4), lead (BH4, BH5, BH6) and zinc (BH5) exceeded the adopted acceptance criteria, however the levels reported are only marginally above the laboratories limits of reporting (LOR) and are not considered to restrict the proposed future use of the site.

Table 2: Results of physio-chemical water quality of groundwater monitoring wells recorded on 10 July 2008

Location	Depth to Water (m)	Depth of Well	DO (ppm)	EC ($\mu\text{s}/\text{cm}$)	pH	Redox Potential (mV)	Temp (C)	Comments
MW4	1.45	5.8	2.86	267	3.58	324	18.5	Clear water, no odour
MW5	1.4	5.8	3.2	401	5.72	12	21.8	Turbid water, no odour
MW6	1.3	7.5	5.32	514	4.86	279	18.5	Clear water, no odour

3 ACID SULFATE SOILS / ACIDIC SOILS

The SBM Acid Sulfate Soils (ASS) investigation (GEOTCOFH01296AA-AO) found that the soils within the ten test locations across the site may contain organic sulfur and classed these soils as acidic soils. The report advised that acidic soils are unlikely to cause significant harm to the environment, as the production of acid is slow and is unlikely to leach from the soils in significant quantities in their natural state. Should the soils be disturbed and be washed into waterways then acidification of the water can occur. Acidic soils can have a negative effect on vegetation growth, especially vegetation that is not native to Australia, and concrete footings can also be corroded by acidic soils.

Options for managing acidic soils include minimising the potential for environmental harm by the implementation of a sediment control plan to prevent acidic soils from entering waterways, or by removing the potential risk through treatment of the acidic soils with lime. The decision as to which of these two options to adopt depends on the need to implement a sediment control plan for the development, and/or the volumes of materials that may be excavated and treated with lime.

Treatment of acidic soils during construction activities with lime will increase the soil pH to within range of pH 6 - 7. A bulk density of $1.6\text{t}/\text{m}^3$ has been assumed for the residual soils. Coffey's report advised that based on the Total Actual Acidity (TAA) results, the liming ratio requirements were assessed to be 10 – 13 kg CaCO_3/m^3 of soil for acidic soils disturbed during earthworks.

Good quality fine agricultural lime should be used to treat the excavated soils. In calculating the liming ratios, a factor of safety of 1.5 has been allowed (as recommended in the ASSMAC guidelines) above the theoretical requirement to take into account the rate of lime reactivity and the possibility of incomplete mixing of lime with the soil.

The geology encountered throughout the site was relatively uniform and it is considered that the results reported in the previous ASS assessments are representative of the entire site. It is considered that further ASS assessment is not required for the site.

4 DETAILED RESPONSE

- **Section 7.4, which considers the nature and profile of the groundwater regime under the site, including any hydrologic impacts which would affect its depth or water quality, result in increased groundwater discharge, impact on the stability of potential acid sulfate soils in the vicinity, or affect groundwater dependent native vegetation.**

The proposed development generally comprises above-ground construction, such as roads, residential buildings and parks. Underground infrastructure will generally be limited to trenches for sewer pipes, electrical cables, telephone cables and other underground services.

The anticipated depth of disturbance on the site to install the underground services is about 1.5m below ground surface (bgs). The groundwater levels measured from monitoring wells located down slope and adjacent to Double Crossing Creek was between 1.28m and 1.45m bgs. It is considered unlikely that given the sites topography and proposed depth of disturbance that the underground service trenches will extend below the water table.

It is anticipated that the residential buildings will be founded upon shallow footings, and roads built above the ground surface which further minimises the potential for these above ground structures to interact with groundwater.

Local groundwater is likely used for small scale irrigation. However the bores registered with DWE are located up-gradient of the proposed development, and as such the proposed development is unlikely to impact on this use.

It is considered that maintenance of aquatic ecosystems is the principal groundwater beneficial use requiring protection. A buffer zone, made up of reserve and parklands, will be established between the proposed residential development and Double Crossing Creek to protect this aquatic ecosystem from potential impacts from the development. It is considered that the proposed residential development will not have a hydrologic impact that would affect groundwater depth or quality, result in increased groundwater discharge, or impact upon groundwater dependent native vegetation.

As stated in Section 3 above, the soils on site are acidic in nature and not ASS.

- **The EA should provide a comprehensive description of proposed water management and drainage across the site, including any reliance on local stormwater or groundwater, and measures to minimise adverse impacts on water quality in receiving waters, such as through erosion and sediment control, stormwater management and buffer zones.**

Local stormwater and groundwater regimes will not be relied upon for water management or drainage. There are no existing stormwater drains in the vicinity of the site, and as such new urban stormwater and drainage systems will be installed.

The proposed development includes establishment of parkland and reserve adjacent to Double Crossing Creek. This buffer zone will aid in minimising stormwater and run-off impacts from the residential development directly entering Double Crossing Creek.

No new groundwater extraction is planned as part of the proposed residential development. The proposed development will include measures to prevent erosion and manage stormwater runoff from the site.

- **The EA should provide a description of the groundwater regime underlying the site, including its general quality, any use by surrounding landholders, and the prevailing depth to water tables, and identify any potential adverse impacts due to the proposal.**

Based on the physico-chemical water quality of groundwater monitoring wells installed on the SBM site the groundwater is described as brackish / marine water. The most recent groundwater monitoring event, 10 July 2008, indicated no significant groundwater contamination was present on the site. The reported levels of copper, lead and zinc were marginally above the acceptance criteria ANZECC 2000

The reported levels of copper (BH4), lead (BH4, BH5, BH6) and zinc (BH5) exceeded the adopted acceptance criteria¹ based upon ANZECC 2000 *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. The levels reported are marginally above the laboratories limits of reporting (LOR) and are not considered to have impacted the groundwater at the site.

A search of groundwater bores registered with Department of Water and Energy indicated there were 25 bores registered with a 1km radius of the site. Information was available on seven of the 25 bores. Each of these seven bores is inferred to be located up-gradient of the site. This information indicated that the bores are registered for domestic use, most likely for irrigation purposes.

Available information on the registered groundwater bores in the area showed standing water levels between 5m and 58m bgs. Measurements recorded for the three monitoring wells Coffey installed on the SBM site showed standing water levels between 1.28m and 1.45m bgs.

It is considered that the proposed development is unlikely to have an adverse impact on groundwater, or nearby Double Crossing Creek. As the registered bores are located up-gradient of the SBM site it is considered that the proposed development will not affect the water quality in these bores.

- **The EA should clarify, in accordance with procedures in the Acid Sulfate Soils Manual, the presence, distribution and potential hazard of any acid sulfate soil material beneath the site, and any likely development interactions and management procedures. Similarly if non-sulfate soil acidity only is confirmed, the EA should outline the risk of acid mobilisation due to the proposal and any management actions to minimise impacts on surface or ground water quality.**

A preliminary acid sulfate soil assessment was undertaken across the SBM site, and the result of this assessment is discussed above in Section 3. This assessment indicated that the soils on site are acidic in nature rather than acid sulfate soils.

Acidic soils are unlikely to cause significant harm to the environment, as the production of acid is slow and is unlikely to leach from the soils in significant quantities in their natural state. Should the soils be disturbed and be washed into waterways then acidification of the water can occur. Acidic soils can have a negative effect on vegetation growth, especially vegetation that is not native to Australia, and concrete footings can also be corroded by acidic soils.

The proposed residential development does not involve extensive cut and fill earthworks or excavations and will have minimal disturbance of soils on the site. A sediment control plan and/or precautionary lime applications will be implemented during construction to minimise potential impacts from acidic soils.

¹ Acceptance criteria based upon guideline values for marine water, South Eastern Australia, slight to moderately disturbed systems with 95-99% species protected.

5 LIMITATIONS

The findings in this report are the result of observations made at discrete locations over a large area and observations of the surface conditions. Subsurface conditions may vary between investigation locations. Should different subsurface conditions to those expected be encountered during construction, Coffey should be contacted immediately.

We draw your attention to the attached sheets entitled "Important Information about your Coffey Report" which should be read in conjunction with this report.

