

Appendix D

Amended Water Cycle Management Plan

Appendix D Amended Water Cycle Management Plan

Malbec Properties Pty Ltd

Amended Water Cycle Management Plan: Proposed Residential Sub-division, South West Rocks, NSW.



ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



P0802023JR05_v2
July 2010

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1 Introduction

1.1 Overview

This Engineering Services report has been prepared by Martens & Associates on behalf of Malbec Properties Pty Ltd ("The Proponent") with respect to their proposal to sub-divide the site for residential purposes.

It is prepared to form part of an Environmental Assessment Report to the Minister for Planning for approval under Part 3A of the *Environmental Planning and Assessment Act 1979*.

1.2 Scope

The scope of the report includes the review of the development in the context of the Director General's Environmental Assessment Requirements (DGEARs), particularly on stormwater and water quality.

This report addresses the following issues:

- Project outline and site description.
- Site assessment and identification of development issues.
- Site management, including water quality and stormwater management.

This report draws on additional information from a number of completed specialist consultants reports (Section 1.3) and includes recommendations for management and mitigation measures to ensure that the proposed development promotes ecologically sustainable development and maintains the integrity of the surrounding environment.

1.3 Information Sources

This Engineering Services document has been prepared by Martens & Associates Pty Ltd and draws on information and investigations by specialist consultant studies completed for the site. These reports included:

- Douglas Partners (2007) - Hydrogeological and contamination assessment.
- WBM Oceanics Australia Pty Ltd (2005) - flood study.

- WBM Oceanics Australia Pty Ltd (2010) – additional flood assessment.
- Connell Wagner Pty Ltd (2007) - Flora and Fauna, Wallum Froglet Studies.

1.4 Proposed Development

The proposed development involves a residential sub-division including;

- Approximately 268 single allotments of varying size;
- One medium density super-lot;
- Three public open space lots;
- Two stormwater treatment wetlands;
- Associated services including reticulated water, electricity, sewer and stormwater drainage, and;
- Internal road network and through road to future development lands north of the site.

A site plan is provided as Attachment A.

These works will involve clearing and some reshaping and construction of development infrastructure, namely roads and services. The development will be serviced from Belle O'Conner Drive to the south and a connection road to the north.

2 Site Description

2.1 Location

South West Rocks is a coastal village located on the North Coast of NSW, approximately 35km northwest of Kempsey and in the Kempsey local government area (LGA).

The subject site has an overall area of 39.5 ha and comprises the following allotments:

- Lot 52 DP 831284
- Lot 84 DP 792945

The site is bounded by rural residential development to the east, Belle O'Connor Drive to the south, a golf course to the west, and the existing Saltwater creek to the north. This creek flows from the west out of the South West Rocks Golf Course (north west of the site) to Saltwater Lagoon (north east of the site). Saltwater Lagoon is connected to the ocean by Saltwater Creek which, together, make up an intermittently closed and open lake or lagoon (ICOLL). The entrance is located at the western end of Trial Bay Beach and is closed 70% of the time (WBM, 2006) by a sand berm. Figure 1 shows the locality of the site in a regional context and indicates these features.

The proposed development is part of a larger land release area encompassing land to the north.



Figure 1: Approximate site locality and regional context. Source: Google Maps, 2008

2.2 Field investigations

Site investigations were undertaken by Martens in March, 2008, and included a walkover inspection of the site to assess the existing site's environment setting and determine any environmental conditions that may have potential to impact on the proposed development and or neighbouring properties.

Further investigations were completed In March and April 2010 to further assess the site's hydrogeological and soil conditions.

2.3 Topography

The site slopes from the south to the north/north east towards Saltwater Creek. Site elevations vary between 5.0 – 5.5 mAHD to 1.0 – 1.5 mAHD adjacent to Saltwater Creek

The site is fairly flat with average slopes of <1 %. Slope grades are highest on the ridge located in the central region of the southern boundary.

The site conveys flow from two discrete catchments to the south which drain through the site and into the creek. The first, flowing into the western portion of the site, is approximately 39.5 ha and largely consists of rural/agricultural properties. The site for a recently approved residential subdivision lies within this catchment with the first stage of this subdivision having already been built. The stormwater modelling, assumes this catchment to be in its ultimate developed condition as the worst case scenario. The second catchment, feeding into the eastern portion of the site is approximately 34.7 ha and primarily consists of cleared grazing land.

2.4 Geology

The Dorrigo Kempsey 1:250,000 Geological Series Sheet indicates that the site is underlain by Quaternary aged alluvial and estuarine sediments typically comprising sands, silts and gravels. The former sediments are underlain by Smokey Cape and Kempsey Beds.

2.5 Soil Profile

Reference to the 1:100,000 Macksville Nambucca Soil Landscape Series Sheet 9436 (1999) indicates that two soil landscape groups that make up the site (Figure 2). Soils in the area of proposed development are primarily characterised as Clybucca (cy) and are comprised back barrier swamps overlying Pleistocene sands at elevations typically less than 5 mAHD. The southern portion of the site also partially contains the Korogoro (kr) landscape; consisting of low transgressive Pleistocene dunes.

Limitations associated with this soil landscape group include the following:

- Poor drainage
- Localised acid sulphate soil potential
- High run on (being on lower slopes)
- Flood Hazard
- Permanently high water table
- Groundwater pollution hazard
- Foundation hazard

2.6 Receiving Waters and Habitat Protection

The drainage lines conveying flows from upstream as well as site runoff, drains to the lower areas of the site adjacent to Saltwater Creek.

The recently completed LES has identified a portion of the site adjacent to Saltwater Creek as habitat of higher biodiversity value and is to be zoned as a 'Conservation Zone' as part of the site rezoning . This zone also contains a SEPP 14 wetland and the flora and fauna studies have indentified that one of the vegetation communities along the creek appears to conform to the description of an Endangered Ecological Community (EEC) known as Swamp Sclerophyll forest on coastal floodplains.

Therefore, it is important that the stormwater management regime for the site includes provision for the protection of this vegetation community and wetland including the management of the water quality and supply as well as the maintenance of hydrological regime so as not to have an adverse impact on these sensitive habitats. Importantly, nutrient and sediment loads need to be managed both during and post-construction to acceptable levels.

3 Land Capability Assessment

3.1 Hydrogeological Assessments

A Hydrogeological Assessment was conducted by Douglas Partners Pty Ltd (2007) as part of the LES for the rezoning of the wider release area including the subject site. That investigation included land to the north as well as the subject site to the south. Field work was undertaken during July and August of 2007 and included the following:

- Ten bores were drilled, of which 4 were located at the site, to a general depth of 5m.
- Installation of a groundwater monitoring well at each bore.
- Rising head (slug) tests on each well.
- Measurement of field chemical parameters.
- Measurement of groundwater piezometric depths at each well.
- Survey of bores.
- Piezo cone penetration tests (CPTu) at 7 locations, 1 of which was located at the site, ranging from 2 m to 23 m.

Further to DoP response to initial project submissions an additional, more detailed hydrogeological assessment of the site has been undertaken by Martens & Associates. This investigation included:

- Drilling 15 test holes.
- Installing 6 groundwater bores.
- Incrementing and monitoring 5 groundwater bores and the downstream creek.
- Detailed ModFlow assessment of the site hydrogeological conditions.

The new assessment is documented in Martens & Associates report P0802023JR04.

This investigation determined that intermittent groundwater levels beneath the site are sufficiently high to mean that drainage swale structures on the site shall, at times, not function as infiltration systems but rather as groundwater drains.

The following is a summary of the findings of the site hydrogeological assessment:

- Observed average water levels beneath the site ranged from 510 to 1980 mm below existing surface.
- Modelling indicates that, as a result of the development, site groundwater recharge shall be reduced.
- As a result of the development there shall be a draw down in groundwater levels beneath the site. This drawdown shall be of the order of 350 mm.
- Modelling of water table beneath vegetated lands to the north of the development indicate drawdown in these areas shall be of the order of 30 – 160 mm only.
- Analysis of possible climate change induced changes to groundwater levels indicate minimal increase in site water tables as a result of a predicted 900 mm rise in ocean levels.

3.2 Water Table and Surface Water Interaction

The subsurface conditions at the site include a confining basement clay layer with a thin overlying, highly permeable sand layer. This results in the groundwater table and surface water system becoming intrinsically connected. For the purposes of water supply for local vegetation, the surface and shall two sources of water act as a single water resource.

Due to this inter connection any transfer of water from surface flows to groundwater or vice-a-versa (as a result of future development) shall not adversely impact vegetation.

3.3 Flood Assessment

Two previous flood assessments have been carried out by WBM Oceanics Australia, described as follows:

- Initial flood assessment (2005) for Kempsey Shire Council detailing flood behaviour of the Saltwater Creek and Lagoon catchment.
- Additional flood assessment (2010), which included an assessment of the additional flows from the subject site due to development; assessment of the impacts of climate change on the site and catchment; and further analysis of site storm surge impacts.

A detailed description of the initial flood assessment is given in the Saltwater Creek Flood Study Final Draft Report (WBM, 2005), with a summary of the report outlined as follows:

- The report used the RAFTS hydrologic model to determine peak flow rates for design flood events including the 1%, 5% and 20% AEP and the PMF (probable maximum flood) on the basis of design storms determined in accordance with AR&R (1987).
- Peak flow rates determined from RAFTS modelling were used in a TUFLOW 1D/2D hydraulic model, which incorporated a digital terrain model of the catchment and geomorphologic model of the entrance sand berm, to simulate the flow behaviour in the creek and adjacent floodplain. Three crest elevations of the entrance sand berm were modelled at 2.0, 2.5 and 3.0 mAHD for the 1% AEP to determine the effect of this berm on flood behaviour.
- Results of flood modelling indicate that the flood behaviour for Saltwater Creek catchment is controlled by a combination of the Phillip Drive Bridge, the channel roughness in Saltwater Creek and the starting level of the entrance sand berm.
- Analyses of the results show that the peak flood levels at the site are marginally higher (of the order of 0.05 m) than those experienced within Saltwater Lagoon, which vary between approximately 3.1 mAHD and 3.4 mAHD depending on the height of the sand berm at the start of the flood event. This equates to flood levels within the site of approximately 3.2 mAHD to approximately 3.4 mAHD depending on the sand berm conditions.
- Results showed the Probable Maximum Flood (PMF) level for the site to be approximately 4.5 mAHD.
- Based on likely future sand berm conditions (i.e. 2.0 mAHD) a design 1 in 100 yr flood level of 3.4 mAHD was adopted for the site.

The additional flood assessment prepared by WBM (2010) for the site utilised the same models as were used in the initial flood assessment, and assessed the following three additional modelling scenarios:

- Increased surface runoff from the developed site, which was assumed to be 80% impervious;
- A 30% increase in rainfall intensity for the 1% AEP storm to assess the potential effects of climate change, and;

- Sea level rise of 0.9 m at the ocean boundary of the model on top of the 1% AEP storm surge level (2.6 mAHD) to assess the potential effects of climate change. This storm surge scenario was modelled assuming that the 1% AEP storm surge coincided with the 1 in 5 year ARI rainfall event for the catchment.

A total of six (6) scenarios were modelled for this assessment using the above scenarios in conjunction with entrance sand berm heights of 2 mAHD and 3 mAHD respectively. For the storm surge scenario, the sand berm height was assumed to be 3 m for both existing storm surge conditions and for the climate change scenario (ocean levels increased by 0.9 m).

Results of the additional modelling indicated that the increased site impervious area does not have a significant impact on the flood levels experienced downstream of the site, with the 1% AEP flood levels on the site varying between approximately 3.2 mAHD and 3.4 mAHD depending on the initial height of the entrance sand berm, which is comparable (to within the resolution of the model) to the results of the initial flood assessment.

Results of the climate change scenario which included a 30% increase in rainfall intensity showed that the peak 1% AEP flood level at the site increases to 3.4 mAHD and 3.6 mAHD for the 2.0 m and 3.0 m high sand berm conditions respectively. Results of the 1% AEP storm surge modelling indicate that the peak flood levels within the site are 3.1 mAHD and 3.2 mAHD for the existing 1% AEP storm surge conditions and climate change conditions respectively.

Developable areas have been identified on the site (WBM, 2006) as all lands more than 50m from the 3.0 mAHD contour. This places most of the development envelope outside of lands impacted by inundation by the 1% AEP flood event.

Previously (Martens report P0802023JR02) a development flood planning level (FPL) of 3.7 mAHD was recommended. This is 0.5m above the site 1% AEP (determined in the WBM (2005) assessment) flood in accordance with recommendations of the Floodplain Development Manual (2005).

The site FPL is determined based on existing 1 in 100 yr flood inundation levels plus an acceptable freeboard. For the purposes of determining design flood levels a Berm height of 2.0 m is assumed in light of Council policies for the maintenance of this Berm. Therefore, the design 1 in 100 yr flood level for the site is 3.2 mAHD being the inundation level determined in Scenario 1 of WBM (2010). With a freeboard of 0.5 m the site flood planning level (FPL) is therefore set to 3.7 mAHD.

3.3.1 Adaptive Capacity

The ability of the proposed site development to adapt to anticipated climate change induced changes is assessed through review of the WBM (2010) analysis and the adopted site FPL.

For the purposes of this review it is assumed that a 0.9 m rise in sea level (as recommended in NSW Sea Level Rise Policy Statement, 2009), as well as a 30 % increase in rainfall intensity (as recommended in Practical Consideration of Climate Change, 2007) shall occur due to climate change processes . It is furthermore assumed that the increase in sea level shall result in a commensurate increase in Berm height.

When considering adaptive capacity the WBM (2010) report identifies Scenario 4 as the conditions which generate the highest design flood level. This scenario assumes an increase in Berm height to 3.0 m (in response to sea level rise) and a 30 % increase in the design 1 in 100 yr precipitation event. The resultant flood level at the site is determined to be 3.6 mAHD.

Review of the proposed FPL (3.7 mAHD) therefore confirms that the development would have sufficient adaptive capacity to accommodate the most severe predicted climate change induced hydrological conditions. This confirms that the proposed site FPL of 3.7 mAHD is appropriate.

3.4 Sediment and Erosion Control

Prior to the commencement of construction works at the site, sediment and erosion control structures shall be implemented to prevent erosion and soil loss at the site and sedimentation of downstream ecosystems. Typical sediment and erosion control structures to be used at the site during the construction phase of the development may include the following measures:

- Sediment control ponds;
- Sediment fencing;
- Straw bales;
- Stabilised site accesses;
- Stabilised stockpile locations; and,
- Diversion bunds.

It is recommended that a site specific Soil and Water Management Plan (SWMP) shall be required at the construction certificate stage of

the development, following the finalisation of the development layout, and should be developed in conjunction with the engineering plans for the sub-division in accordance with the provisions outlined in Landcom (2004).

3.5 Additional Land Capability Assessments

Details of land capability assessments for factors including potential site contamination, geotechnical site assessment and site servicing are provided in MA report P0802023JR02_V7 (March 2009). Details of the land capability assessment with respect to acid sulphate soils is provided in MA report P0802023JR03_V1 (April 2010).

4 Stormwater Management Methodology

4.1 Planning Context

The relevant planning controls and policies that have been considered as part of the formulation of the stormwater management for the site have been summarised in the Sections below.

4.1.1 Kempsey Shire Council Local Environment Plan (LEP) 1987

According to the Kempsey Shire Council LEP, the site falls into 3 zones. Compliance of the proposed development with relevant zone objectives is summarised in Table 6 below.

Table 1: Stormwater Compliance Assessment: Kempsey Shire Council LEP (1987)

LEP Zone	Relevant Objectives	Development Compliance
Zone 2(a): Residential Zone	To provide areas for low density residential development.	The proposed development is part of a larger land release scheme to make the area available for residential development. The proposed sub-division therefore complies with this objective.
Zone 7 (a): Wetlands Protection Zone	To protect the water quality and supply so that the continuing operation of wetland ecosystems is not jeopardised.	The Stormwater Management Plan for the site considers both water quality and quantity. Modelling has been completed to ensure these characteristics closely reflect that of the existing site (i.e. pre-development).
Zone 7 (b)	To protect the environmental qualities and values of natural habitats.	The protected habitat area to the north of the site has been provided with a 50m buffer to the residential development. The proposed water cycle management plan has been designed to maintain water levels and improve its stormwater quality to ensure no adverse impact on this water-dependant habitat area.
	To permit the roads and services to cross habitat areas in a manner that has minimal adverse impacts on habitat values	There are no roads or associated services proposed to cross the habitat area at the north of the site.

4.1.2 Kempsey Shire Council DCP 36; 'D5 – Stormwater Drainage Design' (2000).

The Kempsey DCP 36 is based on the AUSPEC guidelines for stormwater drainage design. The stormwater treatment and management system for the site has been designed in accordance with these guidelines which gives model input parameters and sizes stormwater treatment structures and their associated construction components.

Kempsey Shire Councils DCP 36: D5 – Stormwater Drainage Design, indicates that where development increases the peak flow rate a detention basin is to be provided to limit the post development flows to be less than or equal to the pre-development flows for all storms up to and including the 1 in 100 year event. **Alternatively**, the downstream drainage system is to be upgraded to accommodate the increase in peak flow rate.

The proposed development area drains to adjacent vegetated lands, thence to Saltwater Creek, thence to Saltwater Lagoon. The only built infrastructure affected by the flows from Saltwater Creek is the road bridge at Phillip Drive over the creek. The modelling conducted by WBM (2010) indicates that the increase in flows to Saltwater Creek from the site during the 1% AEP flood as a result of development is insignificant compared to the total flow in Saltwater Creek. Additionally, modelling indicates that the increase in runoff from the site has negligible impact on the 1% AEP peak flood height in Saltwater Creek downslope of the site.

It is therefore concluded that, any increase in flows from the site post-development would not impact adversely on existing stormwater infrastructure downslope of the site (primarily the bridge at Phillip Drive).

4.1.3 Flood Planning – WBM Oceanics Flood Study

The WBM Oceanics (2004) Flood Study determined flood levels for the subject site. Further, the LES for the rezoning of the site incorporated the recommendations from the Saltwater Creek and Lagoon Estuary Management Plan recommendation of adopting a 50m buffer to the 3.0 mAHD contour. The adaptation of this setback by the development means the development footprint is clear of 1% AEP flood inundation extent.

