



23 September 2011

CENTREX METALS LTD

Port Spencer - Surface Water Conceptual Design and Management Study

Submitted to:

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REPORT

Report Number. 107661001-077-R-Rev0

Distribution:

1 copy - Centrex Metals Ltd
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Executive Summary

Centrex Metals Limited (Centrex) has engaged Golder Associates Pty Ltd (Golder) to conduct a *Surface Water Conceptual Design and Water Management Strategy* analysis for the proposed Port Spencer Deep Water Marine Port (the Project). This *Surface Water Conceptual Design and Management Study* report has been prepared in support of the Public Environment Report for the Project.

A site visit and hydrologic analysis has been performed for the existing site conditions and Project development conditions. The results of the hydrologic analysis are used to develop a conceptual storm water conveyance design. Recommended strategy and relevant guidelines are provided for stormwater management for Project construction and facility management.

This study presents the following findings for existing conditions:

- Existing conditions in the Project catchment consist primarily of agricultural wheat fields, fallow paddock, grazing pastures and native vegetation.
- No significant trees are present and native vegetation is restricted to coastal zone (Golder 2011).
- Drainage courses are ephemeral and flow intermittently; primarily in the winter months.
- No standing water or groundwater seepage was observed during the site visit.
- The existing catchment is 909 ha in size and outfalls to a flat zone at north-east of site prior to flowing to Roger's Beach (the flat zone is described as Zone B in the Environmental Site Assessment Sheep Hill Marine Port Facility Baseline Study(Golder 2009a))

This study presents the following results and recommendations for the Project:

- The Project catchment is 169 ha for proposed conditions.
- Offsite catchments total 740 ha.
- Offsite catchments will drain to a flood control and storm water diversion channel facility that will route storm water around the Project and outfall to the same location as existing conditions at the intertidal zone prior to Roger's Beach.
- Storm water diversion channels are sized for the 100 year Average Recurrence Interval (ARI) storm event
- Conceptual design of storm water diversion channels are based on the following:
 - Trapezoidal shaped channel sized for 100 year ARI.
 - Channel designed for a preferred sub-critical flow regime to minimise erosive water velocities.
 - Energy dissipation and sediment basin used prior to discharge leaving the Project site.
- Culvert designed for 100 year ARI.
- Port facility storm water management will consist of a 136 ML extended detention basin sized for the 100 year ARI storm event.



Comparison of existing and proposed conditions peak storm runoff shows 100 year, 1 hour ARI of 68 m³/s and 56 m³/s, respectively. The existing and proposed conditions peak storm runoff volume decreases from 304 M to 251 ML, respectively. This is the result of removing the 169 ha Project catchment from the overall catchment that outfalls to Roger's Beach. The development of the Project reduces stormwater discharge to marine environment

Recommended management measures for construction and marine Project operation include the following:

- Construction measures:
 - Early construction of channels
 - Early construction of extended detention basin as a temporary sedimentation pond
 - Minimise disturbed soil area by planning staged construction
 - Erosion control and sediment control
 - Non-storm water discharge measures.
- Operational measures:
 - Water Sensitive Urban Development (WSUD)
 - Extended detention basin sized for 100 year ARI
 - Stormwater retention reservoir to harvest storm water for industrial use
 - Offsite drainage catchments and diversion channels
 - Maintain vegetation and/or channel stabilization for erosion control
 - Sediment control at energy dissipation basin/sediment trap
 - Operational environmental monitoring and management plan
 - Non-stormwater pollution control
 - Maintain a water pollution control plan
 - Fuelling and fuel storage management measures
 - Material and waste management
 - Emergency response.



Record of Issue

Company	Client Contact	Version	Date Issued	Method of Delivery
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1.0 INTRODUCTION

Centrex Metals Ltd (Centrex) engaged Golder Associates Pty Ltd (Golder) to undertake storm water conceptual design and management strategies for the proposed Port Spencer (the Project) located on the Eyre Peninsula, South Australia, approximately 21 km north-east of Tumby Bay. This report has been prepared in support of the Public Environment Report for the Project. Note that the Project was previously referred to as Sheep Hill Port, as can be seen in earlier documents and drawings referenced in this report.

This report presents results and findings for the conceptual storm water management strategy and conceptual design to address the *Guidelines for the Preparation of a Public Environment Report Sheep Hill Deep Water Port Facility (Stage 1) on Eyre Peninsula* (Department of Planning and Local Government 2011).

This report includes the following:

- Existing conditions surface water site investigation
- Desktop review of relevant stormwater regulatory and management guidelines
 - Construction stormwater measures
 - Operational measures, stormwater quality improvement devices and suitable stormwater retention devices
 - Water Sensitive Urban Design (WSUD)
 - Stormwater management and mitigation measure recommendations
- Existing and project conditions stormwater runoff hydrology
 - 100-year Annual Recurrence Intervals (ARI) for existing conditions
 - 10-year and 100-year ARI for proposed conditions
- Conceptual design of stormwater improvements for proposed conditions
 - Onsite stormwater extended detention basin
 - Coordinate extended detention basin size and location with site engineers
 - Offsite diversion channels, culverts and related stormwater improvements.

The existing conditions hydrology excludes model calibration. Site-specific rainfall data and runoff flow measurement data was not available to calibrate the model used for the Project.

Golder has previously submitted to Centrex the *Surface Hydrology Site Investigation Sheep Hill Marine Port Facility Baseline Study* (Golder 2009b). That study includes a preliminary site hydrology assessment, a preliminary site water balance model and a regional climate summary. This report supersedes the peak runoff rates and volumes presented in Golder 2009b.

Golder has previously performed an *Environmental Site Assessment Sheep Hill Marine Port Facility Baseline Study* (Golder 2009a) which provides a limited assessment of the surface water and groundwater interaction and water quality.

The *Geotechnical Investigation and Soil Study Sheep Hill Marine Port Facility Baseline Study* performed a limited assessment of soil erosion potential, soil landscapes and potential constraints on development and revegetation (Golder 2009c).



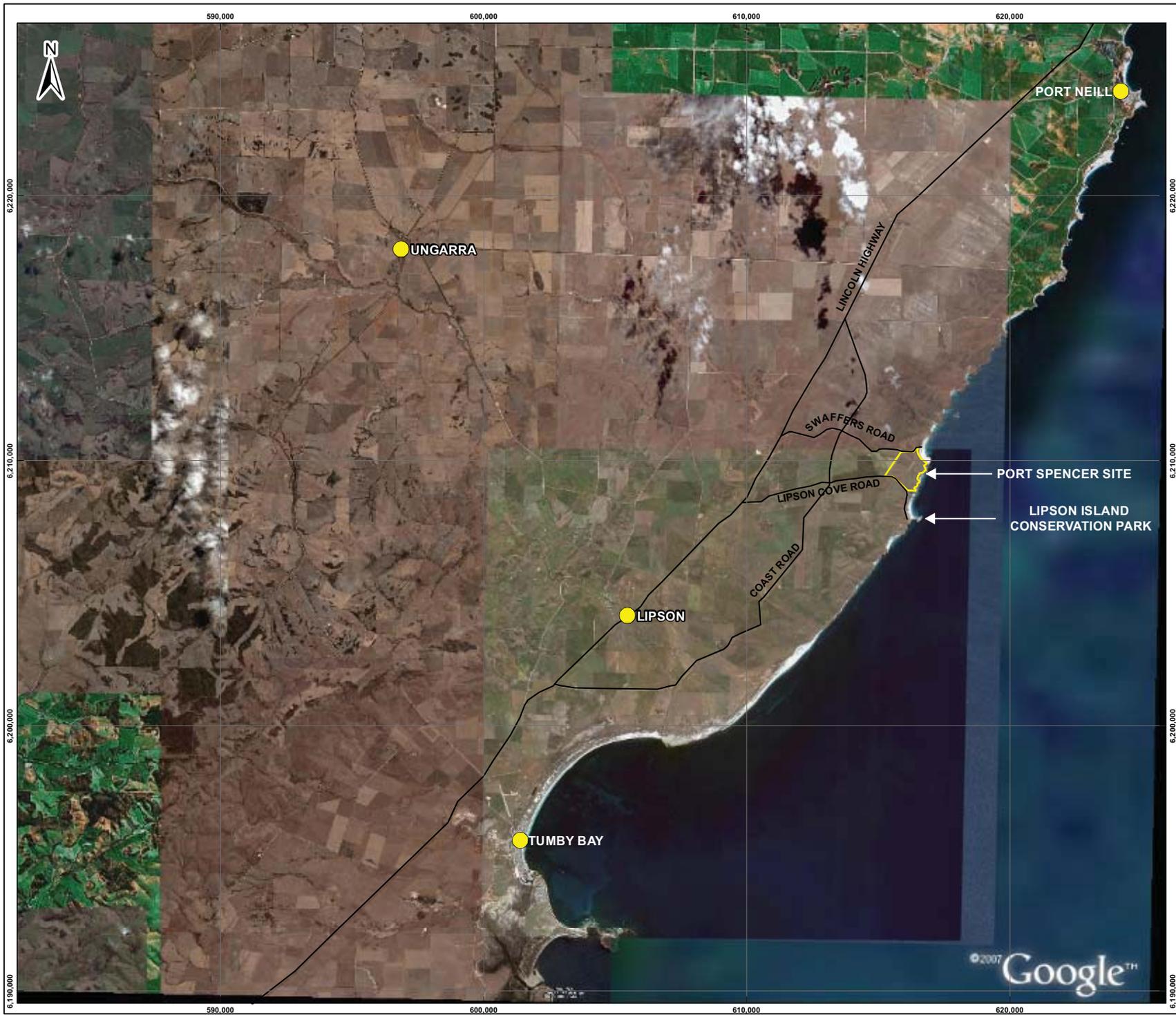
1.1 Site and Catchment Description

The Port will be located on Eyre Peninsula, South Australia, approximately 21 km north-east of Tumby Bay, approximately 70 km north of Port Lincoln and 225 km east of Adelaide. The Stage 1 development will include grain and hematite storage, grain and hematite out-loading, ship loading facilities and associated infrastructure. The Lipson Island Conservation Park is located 1.5 km south of the Project.

The location of the proposed Port is shown in Figure 1 Figure 1: Site Location - Regional Perspective.

Climate for the area is semi-arid with annual rainfall on the order of 500 mm or less. The majority of precipitation falls in the winter months. Evaporation rates are high relative to rainfall. This tends to result in low storm water runoff during the more frequent and smaller storm events (Golder 2009b).

The catchment at Sheep Hill drains to Roger's Beach as shown in Figure 2. The total catchment area contributing to runoff at Rogers Beach is 909 ha (9.1 km²). Land use in the catchment is comprised of undeveloped land and agricultural use with no impervious surfaces. Roads are compacted gravel or earthen and there are only three residences within the catchment. Agricultural use consists of fallow paddock and wheat cropping (Golder 2011).



**PORT SPENCER
SURFACE WATER**
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**SITE LOCATION -
REGIONAL PERSPECTIVE**



- LEGEND**
- Township
 - Approximate Site Boundary
 - Road

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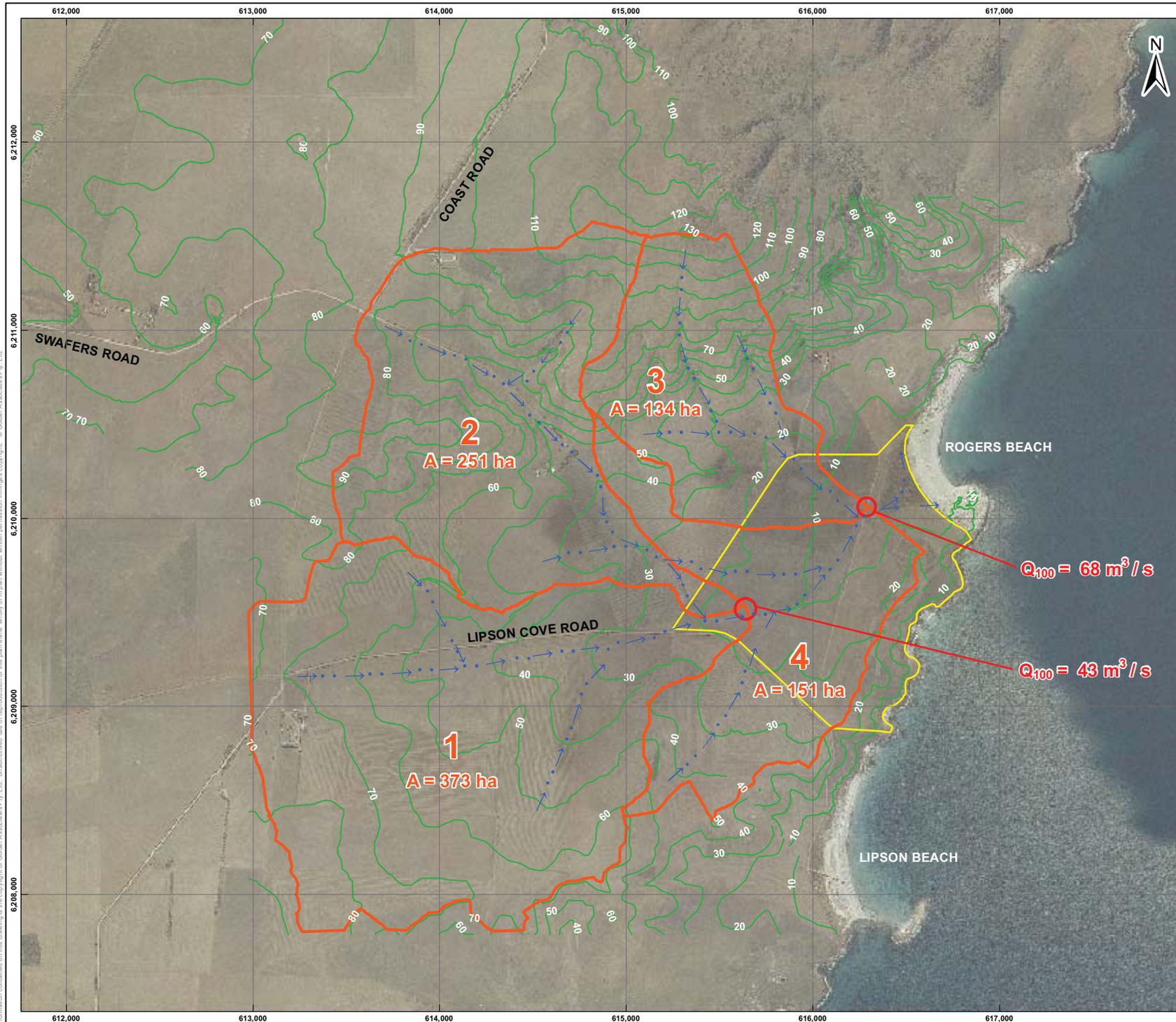
0 1,000 2,000 4,000 6,000 8,000 Meters
SCALE (at A3) 1:140,000
DATUM GDA 94, PROJECTION MGA Zone 53

PROJECT: 107661001
DATE: 23 SEP 2011
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FIGURE 1



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PORT SPENCER SURFACE WATER

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EXISTING CONDITIONS CATCHMENT MAP



LEGEND

- Catchment Boundary and Label
- Approximate Site Boundary
- Contour (m AHD)
- Drainage Pattern
- A Catchment Area, ha
- Catchment Runoff Combination Point

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Aerial image and contour data sourced from Department for Environment and Heritage, South Australian Government.
Site data sourced from Parsons Brinckerhoff, Drawing No: 2172612A-CIV-0003 Rev C, Drawn By: J.Mc, Drawing Date: 15.08.2011. Lidar contour data sourced from Centrex Metals Ltd, February 2011.

