STORMWATER MANAGEMENT REPORT

FOR

192 NARELLAN ROAD (LOT 4), CAMPBELLTOWN – STAGE 1

PROJECT TITLE: 192 Narellan Road (Lot 4), Campbelltown

PROJECT NUMBER: 7663-1

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LIST OF ABBREVIATIONS

The following abbreviations are utilised in this report.

Abbreviation	Description
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Annual Recurrence Interval
ARR	Australian Rainfall & Runoff (2016)
DA	Development Application
DCP	Development Control Plan
DP	Deposited Plan
Ha	Hectare
LEP	Local Environment Plan
LGA	Local Government Area
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
OSD	Onsite Detention
PSD	Permissible Site Discharge
SMR	Stormwater Management Report
SWC	Subdivision Works Certificate
WSUD	Water Sensitive Urban Design

1. INTRODUCTION

Indesco has prepared this Stormwater Management Report (SMR) on behalf of Clearstate CamNarr192 Pty Ltd (the Proponent) in support of the development application for the proposed development of Stage 1 of 192 Narellan Road (Lot 4), Campbelltown (the Site).

The Proponent proposes to develop the Site as a Torrens Title residential subdivision as further detailed in this report.

The SMR outlines the conceptual stormwater management strategy for the proposed development and demonstrates the application of water sensitive urban design principles and compliance with Campbelltown City Council (Council) requirements.

This report should be read in conjunction with Indesco's drawing set.

2. SITE CHARACTERISTICS

2.1 SITE DETAILS

Site Address	Part of 192 Narellan Road (Lot 4), Campbelltown
Property Description	Lot 4 on DP1213869 Lot 1428 & 1429 on DP1047382

The Site is located in the Council's jurisdiction and is also within the Maryfields Precinct. As shown in Figure 1, the site is bounded by:

- The Hume Motorway to the north;
- Blair Athol to the east (residential dwellings & Maryfields Drive);
- Lot 6 on DP1213869 to the west; and
- Lots 2 & 5 on DP1213869 to the south.

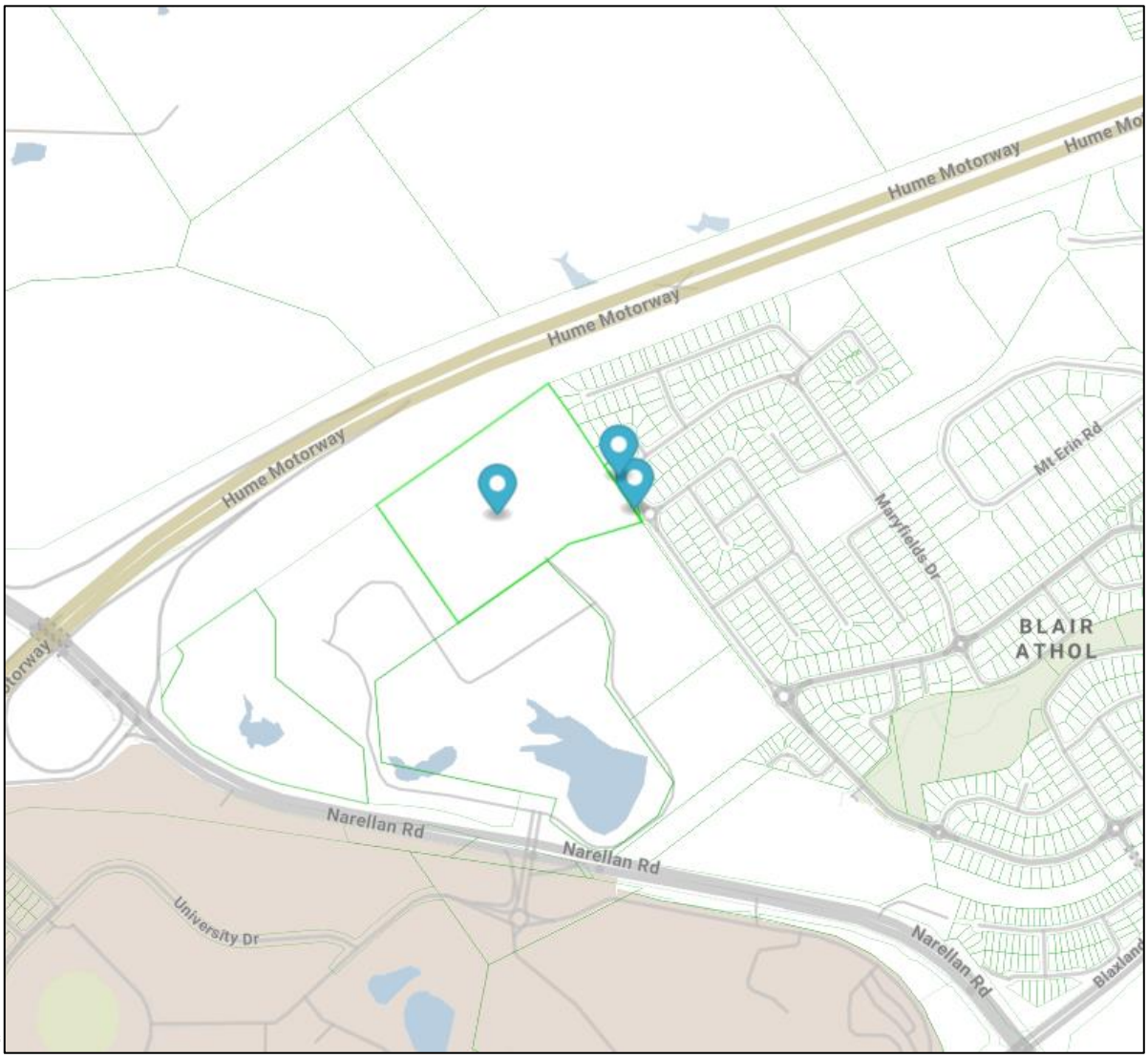

Figure 1. Locality Plan

The Site is relatively steeply graded. There is a crest that runs in a north-south direction, and a secondary crest in eastern part of the Site that runs in an east-west direction, as shown in Figure 2. An existing unnamed creek forms the western boundary of the Site.

Figure 2 - Existing Surface Contors

2.2 EXISTING STORMWATER CATCHMENT ANALYSIS

The Site is comprised by three internal catchments – the western, north-eastern and south-eastern catchments, as outlined in Indesco's engineering drawings. The south-eastern catchment is also subject to an upstream catchment, as also outlined in the engineering drawings.