4.1.4 Saltwater Creek Estuary Management Plan (Saltwater EMP)

The primary aim of the Saltwater EMP is to achieve an equitable balance between opportunities for future development and ensuring such development does not degrade the natural values of the area. The EMP outlines a number of objectives for future management in the

catchment. The objectives relevant to stormwater management and water quality at the site are summarised in Table 7.

Table 7: Development compliance with Saltwater EMP Water Quality objectives

Objective	Compliance
Reduce the existing urban stormwater pollutant loads entering Saltwater Creek and Lagoon.	Stormwater management at the site aims to treat water to a standard that is equal to or better than the existing water quality.
Ensure that the water quality of Saltwater Creek and Lagoon is compatible with the recreational uses of the estuary.	The proposed development will supply runoff to the estuary system which is of equal or better quality than that of the existing and thus have no impact on the current recreational use of the Creek and Lagoon.
Ensure that the contamination of the former oil terminal sites does not degrade the existing or future estuarine environment of Saltwater Creek and Lagoon.	Not applicable. The proposed development will not result in the former oil terminal sites being a source of contamination.
Reduce the impact of on-site sewage treatment systems on the surface water quality of Saltwater Creek and Lagoon.	Not Applicable. The development will be serviced by reticulated town sewer.
Prevent the generation of acidic runoff resulting from activities carried out on potentially acid sulphate soils surrounding Saltwater Creek and Lagoon.	As a risk management measure, an ASS Management Plan will be instigated for works that are proposed at depth of 2m or more.

4.1.5 Protection of Vegetation and Stormwater Management

A portion of the site, towards Saltwater Creek, has been identified as habitat of higher biodiversity value and is to be conserved as a 'Conservation Zone' as part of the rezoning of the site. This zone also contains a SEPP 14 wetland and the Flora and Fauna Study indicates that a vegetation community adjacent to the creek has a structural affinity with the EEC Swamp Sclerophyll Forest on coastal floodplains.

Therefore, water quality and quantity as well as the drainage scheme are a consideration in the development design to ensure that the hydrological regime, nutrient and sediment loads draining to these sensitive areas, do not have an adverse impact. As such, it is important that nutrient and sediment loads from the development are managed.

4.2 Demonstration of Compliance with DGEARs

4.2.1 Hydrological Regime on-site

The identified shallow and variable groundwater table, if not mitigated by engineering works, has the potential to result in: degradation of road pavements; poor drainage; and foundation settlement. To mitigate potential adverse effects a range of works are recommended for the site development. These should include:

- Construction of sub-soil drainage for road pavements to be placed as low in the profile as possible to maximise the moisture stability of sub-grade and pavements. As roads are located adjacent to drainage swales the roadside swales will form the discharge point for pavement sub-soil drains. Where swale depths do not allow sub-soil drainage systems road pavements are to be designed to accommodate potential moisture variability.
- The construction of road drainage swales shall form a series of artificial drains across the site. These will act to limit the rise of groundwater tables beneath the site.
- Building foundation zones will be drained with sub-soil drainage systems to maximise soil moisture stability. These drainage systems shall discharge to the roadside drainage swales. This is standard engineering practice in areas with shallow groundwater tables, is not expected to have significant water cycle impacts; and is appropriately considered at dwelling construction approval stage. Where site levels prevent design of appropriate sub-soil drainage systems foundations are to be designed to accommodate variable site moisture conditions.

4.2.2 Hydrological Regime Downstream of the Site

The development of the site will increase impervious areas (roofs, driveways, roads, footpaths etc) thereby reducing site groundwater recharge.

This effect has the potential to lower groundwater table which with potential practical and environmental impacts. These impacts have to be assessed in order to determine whether they require to be mitigated. The potential impacts are discussed as follows:

- The lowering of the water table in the development area in regards to protection of road pavements and structures as well as limiting watertable rise (that would otherwise create potential ponding issues) is a positive aspect to site development;

- Impacting the groundwater table downstream of the development area may have adverse effects on water-dependant ecosystems and habitat. This effect would need to be mitigated if significant;
- Impact on the water quality in downstream environs including saltwater lagoon;
- Exposure of acid sulphate soils through water table lowering may occur. Where acid sulfate soils have been identified and site hydrogeological assessment indicates groundwater lowering below typical water table depth inclusion of measures to mitigate possible acid drainage shall be required at detailed design.
- Increased saltwater intrusion from Salt Water Lagoon is not a concern as assessed groundwater table depth changes are minor.

A more detailed assessment of the potential for these impacts and the associated amelioration measures are discussed below.

4.2.2.1 *Assessment and Mitigation*

The potential to affect the hydrological regime on downstream habitats is considered by way of completed hydrogeological assessment and modelling. This assessment concluded that groundwater drawdown in the vegetated areas between the development and the drain to the north was of the order of 30 – 160 mm.

The surface and sub-surface water systems are intrinsically linked at the site so any movement of water from one to the other has minimal impacts on overall water availability to vegetation. This together with the small change in water table levels means that the proposed development is not expected to have adverse impacts on the vegetation to the north of the site.

Stormwater quality is managed through the integration of source and end of pipe water quality control structures. These include drainage swales and wetlands. Seepage from these structures is taken (in MUSIC modelling) to be zero thus ensuring a conservative design. The lining of wetlands is proposed to ensure that stormwater is not discharged directly into the underlying aquifer.

4.2.3 Flood Management

A Flood Study was carried out by WBM Oceanics (2005) which identified the 1 in 100 yr flood extents for the site. The Estuary Management Plan for Saltwater Lagoon identified the 3.0 mAHD contour plus a 50m buffer as an appropriate development extent line to ameliorate effects on the downstream receiving waters and habitats.

This buffer provides an appropriate freeboard for the development to the 1 in 100 yr ARI flood level.

Based on that study it is recommended that a flood planning level be set for the site at 3.7 mAHD being 0.5 m above the local 1% AEP flood inundation level determined. The FPL should be adopted as the minimum floor level for any habitable rooms in future developments on the site.

Results of additional analysis by WBM (2010) confirm the adequacy of the proposed FPL. The proposed FPL is above the modelled flood level for all climate change induced hydrological change scenarios.

The proposed development complies with the provisions in the NSW Floodplain Development Manual as follows;

- The development design utilises the merit approach to comply with the Flood Prone Land Policy by recognising flood prone areas of the site. In accordance with this policy, FPL's have been set to provide a 0.5m freeboard above the 1% AEP flood level. The principles of ecologically sustainable development (ESD) and future impacts of climate change have also been considered.
- Effective floodplain risk management has been applied to the development design by considering and managing the three (3) types of flood risk as follows;
 - **Existing flood risk:** There is currently no development to manage on flood prone lands
 - **Future flood risk:** Future flood prone lands have been identified and appropriate FPL's set to 0.5m above the 1% AEP level. The site has connectivity with South West Rocks during this event allowing site egress. Consideration of anticipated climate change induced flood impacts confirms that proposed FPLs are adequate to manage these risks.
 - **Continuing flood risk:** In the case of rarer events (e.g. the PMF) we recommend Belle O'Conner Drive levels be set at a minimum of 4.5 mAHD to allow for continued egress from the site in all events including the PMF.

- A thorough Flood Study has been completed by WBM Oceanics (2005 and 2010) and determines hydrologic aspects, as well as water levels, velocities, hazard categories (in accordance with the Floodplain Management Manual, 2005) and controlling features (namely the sand berm and Phillip Drive Bridge). These factors have all weighed in selecting FPL's.
- The purpose of this report is to draw together the results of the above study and thus provide a Floodplain Risk Management Study which provides flood management options.
- In accordance with the Floodplain Development Manual, the developer has sought the advice from a number of experts in the field to identify potential impacts and provide mitigation options.

4.2.4 Effect of Climate Change Induced Sea Level Rise and Rainfall Pattern Change.

Current predicted sea level rise over 100 years varies from 0.18 to 0.91m (DECC, 2007) depending on the parameters adopted. The NSW Sea Level Rise policy adopts 0.9 m rise which is considered in this assessment. WBM (2010) includes analysis of a range of scenarios integrating the anticipated sea level rise; assume increase in Berm height (2.0 mAHD going to 3.0 mAHD). Analysis has also been undertaken to assess the impacts of a 30 % increase in rainfall intensity in creek flows.

WBM (2010) analysis results indicate all climate change hydrological effects result in design flood levels below the adopted site FPL. Therefore it is considered that the site has adequate adaptive capacity with regards to climate change.

Re-modelling of the site groundwater system with an oceanic boundary condition 0.9 m higher than current (i.e. sea level rise) results in negligible change in the groundwater levels beneath the site. These changes are insufficient to adversely impact on the developed site.

5 Stormwater Management

5.1 Stormwater and Water Quality Modelling

A number of models and software packages were used to assess the stormwater treatment and management system and confirm it satisfies relevant water quality and water quantity criteria. These models are discussed below.

- DRAINS – This hydraulic and hydrologic model has been used to analyse site hydrology and to design road side swales, as well as to determine the likely impacts of the inclusion of lot accesses to the performance of the swales for design storm events.
- MUSIC – This model has been used to evaluate existing and post-development pollutant loads from the site. The performance of the stormwater management system was investigated and refined iteratively to achieve specified water quality objectives. In particular this model was used to assess the hydrological impact on the downstream wetland/vegetation area at the north of the site and on the water quality implications of the development.
- RAFTS – This hydrologic model was used to determine the peak flow rates from catchments upslope of the site for existing climate conditions and for climate change conditions.

Two scenarios were considered in the hydrological and hydraulic modelling conducted for the site, described as follows:

- Existing climate conditions – for this scenario, the storm events modelled used existing design rainfall intensities, calculated in accordance with AR&R (1987).
- Climate change conditions – for this scenario, the storm events modelled had an additional 30% added to the existing design rainfall intensities calculated for existing climate conditions.

6 Stormwater Quantity

6.1 Drainage Overview

6.1.1 Relevant Design Guidelines

The site stormwater management system has been designed in accordance with the objectives of Kempsey DCP 36 (2000). These guidelines outline the criteria for design of site minor and major systems and provide minimum requirements for site drainage structures including consideration of pedestrian and vehicle safety in accordance with the NSW Floodplain Management Manual (2005).

The following key design objectives from Kempsey DCP 36 (2000) are noted:

- System design ARI's are to be 100 years for major systems and 5 years for residential area minor systems.
- Acceptable gutter flow width in the 20% AEP event is 2.5 m maximum.
- Surcharging of drainage systems for storm frequencies greater than the 5% AEP may be permitted across the road centreline where the road pavement is below the natural surface of the adjoining private property.
- The velocity x depth product of flow across the footpath and within the road reserve shall be such that the safety of children and vehicles is considered. The maximum allowable depth of water is 0.2 m and the maximum velocity x depth product of 0.4 m²/s is permitted. In open channels and surcharge flow paths, the above velocity x depth product criteria will be followed where possible or the design shall address the requirements for safety in relation to children by providing safe egress points from the channel or other appropriate methods. Designs must be in accordance with the NSW Floodplain Management Manual (2005).
- Maximum side slopes on grassed lined open channels shall be 1 in 5.

6.1.2 Off-Site Catchments

Two upslope catchment areas drain through the site from the south of Belle O'Conner Street. It is proposed that these flows be conveyed

through formed grassed swales sized for the 1 in 100 year ARI peak flow. These swales will be designed so as to facilitate the transfer of stormwater flows from upslope of the site to receiving environments downslope of the site.

6.1.3 Roadside Drainage Swales

The stormwater management system for the site includes roadside drainage swales designed to convey site runoff to the main drainage swales traversing the site. Grassed swales are designed primarily to contain and convey design peak flows from site areas to areas downslope of the site. Swales are also expected to provide some treatment of flows prior to discharge.

6.1.4 Outlet Structures

All site drainage swales shall require outlet structures at discharge points from the site to control and disperse flows and prevent the erosion of flow paths downslope of the sub-division. These may include such structures as energy dissipaters and channel reinforcement. The provision of appropriately designed outlet structures shall ensure that sensitive receiving environments are not adversely impacted by the larger magnitude, low frequency storm events.

The detailed design of the outlet structures will be developed at construction certificate stage of the development and all outlet structures will need to be designed to be compatible with any water quality structures or devices that may be located at the downslope end of drainage swales (e.g. wetlands, gross pollutant traps, etc).

6.1.5 Site Wetlands

The development includes two water quality treatment wetlands to treat flows from the two main site catchments (Swales 2 and 6). These wetlands are primarily water quality treatment structures and are not expected to provide any significant reduction in peak flows from the site during larger magnitude, low frequency storm events, with inlet structures to wetland to be designed to be bypassed during high flow events at the site. Detailed design of the site wetlands, including all inlet and outlet structures is to be undertaken at construction certificate stage of the development.

Review of wetland locations, swale design in the vicinity and groundwater information indicates that wetlands shall be located above the local groundwater table. To ensure the direct transfer of stormwater into the groundwater aquifer wetlands are to be lined with an impermeable liner such as ELCOseal geosynthetic clay liner or an appropriate HDPE liner. The lined nature of these wetlands is reflected in MUSIC modelling where seepage loss is assumed to be 0.00 mm/hour. Temporary dewatering may be required during

construction, if this is the case a dewatering plan and license from NoW shall be required.

6.1.6 OSD

On-site detention (OSD) is used in development to attenuate development induced increases in flows where downstream assets are potentially impacted. The stormwater modelling undertaken by WBM (2010) demonstrates that the proposed development shall have negligible impacts on flood flows and peak water levels experienced at Saltwater Lagoon and Creek and the existing Phillip Drive bridge for the 1%AEP event (existing climate conditions).

Minor changes in the hydrology of infrequent major events shall not affect the site's receiving environments as ecological systems are reliant on the hydrology of the more frequent small events, which contribute 99.5% of long term average flows to the system (BMT WBM, 2007), and overall availability of water resources, which are not adversely affected by the proposed development.

Therefore, it is concluded that OSD is not necessary on the site, as the minimal increase in flow from major, infrequent storms will not adversely impact downstream ecological systems and, in accordance with Council's DCP 36, OSD is not required as any local flow increases do not significantly impact on downstream infrastructure.

6.1.7 Hydrological Effect

The stormwater management system has been designed to maintain ecologically relevant aspects of the hydrological regime of downstream EECs, riparian areas and the Saltwater Lagoon system.

Minor frequent storm events are identified by BMT WBM (2007) *Saltwater Lagoon and Creek Catchment Stormwater Management Strategy* as contributing 99.5% of long term average flows to the system. Total flows (via surface and shallow sub-surface flow paths) from these events to the downstream environments are not significantly altered by the development through the implementation of WSUD measures, therefore, it can be concluded that these receiving environment's ecological qualities shall not be compromised.

Infrequent storm events do not generally impact on the environmental quality of receiving environments except where excessive flow concentration and velocities result in localised scour and erosion. Design measures to mitigate these potential impacts include level spreaders and appropriate outlet energy dissipation devices.

The system has been designed to maintain an adequate water supply to downstream environments through the combination of surface and

shallow groundwater flows. The system of swales and level spreaders facilitate the infiltration of excess generated stormwater thus maintaining groundwater levels. Swales shall maintain surface water flows to adjacent vegetation, control high velocity flows and provide water quality treatment to appropriate pre-development levels.

6.2 Swale Design

6.2.1 RAFTS-XP Modelling – Upslope Catchments

The RAFTS-XP hydrological modelling program was used to determine the peak flow rates for the 1% AEP, 5% AEP and 20% AEP and the 1% AEP, 5% AEP and 20% AEP with climate change (additional 30% rainfall intensity) from the catchments upslope of the site for inclusion into the DRAINS model. The catchments modelled in RAFTS are summarised as follows.

Table 2: RAFTS catchments used in hydrological modelling of upslope catchments.

Catchment	Area (ha)	% Impervious Area (Existing Conditions)
Upslope Catchment 2	39.520	5
Upslope Catchment 6	36.290	1

Peak flow rates from design storms modelled for each upslope catchment are summarised as follows.

Table 3: Summary of peak flow rates for upslope catchments.

Catchment	Peak flows for Existing Climate Conditions Storms (m ³ /s)			Peak flows for Climate Change (+30% Rainfall Intensity) Conditions Storms (m ³ /s)		
	20% AEP	5% AEP	1% AEP	20% AEP	5% AEP	1% AEP
Upslope Catchment 2	3.09	4.70	7.15	4.66	7.01	10.03
Upslope Catchment 6	2.43	3.69	5.53	3.65	5.56	7.92

6.2.2 DRAINS Model Set-up – Main Site Swale Design

A DRAINS model was utilised to size the roadside swales and major swales for the development. The model was based on 10 sub-catchments. These sub-catchments were then further subdivided into smaller sub-catchments to determine individual road swale width requirements. The 20% AEP, 5% AEP and 1% AEP events were considered for design purposes.

For the purposes of swale and road design, the following design parameters have been used:

1. Minor swales are located on one side of the road only.
2. Major swales 2 and 6 are located between the site accesses from Belle O'Connor Drive.
3. There is generally a minimum horizontal distance of 1.0 m between the top of bank and edge of road pavement.
4. Swales are 'v' shaped with side slopes of 1 (V) in 5 (H).
5. Swales have been designed to contain the 20% AEP flow in accordance with Kempsey Council DCP 36 (2000).
6. Swales contain the 1% AEP peak flow within the road reserve and do not allow for flows to spill into lots.
7. Roads have been assumed to have a single crossfall towards the swale.
8. All culvert characteristics used in the model are based on commercially available reinforced concrete box culverts as per the Rocla Product Guide for NSW and ACT (2009).
9. The calculated existing conditions 1% AEP peak flow rates calculated above for the upslope catchments has been placed into the model at the upslope ends of swales 2 and 6. This is anticipated to give a more conservative result for the peak flows from the site and peak 1% AEP levels within these swales.

A schematic layout of the DRAINS model and typical sections and culvert inputs used to assess the requirements for site swales is provided in Attachment B. It should be noted that Catchment 1 comprises the proposed medium density super-lot and shall be subject to further design once the layout of this lot is finalised. It is treated in this analysis as an urbanised area.

