Appendix H

Stormwater Report

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Tweed Shire Council

Report for Eviron Road Quarry and Landfill Proposal

Stormwater and Sediment Management

November 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

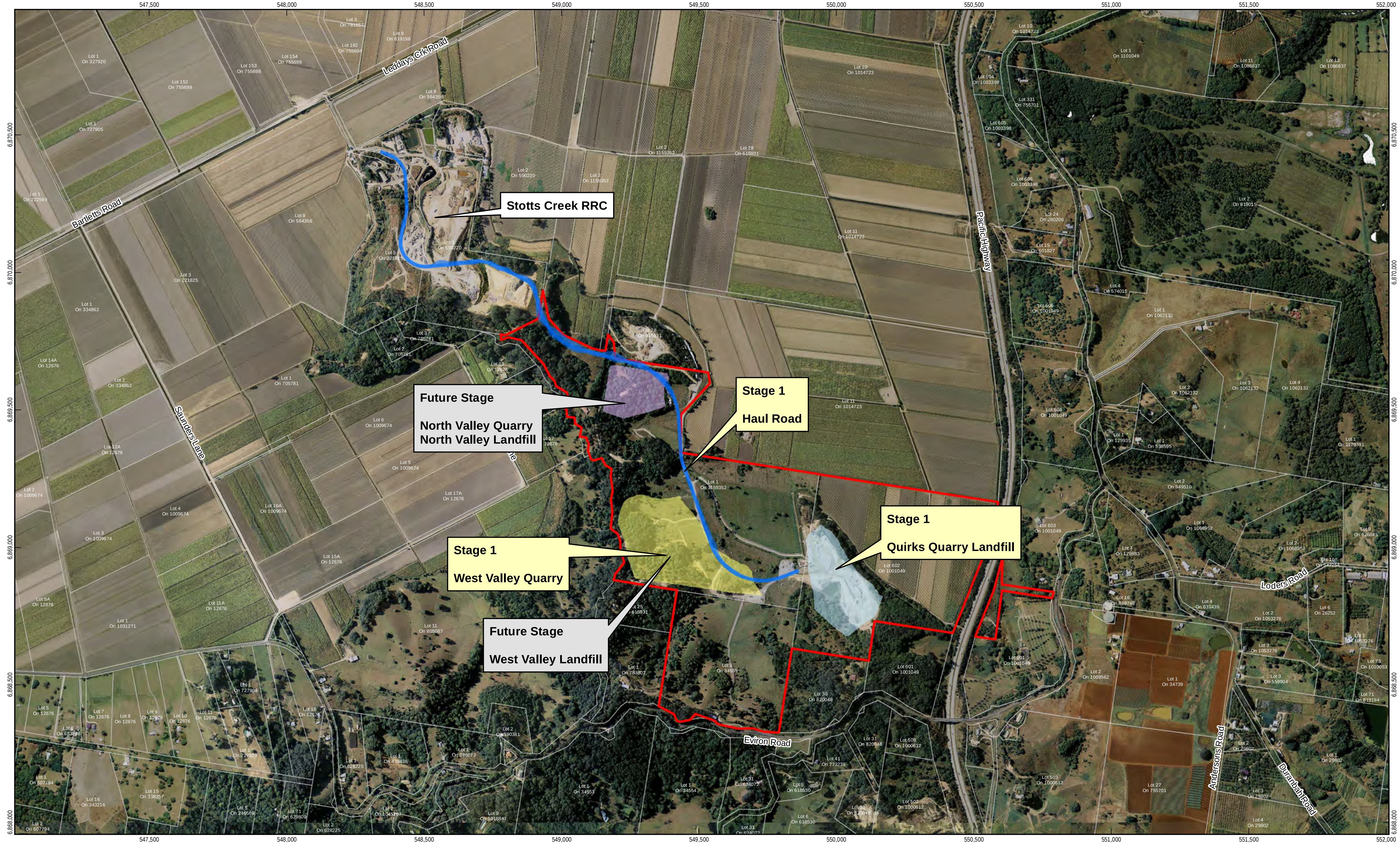
1.1 Project Background

GHD has been commissioned by Tweed Shire Council to Prepare an Environmental Assessment in accordance with the *Environmental Planning and Assessment Act 1979* for the proposed Eviron Road Quarry and Landfill site.

The report identifies potential impacts of the construction and operation of the quarry and measures required for mitigation. This report addresses the stormwater quality and quantity aspects for the proposal as well as the conceptual sediment and erosion management requirements.

1.2 Location and Site Description

The location of the quarry and landfill site falls within the Tweed Shire Council Shire adjacent to the Pacific Highway at Eviron. The council owned site is situated south of Chinderah and approximately 11.3 Kilometres northeast of Murwillumbah and 22 kilometres south of Tweed Heads (Refer to Figure 1.1 below). Specifically the quarry and landfill sites are within Lot 1 DP1159352. The quarry sites are referred to as North and West Valley which fall within Council's Special Purpose Zone 5(a). Council also owns Lot 1 on DP 34555 and Lots 601 & 602 on DP 1001049 which also falls within Zone 5(a).



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Site Boundary
- Cadastre boundary
- Landfill footprint
- West Valley footprint
- North Valley footprint
- Haul Road

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Tweed Shire Council
Eviron Road Quarry and
Landfill Environmental Assessment

Job Number	41-20806
Revision	1
Date	27 MAY 2011

Concept Plan

Figure 1.1

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54-58 Nerang Street Nerang QLD 4211 Australia T 61 7 5557 1000 F 61 7 5557 1000 E goldcoastmail@ghd.com.au W www.ghd.com.au

Data source: Tweed Shire Council - Proposed Haul Road (2011), Aerial Photography (2008), Cadastre boundary (2010). GHD - North Valley footprint (2011), Site Boundary (2011), Landfill footprints (2009), West Valley footprint (2009).

1.3 Topography and Drainage

The North Valley site consists of 3 drainage flow paths that convey surface water to a drainage channel just outside the central northern portion of Lot 1 DP1159352. Site topography varies from approximately 60 m AHD in the northwest to 3 m AHD in the east. The West Valley consists of 2 drainage flow paths that convey surface water to the same drainage channel as the North Valley where flow continues southeast until dispersing into the Stott's Channel. Site topography varies from approximately 78 m AHD in the southwest of Lot 1 DP1159352 to 3 m AHD in the northeastern portion.

Council Flood Mapping shows the 100 year ARI to be 3.9 m AHD. The eastern portion of Lot 1 DP1159352 is therefore inundated with flood back waters from the Tweed River in a regional event.

Detailed catchment information is provided in Section 2 of this report.

1.4 Downstream Environment

The ultimate receiving body is the Tweed River. Stormwater from the North and West Valley Sites flows into natural and man-made drainage channels before entering the Tweed River.

1.5 Data Collection and Review of Background Information

Contour information for the study area was obtained from the following sources:

- GIS property data supplied from Tweed Shire Council;
- Topographic map sheet of the external catchments from the Department of Natural Resources New South Wales; and
- Director Generals and State Agency Requirements.

The following previous studies for the site were also reviewed:

- Site Investigation Addressing Soils, Stratigraphy and Proposed Measures in Relation to Council Land at Eviron, NSW, April 2007, Prepared by Gilbert & Sutherland.
- Eviron Road Quarry and Landfill Proposal – Concept Plan, Stage 1 Application and Preliminary Environmental Assessment, February 2008, Engineering & Operations, Tweed Shire Council.
- Domestic Solid Waste management Strategy for Tweed Shire Council, APrince Consulting environmental management, January 2007;

GHD conducted stormwater quantity analysis to develop the mitigation measures required to maintain Pre development flow rates and minimise local and regional flooding impacts for the proposed construction works. This analysis can be viewed in sections 2 to 4.

2. Catchment Delineation

Catchments for the Landfill and Quarry sites were divided according to each Legal Point of Discharge within Lot 1 DP1159352. Existing external catchments to the west and south of the North and West Valley are referred to as Ext and the Quarry catchment boundaries which contribute to each LPD are referred to as Q. The Post development catchment delineation varies due to the reshaping of the site according to the landfill. The External catchment properties are the same for the Pre and Post development conditions and are diverted around the site to the existing drainage channel that traverses the site. The report calculations and figures cover three development conditions, Pre (Existing), Post (prior to landfill) and Ultimate (at landfill completion) Development conditions.

2.1 LPD A1

This Legal Point of Discharge is located in the North Valley site at the northern boundary line. A small external catchment contributes to the drainage flow path that traverses the north valley site in a North West direction until converging with another tributary that travels north toward Tweed River.

Refer to Figure 2.1 and 2.2 for Pre and Post Development catchment plans.

2.2 LPD A2

This Legal Point of Discharge is located in the North Valley site at the eastern boundary line. A small external catchment contributes to the drainage flow path that traverses the north valley site in a south east direction until converging with the drainage channel that travels toward Stott's Channel.

Refer to Figure 2.1 and 2.2 for Pre and Post Development catchment plans

2.3 LPD B

This Legal Point of Discharge is also located in the North Valley site at the eastern boundary line. The site sub-catchment contributes to the drainage flow path that traverses the north valley site to the east until converging with the drainage channel that travels toward Stott's Channel.

Refer to Figure 2.1 and 2.2 for Pre and Post Development catchment plans.

2.4 LPD C

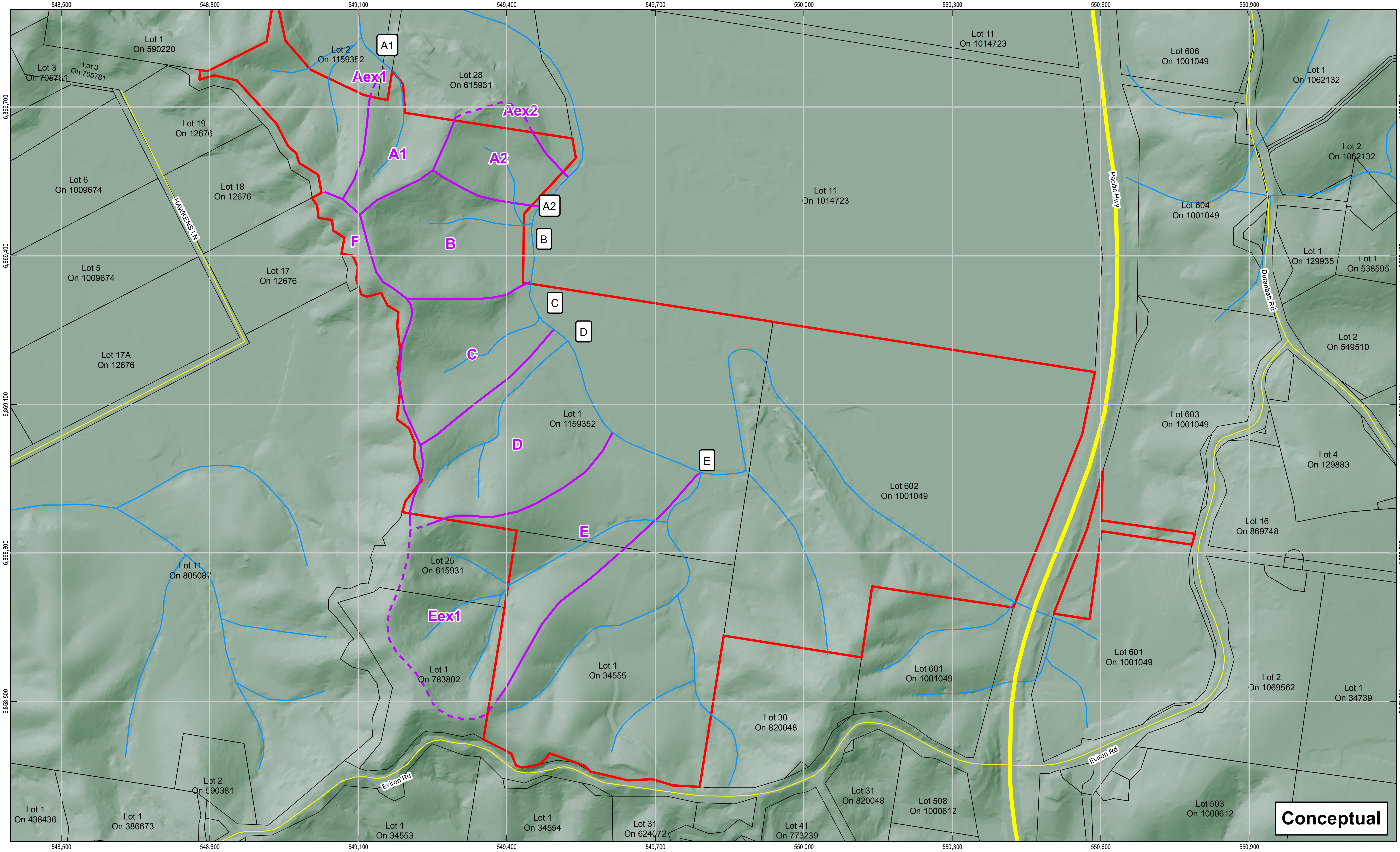
This Legal Point of Discharge is located in the West Valley site in the central portion of Lot 1 DP1159352. The site sub-catchment contributes to the drainage flow path that traverses the West Valley site to the northeast until converging with the drainage channel that travels toward Stott's Channel.

Refer to Figure 2.1 and 2.2 for Pre and Post Development catchment plans.

2.5 LPD D

This Legal Point of Discharge is also located in the West Valley site in the central portion of Lot 1 DP1159352. The site sub-catchment contributes to the drainage flow path that traverses the west valley site to the northeast until converging with the drainage channel that travels toward Stott's Channel.

Refer to Figure 2.1 and 2.2 for Pre and Post Development catchment plans.



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Metres

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Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Site Boundary
- Existing Drainage Lines
- External Catchment Boundaries
- Quarry Catchment Boundaries
- B Legal Point of Discharge

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Tweed Shire Council
Eviron Quarry & Landfill Site

Job Number	41-20806
Revision	2
Date	31 OCT 2011

Pre Development
Catchment Delineation Plan

Figure 2.1

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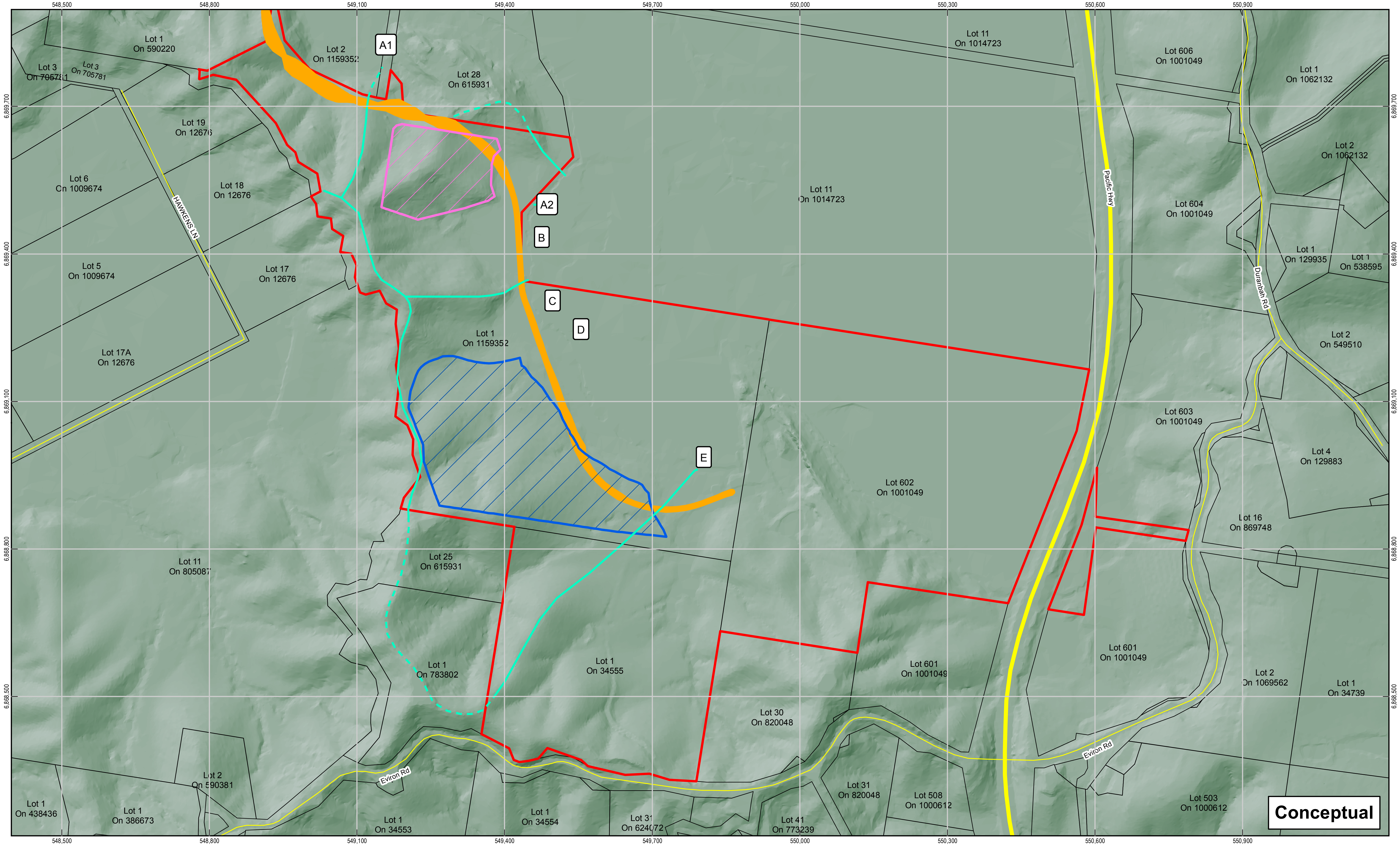
54-58 Nerang Street Nerang QLD 4211 Australia T 61 7 5557 1000 F 61 7 5557 1000 E goldcoastmail@ghd.com.au W www.ghd.com.au

Data source: Tweed Shire Council - Cadastre boundary (2010). GHD - Site Boundary (2011), Roads, Existing Drainage Lines, Catchment Boundaries, Legal Point of Discharge, Hillshade (Derived from Tweed Shire Council ALS data) (2010).



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Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

N

LEGEND

- Site Boundary
- North Valley
- West Valley
- Existing Drainage Lines
- External Catchment Boundaries
- Quarry Catchment Boundaries
- Haul Road
- B Legal Point of Discharge

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Tweed Shire Council
Eviron Quarry & Landfill Site

Job Number 41-20806
Revision 2
Date 31 OCT 2011

Post Development
Catchment Delineation Plan

Figure 2.2

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54-58 Nerang Street Nerang QLD 4211 Australia T 61 7 5557 1000 F 61 7 5557 1000 E goldcoastmail@ghd.com.au W www.ghd.com.au

Data source: Tweed Shire Council - Haul Road (2011), Cadastre boundary (2010). GHD - Site Boundary (2011), Roads, Existing Drainage Lines, Catchment Boundaries, Legal Point of Discharge, Hillshade (Derived from Tweed Shire Council ALS data) (2010), West Valley (2010), North Valley (2011).

3. Hydrologic Assessment

Hydrologic assessment of the quarry sites has been undertaken to identify peak flow rates for the catchments under Pre, Post and Ultimate development conditions. The Pre development scenario or existing scenario is what happens in the catchments currently, Post development is what will occur after quarrying / construction, without provisions of mitigation to match existing conditions; and Ultimate development is the Post development catchments that are mitigated with devices to mimic Pre development conditions. Due to the development having two stages, quarrying and landfill, the devices proposed for mitigation will have different roles; however the sizes will remain the same. Prior to quarrying commencing sediment basins will be built to control sediment dispersion and increase in surface flows running off the cleared catchment. Upon completion of landfill, the sediment basins will be converted into wetlands. Due to the site almost replicating pre development conditions in the Ultimate scenario, requirements for detention will be minimal, however, the size of the wetland systems have been determined by the necessary water quality objectives and environmental values such as aesthetics and habitat production as well as preventing further oxidation of PASS (Potential Acid Sulphate Soils). This scenario is also concurrent with the Botanical Gardens theme of the area.

XP-Storm modelling was used to determine the critical storm durations using 10, 15, 20, 25, 30, 45, 60, 90, 120 and 180 mins to determine peak flows for the 1 year ARI up to and including the 100 year ARI of all catchments contributing to each LPD.

3.1 Model Description

XP-Storm is a runoff routing link-node model that performs hydrology and hydraulics of stormwater drainage systems. XP-Storm generates flow hydrographs, flood levels, pollutant loads or concentrations and analyses water quality control devices. The software offers all the commonly accepted methods for generating stormwater runoff and is capable of modelling and comparing multiple storm events.

3.2 Model Data

XP-Storm estimates the runoff hydrograph from an individual sub-catchment based on rainfall intensities and temporal patterns, and the definition of a series of parameters that describe the sub-catchment characteristics. These parameters include the sub-catchment area, slope, roughness, infiltration and fraction of impervious area.

Sub-catchment outflow hydrographs are routed downstream through the model via links. In XP-Storm, links take the form of either lag links or routing links. Lag links delay the hydrograph by a user specified time interval representing the time it takes for the flow to travel downstream to the next node. Routing links perform Muskingum-type channel routing calculations and require channel cross sectional dimensions and the slope, roughness and the length of the channel.

Sub-Catchment Data:

The sub-catchment areas are shown in Figures 2.1 and 2.2 are presented in the XP-Storm model by nodes at the outlet of the sub-catchment. Junction nodes are used to combine hydrographs at the junction of two or more flow paths.

Sub-catchment areas were determined digitally using ACAD software.

Sub-catchment equal-area slopes were determined using the Contour and Topographic information referenced in Section 1.5.

Sub-catchment roughness was determined based on an area-weighted average of the roughness values shown in Table 3.1.

Table 3-1 XP-Storm Sub-Catchment Properties Pre Development Conditions

Node	Area (ha)	% Impervious	Manning's (Impervious)	Slope %	IL	CL
Aex1	0.61	0	0.045	17.0	10	2
A1	2.31	0	0.045	19.5	10	2
Aex2	0.9	0	0.045	7.0	10	2
A2	3.13	0	0.045	11.5	10	2
B	6.09	0	0.045	6.5	10	2
C	6.06	0	0.045	6.5	10	2
D	8.58	0	0.045	13	10	2
Eex1	7.47	0	0.045	21.5	10	2
E	9.72	0	0.045	11	10	2

Note: IL = Initial Loss (mm), CL = Continuing Loss (mm).

Table 3-2 XP-Storm Sub-Catchment Properties Post Development Conditions

Node	Area (ha)	% Impervious	Manning's (Impervious)	Slope %	IL	CL
Aex1	0.61	0	0.045	17.0	10	2
A1	0.37	0	0.045	19.5	10	2
Aex2	0.90	0	0.045	7.0	10	2
A2	2.34	0	0.045	11.5	10	2
B	10.38	3	0.015	6.5	10	2
CD	16.76	3	0.015	4	10	2
Eex1	7.47	0	0.045	4	10	2
E	8.33	0	0.045	11	10	2

Note: IL = Initial Loss (mm), CL = Continuing Loss (mm).

As mentioned in Section 2 and depicted in Tables 3.2 and 3.3 above, external catchment properties remain unchanged other than a bypass channel conveying flows around the quarry / Landfill sites and into the drainage channel that flows to Stott's Channel. The significant changes between Pre and Post Development is the Manning's properties, existing vegetation is cleared and therefore provides less attenuation and retention of stormwater which creates an increase in flow rates.

3.3 Sensitivity Analysis / Model Validation

The XP-Storm model results were compared to the rational method results as a cross check to determine whether the parameters adopted within the Runoff Routing model are reasonable. While the Rational method is only an estimation of the Peak flow rate exiting the catchment, the runoff routing results should be in the same range as the magnitude of the XP-Storm hydrographs for each catchment.

A comparison of the XP-Storm and Rational Method peak flow rates for the 2, 50 and 100 year ARI event can be viewed in Tables 3.3 and 3.4 below.