3. PROPOSED DEVELOPMENT

The Site is ultimately proposed to be developed as a medium density Torrens Title residential subdivision in accordance with the Site's zoning and the subdivision plan overleaf.

Stage 1 is the subject of the current Development Application, however design of Stage 1 must consider the ultimate development to ensure that a suitable master planned stormwater strategy is adopted. The ultimate development will proceed in four (4) stages that are the subject of separate DAs.

Figure 3 - Proposed Subdivision Plan

4. COUNCIL CONTROLS

4.1 OVERVIEW

The Site is subject to the following planning and legislative controls:

- Environmental Planning and Assessment Act 1979;
- State Environmental Planning Policy (Sydney Region Growth Centres) 2006; and
- Council's Development Control Plan, including Part 13 of the DCP entitled 'Maryfields Development Control Plan'.

The Site is also subject to the following engineering controls, guidelines and reference documents:

- Council's 'Engineering Design for Development';
- 'Flood Impact assessment Report – Maryfields Development Site – 192 Narellan Road, Campbelltown' prepared by John M Daly & Associates and dated March 2015 (the 'Maryfields Precinct Flood Report') and is included in Appendix A;
- Australian Rainfall and Runoff Volumes 1 & 2;
- Water Sensitive Urban Design Technical Guidelines for Western Sydney; and
- Landcom's 'Managing Urban Stormwater Soils and Construction' (the Blue Book).

4.2 PRECINCT WATER CYCLE MANAGEMENT

The Site is within the Maryfields precinct.

While a precinct water cycle management study was not prepared as part of the Maryfields planning proposal, the Maryfields Precinct Flood Report provides guidance regarding the precinct stormwater strategy.

The outcomes of the Maryfields Precinct Flood Report are outlined hereunder as they pertain to the proposed development.

4.3 PRECINCT STAGING

The Site is within the Maryfields precinct.

Clause 13.7.2(1) of Maryfields DCP states the following:

> *Works to safeguard the long term structural stability of the main dam wall must be undertaken to the requirements of Council as part of the first stage of the development of Maryfields Estate.*

Clause 13.3 of the Maryfields DCP states the following:

> *The Maryfields Estate Masterplan contains four distinct precincts comprising the Business Park and main lake, a Heritage Park, a Seniors Housing precinct and a Residential Precinct. The precincts are to be delivered in accordance with the staging plan (Figure 13.3) to ensure orderly and economic development of the land. Variations to the staging plan may be considered if the orderly development of the overall development and associated infrastructure is not compromised.*

Please refer to Figure 4 for a copy of the Maryfields Precinct Staging Plan. The Site comprises Stage 2 and the required upgrade of the Main Dam (located in Stage 1B) was intended to precede Stage 2. Indesco note that the proposed development of Stage 1 of the Site does not affect the Main Dam whatsoever as Stage 1 is within the eastern catchment of the Site, that discharges to Blair Athol rather than to the creek and ultimately the Main Dam.

Based on the above, it is not necessary for upgrade of the Main Dam to occur prior to the proposed Stage 1 works on the Site.

Figure 4 - Maryfields Precinct Staging Plan

4.4 STORMWATER QUANTITY

Council's key objectives for stormwater quantity management are as follows:

- to limit stormwater runoff from development such that they do not exceed the pre-development rates for all storms up to and including the 1% AEP event;
- to minimise potential flooding impacts within the development;
- to ensure no adverse flooding impacts on neighbouring landholdings; and
- to ensure the proposed stormwater network is coordinated with precinct planning.

The Maryfields Precinct Flood Report includes a detailed analysis of stormwater quantity constraints that supplement and supersede the above. The report states that the following:

- '*…there is no need to provide any stormwater detention on the Tributary 1 (Indesco note - the creek) system as a result of proposed development*.'
- '*The development of the northern catchments E1 to E3 (Indesco note - catchments that fall towards Maryfields Drive) will result in increases to peak stormwater flows off those catchments and it will be necessary to provide stormwater detention in these catchments to ensure that the peak discharges from the catchments are not increased as a result of the proposed development.'*

Based on the above the following conclusions can be drawn:

- Stages 1 – 3 of development of the Site, all of which fall to the east, will require stormwater detention. It is noted that consideration of the development of off-site catchments is necessary.
- Stage 4 of development of the Site, which falls towards Tributary 1, will not require stormwater detention.

The Maryfields Precinct Flood Report doesn't include specific guidance regarding where detention infrastructure should be located, however Council indicated at the Pre-DA meeting held on 21 September 2020 that Council would only be willing to accept ownership of 1x detention basin within the Site area.

4.5 STORMWATER QUALITY

Council's design guidelines outline the following stormwater quality targets. Targets are expressed as the reduction in pollutant loads when compared to an equivalent development with no stormwater control measures implemented.

Table 1 - Stormwater Quality Design Requirements

Gross Pollutants	Suspended Solids (TSS)	Total Phosphorous (TP)	Total Nitrogen (TN)	Stream Erosion Index
N/A	80%	45%	45%	1 to 3.5

The Maryfields Precinct Flood Report doesn't provide specific guidance regarding stormwater quality other than stating that compliance with Council controls is required.

4.6 STORMWATER CONVEYANCE

Council's design guidelines outline the following required design storm events when designing major and minor systems:

Table 2 - Stormwater Conveyance Design Criteria

Design Parameter	Design Storm	Conveyance Method
Minor Drainage System (Public Infrastructure)	20% AEP	In Ground (Piped)
Minor Drainage System (Inter-Allotment Drainage)	20% AEP	In Ground (Piped)
Major Drainage System (All)	1% AEP	Overland

5. PROPOSED STORMWATER CONTROLS

5.1 OVERVIEW

The subjection application includes only Stage 1 of the Site, however the stormwater management strategy for the entire Site (including Stages 2 – 4) has been considered to ensure that a suitable strategy is delivered for the ultimate development.

As general commentary regarding the above, we note the following key points:

- The post-development size of the western catchment (Stage 4 area) has been slightly reduced from the pre-development size to ensure that the quantum of stormwater flowing to the creek does not exceed the amount foreseen in the Maryields Precinct Flood Report;
- Per Council's request at the aforementioned pre-DA meeting, the size of the north-eastern catchment has been reduced and the size of the south-eastern catchment has increased to avoid the requirement for 2x basins in the eastern part of the Site (Stages 1 - 3).