6.2.3 DRAINS Results – Main Site Swale Design

Results of DRAINS modelling shows that the proposed roadside drainage swales are able to convey peak discharges arising from the 20% AEP and 1% AEP storm events whilst achieving the design objectives outlined in Kempsey Shire Council's DCP 36 (2000). Table 4 provides details of preliminary swale sizes for the largest swale in each sub-catchment (generally the swale directly upslope of the outlet).

Table 4: Minimum Swale Requirements

	Catchment	Minimum swale depth / width required to achieve design objectives (m)
Roadside Swales	1	0.55 / 6.0
	3	0.40 / 4.5
	4	0.45 / 5.0
	5	0.40 / 4.5
	7	0.30 / 3.5
	8	0.60 / 6.5
	9	0.45 / 5.0
Major Drainage Swales	2	0.87/15.0
	6	0.67/16.0

Note: All swale sizes may be subject to change based on final site layout.

Model results indicate that for the 20% AEP critical storm, all site swales comply with the requirements of Kempsey Shire Council DCP 36 (2000) with the maximum gutter flow across the road pavement being less than 2.5 m in width for all swales.

Peak velocities, depths and depth by velocity product resulting from the 1% AEP critical duration storm were analysed for each of the catchment drainage swales at the centreline of the swale and at the downslope edge of the road pavement adjacent to the swale, to check their compliance with the objectives in Kempsey Shire Council's DCP 36 (2000). Results of these analyses are summarised in Table 5 below, with a full description of these results given on Sheet 1 of the attached plan set (Attachment B).

Table 5: Drains Results - Maximum flow depth, velocity and depth by velocity product at swale centrelines and adjacent road pavement edge of bitumen.

Catchment	Maximum 1%AEP depth of flow over centreline of swale (m)	Maximum 1%AEP depth of flow over pavement lower side edge of bitumen (m)	Maximum 1% AEP depth by velocity product over centreline of swale ¹ (m ² /s)	Maximum 1% AEP depth by velocity product over pavement lower side edge of bitumen ¹ (m ² /s)
1	0.59	0.04	0.35	0.02
2	0.96	0.07	1.74	0.12
3	0.44	0.03	0.58	0.04
4	0.50	0.05	0.38	0.02
5	0.42	0.04	0.54	0.03
6	0.60	n/a	1.02	n/a
7	0.30	0.02	0.44	0.01
8	0.67	0.07	0.68	0.06
9	0.42	n/a	0.48	n/a

Note: ¹. Section of swale with maximum flow depth by velocity product may not necessarily correspond with section of swale with maximum flow depth over centreline of swale or edge of bitumen.

6.2.4 Swale Safety

The model results have been reviewed to assess the requirement for the safety of pedestrians in accordance with Clause 5.13.2 of the Kempsey Shire Council DCP 36 (2000). Mitigating the potential hazard posed by these high velocity x depth products are the following factors:

- Main swales 2 and 6 are located between the contraflow lanes of the site's access roads from Belle O'Conner Drive. Footpaths are to be provided on the side of the access roads on the opposite side of the road to the drainage swales, thus separating pedestrians from the potential hazard.
- Proposed road reserves with minor drainage swales have a footpath provided on the opposite side of the road to the drainage swale. Therefore pedestrian routes are well separated from the swales.

Results indicate that the maximum depth by velocity product over the centreline of a number of the minor drainage swales and for both major drainage swales (2 and 6) are greater than or equal to 0.4 m²/s, indicating a potential hazard. However, the maximum velocity x depth product over the downslope side edge of road pavement for all swales are all less than 0.4 m²/s with flow depths less than 0.2 m and are thus safe.

The design is therefore considered to comply with the requirements of Kempsey Shire Council DCP 36 (2000) and the NSW Floodplain Management Manual (2005) as provision for the safe egress of pedestrians and vehicles has been provided for all site roads during the 1% AEP critical storm event.

6.3 Flood Backwater Analyses

The DRAINS model was re-run for the 1% AEP storm event assuming downstream water levels of 3.4 mAHD, being the level determined by the WBM (2010) report for the initial berm height of 3.0 mAHD. Given that the WBM (2010) peak 1% AEP flood level corresponds to the 36 hour flood event and the site design event is 20 minutes, it is unlikely that these two events would coincide. If they were to coincide, the recurrence interval would be much greater than 100 years.

Results of this analysis showed negligible impacts on the performance of the site drainage system, with all flows remaining within the road reserves for all swales. Results also showed no adverse impacts on the peak flow depth x velocity product at the lower side edge of bitumen for site road pavements and that, therefore, the proposed stormwater management system still complies with the requirements of Kempsey Shire Council DCP 36 (2000) and the NSW Floodplain Management Manual (2005). A full output of results from the DRAINS model is provided as Attachment D.

6.4 Climate Change Analyses

The DRAINS model was subsequently re-run to determine the likely effects of climate change on the performance of the site drainage system. Accordingly, the design storm events used in the DRAINS model were amended to include an increase in rainfall intensity of 30% for the 20% AEP and 1% AEP storms.

Results of these analyses showed that site swales generally continue to comply with the requirements of Kempsey Shire Council DCP 36 (2000) with respect to the maximum gutter flow width for the peak 20% AEP climate change event.

Results of the analyses for the 1% AEP climate change event indicate that for all swales, peak flow depths increase and in some places may result in very shallow flows onto lots from the road reserve (generally less than 20 mm depth). For the main swales 2 and 6, results indicate that peak flow depths in the 1% AEP climate change event increase more than for the minor swales. No modelled flows exceed proposed dwelling floor levels (i.e. natural ground level or Flood Planning Level) and was not more than a maximum of 140 mm of flow depth on lots. It is therefore demonstrated that the site drainage design has adaptive capacity to accommodate the potential effects of climate change on

peak flood characteristics without adverse impacts on proposed site dwellings. A full output of results from the DRAINS model is provided as Attachment E.

6.5 Culverts Analyses

In addition to the above DRAINS modelling, an additional model was set-up to determine the impacts of proposed lot access crossings on the performance of road drainage swales and to determine an acceptable solution for culverts to be included at all lot access crossings (note detailed design at later stage).

Analyses of the peak flow rates for each site catchment determined that, of the swales that shall have lot access crossings constructed over them, the swale for Catchment 8 adjacent to Road 11 in the development layout (hereafter referred to as Swale 8) had the highest peak flow rates in the 1% AEP and 20% AEP critical storm events. This swale was therefore selected for analysis to assess the worst case scenario.

To assess the impacts of the lot access culverts on: peak flow depths; flow depth over road; velocity x depth product; and extent of flows for the 1% AEP, two models were constructed to consider Swale 8 with and without the lot access culverts. A model set-up is provided on Sheet 2 of the attached plan set (Attachment B). All culverts used in the model with lot access culverts were based on the Rocla 3.0 m wide x 0.3 m high reinforced concrete box culverts as detailed in the Rocla Product Guide for NSW and ACT (2009).

Results of this analysis are summarised in Table 6 and Table 7 below, with full results and typical swale section given on Sheet 2 of the attached plan set (Attachment B).

Table 6: Summary of model results for Swale 8 model without culverts.

Node	Maximum 1%AEP depth of flow over centreline of swale (mm)	Maximum 1%AEP depth of flow over pavement lower side edge of bitumen (mm)	Maximum flow velocity in swale (m/s)	Maximum 1% AEP depth by velocity product over centreline of swale ¹ (m ² /s)	Maximum 1% AEP depth by velocity product over pavement lower side edge of bitumen ¹ (m ² /s)
8_OUT	114	0	1.0	0.11	n/a
8A_JUNC	551	0	1.6	0.88	n/a
N8_BC	669	69	0.9	0.60	0.06
N8_BD	618	18	1.1	0.68	0.02
N8B_E	636	36	0.8	0.51	0.03
N8_B	635	35	0.7	0.44	0.02
N8B_Up	279	0	1.2	0.33	n/a
N8_F	567	67	0.4	0.23	0.03
N8_G	391	0	0.7	0.27	n/a
N8_H	145	0	0.8	0.12	0.00

Table 7: Summary of model results for Swale 8 model with culverts included.

Node	Maximum 1%AEP depth of flow over centreline of swale (mm)	Maximum 1%AEP depth of flow over pavement lower side edge of bitumen (mm)	Maximum flow velocity in swale (m/s)	Maximum 1% AEP depth by velocity product over centreline of swale ¹ (m ² /s)	Maximum 1% AEP depth by velocity product over pavement lower side edge of bitumen ¹ (m ² /s)
8OUT	114	0	1.0	0.11	n/a
8AJUNC	549	0	1.6	0.88	n/a
Cul1 DS	703	103	0.6	0.42	0.06
Cul1 US	691	91	0.6	0.41	0.05
Cul2 DS	705	105	0.6	0.42	0.06
Cul2 US	694	94	0.6	0.42	0.06
N8BC	691	91	0.6	0.41	0.05
Cul3 DS	685	85	0.6	0.41	0.05
Cul3 US	668	68	0.7	0.47	0.05
Cul4 DS	680	80	0.6	0.41	0.05
Cul4 US	663	63	0.7	0.46	0.04
N8BD	659	59	0.7	0.46	0.04
N8BE	644	44	0.8	0.52	0.04
N8B	639	35	0.7	0.45	0.02
N8BUp	279	0	1.2	0.33	n/a
N8F	567	67	0.4	0.23	0.03
N8G	391	0	0.7	0.27	n/a
N8H	145	0	0.8	0.12	n/a

The results obtained from the model show that the inclusion of the lot access culverts has the effect of increasing the 1% AEP peak level by approximately 40 mm at corresponding points along the swale. Results also show that the maximum flow depth over the lower side edge of

bitumen for the road pavement does not exceed 200 mm at any point along the swale and that the depth x velocity product at the deepest point of flow on the road pavement does not exceed 0.4 m²/s. The results also indicate that flows will not spill into lots on either side of the road reserve during the peak 1%AEP storm event.

Therefore, the inclusion of lot access culverts within the drainage swales results in a design outcome complying with the design requirements outlined in the Kempsey Shire Council DCP 36 (2005) and the NSW Floodplain Management Manual (2005).

6.6 Stormwater Detention

The requirement for on-site stormwater detention has been assessed using the results of the WBM (2010) flood assessment conducted for the project. Scenarios 1 and 2 of WBM (2010) assess flood conditions with berm height of 2.0 and 3.0 mAHD for the 1% AEP storm. These can be compared to previous modelling without site development as reported in WBM (2005). Comparison of results indicates that the increased site impervious area does not have a significant impact on the flood levels experienced downstream of the site. The 1% AEP flood levels immediately downslope of the site are 3.2 mAHD and 3.4 mAHD respectively for 2.0 and 3.0 mAHD berm heights. This result is, within the resolution of the model, the same as the initial flood assessment levels in which the site was undeveloped.

It is therefore confirmed that the site does not require stormwater detention to be provided, as the development of the site will not result in any adverse impacts on existing flood behaviour downslope of the site. It is noted that the site dwellings shall have rainwater tanks (in accordance with BASIX). These tanks have not been considered in the analysis, they will result in some on-site retention, but do not require additional OSD volume.

7 Stormwater Quality

7.1 Water Quality Objectives

In accordance with the objectives for future management as detailed in the Saltwater Lagoon Estuary Management Plan, water quality modelling was undertaken to satisfy the requirement that the post-development water quality be equal to or better than the pre-development water quality discharging from the site.

7.2 Treatment Train Philosophy

The stormwater quality treatment strategy for the site incorporates a number of stormwater quality improvement devices (SQIDs) configured in series to form a 'treatment train'. The treatment train philosophy focuses on water conservation, 'at source' control, and 'end of line' control to ensure treatment objectives are satisfied. The individual SQIDs are outlined in the following sub-sections.

7.2.1 Swales

A network of roadside swales and two main drainage swales that traverse the site are used to direct flow to downstream receiving waters. These structures shall provide water quality treatment through the removal of suspended solids and nutrients. It is noted that in light of recent groundwater investigations, these swales are assumed not to act as infiltration swales.

7.2.2 Wetlands

Two stormwater treatment wetlands shall have flows directed to them from the main swales (Swales 2 and 6). These structures shall provide water quality treatment through the removal of suspended sediments and nutrient removal and / or uptake by vegetation planted within the wetlands. The main swales shall have a low flow diversion bund placed within the swale upslope of the wetland to direct base flows to the wetland, with higher flows bypassing the treatment wetland.

7.3 MUSIC Modelling

7.3.1 Model Overview

The MUSIC model was utilised to generate the pre- and post-development water quality conditions and to confirm water quality objectives were achieved. The model was run iteratively for existing conditions and developed conditions to determine preliminary

requirements for water quality treatment structures for the development.

7.3.2 Model Set-up

The following set-up and parameters were used in the pre- and post-development MUSIC models;

- A pre-development model consists of 3 catchment areas: the site; and 2 upslope catchments.
- The post-development model consists of sub-catchments for contributing urban areas; road areas; swales and wetlands. The 2 upslope catchments flow into the main swales (swales 2 and 6).
- Areas for contributing catchments are provided in Table 8 (pre-development) and Table 9 (post-development)
- Pollutant concentrations from the Australian Runoff Quality handbook (ARQ) are used for the pre- and post-development models (Table 10).
- Flows from swales 2 and 6 pass are to be bypassed and treated through a wetland.
- All site swales and wetlands were assumed to have no infiltration losses for the purposes of this assessment, given the intermittently shallow groundwater table on the site.
- Attachment B provides the MUSIC layouts for pre- and post-development models, as well as details of input parameters used in the modelling.

Table 8: Pre-Development MUSIC areas

Contributing Area	Area (Ha)	% Impervious
'Site'	26.570	1
Upslope Catchment 2	39.520	20
Upslope Catchment 6	36.290	4

Table 9: Post-Development MUSIC areas.

Sub-Catchment	Total Area (Ha)	Lot Area (Ha)	Roads Area (Ha) ²	Swale Area (Ha) ³	% Impervious Area ¹
1	2.59	2.10	0.44	0.05	Variable
2	6.87	5.07	1.50	0.30	Variable
3	1.20	0.76	0.39	0.05	Variable
4	1.20	0.82	0.34	0.04	Variable
5	1.21	0.82	0.35	0.04	Variable
6	5.39	3.83	1.31	0.25	Variable
7	1.25	0.84	0.37	0.04	Variable
8	3.91	2.73	1.05	0.13	Variable
9	1.30	0.87	0.37	0.06	Variable
10	0.60	0.6	0.00	0.00	Variable
Upslope Catchment 2	39.520	n/a	n/a	n/a	20
Upslope Catchment 6	34.680	n/a	n/a	n/a	4

Notes: ¹ %Impervious area assumed to be 50% for lots and variable for road reserve areas as width of road pavement and adjacent swale variable depending on specific roads within catchments; ² Roads area in MUSIC = road reserve area – swale area; ³ Modelled swale area is half the actual roadside swale length x average width to account for the progressive inflow of stormwater.

Table 10: Pre- and post-development ARQ categories.

Model	MUSIC node	ARQ Category
Pre-	Site Pre-Development	"Forest"
	Upslope Catchment 2	"Forest"
	Upslope Catchment 6	"Forest"
Post-	Urban nodes	"Urban: Residential"
	Roads nodes	"Urban: Roads"

Details of ARQ pollutant generation rates for the three catchment types used in the modelling are provided on Sheet 4 of the attached plan set (Attachment B).

7.3.3 Water Quality Results

Water quality results are described for the following parameters;

- Suspended solids.
- Phosphorus.
- Nitrogen.
- Flow (volume of runoff).

Analyses of the pollutant loads for existing conditions, proposed conditions without treatment and proposed conditions with treatment measures allows comparison with the targets set out for Saltwater Creek and Lagoon, as stated in the Saltwater EMP. These targets call for developments to have no net increase in pollutant/nutrient loads. Similarly, the EMP sets water targets as equal to or better than the existing water quality.

The model was run to include drainage swales and wetlands as water quality treatment structures. Optimal post-development pollutant concentrations are achieved (Table 11) through the provision of wetlands treating flows from catchments 2 and 6 (see Attachment B for MUSIC model layout). These wetlands shall have surface areas of approximately 1500 m² (Catchment 2) and 1900 m² (Catchment 6) respectively and a design depth of approximately 0.5 m.

Table 11: Pre- versus post-development (treatment provided)

Parameter	Pre-Development (kg/yr)	No Treatment (kg/yr)	With Treatment (kg/yr)	Load Reduction (pre vs with treatment)	Criteria Met (Y/N)
Suspended Solids	33 300	75 300	9490	72%	Y
Phosphorus	126	190	59	53%	Y
Nitrogen	538	1 070	537	0%	Y
Flow	508 ML/y	618 ML/y	618 ML/y	-22%	Y

Results in Table 11 indicate that the inclusion of drainage swales and the wetlands for Catchments 2 and 6 satisfies the performance objective of achieving 'neutral or beneficial' (i.e. post-development is equal to or less than the pre-development) pollutant discharge outcome. Modelling indicates that the development results in an increase in runoff, however, this increase in volume is not expected to cause any significant impacts on the receiving environment, as there

will be no reduction to the water resource available to downstream ecosystems.

Review of typical swale performance indicates that, for a 200 m swale, a total of approximately 3 tonnes/year of sediment is removed. Assuming all sediment is retained on the surface of the swale, rather than passing down through the profile, and that sediment has an average density of 1600 kg/m³ a total of 1.7 m³ will accumulate. With an accumulation width of 2 m in a swale typically 3.5 – 5.5 m wide this equates to a depth of accumulation of the order of 4 mm / year. Maintenance interval for such a structure shall therefore be of the order of 15 - 25 years or more and is considered to be appropriate.

8 Development Impact Mitigation

8.1 Water quality

The design of the site stormwater drainage and treatment system achieves the targets set for the site, i.e. that the post development water quality is equal to or better than that of the pre-development quality. Measures required to achieve this outcome include:

1. Grassed drainage swales for the re-treatment of road runoff and for the safe conveyance of water from the site.
2. Central drainage swales to convey and pre-treat water from upslope catchments.
3. Two water quality wetlands of 1500 and 1900 m² on road swales 2 and 6 respectively.

8.2 Water Quantity

The surface and sub-surface flow systems are intrinsically connected at the site due to the shallow groundwater table. As a result of the proposed development, results of modelling predicts surface flow to increase overall by approximately 22% as a result of increased site impervious area. The net effect of this increase is considered negligible and of little impact to the surrounding environment.