Full Rational method calculation details and XP Storm Results are Presented within Appendix A and B respectively at the end of this report.

Table 3-3 Existing Development Comparison of XP-Storm and Rational Method

Catchment	**Peak Flow (m3/s)**					
	2 Year ARI		50 Year ARI		100 Year ARI	
	XP	Rational	XP	Rational	XP	Rational
Aex1	0.165	0.08	0.337	0.20	0.383	0.24
A1	0.7	0.31	1.378	0.78	1.555	0.94
Aex2	0.266	0.12	0.527	0.29	0.596	0.35
A2	0.863	0.44	1.751	1.09	1.986	1.30
B	0.97	0.81	2.262	2.03	2.626	2.43
C	0.998	0.76	2.351	1.91	2.723	2.28
D	1.345	1.10	3.123	2.77	3.627	3.30
Eex1	1.875	1.04	3.91	2.59	4.453	3.11
E	1.299	1.16	3.079	2.93	3.532	3.52

Table 3-4 Post Development Comparison of XP-Storm and Rational Method

Catchment	Peak Flow (m3/s)					
	2 Year ARI		50 Year ARI		100 Year ARI	
	XP	Rational	XP	Rational	XP	Rational
Aex1	0.165	0.08	0.337	0.20	0.383	0.24
A1	0.147	0.06	0.259	0.14	0.288	0.17
Aex2	0.266	0.12	0.527	0.29	0.596	0.35
A2	0.644	0.33	1.308	0.81	1.483	0.97
B	2.887	1.60	5.826	3.94	6.603	4.71
CD	2.79	2.37	6.685	5.91	7.726	7.09
Eex1	1.875	1.04	3.91	2.59	4.453	3.11
E	1.114	1.00	2.641	2.51	3.029	3.02

As can be seen in Table 3-1 to 3-4, there is a reasonable level of increase between the flow rates predicted by XP-Storm and those derived using the Rational Method. It is concluded that the XP-Storm model produces more conservative results to an acceptable level of accuracy for the purposes of this report.

3.4 Detention Basin Requirements

Detention areas were modelled within the XP-Storm model to attenuate the increase in runoff from the additional development works for the quarrying and landfill processes. Percentage increase values can be viewed within Appendix B of this report. The initial sizes of these systems were determined by the sediment production yield and water quality results presented in sections 5 and 6 of this report.

To maintain Water Quality Objectives, minimum sizes of treatment devices were proposed according to the capacity requirement of the calculated sediment accumulation volumes as well as supported by MUSIC modelling. The XP-Storm models were run various times to achieve both stormwater quantity and quality objectives. Detention basin locations can be viewed in Figure 5.2 and 5.3. Cross section details can be viewed in Appendix C of this report. The detention basins have 100 Year ARI regional flood immunity. All basins will be fenced to prevent access due to depth and size of the systems.

Ultimate (Mitigated) flows and water levels are shown in Table 3.5. A summary of the total peak flow rates from the Pre and Ultimate development at each LPD can be viewed in Table 3.6. As depicted in Table 3.6 the proposed detention areas Presented in Table 3.5 maintain Pre development flow rates in the Ultimate development scenario.

Table 3-5 Required Area and Volume for Stage 2 Stormwater Treatment Devices for Quality and Quantity Purposes

					100 yr ARI Peak flows m3/s			WL 20yr	WL 100yr
Legal Point of Discharge	Minimum Area (m^2)	Treatment Depth (m)	Storage Depth (m)	Total Volume (m^3)	Pre	Ultimate	Diff	Depth* (m)	Depth* (m)
B	6,835	0.25	0.80	5,040	2.625	2.525	-3.77%	0.61	0.70
C & D	9,500	0.25	0.80	7,310	6.345	4.15	-34.67%	0.63	0.69

Table 3-6 Total Peak Flows (m^3/s) for the Pre and Ultimate Development Conditions at the LPDs

Legal Point of Discharge	1 year ARI			2 year ARI			10 year ARI			20 year ARI			50 year ARI			100 year ARI		
	Pre	Ult	Diff %	Pre	Ult	Diff %	Pre	Ult	Diff %	Pre	Ult	Diff %	Pre	Ult	Diff	Pre	Ult	Diff %
A1	0.59	0.21	-63%	0.83	0.29	-64%	1.30	0.45	-65%	1.55	0.54	-65%	1.68	0.58	-65%	1.90	0.65	-65%
A2	0.76	0.61	-19%	1.09	0.88	-19%	1.72	1.38	-19%	2.06	1.66	-19%	2.24	1.80	-19%	2.54	2.04	-19%
B	0.68	0.42	-38%	0.97	0.71	-27%	1.60	1.23	-23%	1.93	1.64	-14%	2.26	2.06	-8%	2.62	2.53	-3%
CD	1.64	0.52	-68%	2.34	0.76	-67%	3.86	1.96	-49%	4.67	2.64	-43%	5.48	3.36	-38%	6.35	4.15	-34%
E	1.95	1.84	-5%	2.77	2.59	-6%	4.58	4.29	-6%	5.55	5.20	-6%	6.46	6.05	-6%	7.44	6.96	-6%

Note: * This is the depth above the permanent standing water level of the wetland / sediment pond system.

Detention Basin Sections showing weir heights, length, basin stage storage characteristics etc, can be viewed in Appendix C of this report.

3.5 Model Assumptions

Channel USIL and DSIL data not supplied by the data mentioned in section 1.5 was interpolated based on the closet contour to the channel. All entry and exit losses to all proposed pipes have been modelled as 0.5 and 1.0 respectively as a conservative approach. All proposed caged riser inlets have been modelled with a 50% blockage factor and weirs have been sized to convey the 100 year ARI event.

3.6 Model Results

XP-Storm results for the critical storm duration and peak flow rates for the 1 Year ARI up to and including the 100 Year ARI are presented in Appendix B.

A summary of the XP-Storm modelling results in the Post-Mitigated scenario is provided in Table 3.4.

A summary of the required area for local flood mitigation and treatment can be viewed in Table 3.5. As depicted in Table 3.6 the proposed detention areas presented in Table 3.5 maintain Pre Development (existing) flow rates in the Ultimate development scenario.

3.6.1 Model breakdown:

LPD A1 – In the pre development case, a 0.94ha catchment flows north toward LPD A1 where Aex1 joins the flow path near the central northern boundary of Lot 1 DP1159352 as indicated in Figure 2.1.

In the Post Developed and Ultimate scenarios the external catchments remain the same however catchment A1 is reduced significantly due to the most of this catchment now converging with catchment B for quarrying and land fill purposes. The proposed haul road cuts through catchment A1 and what is left north of the haul road is unchanged and contributes to LPD A1, the area within to the south of the road contributes to LPD B. Refer to Figure 2.2.

Due to an overall catchment reduction no mitigation is required for catchment A1.

LPD A2 – In the pre development case catchments Aex2 and A2 flow south east toward LPD A2 as depicted in Figure 2.1.

In the Post Developed and Ultimate scenarios the external catchments remain the same however catchment A2 is reduced due to the proposed haul road that cuts through catchment A2 and as above in catchment A1, what is to the left north of the haul road is unchanged and contributes to LPD A2, the area within to the south of the road contributes to LPD B. Refer to Figure 2.2.

Due to an overall catchment reduction no mitigation is required for catchment A2.

LPD B – In the pre development scenario, flows from catchment B travel east along the existing drainage flow path to LPD B on the northern lot boundary as indicated in Figure 2.1.

There are no external catchments associated with this catchment.

In the Post Developed and Ultimate scenarios catchment B is increased in area by including parts of Catchment A1, A2 and F. Mitigation is required in the form of a detention area of which consists of two functions. In the “Stage 1” process the detention area will act as a sediment basin to collect all sediment that flows off the cleared land during quarrying and land filling. Upon completion of the landfill “Stage 2” and rehabilitation of the area is complete, the sediment basins will be converted into wetlands. The size of the system remains the same in both stages and was determined by sediment volume requirements shown in Section 6 of this report. Final sizes have been confirmed using runoff routing software XP Storm. The pre development flow rates are maintained in both Stages 1 and 2 as shown in Table 3.5 and Appendix B of this report. The outlet of this detention system disperses into the existing channel through 4 x 375mm culverts at a 100 year ARI flow of 0.9m3/s and velocity of 2m/s. The remaining flows pass over the road which will be designed as a spillway at the basin weir location. Refer to Appendix C for detention basin section details.

All outlets are to be scour protected up to a distance of 4 x diameter of the outlet pipe.

LPD C and D – In the pre development scenario, flows from catchments C and D travel north east along the existing drainage flow paths to LPD C and D in the western portion of the council owned lot. Refer to Figure 2.1.

There are no external catchments associated with this catchment.

In the Post Developed and Ultimate scenarios catchments C & D are combined in area and includes part of catchment E and the remaining portion of catchment F. Mitigation is also required in the form of a detention area as per catchment B of which consists of two functions. In the “Stage 1” process the detention area will act as a sediment basin to collect all sediment that flows off the cleared land during quarrying and land filling. Upon completion of the landfill “Stage 2” and rehabilitation of the area is complete, the sediment basins will be converted into wetlands. The size of the system remains the same in both stages and was determined by sediment volume requirements shown in Section 6 of this report. Final sizes have been confirmed using runoff routing software XP Storm. The pre development flow rates are maintained in both Stages 1 and 2 as shown in Table 3.5 and Appendix B of this report. The outlet of this detention system disperses into the existing channels through 2 x 2 x 375mm culverts at a 100 year ARI flow of 0.475m3/s and velocity of 2.2m/s per pair. The remaining flows pass over the road which will be designed as a spillway at the basin weir location. Refer to Appendix C for detention basin section details.

All outlets are to be scour protected up to a distance of 4 x diameter of the outlet pipe.

LPD E – In the pre development case catchments Eex1 and E flow north east toward LPD E as depicted in Figure 2.1.

In the Ultimate case the drainage regime is the same except with the reduction to catchment E which in affect reduces the peak runoff and ameliorates the need for a mitigation device.

A summary of the XP-Storm modelling results in the Ultimate scenario is provided in Table 3.4.

3.7 Haul Road Infrastructure Requirements

A number of road culverts have been proposed to pass under the proposed haul road from the quarry areas and into the existing drainage channel. These include:

- 4 x 600mm RCPs at the tributary crossing between the Stott’s Creek landfill Site and proposed North valley Site (approx. 5ha catchment, tc of 18mins with approach flow of 2m^3/s);
- 4 x 375mm RCPs at LPD B;
- 2 x 375mm RCPs at LPD C;
- 2 x 375mm RCPs at LPD D; and
- 4 x 600mm RCPs at LPD E.

Refer to Section 4 for hydraulic assessment. The first 4 x 600mm RCPs are not included in the hydraulic modelling. Upon design finalisation of the proposed haul road, peak flow rates will be determined and culvert sizing will be performed for this catchment, however due to it being outside the proposed quarrying / landfill site, detailed calculations have not been performed.

4. Hydraulic Assessment

An hydraulic assessment has been undertaken to identify the affects of peak flood levels and the extent of flooding inundation at the quarry sites under Pre, Post and Ultimate development conditions. The XP-Storm hydraulic model was used for the hydraulic assessment. The hydraulic assessment was undertaken for the 100 year local ARI flood events during the Tweed Shire Council (TSC) recorded Regional peak flood level of 3.9 m AHD.

While the haul road has been designed to act as a levee bank preventing back water from the Tweed River from entering the quarry sites, the outlets of the sediment basins / Wetlands will be affected by the tail water level of the regional flood. These basins will be checked through modelling to assess whether the system is adequately sized to prevent flooding of the quarry sites from the contributing local catchments and can still drain accordingly.

4.1 Model Description

XP-Storm was used for the hydraulic modelling of the 4 major flow paths passing underneath the proposed haul road from the catchments upstream and into the existing drainage channels that are situated within flood prone land.

Ground Roughness Values

Ground roughness was represented by the Manning's 'n' parameter. Manning's roughness values were assigned on the basis of vegetation density as observed during field inspections and/or aerial photography. The assumed roughness values varied from 0.015 for pavement areas, 0.045 for grassed areas, 0.07 for densely vegetated areas and 0.1 for forest areas.

Hydraulic Structures

A number of road culverts have been proposed to pass under the proposed haul road from the detention areas and into the drainage channel. These include:

- 4 x 375 mm RCPs at LPD B, The proposed US/IL 3.2 m AHD and DS/IL 3.1 m AHD length of 25 m and proposed road height of 4.2m.
- 2 x 375 mm RCPs at LPD C, The proposed US/IL 3.2 m AHD and DS/IL 3.1 m AHD length of 25 m and proposed road height of 4.2m.
- 2 x 375 mm RCPs at LPD D, The proposed US/IL 3.2 m AHD and DS/IL 3.1 m AHD length of 25 m and proposed road height of 4.2m.
- 4 x 600 mm RCPs at LPD E, The proposed US/IL 9.0 m AHD and DS/IL 8.7m AHD length of 25 m and proposed road height of approximately 10.0 m.

Flow Rates

Flows for the Ultimate Development 50 & 100 Year ARI Local flood events from:

- Catchment B – 2.06 m^3/s and 2.52 m^3/s respectively.
- Catchment CD – 3.364 m^3/s and 4.5 m^3/s respectively.
- Catchment E – 6.06 m^3/s & 6.96 m^3/s respectively.

Flows for 50 & 100 year ARI flood events were obtained from the XP-Storm model results.

4.2 Model Results under Normal Conditions

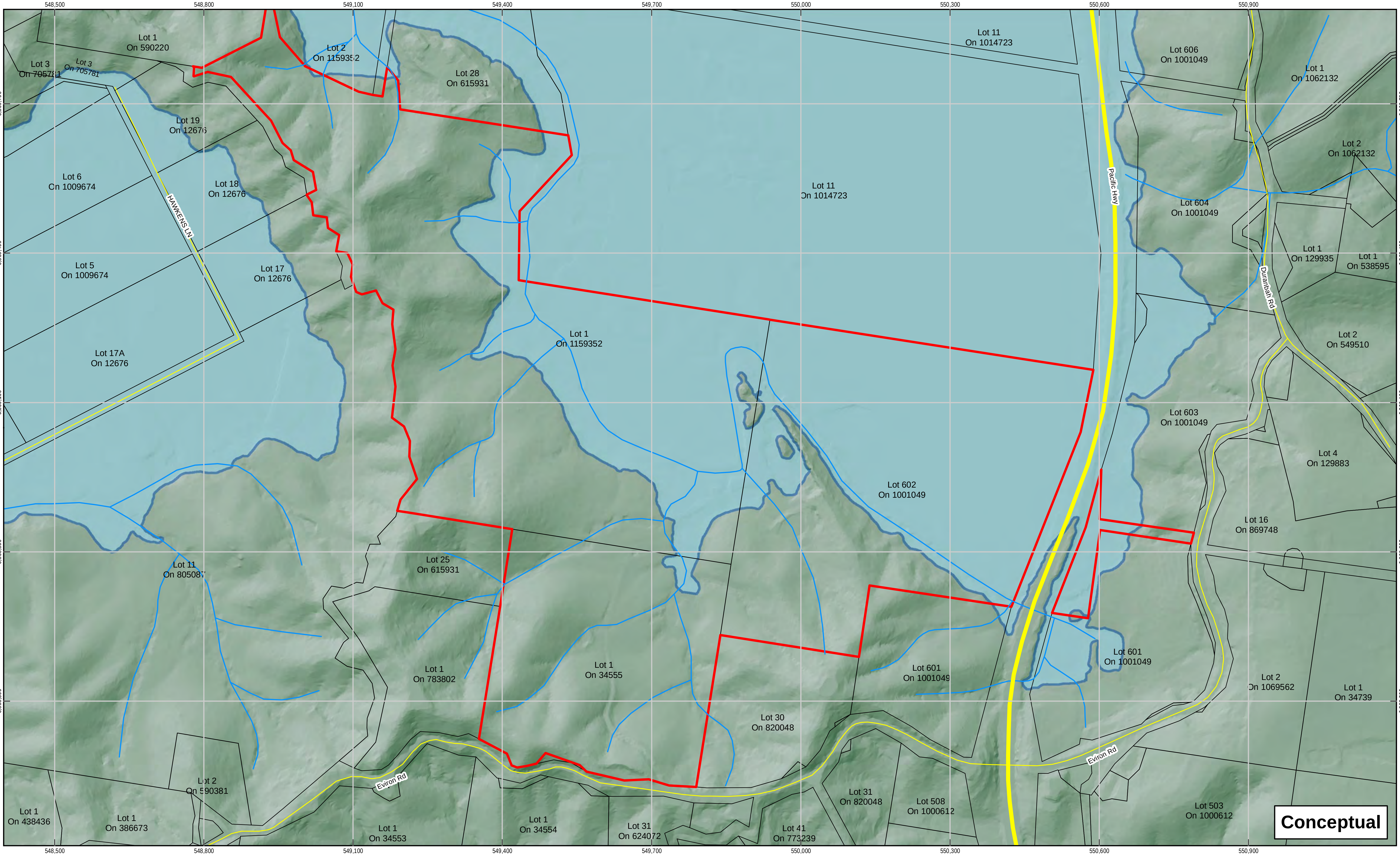
Ultimate Development case:

Table 4.1 Hydraulic Modelling Results

50 Year ARI				**100 Year ARI**			
Culvert	Discharge	Water Level	Weir Flow	Culvert	Discharge	Water Level	Weir Flow
B	0.9	4.36	1.585	B	0.9	4.395	1.585
C	0.45	4.36	1.964	C	0.47	4.39	2.58
D	0.45	4.36	1.964	D	0.47	4.39	2.58
E	3.425	10.25	2.52	E	3.52	10.3	3.53

A full investigation of the regional flood inundation affects are not part of the scope of this report, however regional flood levels have been shown in Figures 4.1 to 4.3 and backwater conditions at the LPD of the detention areas have been assessed through hydraulic modelling for drainage adequacy. Weir levels of the detention areas have been set 300 mm above the regional Flood level and therefore can drain adequately and are unaffected by the regional flood event tail water effects.

A flood area balance is required due to the haul road encroaching and reducing the flood storage area of Lot 1 DP1159352. It is proposed to provide cut volumes to the east of the proposed haul road to balance the difference; however, flood modelling has not been performed to verify the effects of the haul road.



0 100 200 300
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Site Boundary
- Existing Local Flood Lines
- Existing Regional Flood Area (100 Year ARI)

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Tweed Shire Council
Eviron Quarry & Landfill Site

Job Number	41-20806
Revision	1
Date	27 MAY 2011

Pre Development
Flood Inundation Area

Figure 4.1

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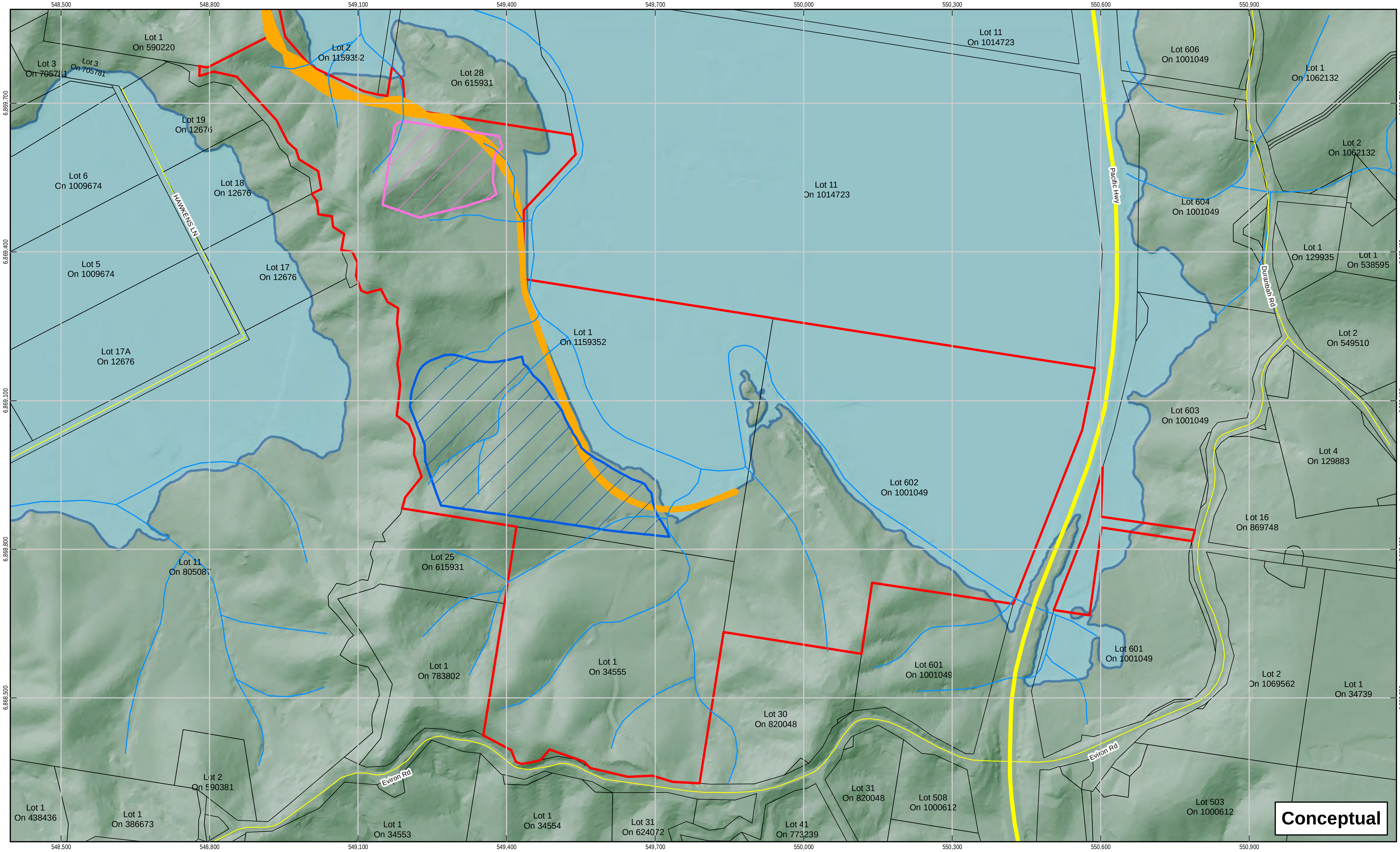
54-58 Nerang Street Nerang QLD 4211 Australia **T** 61 7 5557 1000 **F** 61 7 5557 1000 **E** goldcoastmail@ghd.com.au **W** www.ghd.com.au

Data source: Tweed Shire Council - Cadastre boundary (2010). GHD - Site Boundary (2011), Roads, Existing Drainage Lines, Hillshade (Derived from Tweed Shire Council ALS data), Flood Area (2011).