5.2 STORMWATER QUANTITY

Hydrological analysis for the proposed development has been undertaken using the ILSAX drainage engine within Watercom DRAINS software. DRAINS has been utilised to assess pre-development and post-development stormwater runoff to address the suitability of proposed controls for the development.

Impervious fractions are shown in the table below:

Table 3 - Impervious Fractions

Catchment	Pre-Development Impervious	Post-Development Impervious
South East (On-Site)	5%	80%*
South East (Off-Site)	5%	90%
North-East	5%	55%*
West	5%	87%*

* Impervious percentages have been calculated and incorporate public reserves and future development.

Please refer to Indesco's drawing set for delineation of pre and post-development catchments for the purposes of assessing stormwater quantity requirements.

Pre-development and undetained post-development flow has been calculated to assess whether detention measures are required. These are summarised in the table overleaf:

Table 4 - Comparison of pre-development and undetained post-development runoff

Catchment	Annual Exceedance Probability	Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s) - Undetained	Detention required?
South-East	20%	0.316	1.36	Yes
	10%	0.493	1.65	Yes
	1%	1.20	2.71	Yes
North-East	20%	0.140	0.129	No*
	10%	0.218	0.164	No*
	1%	0.531	0.292	No*
West	20%	0.283	0.663	No**
	10%	0.440	0.811	No**
	1%	1.06	1.30	No**

* Catchment size reduced to reduce post-development discharge as per Council's request.
** Refer to comments in Section 4.4 regarding stormwater catchments that fall to the creek. It is noted that this requirement would be revisited if development of the western catchment (Stage 4 on the Site) were to precede dam works.

Based on the results in the previous table, stormwater detention measures are required to satisfy Council's controls for the south-eastern catchment. Engineering design has been conducted for a proposed stormwater detention basin with the characteristics shown in the table below:

Table 5 - Proposed Detention Characteristics

Basin Characteristic	Details
Type	Above Ground Basin (Permanent)
Low-Flow Outlet	Outlet pipe with DN 275mm orifice at CL 87.14 mAHD
High-Flow Weir Outlet	600mm long crest at 89.10 mAHD to DN 825mm pipe
Emergency Overflow	2m long weir/low point in bank at 90.00 mAHD discharging to Maryfields Dve
Top of Biofilter Level	87.90 mAHD
Extended Detention Level	88.20 mAHD
Basin Volume @ 1% AEP	2,086 m^3
Basin Footprint @ 1% AEP	1,455 m^2

The proposed detention measures result in the following attenuated flows:

Table 6 - Comparison of pre-development and detained post-development runoff

Catchment	Annual Exceedance Probability	Pre-Development Discharge (m^3/s)	Post-Development Discharge (m^3/s)			Council Requirement Satisfied?
			On/Off Site	Bypass	Total	
South-East	20%	0.316	0.208	0.103	0.311	Yes
	10%	0.493	0.325	0.125	0.450	Yes
	1%	1.20	0.86	0.204	1.064	Yes
North-East^	20%	0.140	0.129	N/A	0.129	Yes*
	10%	0.218	0.164	N/A	0.164	Yes*
	1%	0.531	0.292	N/A	0.292	Yes*
West^	20%	0.283	0.663	N/A	0.663	Yes**
	10%	0.440	0.811	N/A	0.811	Yes**
	1%	1.06	1.30	N/A	1.30	Yes**

* Catchment size reduced to reduce post-development discharge.
** Refer to comments in Section 4.4 regarding stormwater catchments that fall to the creek. It is noted that this requirement would be revisited if development of the western catchment (Stage 4 on the Site) were to precede dam works.
^ No detention required for catchment.

It is noted that the basin proposed as part of Stage 1 of the development is sized to suit the entire post-development South-East catchment, which includes the future development of Stages 2 & 3 and future development by other to the south.

5.3 STORMWATER QUALITY

Council standards are consistent with best practice WSUD and require a reduction in post-development pollutant loads from those that would be discharged in an uncontrolled post-development scenario. Stormwater quality controls are required to achieve the specified reduction targets.

Stormwater quality has been modelled using 'Model for Urban Stormwater Improvement Conceptualisation' (MUSIC) software produced by eWater. MUSIC modelling has been undertaken in accordance with 'WSUD Technical Guidelines for Western Sydney' and 'Australian Rainfall and Runoff'. An excerpt of the MUSIC model prepared for the proposed development is shown in the figure below and further details regarding MUSIC model source and treatment nodes are included in the following tables.