0 125 250 500 750 1,000 Meters

SCALE (at A3) 1:20,000

DATUM GDA 94, PROJECTION MGA Zone 53

PROJECT: 107661001
DATE: 23 SEP 2011
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FIGURE 2





2.0 SITE VISIT AND BACKGROUND

Golder visited the Project site on 27 February 2011 with Centrex personnel. The purpose of the visit was to qualify storm water related characteristics within the catchment. Observations noted included the following:

- Drainage patterns and storm water structures
- Vegetation cover density and general type
- General soil characteristics
- Erosion
- Land use.

Photographs and site observations are included in Appendix A. No standing water or groundwater seepage was observed during the site visit.

The site visit and subsequent desktop background study reveals that the Project reduces stormwater discharge to the marine environment. The existing land use in the catchment is primarily agriculture, fallow paddock and grazing. Pollutants of concern for these types of land use categories typically include the following:

- Sediment
- Agricultural chemicals
- Fertilizer
- Animal faeces
- Putrescible waste
- Green waste
- Hard waste.

Golder (2009c) included a limited assessment of soils and surface water and groundwater interaction. In general, groundwater depths vary across the site and range from 9 m deep on the west of the site to as shallow as 1.7 m deep in the flat zone in the north-east corner of the site. Surface soils across the Project site and local catchment are typically fine to coarse clayey sand, clayey silt. No standing water or groundwater seepage was observed during the site visits conducted for Golder (2009b).

The soil study and this study found minimal to localized extensive erosion but that overall erosion was fairly minimal. This study is in concurrence with the findings of the soil study. The soil study notes that the generally alkaline and low in organic matter (Golder 2009c).

In general, the overall catchment exhibits little erosion in the areas exhibiting signs of overland and concentrated runoff. Catchment drainage in an upper reach adjacent to Swaffers Road and running down to the farmhouse exhibited large channel incision and erosion at the end of the culverts under the driveway.



3.0 STORM WATER MANAGEMENT

Golders' review of relevant storm water regulations, guidelines, WSUD and management measures for the Project is presented in this section. This review is limited to the surface water associated with the existing catchments and onsite Port facility catchment as shown in Figure 2 and Figure 3.

3.1 Water Quality and Management Regulations

The *Environment Protection Act 1993* (the Act) and the *Environment Protection (Water Quality) Policy 2003* (the Policy) are the legislative authority and policy documents applicable to the site (Government of South Australia 2010).

3.1.1 Environment Protection Act 1993

The Act is the legislative Act that establishes authority to protect the environment. The South Australia Environmental Protection Agency (EPA) is authorised under the Act.

The following activities are environmentally significant with regards to surface water and water quality conditions that are analogous to the Project:

- Petroleum and chemical
 - Chemical storage and warehouse facilities
- Material handling and transportation
 - Bulk shipping facilities
 - Agricultural crop products
 - Rock, ores and minerals.

3.1.2 South Australia Environment Protection (Water Quality) Policy 2003

The Policy is a water quality policy that is enforced and authorised under the Act. The Policy has the objective to, "...achieve the sustainable management of waters, by protecting or enhancing water quality while allowing economic and social development." With regards to the Project, the Policy establishes the criteria and enforcement of, but not limited to, the following:

- Water quality objectives
- Management and control of point source pollution
 - General obligation to avoid discharge into waters
 - Obligation not to cause certain environmental harm
 - Obligation not to discharge or deposit listed pollutants into waters or onto certain land

The Policy lists pollutants in Schedules 4 and 5. Contaminated stormwater is defined as stormwater that "...is contaminated by a pollutant listed in Schedule 4 or any material that could be reasonably prevented from entering the pipes, gutters and other channels used to collect and convey the stormwater." Potential listed pollutants per Schedule 4 applicable to the marine Port operation could include, but not limited to, the following:

- Air conditioning or cooling system wastewater
- Building wash water



- Condensate from compressors
- Fire sprinkler test water
- Oil, grease or lubricants
- Rubbish
- Petroleum products
- Wastes listed in Part B of Schedule 1 of the Act.

3.2 Construction Guidelines and Measures

Water quality and construction best management practices are contained in the Code of Practice for the Building and Construction Industry (EPA 1999). The Code of Practice for the Building and Construction Industry references the Act as the legislative control that may apply when applying the Code of Practice for the Building and Construction Industry. Part 5 of the Policy states the following:

- **“40—Building and construction industry—stormwater:** If a person undertakes a building or construction activity described in the *Stormwater Pollution Prevention Code of Practice for the Building and Construction Industry 1999* prepared by the Authority, that code applies.”

The construction of the Project will follow the guidelines in the *Code of Practice for the Building and Construction Industry 1999*. Additionally, construction contractors will be required to engage a certified Environmental Management System compliant with ISO 14001:2004 and to develop a Construction Environmental Management and Monitoring Plan.

The geotechnical investigation and soil study (Golder 2009c) recommended the following for erosion and sediment control measures:

- Areas cleared of vegetation – require temporary mulching of exposed surfaces and prompt revegetation or sealing (e.g., pavements) following construction.
- Stockpiled spoil – requires either perimeter catch drains and low bunds or in the case of trench spoil, placement parallel to and up gradient of the excavation, so that any runoff will be trapped in the trench.
- Creek banks and crossings (if applicable) – if disturbed, require temporary stabilisation using pinned geotextile or turf, until more permanent stabilisation is carried out (e.g., re-vegetation, gabions).
- Any access roads or other local corridors – require local catch drains parallel to and down gradient of the road/corridor to direct runoff away from any down gradient water bodies within 100 m of the corridor.

This study additionally recommends the following strategy and practices are implemented during the construction phase of the Project:

- Early construction and stabilisation of offsite catchment diversion channels and extended detention pond:
 - Diversion channels will divert offsite water around construction activities.
 - Extended detention pond can be used as a temporary sediment pond and is sized to contain the 100 year storm event thereby minimising the discharge of stormwater to the marine environment during the construction phase.
- Removal and stockpiling of topsoil for revegetation.



- Early revegetation of cut slopes and earthen channel.
- Implementation of erosion and sediment control.
- Management of non-storm water discharge and materials stored and used onsite.

3.3 Operations Measures

Project development and storm water management will incorporate the following measures:

- Water Sensitive Urban Design:
 - Water re-use and harvesting including rainwater tanks for buildings and harvest of storm water runoff from offsite and Project catchment.
- Extended detention basin and additional onsite stormwater retention reservoir:
 - Extended detention basin sized for 100 year storm event will be operated for storm water detention only and be drained within 72 hours after a storm event.
 - Stormwater retention reservoir will operate as the primary reservoir to store storm water for re-use.
- During Stage 1, harvested or detained storm water will be re-used or exported according to a storm water disposal plan that can incorporate the following aspects:
 - Water for dust control
 - Irrigation for revegetation management
 - Export to other beneficial uses such as irrigation
 - Other non-potable water uses
- A water treatment desalinisation plant will be used in the future Stage 2 Port development to treat harvested or detained storm water prior to re-use.
- Operational environmental monitoring and management plan that covers the following aspects:
 - Excess stormwater disposal plan
 - Non-stormwater pollution control
 - Maintain a water pollution control plan
 - Fuelling facilities
 - Material management
 - Emergency response.

Operation and maintenance of the Project will incorporate a Port Management Company responsible for operations, management and maintenance of the facility.



Part of the Project operation and maintenance will include the upkeep of offsite diversion and flood control channels. These channels will divert storm runoff around the Project. The channels as presented in this report are sized for the 100 year storm event and will provide flood protection for the Project and convey storm runoff from smaller and more frequent storm events. Operation and maintenance of the diversion channels will include the following:

- Maintain vegetation and/or channel stabilization for erosion and sediment control.
- Control sediment at energy dissipation basin/sediment trap.
- Remove sediment from channels regularly.



4.0 METHODOLOGY

This section describes the data sources, preliminary design methodology and assumptions in developing this report.

4.1 Topography

Site topography was used in conjunction with the results of the site visit to establish drainage patterns and catchment boundaries for the hydrology analysis. Centrex provided Golder with 1 m light detection and ranging (LIDAR) for the Project area. LIDAR data was supplemented with 10 m LIDAR data collected from the South Australian Government Department of Environment and Heritage.

A digital elevation model (DEM) was created from the 1 m LIDAR and 10 m data and placed into the software program CatchmentSIM. CatchmentSIM was used to calculate catchment areas and catchment slopes for the existing and proposed site conditions hydrology analysis.

Figure 2 and Figure 3 show the existing site contours with 10 m resolution developed from the 1 m DEM.

4.2 Hydrology

The following describes the hydrologic methods, data source and assumptions used for the stormwater runoff analysis for the Project site. Hydrology was performed for the following conditions:

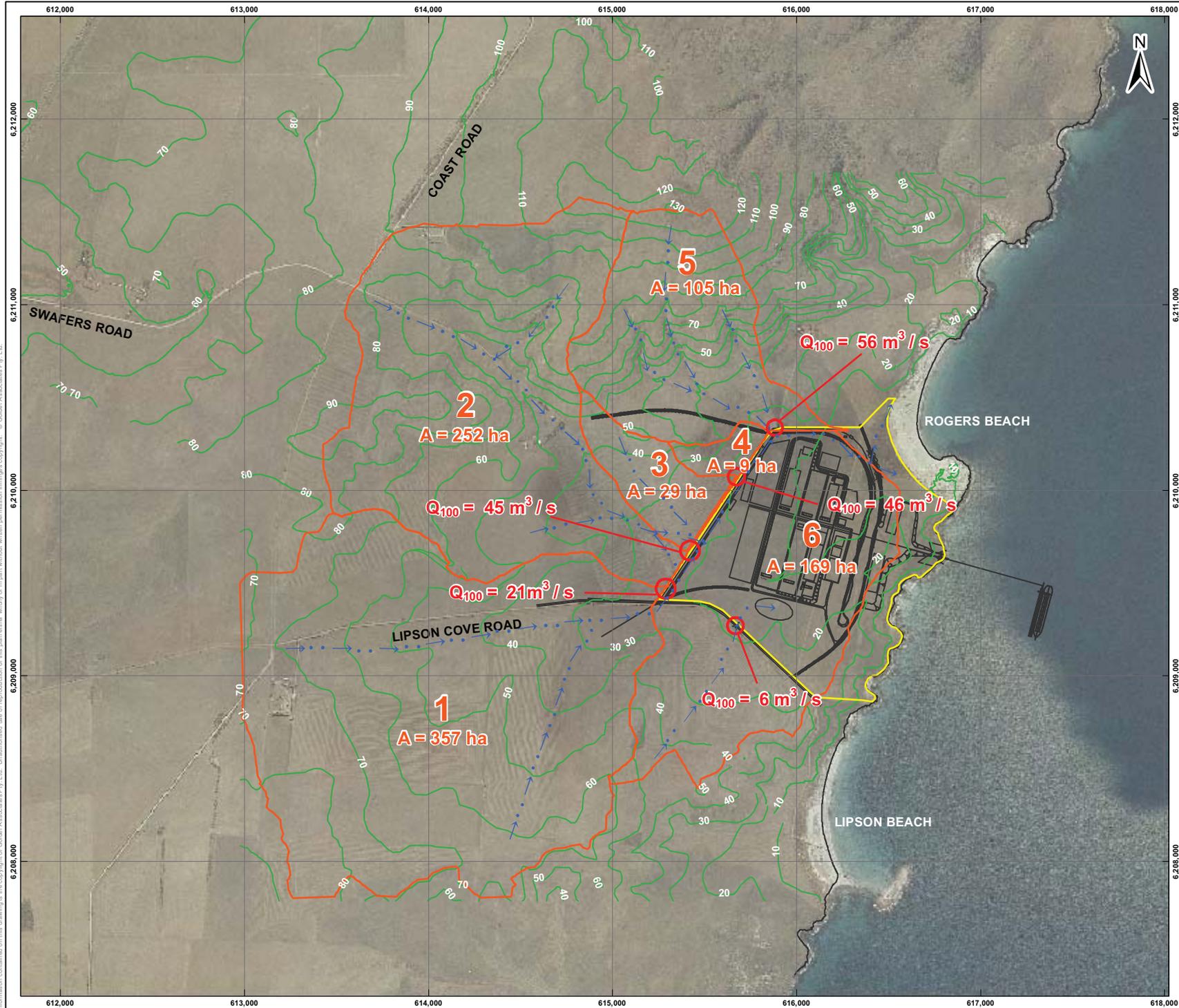
- Existing conditions hydrology for the 100 year ARI storm event
- Offsite conditions hydrology for the 10 year and 100 year ARI storm events during the Project life
- Onsite conditions hydrology for the 100 year ARI storm event during the Project life

4.2.1 Precipitation

Rainfall intensity-frequency-duration (IFD) data for the Sheep Hill area was sourced from the Australian Bureau of Meteorology website. The rainfall temporal patterns were generated by the XP-SWMM software using the methodology from the *Australian Rainfall and Runoff Guidelines* (ARR) (Pilgrim 2001). The IFD table and the IFD chart are presented in Appendix B. Table 1 shows the IFD values for 1 to 100 year ARI storm events.