Results of additional modelling undertaken by WBM (2010) indicate that the development of the site will have negligible impact on the existing flood behaviour downslope of the site and therefore OSD is not required.

8.3 Flooding

The footprint of the proposed development has been designed in accordance with recommendations made in the Saltwater Creek Flood Study (WBM Oceanics, 2006). The footprint of the proposed development is above the 1 in 100 year flood extent. In addition, a 50m buffer has been provided to ameliorate effects on the downstream receiving waters and habitat. This buffer also sets the development extent for the site free of flood effects.

The potential impacts of climate change on rainfall intensity and induced sea level rise have been considered in the modelling undertaken for this report and by WBM (2010). Modelling indicates that the proposed site drainage design has adaptive capacity to

accommodate the potential effects of climate change on peak flood characteristics without adverse impacts on proposed site dwellings. WBM modelling indicates that the maximum flood levels downslope of the site for climate change conditions with respect to increased rainfall intensity are 3.4 and 3.6 mAHD for berm heights of 2.0 and 3.0 mAHD respectively. WBM modelling also indicates maximum flood levels downslope of the site of 3.1 and 3.2 mAHD for 1% AEP storm surge for berm heights of 2.0 and 3.0 mAHD respectively. The proposed flood planning level for the site of 3.7 mAHD is above all modelled levels, therefore confirming that the development has sufficient adaptive capacity to accommodate the most severe predicted climate change induced hydrological conditions. This also confirms that the proposed site FPL of 3.7 mAHD is appropriate.

8.4 Drainage Configuration

The proposed drainage configuration for the site has been designed to ensure adequate conveyance of flows from the site to the receiving environment whilst also providing water quality treatment.

Major grassed swales traverse the site and convey flow from upstream catchments across the site and into the Saltwater Creek and Lagoon ecosystem. These swales also provide water quality treatment of surface flows prior to discharge during low flow events. Proposed site wetlands shall provide additional water quality treatment prior to discharge to downslope environments. Outlets from site drainage swales shall be designed at construction certificate stage of the development to ensure minimisation of potential adverse effects of flow concentration.

8.5 SEPP 14 Wetlands Protection

The proposed drainage system outlined above and throughout this report protects the SEPP 14 wetlands as follows;

1. The proposed drainage system for the site including roadside swales and site wetlands achieves water quality targets and so protects downstream environments, including the SEPP 14 wetlands from water quality related degradation; such as eutrophication.
2. Outlet structures (e.g. flow spreaders and energy dissipaters) for site roadside drainage swales shall ensure that, during high flow events, scour and erosion of SEPP 14 wetlands does not occur.

8.6 Monitoring

Monitoring of downstream receiving environments shall occur during the construction phase and during the revegetation establishment

phase (up to 6 months after development is completed). We recommend the monitoring principles, outlined in Table 12, be included as part of the consent conditions.

Table 12: Schedule of Monitoring to Occur During the Construction and Revegetation Establishment Phase.

Monitoring	Action	Frequency
Water Quality Monitoring	Water quality monitoring shall occur at the each of the site's discharge points and at a location downstream, within Saltwater Creek. Parameters to be monitored include; • pH • Temperature • Dissolved Oxygen • TN, TP and SS • Turbidity	Monitoring shall occur at each location monthly during the construction phase and quarterly during the establishment phase.

All monitoring and subsequent maintenance works are to be carried out and completed by a suitably qualified contractor. Water quality monitoring is to be undertaken in accordance with the Australian Standard and the terms of the Laboratory NATA accreditation.

8.7 Maintenance

Periodic maintenance of the site drainage system shall be required to ensure the continued performance of the system. It is envisaged that maintenance shall include such measures as:

- Periodic inspection of all site wetlands and roadside drainage swales to determine the requirement for removal of accumulated sediments and gross pollutants.
- Periodic grass cutting of all site roadside drainage swales.
- Periodic inspection and maintenance of wetland vegetation and sediment accumulation.
- Periodic inspection and cleaning (if required) of site outlet structures and downslope flow paths for any signs of erosion or other deterioration.

9 Water Servicing

9.1 Water Supply

Supply of potable water for the development shall be from the existing reticulated town water supply servicing South West Rocks. Additionally, potable water shall be available from rainwater tanks to be installed at each dwelling (in accordance with BASIX requirements), which shall reduce the town water demand. There is also potential for the development to have non-potable effluent re-use further reducing the town water demand. Design of the reticulated town water supply mains will be in accordance with the requirements of Kempsey Shire Council DCP 36 (2000) and WSA (2002) guidelines and undertaken at a later stage of the development.

9.2 Sewer

The development is to be connected to a new reticulated sewerage system directing wastewater to the existing sewage treatment plant servicing South West Rocks (adjacent to the subject site). Design of the reticulated sewerage mains will be in accordance with the requirements of Kempsey Shire Council DCP 36 (2000) and WSA (2002) guidelines and undertaken at a later stage of the development.

10 Conclusions and Recommendations

10.1 Overview

The water cycle management plan developed for the site brings together the results of the stormwater quantity and quality assessment, hydrogeological assessment and flood analysis to form an overall water management plan which satisfies performance standards adopted for the site being a neutral or beneficial impact on the downslope receiving environment.

The recommendations made below are considered best practice sustainable engineering solutions and satisfy the principles of Water Sensitive Urban Design and specific performance standards of Council.

10.2 Components of Site Water Management System

From modelling results the following treatment structures have been recommended to sustainably manage stormwater at the site:

1. Road side drainage swales - included on the site to safely and effectively convey flows to downstream receiving waters and to provide water quality treatment of flows.
2. Two main drainage swales (Swales 2 and 6) are proposed to direct drainage from upslope catchments and site catchments through the site and to receiving waters. Swales shall be designed at a later stage to direct low flows to site wetlands for additional water quality treatment, with high flows bypassing site wetlands and continuing along swales to receiving waters. As with road side swales, these also provide water quality treatment.
3. Site wetlands – included on the site to provide treatment of stormwater flows from the site prior to discharge to receiving waters.
4. Site swale outlet structures – proposed to be included on all site stormwater outlets. These structures will provide energy dissipation and erosion control measures for site stormwater discharging to downstream receiving waters.
5. Sub-soil drains – provided to manage episodically shallow groundwater and protection road pavements and other assets from adverse impact.

10.3 Conclusion and Management Outcomes

Outcomes of flooding, stormwater quantity and water quality results together form the water cycle management plan for the site. Assessment of the performance of these components of the water cycle management plan conclude that:

- Hydrological analysis of the existing site has shown that the shallow groundwater table is a site constraint that requires to be managed. The proposed development shall, by design, impact on site groundwater levels. The development also has potential to impact on surface runoff volumes and water quality if not appropriately managed.
- To mitigate the impact on the downstream hydrological regime water management systems are proposed to achieve a regime which maintains or improves that of the existing environment.
- Two (2) 'major' grass swales shall divert upslope catchment drainage to downstream receiving waters whilst also providing water quality treatment.
- Road side swales of varying sizes will collect stormwater from road and pavement areas and divert these flows to downstream wetlands and receiving waters and sensitive habitats. Both roadside and major swales have been sized to appropriately convey the 20% AEP (swale plus gutter flow) and 1% AEP (flow within road reserve) events.
- Assessment of peak flow depths and velocities within site swales and over road reserves indicates that proposed swales comply with the design and safety objectives outlined in the Kempsey Shire Council DCP 36 (2005) and the NSW Floodplain Management Manual (2005) for existing conditions, existing conditions including backwater effects and climate change conditions assuming a 30% increase in rainfall intensity.
- Assessment of lot access culverts indicates that the inclusion of lot access culverts within the drainage swales results in a design outcome complying with the design requirements outlined in the Kempsey Shire Council DCP 36 (2005) and the NSW Floodplain Management Manual (2005).
- A 22% increase in surface flow (as indicated in MUSIC result) as a result of the development shall be directed to the downslope receiving environment. As local surface and groundwater systems are intrinsically linked, this change in surface water hydrology is not expected to detrimentally affect water supply

to downstream environments and vegetation and, as such, the impact from increased flows is considered acceptable.

- Modelling results indicate that the provision of grassed drainage swales and wetlands will treat stormwater flows from the site prior to discharge, thus achieving a total site outcome which satisfies the 'neutral or beneficial' pollution reduction objectives.
- The addition of the outlet structures at each outlet from site swales shall also serve to reduce potential impacts that may arise from the concentration of flows at outlets. These shall be designed at a later stage of the development.
- Results indicate a net improvement in post-development water quality (compared to existing conditions) when site swales and wetlands are provided. This treatment train therefore effectively manages stormwater at the site in a sustainable fashion to ensure the underlying aquifer and surrounding water-dependant ecosystems are not negatively impacted or degraded.
- Assessment of WBM (2005) flooding information indicates a design 1 in 100 yr ARI flood inundation level of 3.2 mAHD applies to the site. FPL's have been set at 1% AEP level plus 0.5 mAHD (3.7 mAHD) to place the entire development footprint outside the flood zone.
- Assessment of the potential effects of climate change (for storm surge and increased rainfall intensity) on flood levels immediately downslope of the site conducted by WBM (2010) confirms that the development would have sufficient adaptive capacity to accommodate the most severe predicted climate change induced hydrological conditions and confirms that the proposed site FPL of 3.7 mAHD is appropriate.
- Modelling conducted by WBM (2010) for developed site conditions, when compared to previous WBM (2005) modelling for undeveloped site conditions, indicates that no on-site detention of stormwater is required for the site.
- The Estuary Management Plan recommended a development extent of 50 m from the 3.0 mAHD contour. This extent has been adopted for development planning.
- Incorporation of the recommended water cycle management plan and its components into the site design, will satisfy relevant Council requirements and objectives with the proposed site development constituting ecologically sustainable development.

This investigation determined that intermittent groundwater levels beneath the site are sufficiently high to mean that drainage swale structures on the site shall, at times, not function as infiltration systems but rather as groundwater drains.

Details of the hydrogeological assessment and design implications for the project are provided in a separate report.

11 References

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Water Services Association of Australia (2002) 'Water Supply Code of Australia'.

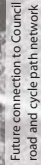
Water Services Association of Australia (2002) 'Sewerage Code of Australia'.

12 **Attachment A – Site Plan**



1. Bike paths in Conservation Zone are indicative positions only. Bike paths in this area to follow existing tracks, to minimise disturbance to natural vegetation. Path positions to be confirmed within voluntary planning agreement.

2. Long term / future site access is indicative only and will be the subject of subsequent approval. Configuration and design will be undertaken in accordance with Council specifications.



Future connection
to Council cycle path
network

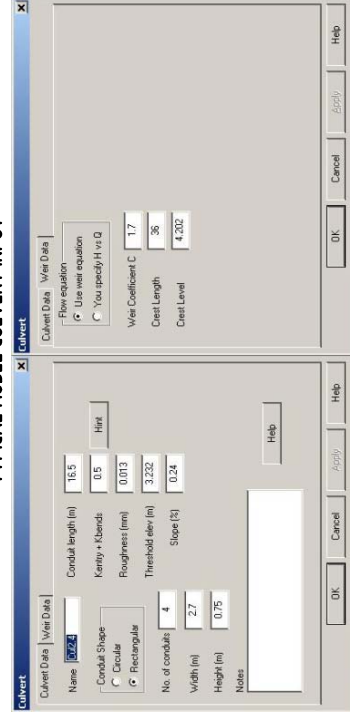
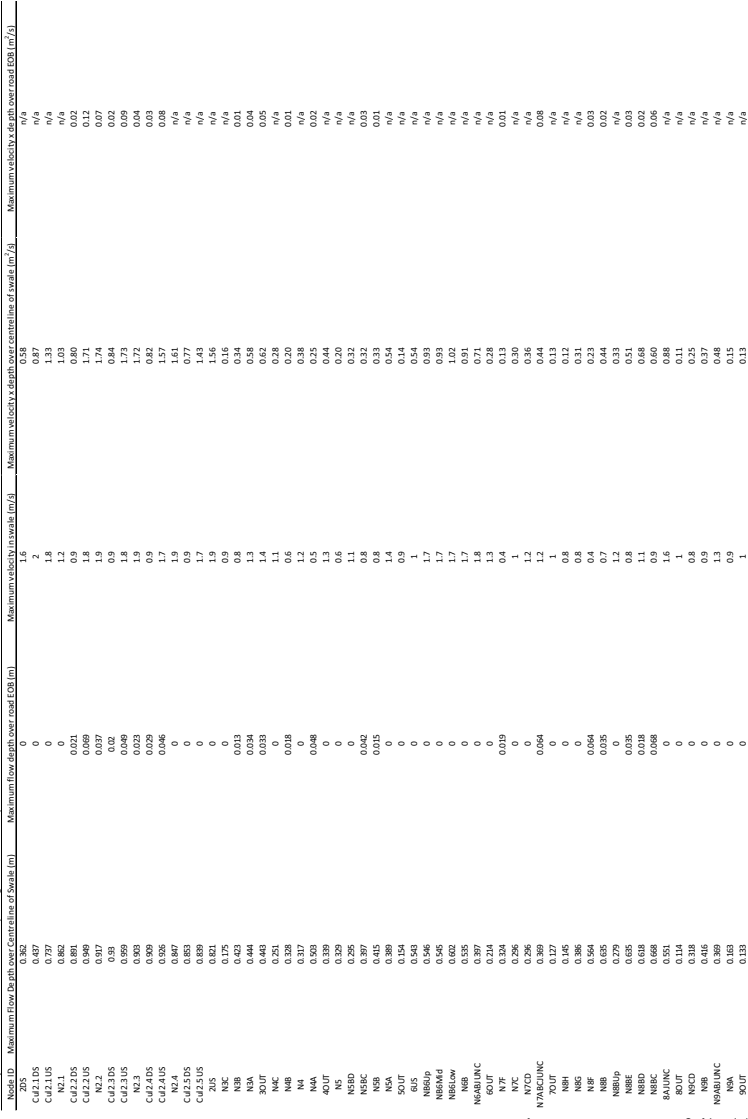
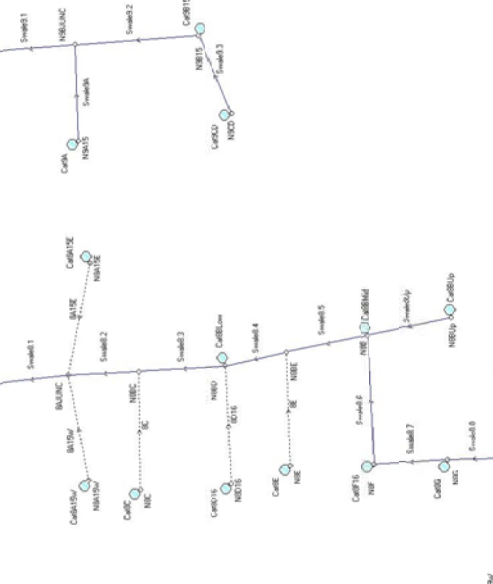
SEPP 14 WETLAND

CONSERVATION ZONE

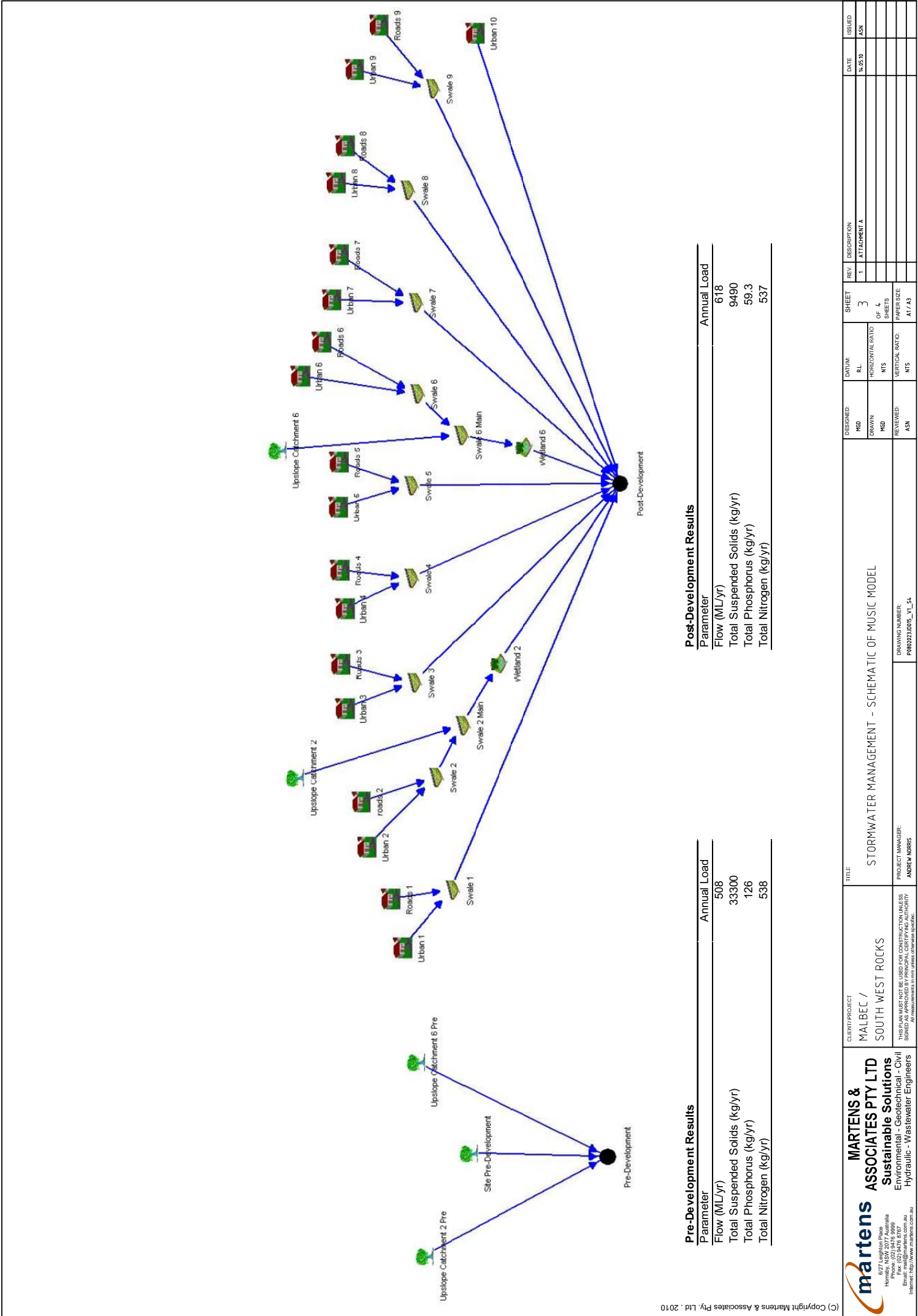
indicative long
term / future site
process

