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UTILA PTY LTD

North Bonville

Stormwater Management Strategy

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NORTH BONVILLE
STORMWATER MANAGEMENT STRATEGY

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PROJECT 301015-01381 - NORTH BONVILLE

REV	DESCRIPTION	ORIG	REVIEW	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Draft report	Chris Moon	Michael Shaw	Michael Shaw	17-05-10	N/A	
B	Issued	Chris Moon	Michael Shaw	Michael Shaw	18-May-2010		

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Appendices

1. INTRODUCTION

The Urban Infrastructure group of WorleyParsons has been engaged by Utila Pty Ltd to prepare a water management strategy for the proposed redevelopment of a site at Lot 112 DP 1073791, Lyons Road, North Bonville NSW, refer **Figure 1**. The study site, known as North Bonville, is located in the local government area of Coffs Harbour City Council, in NSW and approximately 12km south of Coffs Harbour at North Bonville, near Sawtell

WorleyParsons have formulated this water management strategy in concert with the ecological and landscape design consultants. The strategy provides an integrated water management approach which improves the runoff management and adds value in terms of the ecological outcome and the visual amenity of the area. Frequent stormwater flow management and waterway stability management issues have also been addressed.

The development proposed would introduce sufficient measures to reduce runoff pollutant loads to existing levels thereby ensuring no net increase in nutrient/pollutant loads discharging off-site.

Best management practice soil and water management in accordance with the Managing Urban Stormwater guidelines would ensure no net increase in runoff pollutant loads during construction.

This report also addresses the requirements of the Water Management Act (*2000*) in relation to riparian corridors.

1.1 Existing Site

Lot 112 is 38.78 Ha in area in total of which approximately 25 Ha has been cleared and is currently used for cattle grazing. It is proposed to develop the 25 Ha that have been cleared as a residential subdivision, refer **Figure 1**.

The site is bounded by Bongil National Park to the east, south and west. To the north the site adjoins an existing residential development that fronts Lyons Road. It is characterised by a water course that bisects it in an east west direction and drains into adjacent wetlands, Bonville Creek, an estuary and ultimately the South Pacific Ocean. The water bodies located on site appear to be man made as part of the historical farming and grazing of the site.

The portion of the site to the north of the water course grades to the south draining into the water course. The portion of the site the south of the water course contains a ridge line in the centre that generally grades in all directions towards the perimeter of the site.

1.2 Proposed Development

The proposed development would contain around 170 low density lots south of the creek and medium density development north of the creek for seniors living housing, roads, associated infrastructure, public open space areas and residual public reserve, refer **Figure 2** for details.

It is proposed to dedicate some additional land to the adjacent Bongil National Park.

2. OBJECTIVES

The key objectives of the following Departments and Agencies have been identified and incorporated into the proposed water management strategy.

2.1 Department of Planning

Concept approval has been granted for the proposed development by the Department of Planning (DOP) Application No. 08_0080 and Director Generals Requirements (DGRs) have been issued. The Concept Application has also been referred to various Government Agencies for a response to key issues. The DGRs and responses that are relevant to water management are from the Department of Water and Energy and the Department of Environment and Climate Change.

2.1.1 Director Generals Requirements

The following requirements relevant to stormwater management have been included in the DGRs and addressed in this report:

> *7. Water Quality Management*
>
> *7.1 Address and outline measures for Integrated Water Cycle Management (including stormwater) based on Water Sensitive Urban Design principles which addresses impacts on the surrounding environment, drainage and water quality controls for the catchment, and erosion and sedimentation controls at construction and operational stages.*
>
> *7.2 Outline management of site drainage and runoff, and the impact on water courses, including consideration of aquatic and riparian environment and proposed buffer zones.*
>
> *7.3 Assess the impacts of the proposal on surface and groundwater hydrology and quality during both construction and occupation of the site.*

2.1.2 Department of Water and Energy

The following advice relevant to stormwater management has been provided by the Department of Water and Energy (DWE) and addressed in this report:

> *The management of site drainage and runoff, and the impact on water courses, and the aquatic and riparian environment, including any proposed buffer zones.*

2.1.3 Department of Environment and Climate Change

The following advice relevant to stormwater management has been provided by the Department of Environment and Climate Change (DECC) and addressed in this report:

Water Quality

The environmental outcomes for the project in relation to water should be:

- *There is no pollution of waters during the construction and operational phases of the development.*

2.2 Coffs Harbour City Council – North Bonville Development Control Plan

This Development Control Plan (DCP) includes a conceptual sub-division layout and water management strategy for the subject site. The proposed layout that forms the basis of this application has been modified from the layout included in the DCP. The layout and water management strategy has evolved with the design development and shifted away from the layout included in the DCP.

The relevant objectives of the North Bonville DCP to maintain the water quality, scenic amenity, habitat and recreational potential of the natural environment have been incorporated into the proposed water management strategy.

2.3 Coffs Harbour City Council Water Sensitive Urban Design Policy

The objectives of the Coffs Harbour City Council's Water Sensitive Urban Design (WSUD) Policy have been incorporated into the proposed water management strategy. The Policy is includes the following primary objectives.

2.3.1 Frequent Flow Management

The management of frequent flows to achieve the following objectives:

Manage the volume and frequency of surface runoff during small rainfall events so as to minimize change in frequency of disturbance to aquatic ecosystems, and mimic pre-development flow rates by imitating infiltration.

Capture and manage the first 10mm of runoff from all impervious surfaces of the proposed development

2.3.2 Waterway Stability Management

The management of waterway stability to achieve the following objectives:

The control of the impacts of urban development on channel bed and bank erosion by limiting changes in flow rate and flow duration within the receiving waterway.

Limit the post-development peak one-year Average Recurrence Interval (ARI) event discharge to the pre-development peak one year Average Recurrence Interval (ARI) event discharge.

Council may substitute an alternative criterion where catchment scale studies have been undertaken to develop a catchment specific approach to the management of instream erosion impacts.

2.3.3 Stormwater Quality Management

The management of stormwater quality to achieve the following objectives:

- *To implement 'best practice' stormwater management techniques.*
- *To maintain natural drainage patterns.*
- *To maintain watercourses in their natural from, ie. Watercourses should not be piped or channelled.*
- *To maintain adequate and intact vegetation buffers around waterways and sensitive areas*
- *To ensure no net increase in the average annual load of pollutants entering the stormwater systems and receiving waters, above that occurring under pre-developed conditions*
- *To improve water quality where possible.*
- *Apply CHCC Sediment and Erosion Control Policy and Procedures*
- *85% reduction of mean annual load of total suspended solids (min)*
- *65% reduction of mean annual load of total phosphorus (min)*
- *45% reduction of mean annual load of total nitrogen (min)*
- *90% reduction in the average annual gross pollutant (size >5mm) load*
- *To retain sediment coarser than 0.125mm for flows up to 25% of the 1 year ARI peak flow; and*
- *To ensure no visible oils for flows up to 25% of the 1 year peak flow, in areas with concentrated hydrocarbon deposition.*

3. WATER MANAGEMENT STRATEGY

A Water Sensitive Urban Design (WSUD) approach has been adopted to maximise the water management related sustainability components of the proposed development. This approach achieves the objectives outlined in **Section 2** in accordance with the requirements of the DGR's and the various Government Agency submissions.

The elements of the Water Sensitive Urban Design approach adopted for this development are:

- Capture rainwater from roof runoff for use in toilet flushing, washing machines irrigation and hot water, if possible (*to be confirmed*);
- Use of water saving devices in dwellings;
- Treatment of road runoff in bio-retention swales;
- Removal of gross pollutants in GPT's;
- Use of end of line bio-retention basins;
- Rehabilitation of riparian corridors to maximise habitat and provide creek line stability; and
- Contribution to long term management of receiving water quality by matching runoff pollutant to existing levels.

3.1 Frequent Flow Management

3.1.1 Methodology

It is proposed that the implementation of WSUD measures across the site will ensure that run-off from all impervious surfaces will be captured and treated. The treatment train will ensure that any changes to the volume and frequency of stormwater flows will be minimised.

The effect of developing the site on the volume and frequency of stormwater flows is discussed in detail in the following sections. The WSUD management of these effects is also discussed to ensure that any impact is addressed appropriately.