Table 1: Intensity-Frequency-Duration Values for Port Spencer

DURATION	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5 mins	37.7	51.7	74.8	92.6	117	155	189
6 mins	35	48	69.4	85.8	108	143	175
10 mins	28.1	38.4	55.2	68	85.6	113	137
20 mins	20	27.1	38.6	47.2	59.1	77.3	93.5
30 mins	15.9	21.6	30.4	37.1	46.3	60.3	72.7
1 hr	10.4	14	19.6	23.7	29.4	38	45.6
2 hrs	6.55	8.83	12.2	14.7	18.1	23.2	27.7
3 hrs	4.99	6.69	9.17	11	13.5	17.3	20.5
6 hrs	3.11	4.15	5.62	6.69	8.16	10.4	12.3
12 hrs	1.92	2.56	3.44	4.07	4.94	6.25	7.37
24 hrs	1.16	1.55	2.08	2.45	2.97	3.76	4.43
48 hrs	0.672	0.898	1.21	1.43	1.73	2.19	2.59
72 hrs	0.48	0.631	0.85	1.01	1.23	1.55	1.83



**PORT SPENCER
SURFACE WATER**

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**PROPOSED CONDITIONS
CATCHMENT MAP**

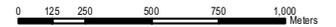


LEGEND

- Catchment Boundary and Label
- Approximate Site Boundary
- Contour (m AHD)
- Drainage Pattern
- A** Catchment Area, ha
- Catchment Runoff Combination Point

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SCALE (at A3) 1:20,000
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FIGURE 3



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4.2.2 Offsite Hydrology

XP-SWMM models were set up to calculate the runoff peak flow and volume at the sub-catchment discharge points for the existing conditions and the proposed offsite conditions. The Laurenson routing method within XP-SWMM was used to estimate the peak runoff discharge from each of the sub-catchments. Rainfall durations up to 6 hours were calculated. The rainfall duration that creates the highest peak flow runoff rate is termed the critical duration for the given ARI storm event.

Following the recommendations for South Australia in the ARR guidelines, the initial and continuous infiltration losses were set as 10 mm/h and 2 mm/h respectively (Pilgrim 2001). A Manning's roughness coefficient n-value of 0.03 was used for the catchment areas. The storage non-linearity exponent (n) was set to -0.285.

The hydrodynamic routing method in the XP-SWMM hydraulics mode was used to route the runoff from each sub-catchment. A Manning's n-value of 0.035 was used for the existing and proposed drain and channel hydraulic design calculations.

Existing condition drain and channel parameters were calculated using CatchmentSIM. For the proposed offsite conditions, the runoff was routed through the segments of the storm water channel as discussed in Section 4.3. For the purpose of this conceptual design, the parameters of the storm water channel segments in XP-SWMM were approximated to the conceptual design presented in Section 6.1.

4.2.3 Proposed Onsite Conditions Hydrology

The Project site storm runoff will drain to an extended detention basin. The extended detention basin is sized to contain the runoff volume for the 100 year ARI storm event. The Rational Method is used to estimate the runoff volume during the 100 year ARI event.

The Rational method utilises the following methodology. The Bransby-Williams Method is used to calculate the time of concentration to derive the rainfall intensity used in the Rational Method.

The Bransby-Williams Method: _____

t_c = time of concentration, min

L = length of catchment flow path, km

A = catchment area, ha

S_e = equal area slope of flow path, %

The Rational Method was used to estimate the peak flow rate from the Project catchment.

Rational Method: _____

Q = peak flow rate, m³/s

C = runoff coefficient, dimensionless

i = rainfall intensity from IFD table, mm/h

A = catchment area, ha



Runoff coefficient values were estimated using the methodology from the Queensland Urban Drainage Manual (QUDM 2008) and the ARR.

QUDM:

F_Y = Frequency factor assumed to equal 1.2 for 100 year ARI (QUDM 2008), dimensionless

C_{10} = assumed to equal 1 for saturated conditions, dimensionless

The results of the Rational Method were used to estimate the runoff volume using the formula:

–

V = runoff volume, m^3

t_c = time of concentration, min

Q = peak flow rate, m^3/s

The dimensions of the onsite extended detention basin were estimated using the equation for a rectangular, truncated pyramid.



- V = volume, m^3
- A = area of top of pond, m^2
- B = area of bottom of pond, m^2

A freeboard depth of 0.5 m was added to the depth of pond. The resulting total volume is reported as the extended detention basin volume to contain the Project runoff for the 100 year ARI storm event.

4.3 Channel Design

The diversion of the offsite catchment storm runoff is designed as a flood control conceptual design. Golder recommends that a stormwater diversion channel around the Project be designed for a minimum 100 year ARI. Diversion channels constructed on the north-western and northern sides of the site boundary will capture the majority of the offsite runoff. The Catchment 6 as shown on Figure 3 includes some offsite catchment area. Runoff from this offsite catchment area will be captured as part of a stormwater harvest and used to augment water use for the Project.

The diversion channel has been separated into four reaches to allow for changes in dimension and slope as it follows the existing topography. Culverts will be installed to allow the stormwater diversion channel to pass under road crossings. The basis of the conceptual design for the diversion channel and related facilities includes the following:

- Trapezoidal shaped channel sized for 100 year ARI and low flow channel for storm events < 10 year ARI
- Design channel for a preferred sub-critical, low velocity flow regime to minimise erosive water velocities:
 - Earthen vegetated channel
 - Use open channel drop structures to maximise sub-critical flow regime, low velocity flow.



- Super-critical flow regime, high velocity: utilise pervious rock lined, gabion mattress or gabion basket:
 - Use energy dissipation and sediment basin prior to discharge leaving the Project site.
- Culvert design for 100 year ARI.

The parameters of the channel segments comply with the standards that have been set out in the QUDM (QUDM 2008). The velocity and flow depth in the earthen vegetated segments are equal to or less than 2.1 m/s and 2.5 m, respectively. Earthen vegetated reaches have side slopes of 1V:3H.

The velocities in the gabion-lined segments are limited to the critical velocity of 5.0 m/s. Gabion lined reaches have side slopes of 1V:2H (Maccaferri 1995).

4.3.1 Stormwater Channel Hydraulics

The following describes the hydraulic methods, data sources and assumptions used to estimate the conceptual design parameters of the offsite stormwater diversion channel and the stormwater culverts. The trapezoidal Manning's equation is used to provide a conceptual channel sizing for each of the four reaches of the stormwater diversion channel. Runoff peak flow rates are used to size the channels and related appurtenances.

Manning's equation:

v = flow velocity, m³/s

R = hydraulic radius, m

S = channel slope, m/m

n = Manning's roughness value assumed 0.035 for all segments, dimensionless

4.3.2 Open Channel Drop Structures

Open channel drop structures are used to maximise sub-critical flow regime, low velocity conditions for the channels. The conceptual design for the open channel drop structures uses parameters and guidelines from the U.S. Department of Transportation (U.S. Department of Transportation, 2006). Figure 4 shows the flow geometry and configuration of an open channel drop structure.

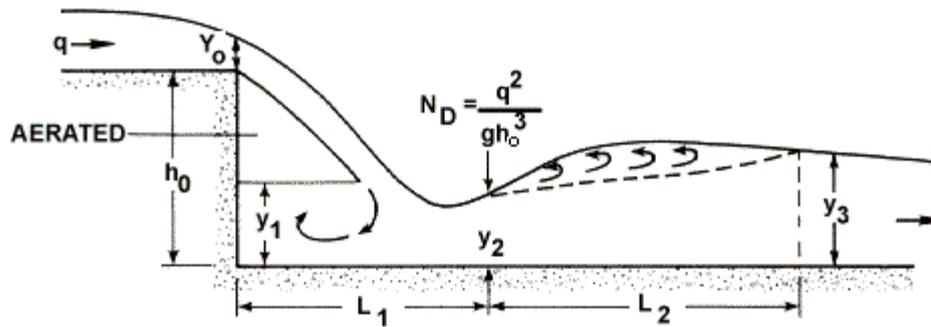


Figure 4: Flow Geometry of a Straight Drop Spillway (USDOT, 2006)

Where:

N_d = drop number

q = unit discharge, $m^3/s/m$

g = acceleration due to gravity, $9.81 m/s^2$

h_0 = drop height assumed 0.9 m

LB ($L_1 + L_2$) = minimum 12 m

4.3.3 Culverts

Culvert hydraulics were calculated using the program HY-8 from the US Department of Transportation and is based on the *Hydraulic Charts for the Selection of Highway Culverts* (Bureau of Public Roads 1965; QLD Department of Main Roads 2002). HY-8 is a hydraulic software program for culvert design and includes features to calculate culvert capacity for inlet control, outlet control, tail water depth and roadway overtopping. The following parameters were used to size the reinforced concrete box (RCB) culverts:

- Peak flows in the storm water diversion channel segments
- Downstream storm water diversion channel dimensions
- Roadway data (Parsons Brinckerhoff, 2011)

The Swaffers Road, Lipson Cove Road and Lipson Cove Road East culverts are sized to convey the 100 year ARI peak flow event.

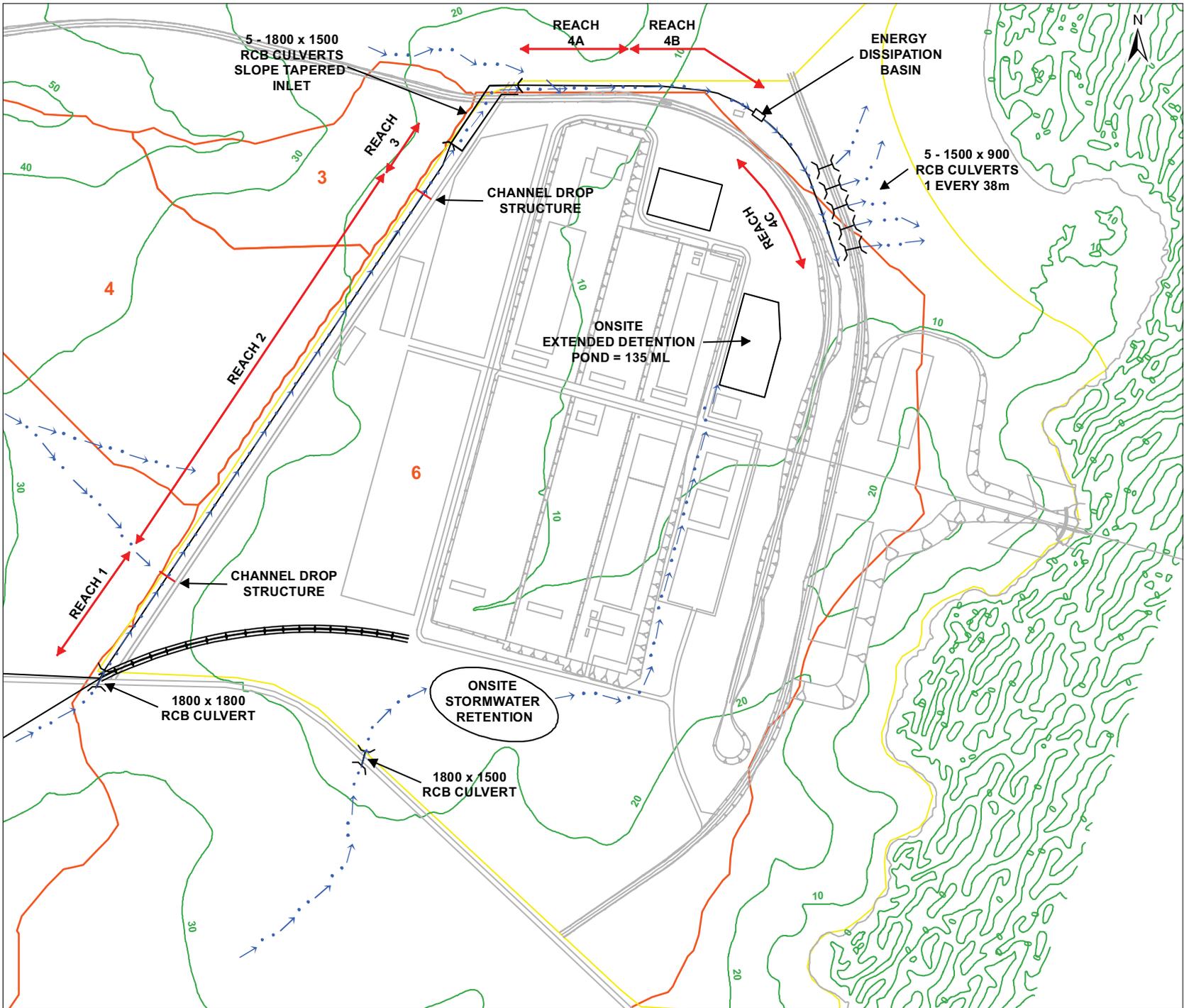
The Roger's Beach Public Access Road culverts are sized to convey the 10 year ARI peak flow event under the access road. The Public Access Road is designed to overtop during peak flow storm events that are greater than >10 year ARI.



4.3.4 Energy Dissipation Basin

A free jump energy dissipation basin is designed at the end Reach 4b of the stormwater diversion channel as shown in Figure 5. The basin will reduce the runoff velocity and dissipate the energy of the runoff in the channel. It can also be used as a sediment trap for events less than the 10 year ARI storm event. The conceptual design for the free energy dissipation basin uses parameters and guidelines from the U.S. Department of Transportation *Hydraulic Design of Energy Dissipation for Culvert and Channels* Hydraulic Engineering Circular No. 14 (U.S. Department of Transportation 2006). Figure 6 shows the flow geometry and configuration of a free jump energy dissipation basin.