Indicative long term / future site access. Design subject to Council specifications and subsequent approval

13 **Attachment B – Plan Set**



 Martens & Associates Pty Ltd Sustainable Solutions Environmental - Geotechnical - Civil Hydraulic - Wastewater Engineers 6/27 Leighton Place Northcote, VIC 3070 Phone: (03) 9476 9999 Fax: (03) 9476 8700 Email: info@martens.com.au Internet: http://www.martens.com.au	CLIENT/PROJECT	TITLE		DESIGNED: MGD DRAWN MGD REVIEWED: ASIN	DWTM: RL HORIZONTAL RATIO NTS VERTICAL RATIO: NTS	SHEET 1 OF 4	REV.	DESCRIPTION	DATE	ISSUED
	SOUTH WEST ROCKS PROJECT MANAGER: ANDREW MORRIS DRAWING NUMBER: PM02023005_V1_S2	STORMWATER MANAGEMENT - SCHEMATIC OF DRAINS MODEL FOR SITE					1	ATTACHMENT A	14.05.10	ASIN



Pre-Development Results

Parameter	Annual Load
Flow (ML/yr)	508
Total Suspended Solids (kg/yr)	33300
Total Phosphorus (kg/yr)	126
Total Nitrogen (kg/yr)	538

Post-Development Results

Parameter	Annual Load
Flow (ML/yr)	618
Total Suspended Solids (kg/yr)	9490
Total Phosphorus (kg/yr)	59.3
Total Nitrogen (kg/yr)	537

 MARTENS & ASSOCIATES PTY LTD Sustainable Solutions Environmental - Geotechnical - Civil Hydraulic - Wastewater Engineers 6/27 Leighton Place North Sydney, NSW 1587 Australia Phone: (02) 9476 9999 Email: mail@martens.com.au Internet: http://www.martens.com.au	CLIENT / PROJECT	TITLE													
	MALBEC / SOUTH WEST ROCKS	STORMWATER MANAGEMENT – SCHEMATIC OF MUSIC MODEL													
	THIS DRAWING MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED OFF BY THE PROJECT MANAGER ANDREW MORRIS All measurements in mm, unless otherwise specified.	PROJECT MANAGER: ANDREW MORRIS	DRAWING NUMBER: PMW2022.005_V1_54	DESIGNED:	SHEET		PAPER SIZE: A1 / A3	VERTICAL RATIO: NTS	HORIZONTAL RATIO: NTS	DATE: 14.05.10	REV.	DESCRIPTION	SHEET	DATE	ISSUED
				MD	3										
				DRAWN	OF 4										
				MD	SHEETS										
				ASN											

TYPICAL INPUTS FOR FOREST CATCHMENT

Properties of Site Pre-Development - Page 2 of 5

Rainfall Runoff Parameters

Impervious Area Properties

Rainfall Threshold (mm/day)

1.00

Peniculus Area Properties

Soil Storage Capacity (mm)

120

Initial Storage (% of Capacity)

30

Field Capacity (mm)

80

Infiltration Capacity Coefficient - a

200.0

Infiltration Capacity Exponent - b

1.00

Groundwater Properties

Initial Depth (mm)

10

Daily Recharge Rate (%)

25.00

Daily Baseflow Rate (%)

5.00

Daily Deep Seepage Rate (%)

0.00

Properties of Site Pre-Development - Page 3 of 5

Base Flow Concentration Parameters

Mean (log mg/L)

1.250

Std Dev (log mg/L)

0.350

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

1.900

Std Dev (log mg/L)

0.200

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Site Pre-Development - Page 4 of 5

Base Flow Concentration Parameters

Mean (log mg/L)

0.050

Std Dev (log mg/L)

0.720

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

1.123

Std Dev (log mg/L)

0.220

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Site Pre-Development - Page 5 of 5

Base Flow Concentration Parameters

Mean (log mg/L)

0.030

Std Dev (log mg/L)

0.340

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

0.090

Std Dev (log mg/L)

0.240

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

NOTE NO SEEPAGE LOSS

TYPICAL INPUTS FOR SITE SWALES

Properties of Swale 4

Swale 4

Location

Swale 4

Inlet Properties

Low Flow By-Pass (cubic metres per sec)

0.000

Storage Properties

Length (metres)

209.1

Bed Slope (%)

0.40

Base Width (metres)

0.0

Top Width (metres)

3.5

Depth (metres)

0.35

Vegetation Height (metres)

0.200

Seepage Loss (mm/hr)

0.00

Fluxes...

Notes...

Cancel

Back

Finish

TYPICAL INPUTS FOR FOREST CATCHMENT

Properties of Urban 1 - Page 2 of 5

Rainfall Runoff Parameters

Impervious Area Properties

Rainfall Threshold (mm/day)

1.00

Peniculus Area Properties

Soil Storage Capacity (mm)

120

Initial Storage (% of Capacity)

30

Field Capacity (mm)

80

Infiltration Capacity Coefficient - a

200.0

Infiltration Capacity Exponent - b

1.00

Groundwater Properties

Initial Depth (mm)

10

Daily Recharge Rate (%)

25.00

Daily Baseflow Rate (%)

5.00

Daily Deep Seepage Rate (%)

0.00

Properties of Urban 1 - Page 3 of 5

Total Suspended Solids

Base Flow Concentration Parameters

Mean (log mg/L)

1.255

Std Dev (log mg/L)

0.462

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

2.175

Std Dev (log mg/L)

0.462

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Urban 1 - Page 4 of 5

Total Phosphorus

Base Flow Concentration Parameters

Mean (log mg/L)

0.007

Std Dev (log mg/L)

0.135

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

0.308

Std Dev (log mg/L)

0.135

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Urban 1 - Page 5 of 5

Total Nitrogen

Base Flow Concentration Parameters

Mean (log mg/L)

0.404

Std Dev (log mg/L)

0.237

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

0.431

Std Dev (log mg/L)

0.237

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

NOTE NO SEEPAGE LOSS

TYPICAL INPUTS FOR SITE MAIN SWALES (SWALES 2 AND 6)

Properties of Swale 2 Main

Swale 2 Main

Location

Swale 2 Main

Inlet Properties

Low Flow By-Pass (cubic metres per sec)

0.000

Storage Properties

Length (metres)

168.4

Bed Slope (%)

0.40

Base Width (metres)

6.3

Top Width (metres)

15.0

Depth (metres)

0.87

Vegetation Height (metres)

0.200

Seepage Loss (mm/hr)

0.00

Fluxes...

Notes...

Cancel

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Finish

TYPICAL INPUTS FOR FOREST CATCHMENT

Properties of Roads 1 - Page 2 of 5

Rainfall Runoff Parameters

Impervious Area Properties

Rainfall Threshold (mm/day)

1.00

Peniculus Area Properties

Soil Storage Capacity (mm)

120

Initial Storage (% of Capacity)

30

Field Capacity (mm)

80

Infiltration Capacity Coefficient - a

200.0

Infiltration Capacity Exponent - b

1.00

Groundwater Properties

Initial Depth (mm)

10

Daily Recharge Rate (%)

25.00

Daily Baseflow Rate (%)

5.00

Daily Deep Seepage Rate (%)

0.00

Properties of Roads 1 - Page 3 of 5

Total Suspended Solids

Base Flow Concentration Parameters

Mean (log mg/L)

1.318

Std Dev (log mg/L)

0.168

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

2.415

Std Dev (log mg/L)

0.168

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Roads 1 - Page 4 of 5

Total Phosphorus

Base Flow Concentration Parameters

Mean (log mg/L)

0.342

Std Dev (log mg/L)

0.482

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

0.595

Std Dev (log mg/L)

0.482

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Properties of Roads 1 - Page 5 of 5

Total Nitrogen

Base Flow Concentration Parameters

Mean (log mg/L)

0.200

Std Dev (log mg/L)

0.298

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

Storm Flow Concentration Parameters

Mean (log mg/L)

0.322

Std Dev (log mg/L)

0.298

Restore Defaults

Estimation Method

Stochastically generated

Serial Correlation (R squared)

0.00

TYPICAL INPUTS FOR SITE WETLANDS

Properties of Wetland 2

Wetland 2

Location

Wetland 2

Inlet Properties

Low Flow By-Pass (cubic metres per sec)

0.000

High Flow By-Pass (cubic metres per sec)

0.125

Inlet Pond Volume (cubic metres)

0.0

Storage Properties

Surface Area (square metres)

1500.0

Extended Detention Depth (metres)

0.05

Permanent Pool Volume (cubic metres)

450.0

Vegetation Cover (% of surface area)

50.0

Seepage Loss (mm/hr)

0.00

Evaporative Loss as % of PET

100.00

Outlet Properties

Equivalent Pipe Diameter (mm)

450

Overflow Weir Width (metres)

6.0

Notional Detention Time (hrs)

0.137

Fluxes...

Notes...

Cancel

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Finish

Properties of Wetland 6

Wetland 6

Location

Wetland 6

Inlet Properties

Low Flow By-Pass (cubic metres per sec)

0.000

High Flow By-Pass (cubic metres per sec)

0.125

Inlet Pond Volume (cubic metres)

0.0

Storage Properties

Surface Area (square metres)

1900.0

Extended Detention Depth (metres)

0.05

Permanent Pool Volume (cubic metres)

500.0

Vegetation Cover (% of surface area)

50.0

Seepage Loss (mm/hr)

0.00

Evaporative Loss as % of PET

100.00

Outlet Properties

Equivalent Pipe Diameter (mm)

450

Overflow Weir Width (metres)

6.0

Notional Detention Time (hrs)

0.250

Fluxes...

Notes...

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Sustainable Solutions
Environmental - Geotechnical - Civil
Hydraulic - Wastewater Engineers

CLIENT PROJECT
MALBEC / SOUTH WEST ROCKS

TITLE
STORMWATER MANAGEMENT - MUSIC MODEL INPUTS

PROJECT MANAGER
ANDREW NORRIS

DRAWING NUMBER
PWR2023D05_V1_54

DESIGNED
MDO

DRAWN
MDO

REVIEWED
ASN

DATE
14-05-10

ISSUED
ASN

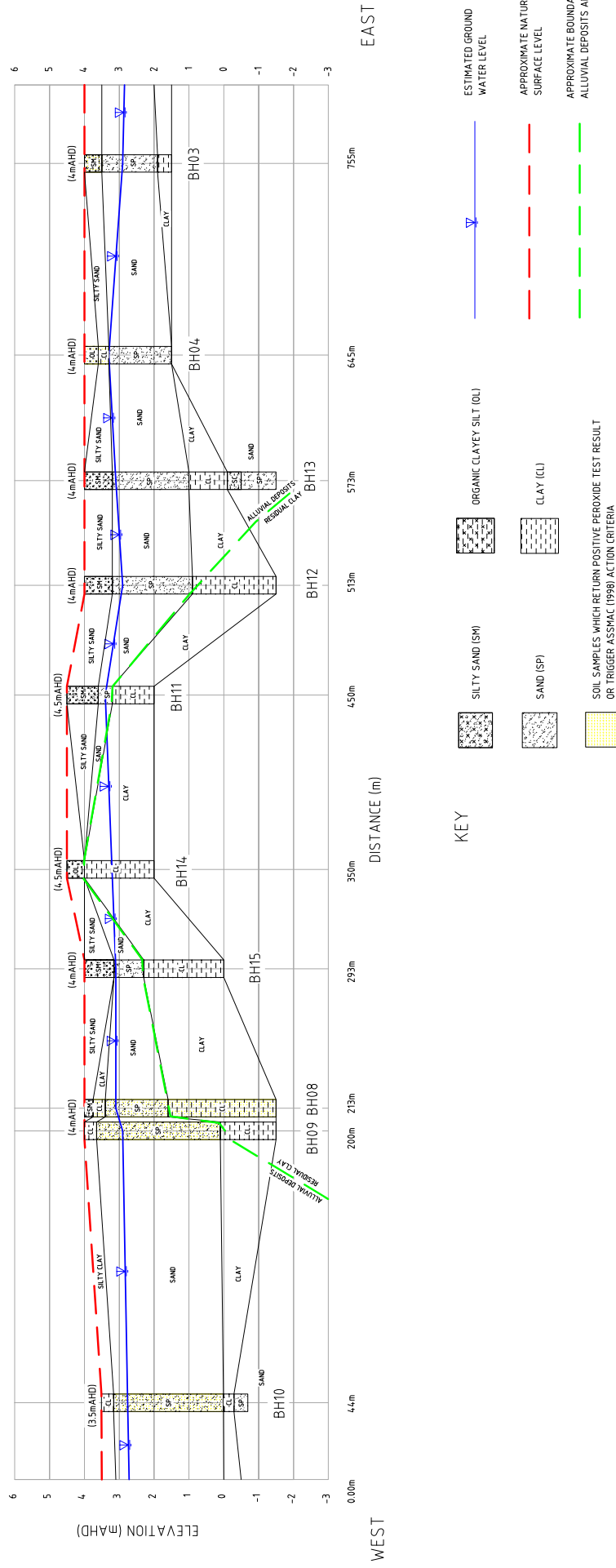
SHEET
4

HORIZONTAL RATIO
OF 1

VERTICAL RATIO
NTS

PAPER SIZE
A1 / A3

14 **Attachment C – Site Catenary Sequence**



DESIGNED	DATUM	SHEET	REV.	DESCRIPTION	DATE	ISSUED
MT	RAHD	1	1	MARTENS APRIL 2010 ASS REPORT ATTACHMENT	28-04-2010	MT
KT	HORIZONTAL RATIO: DRAWN: 1:1250 @ A1 1:2500 @ A3	OF 1 SHEETS				
AN	VERTICAL RATIO: 1:1250 @ A1 1:2500 @ A3	PAPER SIZE: A1 / A3				
	REVIEWED					

TITLE CATENARY SEQUENCE: PROPOSED SUBDIVISION; SOUTH WEST ROCKS, NSW.	PROJECT MANAGER: MR ANDREW MORRIS
	DRAWING NUMBER: P0002023.03DV01_SHEET 5

CLIENT/PROJECT	MALBEC PROPERTIES PTY LTD
THIS PLAN MUST NOT BE USED FOR CONSTRUCTION UNLESS SIGNED AS APPROVED BY PRINCIPAL CERTIFYING AUTHORITY All measurements in metres otherwise specified.	

Martens
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 Hydraulic - Wastewater Engineers
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15 Attachment D – DRAINS Model Results for Backwater Conditions

Drains Results - 1 in 100 Year ARI with Backwater Effects (3.4 mAHD - 3.0 m AHD berm height)

DRAINS results prepared 14 May, 2010 from Version 2010.06

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
N2D	4			0.419			
N3A	3.71			0.084			
3OUT	3.4			0			
2US	4.3			0			
N2.4	4.24			0.709			
N2.3	4.09			1.694			
N2.2	3.92			0.469			
N2.1	3.7			0.291			
2DS	3.4			0			
N3C	4.95			0.14			
HW3C	4.48		0		0.04	0	None
N3B	4.47			0.585			
N4C	5.39			0.346			
N4B	4.17			0			
N4	4.06			0.282			
N4A	3.6			0.133			
4OUT	3.4			0			
6US	4.62			0			
N6GUp	4.55			0			
N6BMid	4.28			0.633			
N6BLow	3.96			0.953			
N6B	3.67			0			
N6ABJUNC	3.46			0.18			
6OUT	3.4		0.744	0			
HW6G	4.6				-0.08	0.165	Headwall height/system capacity
HW6L	4.31		0.33		0.21	0	None
N7F	4.22			0.207			
N7C	4.08			0.248			
N7CD	3.77			0.071			
N7ABCIUNC	3.57			0.31			
7OUT	3.4			0			
N88Up	4.58			0.451			
N8B	4.14			0.441			
N8BE	4.04			0.172			
N8BD	3.87			0.497			
N8BC	3.72			0.083			
8AJUNC	3.42			0.274			
8OUT	3.4			0			
N8H	4.25			0.087			
N8G	4.19			0.251			
N8F	4.16			0.332			
N9A	3.51			0.121			
N9ABJUNC	3.4			0			

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
9OUT	3.4			0			
N5	4.38			0.35			
N58D	4.2			0.137			
N58C	4.02			0.188			
N58	3.84			0			
N5A	3.74			0.372			
SOUT	3.4			0			
N9CD	4.27			0.287			
N9B	4.13			0.527			
HW2G	4.05		0.14		-0.1	0.225	Headwall height/system capacity
HW2J	4.25		0.752		-0.2	0.887	Headwall height/system capacity
HW2P	4.22		0.102		-0.07	0.173	Headwall height/system capacity
HW2L	4.21		0.068		-0.06	0.102	Headwall height/system capacity
HW2N	4.21		0.082		-0.06	0.157	Headwall height/system capacity
HW2K	4.07		0.137		-0.12	0.284	Headwall height/system capacity
HW2H	3.96		0.226		-0.11	0.357	Headwall height/system capacity
HW2F	4.01		0.133		-0.11	0.248	Headwall height/system capacity
HW2E	3.99		0.222		-0.09	0.228	Headwall height/system capacity
HW2U	3.76		0.106		-0.11	0.246	Headwall height/system capacity
HW2B	3.64		0.195		-0.09	0.291	Headwall height/system capacity
HW6N	4.54		0.088		-0.02	0.031	Headwall height/system capacity
HW6K	4.56		0.122		0.22	0	None
HW6P	4.77		0.089		0.01	0	None
HW6C	4.15		0.151		-0.05	0.099	Headwall height/system capacity
HW6D	4.14		0.137		-0.04	0.086	Headwall height/system capacity
HW6F	4.11		0.105		-0.01	0.008	Headwall height/system capacity
HW6E	4.15		0.177		-0.05	0.127	Headwall height/system capacity