3.2 Waterway Stability Management

3.2.1 Methodology

Simulations were undertaken to determine the Stream Erosion Index of the proposed development. The purpose in determining the Stream Erosion Index for the development is to assess the impact on the watercourses downstream of the proposed site in terms of the erosive potential caused by runoff from the site. This is a measure used to predict the impact of the development runoff rates on creek bank and bed stability.

The stream erosion index is defined as the number of post-development flows greater than the stream-forming flow divided by the number of pre-development flows greater than the stream-forming flow. An index of 1 indicates zero variation from the existing conditions. An index of 3.5 – 5 is considered permissible where an index of 1 represents the 'ideal outcome' as set out by DEC in, 'Western Sydney Growth Centres – Stormwater Guidance For Precinct Planning, November 2006'. Furthermore, the DEC 2006 document defines the stream forming flow as half of the 2 year Average Recurrence Interval (ARI) flow of the catchment under existing conditions.

The 2 year ARI flows were estimated by running a RAFTS hydrological model for the existing pre-development conditions.

The frequency of pre-development and post development stream forming flows obtained from the MUSIC model were used to determine the stream erosion index.

3.2.2 RAFTS

The peak flows for the 2 year ARI event were determined for each of the six downstream discharge points. The stream forming flows were adopted as half the 2 year ARI flows.

RAFTS is a program consisting of five discrete modules that simulate the rainfall/runoff routing process, namely:

- A library module;
- A hydrograph generation module;
- A loss module;
- A reservoir routing module; and
- A river/channel routing module.

Intensity Frequency Duration (*IFD*) data for the site was obtained from *the Bureau of Meteorology website* (http://www.bom.gov.au/hydro/has/cdirswebx/index.shtml) and is shown in **Table 3-1** below.

Table 3-1 - Storm Data

Storm Event	Duration	Rainfall Intensity
2 year ARI	1 hour storm	47.3 mm/hr
2 year ARI	12 hour storm	10.3 mm/hr
2 year ARI	72 hour storm	3.47 mm/hr
50 year ARI	1 hour storm	93.2 mm/hr
50 year ARI	12 hour storm	23.3 mm/hr

Storm Event	Duration	Rainfall Intensity
50 year ARI	72 hour storm	7.7 mm/hr

- Location skew (g) 0.04
- Geographical factor (f2) 4.37
- Geographical factor (f50) 16.49

The site has been divided into eight sub-catchments according to its topography, refer **Section 3.3.6** for details. Other input parameters adopted in the formation of the RAFTS model were as follows:

- manning's 'n' was taken to be 0.012 for impervious areas and 0.03 for pervious areas;
- Initial and continuing losses for pervious areas were modelled as 30 mm and 5 mm/hr respectively; and
- Initial and continuing losses for impervious areas were modelled as 2.5 mm and 0 mm/hr respectively.

3.2.3 MUSIC

The flows generated from the catchments draining to the discharge points were exported from the MUSIC models used for the water quality analysis at an hourly time-step, refer **Section 3.3** for a description of the MUSIC model. This is continuous data for a continuous five year period. The exported flow data was compared against the stream forming flow to distinguish how frequently the flows in both scenarios would exceed the stream forming flow.

3.2.4 Results

The stream forming flow exceedance rates and corresponding Stream Erosion Index values are shown in **Table 3-2**.

Table 3-2 – Results of Erosion Index Simulation

Location	Stream Forming Flow (m3/s)	Site Condition	Exceedance % at stream forming flow	Stream Erosion Index
Outlet 1	0.40	Existing	0.0205	1.44
		Proposed development	0.0296	
Outlet 2	0.66	Existing	0.0182	0.5
		Proposed development	0.0091	
Outlet 3	1.29	Existing	0.0273	0.75

Location	Stream Forming Flow (m3/s)	Site Condition	Exceedance % at stream forming flow	Stream Erosion Index
		Proposed development	0.0205	
Outlet 4	0.13	Existing	0.0251	1.08
		Proposed development	0.0296	
Outlet 5	0.28	Existing	0.0068	1.00
		Proposed development	0.0068	
Outlet 6	0.43	Existing	0.0114	1.00
		Proposed development	0.0114	

The stream erosion indices for all outlets lie within the range of a permissible increase. Consequently, it can be concluded that the development would result in no significant increase in the risk of bank stability as a result of the development.

3.3 Stormwater Quality

3.3.1 Methodology

To undertake the stormwater quality assessment component of the Stormwater Management Plan, a long-term MUSIC model was established for the proposed subdivision site. MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (*CRCCH*). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. The program is able to conceptually simulate the performance of a group of stormwater treatment measures (*treatment train*) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

The model was used to estimate the annual pollutant load generated under existing state and developed conditions over a 5 year period of historically average rainfall.

MUSIC was chosen for this investigation because it has the following attributes:

- It can account for the temporal variation in storm rainfall throughout the year;
- Modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- It can model a range of treatment devices;
- It can be used to estimate pollutant loads at any location within the catchment; and
- It is based on logical and accepted algorithms.

3.3.2 Rainfall

In order to develop a model that could comprehensively assess the performance of stormwater quality treatment devices such as bio-retention swales and basins, the use of pluviograph rainfall data (*captured at six minute intervals*) was considered necessary. The nearest station to the sire with similar elevation for which pluvial data was available was the Coffs Harbour station. The mean annual rainfall at Coffs Harbour is 1968 mm.

Six-minute pluviograph data was used for the five year period of rainfall data from 1/11/1960 to 2/11/1965 from the Coffs Harbour station. The average rainfall for this period was 1,968 mm/yr, which matched the long term average and the dataset contains the highest recorded rainfall over a five-year period for the Coffs Harbour station. As such, this is the best available dataset to represent an average and wet rainfall period at Bonville.

3.3.3 Evaporation

Monthly areal potential evapotranspiration values were obtained for Coffs Harbour from the Bureau of Meteorology data and are shown in **Table 3-3**.

Table 3-3 – Monthly Areal Potential Evapotranspiration

Month	Areal Potential Evapotranspiration (*mm*)
January	195
February	160
March	150
April	95
May	65
June	55
July	55
August	70
September	105
October	145
November	170
December	190
Total	**1455**

3.3.4 Soil Data

A rainfall-runoff calibration was undertaken for the subject site. The following parameters within the model were calibrated, based on the recommendations of the Gold Coast City Council MUSIC Guidelines 2006, and as directed in the Coffs Harbour City Council WSUD DCP. **Table 3-4** shows the adopted and the MUSIC default soil properties.

The model generates a volumetric runoff coefficient (C_v) of **0.45** for the existing site conditions when a 0% daily deep seepage is applied to the source nodes. The model generated C_v has good agreement with the recommended C_v (*of 0.45*) extracted from Figure 3-12 of NSW MUSIC Modelling Guidelines, by BMT WBM, April 2008.

Table 3-4 – Soil Properties

Parameter	MUSIC Default	Forest	Urban
Impervious			
Rain threshold	1	1	1

Parameter	MUSIC Default	Forest	Urban
Pervious			
Soil Storage Capacity	120	120	400
Initial Storage	30	25	10
Field Capacity	80	80	200
Infiltration - a	200	200	50
Infiltration - b	1	1	1
Groundwater			
Initial depth	10	50	50
Daily recharge	25	25	25
Daily base flow	5	5	5
Daily deep seepage	0	0	0

3.3.5 Pollutant Concentration

The pollutant concentrations used for the various land-uses in the existing and developed catchments were derived from the Gold Coast City Council MUSIC Modelling Guidelines and as directed by the Coffs Harbour City Council WSUD DCP. The adopted pollutant concentrations are shown in **Table 3-5**.

Table 3-5 – Adopted Pollutant Concentrations

	Pollutant Concentration (mg/L)		
	Wet Weather Concentration (mg/L)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Existing Land Use			
Rural Residential	182	0.28	2.1
Proposed Land Use			
Roads	270	0.5	1.82
Roofs	20	0.13	1.82
Residential	151	0.34	1.82
Forest	80	0.08	0.84

3.3.6 Existing Conditions

The Council WSUD Policy aims to achieve the greater level of treatment from two scenarios. Either no net increase in pollutant export relative to existing conditions or to achieve 85% of removal of total suspended solids, 65% of removal of total phosphorus and 45% total nitrogen for runoff from the development. Therefore, the existing pollutant export from the site was estimated to establish the base case against which to measure the performance of the proposed treatment train.

The existing catchment is defined as areas where the proposed development would take place and the data in **Table 3-6** was used to create a MUSIC model for the site.