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**PORT SPENCER
SURFACE WATER**

CENTREX METALS LTD

**CONCEPTUAL STORMWATER
DESIGN GENERAL
ARRANGEMENT**



LEGEND

- Catchment Boundary and Label
- Approximate Site Boundary
- Contours (m AHD)
- - - Drainage Pattern

COPYRIGHT

Lidar contour data sourced from Centrex Metals Ltd, February 2011.
Base plan sourced from Parsons Brinckerhoff Drawing No: 2172612A-CIV-0003 Rev C. Drawn By: JMc Drawn Date: 15.08.2011

0 25 50 100 150 200 Meters

SCALE (at A3) 1:6,000

DATUM GDA 94, PROJECTION MGA Zone 53

PROJECT: 107661001
DATE: 23 SEP 2011
DRAWN: KB
CHECKED: CRA

FIGURE 5





Conjugate depth equation: _____

y_2 = conjugate depth, m

y_1 = upstream depth entering basin, m

C = ratio of tail water to conjugate depth y_2

Fr = Froude number of flow entering basin

The following assumptions were made for the conceptual design:

- Froude Number (Fr) is same as upstream channel reach; $Fr = 2.0$
- Ratio of L_B/y_2 is 6 for free jump basin per Figure 8.2 of HEC-14 (USDOT, 2006)
- $S_T = S_0$; See Figure 6.
- $C=1$

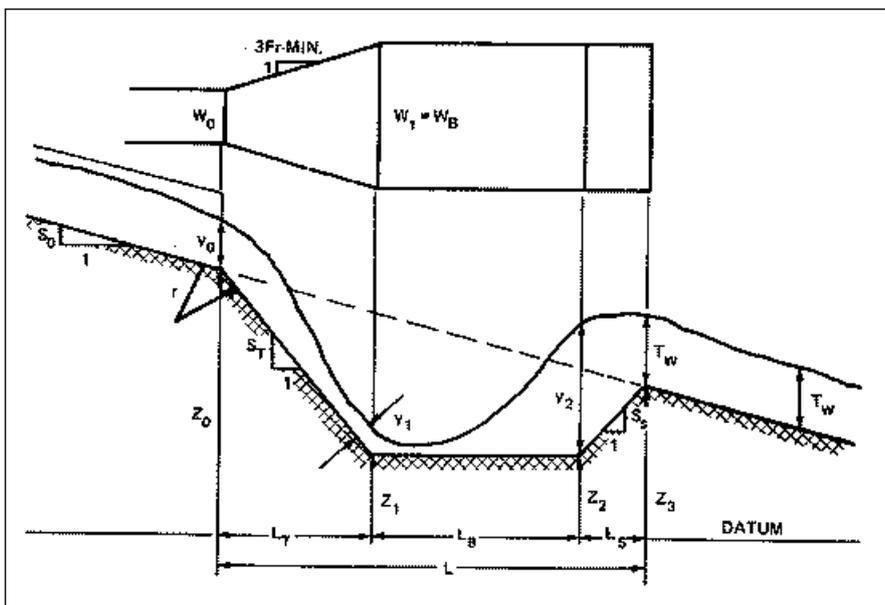


Figure 6: Flow Definition sketch for Free Jump Energy Dissipation Basin (USDOT, 2006)



5.0 HYDROLOGY RESULTS

The following sections present the results of the conceptual hydrologic analysis.

5.1 Existing Conditions

Runoff from surrounding catchments flow through the proposed Port site and discharge at the north-east corner of the site as shown in Figure 2. Catchment parameters and 100 year runoff results are shown in Table 2. The storm runoff peak flow in Table 2 and Figure 2 are the combined runoff hydrograph peak flow for the catchments as shown and estimated using XP-SWMM.

Table 2: Existing Conditions Catchment Parameters and XP-SWMM 100 Year Peak Flow

Catchment	Area (ha)	Slope (%)	Runoff Peak Flow (m ³ /s)
1	373	2.85	43
2	251	5.29	
3	134	6.97	68
4	151	3.19	
Total	909		

The estimated total catchment runoff for the existing conditions at the flat zone before Roger's Beach is 68 m³/s.

The XP-SWMM hydrographs for all storm durations are summarised in Appendix C.

5.2 Proposed Conditions

The stormwater channels are sized based on the results of the proposed conditions hydrology for the 100 year ARI storm event. Proposed conditions catchments are shown in Figure 3. Hydrographs from the XP-SWMM analysis are contained in Appendix C. Catchment parameters and 100 year runoff results are shown in Table 3.

Table 3: Proposed Conditions Catchment Parameters and 100 Year Peak Flow

Channel Reach	Catchment	Area (ha)	Slope (%)	Runoff Peak Flow (m ³ /s)	Critical Storm Duration (min)
1	1	357	2.58	21	180
2	2	252	5.75	45	60
	3	29	3.74		
3	4	9	4.33	46	60
4	5	105	9.16	56	60
Total		752			

The estimated total catchment runoff for the proposed conditions at the flat zone prior to Roger's Beach is 56 m³/s.



5.2.1 Existing and Proposed Offsite Hydrology Comparison

This section presents a brief comparison of the 100 year ARI peak flow event for the existing and proposed conditions hydrology. The comparison shows the change in runoff peak flow and volume at the flat zone before Roger’s Beach.

Table 4 shows the results of the peak flows and total volumes for the one hour storm durations. Figure 7 displays the peak flow event for the two conditions.

Table 4: Comparison of the 100 Year ARI Peak Flows and Total Runoff Volumes for the Existing and Proposed Conditions

Condition	Peak Flow (m ³ /s)	Total Runoff Volume (ML)
Existing Conditions (Existing)	68	304
Proposed Offsite Diversion (Reach 4)	56	251

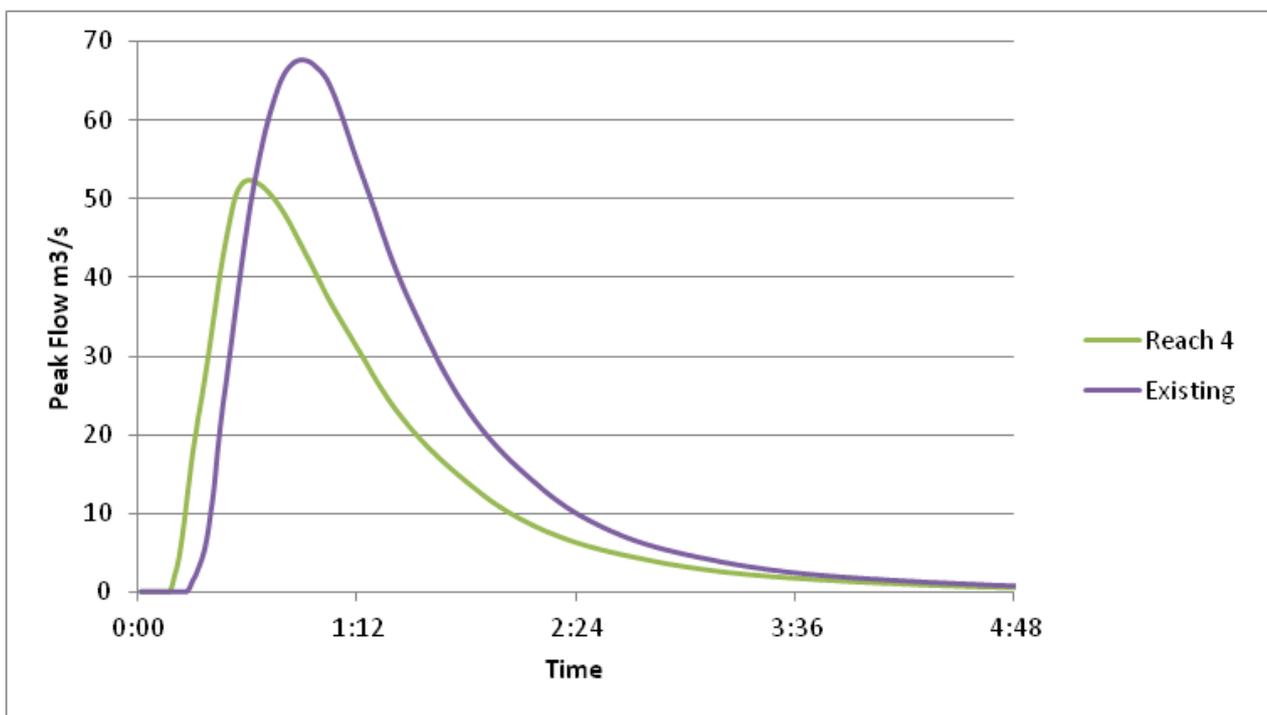


Figure 7: Comparison of 100 Year ARI Peak Flow Event for the 1 hr Storm Duration for the Existing and Proposed Offsite Conditions

The proposed offsite conditions have a smaller peak flow and total volume due to the isolation of the proposed Port facility catchment area runoff.



5.2.2 Proposed Onsite Conditions

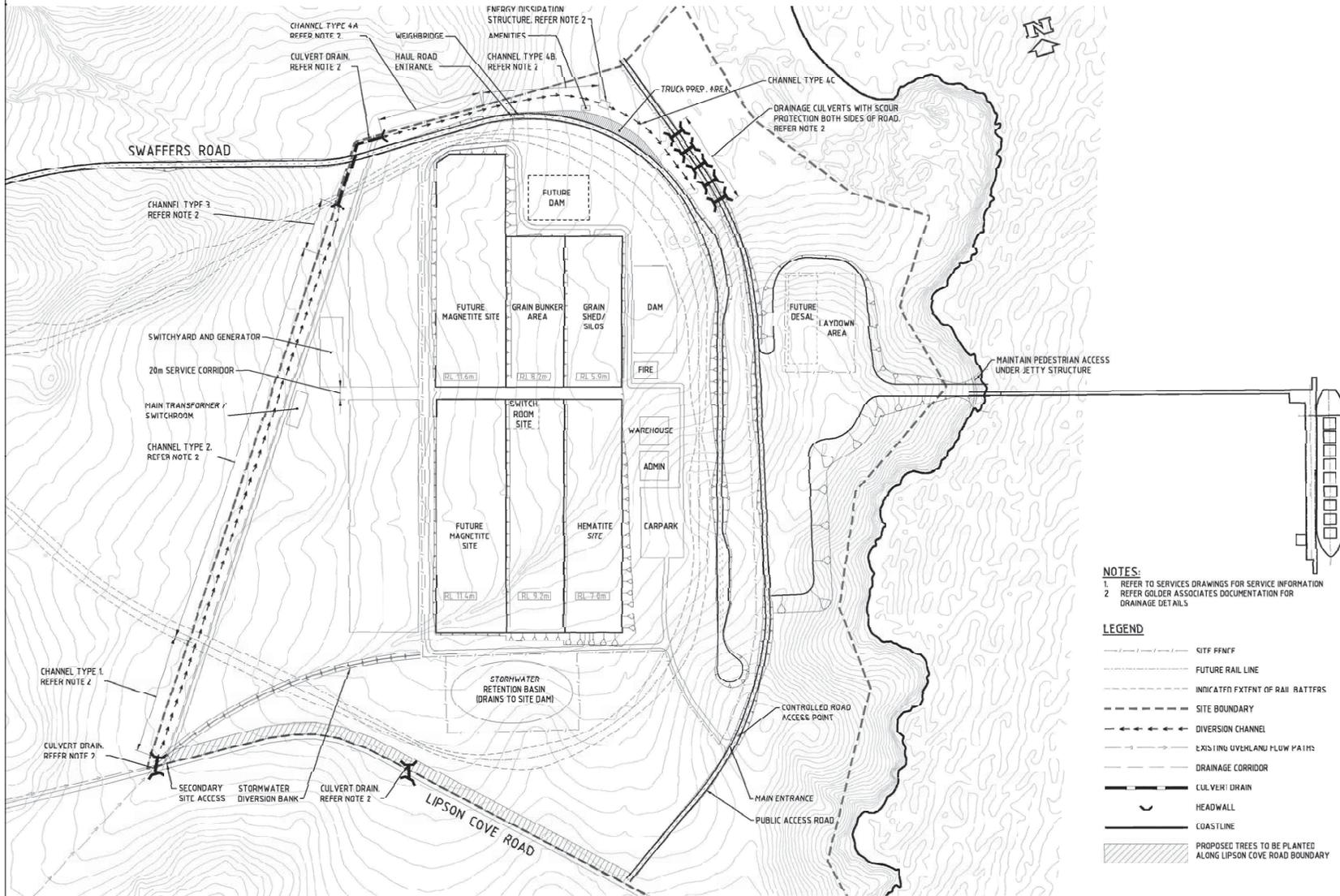
Proposed onsite conditions are shown in Figure 3 and Figure 5. The catchment for the onsite condition includes portions of undisturbed catchment to the south of Lipson Cove Road and is shown as Catchment 6 in Figure 3. Catchment 6 is 169 ha in size. Table 5 summarises the conceptual design of the onsite stormwater extended detention basin.

Table 5: Port Stormwater Extended Detention Basin Sizing

Parameters	Calculated Values
Time of Concentration t_c (min)	73
Runoff Coefficient C (dimensionless)	1
Peak Runoff Q (m^3/s)	19.7
Runoff Volume (ML)	115
Length, (m)	240
Width, (m)	180
Depth, (m)	3
Freeboard, (m)	0.5
Total Pond Volume with 0.5 m Freeboard (ML)	136

The proposed location of the stormwater detention basin is shown on Figure 5 and Figure 8.

**PARSONS BRINCKERHOFF
CIVIL SITE LAYOUT**



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Base image sourced from Parsons Brinckerhoff, Drawing No: 2172612A-CIV-0003 Rev C, Drawn By: JMc, Drawing Date: 15.08.2011.