For and on behalf of Coffey Geotechnics Pty Ltd

A handwritten signature in black ink, appearing to read "Andrew Ballard". The signature is fluid and cursive, with a large initial 'A' and 'B'.

Andrew Ballard

Associate Environmental Scientist

Environmental Team Leader – Coffs Harbour

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by

earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.

Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures



drawn	JP
approved	
date	30-June-2009
scale	NTS
original size	A3



client:	Sandy Beach Mill Pty Ltd	
project:	Response to Information Request from the NSW Department of Planning – Sandy Beach Mill, Sandy Beach	
title:	Groundwater Monitoring Well Locations at Sandy Beach Mill	
project no:	GEOTCOFH01296AD-AU	figure no: Figure 1

Tables

Table LR1: Summary of Laboratory Results for Groundwater Samples
(all results in mg/L)

Area of Investigation Sample ID Material Date of Sampling	Threshold Concentrations	Groundwater Monitoring Wells		
		BH4	BH5	BH6
		Water 10-Jul-08	Water 10-Jul-08	Water 10-Jul-08
Heavy Metals				
Arsenic	0.0045 ^{1c}	< 0.001	0.003	< 0.001
Cadmium	0.0007 ¹	< 0.0002	< 0.0002	< 0.0002
Chromium	0.0044 ^{1b}	< 0.001	< 0.001	< 0.001
Copper	0.0013 ¹	0.002	< 0.001	< 0.001
Lead	0.0044 ¹	0.006	0.007	0.011
Mercury	0.0001 ¹	< 0.0001	< 0.0001	< 0.0001
Nickel	0.007 ¹	< 0.001	0.002	< 0.001
Zinc	0.015 ¹	0.013	0.02	0.006
Total Petroleum Hydrocarbons				
C ₆ -C ₉ Fraction by GC	-	< 0.02	< 0.02	< 0.02
C ₁₀ -C ₁₄ Fraction by GC	-	< 0.05	< 0.05	< 0.05
C ₁₅ -C ₂₈ Fraction by GC	-	< 0.1	< 0.1	< 0.1
C ₂₉ -C ₃₆ Fraction by GC	-	< 0.1	< 0.1	< 0.1
Total C ₁₀ -C ₃₆ Fraction	-	< 0.25	< 0.25	< 0.25
BTEX				
Benzene	0.5 ¹	< 0.001	< 0.001	< 0.001
Toluene	0.18 ^{1c}	< 0.001	< 0.001	< 0.001
Ethyl-benzene	0.08 ^{1c}	< 0.001	< 0.001	< 0.001
Xylene	0.625 ^{1c}	< 0.001	< 0.001	< 0.001
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	< 0.001	< 0.001	< 0.001
Acenaphthylene	-	< 0.001	< 0.001	< 0.001
Anthracene	0.00001 ^{1c}	< 0.001	< 0.001	< 0.001
Benz(a)anthracene	-	< 0.001	< 0.001	< 0.001
Benzo(a)pyrene	0.0001 ^{1c}	< 0.001	< 0.001	< 0.001
Benzo(b)fluoranthene	-	< 0.001	< 0.001	< 0.001
Benzo(g,h,i)perylene	-	< 0.001	< 0.001	< 0.001
Benzo(k)fluoranthene	-	< 0.001	< 0.001	< 0.001
Chrysene	-	< 0.001	< 0.001	< 0.001
Dibenz(a,h)anthracene	-	< 0.001	< 0.001	< 0.001
Fluoranthene	0.001 ^{1c}	< 0.001	< 0.001	< 0.001
Fluorene	-	< 0.001	< 0.001	< 0.001
Indeno(1,2,3-cd)pyrene	-	< 0.001	< 0.001	< 0.001
Naphthalene	0.05 ¹	< 0.001	< 0.001	< 0.001
Phenanthrene	0.0006 ^{1c}	< 0.001	< 0.001	< 0.001
Pyrene	-	< 0.001	< 0.001	< 0.001
Total PAH	-	< 0.001	< 0.001	< 0.001
Organochlorine Pesticides				
4,4'-DDD	-	< 0.0001	< 0.0001	< 0.0001
4,4'-DDE	-	< 0.0001	< 0.0001	< 0.0001
4,4'-DDT	-	< 0.0001	< 0.0001	< 0.0001
a-BHC	-	< 0.0001	< 0.0001	< 0.0001
Aldrin	-	< 0.0001	< 0.0001	< 0.0001
b-BHC	-	< 0.0001	< 0.0001	< 0.0001
Chlordane	-	< 0.001	< 0.001	< 0.001
d-BHC	-	< 0.0001	< 0.0001	< 0.0001
Dieldrin	-	< 0.0001	< 0.0001	< 0.0001
Endosulfan I	0.000005 ¹	< 0.0001	< 0.0001	< 0.0001
Endosulfan II	-	< 0.0001	< 0.0001	< 0.0001
Endosulfan sulphate	-	< 0.0001	< 0.0001	< 0.0001
Endrin	0.00004 ¹	< 0.0001	< 0.0001	< 0.0001
Endrin aldehyde	-	< 0.0001	< 0.0001	< 0.0001
Endrin ketone	-	< 0.0001	< 0.0001	< 0.0001
g-BHC (Lindane)	-	< 0.0001	< 0.0001	< 0.0001
Heptachlor	-	< 0.0001	< 0.0001	< 0.0001
Heptachlor epoxide	-	< 0.0001	< 0.0001	< 0.0001
Hexachlorobenzene	-	< 0.0001	< 0.0001	< 0.0001
Methoxychlor	-	< 0.0001	< 0.0001	< 0.0001
Toxophene	-	< 0.001	< 0.001	< 0.001
Phenols				
2-Chlorophenol	-	< 0.001	< 0.001	< 0.001
2-Methylphenol (o-Cresol)	-	< 0.001	< 0.001	< 0.001
2-Nitrophenol	-	< 0.005	< 0.005	< 0.005
2,4-Dichlorophenol	-	< 0.001	< 0.001	< 0.001
2,4-Dimethylphenol	-	< 0.001	< 0.001	< 0.001
2,4,6-Trichlorophenol	-	< 0.001	< 0.001	< 0.001
2,6-Dichlorophenol	-	< 0.001	< 0.001	< 0.001
3&4-Methylphenol (m&p-Cresol)	-	< 0.002	< 0.002	< 0.002
4-Chloro-3-methylphenol	-	< 0.001	< 0.001	< 0.001
Pentachlorophenol	0.011 ¹	< 0.005	< 0.005	< 0.005
Phenol	0.4 ¹	< 0.001	< 0.001	< 0.001

Notes:

- No guideline value adopted

Bold	Concentration exceeds the Threshold Criteria
Value	Laboratory Limit of Reporting (LOR) exceeds Threshold Criteria

¹ Based on ANZECC/ARMCANZ (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Marine Water, South Eastern Australia, slight to moderately disturbed system, 95% - 99% species protected).

^{1a} Criteria for Arsenic V in marine water, whereas our results are for total arsenic

^{1b} Criteria for Chromium VI in marine water, whereas our results are for total chromium

^{1c} Low reliability trigger values

Laboratory Certificates of Analysis



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CERTIFICATE OF ANALYSIS

Coffey Geotechnics Pty Ltd
 Unit 1 18 Hurley Dve
 Coffs Harbour
 NSW 2450
 Site: GEOTCOFH01296AD

Report Number: 230345 Page 1 of 9
 Order Number:
 Date Received: Jul 11, 2008
 Date Sampled: Jul 12, 2008
 Date Reported: Jul 23, 2008
 Contact: Andrew Ballard

Methods

- USEPA 8270C Phenols
- USEPA 6020 Heavy Metals & USEPA 7470/71 Mercury
- USEPA 8081A Organochlorine Pesticides
- USEPA 8270C Polycyclic Aromatic Hydrocarbons
- USEPA 8260B - MGT 350A Monocyclic Aromatic Hydrocarbons
- MGT100A-GC (based on USEPA8015)Total Recoverable Hydrocarbons
- APHA 4500 pH by Direct Measurement

Comments

Notes

1. The results in this report supersede any previously corresponded results.
2. All Soil Results are reported on a dry basis.
3. Samples are analysed on an as received basis.
4. LOR's are matrix dependent. Stated LOR's may be raised where sample extracts are diluted due to interferences.