Table 3-6 – Existing Catchment Data

Sub Catchment	Area (ha)	Impervious Area (%)	Land Use
E1	4.72	0	Rural Residential
E2	3.74	0	Rural Residential
E3	3.6	0	Rural Residential
E4	1.66	0	Rural Residential
E5	2.24	0	Rural Residential
E6	4.16	0	Rural Residential
E7	3.69	0	Rural Residential
E8	1.46	0	Rural Residential
Total	**25.27**		

3.3.7 Proposed Conditions (No Treatment)

To assess the treatment requirements, the existing state model was modified to reflect the proposed development. No treatment techniques were implemented in the developed (*no treatment*) model. The model was modified to reflect the impervious proportions of the catchment as defined in **Table 3-7** and the pollutant concentrations in **Table 3-5**. The annual runoff coefficient for post-development conditions was calculated to be **0.68**.

In the developed conditions model the roof area for the residential areas was assumed as 200m^2 per lot.

Table 3-7 Developed Catchment Data

Sub Catchment	Area (ha)	Impervious Area (%)	Land Use
P1A	0.97	60	Roof, Residential, Road
P1B	0.99	0	Forest
P1C	0.68	60	Roof, Residential, Road

P1D	1.34	60	Roof, Residential, Road
P1E	1.99	60	Roof, Residential, Road
P2A	0.88	60	Roof, Residential, Road
P2B	0.91	60	Roof, Residential, Road
P2C	2.26	60	Roof, Residential, Road
P2D	1.57	60	Roof, Residential, Road
P3A	1.08	60	Roof, Residential, Road
P3B	3.15	0	Forest
P3C	1.15	60	Roof, Residential, Road
P4	1.86	60	Roof, Residential, Road
P5A	1.61	60	Roof, Residential, Road
P5B	0.64	0	Forest
P6A	2.76	60	Roof, Residential, Road
P6B	1.39	0	Forest
Total	**25.23**		

3.3.8 Proposed Conditions (*With Treatment*)

The proposed water management strategy was incorporated into the model and simulated. The strategy consists of rainwater tanks, bio-retention systems, gross pollutant traps and buffer areas.

The proposed treatment strategy has been based on a treatment train approach in which runoff is treated a number of times prior to discharge to creeks. This ensures the strategy is robust and will achieve the objectives. The proposed treatment measures are listed in **Table 3-8.**

Table 3-8 Water Quality Treatment Devices

Sub Catchment	Treatment Measures
P1A	Rainwater Tank (35KL)
	Bio-retention Swale (560m2)
	Bio-retention Basin (400m2)
P1B	Rehabilitated riparian corridor
P1C, P1D, P1E	Rainwater Tanks (205KL)
	Bio-retention Swales (560m2)
	GPT
	Bio-retention Basins (600m2)
P2A	Rainwater Tank (45KL)
	Bio-retention Swale (280m2)
P2B	Rainwater Tank (45KL)

Sub Catchment	Treatment Measures
P2C, P2D	Rainwater Tanks (100KL)
	Bio-retention Swales (680m2)
	GPT
	Bio-retention Basins (1,300m2)
P3A	Rainwater Tanks (70KL)
	Bio-retention Swales (584m2)
P3B	Rehabilitated open space
P3C	Rainwater Tanks (50KL)
	Bio-retention Swales (240m2)
P4	Rainwater Tank (85KL)
	Bio-retention Swale (1,080m2)
	Bio-retention Basin (100m2)
P5A	Rainwater Tanks (95KL)
	GPT
	Bio-retention Basins (500m2)
P5B	Rehabilitated open space
P6A	Rainwater Tanks (95KL)
	GPT
	Bio-retention Basins (500m2)
P6B	Rehabilitated open space

3.3.9 Groundwater

WorleyParsons has been commissioned under a separate engagement to undertake a baseline groundwater investigation. In summary, work was carried out in several stages, as follows:

- Installation of four groundwater monitoring wells at the site;
- Groundwater elevation monitoring and sampling for physio-chemical testing;
- Development of groundwater profile;
- Determination of potential for groundwater / WSUD system connectivity and identification of associated mitigation measures; and
- Present findings of the assessment in a report.

The key outcomes for the WSUD strategy design strategy are as follows:

- the hydraulic conductivity (K) values of the near-surface soils in the upper 1m of the site is typically in the range of 10^{-6} m/s and 10^{-8} m/s;

- If there is development on the site, reduced infiltration would mean groundwater would not be expected within 1m of the surface; and
- The invert of all bio-retention filters is above 5m AHD the probability of groundwater intersection is assessed to be low.

The above criteria have been incorporated into the design.

3.3.10 Rainwater Tanks

Rainwater tanks help reduce pollutant export into receiving waters by collecting and storing rainwater for reuse. Furthermore, rainwater tanks assist in the reduction of potable water demand. It is proposed to utilise 5kL rainwater tanks allocated to each residential dwelling and medium density dwelling to collect and capture rainwater for re-use in irrigation, toilet flushing and in the laundry. The locations of rainwater tanks are to be confirmed in future detailed architectural planning.

The rates of reuse of water were adopted from BASIX demand data and an occupancy rate of 2.4 people per dwelling. The typical value adopted for outdoor irrigation rates were are 34kL/yr/dwelling scaled by PET (*Potential Evaporation*) and a typical rate for daily internal use rate of 0.13kL/day/dwelling.

3.3.11 Bio-retention Swales / Basins

Bio-retention swales consist of low relief areas of native grasses, shrubs and trees with an infiltration area comprising of engineered filter media and a sub-soil drainage network. The purpose of bioretention is to provide a filtering effect to remove pollutants in the runoff when the runoff flows across the surfaces and through the vegetation. Further treatment would be achieved by filtering through the gravel trench and biological action due to growth on the gravel. Low flows are maintained as much as possible on the surface exposed to sunlight and with turbulence introducing oxygen to the flows.

The proposed stormwater strategy includes the following bioretention systems:

- 6 downstream bio-retention basins;
- A 4m wide perimeter bio-retention swale adjacent to the perimeter road; and
- A 4m wide bio-retention swale located centrally within the spine road.

The extent and location of the bioretention systems are shown on **Figure** 3. Typical sections of the proposed bio-retention systems are shown on **Figure 4**.

Values for seepage loss of 0.36 mm/hr have been applied to the swales based on the groundwater investigations, refer **Section 3.3.5**.

All of the basins are at the downstream discharge points and are hence the lowest points in the stormwater management system. It is a key requirement that the invert of the filter media is kept above the groundwater table and that the system is lined with an impermeable liner at these locations.

This is to ensure that there is no direct interception or interaction with the groundwater table. As such, no infiltration has been assumed in the basins.

Native grasses would be planted above the gravel trench to absorb nutrients. These grasses would be trimmed regularly to harvest accumulated nutrients. The swales do not require irrigation or fertilizer application. Flushing points will be provided in the subsoil drainage system in the swale to ensure no blockage of this system and ready access for maintenance.

3.3.12 Gross Pollutant Traps

GPT's are proposed at the end of the main stormwater lines and will be located adjacent to the proposed bioretention basins. GPT's capture litter, coarse sediment, some nutrients, oils and greases (*hydrocarbons*). While the pollutant capture efficiency of various traps may vary, the paper "Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap" (*Cooperative Research Centre for Catchment Hydrology, 1999*) suggests the following efficiencies:

- gross pollutants majority
- sediments up to 70%
- total phosphorous up to 30%
- total nitrogen up to 13%

3.3.13 Model Results

The water quality controls were incorporated into the MUSIC model for the developed scenario. **Figure 3** shows the MUSIC sub-catchment layout for the post developed conditions with the locations of proposed treatment measures.

The estimated annual exports of pollutants from the developed (*with treatment*) site and a comparison of the three scenarios are presented in **Table 3-10.**

The annual runoff coefficient was calculated to be **0.68**, which is less than for the developed (*no treatment*) case.

Table 3-9 Annual Pollutants Export Loads - Comparison

Scenario	Pollutant Load (kg/yr)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Existing Conditions	54,500	55.1	444
Proposed Conditions (no treatment)	50,700	103	582
Proposed Conditions (with treatment)	9,003	30.5	341

Table 3-9 shows that the water quality objective of maintaining pollutant export rates in the developed scenario at levels equivalent or less to the existing condition has been readily achieved. In fact there has been considerable improvement in the sediment and nutrient load discharged from the site. This would contribute to the long term improvement in receiving water quality.