SCALE (at A3) Not To Scale

PROJECT: 107661001
DATE: 23 SEP 2011
DRAWN: KB
CHECKED: CRA

FIGURE 8



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6.0 CONCEPTUAL DESIGN RESULTS

This section presents the results of the conceptual design of the storm water diversion channel, the culverts and the energy dissipation basin for the Project conditions.

6.1 Stormwater Diversion Channels

Open channel drop structures are shown for Reaches 1, 2 and 3 to reduce the channel flow velocity of the runoff during the 100 year ARI peak flow event. The runoff in Reaches 4a and 4b have channel velocity exceeding 2.1 m/s during the 100 year ARI peak flow event. Reaches 4a and 4b are designed as gabion mattress lined channels due to civil site layout constraints and the higher flow velocity. Table 6 summarises the design parameters for each of the channel reaches.

Table 6: Storm Water Channel Design Summary

Design	Channel Reach					
	1	2	3	4A	4B	4C
Channel Lining	Earthen Vegetated	Earthen Vegetated	Earthen Vegetated	Gabion Mattress	Gabion Mattress	Earthen Vegetated
Channel Width (m)	3	10	11	11	11	11
Channel Side Slope (H:V)	3:1	3:1	3:1	2:1	2:1	3:1 and 2:1
Channel Length (m)	180	700	90	160	220	250
Drain Slope (%)	0.55	0.36	0.5	0.63	4.8	0.5
Peak Flow (m ³ /s)	21	45	46	55	55	55
Flow Depth (m)	1.40	1.6	1.4	1.5	0.86	1.4
Flow Velocity (m/s)	1.9	1.9	2.1	2.6	5.1	2.1
Top width + 0.3 m Freeboard (m)	13.2	21.4	21.3	18.3	15.6	23

Figure 5 shows the location of channel reaches and the offsite catchment boundaries that will report runoff to the channel reaches.

Figure 9 shows the conceptual design of the channel sections.

6.2 Culvert Design

The conceptual design includes four culverts to convey runoff under roadway crossings. The location of the four culvert crossings are shown in Figure 5. Table 7 summarises the conceptual designs for the four culverts.

Table 7: Culvert Design Summary

Culvert	Swaffers Rd	Lipson Cove	Lipson Cove East	Roger's Beach Public Access Road
Design Storm ARI (year)	100	100	100	10
Design Flow (m ³ /s)	46	19	5.5	16
Type	Box	Box	Box	Box
Material	Concrete	Concrete	Concrete	Concrete
Inlet Type	Slope-Tapered	Conventional	Conventional	Conventional
Span	1800	1800	1800	1500
Rise	1500	1800	1500	900
No. of Barrels	5	3	1	5
Overtopping (100 Year ARI)	No	No	No	Yes



The Roger’s Beach Public Access Road culverts are sized to convey the 10 year ARI peak flow event under the access road. The access road is designed to overtop during storm events greater than the 10 year ARI storm event. The overtopping of the access road is intended to allow the smaller, more frequent storm events to pass under the road while the larger, less frequent storm events will overtop the road. This concept is incorporated into the conceptual design on the basis of minimising the Public Access Road grading and embankment height.

6.3 Open Channel Drop Structures

The conceptual design of the open channel drop structures are summarised in Table 8.

Table 8: Open Channel Drop Structure Design Summary

Design	Value
Design Storm ARI (year)	100
h_0 (m)	0.9
LB (L1 + L2) (m)	12

A typical section and profile of the conceptual design is shown in Figure 9.

6.4 Energy Dissipation Basin Design

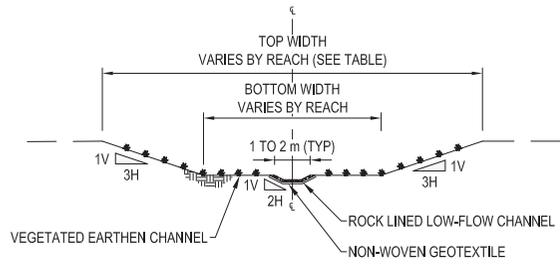
The conceptual design of the free jump energy dissipation basin is summarised in Table 9.

Table 9: Energy Dissipation Basin Design Summary

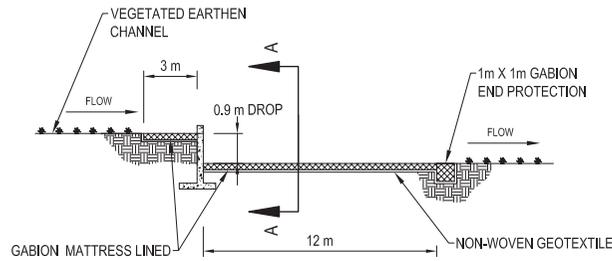
Design	Value
Design Storm ARI (year)	100
Design Flow (m^3/s)	56
Material	Gabion mattress
y_2 conjugate depth (m)	2
Tail water depth (m)	1.5
Basin Length L_b (m)	12
S_s	0.5
Basin depth (m)	0.6

A typical profile of the conceptual design is shown in Figure 9.

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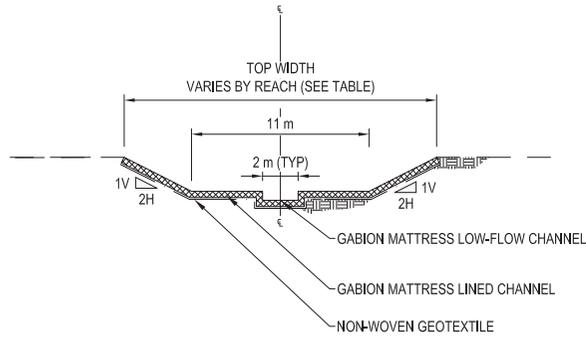
REACHES 1, 2 AND 3 (NTS)



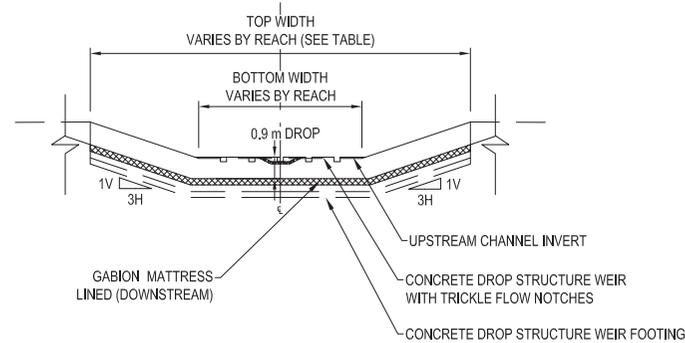
PROFILE VIEW (NTS)

LEGEND

- EARTH
- RENO MATTRESS OR GABION
- CONCRETE
- VEGETATED CHANNEL
- ROCK RIP RAP

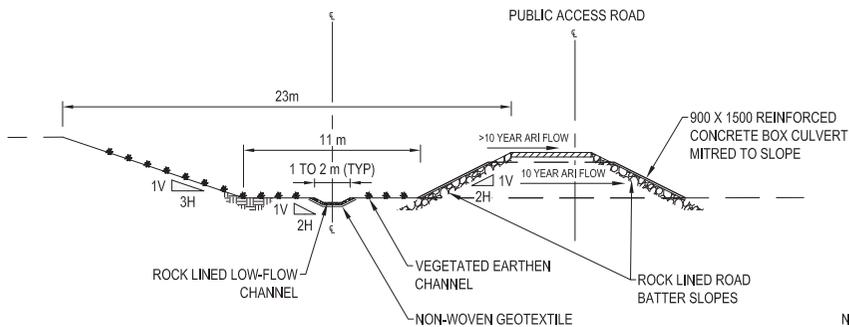


REACHES 4A AND 4B (NTS)



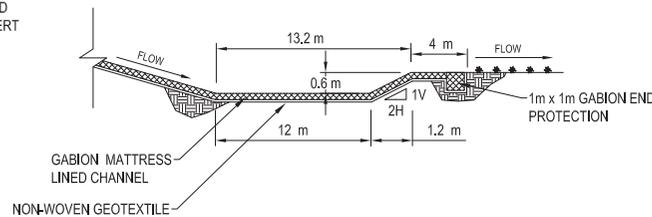
SECTION A-A (NTS)

TYPICAL OPEN CHANNEL DROP STRUCTURE



REACH 4C (NTS)

TYPICAL OPEN CHANNEL SECTIONS BY REACH



FREE JUMP ENERGY DISSIPATION BASIN (NTS)

CHANNEL REACH	BOTTOM WIDTH (m)	TOP WIDTH (m)	CHANNEL LINING
1	3	13.2	VEGETATED EARTHEN
2	10	21.4	VEGETATED EARTHEN
3	11	21.4	VEGETATED EARTHEN
4A	11	18.3	GABION MATTRESS
4B	11	15.6	GABION MATTRESS
4C	11	23.0	VEGETATED EARTHEN

PRELIMINARY
NOT FOR CONSTRUCTION

<p>www.golder.com GOLDER ASSOCIATES PTY. LTD.</p>	CLIENT: CENTREX METALS LTD		PROJECT: PORT SPENCER - SURFACE WATER				
	DRAWN BY: DDW	DATE: 23/09/2011	DRAWING TITLE: TYPICAL SECTIONS CONCEPTUAL DESIGN FOR PROPOSED CONDITIONS				
	CHECKED BY: CRA	DATE: 23/09/2011					
SCALE: NTS	SHEET SIZE: A3	PROJECT NO: 107661001	DOC NO: 077	DOC TYPE: R	FIGURE NO: F0009	REVISION: 0	FIGURE 9



7.0 DISCUSSION

Golder has undertaken a conceptual level hydrologic analysis and design for the Project conditions. This work includes existing conditions surface water site visit, desktop review of stormwater regulatory and management guidelines, existing and proposed conditions hydrology analysis and conceptual design for offsite diversion channels and an extended detention basin for the Project.

7.1 Site Visit

Golder visited the Project site on 27 February 2011 with Centrex personnel. Photographs and site observations are included in Appendix A.

Existing land use in the Sheep Hill catchment consists of a mix of agricultural wheat fields, fallow paddock, grazing and undeveloped land use. The site visit and desktop analysis show that the Project will decrease the amount of surface water runoff. No standing water or groundwater seepage was observed during the site visit or during prior Golder site visits.

The existing catchments outfall to a low, flat zone before Roger's Beach. Storm runoff diffuses into flat, overland flow and subsequently outfalls to Roger's Beach at three distinct locations. The flat zone shows evidence of sedimentation associated with shallow and low velocity overland flow. Golder (2009b) names and describes the flat zone as Zone B.

7.2 Stormwater Management

The review of water quality and stormwater management regulations and practices is limited to surface water associated with the Port. The Act and the Policy are the legislative authority and policy documents applicable to the site. The review summarises and makes recommendations for the construction and operation of the Project.

The Act lists the following activities as environmentally significant with regards to surface water and water quality analogous to the proposed Port facility: petroleum and chemical storage and warehouse facilities and material handling and transportation (agricultural and extractive industry).

7.2.1 Construction Guidelines and Measures

Water quality and construction best management practices are contained in the *Code of Practice for the Building and Construction Industry* (EPA, 1999). The Project falls under the Building and Construction Industry category. The construction of the marine port will follow the guidelines in the *Code of Practice for the Building and Construction Industry*. Additionally, construction contractors will be required to engage a certified Environmental Management System compliant with ISO 14001:2004 and to develop a Construction Environmental Management and Monitoring Plan. The following strategy and practices are recommended:

- Early construction and stabilisation of offsite catchment diversion channels and extended detention pond.
- Removal and stockpiling topsoil for revegetation.
- Early revegetation of cut slopes and earthen channel.
- Control of erosion and sediment.
- Management of non storm water discharge and materials stored and used onsite.



7.2.2 Development and Operation

The Project development and storm water management will include the following:

- WSUD
- Extended detention basin and additional onsite stormwater retention reservoir sized for 100 year storm event will be operated for storm water detention
- Operational environmental monitoring and management plan.

Operation and maintenance of the Project will incorporate a port management company responsible for operations, management and maintenance.

Operation and maintenance of the diversion and flood control channels will include the following:

- Maintain vegetation and/or channel stabilization for erosion and sediment control
- Sediment control at energy dissipation basin/sediment trap
- Remove sediment from channels on regular basis.

7.3 Hydrology Analysis and Conceptual Design

A conceptual level hydrology analysis was performed for the existing and proposed conditions.

7.3.1 Hydrology Analysis

The results of the hydrology analysis for the 100 year ARI for proposed and existing conditions shows a reduction in peak runoff rate from 68 m³/s to 56 m³/s, respectively. The total runoff volume decreased from 304 ML to 251 ML from existing to proposed conditions, respectively. This difference results from the isolation of the Project catchment area runoff.

7.3.2 Conceptual Design Stormwater Facilities

Conceptual level design of storm water facilities are performed for the 100 year ARI. The results of the hydrology analysis are used for the conceptual design. The design incorporates preliminary site development features provided by Centrex and Parsons Brinckerhoff.

An important aspect of the conceptual design is the outfall to the flat zone prior to Roger's Beach. This concept mimics the existing condition drainage pattern at this location. This concept will promote the distribution of storm runoff to Roger's Beach in the same manner as existing conditions. This will also mimic the sedimentation and groundwater interaction at this location.

The diversion and flood control channels diverting runoff around the Project site emphasise low velocity design where feasible. Low velocity flow is utilised in Reaches 1, 2 and 3 using open channel drop structures to decrease the slope of the channels. The resulting design allows for the use of vegetated earthen channels.

A reinforced channel is designed using gabion mattress reinforcement where channel slopes, high flow velocities and site civil constraints dictated a reinforced channel. Energy dissipation is achieved using a free jump energy dissipation basin design.

The design concept at the outfall to the flat zone prior to Roger's Beach incorporates a low velocity earthen vegetated channel parallel to the Roger's Beach Public Access Road.



The energy dissipation basin and the low velocity channel in Channel Reach 4c next to the public access road can allow for sediment to settle out from the smaller and more frequent storm events and be removed as part of the Project management and operation.

Figure 5 and Figure 9 show the conceptual design of storm water runoff facilities.