ABBREVIATIONS

mg/kg : milligrams per kilograms, mg/L : milligrams per litre, ppm : parts per million,

LOR : Limit of Reporting

RPD : Relative Percent Difference

CRM : Certified Reference Material

LCS : Laboratory Control Sample

Authorised

Report Number: 230345

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 ACCREDITATION

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Member



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Coffey Geotechnics Pty Ltd		Client Sample ID	BH4	BH5	BH6	QC1AA
Unit 1 18 Hurley Dve		Lab Number	08-JL05738	08-JL05739	08-JL05740	08-JL05741
Coiffs Harbour		Matrix	Water	Water	Water	Water
NSW 2450		Sample Date	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Analysis Type		LOR	Units			
Organochlorine Pesticides						
4,4'-DDD	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
4,4'-DDE	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
4,4'-DDT	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
a-BHC	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Aldrin	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
b-BHC	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Chlordane	0.0005		< 0.001	< 0.001	< 0.001	< 0.001
d-BHC	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Dieldrin	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endosulfan I	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endosulfan II	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endosulfan sulphate	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endrin	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endrin aldehyde	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Endrin ketone	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
g-BHC (lindane)	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Hepachlor	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Hepachlor epoxide	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Hexachlorobenzene	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Methoxychlor	0.0001		< 0.0001	< 0.0001	< 0.0001	< 0.0001
Toxophene	0.0005		< 0.001	< 0.001	< 0.001	< 0.001
Dibutylchloridate (sur.)	1		69	70	74	109
Tetrachloro-m-xylene (sur.)	1		53	64	91	101
Phenols						
2-Chlorophenol	0.001		< 0.001	< 0.001	< 0.001	< 0.001
2-Methylphenol (o-Cresol)	0.001		< 0.001	< 0.001	< 0.001	< 0.001
2-Nitrophenol	0.005		< 0.005	< 0.005	< 0.005	< 0.005
2,4-Dichlorophenol	0.001		< 0.001	< 0.001	< 0.001	< 0.001

COMMENTS:



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Coffey Geotechnics Pty Ltd		Client Sample ID	BH4	BH5	BH6	QC1AA
Unit 1 18 Hurley Dve		Lab Number	08-JL05738	08-JL05739	08-JL05740	08-JL05741
Coffs Harbour		Matrix	Water	Water	Water	Water
NSW 2450		Sample Date	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Analysis Type		LOR	Units			
2,4-Dimethylphenol		0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,4,6-Trichlorophenol		0.001	< 0.001	< 0.001	< 0.001	< 0.001
2,6-Dichlorophenol		0.001	< 0.001	< 0.001	< 0.001	< 0.001
3&4-Methylphenol (m&p-Cresol)		0.002	< 0.002	< 0.002	< 0.002	< 0.002
4-Chloro-3-methylphenol		0.001	< 0.001	< 0.001	< 0.001	< 0.001
Pentachlorophenol		0.005	< 0.005	< 0.005	< 0.005	< 0.005
Phenol		0.001	< 0.001	< 0.001	< 0.001	< 0.001
Phenol-d6 (surr.)		1	75	67	70	66
pH		0.1	4.0	6.0	5.4	5.4
Heavy Metals (7)						
Arsenic		0.001	< 0.001	0.003	< 0.001	< 0.001
Cadmium		0.002	< 0.002	< 0.002	< 0.002	< 0.002
Chromium		0.001	< 0.001	< 0.001	< 0.001	< 0.001
Copper		0.001	0.002	< 0.001	< 0.001	< 0.001
Lead		0.001	0.006	0.007	0.011	0.010
Nickel		0.001	< 0.001	0.002	< 0.001	< 0.001
Zinc		0.001	0.013	0.020	0.006	0.006
Heavy Metals						
Mercury		0.001	< 0.001	< 0.001	< 0.001	< 0.001

COMMENTS:



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Coffey Geotechnics Pty Ltd

Unit 1 18 Hurley Dve
 Coffs Harbour
 NSW 2450

Client Sample ID		TRIP BLANK 322
Lab Number		08-JL05743
Matrix		Water
Sample Date		Jul 12, 2008
LOR		Units
Benzene	0.001	mg/L < 0.001
Toluene	0.001	mg/L < 0.001
Ethylbenzene	0.001	mg/L < 0.001
Xylenes(ortho,meta and para)	0.001	mg/L < 0.001
Fluorobenzene (surr.)	1	% 57

COMMENTS:

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Client Sample ID	BH4	BH4	RPD	SPIKE	LCS	Method blank
Unk 1 18 Hurley Dye Coffs Harbour NSW 2450	08-JL05738	08-JL05738	08-JL05738	08-JL05738	Batch	Batch
Analysis Type	Water	Duplicate	Duplicate % RPD	Spike % Recovery	% Recovery	mg/L
Monocyclic Aromatic Hydrocarbons	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Benzene	-	<0.001	<1	109	101	<0.001
Toluene	-	<0.002	<1	111	80	<0.001
Ethylbenzene	-	<0.001	<1	113	88	<0.001
Xylenes(ortho,meta and para)	-	<0.001	<1	116	86	<0.001
Heavy Metals (7)						
Arsenic	<0.001	<0.001	<1	110	104	<0.001
Cadmium	<0.0002	<0.0002	<1	102	101	<0.0002
Chromium	<0.001	<0.001	<1	88	98	<0.001
Copper	0.002	0.002	1.4	91	103	<0.001
Lead	0.006	0.006	1.8	107	115	<0.001
Nickel	<0.001	<0.001	<1	87	97	<0.001
Zinc	0.013	0.013	3.4	91	100	<0.001
Heavy Metals						
Mercury	-	-	<1	96	117	<0.0001

COMMENTS:

Client Sample ID	BH6	BH6	BH6	RPD	SPIKE	LCS	Method blank
Lab Number	08-JL05740	08-JL05740	08-JL05740	08-JL05740	08-JL05740	Batch	Batch
QA Description		Duplicate	Duplicate	Duplicate %	Spike % Recovery	% Recovery	
Matrix	Water	Water	Water	Water	Water	Water	Water
Sample Date	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Units				% RPD	% Recovery	% Recovery	mg/L
Analysis Type							
Total Recoverable Hydrocarbons							
TRH C6-C9 Fraction by GC				< 1	112	97	< 0.02
TRH C10-C14 Fraction by GC	< 0.05	< 0.05	< 0.05	< 1	87	74	< 0.05
TRH C15-C28 Fraction by GC	< 0.1	< 0.1	< 0.1	< 1	-	-	< 0.1
TRH C29-C36 Fraction by GC	< 0.1	< 0.1	< 0.1	< 1	-	-	< 0.1
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	< 0.001	< 0.001	< 0.001	< 1	95	93	< 0.001
Acenaphthylene	< 0.001	< 0.001	< 0.001	< 1	93	111	< 0.001
Anthracene	< 0.001	< 0.001	< 0.001	< 1	74	128	< 0.001
Benz(a)anthracene	< 0.001	< 0.001	< 0.001	< 1	111	113	< 0.001
Benzo(a)pyrene	< 0.001	< 0.001	< 0.001	< 1	100	111	< 0.001
Benzo(b)fluoranthene	< 0.001	< 0.001	< 0.001	< 1	112	109	< 0.001
Benzo(g,h,i)perylene	< 0.001	< 0.001	< 0.001	< 1	94	95	< 0.001
Benzo(k)fluoranthene	< 0.001	< 0.001	< 0.001	< 1	90	130	< 0.001
Chrysene	< 0.001	< 0.001	< 0.001	< 1	96	110	< 0.001
Dibenz(a,h)anthracene	< 0.001	< 0.001	< 0.001	< 1	103	99	< 0.001
Fluoranthene	< 0.001	< 0.001	< 0.001	< 1	84	98	< 0.001
Fluorene	< 0.001	< 0.001	< 0.001	< 1	97	104	< 0.001
Indeno(1,2,3-cd)pyrene	< 0.001	< 0.001	< 0.001	< 1	97	99	< 0.001
Naphthalene	< 0.001	< 0.001	< 0.001	< 1	107	93	< 0.001
Phenanthrene	< 0.001	< 0.001	< 0.001	< 1	117	93	< 0.001
Pyrene	< 0.001	< 0.001	< 0.001	< 1	93	96	< 0.001
Organochlorine Pesticides							
4,4'-DDD	< 0.0001	< 0.0001	< 0.0001	< 1	122	86	< 0.0001
4,4'-DDE	< 0.0001	< 0.0001	< 0.0001	< 1	118	88	< 0.0001
4,4'-DDT	< 0.0001	< 0.0001	< 0.0001	< 1	98	98	< 0.0001
p-BHC	< 0.0001	< 0.0001	< 0.0001	< 1	119	90	< 0.0001
o-BHC	< 0.0001	< 0.0001	< 0.0001	< 1	98	82	< 0.0001
g-BHC	< 0.0001	< 0.0001	< 0.0001	< 1	110	83	< 0.0001