The riparian corridor and areas in the south eastern and south western corners that are to be rehabilitated have been nominated as forest areas. Therefore these areas are not included in the treatment train efficiency calculations as outline in **Table 3-10** below.

Table 3-10 Annual Pollutants - Treatment Train Efficiency

Scenario	Pollutant Load (kg/yr)		
	Suspended Solids	**Total Phosphorous**	**Total Nitrogen**
Proposed Conditions (with treatment, no forest)	5,640	26.7	298
Treatment train efficiency %	88%	73%	45%

Table 3-10 shows that the reduction in pollutant export (*Proposed Condition (No Treatment) compared Proposed Condition (With Treatment)*) meets the objective of 85% of removal of total suspended solids, 65% of removal of total phosphorus and 45% total nitrogen for runoff from the development..

3.4 Maintenance of Water Quality Control/Measures

The bioretention swales and basins would be designed to minimise the maintenance requirements by:

- Being located in low slope areas to minimise flow velocities and scour potential;
- Use of large gravel / rock mulch as the surface layer to minimise scour;
- Incorporation of flushing points at regular intervals to permit flushing of the subsoil drainage pipe at the base of the swale and maintain drainage;
- Use of heavy native grass and other vegetation to protect the surface from scour; and
- Use of coarse media to provide long filtration life.

The GPTs would be maintained by regular removal of accumulated gross pollutants. Accumulated sediment on buffer strips would be removed manually by regular raking and shovelling of the sediment and any debris. These treatment measures would minimise the coarse pollutants discharged to the proposed wetlands

The proposed treatment strategy would require a recommended maintenance program for the proposed water quality control measures which would consist of the following:

- Periodic (*6monthly*) inspection and removal of any gross pollutants and coarse sediment that is deposited in the bio-retention swales / basins and replacement of vegetation as necessary;
- Periodic (*3 monthly*) and episodic (*post storm greater than 1 year ARI*) inspection and removal of trapped pollutants from all GPTs; and
- Periodic (*annually*) inspection (*and flushing if required*) of the bio-retention swale / basins under drain systems.

3.5 Construction Phase Water Quality

Sediment and erosion control plans would be designed in accordance with the NSW Department of Housing "Managing Urban Stormwater – Soils and Construction" (Blue Book) and to the satisfaction of Council. Staging of the development would minimise impacts during construction.

A sediment and erosion control plan would be prepared prior to construction, outlining the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction. It is recommended that the following measures be implemented:

- At the upstream end of works, clean water would be temporarily diverted around disturbed areas;
- A sediment fence would be erected at the downstream end of any disturbed areas;
- The area of soil disturbed at any one time would be minimised where possible;
- Sediment basins would be constructed as required; and
- Disturbed areas would be rehabilitated as soon as practical.

These controls would ensure that there are no significant adverse impacts on receiving water quality during construction for the majority of the site.

3.6 Stormwater Quality Monitoring Strategy

For the existing conditions and the construction and operations phases of the proposed development a stormwater quality monitoring strategy has been developed. This is to monitor the health of the surrounding environment through assessing the pollutant levels within the affected catchment draining to Bonville Creek.

The main objectives of the monitoring assessment are to:-

- develop an understanding of the pre-development conditions present in the waterways within and adjacent to the site;
- assess the quality of these waterways during the construction phase of the sectors; and

- assess the impact of constructed water quality measures following construction to ensure the developments are ecologically sustainable.

Monitoring undertaken prior to the development of the site will be used to provide a guiding benchmark to the health of the waterways adjacent to the site it's catchment. This data will be compared with results collated during the post construction monitoring to assess whether the proposed and construction control measures are operating adequately and meeting the objectives.

3.6.1 Monitoring Locations

Samples will be collected from Outlets 1, 2 and 3 within the existing creek line, refer **Figure 3**. These locations correspond to key discharge locations from the site. The same monitoring locations would be used where possible for progressive rounds of monitoring for the length of the assessment.

3.6.2 Types of Monitoring

The monitoring strategy consists of four main categories:

- Physio-chemical water quality monitoring;
- Ecosystem/rapid biological assessment monitoring;
- Salinity inspections; and
- Bed sediment toxicant assessment.

3.6.3 Water Quality Monitoring (Discrete Sampling)

The water quality monitoring component of the plan consists of:

- dry weather sampling undertaken quarterly (At least 4 times a year); and
- wet weather sampling undertaken for 2 events (recording a rainfall depth greater than 20mm over the catchment in a 24 hour period) spread evenly over the year and sampling throughout the rainfall event (rising and falling limbs of storm hydrograph).

The discrete sampling will be tested for the constituents listed in **Table 3-11**.

Table 3-11 – Tested Constituents for Discrete Water Quality Sampling

Variable	Units	Dry Weather	Wet Weather
pH	pH unit	✓	✓
Conductivity	ms/cm	✓	✓
Turbidity	NTU	✓	✓
Temperature	^{o}C	✓	✓

Variable	Units	Dry Weather	Wet Weather
Dissolved Oxygen	mg/L	✓	✓
Biological Oxygen Demand	mg/L	✓	
Suspended Solids	mg/L	✓	✓
Dissolved metals	mg/L	✓	
Hardness	mg/L	✓	✓
Salinity	%	✓	
Total Nitrogen	mg/L	✓	✓
Ammonia	mg/L	✓	✓
Total Kjeldalh Nitrogen	mg/L	✓	✓
Nitrates	mg/L	✓	✓
Nitrites	mg/L	✓	✓
Total Phosphorous	mg/L	✓	✓
Ortho Phosphorus	mg/L	✓	✓
Polycyclic Aromatic Hydrocarbons (PAH's)	mg/L	✓	
Phenolic Compounds	mg/L	✓	
OC/OP Pesticides	mg/L	✓	
Oil and Grease	mg/L	✓	
Faecal Coliform Count	Cfu/100mL	✓	✓
Chlorophyll-a	Mg/m^3	✓	

Two dry weather events are to substitute any wet weather event that cannot be sampled during the monitoring period.

Samples are tested for the constituents listed above and reported to conform to ANZECC specification.

3.6.4 Rapid Biological Assessment

Habitat monitoring will be undertaken on an annual basis using the Biotic Index Signal to measure biological activity.

The assessment would be undertaken at Outlets 1, 2 and 3. The assessment would be undertaken within a two year period.

3.6.5 Sediment Toxicant Monitoring

Sampling and testing of bed sediment will be programmed to be undertaken on an annual basis at Outlets 1, 2 and 3.

Parameters to be tested during the two year monitoring period include:

- Chromium;
- Lead;
- Zinc;
- Arsenic;
- Mercury;
- Copper;
- Phenolic Compounds;
- Organochlorine Pesticides; and
- PAH.

Reporting will conform to consent conditions and ANZECC guidelines.

3.6.6 Quality Assurance/Measurement Accuracy

All samples collected for the monitoring plan will be tested by a NATA certified laboratory. Copies of all original data testing certificates will be provided along with information detailing the collection and preservation status upon delivery at the laboratory.

The laboratory testing detection limits will also be included on all test certificates.

3.7 Riparian Corridor

3.7.1 Background

All controlled development on or under waterfront land is regulated by the Water Management Act (WMA) 2000. The Act aims to minimise impacts on waterfront land and water courses and requires a buffer zone, called the riparian corridor, between the waterfront and the adjacent development.

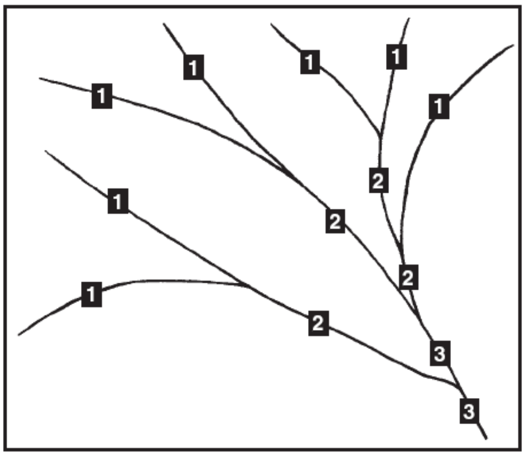
Riparian land is defined as land which adjoins or directly influences a body of water (Tubman & Price 1999). It forms the transition between terrestrial and aquatic environments.