The Project stormwater runoff management will be managed and mitigated with the 136 ML extended detention basin. The extended detention basin will be operated in conjunction with stormwater reservoirs at the site. This will allow the extended detention basin to be drained within 72 hours of a storm event allowing the basin to maximise storage capacity to mitigate the capture and detention of storm runoff.



8.0 LIMITATIONS

Your attention is drawn to the document – “Limitations”, which is attached to this report in Appendix D. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.



9.0 REFERENCES

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Report Signature Page

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APPENDIX A

Site Visit Photograph Log, Notes and Map



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4055.jpg	Date:	10/02/2011 10:12	
Desc:					Slide:	1
Site 1: Facing south-east towards the ocean. Four wheel drive road accessing the coast. Fence showing boundaries of Centrex property. Ground cover approximately 70%. Vegetation in foreground and right consists of small ground hugging shrubs and grasses. Vegetation to left is agriculture wheat.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4056.jpg	Date:	10/02/2011 10:12	
Desc:					Slide:	2
Site 1: Facing north into Centrex property (boundary is marked by fence). Agricultural use. Ground cover ~80%.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4057.jpg	Date:	10/02/2011 10:13
Desc:				Slide:	3
Site 1: Facing north-west, showing Lipson Cove Road that runs along the southern side of the Centrex property. Catchment extends to hills in background.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4058.jpg	Date:	10/02/2011 10:13
Desc:				Slide:	4
Site 1: Facing south-west across Lipson Cove Road. Photo displaying property adjoining the Centrex property, separated by the public access four wheel drive road. Agricultural land use.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4059.jpg	Date:	10/02/2011 10:13	
Desc:					Slide:	5
Site 1: Facing south-east towards the ocean. Lipson Island in right background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4060.jpg	Date:	10/02/2011 10:14	
Desc:					Slide:	6
Site 1: Facing south. Lipson Cove Road leads to camping grounds.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4061.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	7
Site 2: Facing north-east towards beach. Fallow agriculture use in foreground. Ground cover is ~90%. Roger's Beach in middle of view is the outfall of catchment to marine environment.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4062.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	8
Site 2: Facing north-west. Fallow agricultural use in foreground.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4063.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	9
Site 2: Facing north-west. Land in foreground and middle of frame is in Centrex project boundary. Fallow agricultural land use. Public access earthen road to Roger's Beach and farm in middle of frame. Existing drainage in middle of frame and background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4064.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	10
Site 2: Facing west. Drainage feature in right of frame. Fallow agricultural use. Middle of frame is the majority of Centrex land where project is proposed.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4065.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	11
Site 2: Facing south-west. South-western portion of Centrex property. Main catchment drainage course is shown in middle left of frame. Fallow agricultural use.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4066.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	12
Site 2: Facing south south-west back towards Lipson Cove Road. Fallow agricultural use. ~90% ground cover.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4067.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	13
Site 2: Facing south. Same as Slide 12.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4068.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	14
Site 2: Facing south.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4069.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	15
Site 2: Facing south.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4070.jpg	Date:	10/02/2011 10:46	
Desc:					Slide:	16
Site 2: Facing south-east.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4071.jpg	Date:	10/02/2011 10:47	
Desc:					Slide:	17
Site 2: Facing east. Approximate location of proposed jetty.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4072.jpg	Date:	10/02/2011 10:47	
Desc:					Slide:	18
Site 2: Facing north-east. Roger's Beach in left of frame.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4073.jpg	Date:	10/02/2011 10:47	
Desc:					Slide:	19
Site 2: Same as Slide 7.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4074.jpg	Date:	10/02/2011 10:55	
Desc:					Slide:	20
Site 3: Facing east. Roger's Beach located in far left corner. Top of hill near where proposed pier to be constructed. 80% vegetation cover. Ground rocky.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4075.jpg	Date:	10/02/2011 10:55	
Desc:					Slide:	21
Site 3: Facing north towards Roger's Beach.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4076.jpg	Date:	10/02/2011 11:03	
Desc:					Slide:	22
Site 3: Facing south. Location of proposed jetty. A few large rocks/boulders. Ground vegetation cover 65%. Centrex weather station in right background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4077.jpg	Date:	10/02/2011 11:03	
Desc:					Slide:	23
Site 4: Facing north. Native vegetation. ~70% ground cover.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4078.jpg	Date:	10/02/2011 11:03	
Desc:					Slide:	24
Site 4: Facing west. Exposed rock.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4079.jpg	Date:	10/02/2011 11:03	
Desc:					Slide:	25
Site 4: Facing south-west. Looking uphill. Exposed rock and ~70% natural vegetation cover.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4080.jpg	Date:	10/02/2011 11:35	
Desc:					Slide:	26
Site 5: Facing west. Edge of beach at interface with the low, flat area at bottom of catchment. Mostly flat. Sandy clay like soil to sandy beach. Signs of head cutting and scouring at beach/flat area interface. No definable channel except at beach interface. Flat area in middle of frame shows signs of sediment deposition indicative of shallow, low velocity flow. Vegetation cover is sparse scrubs and grass ~40%.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4081.jpg	Date:	10/02/2011 11:35	
Desc:					Slide:	27
Site 5: Facing south-west. View of fence separating Roger's Beach and Centrex property. Middle foreground is drainage area from catchment to beach.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4082.jpg	Date:	10/02/2011 11:36	
Desc:					Slide:	28
Site 5: Facing south-west away from beach. Flat area at bottom of catchment. Same observations as Slide 26.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4083.jpg	Date:	10/02/2011 11:36	
Desc:					Slide:	29
Site 5: Facing south-west away from beach. Flat area at bottom of catchment. Same observations as Slide 26.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4084.jpg	Date:	10/02/2011 11:36	
Desc:					Slide:	30
Site 5: Facing south. Flat area at bottom of catchment. Same observations as Slide 26. Photograph Site 2 in middle background of slide.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4085.jpg	Date:	10/02/2011 11:36	
Desc:					Slide:	31
Site 5: Facing south-west towards Centrex property. Flat area drainage point to Roger's Beach. Flat area at bottom of catchment. Signs of sediment deposition in flat area. Vegetation cover in flat area is shrubs and grass ~70% cover. Head cutting and erosion at interface with beach.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4086.jpg	Date:	10/02/2011 11:39	
Desc:					Slide:	32
Site 5: Facing north-west. View along fence. Farm house in distance. Dense ground cover in left foreground. Beach dunes to right.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4087.jpg	Date:	10/02/2011 11:39	
Desc:					Slide:	33
<p>Site 5: Facing west. Vegetation ground ~60% cover in middle of frame. Grasses, shrubs, larger bushes in background. Large flat area where catchment runoff spreads out into shallow overland flow. Signs of sediment deposition associated with shallow, low velocity runoff.</p>						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4088.jpg	Date:	10/02/2011 11:39	
Desc:					Slide:	34
<p>Site 5: Facing west. Same observations as Slide 33.</p>						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4089.jpg	Date:	10/02/2011 11:40	
Desc:					Slide:	35
Site 5: Facing south-west back up catchment.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4090.jpg	Date:	10/02/2011 11:40	
Desc:					Slide:	36
Site 5: Facing south. Same as Slide 26.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4091.jpg	Date:	10/02/2011 11:40	
Desc:					Slide:	37
<p>Site 6: Facing west. Edge of beach at interface with the low, flat area at bottom of catchment. Mostly flat. Sandy clay like soil to sandy beach. Signs of head cutting and scouring at beach/flat area interface. No definable channel except at beach interface. Flat area in middle of frame shows signs of sediment deposition indicative of shallow, low velocity flow. Vegetation cover is sparse shrubs and grass ~40%. This is 2 of 3 distinct runoff discharge locations to Roger's Beach.</p>						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4092.jpg	Date:	10/02/2011 11:48	
Desc:					Slide:	38
<p>Site 6 - Second beach runoff channel. Flat to slight slope. Slight discharge to beach. 30 cm topsoil layer is silty clay sand, 50 cm consolidated sandstone. Farmer has dumped cars, appliances, sheets of steel on land right next to beach. Scouring at beach/land interface, head cutting, erosion.</p>						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4093.jpg	Date:	10/02/2011 11:48	
Desc:					Slide:	39
Site 6: Facing north-west. More rubbish piles.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4094.jpg	Date:	10/02/2011 11:49	
Desc:					Slide:	40
Site 6: Facing west. Interface of low flat area and runoff discharge to beach. Low area in middle of frame shows ~85% vegetation cover and signs of shallow overland flow. Runoff concentrates at discharge point to beach in foreground.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4095.jpg	Date:	10/02/2011 11:49	
Desc:					Slide:	41
Site 6: Facing north-west. Interface of low flat area and runoff discharge to beach. Same location as Slide 40.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4096.jpg	Date:	10/02/2011 11:50	
Desc:					Slide:	42
Site 6: Facing east. Runoff drainage course from low flat zone to Roger's Beach. Same location as Slide 40. Note sediment deposition over beach sand.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4097.jpg	Date:	10/02/2011 11:57	
Desc:					Slide:	43
Site 7: Facing north. 3 of 3 distinct discharge locations to Roger's Beach. Drainage course behind dunes.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4098.jpg	Date:	10/02/2011 11:57	
Desc:					Slide:	44
Site 7: Facing south-west. 3 of 3 distinct discharge locations to Roger's Beach. Same location as Slide 43. Transition from low, flat area at bottom of catchment to drainage course shown in Slide 43.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4099.jpg	Date:	10/02/2011 12:00
Desc:				Slide:	45
Site 7: Facing north. 3 of 3 distinct discharge locations to Roger's Beach. Drainage course behind dunes. Bottom of drainage course shown in Slide 43. Location is used for vehicle access to Roger's Beach.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4100.jpg	Date:	10/02/2011 12:00
Desc:				Slide:	46
Site 7: Facing south-west. Location is used for vehicle access to Roger's Beach. Same location as Slide 45.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4101.jpg	Date:	10/02/2011 12:00	
Desc:					Slide:	47
Site 7: Facing south. Location is used for vehicle access to Roger's Beach. Same location as Slide 46.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4102.jpg	Date:	10/02/2011 12:05	
Desc:					Slide:	48
Site 8: Facing north. Public and farm access dirt road. Low, flat area is the conjunction of site sub-catchments prior to discharging to Roger's Beach. Ground cover is ~85%. Note signs of sediment deposition associated with shallow, low velocity runoff.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4103.jpg	Date:	10/02/2011 12:05	
Desc:					Slide:	49
Site 8: Facing east. Same location as Slide 48. Looking towards Photograph Site 5. Low, flat area is the conjunction of site sub-catchments prior to discharging to Roger's Beach. Ground cover is ~60%. Note signs of sediment deposition associated with shallow, low velocity runoff.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4104.jpg	Date:	10/02/2011 12:05	
Desc:					Slide:	50
Site 8: Facing south. Same location as Slide 48. Looking towards Photograph Site 5. Low, flat area is the conjunction of site sub-catchments prior to discharging to Roger's Beach. Ground cover is ~60%. Note signs of sediment deposition associated with shallow, low velocity runoff.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4105.jpg	Date:	10/02/2011 12:05	
Desc:					Slide:	51
Site 8: Facing west. Same location as Slide 48. Looking towards earthen beach and farm access road. Low, flat area is the conjunction of site sub-catchments prior to discharging to Roger's Beach. Ground cover is ~60%. Note signs of sediment deposition associated with shallow, low velocity runoff.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4106.jpg	Date:	10/02/2011 12:11	
Desc:					Slide:	52
Site 9: Facing west. Runoff drainage course through fallow agricultural field. This is the northern portion of the Centrex site. Wide, shallow flow pattern with loose soil. Foreground is the graded shoulder of the earthen farm and public access road. Note the silty, sandy clayey nature of soil.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4107.jpg	Date:	10/02/2011 12:11
Desc:				Slide:	53
Site 9: Facing south along the earthen farm and public access road towards Lipson Cove Road. Same location as Slide 52. The main catchment drainage course is middle, right of frame.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4108.jpg	Date:	10/02/2011 12:13
Desc:				Slide:	54
Site 9: Facing south along the earthen farm and public access road towards Lipson Cove Road. Same location as Slide 52. The main catchment drainage course is middle of frame.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4109.jpg	Date:	10/02/2011 12:16	
Desc:					Slide:	55
Site 10: Facing south-west up the main catchment drainage course. Wide, shallow drainage with established vegetation. Does not show the erosion or sediment deposition of the drainage course in Slide 52. Lipson Cove Road is in background. Vegetation cover is low grass, shrubs ~80%.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4110.jpg	Date:	10/02/2011 12:16	
Desc:					Slide:	56
Site 10: Facing north-east down the main catchment drainage course. Same observations as Slide 55. Roger's Beach and low, flat area in background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4111.jpg	Date:	10/02/2011 12:24
Desc:				Slide:	57
Site 11: Facing north-west up the main catchment drainage course. Drainage course through fallow agricultural field west of Centrex property. A drainage bund has been graded through the field. Wide, shallow drainage. Dense vegetation cover.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4112.jpg	Date:	10/02/2011 12:25
Desc:				Slide:	58
Site 11: Facing south. Looking back onto Centrex property. Same location as Slide 57. Road is boundary of west side Centrex property. Note small drainage conveyance under fence in centre foreground of frame.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4113.jpg	Date:	10/02/2011 12:28
Desc:				Slide:	59
Site 11: Facing north-west. Offsite Drainage - about 100 m west of Slide 57 along the drainage bund through the agricultural field. Consolidated soil, streambed mostly bare, weeds, channel 50% vegetated. Wheat growing next to stream bed. 20 m upstream is a rock check dam. Some minor scour, pretty stable conveyance. About 2 cm of loose material in bottom of channel. Channel cross-section measured: 4 m top width, 55 cm depth. slope -0.013.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4114.jpg	Date:	10/02/2011 12:28
Desc:				Slide:	60
Site 11: Facing south. Same location as Slide 59. Looking back towards Centrex property.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4115.jpg	Date:	10/02/2011 12:29	
Desc:					Slide:	61
Site 11: Looking down at drainage conveyance. Same location as Slide 60. Clayey, silty sand. Some loose soil on top, otherwise consolidated.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4116.jpg	Date:	10/02/2011 12:43	
Desc:					Slide:	62
Site 12: Facing west. Small offsite drainage. No real stream channel. Fallow wheat field. Fence showing border of Centrex property. Note head cutting at centre of frame where runoff comes off field under fence.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4117.jpg	Date:	10/02/2011 12:43	
Desc:					Slide:	63
Site 12: Facing east. Same location as Slide 62. Looking downstream onto Centrex property. Broad, shallow drainage with signs of sediment deposition.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4118.jpg	Date:	10/02/2011 12:47	
Desc:					Slide:	64
Site 13: Facing north-west. Facing fence separating Centrex property and wheat field. Very mild slope. Mostly bare loose soil at top. Sediment in bottom of dry stream bed. Consolidated earth on side of ditch downstream. Head cutting at wheat field where runoff comes off the field.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4119.jpg	Date:	10/02/2011 12:48	
Desc:					Slide:	65
Site 10: Facing south-east. Same location as Slide 64. Looking downstream onto Centrex property. Measured cross-section of drainage course: Top width 3 m, depth about 15 cm. Very little loose soil. Consolidated silty, sandy-clayey. Low flat area and Roger's Beach in left background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4120.jpg	Date:	10/02/2011 13:03	
Desc:					Slide:	66
Site 13: Facing south-east. Same location as Slide 64. Looking downstream onto Centrex property. Measured cross-section of drainage course: Top width 3m, depth about 15cm. Very little loose soil. Consolidated silty, sandy-clayey. Low flat area and Roger's Beach in left background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4121.jpg	Date:	10/02/2011 13:04	
Desc:					Slide:	67
Site 14: Facing south. Lipson Cove Road. Fallow agricultural field.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4122.jpg	Date:	10/02/2011 13:04	
Desc:					Slide:	68
Site 14: Facing south-west. Lipson Cove Road. Fallow agricultural field. Possible catchment area that would flow onto Centrex property. Same location as Slide 67.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4123.jpg	Date:	10/02/2011 13:04
Desc:				Slide:	69
Site 14: Facing south-west. Lipson Cove Road. Fallow agricultural field. Possible catchment area that would flow onto Centrex property. Same location as Slide 67. This appears to be a low point that would cross Lipson Cove Road onto Centrex property.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4124.jpg	Date:	10/02/2011 13:04
Desc:				Slide:	70
Site 14: Facing west. Lipson Cove Road. Fallow agricultural field. Possible catchment area that would flow onto Centrex property. Same location as Slide 67.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4125.jpg	Date:	10/02/2011 13:04	
Desc:					Slide:	71
Site 14: Facing west. Lipson Cove Road. Same location as Slide 67.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4126.jpg	Date:	10/02/2011 13:15	
Desc:					Slide:	72
Site 15: Facing east. Top of Swaffers Road. Looking down catchment towards ocean. This is the top of the catchment. Fallow agricultural fields and undeveloped hills. Vegetation cover is grass ~90%.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4127.jpg	Date:	10/02/2011 13:16
Desc:				Slide:	73
Site 16: Facing south-east. Top portion of Swaffer Road. Looking down catchment towards ocean. Undeveloped hills. Vegetation cover is grass ~90%. Trees in background are location of farmhouse.					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4128.jpg	Date:	10/02/2011 13:18
Desc:				Slide:	74
Site 17: Facing north-west. Culvert of unknown size under farmhouse access road. Lots of debris (bushes, cut up timber).					