COMMENTS:



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 Coffs Harbour
 NSW 2450

Client Sample Lab Number	BH6 08-JL05740	BH6 08-JL05740	RPD... 08-JL05740	SPIKE 08-JL05740	LCS Batch	Method blank Batch
QA Description	Duplicate Water	Duplicate Water	Duplicate % RPD	Spike % Recovery	% Recovery	
Matrix	Water	Water	Water	Water	Water	Water
Sample Date	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Units			% RPD	% Recovery	% Recovery	mg/L
Analysis Type						
Organochlorine Pesticides						
Chlordane	< 0.001	< 0.001	< 1	-	-	< 0.001
d-BHC	< 0.0001	< 0.0001	< 1	125	93	< 0.0001
Dieldrin	< 0.0001	< 0.0001	< 1	110	84	< 0.0001
Endosulfan I	< 0.0001	< 0.0001	< 1	116	87	< 0.0001
Endosulfan II	< 0.0001	< 0.0001	< 1	116	86	< 0.0001
Endosulfan sulphate	< 0.0001	< 0.0001	< 1	114	90	< 0.0001
Endrin	< 0.0001	< 0.0001	< 1	127	94	< 0.0001
Endrin aldehyde	< 0.0001	< 0.0001	< 1	70	78	< 0.0001
Endrin ketone	< 0.0001	< 0.0001	< 1	118	100	< 0.0001
g-BHC (Lindane)	< 0.0001	< 0.0001	< 1	114	87	< 0.0001
Heptachlor	< 0.0001	< 0.0001	< 1	129	81	< 0.0001
Heptachlor epoxide	< 0.0001	< 0.0001	< 1	111	86	< 0.0001
Hexachlorobenzene	< 0.0001	< 0.0001	< 1	105	88	< 0.0001
Melnoxochlor	< 0.0001	< 0.0001	< 1	122	104	< 0.0001
Toxophens	< 0.001	< 0.001	< 1	-	-	< 0.001
Dibutylchlorandate (surr.)	74	73	-	86	86	91
Tetrachloro-m-xylene (surr.)	91	100	-	-	111	51
Phenols						
2-Chlorophenol	< 0.001	< 0.001	< 1	91	121	< 0.001
2-Methylphenol (o-Cresol)	< 0.001	< 0.001	< 1	90	97	< 0.001
2-Nitrophenol	< 0.005	< 0.005	< 1	110	119	< 0.005
2,4-Dichlorophenol	< 0.001	< 0.001	< 1	104	97	< 0.001
2,4-Dimethylphenol	< 0.001	< 0.001	< 1	77	96	< 0.001
2,4,6-Trichlorophenol	< 0.001	< 0.001	< 1	98	86	< 0.001
2,6-Dichlorophenol	< 0.001	< 0.001	< 1	104	109	< 0.001
3,6,4-Methylphenol (m&p-Cresol)	< 0.002	< 0.002	< 1	77	97	< 0.002
4-Chloro-3-methylphenol	< 0.001	< 0.001	< 1	97	81	< 0.001
Pentachlorophenol	< 0.005	< 0.005	< 1	119	96	< 0.005

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Client Sample	BH6	BH6	RPD	SPIKE	Method blank
Lab Number	08-JL05740	08-JL05740	08-JL05740	08-JL05740	Batch
QA		Duplicate	Duplicate % RPD	Spike % Recovery	
Description	Water	Water	Water	Water	Water
Matrix	Water	Water	Water	Water	Water
Sample Date	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008	Jul 12, 2008
Units		% RPD	% RPD	% Recovery	mg/L
Analysis Type					
Phenols					
Phenol	< 0.001	< 0.001	< 1	93	< 0.001

COMMENTS:

MGT Report No. 230345
 Page 9 of 9

**Sapphire Beach
Properties Pty Ltd**

Report for Sandy Beach Mill
Subdivision

Water Quality Assessment

June 2006



Contents

1.	Background	1
2.	Site Characteristics	2
2.1	Location and Details	2
2.2	Topography and Existing Drainage	2
2.3	Existing Land Use	2
2.4	Proposed Land Use/Layout	2
2.5	Geology	2
3.	Site Opportunities and Constraints	3
4.	Water Quality Objectives (WQOs) for Receiving Environment	4
5.	Water Treatment Options	6
5.1	Rainwater Tanks	6
5.2	Swales and Vegetated Overland Flow Paths	7
5.3	Bio-Retention Basins	7
6.	Model Establishment	8
6.1	Catchment Delineation	8
6.2	Model Data	11
6.3	Model Layout	12
7.	Results	16
7.1	Southern Portion of Development	16
7.2	Northern Portion of Development	19
8.	Maintenance	21
8.1	Vegetated Swales and Bioretention Devices	21
8.2	Rainwater Tanks	21
9.	Discussion	22

Table Index

Table 1	Catchment Information for Stage 1	10
Table 2	Catchment Information for Entire Development	10



Table 3	Summary of Calibration Parameters	11
Table 4	MUSIC Base and Stormflow Concentration Parameters	12
Table 5	Results from Stage 1	16
Table 6	Results from Stage 2	16
Table 7	Buffer Strip parameters for Southern Section	17
Table 8	Swale Parameters for Southern Portion of Development	18
Table 9	Bio-Retention Parameters for Southern Portion of Development	18
Table 10	Results from Northern Portion of Development	19
Table 11	Swale Parameters for Northern Portion of Development	20

Figure Index

Figure 1	Site Locality	1
Figure 2	Catchment Delineation	9
Figure 3	Stage 1 Southern Portion Only	13
Figure 4	Stages 1 and 2 Southern Portion Only	14
Figure 5	Stage 2 Northern Portion Only	15



1. Background

Sapphire Beach Properties Pty Ltd proposes to develop land west of the Pacific Highway at Sandy Beach in the Hearn's Lake catchment for residential purposes.

This report has been prepared to document the assessment of the water quality strategy for the proposed development.

The site comprises the following properties:

- ▶ Lot 260 DP 752853
- ▶ Lot 1 DP 726077
- ▶ Lot 2 DP 354878
- ▶ Lot 1 DP 726078

The land is mainly zoned Residential 2E (Tourist) with an Environmental Protection 7A (Habitat and Catchment) zone applying to Double Crossing Creek; it is Council's intention to rezone the 2E zoned land to Residential 2A (Low Density).

All properties are located adjacent to the Double Crossing Creek, which drains the catchment into Hearn's Lake. The development application site is situated on Graham Drive, Sandy Beach approximately 5km south of Woolgoolga and 20km north of Coffs Harbour as shown below in Figure 1.