"Riparian land provides a number of important environmental and other values which can include:

- A diversity of habitat for terrestrial, riparian and other aquatic species;
- A food source for a diversity of aquatic and terrestrial fauna (such as organic material, fruiting and flowering plants);
- Promotion of the movement and re-colonisation of individual species and plant and animal populations;
- Shading and temperature regulation;
- Conveyance of flood flows;
- Settlement of high debris loads;
- Reduction of bank and channel erosion through root systems binding the soil;
- Water quality maintenance through the trapping of sediments, nutrients and other contaminants;
- An interface between developments and waterways;
- Visual amenity; and
- A sense of place with green belts naturally dividing localities and suburbs" (DNR Draft Wollongong Riparian Corridor Management Study - May 2003).

The width of a riparian zone as specified by DWE depends on the order of the watercourse / water body that fronts the site. Water courses can be ordered according to the Strahler method as first, second and third order and so on. Starting at the top of the catchment any watercourse that has no other water courses flowing into it is first order. Where two first order watercourses join the watercourse becomes second order. When two or more second order watercourse joins a third order watercourse is formed and so on. This is illustrated in **Diagram 1**.

Diagram 1 – Graphical Representation of the Strahler System

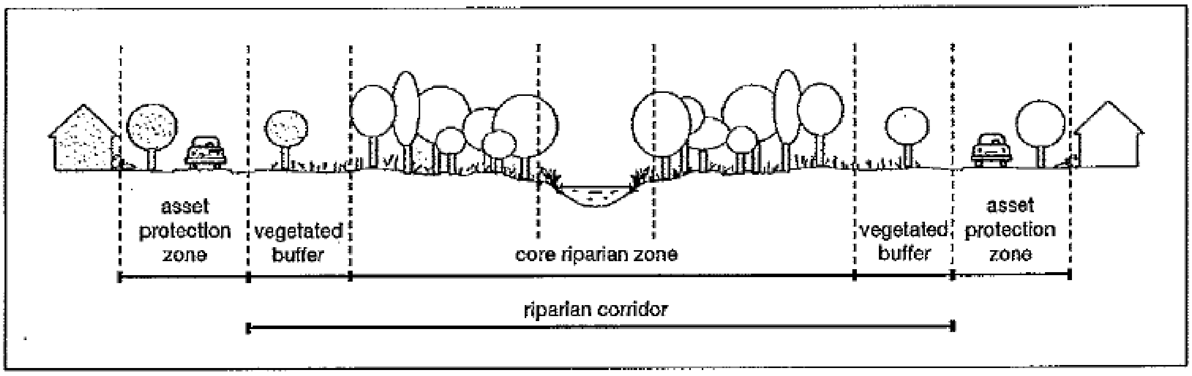


DWE recommends core riparian zone (CRZ) widths for various order water courses, as classified by the Strahler system, in their document *Guidelines for controlled activities, Riparian corridors, February 2008*. The CRZs widths are:

- First order, 10m;
- Second order, 20m; and
- Third order, 20-40m.

The above CRZs are measured from the top of the highest bank on both sides of the watercourse. A diagram illustrating the WMA (2000) riparian corridor is shown in **Diagram 2**.

Diagram 2 – Diagram of the WMA (2000) Riparian Corridor



3.7.2 Site Assessment

In order to assess the riparian corridors located on the subject site the following has been undertaken:

- Review of topographic mapping;
- Detailed site inspection; and
- Merit based assessment.

3.7.3 Review of Topographic Mapping

Interrogation of local mapping provides an initial assessment of the stream order of the watercourses located on site. The assessment has been undertaken utilising the Strahler methodology as outlined in **Section 3.7.1**. In our opinion the subject site contains one watercourse that would be classified as first order and one water course that would be classified as second order. This classification is graphically represented in **Diagram 3**.

Diagram 3 – Graphical Representation of the Strahler System at the Site

3.7.4 Site Inspection

A detailed site inspection was undertaken on 14/09/09. Photographic representation of the site is included in **Figures 6** and **7**. These Figures have been included to provide context for the watercourse settings.

The inspection shows that the cleared area of the site that is currently subject to cattle grazing includes the first order watercourse and a portion of the second order watercourse. These areas of the watercourses are in a heavily degraded state. They contain erosion gullies along some portion of the banks. Standing water is highly turbid and suffering eutrophication.

Further downstream at the second order water course is in better condition. The watercourse is protected from the cattle and contains pockets of Swamp Sclerophyll Forest. The vegetation is vigorous and healthy and surrounds an existing excavated farm dam.

3.7.5 Merit Base Assessment

In determining appropriate CRZ widths a holistic approach that considers natural topography, creek channel widths, flooding, ecology, geomorphology and future land use is proposed. The extent of the recommended CRZ widths upon the site is shown in **Figure 5**.

The recommended preliminary riparian corridor widths are depicted as 10m for the first order watercourse and 20m for the second order watercourse. **Figure 5** shows that the existing degraded EEC is protected and that the proposed land use would not impinge on the recommended riparian corridors.

The recommended widths take into account the natural topography, creek channel widths, flooding, geomorphology, category and DWE guidelines.

3.7.6 Proposed Management

Controlled activities are permitted within the CRZ, subject to obtaining a permit from DWE. It is proposed that the following activities will be undertaken within the CRZ.

3.7.7 Watercourse Rehabilitation Works.

A vegetation management plan will be prepared by JWA site investigations. The plan will outline the watercourse rehabilitation works and the on-going vegetation management.

It is proposed that the watercourses be rehabilitated to create a more natural environment that would provide improved ecological habitat as well as visual amenity. The environmental value of the existing watercourses would be enhanced by this process through the removal of the existing non-indigenous species and incorporation of native vegetation.

3.7.8 Stormwater Infrastructure

The proposed water management strategy for the site will be designed to meet the following objectives through implementing principles of Water Sensitive Urban Design (*WSUD*) and Stormwater Management:

- Water sustainability;
- Minimise Impacts on Stormwater Quality;
- Minimise Impacts on Stormwater Quantity; and
- Manage the Effects of Flooding in the watercourses (analysis of erosivity).

In order to achieve the above outcomes it is proposed to incorporate water management infrastructure within the CRZs. This infrastructure will potentially include bio-retention basins and stormwater discharge outlets, refer **Figure 3**. These devices would be designed in accordance with DWEs guidelines and industry best practice.

3.7.9 Creek Crossing

It will be necessary to cross the water courses at one location. It is proposed that box culverts would be used at this crossing. In accordance with DWEs requirements the culverts would be aligned with downstream channel. They will also incorporate elevated 'dry cells' and recessed 'wet cells' with the invert at or below the stable bed level.

4. CONCLUSION

A best practice water sensitive urban design strategy has been formulated in concert with the ecological and landscape design experts to provide an integrated water management strategy which significantly improves the runoff management and adds value in terms of ecological outcome and visual amenity of the area. The stormwater management strategy proposed for the development which is based on water sensitive urban design principles including:

- rainwater tanks to reuse runoff which reduces the runoff volume and pollutant loads and slows down the flow;
- bio-retention swales along the roads to treat and slow down runoff from lots and roads, and to promote subsurface flows;
- gross pollutant traps to remove sediment, debris, organic matter and litter;
- rehabilitate riparian corridors with native vegetation to stabilise banks and provide significantly improved habitat value;
- provide stormwater quality treatment, storage and promote infiltration in bioretention systems of runoff to balance the surface/subsurface flows and slow down flows; and
- proposes a stormwater monitoring program that will ensure the long term objectives of sustainable development are being achieved.

The strategy would significantly improve the stability, natural function and water quality of the downstream creek systems. This would contribute to the long term improvement in these receiving waters.

The development proposed would significantly reduce runoff pollutant loads below existing levels thereby ensuring no net increase in nutrient/pollutant loads entering watercourses. Best management practice soil and water management practices in accord with the Managing Urban Stormwater guidelines would ensure no net increase in runoff pollutant loads during construction.