0 100 200 300

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND

- Site Boundary
- Haul Road
- North Valley
- Developed Local Flood Line
- West Valley
- Developed Regional Flood Area (100 Year ARI)

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Post Development
Flood Inundation Area

Figure 4.2

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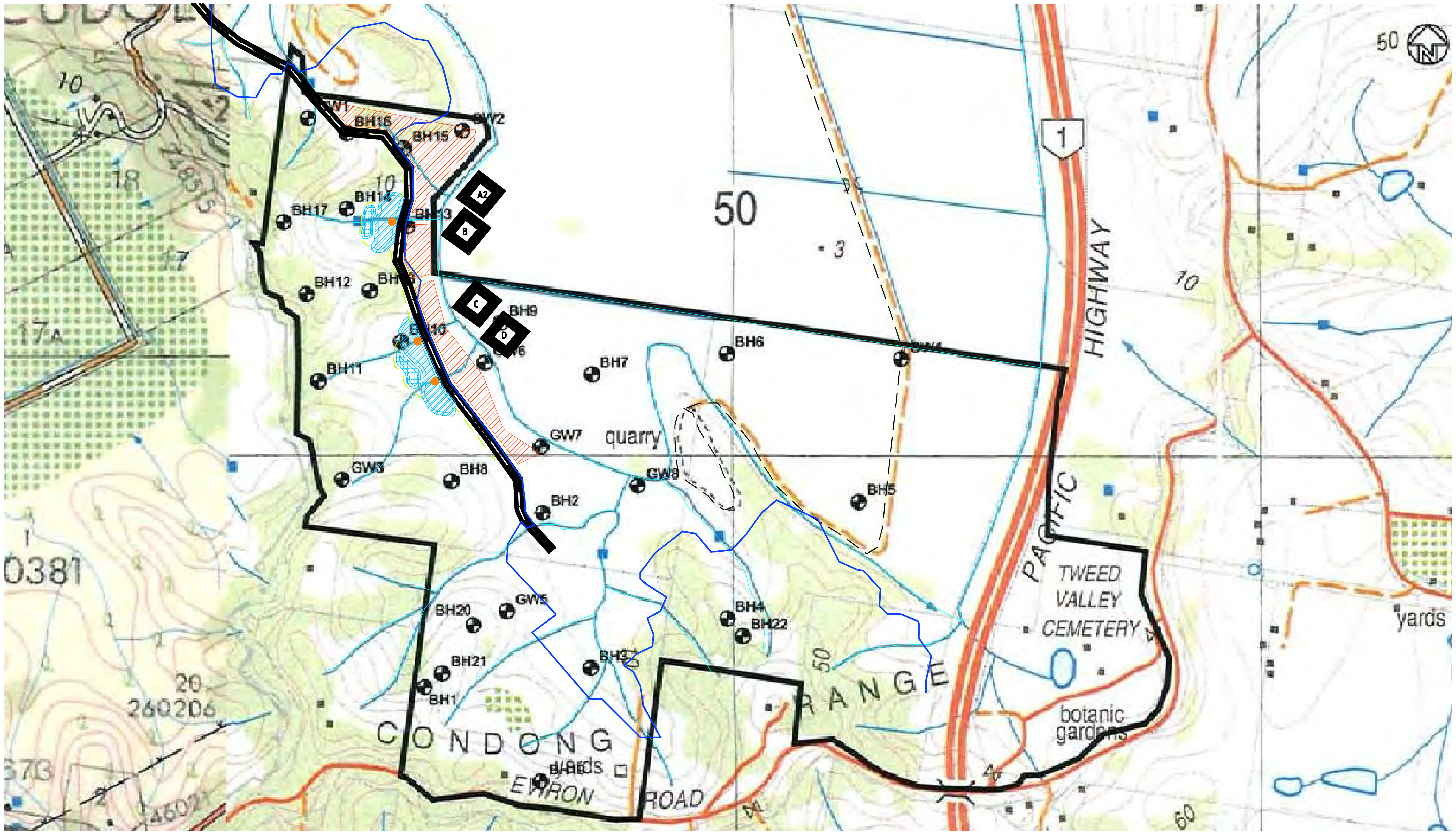
54-58 Nerang Street Nerang QLD 4211 Australia **T** 61 7 5557 1000 **F** 61 7 5557 1000 **E** goldcoastmail@ghd.com.au **W** www.ghd.com.au

Data source: Tweed Shire Council - Haul Road (2011), Cadastre boundary (2010). GHD - Site Boundary (2011), Roads, Existing Drainage Lines, Hillshade (Derived from Tweed Shire Council ALS data), Flood Area, West Valley (2010), North Valley (2011).



LEGEND

	ULTIMATE REGIONAL FLOODLINE
	ULTIMATE LOCAL FLOODLINE
	FLOOD CUT BALANCE ZONE

CONCEPTUAL

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

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Drawn NJC	Designed NJC
Drafting Check	Design Check
Approved	
Date	
Scale AS SHOWN	This Drawing must not be used for Construction unless signed as Approved

Client **TWEED SHIRE COUNCIL**
Project **EVIRON QUARRY & LANDFILL SITE**
Title **Ultimate Development Flood Inundation Lines Lot 26 on DP 615931 Eviron Road, Eviron**

Original Size A1 **Drawing No: 41-20806-G001-Fig 4.3** **Rev: A**

Plot Date: 9 December 2008 - 9:27 AM Cad File No: G:\41\20806\Tech\Stormwater Quality and Quantity\ACAD\41-20608-G001_DRAI_REV0.dwg

5. Water Quality Assessment

5.1 Objectives

The overall objectives of the water quality assessment are to:

- Define appropriate water quality objectives for the catchments;
- Estimate stormwater quality for fully developed catchment conditions using recognised software;
- Assess the level of stormwater quality infrastructure required to treat runoff from the developed catchment; and
- Propose stormwater treatment measures to meet agreed water quality objectives.

This section of the report outlines the development of the water quality model for the catchments.

5.2 Water Quality Objectives

Stormwater Quality Improvement Devices (SQIDs) will be required to mitigate the impacts of additional pollutant loads generated by the proposal. The Director Generals Requirements for the proposal requires the waters discharged from the site or from any water quality treatment device must comply with the ANZECC 2000 guidelines.

Table 5.1 shows the Water Quality Objectives for the proposal. This assessment aims to meet the ANZECC criteria and the Tweed Shire Council interim values shown in the table.

Table 5-1 Water Quality Objectives for the Quarry / Landfill Project

Pollutant	TSC Interim Values[3]	ANZECC Trigger Values[1]
suspended solids	<20 mg/L	<22 mg/L[1]
chlorophyll *a*	<10 mg/L	<5 µg/L[2]
total nitrogen	<750 µg/L	<500 µg/L[2]
oxidised N	-	<40 µg/L[1]
ammonia N	-	<20 µg/L[1]
total phosphorus	<100 µg/L	<50 µg/L[1]
filterable reactive phosphorus (FRP)	-	<20 µg/L[2]
dissolved oxygen	>6 mg/L	85% saturation[1]
pH	6.5 – 9.0	6.5 – 8.0[2]

1. *Australia and New Zealand Guidelines for Fresh and Marine Water Quality Volume 2*, Australia and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and new Zealand, October 2000.

2. *Australia and New Zealand Guidelines for Fresh and Marine Water Quality*, Australia and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and new Zealand, October 2000.

3. *Tweed Shire Council – Urban stormwater Quality Management Plan-* interim Water Quality Objectives. This is for comparison purposes only.

5.3 Water Quality Modelling

The industry standard water quality model MUSIC (Model for Urban Stormwater Improvement Conceptualisation) was used to determine stormwater quality for existing and fully developed catchment conditions. MUSIC was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology. MUSIC provides the ability to simulate both stormwater quantity and quality from catchments ranging from a single house block up to many square kilometres in area, 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 model was used to determine a set of appropriate mitigation options to meet the WQOs defined for the catchments. Modelled pollutants included total suspended solids, total nitrogen, total phosphorous and gross pollutants.

5.3.1 Modelling Scenarios

The following catchment development scenarios were assessed:

- Existing conditions;
- Ultimate development conditions Stage 1 (with sediment basins); and
- Ultimate development conditions Stage 2 (with wetlands).

5.3.2 Land Use Classification

Two types of land use nodes (source node) are available to characterise the hydrologic and pollutant export properties of each sub-catchment area in MUSIC. These are Forest and Urban. The User Defined option can be used to simulate any type of land use by specifying impervious areas, soil properties and pollutant concentrations. This land use nodes were used to simulate industrial and forest land use.

5.3.3 Pervious and Effective Impervious Proportions

The effective percentage (%) impervious values for each MUSIC sub-catchment (source node) were adopted from the TSC Urban Stormwater Quality Management Plan (Chapter 7.13.3 Table 1). Were no information was available for other nodes the Draft Guidelines for Pollutant Export Modelling in Brisbane (Brisbane City Council, 2003) and listed in Table 5.2 was used.

Table 5.2 MUSIC Impervious Area Reduction Factors (Brisbane City Council, 2003)

Source Node	% Impervious of Total Impervious Area
Urban Residential	31
Commercial	50
Industrial	76
Rural Residential	55
Agricultural	55
Forested	0

5.3.4 Soil Properties

The soil properties of each land use type were selected in accordance with TSC Urban Stormwater Quality Management Plan (Chapter 7.13.3 Table 1). Were no data existed for other land use types the Draft Guidelines for Pollutant Export Modelling in Brisbane (Brisbane City Council, 2003) was used.

Table 5.3 reproduces the soil parameters adopted in the MUSIC model. These soil properties are used in the rainfall-runoff generation calculations.

5.3.5 Pollutant Generation Parameters

MUSIC generates pollutant concentrations for both the storm flow and base flow components of runoff from the rainfall runoff model. The pollutant generation parameters used in the MUSIC model were selected in accordance with the TSC Urban Stormwater Quality Management Plan and the Draft Guidelines for Pollutant Export Modelling in Brisbane (Brisbane City Council, 2003) and are reproduced in Table 5.4.

5.3.6 Meteorological and Global MUSIC Parameters

The meteorological and global parameters used in the MUSIC model are presented in Table 5.5.

Table 5.3 MUSIC Rainfall / Runoff Parameters (Brisbane City Council, 2003 & TSC USQMP)

Parameter	Urban Residential	Industrial	Rural	No Development
Field Capacity (mm)	50	80	50	50
Infiltration Capacity Coefficient a	50	200	50	50
Infiltration Capacity Coefficient b	2	1	2	2
Rainfall Threshold (mm)	1	1	1	1
Soil Capacity (mm)	150	120	150	150
Initial Storage (%)	25	25	25	25
Daily Recharge Rate (%)	65	25	65	65
Daily Drainage Rate (%)	5	5	5	5
Initial Depth (mm)	50	50	50	50

Table 5.4 MUSIC Base and Stormflow Concentration Parameters (BCC, 2003 & TSC USQMP)

		TSS (Log_{10} mg/L)		Total Phosphorus (Log_{10} mg/L)		Total Nitrogen (Log_{10} mg/L)	
Source Node		**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**	**Base Flow**	**Storm Flow**
Urban Residential	Mean	0.80	2.00	-1.00	-0.68	-0.10	0.193
	Std. Dev.	0.20	0.145	0.34	0.28	0.05	0.05
Industrial	Mean	0.78	1.92	-1.11	-0.59	0.14	0.25
	Std. Dev.	0.45	0.44	0.48	0.36	0.20	0.32
Rural Residential	Mean	0.60	1.627	-1.40	-0.95	-1.50	-0.25
	Std. Dev.	0.20	0.20	0.40	0.10	0.40	0.197
Forested	Mean	0.80	1.20	-1.00	-1.47	-0.10	0.90
	Std. Dev.	0.20	0.145	0.34	0.30	0.05	0.10

Table 5.5 Meteorological and Global MUSIC Parameters

Parameter	Data Used
Rainfall	Jan 1978-Dec 1978 Rainfall Period
Rainfall Station	Murwillumbah. (Station No. 58158)
Potential Evapo-Transpiration	Mean Monthly ET
Model Time Step	6 Minute
Pollutant export	Stochastic Generated Default Values.

5.4 Water Quality Options

The selection of water quality treatment measures typically depends on a wide range of criteria. Common stormwater treatment methods should be assessed against a number of categories with particular emphasis on the following:

- Availability of suitable sites and site topography;
- Available hydraulic head loss at the selected site;
- Site geology;
- Site groundwater levels;
- Effectiveness of the treatment measure to achieve desired pollutant retention;
- Compatibility with existing site constraints;
- Aquatic and wild-life habitat;
- Public safety;
- Capital cost and maintenance; and
- Aesthetic appeal.

The water quality treatment devices selected for the quarry / landfill project consist of grass filter strips, grassed diversion drains, sediment basins and wetlands. These measures have been selected for the following reasons:

- These are the most effective devices in meeting government Water Quality Objectives and Environmental Value requirements.
- Vegetated Swales and Buffers are effective in both treatment and conveyance of stormwater to secondary and tertiary treatment devices.
- Planted Detention devices can be aesthetically pleasing if appropriately designed and landscaped.

A brief description of each of the recommended water quality treatment devices is provided below.

5.4.1 Swales

Can be an alternative to the roadside kerb and channel system. Swales are also used as drainage channels that direct flows from a sag point to the secondary treatment device such as a wetland. Swales slow down the flow and allow sediment to be captured in the vegetation area.

Advantages

- Improved water quality as sediments are captured near the source;
- Encourages local groundwater recharge;
- Reduced runoff peak flows; and
- Reduced infrastructure costs compared with traditional systems

Disadvantages

- Potential erosion problems, particularly f the channel invert is unprotected; and
- Difficulty in integrating swales with driveway or road access points

5.4.2 Buffer Areas

Buffer areas are grasses or vegetated areas where stormwater flows as sheet flow, trapping sediment and some nutrients prior to entering other stormwater treatment devices.

Advantages

- Improved water quality as sediment is captured near the source
- Encourages local groundwater recharge; and
- Improves visual aesthetics and can promote native fauna to gather.

Disadvantages

- Limited removal of fine sediments and soluble pollutants; and
- Potential formation of preferential pathways.

5.4.3 Sediment Basins

Sediment Basin systems are depressions where stormwater ponds on the surface and allows sediment to settle to the base of the pond while the increased water level slowly recedes to a defined level. Various processes are involved in extracting the nutrients from the stormwater including absorption, biological uptake, evapo-transpiration and deposition.

Advantages

- Treats sediment filled stormwater close to source;
- Treatment at the surface and within 200 mm of the surface hence performance is not impacted by presence of high groundwater;
- Water storage for irrigation and wash down demands; and
- Decreases flow rates to downstream system;

Disadvantages

- Requires flocculation by application of gypsum (or equivalent) to promote aggregation of small flocs to larger ones. This promotes increased settlement in highly dispersive soils.
- Requires regular maintenance of outlets and dredging of settled sediment after significant rainfall events.

5.4.4 Wetlands

Wetland systems are landscaped depressions where stormwater ponds on the surface and slowly recedes to a defined water level. Various processes are involved in extracting the nutrients from the stormwater including absorption, biological uptake, evapo-transpiration and deposition.

Advantages

- Treats stormwater close to source;
- Treatment at the surface and within 200 mm of the surface hence performance is not impacted by presence of high groundwater.
- Decreases flow rates to downstream system;
- Has the potential to reduce the size of stormwater structures;
- Self propagates;
- Provides treatment for fine sediments, particulate pollutants, and dissolved pollutants; and
- Can be used to provide a setback buffer to existing waterways.

Disadvantages

- Outlets can accumulate clutter and rubbish after major storm events.

Refer to Figure 5.1 for MUSIC Screen Capture.

- Refer to Figures 5.2 and 5.3 for stormwater treatment device locations.

5.4.5 Supporting Devices

- The devices not modelled but do contribute to minimising sediment decomposition in natural waterways or major drainage flow paths are sediment fences and straw bales. These devices will be in abundance during the quarrying and landfill processes to capture sediment closer to the source prior to entry into the sediment basins. These devices are discussed further in Section 6 of this report.
- Should they be incorporated into the detail design of the landfills in the North and West Valleys leachate ponds could become another significant device to collect seepage flows from the fill layers and drain any infiltration waters and prevent these flows from entering the mainstream flow paths. However Council's preference at this stage is not to have landfill leachate ponds.
- The amphitheatre shape has also been maintained in this detailed analysis as depicted in the Gilbert & Sutherland Report (April 2007).

Table 5.6 Mean Concentration Values at Catchment Outlets to the Drainage Channel (Existing)

Receiving Node - All Data Statistics

Inflow	mean	standard deviation	median	maximum	minimum	10 percentile	90 percentile
Flow (cubic metres/sec)	0.007	0.099	0.001	7.670	0.000	0.000	0.006
TSS Concentration (mg/L)	**7.090**	2.610	6.640	35.600	1.360	4.290	10.400
Log [TSS] (mg/L)	0.824	0.151	0.822	1.550	0.134	0.633	1.020
TP Concentration (mg/L)	**0.135**	0.089	0.113	1.820	0.009	0.053	0.242
Log [TP] (mg/L)	-0.946	0.258	-0.948	0.260	-2.070	-1.280	-0.616
TN Concentration (mg/L)	**0.795**	0.088	0.796	1.120	0.086	0.713	0.887
Log [TN] (mg/L)	-0.104	0.073	-0.099	0.049	-1.070	-0.147	-0.052

Table 5.7 Mean Concentration Values at Catchment Outlets to the Drainage Channel (Stage 2 Ultimate)

Receiving Node - All Data Statistics

Inflow	mean	standard deviation	median	maximum	minimum	10 percentile	90 percentile
Flow (cubic metres/sec)	0.006	0.081	0.000	6.300	0.000	0.000	0.009
TSS Concentration (mg/L)	**3.070**	3.210	0.000	20.500	0.000	0.000	6.010
Log [TSS] (mg/L)	0.786	0.054	0.779	1.310	0.778	0.778	0.779
TP Concentration (mg/L)	**0.030**	0.030	0.000	0.099	0.000	0.000	0.060
Log [TP] (mg/L)	-1.220	0.014	-1.220	-1.010	-1.420	-1.220	-1.220
TN Concentration (mg/L)	**0.496**	0.502	0.000	1.020	0.000	0.000	1.020
Log [TN] (mg/L)	-0.005	0.068	0.005	0.007	-0.905	0.000	0.007

Comparison of the predicted pollutant loads from the Ultimate development catchment (with treatment measures) given in Table 5.8 against the WQOs listed in Table 5.1 demonstrates that the stormwater quality treatment measures proposed for the project are sufficient to achieve the WQOs for the catchment. The proposed measures will ensure that the suspended solids, total phosphorus and total nitrogen that will be discharged to the drainage channels will meet the required concentration values.

The existing pollutant loads produced from the quarry / landfill catchment in Table 5.7 has been added as a comparison to the WQOs listed in Table 5.1. Results show that the proposed measures also improve upon the existing situation and meet both concentration production value criteria.

The water quality treatment strategy proposed in this report is a preliminary estimate of the location and minimum total size of the treatment measures required to reduce mean annual loading of stormwater generated pollutants from the quarry / landfill catchment. A more detailed assessment of each recommended treatment measure will be required to determine the final locations, numbers, sizes, and arrangements of each of the proposed stormwater quality treatment measures during the civil design stage.

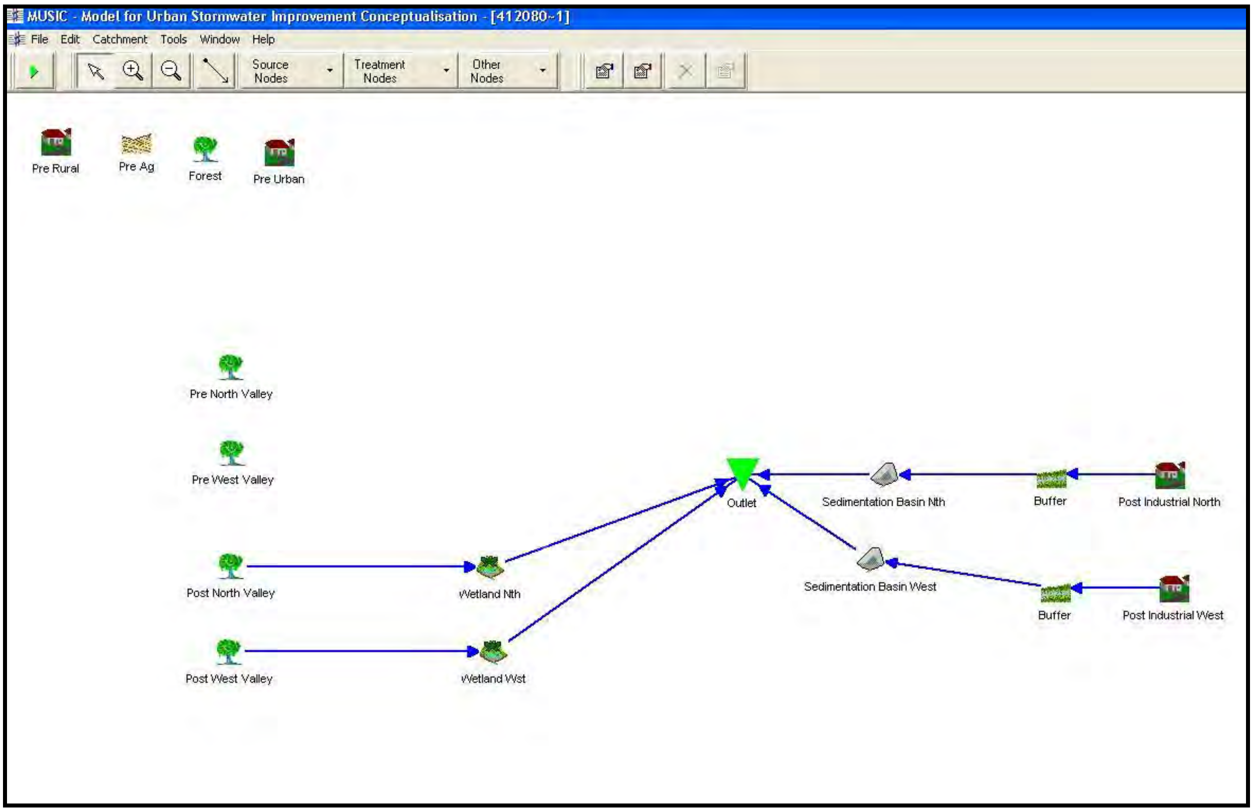
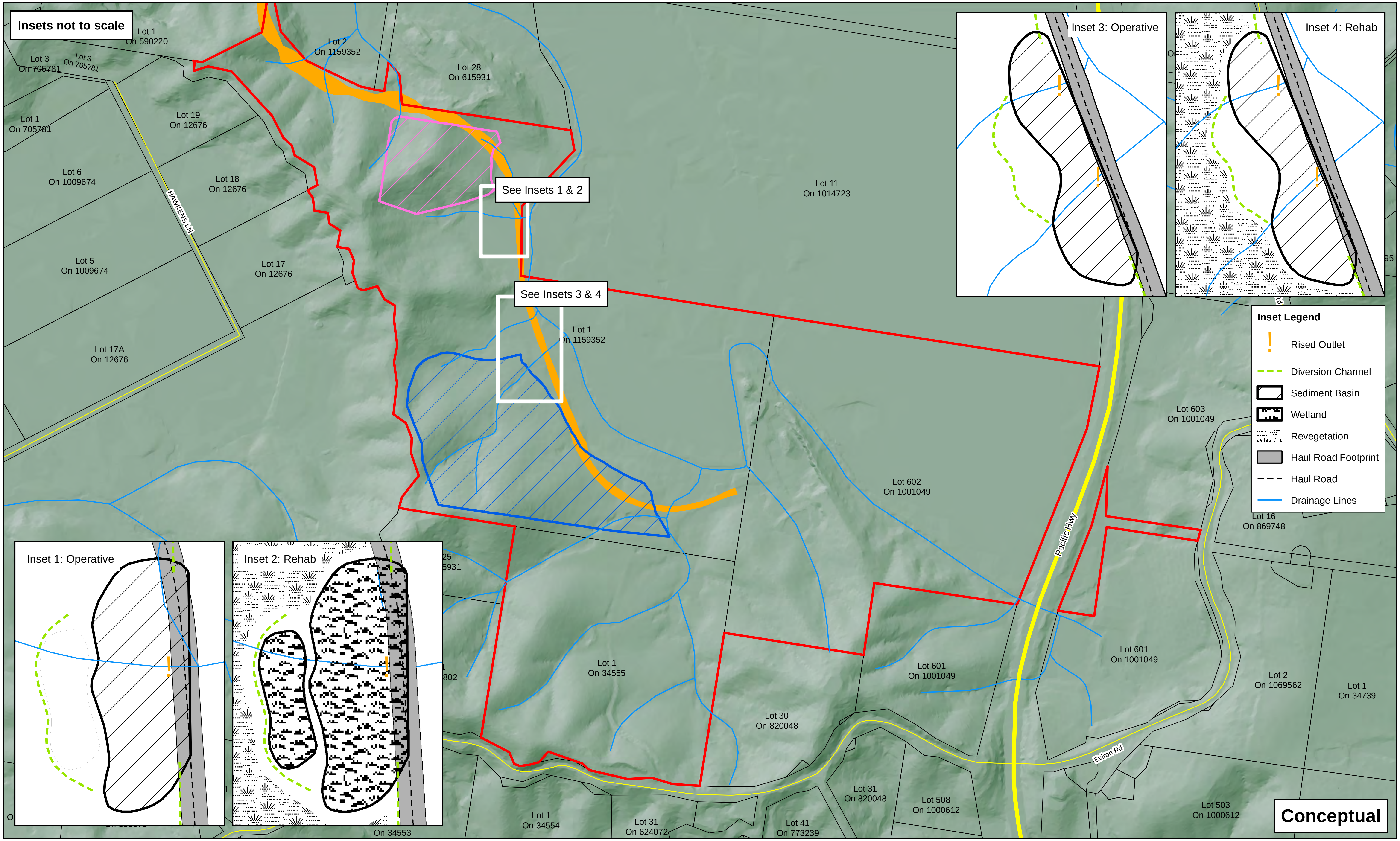


Figure 5-1 MUSIC Screen Capture of Treatment Train

5.5 Stormwater Quality Improvement Devices (SQIDs) Design Requirements

The land use of the proposed site requires some specific design criteria. These criteria include:

- Impermeable layer at the base of the sediment / wetland basins to prevent seepage (Refer to Appendix C Typical Section Details);
- Diversion drains on the upstream side of disturbed areas to divert surface runoff into the sediment basins (refer to Figures 5.2 and 5.3);
- Grass filter strips / vegetative buffers at base of last fill layer and upon layer batters that are complete (refer to Figures 6.1 and 6.2);
- Provide a layer of compacted gravel on the base of the sediment basins to prevent backhoes from digging too deep and impacting upon the impermeable layer upon dredging of the sediment basins;
- Protect the batters of the roadway (proposed haul road) at the proposed sag points to be a spillway for the basins weir flow in major storm events to prevent pavement failure;
- Detention ponds / basins shall be stabilised immediately after completion and densely plated with native drought tolerant ephemeral species. No mulching to internal batters; and
- All proposed sediment fences depicted in Figure 6.1 to remain until the completion of the wetlands and the landscape has been rehabilitated.