Figure 1 Site Locality





2. Site Characteristics

2.1 Location and Details

The site is located at the northern end of Graham Drive, Sandy Beach, and occupies an area of approximately 10 hectares. The site comprises Lot 260 DP752853, Lot 1 DP726077, Lot 1 DP726078, and Lot 2 DP354878. The site is bounded by Graham Drive to the north and west, and rural / residential properties to the east and south.

2.2 Topography and Existing Drainage

Double Crossing Creek traverses the site and separates Lot 260 from the remaining lots. The site to the north of Double Crossing Creek is moderately sloping land, falling south to Double Crossing Creek. The site to the south of Double Crossing Creek (Lot 260) is gently sloping. The majority of the southern portion of the site generally falls to the north towards Double Crossing Creek. The most southern section of Lot 260 falls gently to the south-east.

2.3 Existing Land Use

The site is not currently in use. The site contains a disused sawmill, related sheds and residences, and a disused concrete batching plant. Coffey Geosciences Report "Stage 1 Environmental Site Assessment" (November 2005) provides a detailed history of this site.

2.4 Proposed Land Use/Layout

The proposed land use is for the development of 64 residential lots on Lot 260. Stage One consists of the development of 24 of the southern most of these lots. The remainder of the site to the north of Double Crossing Creek will be developed for integrated housing.

2.5 Geology

The 1:250,000 geological map of Coffs Harbour / Dorrigo indicates that the site is on the boundary between Quaternary Alluvium comprising of sands, silts, clays and gravels, and the Coramba Beds comprising of siltstone, siliceous siltstone and mudstone.

The soil on the site generally consists of fill over clayey soil types. Detailed results are outlined in Coffey Geosciences report mentioned above.



3. Site Opportunities and Constraints

Potential constraints with respect to the implementation of stormwater quality controls include:

- ▶ The lower reaches of the site have very flat topography
- ▶ The soil type is predominately clayey
- ▶ The development will be staged

Key opportunities identified for the catchment in relation to the application of stormwater quality control measures include:

- ▶ Open space and a central road reserve area are available for location of treatment measures
- ▶ Lot sizes are suitable for rainwater tanks
- ▶ Development would benefit from aesthetic appeal of treatment devices



4. Water Quality Objectives (WQOs) for Receiving Environment

Coffs Harbour City Council has set down stormwater management objectives for new developments in their Urban Stormwater Management Plan – 2000.

To ensure stormwater quality is considered in the planning of new developments, three sets of objectives have been adopted:

- ▶ All developments must comply with the objectives listed in Set A
- ▶ All developments must comply with the objectives listed in either Set B or Set C

The new development at Sandy Beach will comply with Set A and Set C:

Set A

- A.1** To implement 'best practice' stormwater management techniques
- A.2** To maintain natural drainage patterns as far as possible
- A.3** To maintain watercourses in their natural form, i.e. Watercourses should not be piped or channeled
- A.4** To maintain adequate vegetation buffers around waterways and sensitive areas, i.e. At least 20 metres

Set C

Construction Phase

- C.1 – Soil Type C*** To ensure suspended solids concentrations do not exceed 50mg/L for all flow events up to 25% of the 1 year ARI flow
- C.1 – Soil Types F** and D***** To ensure suspended solid concentrations do not exceed 50mg/L for all 5 day rainfall totals up to the 75th percentile rainfall event (75thile rainfall event in Coffs Harbour = 34.4mm)
- C.2** To limit the application, generation and migration of toxic substances to the maximum extent practical

Post Construction Phase

- C.3** To retain 80% of the average annual load of suspended solids
- C.4** To retain 45% of the average annual load of Total Phosphorus
- C.5** To retain 45% of the average annual load of Total Nitrogen
- C.6** To retain litter greater than 50mm for flows up to 25% of the 1 year ARI peak flow



C.7 To retain sediment coarser than 0.125mm for flows up to 25% of the 1 year ARI peak flow

C.8 To ensure no visible oils for flows up to 25% of the 1 year ARI peak flow, in areas with concentrated hydrocarbon deposition.



5. Water Treatment Options

Water Sensitive Urban Design (WSUD) encompasses all aspects of integrated urban water cycle management, including water supply, sewerage and stormwater management. As such, it represents a significant shift in the way water related environmental resources and water infrastructure are considered in the planning and design of subdivisions. In terms of stormwater management in urban developments, the WSUD philosophy has a number of objectives. These include:

- ▶ **Protect natural systems** - protect and enhance natural water systems within urban developments;
- ▶ **Integrate stormwater treatment into the landscape** - use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of urban developments;
- ▶ **Protect water quality** - protect the water quality draining from urban developments;
- ▶ **Reduce run off and peak flows** - reduce peak flows from urban developments by local detention measures and minimising impervious areas; and
- ▶ **Add value while minimising development costs** - minimise the drainage infrastructure cost of urban developments.

When applied to the design and operation of urban developments, WSUD adopts a source control and a more storage oriented system than does the conventional approach of stormwater management (conveyance orientated) and, by its very nature, adopts a more site responsive range of design solutions.

The Sandy Beach development will utilise a variety of best management practise source controls to ensure WQOs are met and also to add to the aesthetics and liveability of the development. The following sections discuss briefly stormwater quality improvement measures that will be incorporated into the development.

5.1 Rainwater Tanks

The first step in ensuring that a development is in keeping with WSUD principles is the installation of rainwater tanks at the lot scale. This will allow each lot to utilise the captured roof rainfall (stormwater harvesting) for either outdoor use, including irrigation, toilet flushing and other non-potable uses in the household. The decision will need to be made in respect to the specific uses for rainwater with indoor, non-potable use requiring a dual reticulation system. The rainwater tank will be fitted with a first flush device. This may not be deemed feasible or necessary. Rainwater tanks also act as an attenuation device as well as aiding in the sedimentation processes and this will form the most upstream WSUD feature.



5.2 Swales and Vegetated Overland Flow Paths

Buffer strips and vegetated swales are common and cost effective methods of stormwater management as they facilitate both flow attenuation and pollutant removal.

Swales and filter strip (buffer strips/zones) use vegetation in conjunction with slow and shallow-depth flow for stormwater runoff treatment. As runoff passes through the vegetation, the combined effects of filtration, infiltration, adsorption, and biological uptake remove contaminants. Vegetation also decreases the velocity of flow and allows for particulates to settle.

The principal difference between swales and filter strips is that swales accept concentrated flow while filter strips accept flow as distributed or sheet flow.

Contaminant removal depends on the residence time of water through the swale or filter strip and the depth of water relative to the height of vegetation. Good contact with vegetation and soil is required to promote the operation of the various mechanisms that capture and transform contaminants, so spreading flow in minimal depth over a wide area is best.

5.3 Bio-Retention Basins

Bioretention systems can provide efficient treatment of stormwater through fine filtration, extended detention and some biological uptake. They also provide flow retardation and are thought to be particularly efficient at removing nitrogen.

Bioretention systems are not intended to be infiltration systems, rather they convey collected water to downstream waters and not 'lose' water to surrounding soils. However, where soils allow, infiltration can be promoted. Runoff is filtered through a fine media layer as it percolates downwards. It is then collected via a perforated pipe and discharged either directly or via conventional stormwater pipes. Vegetation is a crucial component of bio-retention systems. Above-ground, appropriate vegetation acts to retard and distribute flows and protects the surface of the system. Under these circumstances the vegetation is also helping the trap suspended sediments. Below ground the root zone is high in biological activity aiding in pollutant uptake.



6. Model Establishment

To evaluate stormwater quality within the development area, a water quality model of the development area was developed using MUSIC Version 3, the Model for Urban Stormwater Improvement Conceptualisation, developed by CRC for Catchment Hydrology.

MUSIC provides the ability to simulate both quantity and quality of runoff from catchments ranging from a single house block up to many square kilometres, and the effect of a wide range of treatment facilities on the quantity and quality of runoff downstream using a range of time steps from daily down to 6 minutes. The Sandy Beach model used a 6 min time step.

6.1 Catchment Delineation

Catchments for modelling purposes were delineated and grouped according to impervious properties and runoff destination.