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat1E		0.25	0.141	0.109	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1CMainU		0.172	0.095	0.078	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1ABC		0.476	0.153	0.323	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1CMainD		0.393	0.213	0.179	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1C		0.148	0.083	0.065	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1D		0.071	0.037	0.033	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat1FG		0.296	0.159	0.137	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2B16		0.195	0.109	0.086	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2D		0.419	0.222	0.197	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat3A19		0.084	0.05	0.034	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2E16		0.222	0.123	0.099	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2F		0.133	0.07	0.063	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2H16		0.226	0.125	0.101	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2J16		0.194	0.109	0.085	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat2R	0.164	0.093	0.071	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2M	0.106	0.056	0.05	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2Q19	0.232	0.129	0.103	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2S	0.071	0.037	0.033	3	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2N19	0.082	0.049	0.033	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2CHigh	0.333	0.161	0.171	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2CMid	0.555	0.267	0.289	8	8	8	8 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2CLow	0.579	0.278	0.301	8	8	8	8 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2AB	0.535	0.245	0.289	7	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2P19	0.056	0.034	0.023	3	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2T19	0.045	0.027	0.018	3	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat3C	0.14	0.074	0.066	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat3B	0.585	0.328	0.256	8	8	8	8 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat4C15	0.346	0.193	0.153	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat4B	0.282	0.156	0.126	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat4A	0.133	0.075	0.058	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat5A15W	0.274	0.152	0.122	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat5A15E	0.105	0.058	0.047	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat5C	0.188	0.099	0.089	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat5D	0.137	0.072	0.065	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6AW	0.09	0.051	0.039	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6AE	0.09	0.051	0.039	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6F	0.177	0.093	0.083	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6BUp	0.464	0.226	0.239	7	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6BLow	0.686	0.324	0.362	8	8	8	8 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6G16	0.179	0.1	0.079	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6H16	0.291	0.16	0.13	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6I	0.293	0.155	0.138	6	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6L16	0.183	0.102	0.081	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6M16	0.156	0.086	0.07	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6N	0.088	0.047	0.042	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6P19	0.089	0.053	0.036	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7B15	0.194	0.107	0.087	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7A15	0.116	0.064	0.053	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7D	0.071	0.037	0.033	3	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7E15	0.089	0.051	0.038	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7F15	0.207	0.114	0.093	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7C15	0.124	0.071	0.052	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat7G	0.035	0.019	0.017	3	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8A15W	0.168	0.093	0.075	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8A15E	0.11	0.06	0.05	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8C	0.083	0.044	0.039	4	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8D16	0.229	0.127	0.102	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8E	0.172	0.091	0.081	5	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8BUp	0.451	0.248	0.203	7	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8BMid	0.441	0.241	0.2	7	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat88Low	0.268		0.148	0.12	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8G	0.251		0.133	0.119	5	5	5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8F16	0.332		0.184	0.148	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8H19W	0.056		0.033	0.023	2	2	2 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat8H19E	0.031		0.019	0.013	2	2	2 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat9A	0.121		0.066	0.054	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat5B	0.35		0.194	0.156	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat9CD	0.287		0.156	0.13	6	6	6 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat9B15	0.527		0.294	0.233	7	7	7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2U	0.106		0.056	0.05	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2G		0.14	0.074	0.066	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2K	0.137		0.072	0.065	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat2L	0.068		0.036	0.032	3	3	3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6K19	0.122		0.073	0.049	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6C	0.151		0.079	0.071	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6D	0.137		0.072	0.065	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Cat6F	0.105		0.055	0.05	4	4	4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

Outflow Volumes for Total Catchment (12.6 impervious + 12.6 pervious = 25.2 total ha)

Storm	Total Rainfall cu.m	Total Runoff cu.m (Runoff %)	Impervious Runoff cu.m (Runoff %)	Pervious Runoff cu.m (Runoff %)
AR&R 100 year, 20 minutes storm, average 164 m	13780.37	11835.57 (85.9%)	6761.46 (98.2%)	5074.11 (73.6%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P3C	0.14		0.4	4.474	4.473 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P6G	0.58		2.2	4.338	4.285 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P6L	0.33		0.8	4.29	4.285 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2G	0.029		0.4	3.96	4.092 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2J	0.238		1.1	4.067	4.092 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2P	0.026		0.4	4.156	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2L	0.016		0.4	4.157	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2N	0.016		0.2	4.155	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2K		0	0	3.967	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2H		0	0	3.876	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2F	0.011		0.1	3.913	4.092 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2E	0.092		1.3	3.911	4.092 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2U	0.006		0.1	3.662	3.917 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P2B	0.024		0.3	3.567	3.917 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6NP	0.058		1.5	4.436	3.7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
P6K	0.122		0.6	4.554	4.285 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6PP	0.089		1.4	4.631	4.551 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6CP	0.059		1.5	4.066	4.551 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6DP	0.059		1.5	4.065	3.958 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/s HGL (m)	Max D/s HGL (m)	Due to Storm
6FP	0.097		1.4	4.047	3.958 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6EP	0.058		1.5	4.07	3.958 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
IADSwale2D	0.419		0.8	0	3.995 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale3.1	1.181		0.4	198.6	3.709
			1.3	0	3.709 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.5	7.15		1.4	31.3	3.4
			1.9	0	4.302 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.4B	7.15		1.7	5	4.306
			0.9	0	4.259 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.4A	7.532		1.9	5	4.241
			1	0	4.241 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.3B	7.864		1.9	55.8	4.167
			1.7	60.8	4.17
MSwale2.3	9.075		0.9	0	4.109 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			1.9	5	4.092
MSwale2.2B	9.604		1	0	4.092 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			1.9	55.5	4.009
MSwale2.2A	9.913		1.5	60.5	4.011
			0.9	0	3.938 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.1A	10.482		1	5	3.917
			1.1	0	3.917 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale2.1B	10.653		1.5	53	3.829
			1	58	3.832
MSwale2Out	11.166		0.8	0	3.733 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			1.3	5	3.7
Swale3C	0.14		1.1	0	3.7 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			1.1	52.66	3.548
Swale3.2	0.703		0.9	57.66	3.555
			1.1	0	3.4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale4.4	0.346		0.5	5.5	3.4
			0.9	0	4.946 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale4.3	0.346		0.7	43	4.477
			0.8	0	4.473 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale4.2	0.619		0.8	224.5	3.709
			1.1	0	5.392 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale4.1	0.738		0.6	127.2	4.166
			0.6	0	4.166 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale6.5	5.53		0.7	20.5	4.059
			1.2	0	4.059 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.4	137.7	3.604
			0.5	0	3.604 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.9	84	3.4
			1	0	4.62 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
MSwale6.5	5.741		1.7	21.9	4.551
MSwale6.4			1	0	4.551 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale6.3	7.333		1.7	82	4.285
MSwale6.2	8.525		1.2	0	4.285 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
MSwale6.1	8.525		1.7	87.5	3.958
MSwale6Out	8.67		1.3	0	3.958 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale7.4	0.207		1.7	44.6	3.673
Swale7.3	0.452		1.5	0	3.673 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale7.2	0.522		1.8	16	3.457
Swale7.1	0.833		1.8	0	3.457 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale8Up	0.451		0.4	39	3.4
Swale8.5	1.53		0.4	0	4.225 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale8.4	1.69		0.5	75.6	4.077
Swale8.3	2.162		0.7	0	4.077 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale8.2	2.238		1.1	43.5	3.771
Swale8.1	2.494		1.2	0	3.771 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale8.8	0.087		0.8	39.1	3.569
Swale8.7	0.338		1.2	0	3.569 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale8.6	0.662		0.3	30	3.4
Swale9A	0.121		1.2	0	4.579 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale9.1	0.91		0.2	104.5	4.14
Swale5.5	0.35		0.7	0	4.14 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale5.4	0.484		0.8	35.3	4.035
Swale5.3	0.666		0.9	47.9	3.868
			1.1	0	3.868 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.9	39.1	3.718
			1.5	50.1	3.423
			1.6	0	3.423 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.1	56.7	3.4
			0.8	0	4.245 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.2	32.9	4.186
			0.8	0	4.186 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.2	49.2	4.164
			0.4	0	4.164 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.3	35.3	4.14
			0.9	0	3.512 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.1	46	3.4
			1	0	3.4 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.1	58.8	3.4
			0.6	0	4.379 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.8	32	4.204
			1.1	0	4.204 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.6	55.5	4.017
			0.8	0	4.017 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.8	38.9	3.844

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm	
Swale5.2	0.666		0.8	0	3.844	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.9	16	3.739	
Swale5.1	1.038		1.4	0	3.739	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.5	35	3.4	
Swale9.3	0.287		0.7	0	4.271	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.4	76	4.135	
Swale9.2	0.805		1.2	0	4.135	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
			0.9	217.9	3.4	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DV	Max Width	Max V	Due to Storm	
Swale1E16	0.25		0.25	0.752	0.309	0.12	8.92	0.38	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
SwaleMain1	0.701		0.701	1.12	0.473	0.24	11.5	0.51	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF1DS	1.694		1.694	1.919	0.653	0.42	15.95	0.65	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
SwaleROW1	1.248		1.248	1.616	0.588	0.35	13.97	0.6	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale1C16	0.148		0.148	0.611	0.251	0.08	7.29	0.34	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
IAD	0.071		0.071	0.611	0.18	0.08	1.8	0.44	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
Swale1FG	0.296		0.296	1.454	0.279	0.21	2.79	0.76	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2B16	0.195		0.195	0.57	0.311	0.09	9.11	0.29	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2.00E+16	0.222		0.222	0.57	0.319	0.09	9.93	0.3	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.133		0.133	0.57	0.284	0.08	6.4	0.29	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.226		0.226	0.658	0.311	0.1	9.11	0.34	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.752		0.752	1.253	0.426	0.27	11.24	0.64	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2R16	0.164		0.164	1.266	0.204	0.16	2.04	0.79	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2M	0.106		0.106	0.757	0.242	0.09	2.42	0.36	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2Q19	0.303		0.303	0.757	0.352	0.14	8.34	0.41	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2S	0.071		0.071	1.034	0.148	0.1	1.48	0.64	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2N19	0.082		0.082	0.766	0.219	0.07	2.19	0.34	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2P19	0.102		0.102	1.028	0.213	0.1	2.13	0.45	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2T19	0.045		0.045	2.093	0.116	0.08	1.16	0.68	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF3C	0		0	7.665	0	0	0	0	
5A15W	0.274		0.274	0.871	0.305	0.13	8.55	0.44	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
5A15E	0.105		0.105	1.068	0.17	0.12	1.7	0.73	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
5C	0.188		0.188	1.327	0.243	0.15	2.43	0.64	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
5D	0.137		0.137	1.014	0.207	0.13	2.07	0.64	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6AW15	0.09		0.09	0.422	0.245	0.06	6.63	0.23	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6AE15	0.09		0.09	0.378	0.251	0.05	7.23	0.21	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6E	0.177		0.177	0.804	0.287	0.12	2.87	0.43	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6G16	0.744		0.744	1.397	0.457	0.28	9.89	0.62	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6H16	0.291		0.291	1.014	0.299	0.15	7.92	0.51	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6J	0.293		0.293	1.454	0.277	0.21	2.77	0.76	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6L16	0.33		0.33	0.685	0.365	0.14	9.71	0.38	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6M16	0.156		0.156	0.465	0.31	0.07	8.99	0.24	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6N	0.088		0.088	0.685	0.235	0.08	2.35	0.32	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
6P19	0.089		0.089	0.685	0.236	0.08	2.36	0.32	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHWG6	0.165		0.165	7.665	0.042	0.02	12.35	0.58	AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6L	0		0	7.665	0	0	0	0	

OVERFLOW ROUTE DETAILS

Name	Max Q U/s	Max Q D/s	Safe Q	Max D	Max D _{xV}	Max Width	Max V	Due to Storm
7B15	0.194	0.194	0.194	0.685	0.326	0.11	5.69	0.35 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
7A15	0.116	0.116	0.116	1.139	0.172	0.14	1.72	0.79 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
7D	0.071	0.071	0.071	0.465	0.216	0.07	2.16	0.3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.124	0.124	0.124	0.465	0.294	0.07	7.42	0.23 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.035	0.035	0.035	0.378	0.166	0.04	1.66	0.26 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
	0.168	0.168	0.168	0.599	0.298	0.09	7.79	0.3 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8A15W	0.11	0.11	0.11	0.462	0.251	0.06	7.23	0.25 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8A15E	0.083	0.083	0.083	1.593	0.167	0.1	1.67	0.59 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8C	0.229	0.229	0.229	0.918	0.289	0.13	6.92	0.46 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8D16	0.172	0.172	0.172	1.137	0.249	0.14	2.49	0.55 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8E	0.056	0.056	0.056	0.84	0.183	0.06	1.83	0.33 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8H19W	0.031	0.031	0.031	1.282	0.126	0.05	1.26	0.39 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
8H19E	0.106	0.106	0.106	7.665	0.035	0.02	11.09	0.51 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF2U	0.14	0.14	0.14	0.597	0.249	0.08	7.11	0.33 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF2G	0.225	0.225	0.225	7.665	0.047	0.03	13.43	0.64 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2G	0.137	0.137	0.137	0.844	0.228	0.11	4.9	0.46 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
2K	0.887	0.887	0.887	7.665	0.083	0.08	20.61	0.92 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2J	0.173	0.173	0.173	7.665	0.043	0.03	12.53	0.59 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF2P	0.102	0.102	0.102	7.665	0.035	0.02	11.09	0.49 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2L	0.068	0.068	0.068	0.597	0.179	0.08	1.79	0.43 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF2L	0.157	0.157	0.157	7.665	0.042	0.02	12.35	0.56 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2N	0.284	0.284	0.284	7.665	0.053	0.04	14.51	0.67 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2K	0.357	0.357	0.357	7.665	0.057	0.04	15.41	0.72 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2H	0.248	0.248	0.248	7.665	0.049	0.03	13.79	0.66 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2F	0.228	0.228	0.228	7.665	0.048	0.03	13.61	0.63 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2E	0.246	0.246	0.246	7.665	0.049	0.03	13.79	0.65 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW2B	0.291	0.291	0.291	7.665	0.053	0.04	14.51	0.68 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6N	0.031	0.031	0.031	7.665	0.023	0.01	7.63	0.35 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6K	0	0	0	7.665	0	0	0	0
OF6K	0.122	0.122	0.122	0.802	0.172	0.14	1.72	0.83 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6P	0	0	0	7.665	0	0	0	0
OFHW6C	0.099	0.099	0.099	7.665	0.035	0.02	10.91	0.5 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6D	0.086	0.086	0.086	7.665	0.033	0.02	10.56	0.48 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6F	0.008	0.008	0.008	7.665	0.014	0	4.64	0.25 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OFHW6E	0.127	0.127	0.127	7.665	0.038	0.02	11.63	0.53 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF6C	0.151	0.151	0.151	1.084	0.241	0.12	2.41	0.52 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF6D	0.137	0.137	0.137	1.38	0.204	0.13	2.04	0.66 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1
OF6F	0.105	0.105	0.105	1.38	0.185	0.11	1.85	0.61 AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

CONTINUITY CHECK for AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
1ENode	178.83	178.83	0	0
1CENode	507.5	507.5	0	0
1Out	1282.21	1282.21	0	0
1BNode	945.46	945.46	0	0
1C16Node	101.26	101.26	0	0
1DS	1282.21	1282.21	0	0

CONTINUITY CHECK for AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
1DNode	48.06	48.06	0	0
1FGNode	210.89	210.89	0	0
N2B	133.76	133.76	0	0
N2D	307.64	307.64	0	0
N3A	901.88	901.88	0	0
3OUT	901.88	901.88	0	0
N2E	151.62	151.62	0	0
N2F	90.36	90.36	0	0
N2H	154.42	154.42	0	0
N2J	524.37	524.37	0	0
N2R	112.67	112.67	0	0
N2M	72.01	72.01	0	0
N2Q	206.84	206.84	0	0
N2S	48.06	48.06	0	0
N2N	56.63	56.63	0	0
2US	40755	40755.1	0	0
Cul2.5	40755.1	40612.1	0	0.4
N2.4	40876.23	40735.7	0	0.3
Cul2.4	40970.29	40827.29	0	0.3
N2.3	41688.91	41548.5	0	0.3
Cul2.3	41962.21	41819.2	0	0.3
N2.2	42041.54	41900.29	0	0.3
Cul2.2	42331.56	42188.55	0	0.3
N2.1	42321.61	42179.3	0	0.3
Cul2.1	42566.64	42423.65	0	0.3
2S	42423.65	42423.65	0	0
N2P	70.14	70.14	0	0
N2T	31.22	31.22	0	0
N3C	95.07	95.07	0	0
HW3C	95.07	95.07	0	0
N3B	536.65	536.65	0	0
N4C	247.05	247.05	0	0
N4B	247.05	247.05	0	0
N4	448.03	448.03	0	0
N4A	539.25	539.25	0	0
4OUT	539.25	539.25	0	0
N5A15W	195.35	195.35	0	0
N5A15E	71.98	71.98	0	0
N5C	127.86	127.86	0	0
N5D	93.19	93.19	0	0
N6AW	61.87	61.87	0	0
N6AE	61.41	61.41	0	0
N6E	120.34	120.34	0	0
6US	31521	31521.11	0	0
N86Up	31666.51	31555.92	0	0.3
N68Mid	32724.67	32614.09	0	0.3
N68Low	33511.67	33401.08	0	0.3