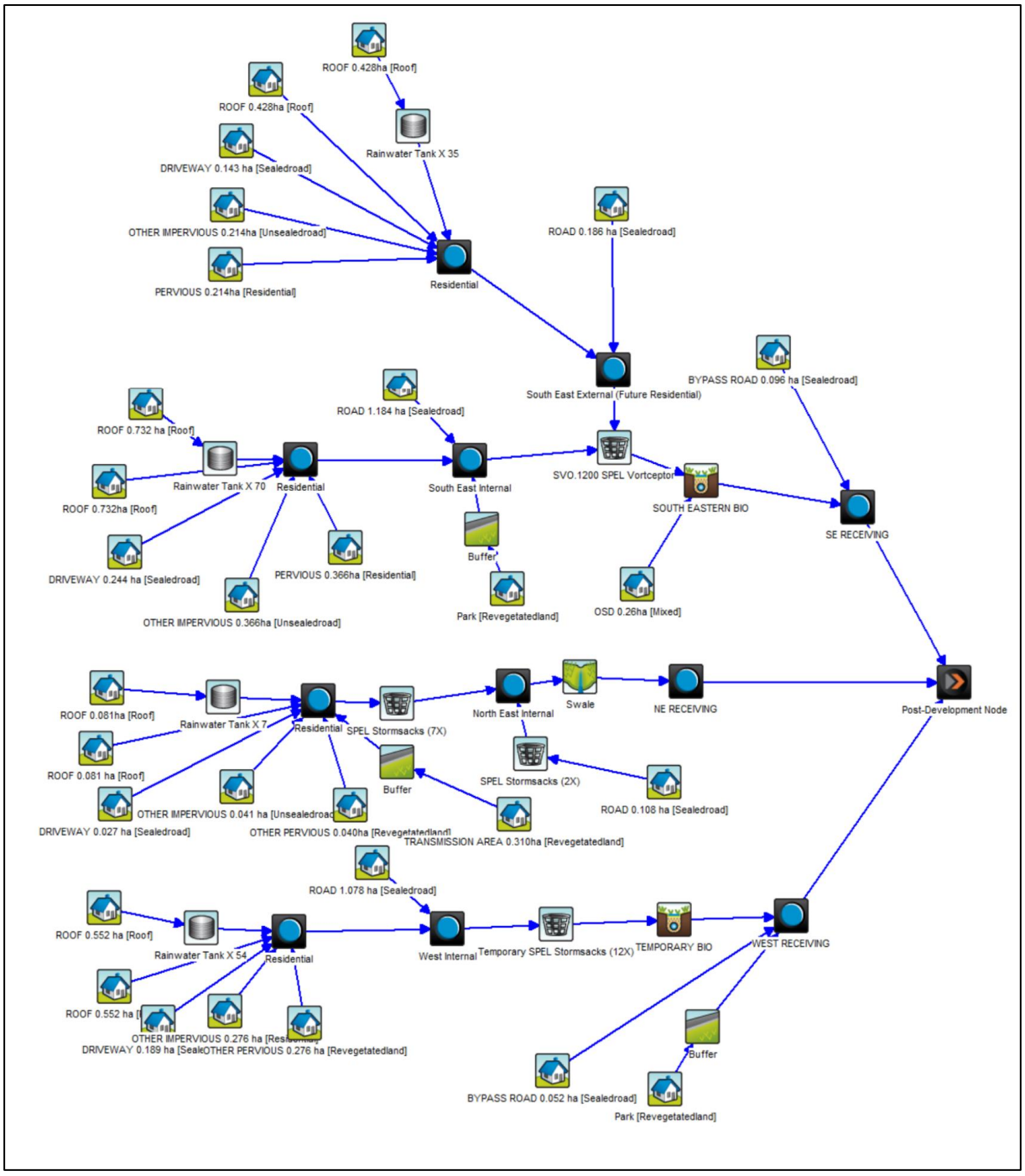

Figure 5 - MUSIC Model Establishment

Table 7 - Source Node Rainfall-Runoff Parameters

Parameter	Adopted Value
Impervious Area Properties	
Rainfall Threshold (mm)	1.0
Pervious Area Properties	
Soil Capacity (mm)	120
Initial Storage (%)	25
Field Capacity (mm)	80
Infiltration Capacity Coefficient - a	200
Infiltration Capacity Coefficient - b	1.00
Groundwater Properties	
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	5
Deep Deep Seepage Rate (%)	0

Table 8 - Source Node Parameters

Land-use Category		% Impervious	Log_{10} TSS (mg/L)		Log_{10} TP (mg/L)		Log_{10} TN (mg/L)	
			Storm Flow	Base Flow	Storm Flow	Base Flow	Storm Flow	Base Flow
Public Reserve Areas	Mean	0%	1.95	1.15	-0.66	-1.22	0.30	-0.05
	Std Dev		0.32	0.17	0.25	0.00	0.19	0.12
Public Road Areas	Mean	80%	2.43	1.20	-0.30	-0.85	0.34	0.11
	Std Dev		0.32	0.17	0.25	0.00	0.19	0.12
Lot Roof Areas	Mean	100%	1.30	-	-0.89	-	0.30	-
	Std Dev		0.32	-	0.25	-	0.19	-
Lot Driveway Areas	Mean	100%	2.43	-	-0.30	-	0.34	-
	Std Dev		0.32	-	0.25	-	0.19	-
Lot Other Impervious Areas	Mean	100%	3.00	-	-0.30	-	0.34	-
	Std Dev		0.32	-	0.25	-	0.19	-
Lot Pervious Areas	Mean	0%	1.95	1.15	-0.66	-1.22	0.30	-0.05
	Std Dev		0.32	0.17	0.25	0.00	0.19	0.12

Table 9 - Treatment Node Parameters

Treatment Node	Property	Detail	Quantity
Rainwater Tank	Inlet	Low Flow Bypass	0 m³/s
		High Flow Bypass	100 m³/s
	Individual Tank	Number of Tanks	South-Eastern = 71 + 35 North-Eastern = 7 Western = 54
		Volume below overflow pipe	2.00 kL
		Depth above overflow	0.2 m
		Surface Area	1.7 m²
		Initial Volume	2.00 kL
	Outlet	Overflow Pipe Diameter (Each Tank)	50 mm
	Re-Use	Max Drawdown Height	0.776 m
		Annual Demand	25 kL/yr, PET Distribution
		Daily Demand	0.1 kL/day, Uniform Distribution
Bioretention	Inlet	Low Flow Bypass	0 m³/s
		High Flow Bypass	100 m³/s
	Storage	Extended Detention Depth	South-Eastern = 300 mm South-Western (Temp) = 700mm
		Surface Area	South-Eastern = 450 m² South-Western (Temp) = 200 m²
	Filter & Media	Filter Area	South-Eastern = 450 m² South-Western (Temp) = 200 m²
		Unlined Filter Media Perimeter	0.01 m
		Saturated Hydraulic Conductivity	100 mm/hr
		Filter Depth	0.5m
		Total Nitrogen Content of Filter Media	800 mg/kg
		Orthophosphate Content of Filter Media	55.0 mg/kg
	Infiltration	Exfiltration Rate	0 mm/hr
	Lining	Base is lined	
	Vegetation	Vegetation with Effective Nutrient Removal	
	Outlet	Overflow Weir	2m
		Underdrain is present	
		Submerged Zone with Carbon is not present	
Gross Pollutant Trap	Item	SPEL Vortceptor 1200 or similar approved.	
	Number	South-Eastern = 1 North-Eastern = 0 Western = 0	
Pit Baskets	Item	SPEL Stormsacks (200 micron)	
	Number	South-Eastern = 0 North-Eastern (Permanent) = 1x in each inter-allotment pit and 1x in each kerb inlet pit Western (Temporary) = 1x in each kerb-inlet pit	

The table below illustrates the effectiveness of the proposed treatment rain, demonstrating compliance with Council's controls.