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4129.jpg	Date:	10/02/2011 13:19	
Desc:					Slide:	75
Site 17: Facing north-west. Looking up catchment towards top of Swaffers Road. Wide v-shaped drainage course with stable vegetation and no major erosion.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4130.jpg	Date:	10/02/2011 13:23	
Desc:					Slide:	76
Site 18: Facing north-west towards top of catchment along Swaffers Road. Large drainage course, very incised with signs of erosion on banks. Stable vegetation on bottom of channel.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4131.jpg	Date:	10/02/2011 13:23	
Desc:					Slide:	77
Site 18: Facing south-east down catchment along Swaffers Road. Same location as Slide 76. Large drainage course, very incised with signs of erosion on banks. Stable vegetation on bottom of channel. Farmhouse in background.						



Title:	Centrex Sheep Hill Site Visit	File:	IMG_4132.jpg	Date:	10/02/2011 13:26	
Desc:					Slide:	78
Site 18: Facing north-west towards top of catchment along Swaffers Road. A bit upstream from location in Slide 76. Drainage course less incised with fewer signs of erosion on banks. Stable vegetation on bottom of channel.						

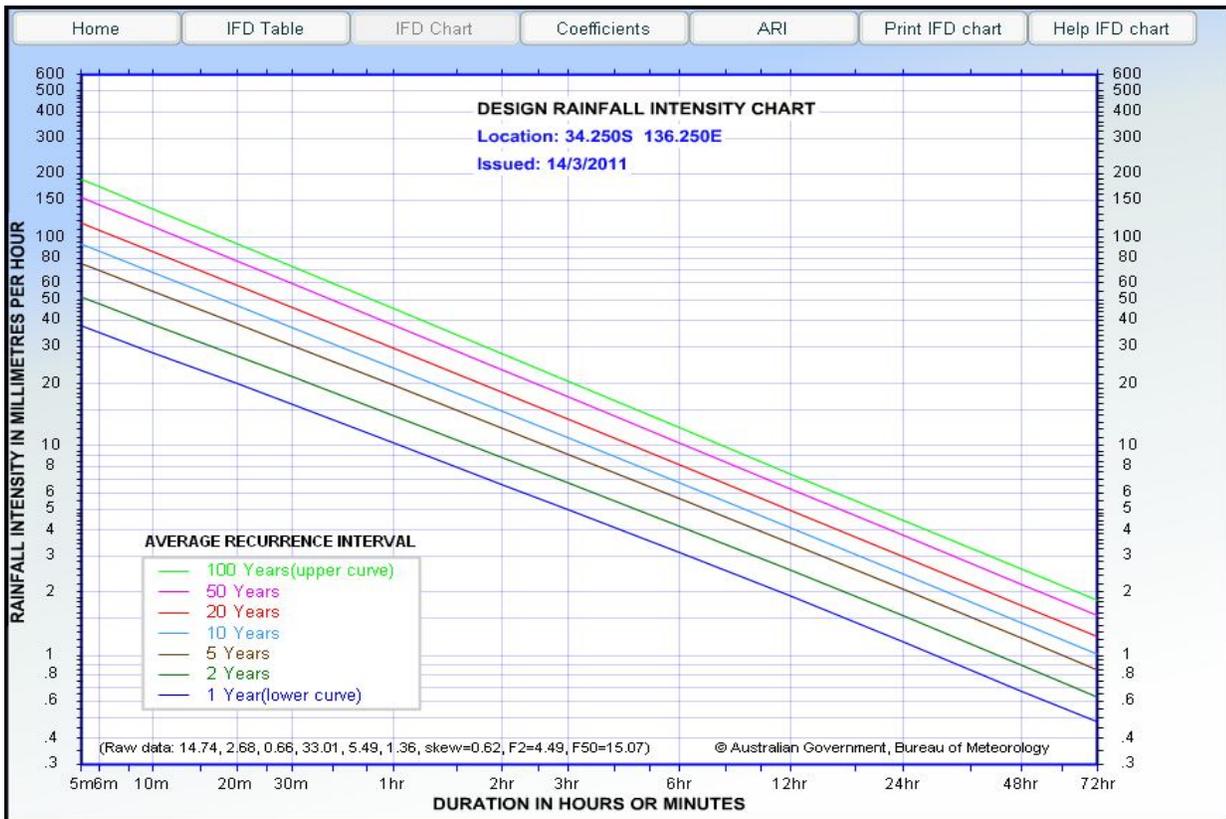




APPENDIX B

Bureau of Meteorology Intensity-Duration-Frequency Data for Sheep Hill

DURATION	1 Year	2 years	5 years	10 years	20 years	50 years	100 years
5Mins	37.7	51.7	74.8	92.6	117	155	189
6Mins	35	48	69.4	85.8	108	143	175
10Mins	28.1	38.4	55.2	68	85.6	113	137
20Mins	20	27.1	38.6	47.2	59.1	77.3	93.5
30Mins	15.9	21.6	30.4	37.1	46.3	60.3	72.7
1Hr	10.4	14	19.6	23.7	29.4	38	45.6
2Hrs	6.55	8.83	12.2	14.7	18.1	23.2	27.7
3Hrs	4.99	6.69	9.17	11	13.5	17.3	20.5
6Hrs	3.11	4.15	5.62	6.69	8.16	10.4	12.3
12Hrs	1.92	2.56	3.44	4.07	4.94	6.25	7.37
24Hrs	1.16	1.55	2.08	2.45	2.97	3.76	4.43
48Hrs	0.672	0.898	1.21	1.43	1.73	2.19	2.59
72Hrs	0.48	0.631	0.85	1.01	1.23	1.55	1.83





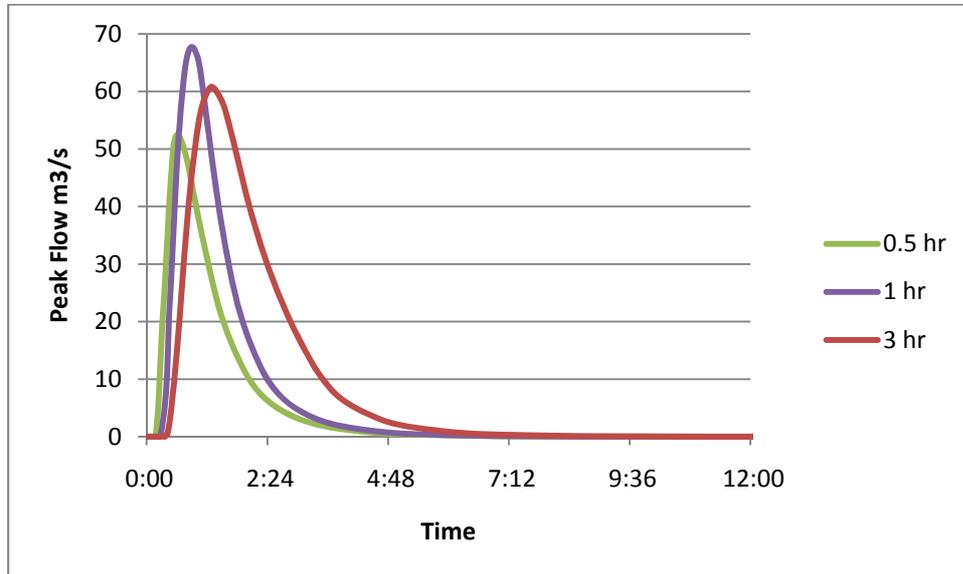
APPENDIX C

XP-SWMM Results Summary and Hydrographs

XP-RAFTS RESULTS

Existing Conditions Catchments

Existing conditions hydrographs for the 100 year ARI event are shown below.

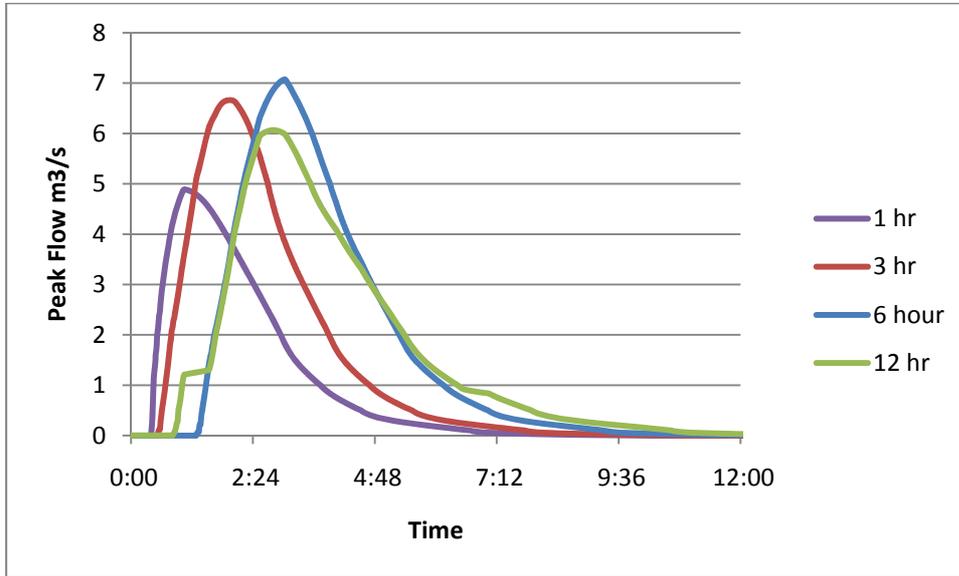


Catchments 1,2, 3 and 4; Existing Conditions 100 year ARI Hydrograph

Proposed Conditions Offsite Catchments

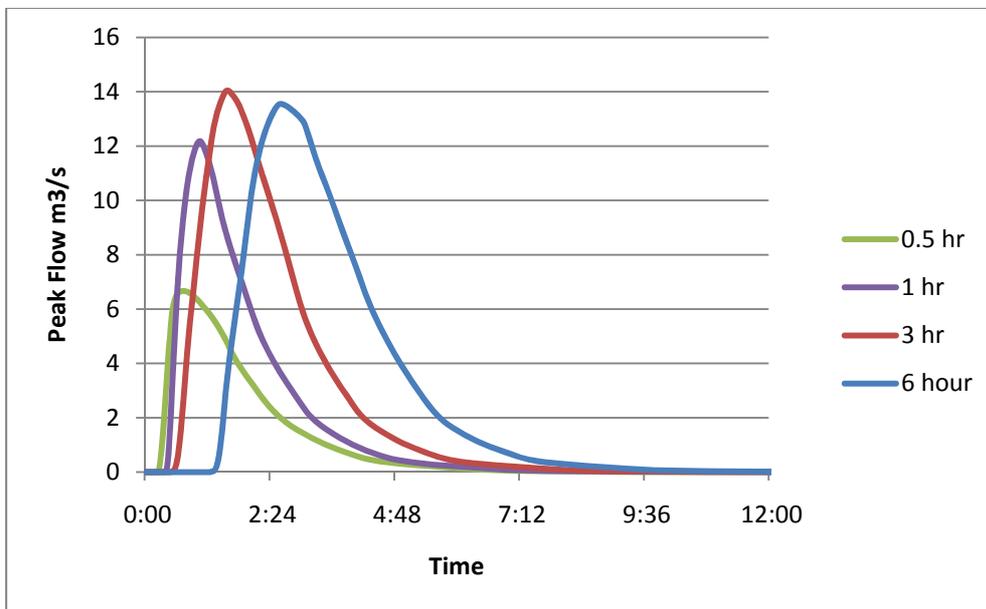
10 Year ARI Results

Hydrograph for the offsite storm water diversion Channel Reach 1 for the 10 year ARI storm durations. The 6 hour storm duration produces the maximum peak flow of 7 m³/s.