0 100 200 300
Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 56

LEGEND
- Site Boundary
- North Valley
- West Valley
- Haul Road
- Drainage Lines

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Tweed Shire Council
Eviron Quarry & Landfill Site

Quarry Stormwater
Treatment Device Locations

Job Number	41-20806
Revision	2
Date	27 MAY 2011

Figure 5.1

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54-58 Nerang Street Nerang QLD 4211 Australia T 61 7 5557 1000 F 61 7 5557 1000 E goldcoastmail@ghd.com.au W www.ghd.com.au

Data source: Tweed Shire Council (2011) - Haul Road, Haul Road Footprint, Cadastre boundary (2010). GHD (2010) - Site Boundary (2011), Roads, Drainage Lines, Hillshade (Derived from Tweed Shire Council ALS data), Rised Outlet, Diversion Channel, Leachate Pond, Sediment Basin, Revegetation, Wetland, Irrigation Pond, West Valley, North Valley (2011).

6. Erosion and Sediment Control Measures

6.1 Treatment Measure Options & Selection Criteria

There are a number of treatment measure options available for selection and use. The appropriate selection is important to best achieve the desired outcomes. Prior to selection of treatment measures, desired outcomes and principles of effective erosion and sediment control are:

- Minimise the extent and duration of soil disturbance;
- Control the location and velocity of drainage flow;
- Minimise soil erosion initiated by wind, rain or concentrated flow;
- Minimise sediment flow from the site;
- Promptly revegetate/stabilise all exposed and/or unstable soil surfaces; and
- Appropriately install, operate and maintain all ESC measures.

Depending on the improvement to stormwater quality achieved by the treatment measure and approach, ESC can be divided into three sets of control measures:

- Erosion control measures.
- Drainage control measures.
- Sediment control measures.

The particular types of ESC measures considered for the site are briefly described for the following Erosion, Drainage and Sediment controls.

6.1.1 Erosion Control

Erosion control measures are principally used to minimise movement and loss of sediments at the source. Typical measures include:

- Minimise soil and stockpile erosion caused by wind and rain.
- Minimise turbidity levels in stormwater runoff by minimising the exposure of soil to rain and stormwater flow.

Revegetation and Mulching

Vegetation or revegetation of a site provides:

- A physical protection against raindrop impact;
- A barrier between the earth and flow;
- Increased surface roughness that reduces erosive flow velocities; and
- Increased absorption of rainfall by the soil profile, reducing the volume of runoff.

Revegetation should be carried out on any exposed soil surface that has the potential to erode and cause sediment movement into the surrounding environment during rain events. Revegetation is an effective long term ESC measure. Ideally, plants should be native to the area, have good soil binding capability and compete successfully with weed species. Temporary sediment fences should be incorporated at the downstream edge of revegetation until establishment and stabilisation have been achieved.

6.1.2 Drainage Control

Drainage control measures are principally used to:

- Divert 'clean' upslope water around any soil disturbances.
- Contain and transport potentially contaminated stormwater through disturbed areas to treatment measure(s), minimising contact with erodible soils.

Open channels are economical where large flows are to be carried and space is not restricted. They provide for the continuous collection of surface runoff. Where surcharging occurs, general shallow flow results, rather than concentrated flooding upstream of a closed drainage system.

Bunds are utilised to divert or contain flow when the flow is desired to be on the natural surface and the site has a cross-fall such that the contained flow does not lead to an extensive width of flow. The flow is contained on the natural surface by a raised bank (the bund) formed by raising compacted earth on the surface.

The channel or bund lining is specified to protect the subsoil from erosion, and can additionally provide treatment benefits to the flow for low-flows.

Diversion Bunds

Diversion Channels are excavated channels often incorporating a diversion bank on the down slope side. Typical gradients are flat, ranging between 0.2% and 0.6% as bare earth readily erodes. Use of rock check dams can reduce the effective channel gradient during flow conditions for steeper channels up to typically 5%.

Diversion channels can be placed above batters, borrow pits, exposed and disturbed surfaces to protect them from upslope stormwater runoff. They can also be incorporated at the base of cut and fill slopes and disturbed/exposed areas (sediment fences are often appropriate to install between the slope and channel) to direct sediment laden flows to treatment measures.

NB. Excavated channels within highly erosive soils require a suitable channel lining such as grass or rock where infiltration is desirable and plastic sheeting, concrete or asphalt where it is not.

Rock Lined Channel

Rock-lined channels are used to convey concentrated flows on grades of up to 10% and in critical sections of other types of channels (grassed, earth) such as bends and stormwater outlets where localised high velocities are likely to occur. The increased channel roughness provided by the rock lining slows flow velocities providing sediments opportunity to settle out. Design criteria include:

- Appropriately sized and graded rock is specified to resist movement (including on the channel embankments) by the anticipated flow velocity in the channel;
- The thickness of the rock protection layer is at least twice the nominal rock diameter;

- A geo-textile or rock filter layer is used underlying the rock layer to protect underlying fine/ erodible soils entering the flow (generally required unless the rock layer is at least three times the nominal rock diameter); and
- Particular attention must be given to the crest, toe and side details to avoid edge effects of seepage undermining the drain and to ensure the flow does not scour, easily erodible soils

6.1.3 Sediment Controls

Sediment controls are measures that trap and retain sediments, removing sediment from the stormwater flow. Where practical, sediment should be trapped close to its source, reducing breakdown of soil particles and the release of dispersive clays (if present). Additionally, a final control is usually required immediately prior to the site discharge. This combination, plus the other treatment measures lead to the "treatment train" concept.

Sediment controls have the greatest maintenance requirements of ESC measures as their primary function is to accumulate sediments. If a sediment control measures does not need sediment removal (maintenance) after a storm event, it may not be working properly.

Sediment Fences

Sediment fences provide physical filtration of sheet flow as it passes through the filter material, and allows settling of suspended sediments by the ponding of water behind the fence. Sediment fences typically:

- Consist of a filter fabric attached to a wire and post fence at a maximum height of 700mm with an additional 200mm (min) buried and compacted into an upstream trench;
- Should be constructed along a contour with turn-ups at either end to prevent runoff flowing around the fence;
- Are most effective for coarse fraction sediments as a source control of sheet flow;
- Trap sediment larger than 0.14 mm, and have little impact on fine silts;
- May be used in the control of sediment runoff from exposed land, unsealed roads, batters and
- stockpiles; and
- For large areas on moderate slopes, may be placed at intervals down slope with a catch drain on their downstream side to trap flow will contain sediments at the source and minimise concentration of flow.

Sediment Basins

A sediment basin is an effective sediment containment system to trap and retain a wide range of sediment particle sizes down to 0.045 mm depending on its hydraulic characteristics (retention time and flow distribution). It is noted that:

- Sediment basins are usually required when the disturbed area is greater than (1) hectare, the soils are dispersible, and/or when there is a need to control runoff turbidity;
- Sediment basins should be located upstream of water bodies, bushland and major stormwater systems;

- Sediment basins are sized to either contain and slowly settle fine particles, or to slow the flow's velocity allowing settlement of coarser particles during flowthrough; and
- Both the coarse sediment concentration and turbidity levels can be reduced.

6.2 Proposed Erosion and Sediment Control Measures

This sub-section provides Sediment and Erosion Control (ESC) measures presented in Figure 6.1, installation sequence and maintenance requirements.

6.2.1 Installation Sequence

The erosion and sediment works described in chapter 6 are for construction, operation and revegetation / rehabilitation of the Quarry / Landfill sites. The timing in this sequence of the control measures are itemised in Table 6.1 below.

Table 6.1 Erosion and Sediment Control Installation Sequence

Item	Figure	Installation	Removal
Diversion Bund / swale drain	6.1	Pre - construction	N/A
Sediment Fences and Straw Bales	6.1	Pre - construction and upon completion of each fill layer on the downstream batter	After rehabilitation of Site
Grass / Vegetation Filter Strip	6.1	Pre - construction and upon completion of each fill layer on the downstream batter	N/A
Hydro-mulching of Batters	6.1	Upon completion of detention areas & each fill layer on the batter	N/A
Sediment Basins	6.1	Pre-construction	converted to a wetland at rehabilitation stage

6.2.2 Explanatory Notes and Calculations

Vegetation Management

Clearing of remaining trees should only occur where necessary and/or revegetation can take place immediately upon completion of operations.

Revegetation is to occur pre-construction in areas not needed for construction access.

Revegetation is to continue throughout the development as soon as practical. This will reduce impact erosion and help to re-establish the natural landscape as early as possible.

Hydroseeding / mulching is a efficient form of erosion control. Any areas being revegetated will have planted native grass species in between plants. This will give additional impact erosion protection and act as a weed suppressant, thus improving revegetation rates and coverage.

All exposed batter slopes are to be hydro-mulched, as shown in Figure 6.1.

Sediment Basins

The catchment to SB Nth is approximately 9 ha and SB Wst is 14.5 ha. The required settling volumes were estimated using the procedures listed in the *Managing Urban Stormwater* (Landcom) as follows:

$Vs\ [m^3] = 10 \times Cv \times Area\ [ha] \times R_{(y5,5\text{-}day)}$

The above formula is for Type D & F soils, applicable when there is greater than 33% of the soil with an average diameter less than 0.02 mm. Table 6.2 provides a summary of the required dimensions for the sediment basin.

Table 6.2 Required Sediment Basin Dimensions

Basin	$R_{(y5,5\text{-}day)}$ ℵ	Cv	Area	Required Settling Volume	Sediment Storage Volume (50%Vs)	Total volume
	(mm)		**(ha)**	**(m^3)**	**(m^3)**	**(m^3)**
SB Nth	62.5	0.79	9.0	3,938	1,969	5,907
SB Sth	62.5	0.79	14.5	6,344	3,172	9,516

Table 6.3 provides a potential configuration of the sediment basin to meet the required dimensions as set out in Table 6.2.

ℵ 1-year, 5- day 85% Rainfall Depth for Tweed Heads. Table 6.3a, *Managing Urban Stormwater (*Landcom 2004).

Table 6.3 Potential Sediment Basin Configurations

Basin	Surface Area	Average Depth	Length	Width
	(m^2)	**(m)**	**(m)**	**(m)**
SB Nth	6,835	1.5	95	47
SB Sth	9,500	1.5	125	60

The MUSIC model determined minimum size for water quality objectives for each site was 4500m^2 for the North Valley site and 7500m^2 for the West Valley site. Concentration values of sediment and nutrients to be compared to existing values can be viewed in Tables 6.4 & 6.5 below. The larger calculated surface areas in Table 6.3 have been selected for each device due to its dual function requirement.

A sediment accumulation depth post should be installed that will clearly indicate when the sediment storage volume is at its capacity and cleanout is required.

Sediment fences are to be installed where indicated in Figure 6.1. Sediment fences are to install as per the "*Managing Urban Stormwater: Soils and Construction*" (Landcom), specification standards. The total length of Sediment fencing required is estimated to be approximately 2000m.

As can be seen from the two tables below, TP and TN are improved upon from existing concentration values. Although TSS is higher than the existing value it is still within the government standard range of below 20mg/L

Table 6.4 Mean Concentration Values at Catchment Outlets to the Drainage Channel (Existing)

Receiving Node - All Data Statistics

Inflow	mean	standard deviation	median	maximum	minimum	10 percentile	90 percentile
Flow (cubic metres/sec)	0.007	0.099	0.001	7.670	0.000	0.000	0.006
TSS Concentration (mg/L)	**7.090**	2.610	6.640	35.600	1.360	4.290	10.400
Log [TSS] (mg/L)	0.824	0.151	0.822	1.550	0.134	0.633	1.020
TP Concentration (mg/L)	**0.135**	0.089	0.113	1.820	0.009	0.053	0.242
Log [TP] (mg/L)	-0.946	0.258	-0.948	0.260	-2.070	-1.280	-0.616
TN Concentration (mg/L)	**0.795**	0.088	0.796	1.120	0.086	0.713	0.887
Log [TN] (mg/L)	-0.104	0.073	-0.099	0.049	-1.070	-0.147	-0.052

Table 6.5 Mean Concentration Values at Catchment Outlets to the Drainage Channel (Stage 1 Ultimate)

Receiving Node - All Data Statistics

Inflow	mean	standard deviation	median	maximum	minimum	10 percentile	90 percentile
Flow (cubic metres/sec)	0.005	0.076	0.000	6.310	0.000	0.000	0.004
TSS Concentration (mg/L)	**8.980**	10.200	0.000	83.600	0.000	0.000	20.000
Log [TSS] (mg/L)	1.300	0.032	1.300	1.920	1.300	1.300	1.300
TP Concentration (mg/L)	**0.058**	0.065	0.000	0.262	0.000	0.000	0.130
Log [TP] (mg/L)	-0.884	0.016	-0.886	-0.581	-0.887	-0.886	-0.886
TN Concentration (mg/L)	**0.625**	0.701	0.000	2.320	0.000	0.000	1.400
Log [TN] (mg/L)	0.148	0.020	0.145	0.366	0.138	0.141	0.146

Diversion Bunds

Diversion channels have been specified to convey concentrated flows into the sediment basins.

The diversion channels (DB 001 & DB 002) have been sized to cater for more than the 1 in 100 year ARI storm event. Table 6.6 gives the channel dimensions, which have been standardised for ease of construction and maintenance.

Table 6.6 Open Channel Dimensions for DB 001 & 002

Base Width (m)	Depth (m) (includes 0.15 m freeboard)	Batter Slope (Vertical: Horizontal)	Top Width (m)
4.5	0.5	1:2	6.5
7	0.5	1:2	9.0

These dimensions are based on the channels having a grade of 1.5% and the base lined with grouted riprap.

Roads

All internal roadway and track surfaces (used by reuse traffic) are to be stabilized by maintaining a hard compacted gravel surface to minimize soil erosion and sediment discharge (Refer to figure 6.1).

The proposed haul road should be sealed and batters stabilized prior to quarry construction.

Sag points should be located at the spill crests of the sediment basins (Stage 2 wetlands) to allow the road to convey major storm flows over it and to each LPD.

The roadway at the weir locations shall be one way cross fall to allow unrestricted sheet flow.

LEGEND

- SEDIMENT BASIN
- LEACHATE POND
- DIVERSION CHANNEL / SWALE
- EXISTING DRAINAGE CHANNELS
- RISED OUTLET STRUCTURE
- SEDIMENT FENCE
- STRAWBALE WEIR
- GRASS STRIP
- HYDROSEED / MULCH

0 10 20 30 40 50mm
SCALE 1:1 AT ORIGINAL SIZE

CONCEPTUAL

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

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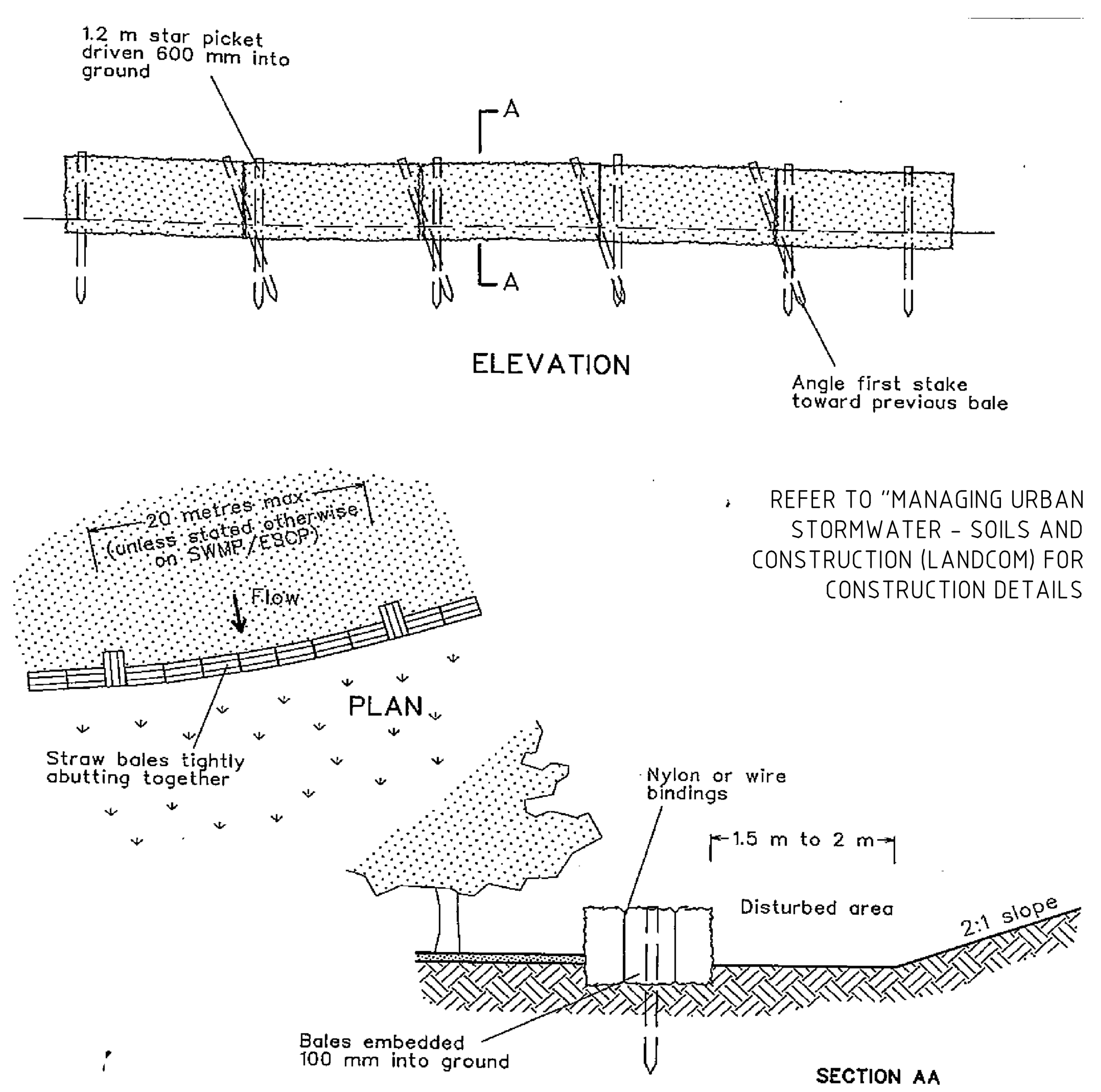
Project **EVIRON QUARRY & LANDFILL SITE**
Title **Erosion and Sediment Control Plan**
Lot 26 on DP 615931, Eviron Road, Eviron

Original Size **A1** **Drawing No: 41-20806-G001-Fig 6.1** **Rev: A**

Plot Date: 11 December 2008 - 9:18 AM Cad File No: G:\41\20806\Tech\Stormwater Quality and Quantity\ACAD\41-20608-G001_DRAI_REV0.dwg