Table 10 - Stormwater Quality Model Results

Catchment	Pollutant	Council Pollutant Reduction Target	Actual Pollutant Reduction	Council Requirement Satisfied?
South-East	Total Suspended Solids (TSS)	80%	91.7%	Yes
	Total Phosphorous (TP)	45%	57.8%	Yes
	Total Nitrogen (TN)	45%	47.5%	Yes
	Gross Pollutants	N/A	98.2%	Yes
North-East	Total Suspended Solids (TSS)	80%	89.2%	Yes
	Total Phosphorous (TP)	45%	55.2%	Yes
	Total Nitrogen (TN)	45%	23.4%	No
	Gross Pollutants	N/A	100%	Yes
West	Total Suspended Solids (TSS)	80%	85.9%	Yes
	Total Phosphorous (TP)	45%	56.7%	Yes
	Total Nitrogen (TN)	45%	55.1%	Yes
	Gross Pollutants	N/A	98.2%	Yes
TOTAL	**Total Suspended Solids (TSS)**	**80%**	**90.2%**	**Yes**
	Total Phosphorous (TP)	**45%**	**57.3%**	**Yes**
	Total Nitrogen (TN)	**45%**	**48.8%**	**Yes**
	Gross Pollutants	**N/A**	**98.3%**	**Yes**

An analysis of the Stream Erosion Index for the West Catchment has been performed using MUSIC to ensure that environmental flows in the creek do not cause undue erosion, with calculations detailed below:

Critical Flow Calculation

Site Area	A	0.030963 km^2
Time of Concentration	T_c	0.2029 hours = 12.2 minutes (using Rational Method)
2 year ARI Storm Intensity	I_2	14.7 mm / hour (using Bureau of Meteorology rainfall data)
2 year ARI Runoff Coefficient	C_2	0.444 (using Equation 1.5 of ARR Volume 1, Book 4)
2 year ARI Flow	Q_2	0.0562 m^3 / second (using Rational Method)
Critical Flow	Q_{CRIT}	0.0140 m^3 / second (= Q_2/4)

Mean Annual Flow

Pre-Development Mean Annual Flow	1.32 m^3 / second (from MUSIC)
Post-Development Mean Annual Flow	4.59 m^3 / second (from MUSIC)

Stream Erosion Index 3.48

Based on the above calculation, the Stream Erosion Index is less than the maximum of 3.5. The Stream Erosion Index is therefore compliant with Council standards.

6. FLOOD IMPACT ASSESSMENT

Stage 1 is not flood affected, nor is it subject to overland flows that require special consideration in engineering design. No flood related controls are required.

APPENDIX A – MARYFIELDS PRECINCT FLOOD REPORT

FLOOD IMPACT ASSESSMENT REPORT
MARYFIELDS DEVELOPMENT SITE
192 NARELLAN ROAD, CAMPBELLTOWN

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FOR FRANCISCAN FRIARS

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1. Introduction

JMD have been engaged by the Franciscan Friars to prepare a flood impact assessment to assist Council and other authorities in the consideration of the proposed future development of the Maryfields Development Site.

The Maryfields Site which measures some 43.4ha in area is located on the north-east corner of the intersection of Narellan Road with the Hume Motorway and incorporates the following parcels:-

Lot 2 in DP569795
Lot12 in DP829093
Lot 13 in DP1034409
Lots 11 to 13 in DP1198323.

The Maryfields Site is bounded in the northwest by the Hume Motorway, in the northeast by existing residential land known as Blair Athol, in the southeast by bushland understood to be Council reserve and in the southwest by Narellan Road.

The site is affected by two main creek systems both originating on the eastern slopes of Kenny Hill to the west of the Hume Motorway which join at a large dam located in the southeast corner of the site to become a creek system which is understood to be known as Monastery Creek but has been referred to a Tributary 1 of Bow Bowing Creek in a previous drainage assessment prepared by Lyall & Associates for RMS. Hereinafter the creek is referred to as Tributary 1. Tributary 1 discharges across the south-east boundary of the site into the Council reserve land known as Lots 841 and 843 in DP1024090 which is a natural system for about 450m and then becomes a formed grass lined flow path with a low flow pipe system.

The southern arm of Tributary 1 enters the Maryfields Site via an existing 1200mm dia stormwater pipe at the southwest corner of the site at a level of approximately RL100m AHD and falls to approximately RL84.2m AHD at the main dam with a channel length of some 867m.

The northern arm of Tributary 1 enters the Maryfields Site mid-way along the western boundary of the site and is fed by two pipes constructed under the Hume Motorway. The southern pipe is 900mm in diameter and the northern pipe 1200mm in diameter. The two branches of the northern arm meet at approximately the western boundary of the Maryfields Site at a level of approximately 94.6m AHD and then falls to RL84.2 at the main dam with a channel length of some 671m.

This assessment investigates the flood risk in the creek systems within the extent of the Maryfields Site under current conditions and assuming the site is developed in accordance with the planning proposal that has been 'gateway determined' by NSW Planning & Environment in December 2014 and subsequent adjustments thereto as agreed between the proponent and Campbelltown City Council following further investigative reporting and consultation. This assessment has been completed based on the assumption that there will be no further development on the land downstream of the Maryfields Site as identified above.

2. Previous Studies

It is understood from recent discussions with Council's Drainage Engineer that to date there has not been a full flood risk assessment for the Maryfields Site. JMD have been provided with copies of reports by Rust PPK circa 1994 and Lyall & Associates dated May 2013 which review aspects of drainage relating to the Maryfields Site.

a) Rust PPK Report

The Rust PPK report is titled "Investigation – Stormwater Drainage Land Owned by Association of Franciscan Orders of Friars Minor Narellan Road, Campbelltown" and is dated 2 June 1994 (Ref No. 65F018A). This report has assessed the stormwater flows through the site using the Rational Method as documented in Australian Rainfall and Runoff.

The report documents little in the way of hydrological data. In the introduction, the report indicates that the site accepts water from the land on the western side of the Hume Motorway and again at section 3 indicates that the estimated flows include flows off the catchments to the west of the Hume Motorway but then states that the estimated flow off the entire site using the rational method is 9.4m³/s. This flow has been reviewed by JMD as detailed in Appendix A and is considered to be an estimate of the peak flow off the Maryfields Site alone rather than for the whole of the catchment.