Water quality modelling results show that the following two water quality objectives are met:

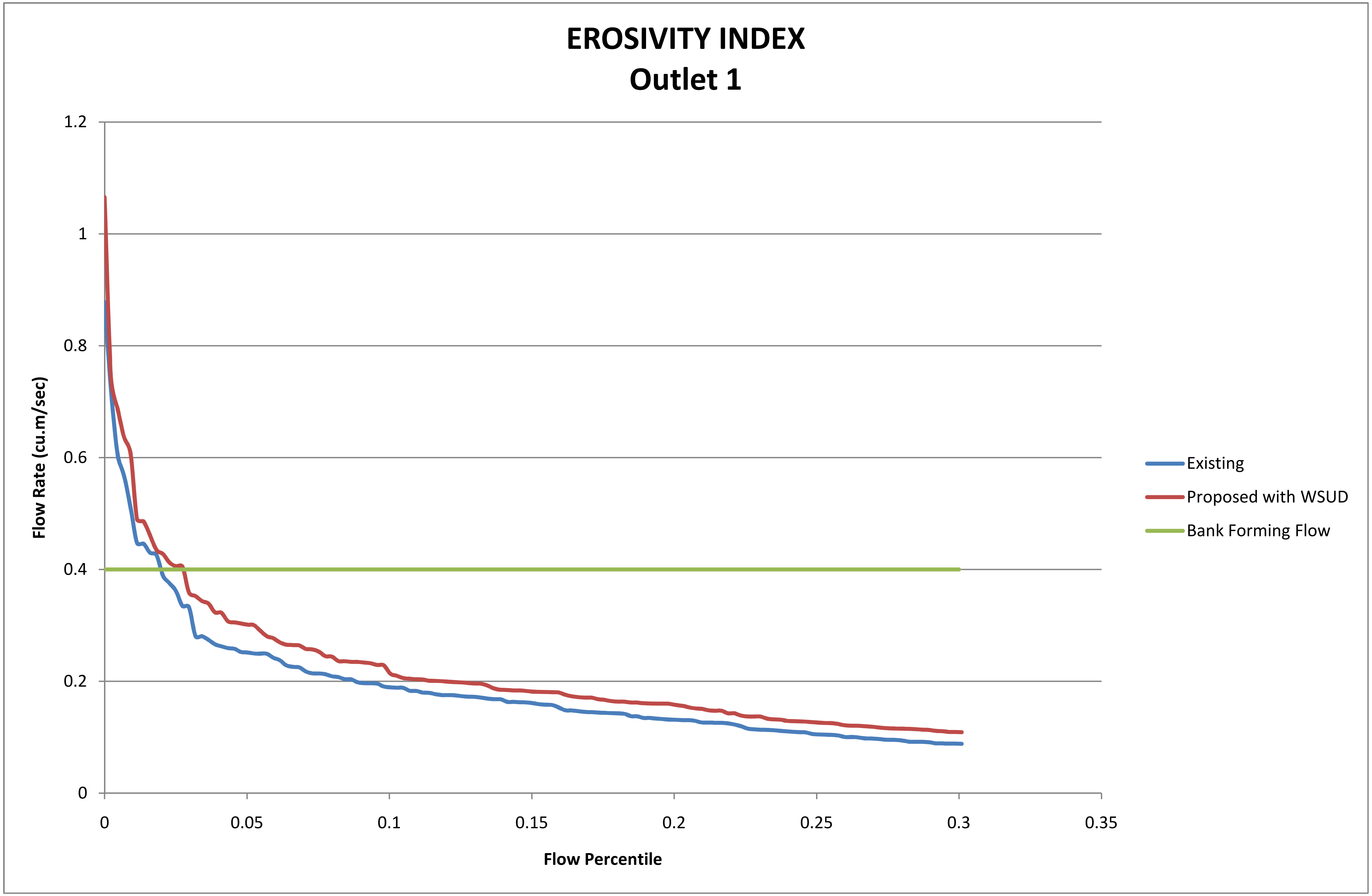
- No increase in the pollutant export loads from the existing to the post developed state; and
- Treatment requirements, i.e. an 80% reduction in TSS, 65% reduction in TP and 45% reduction in TN when comparing the proposed development (*no treatment*) and proposed development (*with treatment*).

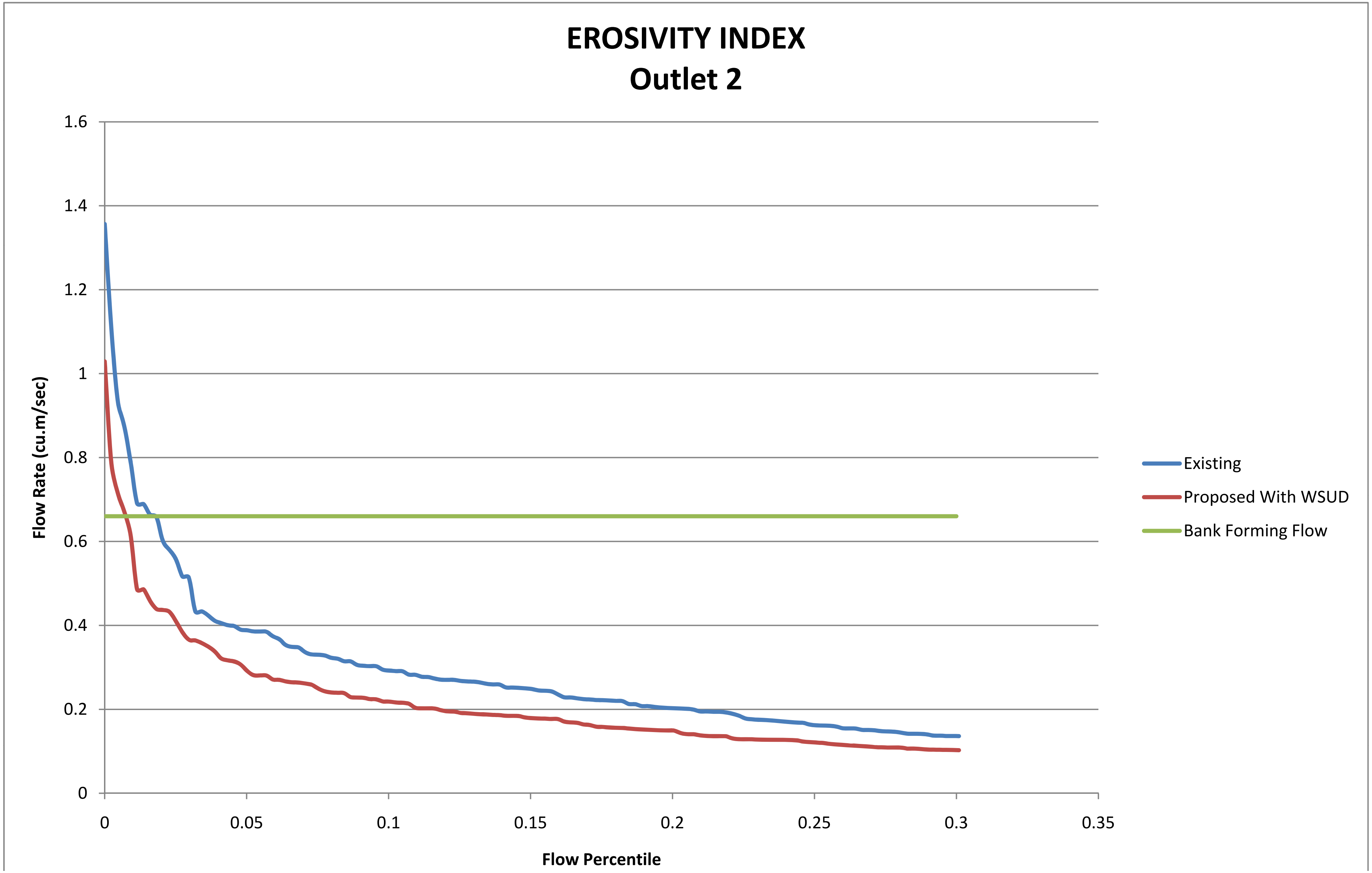
This combination of measures will achieve better than industry best management practice and will contribute significantly to the long term improvement in receiving water quality.