TYPICAL SEDIMENT BASIN SECTION

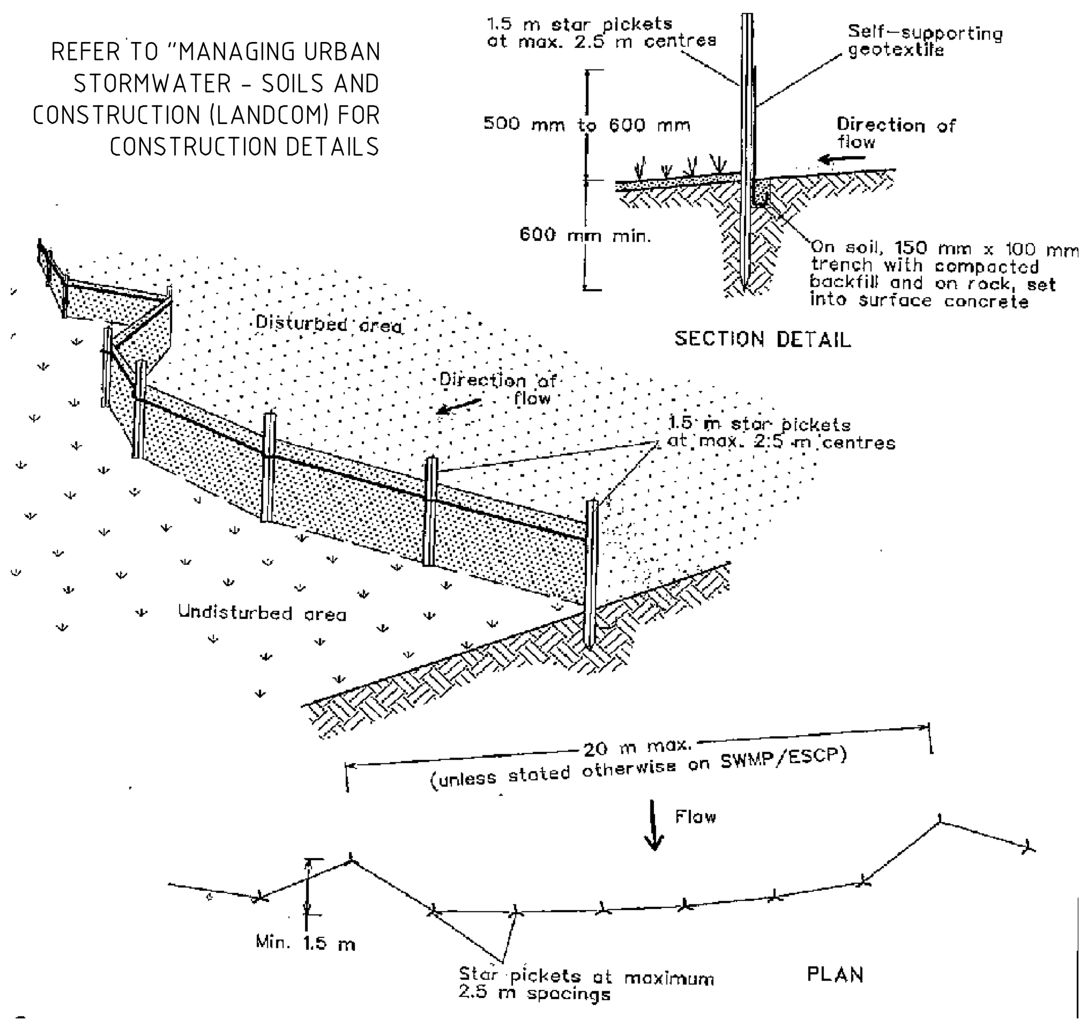
NTS



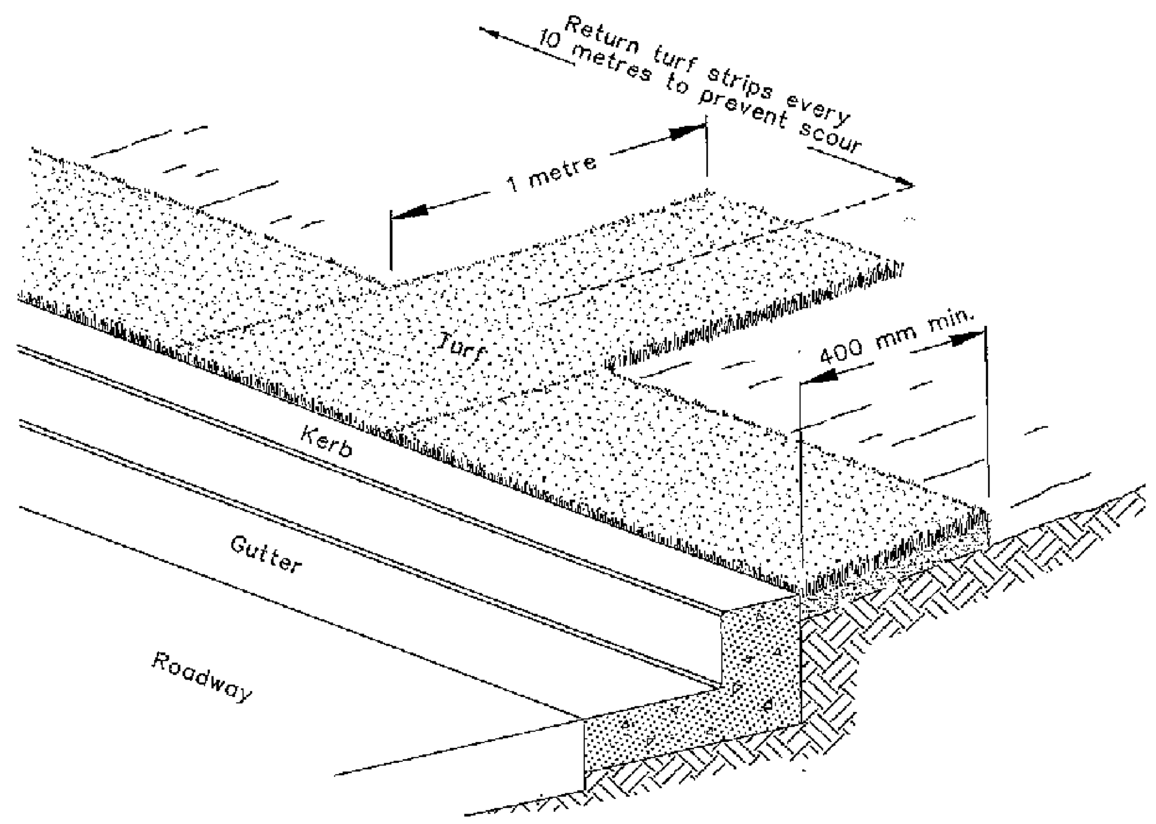
REFER TO "MANAGING URBAN STORMWATER - SOILS AND CONSTRUCTION (LANDCOM) FOR CONSTRUCTION DETAILS

TYPICAL STRAW BALE DETAILS

REFER TO "MANAGING URBAN STORMWATER - SOILS AND CONSTRUCTION (LANDCOM) FOR CONSTRUCTION DETAILS



TYPICAL SEDIMENT FENCE DETAILS

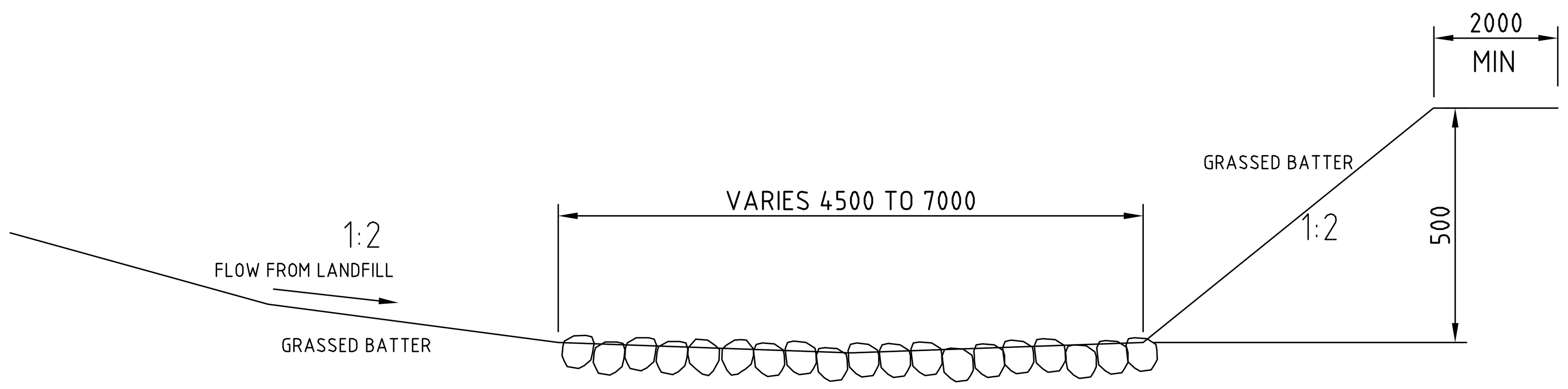


REFER TO "MANAGING URBAN STORMWATER - SOILS AND CONSTRUCTION (LANDCOM) FOR CONSTRUCTION DETAILS

TYPICAL GRASS STRIP DETAILS

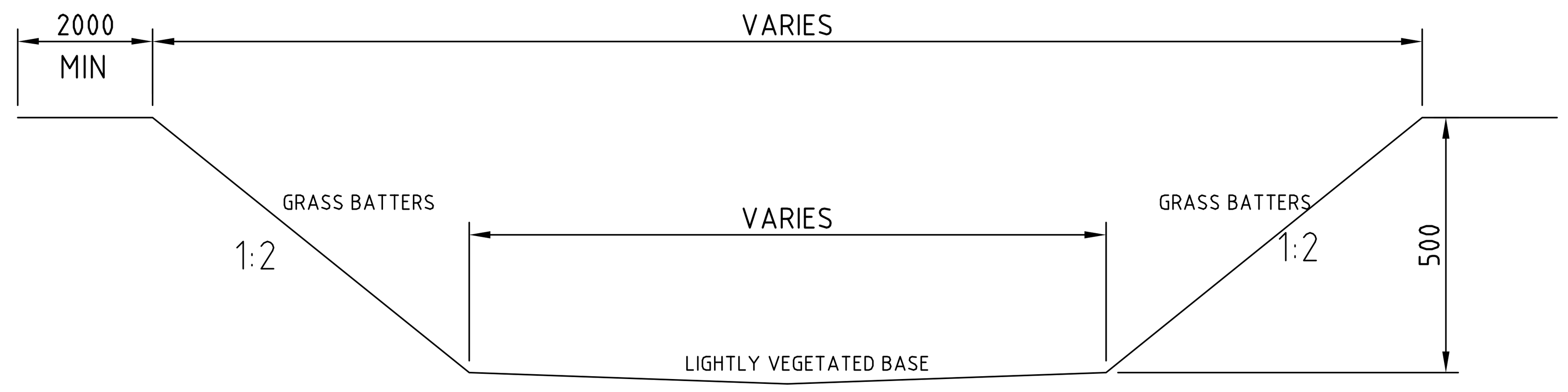
NOTES

SOIL STOCKPILES SHALL HAVE SEDIMENT FENCES SURROUNDING THE BASE OF THE DOWNSTREAM SIDE. ANY STOCKPILE THAT WILL REMAIN FOR MORE THAN 4 WEEKS SHALL BE STABILISED WITH HYDROSEED OR EQUIVALENT



TYPICAL SEDIMENT DIVERSION CHANNEL SECTION

NTS



TYPICAL CLEAN WATER DIVERSION CHANNEL SECTION

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Project **EVIRON QUARRY & LANDFILL SITE**
Title **Erosion and Sediment Control Details Plan**
Lot 26 on DP 615931, Eviron Road, Eviron

Original Size **A1** Drawing No: **41-20806-G001-Fig 6.2** Rev: **A**

Plot Date: 11 December 2008 - 9:21 AM Cad File No: G:\41\20806\Tech\Stormwater Quality and Quantity\ACAD\41-20608-G001_DRAI_REV0.dwg

6.3 Maintenance Requirements

The proposed erosion and sediment controls for the site has been prepared with the following maintenance philosophy in mind:

- Selection of mitigation measures requiring minimal regular maintenance or simple maintenance procedures.
- If maintenance is required on any structure, access must be provided.

A maintenance program for all elements of this ESC is outlined in Table 6.7. A checklist should be developed that lists the maintenance problems likely to occur for each of the ESC measures adopted on site. This will assist the site personnel in making a thorough inspection.

Maintenance of the primary mitigation measures is discussed in detail below. Erosion and sediment control devices that fail on a regular basis should be investigated by experienced personnel with the aim of either modifying the design or replacing such measures with an alternative treatment.

Inspection frequency will need to be adjusted according to the prevailing weather conditions, i.e. increased during wet periods and reduced during dry periods. During minor runoff events weekly inspections will be sufficient. However, an inspection is required after any major runoff event.

Inspection and maintenance requirements will be documented within the Landfill Environmental Management Plans and Quarry Plans of Management as appropriate.

Table 6.7 Erosion and Sediment Control Maintenance Requirements

ESC Element	Inspection Frequency	Maintenance Frequency	Maintenance Activities
		Erosion Control	
Revegetation	Weekly during minor runoff events and after every major runoff event	When areas of grass or vegetation have been eroded or damage of channel banks has occurred	Treat channelling or erosion, replace grass, and take action to prevent future damage Application of additional mulch or rock stabilisation
		Drainage Control	
Diversion Bund	Weekly during minor runoff events and after every major runoff event	When litter has accumulated or sediment has filled 30% of the drain depth Damage of channel banks has occurred	Remove accumulated litter and sediment Reform channel or bund

ESC Element	Inspection Frequency	Maintenance Frequency	Maintenance Activities
		Sediment Control	
Sediment Basin	Weekly during minor runoff events and after every major runoff event	When litter has accumulated or sediment has filled 30% of the sediment basin volume.	Remove accumulated litter and sediment, spreading it well away from drainage lines

6.3.1 Erosion Control

Revegetation

Inspection of revegetation zones should be undertaken regularly to assess vegetation condition and to identify if any erosion, channelling or weed problems are occurring.

Maintenance activities typically include:

- Watering, reseeding and weeding to maintain a dense, vigorous growth of vegetation. Fertiliser application should be kept to a minimum. Regular watering during establishment period with possible soil conditioning;
- Application of additional mulch as required;
- Maintenance of any upslope diversion channels or protective fences; and
- Re-firming of plants loosened by wind or rock.

6.3.2 Drainage Control

Diversion Bunds

Diversion bunds require regular inspections; this should identify any damaged or eroded areas due to sediment accumulated in the channel, vehicular damage to the banks, settlement of banks and/or scour due to excessive flow velocity.

Maintenance to diversion channels typically include:

- Reformation of channel banks to design grade;
- Removal of litter and debris from the channel surface; and
- Removal of sediment upstream of check dams (if applicable).

6.3.3 Sediment Control

Sediment Basin

Regular inspections and maintenance of sediment basin is required to ensure proper operation occurs.

Maintenance to sediment basin may include:

- Removal of accumulated sediment;
- Pump-out of retained water to maintain capacity for subsequent inflow events; and

- Repair of any scouring damage to inlet and outlet and embankment vegetation.

Sediment Fences

Regular inspection and maintenance of sediment fences is necessary to repair damage caused by on-site vehicles or excessive sediment movement. Inspections should occur after each storm event that generates runoff.

Maintenance to sediment fences may include:

- Remove excessive sediment deposit; and
- Repair damage done by vehicles;

6.4 Monitoring Checklist

A monitoring checklist should be kept of all erosion and sediment control measures with entries made weekly and after rainfall events on:

- Removal of ESC measures;
- Condition of ESC structures and stabilised surfaces;
- Repair of any damage to ESC structures; and
- Rainfall, including duration and times.

Where findings of the ESC monitoring indicate a non-conformance, corrective actions will be investigated and implemented within 24 hours where practicable.

7. Conclusions

A Soil and Water Assessment for Stormwater and Sediment has been developed for the Quarry / Landfill site catchment at Eviron. The report identifies the potential impacts of proposed future development in the catchment on stormwater quantity and quality. Stormwater infrastructure to mitigate and accommodate these impacts has been determined.

The outcomes and recommendations from the study are as follows:

- The philosophy of the *Site Investigation Addressing Soils, Stratigraphy and Proposed Management Measures* report by Gilbert & Sutherland regarding amphitheatre design and leachate drainage layout has been maintained as part of this soil and water assessment.
- Hydrologic and hydraulic modelling performed as part of this drainage assessment showed the quarry / landfill design can maintain water quality objectives and reduce localised flooding.
- The Stage 1 and 2 Ultimate development flow rates from 1 up to and including 100 Year ARI are equal to or better than the Pre development flow rates due to the incorporation of detention areas for flood mitigation and stormwater treatment. These results have been showed in Table 3.5 of Section 3.6 of this report and in detail in Appendix B.
- Water quality controls required to mitigate the impacts of the proposed land use on stormwater quality have been assessed using a MUSIC model of the catchment. Water quality controls proposed for the catchments include vegetated buffers, swales and Constructed Wetland devices at the legal point of discharge (LPD) for each catchment. Minimum sizes and locations of the proposed water quality controls are shown in Figures 5.2 and 5.3. A more detailed design of each recommended treatment measure can be viewed in Appendix C of this report. A final design will be required to determine the exact locations, batter encroachment, sizes, and arrangements of each of the proposed stormwater quality treatment measures. This will be completed during detailed civil design.
- Proposed infrastructure passing under the proposed haul road has been determined and can be viewed in section 3.7.
- It is proposed to reuse stormwater captured onsite from the proposed leachate ponds and detention areas to reduce water demands from council reservoirs.
- The proposed detention areas are regional flood immune with a weir height 300 mm above the designated flood level of 3.9 m AHD. These systems can still drain under a regional event without causing flooding of the quarry site.
- A Stormwater Quality Improvement Device Design criterion has been recommended and can be viewed in Section 5.5.
- A minimum of 1% and maximum of 4% grade shall apply to fill platform layers and must flow toward proposed basins.

8. References

CRC for Catchment Hydrology (2005), *MUSIC User Manual*, April 2005.

Gilbert & Sutherland (April 2007), *Site Investigation Addressing Soils, Stratigraphy and Proposed Management Measures in relation to Council Land at Eviron, NSW.*

Landcom (2004), Managing Urban Stormwater – Soils and Construction.

The Institution of Engineers, Australia (1987), *Australian Rainfall and Runoff: A Guide to Flood Estimation. Volume 2*.

The Institution of Engineers, Australia (1999), *Australian Rainfall and Runoff: A Guide to Flood Estimation. Volume 1*.

Tweed Shire Council, Engineering and Operations Design Unit (February 2008), *Eviron Road Quarry and Landfill Proposal – Concept Plan, Stage 1 Application, and Preliminary Environmental Assessment.*

Appendix A

Rational Method Calculations

Table A1

Rational Method Calculations for Existing Development Catchments											
			Friends Formula as per QUDM				Additional Flow QUDM				
Catchment	Area (ha)	Flow length (m)	Friends length	Mannings 'n'	Friends S (%)	Friends Tc	Flow length - friends length	S (%)	Velocity m/s	Tc	Total Tc
Aex1	0.61	260	50	0.07	11	17.06	210	17	3	1.17	18.23
A1	2.31	220	50	0.07	14	16.26	170	19.5	3	0.94	17.20
Aex2	0.9	140	50	0.07	9.5	17.57	90	7	0.9	1.67	19.23
A2	3.13	210	50	0.07	25	14.48	160	11.5	1.5	1.78	16.25
B	6.09	315	50	0.07	49	12.65	265	6.5	0.9	4.91	17.56
C	6.06	290	50	0.07	16.5	15.73	240	6.5	0.9	4.44	20.17
D	8.58	465	50	0.07	22	14.85	415	13	1.5	4.61	19.46
Eex1	7.47	240	50	0.07	21	14.99	190	21.5	3	1.06	16.05
E	9.72	595	50	0.06	7	16.01	545	11	1.5	6.06	22.06
F	2.43	50	20	0.07	7.5	13.57	30	7.5	0.9	0.56	14.13

Table A2

Rational Method Calculations for Post Development Catchments											
			Friends Formula as per QUDM				Additional Flow QUDM				
Catchment	Area (ha)	Flow length (m)	Friends length	Mannings 'n'	Friends S (%)	Friends Tc	Flow length - friends length	S (%)	Velocity m/s	Tc	Total Tc
Aex1	0.61	260	50	0.07	11	17.06	210	17	3	1.17	18.23
A1	0.37	65	20	0.07	14	11.98	45	19.5	3	0.25	12.23
Aex2	0.9	140	50	0.07	9.5	17.57	90	7	0.9	1.67	19.23
A2	2.34	210	50	0.07	25	14.48	160	11.5	1.5	1.78	16.25
B	10.38	315	50	0.029	4	8.65	265	6.5	0.9	4.91	13.56
CD	16.76	465	50	0.029	4	8.65	415	6.5	0.9	7.69	16.34
Eex1	7.47	240	50	0.07	21	14.99	190	21.5	3	1.06	16.05
E	8.33	595	50	0.06	7	16.01	545	11	1.5	6.06	22.06

Flow Details:

Existing Development Flow Rates

Catcht.	Ac =	tc	I_{100}	C	Q100	I_{50}	C	Q50	I_{20}	C	Q20	I_{10}	C	Q10	I_2	C	Q2	I_1	C	Q3month
ID	(ha)	(min)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)
Aex1	0.61	18.23	193.00	0.74	**0.24**	175.00	0.68	**0.20**	151.00	0.62	**0.16**	132.00	0.59	**0.13**	95.00	0.50	**0.08**	74.00	0.47	**0.03**
A1	2.31	17.20	198.00	0.74	**0.94**	179.00	0.68	**0.78**	155.00	0.62	**0.62**	136.00	0.59	**0.51**	97.00	0.50	**0.31**	76.00	0.47	**0.12**
Aex2	0.9	19.23	188.00	0.74	**0.35**	171.00	0.68	**0.29**	147.00	0.62	**0.23**	129.00	0.59	**0.19**	92.00	0.50	**0.12**	72.00	0.47	**0.04**
A2	3.13	16.25	203.00	0.74	**1.30**	184.00	0.68	**1.09**	159.00	0.62	**0.86**	139.00	0.59	**0.71**	100.00	0.50	**0.44**	79.00	0.47	**0.16**
B	6.09	17.56	195.00	0.74	**2.43**	177.00	0.68	**2.03**	153.00	0.62	**1.60**	134.00	0.59	**1.34**	96.00	0.50	**0.81**	75.00	0.47	**0.30**
C	6.06	20.17	184.00	0.74	**2.28**	167.00	0.68	**1.91**	144.00	0.62	**1.50**	126.00	0.59	**1.25**	90.00	0.50	**0.76**	71.00	0.47	**0.28**
D	8.58	19.46	188.00	0.74	**3.30**	171.00	0.68	**2.77**	147.00	0.62	**2.17**	129.00	0.59	**1.81**	92.00	0.50	**1.10**	72.00	0.47	**0.40**
Eex1	7.47	16.05	203.00	0.74	**3.11**	184.00	0.68	**2.59**	159.00	0.62	**2.04**	139.00	0.59	**1.70**	100.00	0.50	**1.04**	79.00	0.47	**0.39**
E	9.72	22.06	177.00	0.74	**3.52**	160.00	0.68	**2.93**	138.00	0.62	**2.31**	121.00	0.59	**1.93**	86.00	0.50	**1.16**	67.00	0.47	**0.43**
F	2.43	14.13	215.00	0.74	**1.07**	195.00	0.68	**0.89**	168.00	0.62	**0.70**	148.00	0.59	**0.59**	107.00	0.50	**0.36**	84.00	0.47	**0.13**

Post Development Flow Rates

Catcht.	Ac =	tc	I_{100}	C	Q100	I_{50}	C	Q50	I_{20}	C	Q20	I_{10}	C	Q10	I_2	C	Q2	I_1	C	Q3month
ID	(ha)	(min)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)	(mm/hr)		(cumec)
Aex1	0.61	18.23	193.00	0.74	**0.24**	175.00	0.68	**0.20**	151.00	0.62	**0.16**	132.00	0.59	**0.13**	95.00	0.50	**0.08**	74.00	0.47	**0.03**
A1	0.37	12.23	228.00	0.74	**0.17**	207.00	0.68	**0.14**	179.00	0.62	**0.11**	158.00	0.59	**0.10**	114.00	0.50	**0.06**	90.00	0.47	**0.02**
Aex2	0.90	19.23	188.00	0.74	**0.35**	171.00	0.68	**0.29**	147.00	0.62	**0.23**	129.00	0.59	**0.19**	92.00	0.50	**0.12**	72.00	0.47	**0.04**
A2	2.34	16.25	203.00	0.74	**0.97**	184.00	0.68	**0.81**	159.00	0.62	**0.64**	139.00	0.59	**0.53**	100.00	0.50	**0.33**	79.00	0.47	**0.12**
B	10.38	13.56	218.00	0.75	**4.71**	198.00	0.69	**3.94**	170.50	0.63	**3.10**	150.00	0.60	**2.60**	108.50	0.51	**1.60**	85.50	0.48	**0.59**
CD	16.76	16.34	203.00	0.75	**7.09**	184.00	0.69	**5.91**	159.00	0.63	**4.66**	139.00	0.60	**3.88**	100.00	0.51	**2.37**	79.00	0.48	**0.88**
Eex1	7.47	16.05	203.00	0.74	**3.11**	184.00	0.68	**2.59**	159.00	0.62	**2.04**	139.00	0.59	**1.70**	100.00	0.50	**1.04**	79.00	0.47	**0.39**
E	8.33	22.06	177.00	0.74	**3.02**	160.00	0.68	**2.51**	138.00	0.62	**1.98**	121.00	0.59	**1.65**	86.00	0.50	**1.00**	67.00	0.47	**0.37**