CONTINUITY CHECK for AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
N6B	33401.08	33290.48		0
N6ABJUNC	33413.76	33303.16		0
6OUT	33303.16	33303.16		0
N6G	538.29	538.29		0
N6H	207.48	207.48		0
N6J	208	208		0
N6L16	232.15	232.15		0
N6M	106.96	106.96		0
N6N	60.24	60.24		0
N6P	61.43	61.43		0
HW6G	538.29	538.29		0
HW6L	232.15	232.15		0
N7B15	132.52	132.52		0
N7A15	79.51	79.51		0
N7D	48.06	48.06		0
N7E15	84.98	84.98		0
N7F	141.43	141.43		0
N7C	311.37	311.37		0
N7CD	359.43	359.43		0
N7ABCIJUNC	571.46	571.46		0
7OUT	571.46	571.46		0
N7G	24.03	24.03		0
N8A15W	115.07	115.07		0
N8A15E	75.25	75.25		0
N8C	56.48	56.48		0
N8D16	156.83	156.83		0
N8E	117.05	117.05		0
N88Up	332.06	332.06		0
N8B	1124.96	1124.96		0
N8BE	1242.01	1242.01		0
N8BD	1589.78	1589.78		0
N8BC	1646.25	1646.25		0
8AJUNC	1836.58	1836.58		0
8OUT	1836.58	1836.58		0
N8H	60.11	60.11		0
N8G	231.22	231.22		0
N8F	468.2	468.2		0
N8H19W	38.47	38.47		0
N8H19E	21.64	21.64		0
N9A	82.42	82.42		0
N9ABJUNC	675.43	675.43		0
9OUT	675.43	675.43		0
N5	249.75	249.75		0
N58D	342.94	342.94		0
N58C	470.8	470.8		0
N5B	470.8	470.8		0
N5A	738.14	738.14		0

CONTINUITY CHECK for AR&R 100 year, 20 minutes storm, average 164 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %	
SOUT	738.14	738.14		0	0
N9CD	204.29	204.29		0	0
N9B	593.01	593.01		0	0
N2U	72.48	72.48		0	0
N2G	95.07	95.07		0	0
HW2G	95.07	95.07		0	0
N2K	93.19	93.19		0	0
HW2J	524.37	524.37		0	0
HW2P	70.14	70.14		0	0
HW2L	46.65	46.65		0	0
N2L	46.65	46.65		0	0
HW2N	56.63	56.63		0	0
HW2K	93.19	93.19		0	0
HW2H	154.42	154.42		0	0
HW2F	90.36	90.36		0	0
HW2E	151.62	151.62		0	0
HW2U	72.48	72.48		0	0
HW2B	133.76	133.77		0	0
HW6N	60.24	60.22		0	0
HW6K	83.98	83.98		0	0
N6K	83.98	83.98		0	0
HW6P	61.43	61.43		0	0
HW6C	102.6	102.6		0	0
HW6D	93.19	93.19		0	0
HW6F	71.54	71.54		0	0
HW6E	120.34	120.34		0	0
N6C	102.6	102.6		0	0
N6D	93.19	93.19		0	0
N6F	71.54	71.54		0	0

Run Log for P0802023DRN04_V4 Main Culverts Added run at 12:21:03 on 14/5/2010

16 Attachment E – DRAINS Model Results for Climate Change Conditions

Drains Results - 1 in 100 Year ARI with Climate Change (+30% Rainfall Intensity)

DRAINS results prepared 14 May, 2010 from Version 2010.06

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
N2D	4.03		0.553	0			
N3A	3.75		0.11	0			
3OUT	3.53		0	0			
2US	4.47		0	0			
N2.4	4.36		0.968	2.333			
N2.3	4.2		2.333	0.679			
N2.2	4.02		0.679	0.384			
N2.1	3.8		0.384	0			
2DS	3.03		0	0.184			
N3C	4.97		0	0			
HW3C	4.49		0	0	0.03	0	None
N3B	4.49		0	0.77			
N4C	5.42		0.455	0			
N4B	4.2		0	0.371			
N4	4.12		0.175	0			
N4A	3.64		0	0			
4OUT	3.38		0	0			
6US	4.62		0	0			
N6GUp	4.56		0.019	0.994			
N6BMid	4.3		1.355	0			
N6Low	3.99		0	0.236			
N6B	3.7		0	0			
N6ABIJUNC	3.49		0	0			
6OUT	3.13		0.98	0			
HW6G	4.66		0.434	0	-0.14	0.359	Headwall height/system capacity
HW6L	4.35				0.18	0	None
N7F	4.25			0.272			
N7C	4.13			0.326			
N7CD	3.83			0.093			
N7ABIJUNC	3.59			0.408			
7OUT	3.25			0			
N88Up	4.61			0.594			
N8B	4.19			0.581			
N8BE	4.08			0.226			
N8BD	3.9			0.654			
N8BC	3.76			0.109			
8AJUNC	3.54			0.36			
8OUT	2.89			0			
N8H	4.26			0.114			
N8G	4.23			0.331			
N8F	4.21			0.437			
N9A	3.53			0.159			
N9ABIJUNC	3.36			0			

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
9OUT	2.91			0			
N5	4.41		0.46	0.46			
N58D	4.23		0.18	0.18			
N58C	4.05		0.247	0.247			
N58	3.88		0	0			
N5A	3.81		0.49	0.49			
5OUT	3.37		0	0			
N9CD	4.3		0.377	0.377			
N9B	4.15		0.694	0.694			
HW2G	4.08		0.184		-0.13	0.306	Headwall height/system capacity
HW2J	4.3		0.99		-0.25	1.29	Headwall height/system capacity
HW2P	4.23		0.134		-0.08	0.249	Headwall height/system capacity
HW2L	4.23		0.09		-0.08	0.147	Headwall height/system capacity
HW2N	4.23		0.108		-0.08	0.224	Headwall height/system capacity
HW2K	4.09		0.18		-0.14	0.36	Headwall height/system capacity
HW2H	3.98		0.297		-0.13	0.457	Headwall height/system capacity
HW2F	4.03		0.175		-0.13	0.325	Headwall height/system capacity
HW2E	4.02		0.292		-0.12	0.375	Headwall height/system capacity
HW2U	3.78		0.14		-0.13	0.308	Headwall height/system capacity
HW2B	3.66		0.257		-0.11	0.384	Headwall height/system capacity
HW6N	4.55		0.116		-0.03	0.058	Headwall height/system capacity
HW6K	4.57		0.16		0.21	0	None
HW6P	4.8		0.117		-0.02	0.019	Headwall height/system capacity
HW6C	4.16		0.198		-0.06	0.151	Headwall height/system capacity
HW6D	4.16		0.18		-0.06	0.133	Headwall height/system capacity
HW6F	4.13		0.138		-0.03	0.047	Headwall height/system capacity
HW6E	4.17		0.233		-0.07	0.186	Headwall height/system capacity

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat1E	0.329		0.183	0.146	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat1CMainU	0.227		0.123	0.104	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat1ABC	0.631		0.199	0.432	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat1CMainD	0.517		0.277	0.24	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat1C	0.194		0.108	0.086	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat1D	0.093		0.048	0.045	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat1FG	0.39		0.207	0.183	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat2B16	0.257		0.142	0.115	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat2D	0.553		0.289	0.264	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat3A19	0.11		0.065	0.045	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2E16	0.292		0.16	0.132	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat2F	0.175		0.091	0.084	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2H16	0.297		0.163	0.134	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat2J16	0.255		0.141	0.114	5	5	5 1 in 100 year ARI Climate Change, 20 minutes

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat2R	0.216		0.121	0.095	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat2M	0.139		0.072	0.067	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2Q19	0.305		0.168	0.137	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat2S	0.093		0.048	0.045	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat2N19	0.108		0.064	0.044	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2CHigh	0.439		0.21	0.229	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat2CMid	0.733		0.347	0.386	8	8	8 1 in 100 year ARI Climate Change, 20 minutes
Cat2CLow	0.764		0.362	0.402	8	8	8 1 in 100 year ARI Climate Change, 20 minutes
Cat2AB	0.706		0.319	0.387	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat2P19	0.074		0.044	0.03	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat2T19	0.06		0.035	0.024	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat3C	0.184		0.096	0.088	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat3B	0.77		0.427	0.343	8	8	8 1 in 100 year ARI Climate Change, 20 minutes
Cat4C15	0.455		0.25	0.205	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat4B	0.371		0.203	0.168	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat4A	0.175		0.097	0.078	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat5A15W	0.36		0.197	0.163	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat5A15E	0.139		0.075	0.063	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat5C	0.247		0.129	0.118	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat5D	0.18		0.094	0.086	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6AW	0.119		0.067	0.052	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6AE	0.118		0.066	0.052	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6F	0.233		0.121	0.111	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat6BUp	0.613		0.294	0.319	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat6BLow	0.905		0.421	0.484	8	8	8 1 in 100 year ARI Climate Change, 20 minutes
Cat6G16	0.236		0.13	0.106	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat6H16	0.383		0.208	0.174	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat6J	0.385		0.201	0.184	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat6L16	0.241		0.133	0.108	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat6M16	0.206		0.112	0.094	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat6N	0.116		0.061	0.056	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6P19	0.117		0.069	0.048	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat7B15	0.255		0.139	0.116	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat7A15	0.153		0.083	0.07	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat7D	0.093		0.048	0.045	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat7E15	0.117		0.066	0.051	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat7F15	0.272		0.148	0.124	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat7C15	0.163		0.093	0.07	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat7G	0.046		0.024	0.022	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat8A15W	0.221		0.121	0.1	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat8A15E	0.145		0.078	0.067	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat8C	0.109		0.057	0.052	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat8D16	0.302		0.166	0.136	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat8E	0.226		0.118	0.108	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat8BUp	0.594		0.322	0.272	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat8BMid	0.581		0.313	0.268	7	7	7 1 in 100 year ARI Climate Change, 20 minutes

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Cat88Low	0.352	0.192	0.16	6	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat8G	0.331	0.172	0.158	5	5	5	5 1 in 100 year ARI Climate Change, 20 minutes
Cat8F16	0.437	0.239	0.198	6	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat8H19W	0.073	0.043	0.03	2	2	2	2 1 in 100 year ARI Climate Change, 20 minutes
Cat8H19E	0.041	0.024	0.017	2	2	2	2 1 in 100 year ARI Climate Change, 20 minutes
Cat9A	0.159	0.086	0.072	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat5B	0.46	0.252	0.208	6	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat9CD	0.377	0.203	0.174	6	6	6	6 1 in 100 year ARI Climate Change, 20 minutes
Cat9H15	0.694	0.383	0.312	7	7	7	7 1 in 100 year ARI Climate Change, 20 minutes
Cat2U	0.14	0.073	0.067	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2G	0.184	0.096	0.088	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2K	0.18	0.094	0.086	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat2L	0.09	0.047	0.043	3	3	3	3 1 in 100 year ARI Climate Change, 20 minutes
Cat6K19	0.16	0.095	0.066	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6C	0.198	0.103	0.095	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6D	0.18	0.094	0.086	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes
Cat6F	0.138	0.072	0.066	4	4	4	4 1 in 100 year ARI Climate Change, 20 minutes

Outflow Volumes for Total Catchment (12.6 impervious + 12.6 pervious = 25.2 total ha)

Storm	Total Rainfall cu.m	Total Runoff cu.m (Runoff %)	Impervious Runoff cu.m (Runoff %)	Pervious Runoff cu.m (Runoff %)
1 in 100 year ARI Climate Change, 20 minutes	17914.48	15961.28 (89.1%)	8827.72 (98.6%)	7133.56 (79.6%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
P3C	0.184	0	0.5	4.487	4.485 1 in 100 year ARI Climate Change, 20 minutes
P6G	0.621	0	2.1	4.362	4.302 1 in 100 year ARI Climate Change, 20 minutes
P6L	0.434	1	1	4.31	4.302 1 in 100 year ARI Climate Change, 20 minutes
P2G	0.004	0	0.1	3.969	4.202 1 in 100 year ARI Climate Change, 20 minutes
P2J	0.012	0	0.1	4.085	4.202 1 in 100 year ARI Climate Change, 20 minutes
P2P	0	0	0	4.163	4.363 1 in 100 year ARI Climate Change, 20 minutes
P2L	0	0	0	4.164	4.363 1 in 100 year ARI Climate Change, 20 minutes
P2N	0	0	0	4.16	4.363 1 in 100 year ARI Climate Change, 20 minutes
P2K	0	0	0	3.976	4.363 1 in 100 year ARI Climate Change, 20 minutes
P2H	0	0	0	3.893	4.202 1 in 100 year ARI Climate Change, 20 minutes
P2F	0.004	0	0.1	3.922	4.202 1 in 100 year ARI Climate Change, 20 minutes
P2E	0.03	0.4	0.4	3.929	4.021 1 in 100 year ARI Climate Change, 20 minutes
P2U	0.009	0.1	0.1	3.669	4.021 1 in 100 year ARI Climate Change, 20 minutes
P2B	0.023	0.3	0.3	3.58	3.796 1 in 100 year ARI Climate Change, 20 minutes
6NP	0.059	1.5	1.5	4.458	4.302 1 in 100 year ARI Climate Change, 20 minutes
P6K	0.16	0.7	0.7	4.56	4.555 1 in 100 year ARI Climate Change, 20 minutes
6PP	0.098	1.5	1.5	4.653	4.555 1 in 100 year ARI Climate Change, 20 minutes
6CP	0.059	1.5	1.5	4.079	3.99 1 in 100 year ARI Climate Change, 20 minutes
6DP	0.059	1.5	1.5	4.077	3.99 1 in 100 year ARI Climate Change, 20 minutes

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/s HGL (m)	Max D/s HGL (m)	Due to Storm
6FP	0.099		1.4	4.063	3.99 1 in 100 year ARI Climate Change, 20 minutes
6EP	0.058		1.5	4.087	3.99 1 in 100 year ARI Climate Change, 20 minutes

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
IADSwale2D	0.553		0.8	0	4.027 1 in 100 year ARI Climate Change, 20 minutes
Swale3.1	1.555		0.5	198.6	3.745
			1.3	0	3.745 1 in 100 year ARI Climate Change, 20 minutes
MSwale2.5	10.025		1.4	31.3	3.529
			2	0	4.473 1 in 100 year ARI Climate Change, 20 minutes
MSwale2.4B	10.025		1.9	5	4.476
			1	0	4.384 1 in 100 year ARI Climate Change, 20 minutes
MSwale2.4A	10.527		2	5	4.363
			1.2	0	4.363 1 in 100 year ARI Climate Change, 20 minutes
			2	55.8	4.302
			1.9	60.8	4.303
MSwale2.3B	10.966		1	0	4.218 1 in 100 year ARI Climate Change, 20 minutes
			2	5	4.202
MSwale2.3	12.56		1.1	0	4.202 1 in 100 year ARI Climate Change, 20 minutes
			2	55.5	4.136
MSwale2.2B	13.259		1.9	60.5	4.137
			1.1	0	4.042 1 in 100 year ARI Climate Change, 20 minutes
			2	5	4.021
MSwale2.2A	13.666		1.2	0	4.021 1 in 100 year ARI Climate Change, 20 minutes
			2	53	3.949
			1.9	58	3.951
MSwale2.1A	14.416		1	0	3.831 1 in 100 year ARI Climate Change, 20 minutes
			2	5	3.796
MSwale2.1B	14.642		1.2	0	3.796 1 in 100 year ARI Climate Change, 20 minutes
			2	52.66	3.561
MSwale20ut	15.32		2	57.66	3.575
			2.2	0	3.15 1 in 100 year ARI Climate Change, 20 minutes
Swale3C	0.184		1.7	5.5	3.031
			1	0	4.966 1 in 100 year ARI Climate Change, 20 minutes
Swale3.2	0.926		0.8	43	4.494
			1	0	4.485 1 in 100 year ARI Climate Change, 20 minutes
Swale4.4	0.455		0.8	224.5	3.745
			1.2	0	5.421 1 in 100 year ARI Climate Change, 20 minutes
Swale4.3	0.455		0.7	127.2	4.202
			0.6	0	4.202 1 in 100 year ARI Climate Change, 20 minutes
Swale4.2	0.815		0.7	20.5	4.124
			1.3	0	4.124 1 in 100 year ARI Climate Change, 20 minutes
Swale4.1	0.972		0.5	137.7	3.637
			0.6	0	3.637 1 in 100 year ARI Climate Change, 20 minutes
MSwale6.5	5.53		1.4	84	3.378
			1	0	4.622 1 in 100 year ARI Climate Change, 20 minutes

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
MSwale6.4	5.807		1.7	21.9	4.555 4.555 1 in 100 year ARI Climate Change, 20 minutes
MSwale6.3	7.905		1.7	82	4.302 4.302 1 in 100 year ARI Climate Change, 20 minutes
MSwale6.2	9.478		1.7	87.5	3.99 3.99 1 in 100 year ARI Climate Change, 20 minutes
MSwale6.1	9.478		1.7	44.6	3.7 3.7 1 in 100 year ARI Climate Change, 20 minutes
MSwale6Out	9.669		1.8	16	3.485 3.485 1 in 100 year ARI Climate Change, 20 minutes
Swale7.4	0.272		1.3	39	3.129 4.247 1 in 100 year ARI Climate Change, 20 minutes
Swale7.3	0.595		0.5	75.6	4.126 4.126 1 in 100 year ARI Climate Change, 20 minutes
Swale7.2	0.687		1.2	43.5	3.827 3.827 1 in 100 year ARI Climate Change, 20 minutes
Swale7.1	1.096		1.2	39.1	3.592 3.592 1 in 100 year ARI Climate Change, 20 minutes
Swale8Up	0.594		1.1	30	3.249 4.611 1 in 100 year ARI Climate Change, 20 minutes
Swale8.5	2.014		1.2	104.5	4.188 4.188 1 in 100 year ARI Climate Change, 20 minutes
Swale8.4	2.225		0.8	35.3	4.083 4.083 1 in 100 year ARI Climate Change, 20 minutes
Swale8.3	2.848		1.3	47.9	3.904 3.904 1 in 100 year ARI Climate Change, 20 minutes
Swale8.2	2.948		0.9	39.1	3.763 3.763 1 in 100 year ARI Climate Change, 20 minutes
Swale8.1	3.285		1.5	50.1	3.537 3.537 1 in 100 year ARI Climate Change, 20 minutes
Swale8.8	0.114		1.1	56.7	2.887 4.262 1 in 100 year ARI Climate Change, 20 minutes
Swale8.7	0.445		0.2	32.9	4.231 4.231 1 in 100 year ARI Climate Change, 20 minutes
Swale8.6	0.871		0.2	49.2	4.211 4.211 1 in 100 year ARI Climate Change, 20 minutes
Swale9A	0.159		0.3	35.3	4.188 4.188 1 in 100 year ARI Climate Change, 20 minutes
Swale9.1	1.199		0.9	46	3.362 3.362 1 in 100 year ARI Climate Change, 20 minutes
Swale5.5	0.46		1.4	58.8	2.907 4.406 1 in 100 year ARI Climate Change, 20 minutes
Swale5.4	0.637		0.7	32	4.229 4.229 1 in 100 year ARI Climate Change, 20 minutes
Swale5.3	0.877		1.2	55.5	4.051 4.051 1 in 100 year ARI Climate Change, 20 minutes
			0.6	0	
			0.8	38.9	3.882