Roof Areas

- ▶ Roofed areas were denoted as being 100% impervious
- ▶ Only 50% of roofed areas were assumed to drain to rainwater tanks
- ▶ The remaining 50% of roofed areas was included in remaining areas

Road Areas

- ▶ Road areas were assumed to be 100% impervious

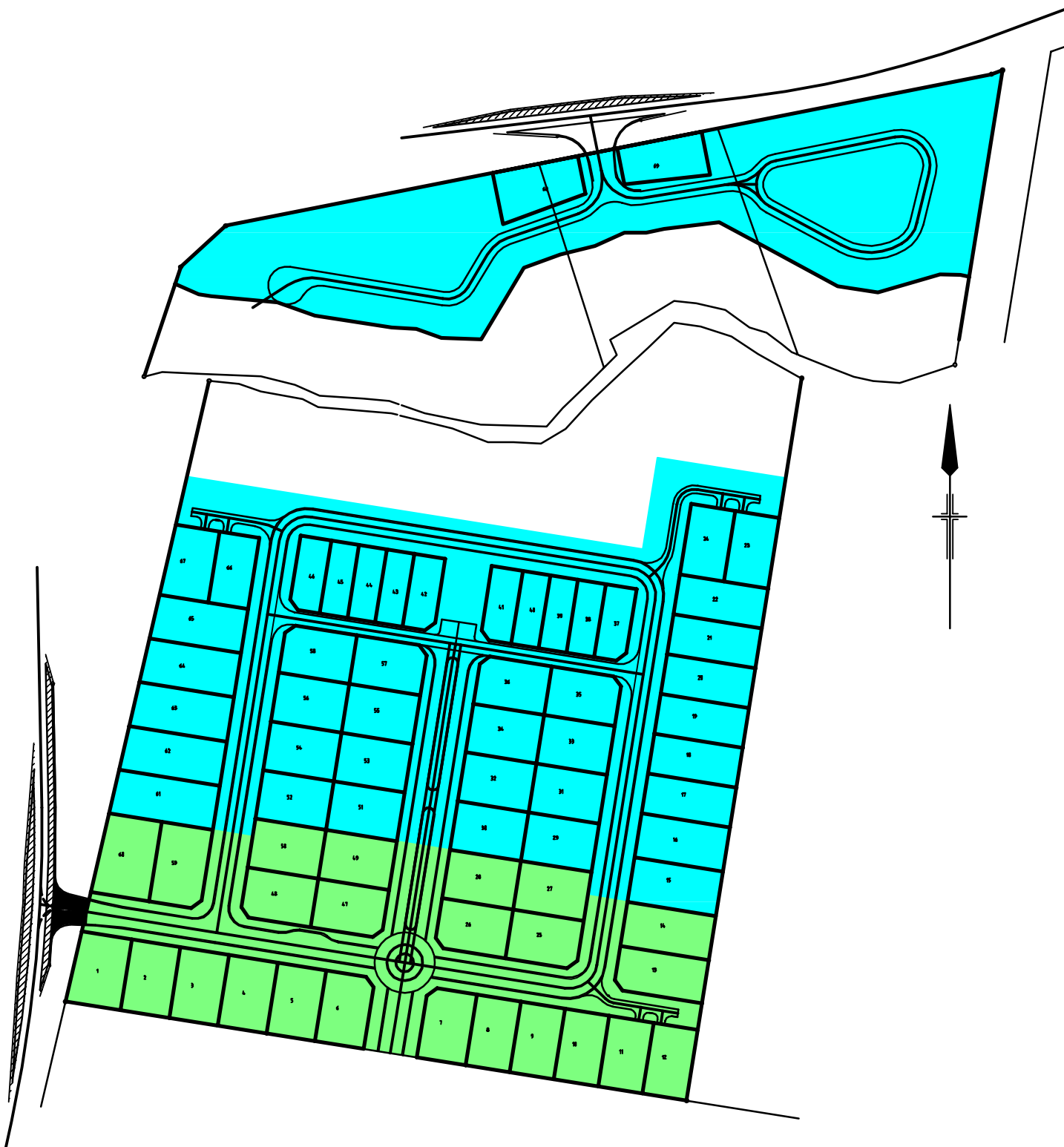
Remaining Areas

- ▶ Remaining areas are all areas that are not roofed (50% only) or road areas.
- ▶ Remaining areas were assumed to be 40% impervious (this accounts for driveways, outdoor paved areas and the remaining 50% of roofed areas)

Sandy Beach development will be achieved in two stages:

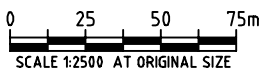
- ▶ Stage 1 will consist of the 24 most southern lots
- ▶ Stage 2 will consist of all remaining lots
- ▶ The Stage 1 MUSIC model will address the southern most 24 lots
- ▶ The Stage 2 MUSIC model will address all lots

Delineation for MUSIC modelling purposes for stage 1 and stage 2 is shown in Figure 2.



LEGEND

- STAGE 1
- STAGE 2



CLIENTS | PEOPLE | PERFORMANCE

SAPPHIRE BEACH PROPERTIES PTY LTD
 SANDY BEACH MILL
**CATCHMENT
 DELINEATION**
 scale | 1:2500 for A4 date | JULY 2006

job no. | 22-12430
 rev no. | A

Figure 2



Table 1 outlines catchment information for Stage 1.

Table 1 Catchment Information for Stage 1

Catchment Name	Area (ha)	MUSIC Fraction Impervious (%)	Assigned Music Land Use
Stage 1- Roof	0.313	100	Urban Residential
Stage 1- Road	0.460	100	Urban Residential
Stage 1- Remaining	1.400	40	Urban Residential

Table 2 outlines catchment information for entire development.

Table 2 Catchment Information for Entire Development

Catchment Name	Area (ha)	MUSIC Fraction Impervious (%)	Assigned Music Land Use
S1- Roof	0.150	100	Urban Residential
S1- Road	0.756	100	Urban Residential
S1- Remaining	0.666	40	Urban Residential
S2- Roof	0.688	100	Urban Residential
S2- Road	1.192	100	Urban Residential
S2- Remaining	3.033	40	Urban Residential
N- Roof	0.110	100	Urban Residential
N- Road	0.273	100	Urban Residential
N- Remaining	1.033	40	Urban Residential



6.2 Model Data

6.2.1 Climate

Climate data for the catchment was sourced from the MUSIC Database using the rainfall and Potential Evapotranspiration (PET) values for Coffs Harbour. The period 1960 to 2002 represented the rainfall variability of the whole data set and was thus selected.

6.2.2 Rainfall/Runoff Parameters

Catchment runoff volumes were estimated from the majority of rainfall/runoff parameters determined by *WBM Oceanics Australia* in their report titled "MUSIC Modelling of Hearn's Lake Catchment" dated 7th October 2005. Parameters adopted for urban land use are given in Table 3 below.

Table 3 Summary of Calibration Parameters

Parameter	Value
Impervious Threshold (mm/day)	1
Soil Moisture Capacity (mm)	200
Field Capacity (mm)	80
Infiltration Capacity Coefficient (mm)	300
Infiltration Capacity Exponent	2.5
Initial Groundwater Depth (mm)	10
Daily Recharge Rate (%)	0.55
Daily Baseflow Rate (%)	0.15
Daily Seepage Rate (%)	0

6.2.3 Pollutant Generation Rates

MUSIC default pollutant generation rates were used for urban residential land use and are contained in Table 4 below.



Table 4 MUSIC Base and Stormflow Concentration Parameters

Land Use		Total Suspended Solids (Log ₁₀ mg/l)	Total Phosphorus (Log ₁₀ mg/l)		Total Nitrogen (Log ₁₀ mg/l)		
		Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow
Urban Residential	Mean	1.00	2.18	-0.97	-0.47	0.20	0.26
	Std Deviation	0.34	0.39	0.31	0.31	0.20	0.23

6.3 Model Layout

6.3.1 Southern Portion of Development

Stage 1

The proposed water quality design for stage 1 involves the 24 most southern lots being directed into the central southern swale, which will discharge into the creek system. Rainwater tanks will be used on a lot scale.