The RUST PPK report assumes that the whole of the site was to be developed for low density residential with roads to be located in the major creek lines. The total flow off the undeveloped site was estimated at 9.4m³/s and under fully developed conditions 17.8m³/s. The report recommended the use of the large dam for detention storage but no specific details of the basin configuration are provided. Due to the lack of detail in the report and inconsistency between the assumed development pattern and the current proposal, this report is not considered further.

b) Lyall & Associates

Lyall & Associates prepared a report on existing and proposed stormwater systems for Narellan Road upgrade works in May 2013 (Ref NRU_r3.0_v1_Report.doc). This report does not consider the drainage system for the whole of the Maryfields Site but does review drainage systems near Narellan Road and describes the changes in the hydrologic patterns which will result from the upgrade works. The Catchment C11 in the Lyall Report is consistent with the JMD Catchment S1. The results by Lyall and JMD are reviewed in Appendix 1.

The details in the Lyall Report relating to the extent of the Narellan Road Upgrade have been used to estimate the impact on flows in the site arising from the upgrade works.

3. Narellan Road Upgrade Works

The Lyall Report was used by JMD to estimate the changes in catchments resulting from the upgrade works currently underway on Narellan Road. These works will impact on JMD Catchments S1, S5RD as detailed in the JMD Catchment Plan (Ref 12100E1 sheet 1 of 1 – refer Appendix B). The extent of the Upgrade works and the impact on flows through the site is detailed in Appendix A and was found to be of negligible impact.

4. Site Hydrology & Hydraulics

a. Hydrology

The nature of the site under current conditions has been examined by JMD. As described in Section1 of the report, the site is affected by two creeks which join at a large farm dam to form Tributary 1 of Bow Bowing Creek. For the purposes of description of the creeks in this report, the northern arm of Tributary 1 has been denoted North and the southern arm as South.

There are three catchments along the northern boundary of the site which do not fall to the Tributary No.1. These discharge to the existing Blair Athol residential development to the north.

A portion of land, approximately 29.67ha in area located on the western side of the Hume Motorway falls towards the Motorway and the subject site. The Motorway itself generally grades away to the north and other than a minor part of the Narellan Road southbound off ramp, does not drain tho the site. The land to the west of the Hume Motorway has been divided into three catchments interpreted from topographic data obtained from NSW Dept of Lands. These Catchments are denoted S1, N1 and N2 on the Catchment Plan attached at Appendix B. Catchment S1 drains to the site via a 1200mm diameter pipe approximately 315m long passing under the Hume Motorway. Catchment N1 drains to the site via a 900mm diameter pipe approximately 167m long passing under the Hume Motorway. Catchment N2 drains to the site via a 1200mm diameter pipe approximately 155m long passing under the Hume Motorway. The outlets for each of these catchments act as detention systems with flows in excess of the piped capacity being withheld in depressions formed on the western side of the Hume Motorway by the raise nature of the road embankment.

The hydrology of the site catchments has been modelled using the XP-Rafts computer program. This program estimates the flows off catchments using data inputs to calculate unit hydrographs. The flows off each catchment are distributed down the system using link data which simulates a typical creek section with link lengths and grades interpreted from the site survey data. The velocity data from the XP-Rafts results were compared to the subsequent hydraulic model flow results to ensure that the links in the XP-Rafts model were providing realistic results. The velocities from both models were found to be similar and so the linkage in the XP-Rafts model were considered to be reasonable for the assessment.

The XP-Rafts nodes for the three catchments located to the west of the Hume Motorway were interrogated for depth of pondage as overflows from Node N2 are diverted to Node N1 and those from Node N1 to the north out of the system by the Hume Motorway Embankment. The volume of storage in the depressions was estimated from the available topographic data and Nodes S1, N1 and N2 were modelled in the XP-Rafts file as detention basins (refer Appendix A for details). The maximum capacity of the pipe outlets was modelled using the orifice equation assuming free outfall at the downstream end (verified as correct later in the hydraulic model). Nodes N1 and N2 were found to have insufficient capacity for the catchment flows in all storm events. This limitation was modelled in the Xp-Rafts file by the inclusion of diversion nodes and links with the bypass thresholds for the diversion links being set at the inlet capacity of the pipe assuming the depth of water in the storage was at Hume Motorway level. Overflows from Node N2 divert to Node N1 and those from Node N1 divert to the north out of the system. This has been included in the XP-Rafts model as dummy Node “Out”.

The estimated flows through the site under current conditions are detailed in Appendix A and repeated below in Table 4.1.

Table 4.1 – Summary of existing stormwater flows through Maryfields Site

Catchment	Peak Flow for Storm Event Average Recurrence Interval (m^3)					
	5	10	20	50	100	PMF
S1	2.17	2.46	2.87	3.16/3.17	3.48	
S2	2.92/2.93	3.33/3.34	3.92/3.94	4.40/4.41	4.84/4.86	~~11.85~~ 22.64
S3	3.48/3.49	4.00/4.02	4.73/4.76	5.37/5.39	6.00/6.03	~~16.47~~ 34.21
S4	3.91/3.92	4.51/4.53	5.37/5.40	6.13/6.17	6.90/6.93	~~20.05~~ 43.41
N1	1.16	1.40	1.73	2.02	2.29	~~7.55~~
N2	1.32	1.57	1.99	2.17	2.42	~~8.59~~
N3	3.79	4.58	5.65	6.56	7.44	~~18.86~~ 37.02
N4	4.43	5.35	6.61	7.71	8.73	~~23.69~~ 50.3
N5	4.72	5.68	7.03	8.19	9.32	~~25.89~~ 56.05
S5,S5RD+N6	9.45/9.46	11.23/11.24	13.77/13.79	16.07/16.09	18.3 /18.32	~~54.62~~ 121.9
S6	9.93/9.94	11.84/11.85	14.61/14.63	17.05/17.07	19.43 /19.45	~~59.47~~ 135
E1	0.58	0.7	0.86	0.98	1.10	~~3.58~~ 8.90
E2	0.79	1.01	1.27	1.50	1.72	~~5.70~~ 15.44
E3	0.28	0.34	0.42	0.48	0.55	~~1.68~~ 4.17

The second set of figures for catchments S1 to S6 indicate the change in flows through the site as a result of the Narellan Road upgrade works. The changes in flows resulting from these works are not considered significant.

b. Impact of Climate Change

During recent discussions with Campbelltown City Council officers, JMD have been requested to consider the impacts of climate change on the drainage systems in the site. Impacts from climate change are understood to be related to temperature changes. NSW OEH published a document in November 2014 Titled "Metropolitan Sydney Climate Change Snapshot" which states that the temperature increase long term is expected to be 1.9 degrees.