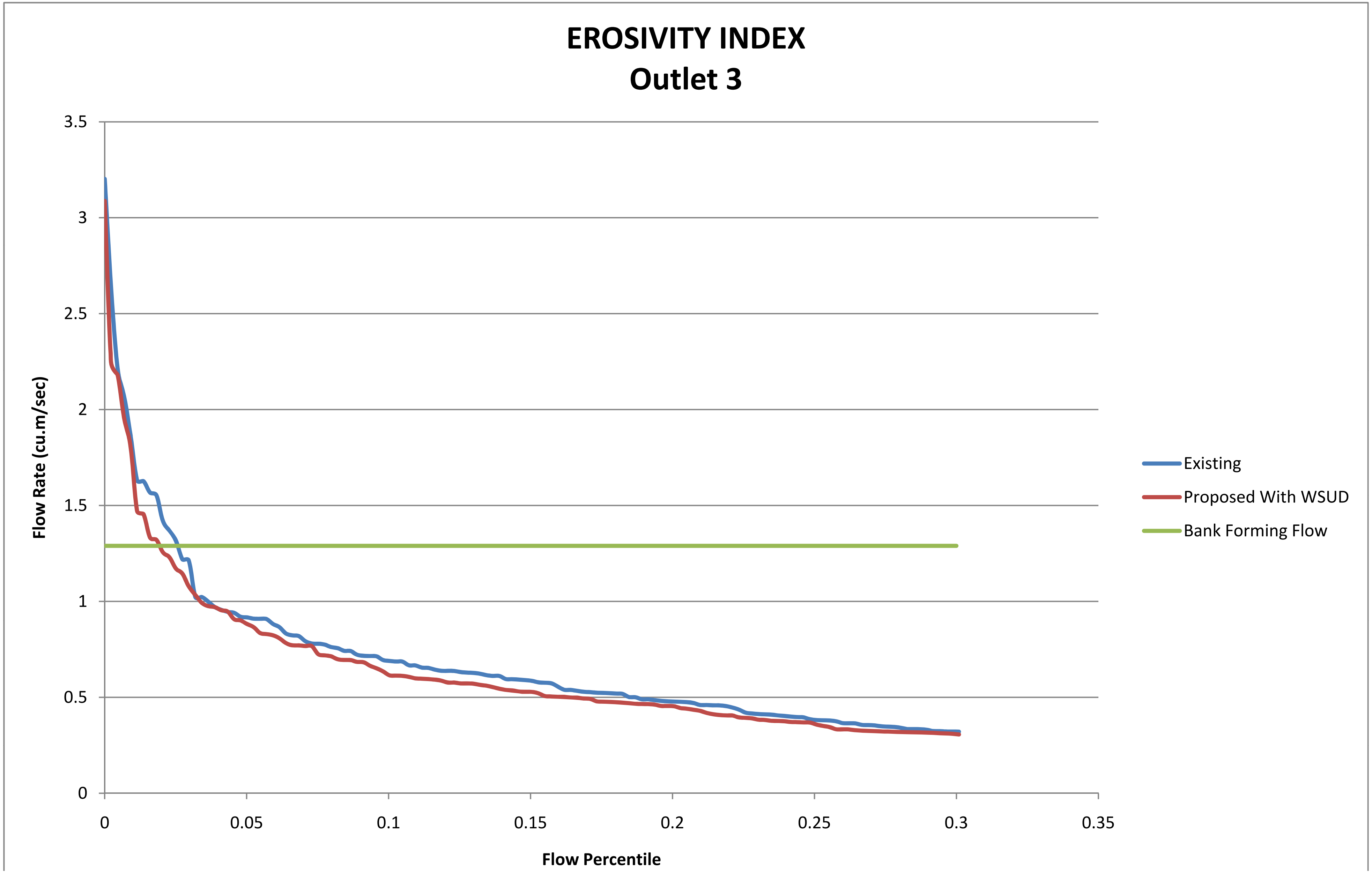
5. REFERNCES

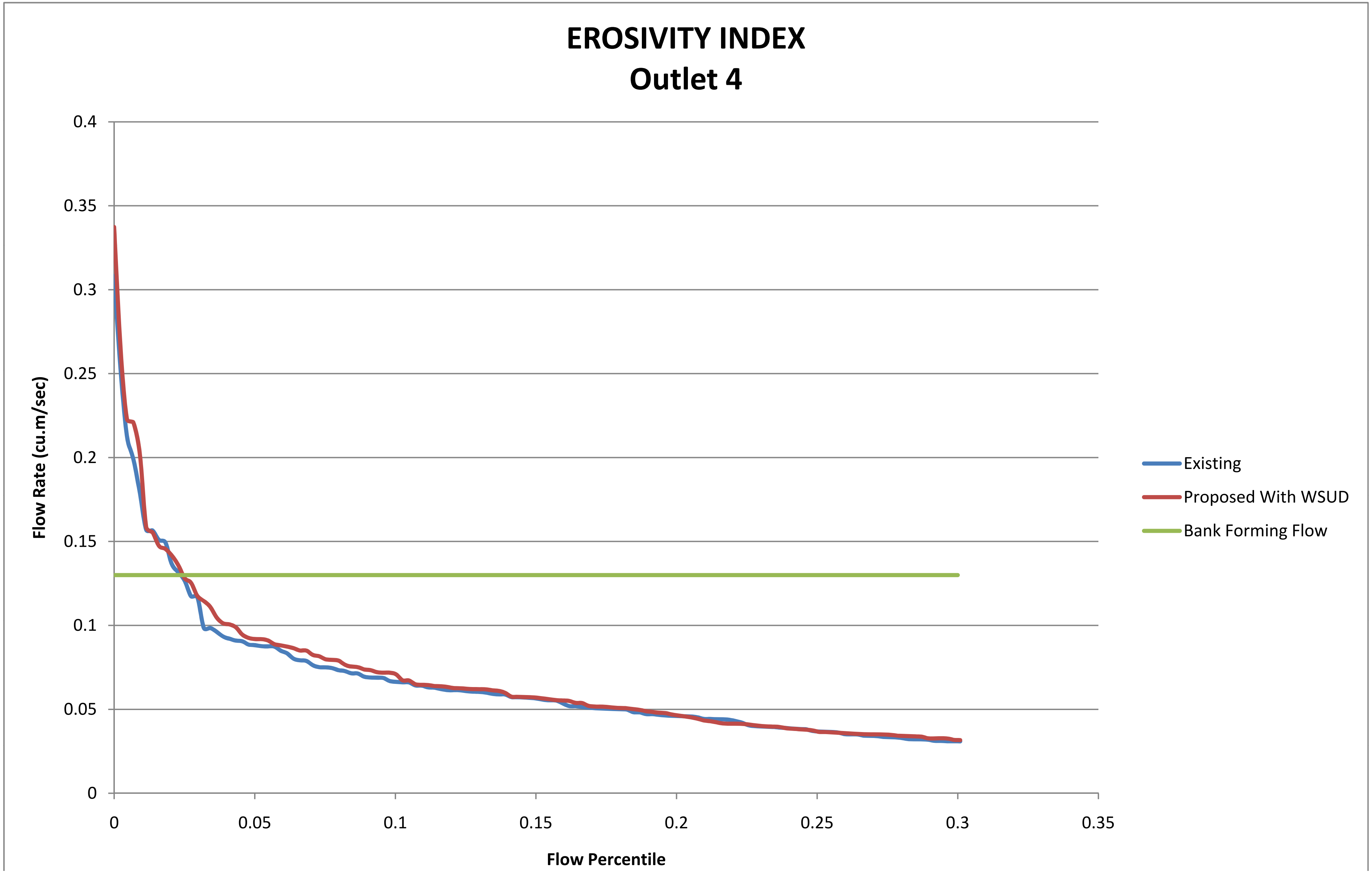
1. Coffs Harbour City Council, *North Bonville DCP*, December 2001
2. Coffs Harbour City Council, *Water Sensitive Urban Design (WSUD) Policy*
3. Gold Coast City Council, *MUSIC Modelling Guidelines,* 2006.
4. Institute of Engineers, Australia, *Australian Rainfall and Runoff*, 1987
5. MUSIC Development Team CRC for Catchment Hydrology, *MUSIC User Manual*, April 2005
6. Department of Environment & Climate Change, *Managing Urban Stormwater: Urban Design – Consultation Draft*, October 2007

Appendix 1 - Erosivity Indices


EROSIVITY INDEX
Outlet 1
Flow Rate (cu.m/sec)
Flow Percentile
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Existing
Proposed with WSUD
Bank Forming Flow


EROSIVITY INDEX
Outlet 2
Flow Rate (cu.m/sec)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Flow Percentile
Existing
Proposed With WSUD
Bank Forming Flow


EROSIVITY INDEX
Outlet 3
Flow Rate (cu.m/sec)
3.5
3
2.5
2
1.5
1
0.5
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Flow Percentile
Existing
Proposed With WSUD
Bank Forming Flow