Stage 2

The proposed water quality design involves catchment S1 being drained into the main swale directed through the central road in the southern section and the swale flowing into the bioretention basin located in the Northern end of the development South of the creek and the bioretention basin draining into the creek. Catchment S2 would drain into the bioretention basin only. Rainwater tanks will be used on a lot scale.

The MUSIC model layouts for Stage 1 & 2 are displayed in Figure 3 and Figure 4 respectively.

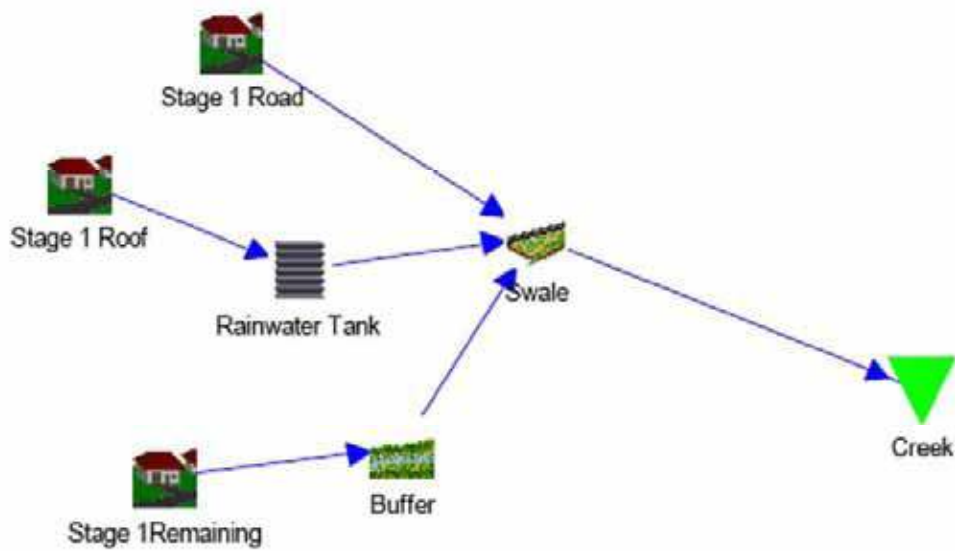


Figure 3 Stage 1 Southern Portion Only

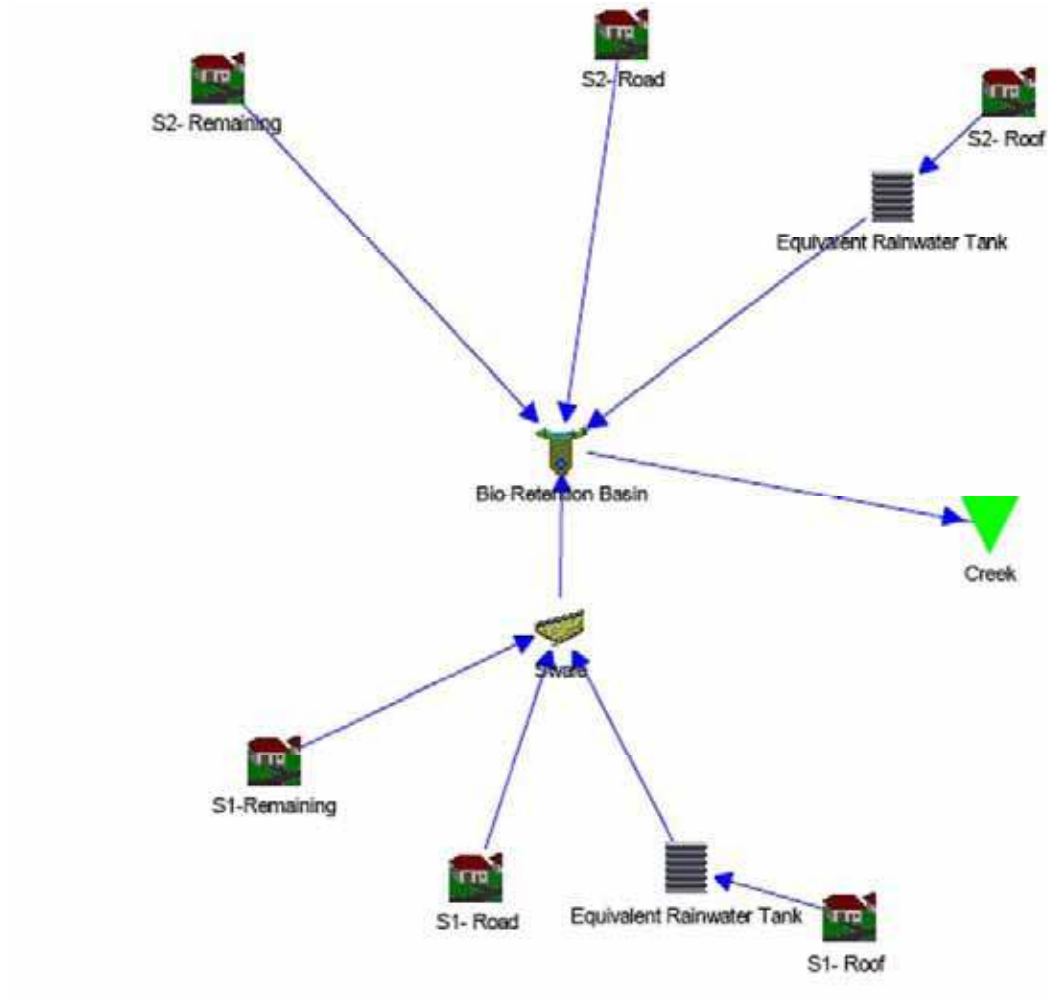


Figure 4 Stages 1 and 2 Southern Portion Only



6.3.2 Northern Portion of Development

The Northern portion of the development will be drained to a main swale along the Northern side of the main road and discharge into the creek. Rainwater tanks will be used on a lot scale.

The MUSIC model layout for the Northern portion of the development is shown in Figure 5.