Engineers Australia have published a discussion paper "An interim Guideline for Considering Climate Change in Rainfall and Runoff" dated November 2014 which proposes a 5% increase in rainfall intensity per degree in temperature rise.

Based on the above references then, the XP-Rafts model has interrogated with rain fall intensities for 2 hour storm events (critical events in previous model runs) increased by 9.5% as detailed in Table 4.2

Table 4.2 – Impact of Climate Change on Rainfall Intensities

Recurrence Interval	1	2	5	10	20	50	100
Current Intensity (2 Hour Duration)	16.3	20.9	26.8	30.2	34.7	40.6	45.0
Climate Change Intensity (2 Hour Duration)	17.8	22.9	29.3	33.1	38.0	44.5	49.3

For the purposes of this investigation, the climate change impacts have only been investigated for the developed conditions as the consideration of climate change impacts on the flows through the site is not relevant to the current site conditions.

c. Hydraulics

The flows estimated using the XP-Rafts model were entered into a hydraulic model of the creek systems created in the HEC-Ras computer program. This program has been developed by the US army for calculating backwater profiles on 1 dimensional flow regimes. The flows in the creeks running through the site are generally linear in nature and so the use of this program to estimate the water levels in the creeks is considered appropriate.

A series of cross sections for both creeks were generated off the survey model held by JMD over the site using the control lines indicated on the catchment plan (HEC-Ras station locations are indicated at the bends in the control lines. The validity of this survey data was confirm by a site walk in March 2015. Sections of the creeks have been generated at 20m centres with control sections at dam walls and rod crossings entered into the model as road embankments.

A review of the sections interpolated from the survey data and inspection on site revealed that the section at station 274 on the south creek was the same as that at station 169 of the north creek and was essentially the top end of the large dam. The HEC-Ras model was therefore developed with north creek joining south creek at station 274.

The roughness factors adopted for the hydraulic model were as described in Appendix A but also examined for a range of values between 0.03 and 0.05. The model was found to be reasonably insensitive to these changes in roughness which is attributed to the depth of flow through the number of dams on site.

The resulting water levels in the creeks under current conditions including the Narellan upgrade works which were generated by the HEC-Ras model are detailed in Appendix C.

The flood levels downstream of the large dam have not been determined in this study as it is understood that this area of the site will be filled and reshaped to stabilise the existing dam wall. This proposal would see the area immediately downstream of the site filled with controlled fill, in effect building a new structurally sound dam wall against the existing wall thereby stabilising the existing dam wall. The design of these earthworks is beyond the scope of this report and will need to incorporate a discharge control path from the dam so that flows which overtop the dam wall do so in a controlled manner which will not impact on the structural integrity of the dam wall.

5. Impacts on Stormwater Flows from Proposed development

JMD were provided at the commencement of this investigation with a sketch showing the proposed development of the site under the current planning proposal. This sketch is reproduced at Figure 5.1. It is understood that this proposal has achieved NSW Gateway consent and Campbelltown City Council endorsement to proceed to a future re-zoning of the Maryfields Site.

This sketch has been overlaid on the site plan and the areas of various development types in each catchment estimated. For the purposes of this assessment, each development type was assigned a % impervious factor in line with Council's design specification as detailed in Table 5.1 below.

These factors were applied to the areas interpreted from the planning proposal layout provided to produce new catchment characteristics for the developed scenario as detailed in table 5.2 below. The % impervious were applied to the estimated areas coloured in Figure 5.1. All open space areas coloured green were assumed to be 5% impervious with the surface areas of existing dames assumed to be 100% impervious.

Figure 5.1 – planning proposal as submitted for Gateway Determination 2014

Table 5.1 – Adopted % Impervious factors for developed scenario

Development Type	Adopted % Impervious
Open Space	5
Low Density Residential	80
High Density Housing	90
Business Park	90
Seniors Living	80

The XP-Rafts models for the site were edited to reflect the above data to produce a hydrology model reflective of the proposed developed conditions. For this exercise, impervious areas were assumed to be grading at 5% to reflect the likely benching which will accompany the development of the site. The resultant stormwater flows have been added in bold to those from Table 4.1 and reproduced at Table 5.3.

Subsequent to the original modelling, JMD have been provided with an updated Structure plan for the site. This plan has been reproduced at Figure 5.2. The development areas depicted in the amended structure plan have been reviewed and are similar to that in the original planning proposal. The updated Structure plan is not considered to be a significant departure from the original planning proposal and will not result in significant changes in flood levels from that documented in this report.

The results from the XP-Rafts modelling, as summarised in Table 5.3, indicate that in general, the proposed development of the site will not result in an increase in peak stormwater flows in the Tributary 1 creek system through the site. The modelling indicates then, that under current conditions, there is no need to provide any stormwater detention on the Tributary 1 system as a result of the

proposed development. Long term climate change impacts as discussed in Section 4b of this report result in an increase in stormwater flows in the Tributary 1 system by approximately 8.5% over current undeveloped conditions.

Table 5.2 – Developed Catchment Characteristics

CATCHMENT SUMMARY - AS DEVELOPED									
CATCH	AREA BUSINESS PARK (90% imp)	AREA SENIORS LIVING (80% imp)	AREA MED DEN RES (90% imp)	AREA LOW DENSITY RES (80% imp)	AREA ROADS (80% imp)	Remaining area (open space 5% imp)	Developed AREA IMPERVIOUS (ha)	Developed AREA PERVIOUS (ha)	CHECK TOTAL AREA (ha)
S1									
S2	0	0.29	0	0	0.1	5.16	0.57	4.98	5.55
S3	0	1.58	0	0	0.66	1.97	1.8905	2.3195	4.21
S4	0.69	0.04	0	0	0.35	2.18	1.042	2.218	3.26
S5	0	0	0	0	0.54	3.37	0.6005	3.3095	3.91
S5RD	0	0	0	0	0				
N1	0	0	0	0	0				
N2	0	0	0	0	0				
N3	0	0.88	1.99	0	0.96	5.34	3.53	5.64	9.17
N4	1.15	0.923	0.204	0	0.6	1.503	2.51215	1.86785	4.38
N5	1.53	0	0.04	0	0.512	-0.082	1.8185	0.1815	2
N6	1.48	0	1.45	0	0.26	1.76	2.933	2.017	4.95
DAM						0	0	0	0
S6	0	0	1.45	0.93	0.646	1.354	2.6335	1.7465	4.38
E1	0	0	0.49	0.9	0.35	1.14	1.498	1.382	2.88
E2	0	0	1.29	2.19	1.05	0.34	3.77	1.1	4.87
E3	0	0	0.29	0.75	0.25	0.00	1.061	0.229	1.29