Appendix B

XP Storm Results Tables

Q1 Results

Peak Discharges (Existing Conditions)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
Aex1	0.076	0.088	0.101	0.116	0.106	0.077	0.111	0.095	0.087	0.081	25	0.116
A1	0.329	0.39	0.427	0.497	0.456	0.327	0.465	0.389	0.358	0.321	25	0.497
LPD A1	0.384	0.454	0.517	0.587	0.539	0.396	0.558	0.476	0.439	0.397	25	0.587
Aex2	0.124	0.146	0.162	0.188	0.172	0.124	0.177	0.149	0.136	0.124	25	0.188
A2	0.396	0.46	0.53	0.605	0.555	0.405	0.578	0.494	0.452	0.421	25	0.605
LPD A2	0.498	0.585	0.677	0.76	0.7	0.519	0.733	0.637	0.586	0.539	25	0.76
B	0.365	0.451	0.546	0.586	0.538	0.485	0.648	0.678	0.626	0.61	90	0.678
LPD B	0.363	0.451	0.545	0.585	0.538	0.485	0.649	0.678	0.626	0.609	90	0.678
C	0.389	0.476	0.579	0.622	0.572	0.503	0.673	0.702	0.644	0.629	90	0.702
D	0.498	0.619	0.748	0.8	0.735	0.671	0.899	0.938	0.867	0.846	90	0.938
LPD CD	0.883	1.093	1.324	1.42	1.305	1.173	1.566	1.638	1.511	1.473	90	1.638
Eex1	0.843	0.965	1.155	1.299	1.193	0.88	1.266	1.115	1.032	0.97	25	1.299
E	0.424	0.548	0.652	0.689	0.689	0.634	0.865	0.887	0.835	0.817	90	0.887
LPD E	1.043	1.392	1.646	1.768	1.651	1.413	1.952	1.95	1.812	1.707	60	1.952

Q1 Results

Peak Discharges (Developed Conditions)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.076	0.088	0.101	0.116	0.106	0.077	0.111	0.095	0.087	0.081	25	0.116	0.00%
A1	0.076	0.101	0.096	0.111	0.101	0.071	0.097	0.078	0.074	0.056	25	0.111	-77.67%
LPD A1	0.144	0.176	0.183	0.213	0.198	0.14	0.2	0.167	0.155	0.135	25	0.213	-63.71%
Aex2	0.124	0.146	0.162	0.188	0.172	0.124	0.177	0.149	0.136	0.124	25	0.188	0.00%
A2	0.296	0.343	0.395	0.451	0.414	0.302	0.432	0.369	0.338	0.314	25	0.451	-25.45%
LPD A2	0.398	0.469	0.545	0.614	0.564	0.417	0.592	0.512	0.471	0.433	25	0.614	-19.21%
B	1.332	1.567	1.762	2.031	1.864	1.348	1.939	1.659	1.511	1.399	25	2.031	199.56%
LPD B	1.33	1.561	1.76	2.025	1.858	1.349	1.933	1.658	1.511	1.402	25	2.025	198.67%
CD	1.168	1.346	1.681	1.851	1.7	1.414	1.906	1.97	1.796	1.772	90	1.97	20.12%
LPD CD	1.168	1.347	1.681	1.85	1.699	1.414	1.909	1.971	1.796	1.773	90	1.971	20.33%
Eex1	0.843	0.965	1.155	1.299	1.193	0.88	1.266	1.115	1.032	0.97	25	1.299	0.00%
E	0.364	0.47	0.559	0.592	0.591	0.544	0.742	0.761	0.716	0.701	90	0.761	-14.21%
LPD E	0.993	1.325	1.565	1.682	1.569	1.326	1.838	1.825	1.695	1.593	60	1.838	-5.84%

Q1 Results

Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.076	0.088	0.101	0.116	0.106	0.077	0.111	0.095	0.087	0.081	25	0.116	0.00%
A1	0.076	0.101	0.096	0.111	0.101	0.071	0.097	0.078	0.074	0.056	25	0.111	-77.67%
LPD A1	0.144	0.176	0.183	0.213	0.198	0.14	0.2	0.167	0.155	0.135	25	0.213	-63.71%
Aex2	0.124	0.146	0.162	0.188	0.172	0.124	0.177	0.149	0.136	0.124	25	0.188	0.00%
A2	0.296	0.343	0.395	0.451	0.414	0.302	0.432	0.369	0.338	0.314	25	0.451	-25.45%
LPD A2	0.398	0.469	0.545	0.614	0.564	0.417	0.592	0.512	0.471	0.433	25	0.614	-19.21%
B	0.794	0.907	1.136	1.249	1.147	0.894	1.266	1.243	1.124	1.097	60	1.266	86.73%
LPD B	0.095	0.111	0.137	0.15	0.138	0.106	0.274	0.391	0.424	0.422	120	0.424	-37.46%
CD	1.425	1.641	1.969	2.214	2.034	1.499	2.19	1.996	1.828	1.753	25	2.214	35.00%
LPD CD	0.309	0.352	0.426	0.475	0.437	0.327	0.465	0.54	0.595	0.598	180	0.598	-63.49%
Eex1	0.843	0.965	1.155	1.299	1.193	0.88	1.266	1.115	1.032	0.97	25	1.299	0.00%
E	0.364	0.47	0.559	0.592	0.591	0.544	0.742	0.761	0.716	0.701	90	0.761	-14.21%
LPD E	0.993	1.325	1.565	1.682	1.569	1.326	1.838	1.825	1.695	1.593	60	1.838	-5.84%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q1 Results

Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)													
Node	10min	15min	20min	0.111	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.076	0.088	0.101	0.116	0.106	0.077	0.111	0.095	0.087	0.081	25	0.116	0.00%
A1	0.076	0.101	0.096	0.111	0.101	0.071	0.097	0.078	0.074	0.056	25	0.111	-77.67%
LPD A1	0.144	0.176	0.183	0.213	0.198	0.14	0.2	0.167	0.155	0.135	25	0.213	-63.71%
Aex2	0.124	0.146	0.162	0.188	0.172	0.124	0.177	0.149	0.136	0.124	25	0.188	0.00%
A2	0.296	0.343	0.395	0.451	0.414	0.302	0.432	0.369	0.338	0.314	25	0.451	-25.45%
LPD A2	0.398	0.469	0.545	0.614	0.564	0.417	0.592	0.512	0.471	0.433	25	0.614	-19.21%
B	0.767	0.883	1.102	1.209	1.111	0.879	1.23	1.223	1.102	1.082	60	1.23	81.42%
LPD B	0.119	0.137	0.164	0.183	0.169	0.126	0.262	0.383	0.418	0.416	120	0.418	-38.35%
CD	0.914	1.063	1.322	1.453	1.335	1.136	1.504	1.585	1.453	1.433	90	1.585	-3.35%
LPD CD	0.304	0.348	0.425	0.473	0.435	0.325	0.465	0.443	0.523	0.518	120	0.523	-68.07%
Eex1	0.843	0.965	1.155	1.299	1.193	0.88	1.266	1.115	1.032	0.97	25	1.299	0.00%
E	0.364	0.47	0.559	0.592	0.591	0.544	0.742	0.761	0.716	0.701	90	0.761	-14.21%
LPD E	0.993	1.325	1.565	1.682	1.569	1.326	1.838	1.825	1.695	1.593	60	1.838	-5.84%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q2 Results

Peak Discharges (Existing Conditions)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
Aex1	0.107	0.126	0.14	0.165	0.154	0.11	0.154	0.132	0.121	0.111	25	0.165
A1	0.461	0.556	0.582	0.7	0.652	0.456	0.638	0.534	0.497	0.432	25	0.7
LPD A1	0.547	0.654	0.71	0.832	0.776	0.558	0.769	0.654	0.608	0.539	25	0.832
Aex2	0.174	0.209	0.222	0.266	0.247	0.174	0.244	0.205	0.19	0.167	25	0.266
A2	0.561	0.664	0.731	0.863	0.805	0.572	0.803	0.684	0.631	0.571	25	0.863
LPD A2	0.708	0.84	0.938	1.093	1.02	0.734	1.022	0.877	0.811	0.732	25	1.093
B	0.54	0.658	0.797	0.88	0.823	0.693	0.922	0.97	0.887	0.874	90	0.97
LPD B	0.537	0.658	0.795	0.879	0.823	0.693	0.922	0.97	0.887	0.874	90	0.97
C	0.574	0.691	0.841	0.932	0.871	0.714	0.954	0.998	0.907	0.895	90	0.998
D	0.737	0.904	1.092	1.204	1.126	0.96	1.275	1.345	1.232	1.214	90	1.345
LPD CD	1.307	1.594	1.93	2.134	1.996	1.674	2.229	2.341	2.14	2.108	90	2.341
Eex1	1.206	1.404	1.613	1.875	1.749	1.261	1.778	1.546	1.416	1.326	25	1.875
E	0.633	0.811	0.962	1.048	1.02	0.92	1.233	1.299	1.214	1.198	90	1.299
LPD E	1.559	2.035	2.373	2.608	2.466	1.988	2.761	2.766	2.55	2.428	90	2.766

Q2 Results

Peak Discharges (Developed Conditions)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.107	0.126	0.14	0.165	0.154	0.11	0.154	0.132	0.121	0.111	25	0.165	0.00%
A1	0.1	0.136	0.129	0.147	0.136	0.098	0.128	0.105	0.1	0.074	25	0.147	-79.00%
LPD A1	0.2	0.242	0.245	0.294	0.274	0.194	0.267	0.226	0.213	0.183	25	0.294	-64.66%
Aex2	0.174	0.209	0.222	0.266	0.247	0.174	0.244	0.205	0.19	0.167	25	0.266	0.00%
A2	0.419	0.495	0.546	0.644	0.601	0.427	0.6	0.511	0.471	0.427	25	0.644	-25.38%
LPD A2	0.571	0.676	0.754	0.877	0.818	0.592	0.82	0.705	0.653	0.589	25	0.877	-19.76%
B	1.878	2.243	2.428	2.887	2.691	1.901	2.685	2.292	2.116	1.896	25	2.887	197.63%
LPD B	1.873	2.236	2.425	2.88	2.685	1.899	2.68	2.292	2.115	1.895	25	2.88	196.91%
CD	1.697	1.941	2.419	2.736	2.556	1.998	2.763	2.79	2.521	2.512	90	2.79	19.08%
LPD CD	1.698	1.942	2.415	2.729	2.551	1.999	2.763	2.789	2.521	2.51	90	2.789	19.14%
Eex1	1.206	1.404	1.613	1.875	1.749	1.261	1.778	1.546	1.416	1.326	25	1.875	0.00%
E	0.544	0.696	0.826	0.9	0.876	0.79	1.058	1.114	1.042	1.028	90	1.114	-14.24%
LPD E	1.485	1.934	2.253	2.478	2.343	1.859	2.594	2.584	2.382	2.261	60	2.594	-6.22%

Q2 Results

Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.107	0.126	0.14	0.165	0.154	0.11	0.154	0.132	0.121	0.111	25	0.165	0.00%
A1	0.1	0.136	0.129	0.147	0.136	0.098	0.128	0.105	0.1	0.074	25	0.147	-79.00%
LPD A1	0.2	0.242	0.245	0.294	0.274	0.194	0.267	0.226	0.213	0.183	25	0.294	-64.66%
Aex2	0.174	0.209	0.222	0.266	0.247	0.174	0.244	0.205	0.19	0.167	25	0.266	0.00%
A2	0.419	0.495	0.546	0.644	0.601	0.427	0.6	0.511	0.471	0.427	25	0.644	-25.38%
LPD A2	0.571	0.676	0.754	0.877	0.818	0.592	0.82	0.705	0.653	0.589	25	0.877	-19.76%
B	1.153	1.313	1.622	1.839	1.718	1.265	1.819	1.73	1.586	1.531	25	1.839	89.59%
LPD B	0.095	0.111	0.137	0.15	0.138	0.106	0.274	0.391	0.424	0.422	120	0.424	-56.29%
CD	2.042	2.38	2.77	3.209	2.995	2.164	3.096	2.758	2.538	2.414	25	3.209	36.96%
LPD CD	0.442	0.512	0.59	0.682	0.637	0.464	0.742	0.802	0.826	0.807	120	0.826	-64.72%
Eex1	1.206	1.404	1.613	1.875	1.749	1.261	1.778	1.546	1.416	1.326	25	1.875	0.00%
E	0.544	0.696	0.826	0.9	0.876	0.79	1.058	1.114	1.042	1.028	90	1.114	-14.24%
LPD E	1.485	1.934	2.253	2.478	2.343	1.859	2.594	2.584	2.382	2.261	60	2.594	-6.22%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q2 Results

Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)													
Node	10min	15min	20min	0.147	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.107	0.126	0.14	0.165	0.154	0.11	0.154	0.132	0.121	0.111	25	0.165	0.00%
A1	0.1	0.136	0.129	0.147	0.136	0.098	0.128	0.105	0.1	0.074	25	0.147	-79.00%
LPD A1	0.2	0.242	0.245	0.294	0.274	0.194	0.267	0.226	0.213	0.183	25	0.294	-64.66%
Aex2	0.174	0.209	0.222	0.266	0.247	0.174	0.244	0.205	0.19	0.167	25	0.266	0.00%
A2	0.419	0.495	0.546	0.644	0.601	0.427	0.6	0.511	0.471	0.427	25	0.644	-25.38%
LPD A2	0.571	0.676	0.754	0.877	0.818	0.592	0.82	0.705	0.653	0.589	25	0.877	-19.76%
B	1.116	1.268	1.577	1.784	1.666	1.23	1.772	1.706	1.56	1.513	25	1.784	83.92%
LPD B	0.17	0.198	0.226	0.261	0.244	0.275	0.557	0.684	0.707	0.698	120	0.707	-27.11%
CD	1.331	1.539	1.909	2.153	2.011	1.615	2.189	2.258	2.053	2.043	90	2.258	-3.63%
LPD CD	0.438	0.507	0.59	0.682	0.637	0.464	0.649	0.738	0.756	0.758	180	0.758	-67.62%
Eex1	1.206	1.404	1.613	1.875	1.749	1.261	1.778	1.546	1.416	1.326	25	1.875	0.00%
E	0.544	0.696	0.826	0.9	0.876	0.79	1.058	1.114	1.042	1.028	90	1.114	-14.24%
LPD E	1.485	1.934	2.253	2.478	2.343	1.859	2.594	2.584	2.382	2.261	60	2.594	-6.22%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q5 Results

Node	Peak Discharges (Existing Conditions)											
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
Aex1	0.146	0.176	0.19	0.226	0.211	0.152	0.213	0.18	0.171	0.152	25	0.226
A1	0.621	0.765	0.774	0.944	0.879	0.619	0.868	0.723	0.69	0.589	25	0.944
LPD A1	0.742	0.902	0.954	1.136	1.059	0.762	1.054	0.886	0.843	0.736	25	1.136
Aex2	0.236	0.288	0.297	0.36	0.335	0.237	0.332	0.278	0.265	0.228	25	0.36
A2	0.765	0.923	0.985	1.178	1.098	0.788	1.104	0.934	0.884	0.782	25	1.178
LPD A2	0.971	1.173	1.269	1.495	1.394	1.014	1.405	1.195	1.133	1.004	25	1.495
B	0.768	0.924	1.134	1.261	1.179	0.962	1.318	1.359	1.255	1.254	90	1.359
LPD B	0.767	0.925	1.133	1.259	1.177	0.962	1.318	1.36	1.255	1.254	90	1.36
C	0.814	0.966	1.192	1.331	1.244	0.986	1.381	1.391	1.291	1.278	90	1.391
D	1.05	1.272	1.556	1.728	1.616	1.336	1.813	1.889	1.742	1.746	90	1.889
LPD CD	1.859	2.236	2.744	3.055	2.857	2.322	3.195	3.278	3.032	3.021	90	3.278
Eex1	1.659	1.97	2.198	2.585	2.41	1.756	2.47	2.125	1.997	1.826	25	2.585
E	0.91	1.157	1.389	1.521	1.423	1.308	1.735	1.862	1.757	1.761	90	1.862
LPD E	2.224	2.856	3.341	3.68	3.471	2.756	3.893	3.858	3.61	3.473	60	3.893

Q5 Results

Node	Peak Discharges (Developed Conditions)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.146	0.176	0.19	0.226	0.211	0.152	0.213	0.18	0.171	0.152	25	0.226	0.00%
A1	0.128	0.177	0.17	0.19	0.176	0.131	0.167	0.139	0.135	0.099	25	0.19	-79.87%
LPD A1	0.262	0.328	0.325	0.397	0.369	0.26	0.364	0.306	0.292	0.248	25	0.397	-65.05%
Aex2	0.236	0.288	0.297	0.36	0.335	0.237	0.332	0.278	0.265	0.228	25	0.36	0.00%
A2	0.571	0.689	0.736	0.879	0.819	0.588	0.825	0.698	0.661	0.584	25	0.879	-25.38%
LPD A2	0.779	0.94	1.02	1.204	1.122	0.815	1.13	0.96	0.91	0.807	25	1.204	-19.46%
B	2.551	3.104	3.266	3.93	3.661	2.612	3.683	3.123	2.959	2.596	25	3.93	189.18%
LPD B	2.548	3.095	3.265	3.92	3.653	2.61	3.679	3.119	2.956	2.595	25	3.92	188.24%
CD	2.382	2.755	3.404	3.87	3.614	2.749	3.97	3.876	3.604	3.573	60	3.97	21.04%
LPD CD	2.373	2.753	3.398	3.86	3.607	2.749	3.971	3.875	3.603	3.57	60	3.971	21.14%
Eex1	1.659	1.97	2.198	2.585	2.41	1.756	2.47	2.125	1.997	1.826	25	2.585	0.00%
E	0.781	0.993	1.192	1.305	1.221	1.122	1.489	1.598	1.507	1.51	90	1.598	-14.18%
LPD E	2.118	2.708	3.161	3.489	3.288	2.599	3.653	3.597	3.369	3.226	60	3.653	-6.16%

Q5 Results

Node	Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.146	0.176	0.19	0.226	0.211	0.152	0.213	0.18	0.171	0.152	25	0.226	0.00%
A1	0.128	0.177	0.17	0.19	0.176	0.131	0.167	0.139	0.135	0.099	25	0.19	-79.87%
LPD A1	0.262	0.328	0.325	0.397	0.369	0.26	0.364	0.306	0.292	0.248	25	0.397	-65.05%
Aex2	0.236	0.288	0.297	0.36	0.335	0.237	0.332	0.278	0.265	0.228	25	0.36	0.00%
A2	0.571	0.689	0.736	0.879	0.819	0.588	0.825	0.698	0.661	0.584	25	0.879	-25.38%
LPD A2	0.779	0.94	1.02	1.204	1.122	0.815	1.13	0.96	0.91	0.807	25	1.204	-19.46%
B	1.613	1.868	2.26	2.584	2.413	1.806	2.584	2.362	2.227	2.144	25	2.584	90.14%
LPD B	0.192	0.223	0.264	0.405	0.528	0.615	0.932	0.979	0.981	0.979	120	0.981	-27.87%
CD	2.82	3.341	3.806	4.449	4.15	3.042	4.333	3.817	3.557	3.346	25	4.449	35.64%
LPD CD	0.605	0.716	0.802	0.936	0.874	0.793	1.119	1.464	1.585	1.594	180	1.594	-51.37%
Eex1	1.659	1.97	2.198	2.585	2.41	1.756	2.47	2.125	1.997	1.826	25	2.585	0.00%
E	0.781	0.993	1.192	1.305	1.221	1.122	1.489	1.598	1.507	1.51	90	1.598	-14.18%
LPD E	2.118	2.708	3.161	3.489	3.288	2.599	3.653	3.597	3.369	3.226	60	3.653	-6.16%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q5 Results

Node	Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)												
Node	10min	15min	20min	0.19	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.146	0.176	0.19	0.226	0.211	0.152	0.213	0.18	0.171	0.152	25	0.226	0.00%
A1	0.128	0.177	0.17	0.19	0.176	0.131	0.167	0.139	0.135	0.099	25	0.19	-79.87%
LPD A1	0.262	0.328	0.325	0.397	0.369	0.26	0.364	0.306	0.292	0.248	25	0.397	-65.05%
Aex2	0.236	0.288	0.297	0.36	0.335	0.237	0.332	0.278	0.265	0.228	25	0.36	0.00%
A2	0.571	0.689	0.736	0.879	0.819	0.588	0.825	0.698	0.661	0.584	25	0.879	-25.38%
LPD A2	0.779	0.94	1.02	1.204	1.122	0.815	1.13	0.96	0.91	0.807	25	1.204	-19.46%
B	1.564	1.806	2.203	2.512	2.346	1.76	2.525	2.337	2.199	2.124	60	2.525	85.80%
LPD B	0.233	0.277	0.305	0.385	0.506	0.593	0.917	0.964	0.971	0.969	120	0.971	-28.60%
CD	1.871	2.159	2.695	3.053	2.852	2.234	3.157	3.154	2.919	2.922	60	3.157	-3.75%
LPD CD	0.604	0.714	0.801	0.936	0.874	0.643	0.9	1.255	1.397	1.452	180	1.452	-55.70%
Eex1	1.659	1.97	2.198	2.585	2.41	1.756	2.47	2.125	1.997	1.826	25	2.585	0.00%
E	0.781	0.993	1.192	1.305	1.221	1.122	1.489	1.598	1.507	1.51	90	1.598	-14.18%
LPD E	2.118	2.708	3.161	3.489	3.288	2.599	3.653	3.597	3.369	3.226	60	3.653	-6.16%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q10 Results

Peak Discharges (Existing Conditions)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
Aex1	0.169	0.204	0.218	0.259	0.244	0.175	0.247	0.21	0.2	0.177	25	0.259
A1	0.713	0.882	0.882	1.076	1.013	0.711	1.001	0.841	0.807	0.686	25	1.076
LPD A1	0.857	1.045	1.091	1.298	1.226	0.878	1.22	1.032	0.989	0.858	25	1.298
Aex2	0.271	0.333	0.338	0.41	0.386	0.273	0.384	0.323	0.31	0.266	25	0.41
A2	0.883	1.07	1.129	1.349	1.272	0.91	1.279	1.089	1.039	0.913	25	1.349
LPD A2	1.125	1.357	1.454	1.716	1.619	1.173	1.63	1.391	1.329	1.173	25	1.716
B	0.905	1.075	1.334	1.477	1.4	1.116	1.569	1.602	1.493	1.493	90	1.602
LPD B	1.511	1.074	1.333	1.476	1.399	1.117	1.569	1.601	1.494	1.494	90	1.601
C	0.959	1.121	1.4	1.557	1.475	1.141	1.639	1.635	1.531	1.518	60	1.639
D	1.239	1.481	1.833	2.025	1.92	1.552	2.16	2.228	2.074	2.081	90	2.228
LPD CD	2.194	2.601	3.229	3.576	3.391	2.692	3.801	3.862	3.605	3.596	90	3.862
Eex1	1.924	2.292	2.532	2.973	2.807	2.041	2.874	2.485	2.354	2.137	25	2.973
E	1.078	1.357	1.646	1.791	1.7	1.534	2.045	2.22	2.091	2.12	90	2.22
LPD E	2.621	3.318	3.913	4.283	4.091	3.24	4.575	4.541	4.269	4.133	60	4.575

Q10 Results

Peak Discharges (Developed Conditions)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.169	0.204	0.218	0.259	0.244	0.175	0.247	0.21	0.2	0.177	25	0.259	0.00%
A1	0.144	0.199	0.193	0.212	0.198	0.149	0.19	0.16	0.157	0.114	25	0.212	-80.30%
LPD A1	0.301	0.378	0.37	0.452	0.425	0.298	0.42	0.356	0.342	0.289	25	0.452	-65.18%
Aex2	0.271	0.333	0.338	0.41	0.386	0.273	0.384	0.323	0.31	0.266	25	0.41	0.00%
A2	0.659	0.798	0.843	1.007	0.95	0.68	0.955	0.813	0.776	0.682	25	1.007	-25.35%
LPD A2	0.902	1.092	1.171	1.378	1.302	0.943	1.309	1.119	1.069	0.943	25	1.378	-19.70%
B	2.942	3.59	3.742	4.496	4.238	3.017	4.264	3.638	3.473	3.03	25	4.496	180.65%
LPD B	2.937	3.581	3.741	4.485	4.233	3.017	4.261	3.635	3.468	3.032	25	4.485	180.14%
CD	2.792	3.229	3.986	4.507	4.267	3.219	4.698	4.55	4.269	4.239	60	4.698	21.49%
LPD CD	2.785	3.226	3.98	4.496	4.258	3.22	4.697	4.549	4.267	4.236	60	4.697	21.62%
Eex1	1.924	2.292	2.532	2.973	2.807	2.041	2.874	2.485	2.354	2.137	25	2.973	0.00%
E	0.926	1.164	1.413	1.538	1.46	1.316	1.754	1.904	1.794	1.818	90	1.904	-14.23%
LPD E	2.496	3.143	3.697	4.056	3.87	3.053	4.291	4.229	3.98	3.836	60	4.291	-6.21%