EROSIVITY INDEX
Outlet 4
Flow Rate (cu.m/sec)
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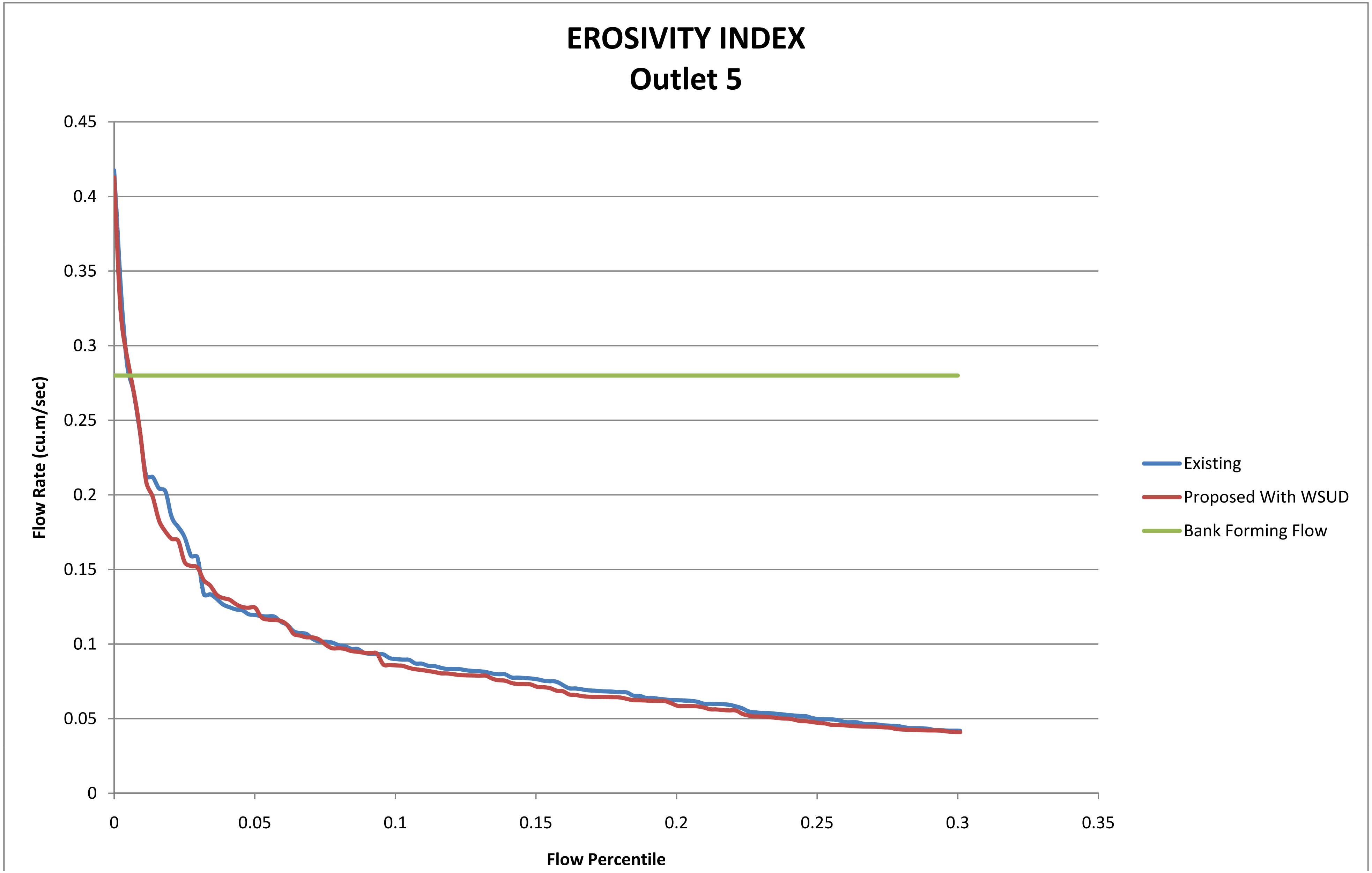
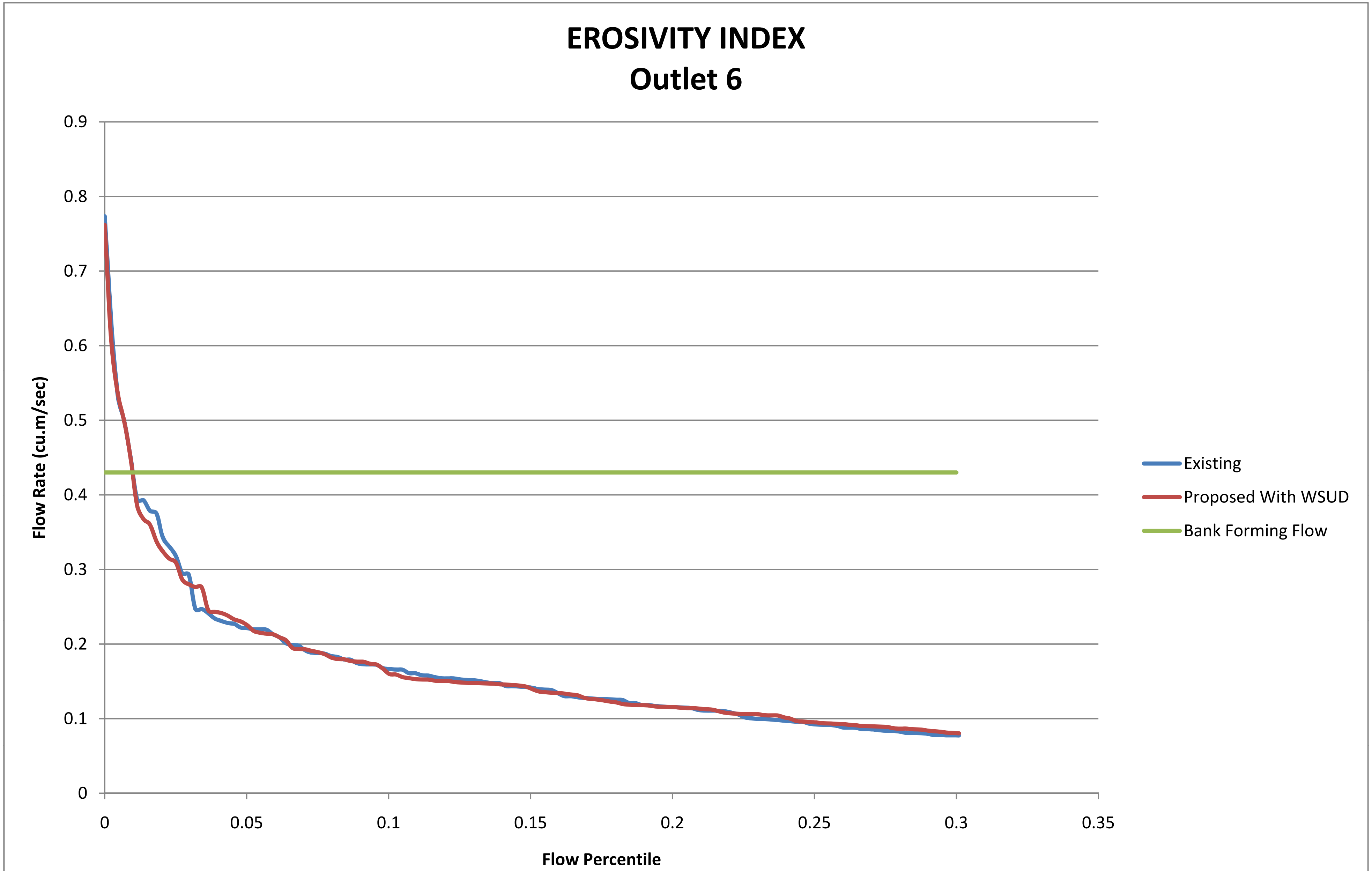
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Flow Percentile
Existing
Proposed With WSUD
Bank Forming Flow



EROSIVITY INDEX
Outlet 5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow Rate (cu.m/sec)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Flow Percentile
Existing
Proposed With WSUD
Bank Forming Flow


EROSIVITY INDEX
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Flow Rate (cu.m/sec)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Flow Percentile
Existing
Proposed With WSUD
Bank Forming Flow