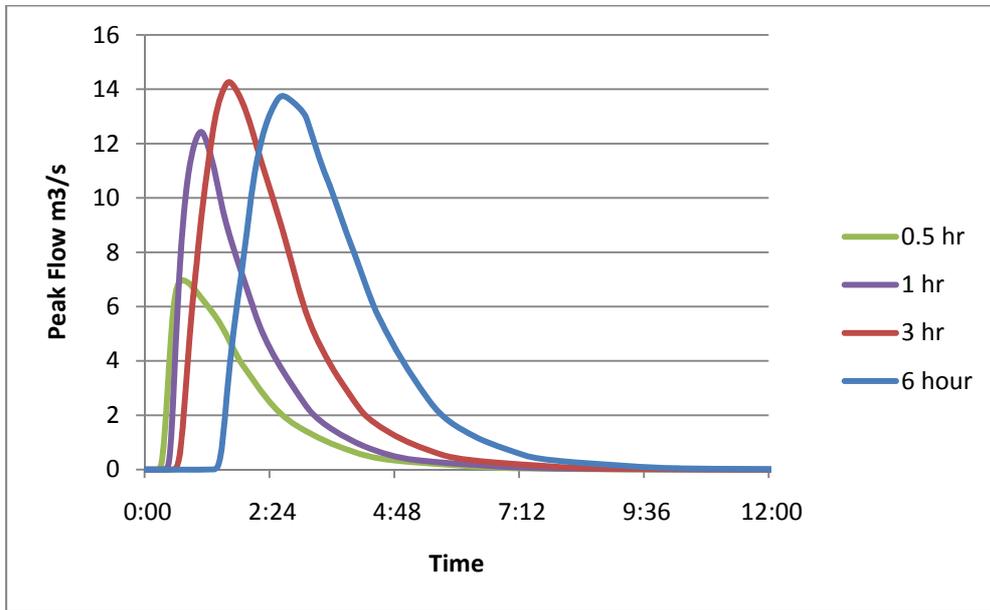
Catchment 1 and Channel Reach 1 10 year ARI Hydrographs

Hydrograph for the offsite storm water diversion Channel Reach 2 for the 10 year ARI storm durations. The 3 hour storm duration produces the maximum peak flow of 14 m³/s.



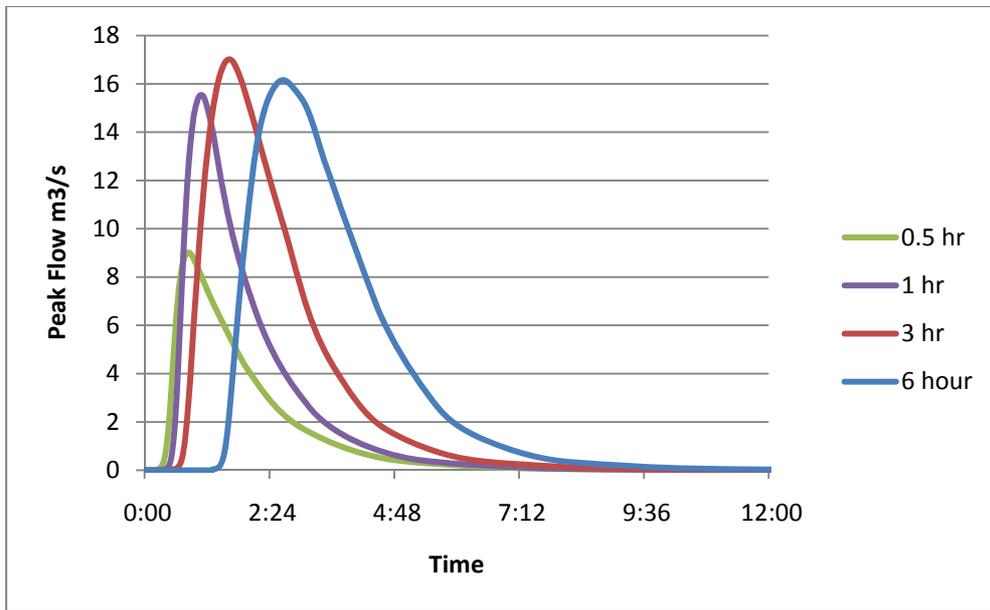
Catchments 1, 2 and 3; Channel Reach 2 10 year ARI Hydrographs

Hydrograph for the offsite storm water diversion Channel Reach 3 for the 10 year ARI storm durations. The 3 hour storm duration produces the maximum peak flow of 14.3 m³/s.



Catchments 1, 2, 3 and 4; Channel Reach 3 10 year ARI Hydrographs

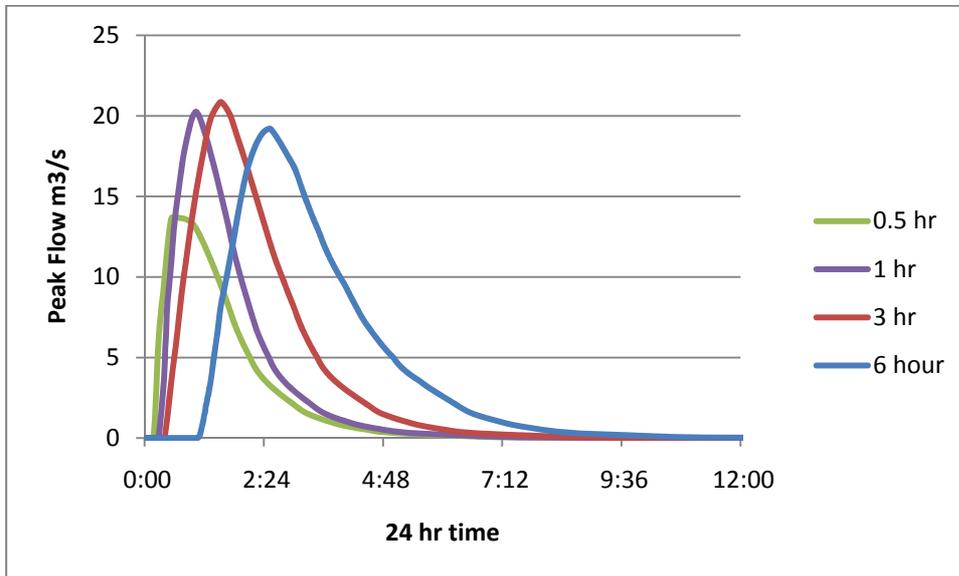
Hydrograph for the offsite storm water diversion Channel Reach 4 for the 10 year ARI storm durations. The 3 hour storm duration produces the maximum peak flow of 17 m³/s.



Catchments 1, 2, 3, 4 and 5; Channel Reach 4a to 4c 10 year ARI Hydrographs

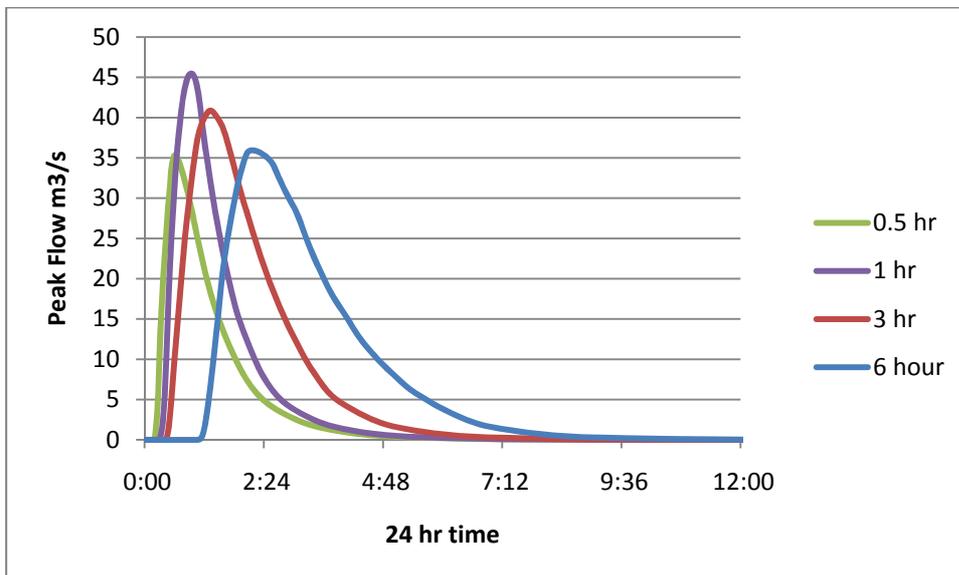
100 Year ARI Results

Hydrograph for the offsite storm water diversion Channel Reach 1 for the 100 year ARI storm durations. The 3 hour storm duration produces the maximum peak flow of 21 m³/s.



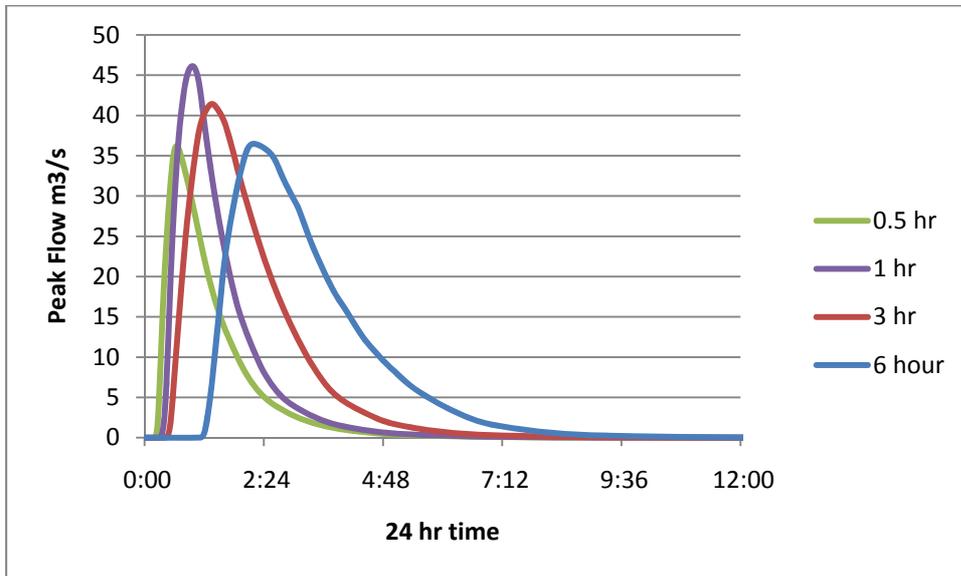
Catchment 1 and Channel Reach 1 100 year ARI Hydrographs

Hydrograph for the offsite storm water diversion Channel Reach 2 for the 100 year ARI storm durations. The 1 hour storm duration produces the maximum peak flow of 45.5 m³/s.



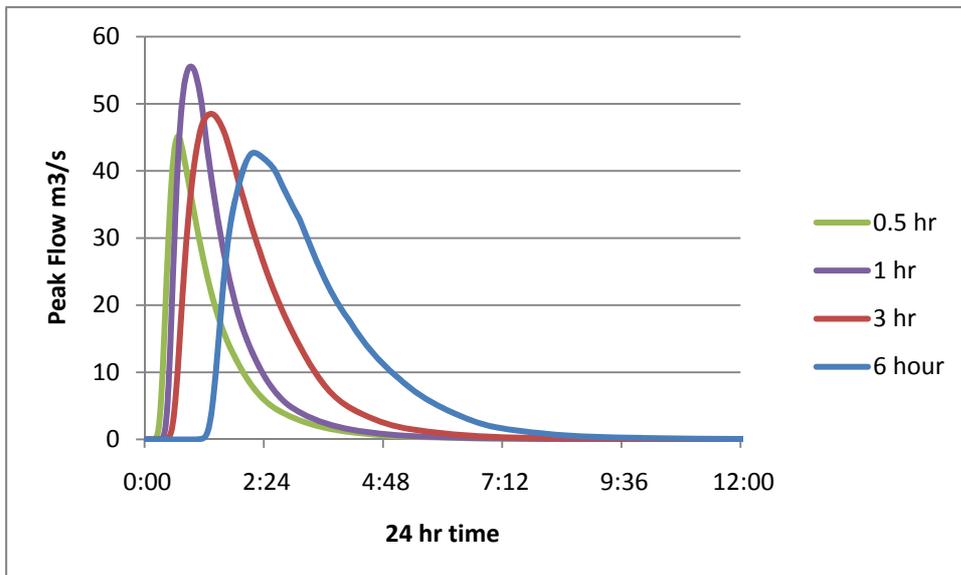
Catchments 1, 2 and 3; Channel Reach 2 100 year ARI Hydrographs

Hydrograph for the offsite storm water diversion Channel Reach 3 for the 100 year ARI storm durations. The 1 hour storm duration produces the maximum peak flow of 46 m³/s.



Catchments 1, 2, 3 and 4; Channel Reach 3 100 year ARI Hydrographs

Hydrograph for the offsite storm water diversion Channel Reach 4 for the 100 year ARI storm durations. The 1 hour storm duration produces the maximum peak flow of 56 m³/s.



Catchments 1, 2, 3, 4 and 5; Channel Reach 4a to 4c 100 year ARI Hydrographs



APPENDIX D

Limitations (LEG04, RL1)



LIMITATIONS

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