Q10 Results

Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.169	0.204	0.218	0.259	0.244	0.175	0.247	0.21	0.2	0.177	25	0.259	0.00%
A1	0.144	0.199	0.193	0.212	0.198	0.149	0.19	0.16	0.157	0.114	25	0.212	-80.30%
LPD A1	0.301	0.378	0.37	0.452	0.425	0.298	0.42	0.356	0.342	0.289	25	0.452	-65.18%
Aex2	0.271	0.333	0.338	0.41	0.386	0.273	0.384	0.323	0.31	0.266	25	0.41	0.00%
A2	0.659	0.798	0.843	1.007	0.95	0.68	0.955	0.813	0.776	0.682	25	1.007	-25.35%
LPD A2	0.902	1.092	1.171	1.378	1.302	0.943	1.309	1.119	1.069	0.943	25	1.378	-19.70%
B	1.887	2.188	2.632	3	2.838	2.123	3.04	2.763	2.615	2.527	60	3.04	89.76%
LPD B	0.223	0.259	0.393	0.552	0.711	0.812	1.02	1.169	1.223	1.239	180	1.239	-22.61%
CD	3.278	3.89	4.404	5.132	4.848	3.552	5.062	4.477	4.209	3.926	25	5.132	32.71%
LPD CD	0.7	0.831	0.923	1.077	1.018	0.971	1.68	2.061	2.157	2.176	180	2.176	-43.66%
Eex1	1.924	2.292	2.532	2.973	2.807	2.041	2.874	2.485	2.354	2.137	25	2.973	0.00%
E	0.926	1.164	1.413	1.538	1.46	1.316	1.754	1.904	1.794	1.818	90	1.904	-14.23%
LPD E	2.496	3.143	3.697	4.056	3.87	3.053	4.291	4.229	3.98	3.836	60	4.291	-6.21%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q10 Results

Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)													
Node	10min	15min	20min	0.212	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.169	0.204	0.218	0.259	0.244	0.175	0.247	0.21	0.2	0.177	25	0.259	0.00%
A1	0.144	0.199	0.193	0.212	0.198	0.149	0.19	0.16	0.157	0.114	25	0.212	-80.30%
LPD A1	0.301	0.378	0.37	0.452	0.425	0.298	0.42	0.356	0.342	0.289	25	0.452	-65.18%
Aex2	0.271	0.333	0.338	0.41	0.386	0.273	0.384	0.323	0.31	0.266	25	0.41	0.00%
A2	0.659	0.798	0.843	1.007	0.95	0.68	0.955	0.813	0.776	0.682	25	1.007	-25.35%
LPD A2	0.902	1.092	1.171	1.378	1.302	0.943	1.309	1.119	1.069	0.943	25	1.378	-19.70%
B	1.831	2.117	2.569	2.919	2.762	2.073	2.973	2.725	2.585	2.506	60	2.973	85.58%
LPD B	0.269	0.319	0.373	0.528	0.684	0.786	1.005	1.15	1.206	1.225	180	1.225	-23.49%
CD	2.196	2.532	3.161	3.561	3.372	2.589	3.743	3.712	3.468	3.474	60	3.743	-3.21%
LPD CD	0.7	0.83	0.924	1.075	1.016	0.751	1.278	1.76	1.904	1.959	180	1.959	-49.27%
Eex1	1.924	2.292	2.532	2.973	2.807	2.041	2.874	2.485	2.354	2.137	25	2.973	0.00%
E	0.926	1.164	1.413	1.538	1.46	1.316	1.754	1.904	1.794	1.818	90	1.904	-14.23%
LPD E	2.496	3.143	3.697	4.056	3.87	3.053	4.291	4.229	3.98	3.836	60	4.291	-6.21%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q20 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
	Peak Discharges (Existing Conditions)											
Aex1	0.202	0.246	0.257	0.311	0.291	0.21	0.294	0.249	0.238	0.21	25	0.311
A1	0.843	1.053	1.033	1.282	1.198	0.845	1.185	0.993	0.955	0.809	25	1.282
LPD A1	1.02	1.256	1.282	1.553	1.453	1.048	1.446	1.221	1.172	1.014	25	1.553
Aex2	0.321	0.399	0.397	0.49	0.458	0.325	0.455	0.382	0.367	0.314	25	0.49
A2	1.052	1.286	1.332	1.618	1.514	1.089	1.523	1.29	1.233	1.079	25	1.618
LPD A2	1.34	1.633	1.718	2.063	1.932	1.404	1.943	1.648	1.577	1.387	25	2.063
B	1.108	1.298	1.626	1.826	1.717	1.342	1.927	1.917	1.795	1.799	60	1.927
LPD B	1.107	1.297	1.624	1.822	1.714	1.342	1.925	1.917	1.794	1.798	60	1.925
C	1.171	1.351	1.702	1.921	1.806	1.399	2.008	1.952	1.835	1.825	60	2.008
D	1.517	1.791	2.236	2.507	2.357	1.869	2.656	2.671	2.496	2.511	90	2.671
LPD CD	2.68	3.14	3.932	4.421	4.157	3.24	4.666	4.621	4.329	4.333	60	4.666
Eex1	2.303	2.769	3.005	3.587	3.36	2.459	3.439	2.954	2.806	2.532	25	3.587
E	1.328	1.655	2.024	2.234	2.102	1.871	2.493	2.691	2.514	2.584	90	2.691
LPD E	3.205	4.004	4.742	5.254	4.973	3.972	5.548	5.431	5.108	4.982	60	5.548

Q20 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Developed Conditions)												
Aex1	0.202	0.246	0.257	0.311	0.291	0.21	0.294	0.249	0.238	0.21	25	0.311	0.00%
A1	0.171	0.23	0.226	0.247	0.229	0.176	0.222	0.188	0.183	0.134	25	0.247	-80.73%
LPD A1	0.355	0.45	0.432	0.539	0.503	0.354	0.499	0.422	0.406	0.341	25	0.539	-65.29%
Aex2	0.321	0.399	0.397	0.49	0.458	0.325	0.455	0.382	0.367	0.314	25	0.49	0.00%
A2	0.785	0.96	0.995	1.208	1.13	0.814	1.137	0.964	0.921	0.807	25	1.208	-25.34%
LPD A2	1.079	1.314	1.381	1.656	1.55	1.13	1.56	1.324	1.269	1.116	25	1.656	-19.73%
B	5.116	5.131	5.133	5.15	5.144	5.118	5.145	5.131	5.128	5.118	25	5.15	167.25%
LPD B	3.493	4.3	4.408	5.383	5.028	3.607	5.07	4.303	4.117	3.58	25	5.383	179.64%
CD	3.393	3.943	4.831	5.537	5.198	3.971	5.734	5.424	5.107	5.09	60	5.734	22.55%
LPD CD	3.381	3.939	4.822	5.523	5.188	3.97	5.733	5.427	5.106	5.088	60	5.733	22.87%
Eex1	2.303	2.769	3.005	3.587	3.36	2.459	3.439	2.954	2.806	2.532	25	3.587	0.00%
E	1.14	1.42	1.737	1.918	1.804	1.605	2.139	2.308	2.156	2.216	90	2.308	-14.23%
LPD E	3.046	3.792	4.474	4.967	4.697	3.738	5.198	5.053	4.758	4.62	60	5.198	-6.31%

Q20 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)												
Aex1	0.202	0.246	0.257	0.311	0.291	0.21	0.294	0.249	0.238	0.21	25	0.311	0.00%
A1	0.171	0.23	0.226	0.247	0.229	0.176	0.222	0.188	0.183	0.134	25	0.247	-80.73%
LPD A1	0.355	0.45	0.432	0.539	0.503	0.354	0.499	0.422	0.406	0.341	25	0.539	-65.29%
Aex2	0.321	0.399	0.397	0.49	0.458	0.325	0.455	0.382	0.367	0.314	25	0.49	0.00%
A2	0.785	0.96	0.995	1.208	1.13	0.814	1.137	0.964	0.921	0.807	25	1.208	-25.34%
LPD A2	1.079	1.314	1.381	1.656	1.55	1.13	1.56	1.324	1.269	1.116	25	1.656	-19.73%
B	2.285	2.668	3.167	3.665	3.439	2.598	3.684	3.313	3.1	3.016	60	3.684	91.18%
LPD B	0.268	0.359	0.585	0.8	0.927	0.986	1.364	1.589	1.617	1.666	180	1.666	-13.45%
CD	3.939	4.708	5.256	6.219	5.828	4.306	6.085	5.336	5.034	4.664	25	6.219	32.91%
LPD CD	0.839	1.001	1.094	1.297	1.216	1.328	2.502	2.941	2.922	3.063	180	3.063	-34.35%
Eex1	2.303	2.769	3.005	3.587	3.36	2.459	3.439	2.954	2.806	2.532	25	3.587	0.00%
E	1.14	1.42	1.737	1.918	1.804	1.605	2.139	2.308	2.156	2.216	90	2.308	-14.23%
LPD E	3.046	3.792	4.474	4.967	4.697	3.738	5.198	5.053	4.758	4.62	60	5.198	-6.31%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q20 Results

Node	10min	15min	20min	0.247	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)												
Aex1	0.202	0.246	0.257	0.311	0.291	0.21	0.294	0.249	0.238	0.21	25	0.311	0.00%
A1	0.171	0.23	0.226	0.247	0.229	0.176	0.222	0.188	0.183	0.134	25	0.247	-80.73%
LPD A1	0.355	0.45	0.432	0.539	0.503	0.354	0.499	0.422	0.406	0.341	25	0.539	-65.29%
Aex2	0.321	0.399	0.397	0.49	0.458	0.325	0.455	0.382	0.367	0.314	25	0.49	0.00%
A2	0.785	0.96	0.995	1.208	1.13	0.814	1.137	0.964	0.921	0.807	25	1.208	-25.34%
LPD A2	1.079	1.314	1.381	1.656	1.55	1.13	1.56	1.324	1.269	1.116	25	1.656	-19.73%
B	2.219	2.584	3.095	3.57	3.351	2.54	3.608	3.264	3.069	2.993	60	3.608	87.23%
LPD B	0.319	0.382	0.56	0.768	0.899	0.969	1.334	1.556	1.595	1.642	180	1.642	-14.70%
CD	2.672	3.095	3.839	4.382	4.116	3.158	4.58	4.438	4.162	4.183	60	4.58	-2.12%
LPD CD	0.837	1.001	1.094	1.296	1.215	0.999	2.001	2.425	2.568	2.644	180	2.644	-43.33%
Eex1	2.303	2.769	3.005	3.587	3.36	2.459	3.439	2.954	2.806	2.532	25	3.587	0.00%
E	1.14	1.42	1.737	1.918	1.804	1.605	2.139	2.308	2.156	2.216	90	2.308	-14.23%
LPD E	3.046	3.792	4.474	4.967	4.697	3.738	5.198	5.053	4.758	4.62	60	5.198	-6.31%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q50 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
	Peak Discharges (Existing Conditions)											
Aex1	0.251	0.287	0.301	0.337	0.32	0.242	0.332	0.27	0.257	0.225	25	0.337
A1	1.047	1.216	1.202	1.378	1.307	0.965	1.33	1.067	1.021	0.865	25	1.378
LPD A1	1.269	1.457	1.494	1.679	1.594	1.202	1.631	1.316	1.259	1.087	25	1.679
Aex2	0.399	0.461	0.463	0.527	0.5	0.372	0.512	0.411	0.393	0.336	25	0.527
A2	1.309	1.497	1.558	1.751	1.663	1.253	1.72	1.395	1.327	1.157	25	1.751
LPD A2	1.668	1.911	2.008	2.235	2.124	1.616	2.195	1.785	1.699	1.488	25	2.235
B	1.401	1.615	1.956	2.047	1.948	1.6	2.262	2.164	2.018	1.974	60	2.262
LPD B	1.401	1.615	1.954	2.045	1.947	1.6	2.262	2.164	2.018	1.973	60	2.262
C	1.48	1.676	2.044	2.148	2.044	1.661	2.351	2.198	2.057	1.997	60	2.351
D	1.919	2.23	2.693	2.813	2.677	2.231	3.123	3.019	2.81	2.759	60	3.123
LPD CD	3.387	3.903	4.73	4.957	4.717	3.857	5.476	5.216	4.867	4.753	60	5.476
Eex1	2.876	3.247	3.531	3.909	3.714	2.846	3.91	3.213	3.038	2.722	60	3.91
E	1.686	2.078	2.456	2.528	2.407	2.255	2.95	3.079	2.875	2.873	90	3.079
LPD E	4.023	4.876	5.678	5.919	5.655	4.694	6.46	6.097	5.711	5.471	60	6.46

Q50 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Developed Conditions)												
Aex1	0.251	0.287	0.301	0.337	0.32	0.242	0.332	0.27	0.257	0.225	25	0.337	0.00%
A1	0.203	0.255	0.249	0.259	0.244	0.197	0.244	0.197	0.192	0.143	25	0.259	-81.20%
LPD A1	0.44	0.518	0.503	0.579	0.548	0.404	0.561	0.454	0.434	0.365	25	0.579	-65.52%
Aex2	0.399	0.461	0.463	0.527	0.5	0.372	0.512	0.411	0.393	0.336	25	0.527	0.00%
A2	0.977	1.117	1.164	1.308	1.242	0.936	1.285	1.042	0.991	0.865	25	1.308	-25.30%
LPD A2	1.34	1.533	1.615	1.798	1.708	1.3	1.765	1.433	1.365	1.197	25	1.798	-19.55%
B	4.354	5.001	5.16	5.826	5.529	4.15	5.726	4.651	4.428	3.84	25	5.826	157.56%
LPD B	4.348	4.994	5.157	5.822	5.528	4.149	5.724	4.649	4.425	3.838	25	5.822	157.38%
CD	4.279	4.697	5.789	6.162	5.859	4.7	6.685	6.103	5.723	5.563	60	6.685	22.12%
LPD CD	4.277	4.695	5.778	6.148	5.848	4.699	6.682	6.105	5.722	5.561	60	6.682	22.02%
Eex1	2.876	3.247	3.531	3.909	3.714	2.846	3.91	3.213	3.038	2.722	60	3.91	0.00%
E	1.447	1.783	2.108	2.17	2.066	1.934	2.53	2.641	2.466	2.464	90	2.641	-14.23%
LPD E	3.82	4.601	5.346	5.579	5.329	4.411	6.046	5.663	5.311	5.067	60	6.046	-6.41%

Q50 Results

Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)												
Aex1	0.251	0.287	0.301	0.337	0.32	0.242	0.332	0.27	0.257	0.225	25	0.337	0.00%
A1	0.203	0.255	0.249	0.259	0.244	0.197	0.244	0.197	0.192	0.143	25	0.259	-81.20%
LPD A1	0.44	0.518	0.503	0.579	0.548	0.404	0.561	0.454	0.434	0.365	25	0.579	-65.52%
Aex2	0.399	0.461	0.463	0.527	0.5	0.372	0.512	0.411	0.393	0.336	25	0.527	0.00%
A2	0.977	1.117	1.164	1.308	1.242	0.936	1.285	1.042	0.991	0.865	25	1.308	-25.30%
LPD A2	1.34	1.533	1.615	1.798	1.708	1.3	1.765	1.433	1.365	1.197	25	1.798	-19.55%
B	2.871	3.169	3.767	4.051	3.852	3.05	4.254	3.664	3.439	3.27	60	4.254	88.06%
LPD B	0.333	0.563	0.856	0.992	1.087	1.223	1.873	2.092	2.065	2.052	90	2.092	-7.52%
CD	4.933	5.538	6.21	6.813	6.473	5.014	6.96	5.839	5.486	5.031	60	6.96	27.15%
LPD CD	1.041	1.174	1.284	1.414	1.862	2.274	3.511	3.868	3.76	3.878	180	3.878	-29.18%
Eex1	2.876	3.247	3.531	3.909	3.714	2.846	3.91	3.213	3.038	2.722	60	3.91	0.00%
E	1.447	1.783	2.108	2.17	2.066	1.934	2.53	2.641	2.466	2.464	90	2.641	-14.23%
LPD E	3.82	4.601	5.346	5.579	5.329	4.411	6.046	5.663	5.311	5.067	60	6.046	-6.41%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling.

Q50 Results

Node	10min	15min	20min	0.259	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
	Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)												
Aex1	0.251	0.287	0.301	0.337	0.32	0.242	0.332	0.27	0.257	0.225	25	0.337	0.00%
A1	0.203	0.255	0.249	0.259	0.244	0.197	0.244	0.197	0.192	0.143	25	0.259	-81.20%
LPD A1	0.44	0.518	0.503	0.579	0.548	0.404	0.561	0.454	0.434	0.365	25	0.579	-65.52%
Aex2	0.399	0.461	0.463	0.527	0.5	0.372	0.512	0.411	0.393	0.336	25	0.527	0.00%
A2	0.977	1.117	1.164	1.308	1.242	0.936	1.285	1.042	0.991	0.865	25	1.308	-25.30%
LPD A2	1.34	1.533	1.615	1.798	1.708	1.3	1.765	1.433	1.365	1.197	25	1.798	-19.55%
B	2.791	3.073	3.687	3.953	3.759	2.986	4.174	3.617	3.409	3.249	60	4.174	84.53%
LPD B	0.396	0.539	0.826	0.96	1.063	1.189	1.84	2.061	2.043	2.026	90	2.061	-8.89%
CD	3.373	3.747	4.611	4.889	4.649	3.748	5.357	5.009	4.678	4.584	60	5.357	-2.14%
LPD CD	1.041	1.174	1.284	1.414	1.344	1.605	2.914	3.348	3.364	3.337	120	3.364	-38.57%
Eex1	2.876	3.247	3.531	3.909	3.714	2.846	3.91	3.213	3.038	2.722	60	3.91	0.00%
E	1.447	1.783	2.108	2.17	2.066	1.934	2.53	2.641	2.466	2.464	90	2.641	-14.23%
LPD E	3.82	4.601	5.346	5.579	5.329	4.411	6.046	5.663	5.311	5.067	60	6.046	-6.41%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Q100 Results

Peak Discharges (Existing Conditions)												
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge
Aex1	0.284	0.328	0.337	0.383	0.364	0.273	0.377	0.305	0.292	0.256	25	0.383
A1	1.175	1.386	1.341	1.555	1.478	1.083	1.505	1.205	1.159	0.982	25	1.555
LPD A1	1.425	1.666	1.671	1.903	1.811	1.351	1.85	1.487	1.427	1.234	25	1.903
Aex2	0.449	0.526	0.517	0.596	0.567	0.418	0.579	0.465	0.446	0.381	25	0.596
A2	1.477	1.715	1.746	1.986	1.89	1.413	1.953	1.577	1.509	1.314	25	1.986
LPD A2	1.886	2.187	2.251	2.538	2.416	1.823	2.494	2.019	1.933	1.69	25	2.538
B	1.613	1.856	2.244	2.375	2.267	1.84	2.626	2.461	2.313	2.268	60	2.626
LPD B	1.606	1.856	2.24	2.371	2.263	1.839	2.624	2.462	2.312	2.267	60	2.624
C	1.701	1.923	2.341	2.488	2.375	1.917	2.723	2.495	2.353	2.291	60	2.723
D	2.211	2.566	3.092	3.266	3.118	2.537	3.627	3.436	3.224	3.171	60	3.627
LPD CD	3.897	4.486	5.426	5.75	5.487	4.455	6.354	5.931	5.577	5.458	60	6.354
Eex1	3.258	3.735	3.974	4.452	4.24	3.223	4.453	3.639	3.464	3.096	60	4.453
E	1.951	2.409	2.837	2.952	2.819	2.575	3.406	3.532	3.297	3.325	90	3.532
LPD E	4.623	5.599	6.486	6.824	6.536	5.386	7.441	6.935	6.533	6.289	60	7.441

Q100 Results

Peak Discharges (Developed Conditions)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.284	0.328	0.337	0.383	0.364	0.273	0.377	0.305	0.292	0.256	25	0.383	0.00%
A1	0.223	0.285	0.277	0.288	0.272	0.22	0.274	0.222	0.217	0.161	25	0.288	-81.48%
LPD A1	0.493	0.59	0.561	0.653	0.621	0.455	0.635	0.513	0.494	0.415	25	0.653	-65.69%
Aex2	0.449	0.526	0.517	0.596	0.567	0.418	0.579	0.465	0.446	0.381	25	0.596	0.00%
A2	1.103	1.28	1.304	1.483	1.412	1.055	1.459	1.178	1.128	0.982	25	1.483	-25.33%
LPD A2	1.515	1.759	1.811	2.042	1.944	1.466	2.006	1.621	1.552	1.359	25	2.042	-19.54%
B	4.909	5.72	5.781	6.603	6.282	4.678	6.496	5.257	5.035	4.36	25	6.603	151.45%
LPD B	4.905	5.717	5.778	6.602	6.27	4.677	6.494	5.256	5.032	4.359	25	6.602	151.60%
CD	4.904	5.458	6.616	7.117	6.787	5.413	7.726	6.924	6.54	6.377	60	7.726	21.67%
LPD CD	4.903	5.451	6.607	7.101	6.774	5.411	7.724	6.927	6.539	6.374	60	7.724	21.56%
Eex1	3.258	3.735	3.974	4.452	4.24	3.223	4.453	3.639	3.464	3.096	60	4.453	0.00%
E	1.675	2.067	2.435	2.534	2.42	2.208	2.923	3.029	2.827	2.851	90	3.029	-14.24%
LPD E	4.385	5.286	6.101	6.424	6.153	5.058	6.958	6.437	6.071	5.821	60	6.958	-6.49%

Q100 Results

Peak Discharges (Ultimate - Mitigated Stage 1 Conditions) (i)													
Node	10min	15min	20min	25min	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.284	0.328	0.337	0.383	0.364	0.273	0.377	0.305	0.292	0.256	25	0.383	0.00%
A1	0.223	0.285	0.277	0.288	0.272	0.22	0.274	0.222	0.217	0.161	25	0.288	-81.48%
LPD A1	0.493	0.59	0.561	0.653	0.621	0.455	0.635	0.513	0.494	0.415	25	0.653	-65.69%
Aex2	0.449	0.526	0.517	0.596	0.567	0.418	0.579	0.465	0.446	0.381	25	0.596	0.00%
A2	1.103	1.28	1.304	1.483	1.412	1.055	1.459	1.178	1.128	0.982	25	1.483	-25.33%
LPD A2	1.515	1.759	1.811	2.042	1.944	1.466	2.006	1.621	1.552	1.359	25	2.042	-19.54%
B	3.28	3.674	4.281	4.657	4.44	3.491	4.888	4.174	3.909	3.733	60	4.888	86.14%
LPD B	0.379	0.742	0.97	1.118	1.38	1.554	2.316	2.557	2.522	2.548	90	2.557	-2.55%
CD	5.605	6.384	7.017	7.786	7.417	5.703	7.953	6.626	6.27	5.73	60	7.953	25.24%
LPD CD	1.179	1.349	1.444	1.975	2.658	2.935	4.343	4.729	4.598	4.894	180	4.894	-22.98%
Eex1	3.258	3.735	3.974	4.452	4.24	3.223	4.453	3.639	3.464	3.096	60	4.453	0.00%
E	1.675	2.067	2.435	2.534	2.42	2.208	2.923	3.029	2.827	2.851	90	3.029	-14.24%
LPD E	4.385	5.286	6.101	6.424	6.153	5.058	6.958	6.437	6.071	5.821	60	6.958	-6.49%

(i) flows developed from a cleared site prior to revegetation during quarrying and filling. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation