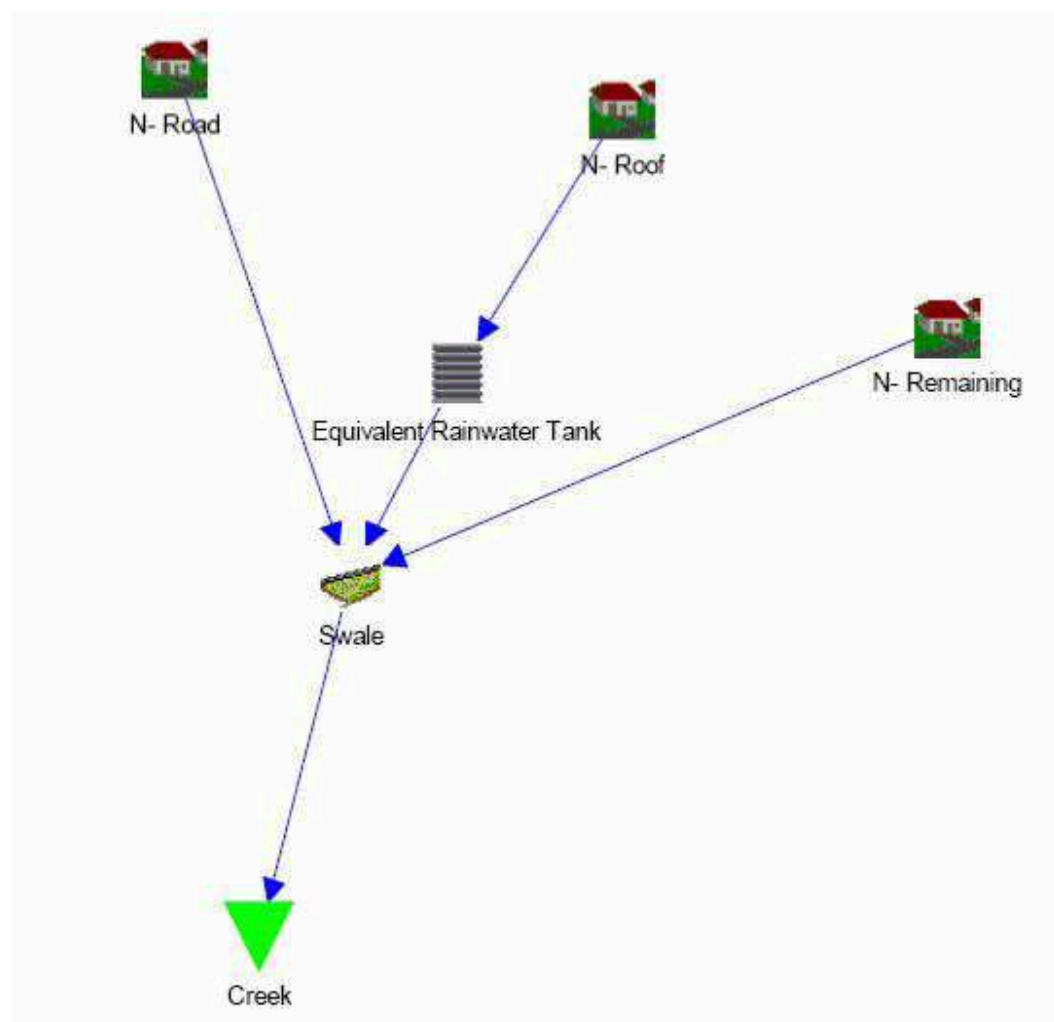


Figure 5 Stage 2 Northern Portion Only



7. Results

7.1 Southern Portion of Development

7.1.1 WQOs

All WQOs were achieved through source controls and maximising vegetated flow paths within the development. Design requirements needed for treatment devices (quality only) are outlined in 7.1.2.

Results of modelling are presented below in Table 5 & Table 6.

Table 5 Results from Stage 1

Parameter	Sources	Residual Load	% Reduction
Flow (ML/yr)	22.1	15.2	31
Total Suspended Solids (kg/yr)	4.6 x 10 ³	346	92.5
Total Phosphorus (kg/yr)	9.17	2.27	75.3
Total Nitrogen (kg/yr)	62.5	34.2	45.3
Gross Pollutants (kg/yr)	509	0	100

Table 6 Results from Stage 2

Parameter	Sources	Residual Load	% Reduction
Flow (ML/yr)	68.4	53.7	21.5
Total Suspended Solids (kg/yr)	1.41 x 10 ⁴	1.54 x 10 ³	89.1
Total Phosphorus (kg/yr)	28.6	7.38	74.2
Total Nitrogen (kg/yr)	198	107	45.7
Gross Pollutants (kg/yr)	1.57 x 10 ³	0	100



7.1.2 Stormwater Treatment Devices for Southern Portion of Development

Rainwater Tanks

The assumed dimensions of the rainwater tanks to be installed on a lot scale are as follows:

- ▶ Each tank has a capacity of 5 kL
- ▶ Each rainwater tank is 2m in height and 1.8m in diameter
- ▶ Each tank has an extended detention depth or air space equal to 0.2m
- ▶ Only roof water is directed to the rainwater tank
- ▶ An average daily reuse amount from the tank was assumed to be 120 L/household (Coffs Harbour City Council)

Buffer Strips

Vegetated overland flow paths will be maximised wherever possible. They will include buffer strips (min 1m width) on all lots Buffer strips have been modelled to service all remaining areas in the southern section of the development (refer 6.1 for remaining area definition). Their inclusion would not only increase treatment efficiency but they will also increase the aesthetic value of the development. Table 7 outlines input data for buffer strips.

Table 7 Buffer Strip parameters for Southern Section

Treatment Properties	Value
% of Upstream area buffered	1
Buffer area (% of upstream)	0.5
Seepage loss	20mm/hr



Swale

Table 8 outlines the swale parameters needed to achieve the WQOs for both option 1 and 2:

Table 8 Swale Parameters for Southern Portion of Development

Parameter	Value
Length (m)	115
Bed Slope (%)	3
Base Width (m)	1
Top Width (m)	5
Depth (m)	0.5
Vegetation Height (m)	0.05
Seepage (mm/hr)	20 (sandy Clay)

Bio-Retention Basins

Table 9 outlines the Bio-Retention parameters needed to achieve the WQOs for Stage 2:

Table 9 Bio-Retention Parameters for Southern Portion of Development

Parameter	Option 1 Value	Option 2 Value
Extended Detention Depth (m)	0.5	0.5
Surface Area (m)	240	288
Seepage Loss (mm/hr)	20 (Sandy Clay)	20 (Sandy Clay)
Filter Area (m ²)	84	108
Filter Depth (m)	0.5	0.5
Filter Median Particle Diameter (mm)	2	2
Saturated Hydraulic Conductivity (mm/hr)	300 (Sand)	300 (Sand)
Overflow Weir Width (m)	2	2



7.2 Northern Portion of Development

7.2.1 WQOs

All WQOs were achieved through source controls and maximising vegetated flow paths within the Northern portion of the development. Design requirements needed for treatment devices (quality only) are outlined in section 7.2.2.

Results of modelling are presented below in Table 10.

Table 10 Results from Northern Portion of Development

Parameter	Sources	Residual Load	% Reduction
Flow (ML/yr)	13.7	8.14	40.7
Total Suspended Solids (kg/yr)	2.72 x 10 ³	146	94.6
Total Phosphorus (kg/yr)	5.61	1.14	79.7
Total Nitrogen (kg/yr)	40	18.6	53.5
Gross Pollutants (kg/yr)	319	0	100

7.2.2 Stormwater Treatment Devices for Northern Portion of Development

Tanks

The assumed dimensions of the rainwater tanks to be installed on a lot scale are as follows:

- ▶ Each tank has a capacity of 5 kL
- ▶ Each rainwater tank is 2m in height and 1.8m in diameter
- ▶ Each tank has an extended detention depth or air space equal to 0.2m
- ▶ Only roof water is directed to the rainwater tank

An average daily reuse amount from the tank was assumed to be 120 L/household (Coffs Harbour City Council)



Swale

Table 11 outlines the swale parameters needed to achieve the WQOs for the Northern portion of the development.

Table 11 Swale Parameters for Northern Portion of Development

Parameter	Value
Length (m)	110
Bed Slope (%)	3
Base Width (m)	1
Top Width (m)	3
Depth (m)	0.5
Vegetation Height (m)	0.05
Seepage (mm/hr)	20 (sandy Clay)

Vegetated Overland Flow Paths

Vegetated overland flow paths will be maximised wherever possible. They will include buffer strips (min 1m width) on all lots. Buffer strips were not modelled in MUSIC for the Northern section, however, their inclusion would not only increase treatment efficiency but they will also increase the aesthetic value of the development.



8. Maintenance

8.1 Vegetated Swales and Bioretention Devices

The vegetation cover of swales, buffers and bioretention devices must be maintained to ensure that the filtering capacity of the vegetation is not reduced. The filtering capacity is maintained by ensuring complete vegetative covering of the soil at an appropriate length, and prevention of activities that will compact the soil's surface, preventing infiltration.

Maintenance activities typically include:

- ▶ Watering, replanting and weeding to maintain vegetation cover especially during establishment;
- ▶ Mowing the surface, if grass vegetation is adopted.
- ▶ Removal of litter and debris from the swale surface;
- ▶ Checking for channelling or erosion; and
- ▶ Checking for ponding areas.

If regular ponding is occurring on filter material, this may indicate that the filter material needs to be replaced. Periodic removal and replacement or re-establishment of filter material and planting will be required.

8.2 Rainwater Tanks

Rainwater tank maintenance will be the responsibility of the individual landowner.



9. Discussion

It has been shown that with the proposed water quality measures in place, WQOs for discharges from Sandy Beach can be achieved for stage 1 and stage 2.

This treatment is performed wholly by source control treatment measures that ensure the adjacent creek will not be adversely affected by this development.

WSUD philosophy was used throughout the developments stormwater management.

The final treatment layout and areas will depend on the final site layout and also on the appropriate modelling and function of civil design of the bioretention systems.



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