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm	
Swale5.2	0.877		0.8	0	3.882	1 in 100 year ARI Climate Change, 20 minutes
			0.9	16	3.814	
Swale5.1	1.366		1.4	0	3.814	1 in 100 year ARI Climate Change, 20 minutes
			0.9	35	3.372	
Swale9.3	0.377		0.8	0	4.302	1 in 100 year ARI Climate Change, 20 minutes
			0.4	76	4.146	
Swale9.2	1.061		1.1	0	4.146	1 in 100 year ARI Climate Change, 20 minutes
			1.3	217.9	3.362	

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DV	Max Width	Max V	Due to Storm	
Swale1E16	0.329	0.329	0.329	0.752	0.327	0.13	10.68	0.4	1 in 100 year ARI Climate Change, 20 minutes
SwaleMain1	0.923	0.923	0.923	1.12	0.501	0.27	14.24	0.54	1 in 100 year ARI Climate Change, 20 minutes
OF1DS	2.237	2.237	2.237	1.919	0.69	0.47	17.67	0.69	1 in 100 year ARI Climate Change, 20 minutes
SwaleROW1	1.644	1.644	1.644	1.616	0.622	0.39	17.17	0.63	1 in 100 year ARI Climate Change, 20 minutes
Swale1C16	0.194	0.194	0.194	0.611	0.266	0.09	8.8	0.35	1 in 100 year ARI Climate Change, 20 minutes
IAD	0.093	0.093	0.093	0.611	0.222	0.08	4.33	0.34	1 in 100 year ARI Climate Change, 20 minutes
Swale1FG	0.39	0.39	0.39	1.454	0.322	0.23	5.27	0.72	1 in 100 year ARI Climate Change, 20 minutes
2B16	0.257	0.257	0.257	0.57	0.329	0.1	10.93	0.3	1 in 100 year ARI Climate Change, 20 minutes
2E16	0.292	0.292	0.292	0.57	0.337	0.1	11.75	0.31	1 in 100 year ARI Climate Change, 20 minutes
2F	0.175	0.175	0.175	0.57	0.303	0.09	8.36	0.29	1 in 100 year ARI Climate Change, 20 minutes
2H16	0.297	0.297	0.297	0.658	0.329	0.11	10.93	0.35	1 in 100 year ARI Climate Change, 20 minutes
2J16	0.99	0.99	0.99	1.253	0.449	0.3	13.61	0.67	1 in 100 year ARI Climate Change, 20 minutes
2R16	0.216	0.216	0.216	1.266	0.226	0.19	2.26	0.85	1 in 100 year ARI Climate Change, 20 minutes
2M	0.139	0.139	0.139	0.757	0.268	0.1	2.68	0.39	1 in 100 year ARI Climate Change, 20 minutes
2Q19	0.398	0.398	0.398	0.757	0.372	0.16	10.36	0.43	1 in 100 year ARI Climate Change, 20 minutes
2S	0.093	0.093	0.093	1.034	0.164	0.11	1.64	0.69	1 in 100 year ARI Climate Change, 20 minutes
2N19	0.108	0.108	0.108	0.766	0.243	0.09	2.43	0.37	1 in 100 year ARI Climate Change, 20 minutes
2P19	0.134	0.134	0.134	1.028	0.236	0.11	2.36	0.48	1 in 100 year ARI Climate Change, 20 minutes
2T19	0.06	0.06	0.06	2.093	0.128	0.09	1.28	0.73	1 in 100 year ARI Climate Change, 20 minutes
OF3C	0	0	0	7.665	0	0	0	0	
5A15W	0.36	0.36	0.36	0.871	0.323	0.15	10.37	0.45	1 in 100 year ARI Climate Change, 20 minutes
5A15E	0.139	0.139	0.139	1.068	0.188	0.15	1.88	0.78	1 in 100 year ARI Climate Change, 20 minutes
5C	0.247	0.247	0.247	1.327	0.27	0.18	2.7	0.68	1 in 100 year ARI Climate Change, 20 minutes
5D	0.18	0.18	0.18	1.014	0.229	0.16	2.29	0.69	1 in 100 year ARI Climate Change, 20 minutes
6AW15	0.119	0.119	0.119	0.422	0.26	0.06	8.13	0.24	1 in 100 year ARI Climate Change, 20 minutes
6AE15	0.118	0.118	0.118	0.378	0.265	0.06	8.68	0.21	1 in 100 year ARI Climate Change, 20 minutes
6E	0.233	0.233	0.233	0.804	0.328	0.13	5.89	0.41	1 in 100 year ARI Climate Change, 20 minutes
6G16	0.98	0.98	0.98	1.397	0.484	0.32	12.62	0.65	1 in 100 year ARI Climate Change, 20 minutes
6H16	0.383	0.383	0.383	1.014	0.317	0.17	9.74	0.52	1 in 100 year ARI Climate Change, 20 minutes
6J	0.385	0.385	0.385	1.454	0.321	0.23	5.21	0.72	1 in 100 year ARI Climate Change, 20 minutes
6L16	0.434	0.434	0.434	0.685	0.386	0.15	11.73	0.4	1 in 100 year ARI Climate Change, 20 minutes
6M16	0.206	0.206	0.206	0.465	0.328	0.08	10.81	0.24	1 in 100 year ARI Climate Change, 20 minutes
6N	0.116	0.116	0.116	0.685	0.26	0.09	2.6	0.34	1 in 100 year ARI Climate Change, 20 minutes
6P19	0.117	0.117	0.117	0.685	0.261	0.09	2.61	0.34	1 in 100 year ARI Climate Change, 20 minutes
OFHWG6	0.359	0.359	0.359	7.665	0.057	0.04	15.41	0.73	1 in 100 year ARI Climate Change, 20 minutes
OFHW6L	0	0	0	7.665	0	0	0	0	

OVERFLOW ROUTE DETAILS

Name	Max Q U/s	Max Q D/s	Safe Q	Max D	Max DxD	Max Width	Max V	Due to Storm
7B15	0.255	0.255	0.255	0.685	0.346	0.13	7.82	0.36 1 in 100 year ARI Climate Change, 20 minutes
7A15	0.153	0.153	0.153	1.139	0.191	0.16	1.91	0.84 1 in 100 year ARI Climate Change, 20 minutes
7D	0.093	0.093	0.093	0.465	0.239	0.08	2.39	0.32 1 in 100 year ARI Climate Change, 20 minutes
7E15	0.163	0.163	0.163	0.465	0.312	0.07	9.24	0.24 1 in 100 year ARI Climate Change, 20 minutes
7G	0.046	0.046	0.046	0.378	0.184	0.05	1.84	0.27 1 in 100 year ARI Climate Change, 20 minutes
8A15W	0.221	0.221	0.221	0.599	0.316	0.1	9.61	0.31 1 in 100 year ARI Climate Change, 20 minutes
8A15E	0.145	0.145	0.145	0.462	0.265	0.07	8.68	0.26 1 in 100 year ARI Climate Change, 20 minutes
8C	0.109	0.109	0.109	1.593	0.185	0.12	1.85	0.63 1 in 100 year ARI Climate Change, 20 minutes
8D16	0.302	0.302	0.302	0.918	0.308	0.14	8.86	0.46 1 in 100 year ARI Climate Change, 20 minutes
8E	0.226	0.226	0.226	1.137	0.276	0.16	2.76	0.59 1 in 100 year ARI Climate Change, 20 minutes
8H19W	0.073	0.073	0.073	0.84	0.203	0.07	2.03	0.36 1 in 100 year ARI Climate Change, 20 minutes
8H19E	0.041	0.041	0.041	1.282	0.139	0.06	1.39	0.43 1 in 100 year ARI Climate Change, 20 minutes
OF2U	0.14	0.14	0.14	7.665	0.04	0.02	11.99	0.54 1 in 100 year ARI Climate Change, 20 minutes
OF2G	0.184	0.184	0.184	0.597	0.264	0.09	8.62	0.34 1 in 100 year ARI Climate Change, 20 minutes
OFHW2G	0.306	0.306	0.306	7.665	0.053	0.04	14.69	0.7 1 in 100 year ARI Climate Change, 20 minutes
2K	0.18	0.18	0.18	0.844	0.245	0.11	6.63	0.46 1 in 100 year ARI Climate Change, 20 minutes
OFHW2J	1.29	1.29	1.29	7.665	0.097	0.1	23.31	1.03 1 in 100 year ARI Climate Change, 20 minutes
OF2P	0.249	0.249	0.249	7.665	0.05	0.03	13.97	0.64 1 in 100 year ARI Climate Change, 20 minutes
OFHW2L	0.147	0.147	0.147	7.665	0.04	0.02	11.99	0.57 1 in 100 year ARI Climate Change, 20 minutes
OF2L	0.09	0.09	0.09	0.597	0.222	0.07	4.27	0.34 1 in 100 year ARI Climate Change, 20 minutes
OFHW2N	0.224	0.224	0.224	7.665	0.047	0.03	13.43	0.64 1 in 100 year ARI Climate Change, 20 minutes
OFHW2K	0.36	0.36	0.36	7.665	0.057	0.04	15.41	0.73 1 in 100 year ARI Climate Change, 20 minutes
OFHW2H	0.457	0.457	0.457	7.665	0.063	0.05	16.66	0.77 1 in 100 year ARI Climate Change, 20 minutes
OFHW2F	0.325	0.325	0.325	7.665	0.055	0.04	15.05	0.7 1 in 100 year ARI Climate Change, 20 minutes
OFHW2E	0.375	0.375	0.375	7.665	0.058	0.04	15.58	0.74 1 in 100 year ARI Climate Change, 20 minutes
OFHW2U	0.308	0.308	0.308	7.665	0.053	0.04	14.69	0.7 1 in 100 year ARI Climate Change, 20 minutes
OFHW2B	0.384	0.384	0.384	7.665	0.059	0.04	15.76	0.74 1 in 100 year ARI Climate Change, 20 minutes
OFHW6N	0.058	0.058	0.058	7.665	0.028	0.01	9.43	0.43 1 in 100 year ARI Climate Change, 20 minutes
OFHW6K	0	0	0	7.665	0	0	0	0
OF6K	0.16	0.16	0.16	0.802	0.191	0.17	1.91	0.88 1 in 100 year ARI Climate Change, 20 minutes
OFHW6P	0.019	0.019	0.019	7.665	0.019	0.01	6.44	0.31 1 in 100 year ARI Climate Change, 20 minutes
OFHW6C	0.151	0.151	0.151	7.665	0.041	0.02	12.17	0.56 1 in 100 year ARI Climate Change, 20 minutes
OFHW6D	0.133	0.133	0.133	7.665	0.039	0.02	11.81	0.54 1 in 100 year ARI Climate Change, 20 minutes
OFHW6F	0.047	0.047	0.047	7.665	0.026	0.01	8.83	0.41 1 in 100 year ARI Climate Change, 20 minutes
OFHW6E	0.186	0.186	0.186	7.665	0.044	0.03	12.89	0.59 1 in 100 year ARI Climate Change, 20 minutes
OF6C	0.198	0.198	0.198	1.084	0.268	0.15	2.68	0.55 1 in 100 year ARI Climate Change, 20 minutes
OF6D	0.18	0.18	0.18	1.38	0.227	0.16	2.27	0.7 1 in 100 year ARI Climate Change, 20 minutes
OF6F	0.138	0.138	0.138	1.38	0.206	0.13	2.06	0.65 1 in 100 year ARI Climate Change, 20 minutes

CONTINUITY CHECK for 1 in 100 year ARI Climate Change, 20 minutes

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
1ENode	240.54	240.54	0	0
1CENode	683.3	683.3	0	0
1Out	1734.61	1734.61	0	0
1BNode	1273.16	1273.16	0	0
1C16Node	136.15	136.15	0	0
1DS	1734.61	1734.61	0	0

CONTINUITY CHECK for 1 in 100 year ARI Climate Change, 20 minutes

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %	
1DNode	64.77	64.77	0	0	0
1FGNode	284.21	284.21	0	0	0
N2B	179.94	179.94	0	0	0
N2D	414.97	414.97	0	0	0
N3A	1214.74	1214.74	0	0	0
3OUT	1214.74	1214.74	0	0	0
N2E	204.01	204.01	0	0	0
N2F	121.81	121.81	0	0	0
N2H	207.8	207.8	0	0	0
N2J	705.64	705.64	0	0	0
N2R	151.48	151.48	0	0	0
N2M	97.07	97.07	0	0	0
N2Q	278.4	278.4	0	0	0
N2S	64.77	64.77	0	0	0
N2N	75.96	75.96	0	0	0
2US	57142.5	57142.5	0	0	0
Cul2.5	57142.41	56941.91	0	0.4	0.4
N2.4	57291.64	57099.9	0	0.3	0.3
Cul2.4	57417.26	57216.78	0	0.3	0.3
N2.3	58368.98	58179.67	0	0.3	0.3
Cul2.3	58739.91	58539.38	0	0.3	0.3
N2.2	58838.37	58640.59	0	0.3	0.3
Cul2.2	59224.56	59024.07	0	0.3	0.3
N2.1	59202.53	59003.51	0	0.3	0.3
Cul2.1	59528.73	59328.23	0	0.3	0.3
2D5	59328.23	59328.23	0	0	0
N2P	94.06	94.06	0	0	0
N2T	41.87	41.87	0	0	0
N3C	128.15	128.15	0	0	0
HW3C	128.15	128.15	0	0	0
N3B	722.53	722.53	0	0	0
N4C	332.49	332.49	0	0	0
N4B	332.49	332.49	0	0	0
N4	603.03	603.03	0	0	0
N4A	725.7	725.7	0	0	0
4OUT	725.7	725.7	0	0	0
N5A15W	262.95	262.95	0	0	0
N5A15E	96.87	96.87	0	0	0
N5C	172.39	172.39	0	0	0
N5D	125.61	125.61	0	0	0
N6AW	83.16	83.16	0	0	0
N6AE	82.54	82.54	0	0	0
N6E	162.25	162.25	0	0	0
6US	31521	31521.11	0	0	0
N86Up	31716.13	31605.55	0	0.3	0.3
N68Mid	33181.68	33071.1	0	0.3	0.3
N68Low	34284.63	34174.04	0	0.3	0.3

CONTINUITY CHECK for 1 in 100 year ARI Climate Change, 20 minutes

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
N6B	34174.04	34063.44	0	0.3
N6ABJUNC	34229.13	34118.54	0	0.3
6OUT	34118.54	34118.54	0	0
N6G	725.05	725.05	0	0
N6H	279.33	279.33	0	0
N6J	280.5	280.5	0	0
N6L16	312.38	312.38	0	0
N6M	143.96	143.96	0	0
N6N	81.21	81.21	0	0
N6P	82.39	82.39	0	0
HW6G	725.05	725.05	0	0
HW6L	312.38	312.38	0	0
N7B15	178.36	178.36	0	0
N7A15	107.03	107.03	0	0
N7D	64.77	64.77	0	0
N7E15	114.3	114.3	0	0
N7F	190.39	190.39	0	0
N7C	418.8	418.8	0	0
N7GD	483.57	483.57	0	0
N7ABCIJUNC	768.96	768.96	0	0
7OUT	768.96	768.96	0	0
N7G	32.39	32.39	0	0
N8A15W	154.86	154.86	0	0
N8A15E	101.29	101.29	0	0
N8C	76.13	76.13	0	0
N8D16	211.03	211.03	0	0
N8E	157.82	157.82	0	0
N88Up	447.25	447.25	0	0
N8B	1514.97	1514.97	0	0
N88E	1672.79	1672.79	0	0
N88D	2140.88	2140.88	0	0
N88C	2217.01	2217.01	0	0
8AJUNC	2473.16	2473.16	0	0
8OUT	2473.16	2473.16	0	0
N8H	80.6	80.6	0	0
N8G	311.3	311.3	0	0
N8F	630.28	630.28	0	0
N8H19W	51.58	51.58	0	0
N8H19E	29.02	29.02	0	0
N9A	110.92	110.92	0	0
N9ABJUNC	909.3	909.3	0	0
9OUT	909.3	909.3	0	0
N5	336.17	336.17	0	0
N58D	461.79	461.79	0	0
N58C	634.18	634.18	0	0
N5B	634.18	634.18	0	0
N5A	994.01	994.01	0	0

CONTINUITY CHECK for 1 in 100 year ARI Climate Change, 20 minutes

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Change (cu.m)	Difference %
SOUT	994.01	994.01	0	0
N9CD	275.16	275.16	0	0
N9B	798.38	798.38	0	0
N2U	97.7	97.7	0	0
N2G	128.15	128.15	0	0
HW2G	128.15	128.15	0	0
N2K	125.61	125.61	0	0
HW2J	705.64	705.64	0	0
HW2P	94.06	94.06	0	0
HW2L	62.87	62.87	0	0
N2L	62.87	62.87	0	0
HW2N	75.96	75.96	0	0
HW2K	125.61	125.62	0	0
HW2H	207.8	207.8	0	0
HW2F	121.81	121.81	0	0
HW2E	204.01	204.01	0	0
HW2U	97.7	97.7	0	0
HW2B	179.94	179.94	0	0
HW6N	81.21	81.21	0	0
HW6K	112.65	112.65	0	0
N6K	112.65	112.65	0	0
HW6P	82.39	82.39	0	0
HW6C	138.3	138.3	0	0
HW6D	125.61	125.61	0	0
HW6F	96.43	96.43	0	0
HW6E	162.25	162.25	0	0
N6C	138.3	138.3	0	0
N6D	125.61	125.61	0	0
N6F	96.43	96.43	0	0

Run Log for P0802023DRN04_V5 Climate Change run at 11:56:42 on 14/5/2010
The maximum flow exceeded the safe value in the following overflow routes: OF1DS, SwaleROW1