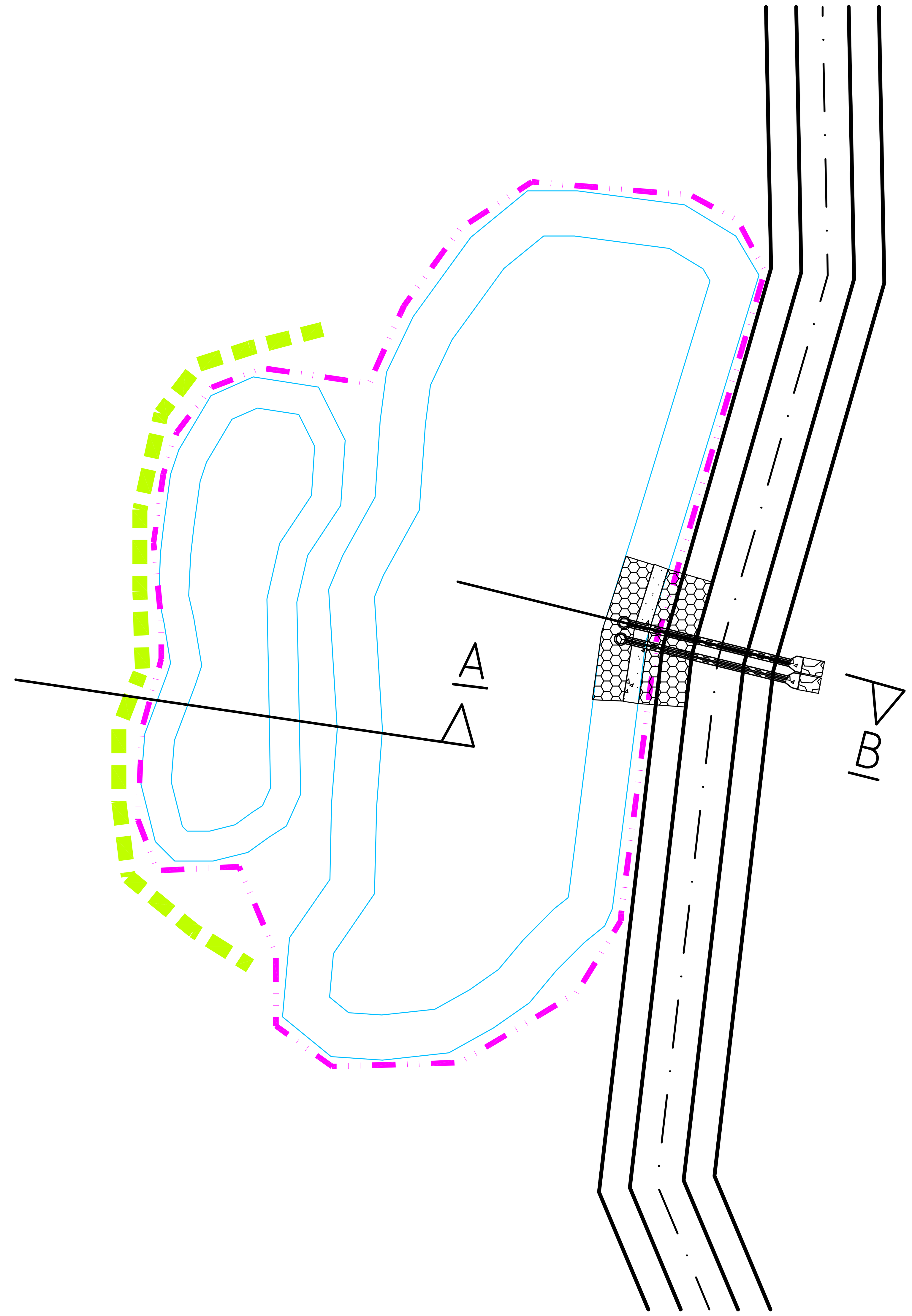
Q100 Results

Peak Discharges (Ultimate - Mitigated Stage 2 Conditions) (ii)													
Node	10min	15min	20min	0.288	30min	45min	60min	90min	120min	180min	Critcal Duration	Max Discharge	% Increase over Existing Conditions
Aex1	0.284	0.328	0.337	0.383	0.364	0.273	0.377	0.305	0.292	0.256	25	0.383	0.00%
A1	0.223	0.285	0.277	0.288	0.272	0.22	0.274	0.222	0.217	0.161	25	0.288	-81.48%
LPD A1	0.493	0.59	0.561	0.653	0.621	0.455	0.635	0.513	0.494	0.415	25	0.653	-65.69%
Aex2	0.449	0.526	0.517	0.596	0.567	0.418	0.579	0.465	0.446	0.381	25	0.596	0.00%
A2	1.103	1.28	1.304	1.483	1.412	1.055	1.459	1.178	1.128	0.982	25	1.483	-25.33%
LPD A2	1.515	1.759	1.811	2.042	1.944	1.466	2.006	1.621	1.552	1.359	25	2.042	-19.54%
B	3.191	3.566	4.194	4.548	4.337	3.422	4.801	4.123	3.875	3.711	60	4.801	82.83%
LPD B	0.447	0.711	0.937	1.073	1.332	1.515	2.275	2.525	2.516	2.517	90	2.525	-3.77%
CD	3.87	4.302	5.279	5.655	5.393	4.324	6.204	5.694	5.357	5.263	60	6.204	-2.30%
LPD CD	1.179	1.348	1.444	1.609	1.763	2.263	3.674	4.135	4.07	4.151	180	4.151	-34.67%
Eex1	3.258	3.735	3.974	4.452	4.24	3.223	4.453	3.639	3.464	3.096	60	4.453	0.00%
E	1.675	2.067	2.435	2.534	2.42	2.208	2.923	3.029	2.827	2.851	90	3.029	-14.24%
LPD E	4.385	5.286	6.101	6.424	6.153	5.058	6.958	6.437	6.071	5.821	60	6.958	-6.49%

(ii) flows from a rehabilitated revegetaetd catchment into a wetland system. Catchments Aex1, Aex2, A1, A2, Eex1 & E are reduced in size or untouched and therefore require no mitigation.

Appendix C

Typical Sections Detention Areas



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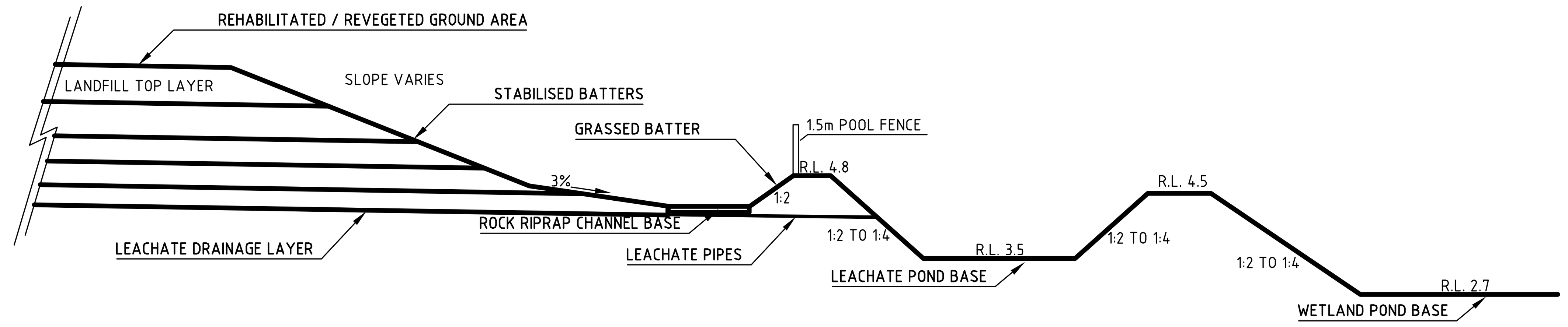
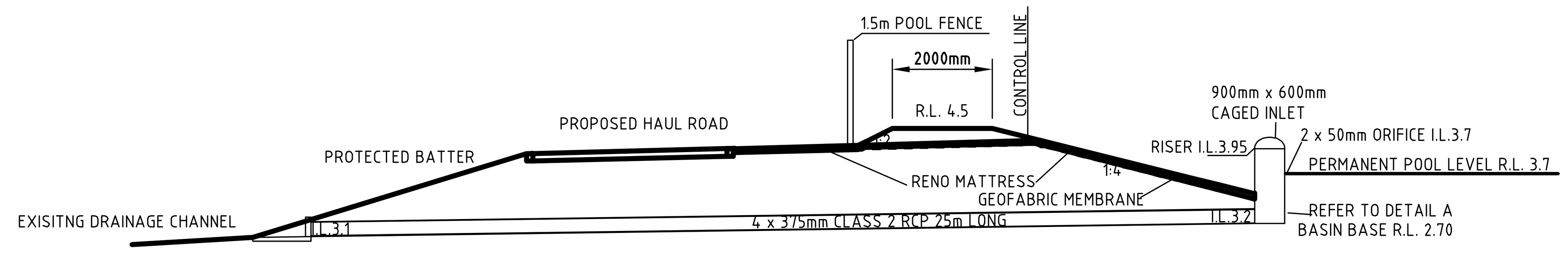
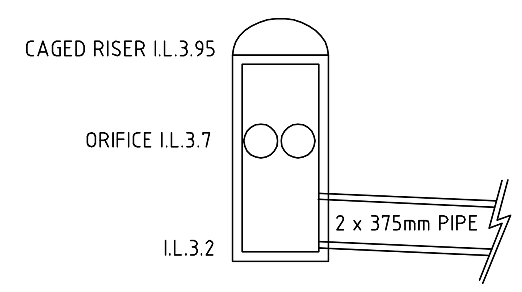


SECTION A
NTS



SECTION B
NTS



DETAIL A
N.T.S.

LEGEND

- CONCRETE WIER
- SCOUR PROTECTION
- RENO MATTRESS
- PROPOSED CONDUITS
- PROPOSED DIVERSION DRAINS
- 1.5m POOL FENCE (OR EQUIVALENT)

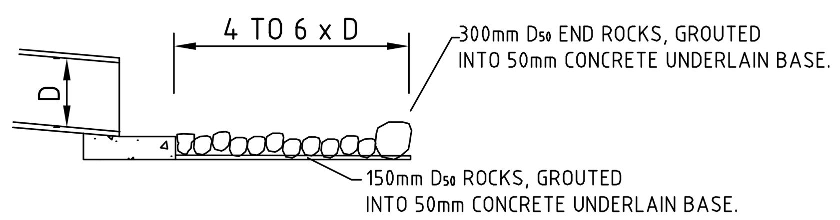
NOTES

BASINS TO BE DENSELY PLANTED WITH EMPHEMERAL NATIVE SPECIES AS PER DLWC CONSTRUCTED WETLAND DESIGN MANUAL.

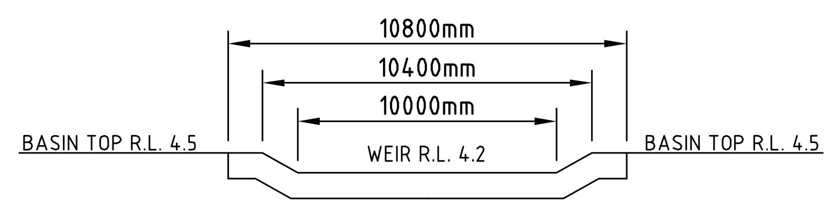
NO MULCHING TO INTERNAL BATTERS

BASIN TO BE STABILISED WITH HYDROSEED OR EQUIVALENT AFTER EARTHWORKS AND PRIOR TO PLANTING AT THE REQUIRED DENSITIES.

BASIN OUTLET TO BE BLOCKED WITH HESSIAN / GEOFABRIC MEMBRANE DURING THE INITIAL CONSTRUCTION STAGE AND REMOVED AFTER BASIN HAS BEEN PLANTED.



TYPICAL OUTLET DETAIL



WEIR CONTROL LINE ELEVATION
N.T.S.

BASIN A STAGE STORAGE TABLE

ELEVATION (RL)	DEPTH (m)	AREA(m)	VOLUME (m3)
2.7	0.00	4,500	0.00
3.7	1.0	5,770	0.00
3.95	1.25	6,100	1,485
4.2	1.5	6,430	3,050
4.5	1.8	6,835	5,040

CONCEPTUAL

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

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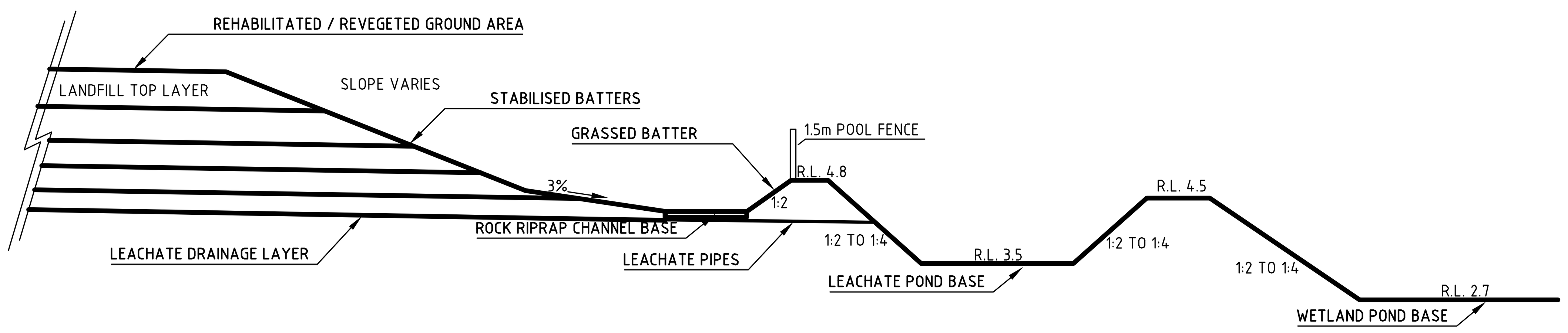
DO NOT SCALE

Drawn	NJC	Designed	NJC
Drafting Check		Design Check	
Approved			
Date			
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

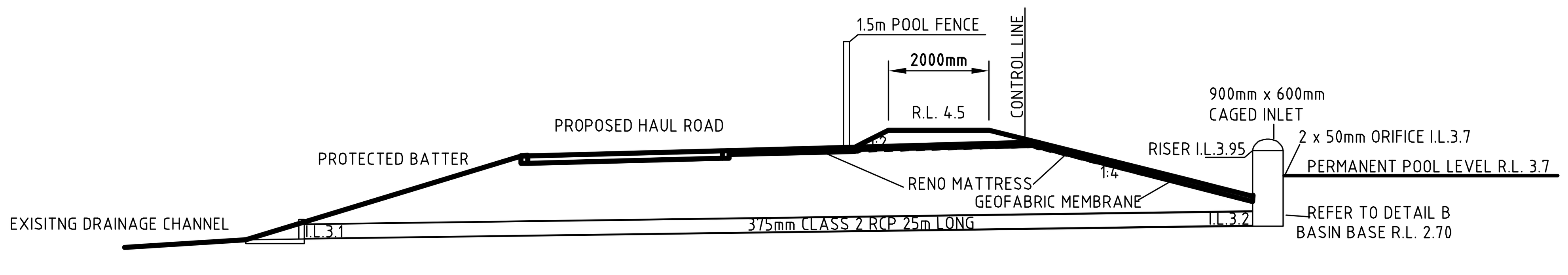
Client **TWEED SHIRE COUNCIL**
Project **EVIRON QUARRY & LANDFILL SITE**
Title **Typical Section Details - Sheet 1 of 2**
Lot 26 on DP 615931 Eviron Road, Eviron

Original Size **A1** **Drawing No: 41-20806-G001-Fig C.1** **Rev: A**

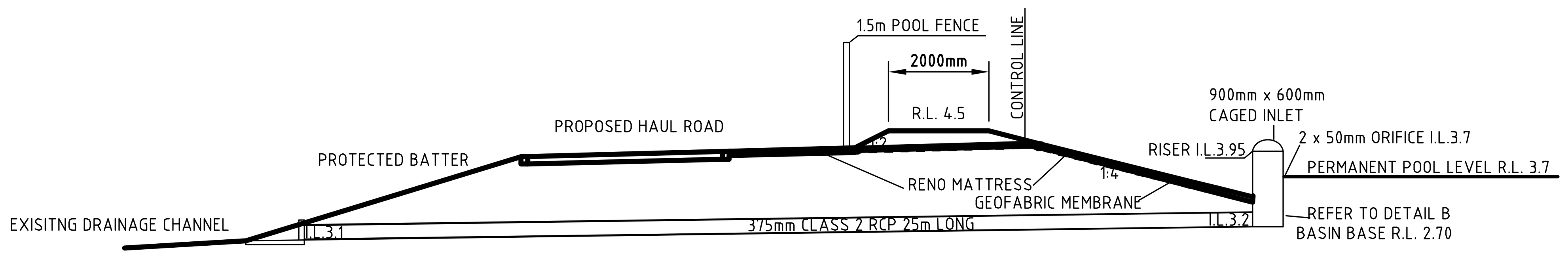
Plot Date: 9 December 2008 - 10:32 AM Cad File No: G:\41\20806\Tech\Stormwater Quality and Quantity\ACAD\41-20608-G001_DRAI_XSECTS.dwg



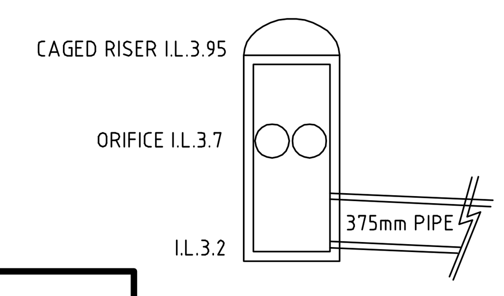
SECTION A
NTS



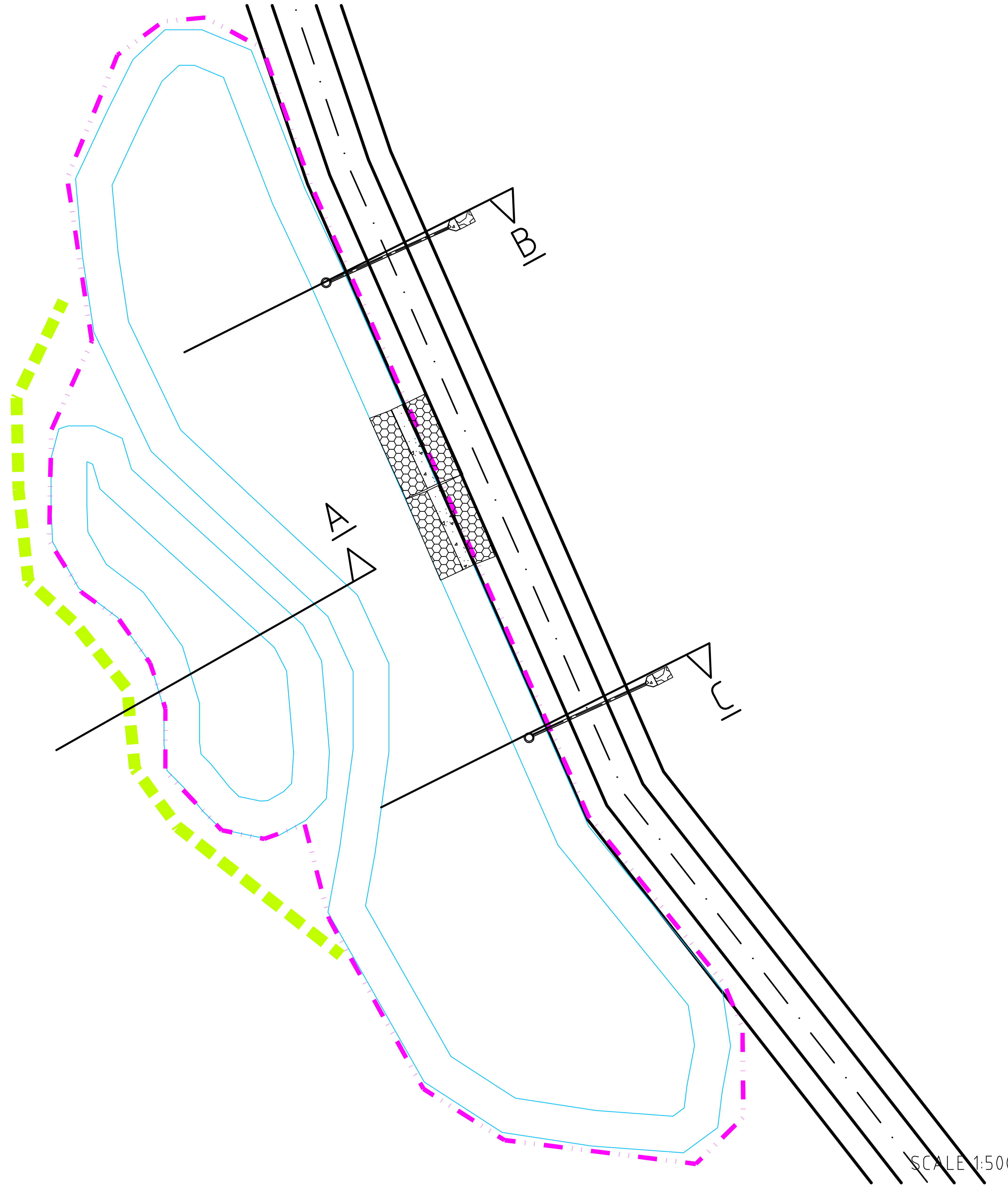
SECTION B
NTS



SECTION C
NTS



DETAIL B
N.T.S.



LEGEND

CONCRETE WIER

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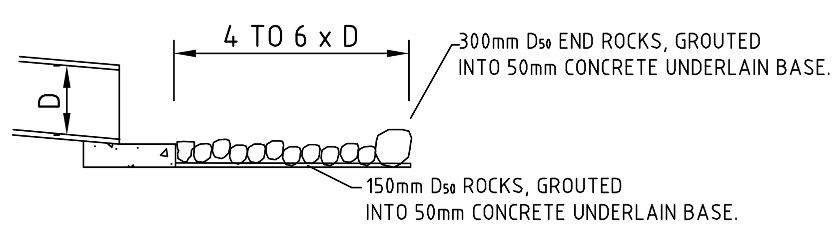
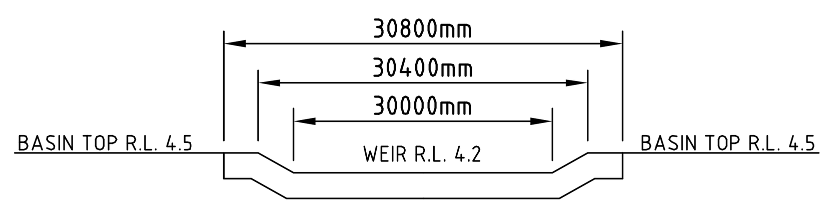


TYPICAL OUTLET DETAIL



WEIR CONTROL LINE ELEVATION
N.T.S.

BASIN A STAGE STORAGE TABLE

ELEVATION (RL)	DEPTH (m)	AREA(m)	VOLUME (m3)
2.7	0.0	7,500	0.00
3.7	1.0	8,775	0.00
3.95	1.25	9,070	2,225
4.2	1.5	9,360	4,500
4.5	1.8	9,500	7,310

CONCEPTUAL

No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Checked	Approved	Date

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Drafting Check | Design Check
Approved
Date
Scale AS SHOWN
This Drawing must not be used for Construction unless signed as Approved

Client **TWEED SHIRE COUNCIL**
Project **EVIRON QUARRY & LANDFILL SITE**
Title **Typical Section Details - Sheet 2 of 2**
Lot 26 on DP 615931 Eviron Road, Eviron

Original Size A1 | Drawing No: **41-20806-G001-Fig C.2** Rev: **A**

Plot Date: 10 December 2008 - 10:07 AM Cad File No: G:\41\20806\Tech\Stormwater Quality and Quantity\ACAD\41-20608-G001_DRAI_XSECTS.dwg

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	N Cooper	B Regan		A Marszalek		