The development of the northern catchments E1 to E3 will result in increases to peak stormwater flows off those catchments and it will be necessary to provide stormwater detention in these catchments to ensure that the peak discharges from the catchments are not increased as a result of the proposed development. The detailed design of the detention systems is not within the scope of this assessment as such designs will need to include the consideration of future site and road levels. Recent detention modelling completed by JMD for development sites at Glenfield indicate that for developments similar in nature to that proposed on this site, detention storage requirements are approximately 350 to 400 cubic metres per hectare of contributing catchment. It should be noted that the volume of storage required and the associated area of land required for the storage is dependent on the design specifications of the storage. For example, an open air basin with grassed batters suitable for active or passive recreation will require more land area than an enclosed tank type basin. Given the many variables which impact on the design of a detention storage and the generic nature of the development proposal at this time, it is not possible to formulate a final design of the storage required for each catchment however, Table 5.4 below provides indicative basin sizes for each catchment which are provided as a guide only and will need to be confirmed as the development of the site progresses. The basin areas assume an open area basin with 1 in 6 batters and a depth of 1.5m. The areas provided do not account for freeboard requirements ,etc.

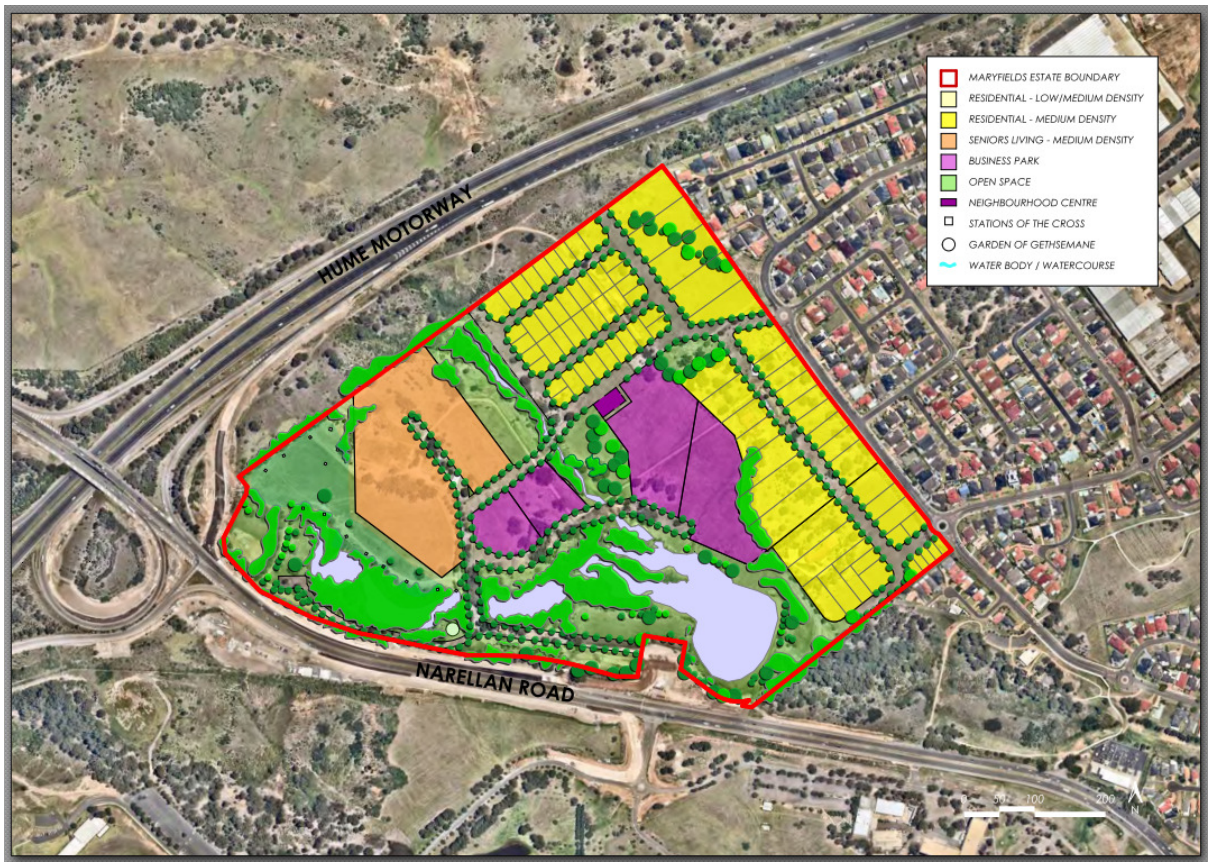

Figure 5.2 – August 2015 Structure Plan

Table 5.3 – Summary of existing and developed conditions stormwater flows through Maryfields Site

Catchment	Peak Flow for Storm Event Average Recurrence Interval (m^3)					
	5	10	20	50	100	PMF
S1	2.17/**2.17** (**2.37**)	2.46/**2.46** (**2.74**)	2.87/**2.87** (**3.12**)	3.17/**3.17** (**3.46**)	3.48/**3.48** (**3.76**)	6.09
S2	2.93/**2.93** (**3.24**)	3.34/**3.33** (**3.74**)	3.94/**3.93** (**4.33**)	4.41/**4.40** (**4.82**)	4.86/**4.85** (**5.31**)	~~11.85~~ 22.64
S3	3.49/**3.40** (**3.78**)	4.02/**3.89** (**4.37**)	4.76/**4.60** (**5.13**)	5.39/**5.21** (**5.76**)	6.03/**5.79** (**6.48**)	~~16.47~~ 34.21
S4	3.92/**3.83** (**4.27**)	4.53/**4.39** (**4.96**)	5.40/**5.21** (**5.86**)	6.17/**5.99** (**6.73**)	6.93/**6.77** (**7.58**)	~~20.05~~ 43.41
N1	1.16/**1.16** (**1.34**)	1.40/**1.40** (**1.62**)	1.73/**1.73** (**1.99**)	2.02/**2.02** (**2.28**)	2.29/**2.29** (**2.56**)	~~7.55~~
N2	1.32/**1.32** (**1.51**)	1.57/**1.57** (**1.80**)	1.90/**1.90** (**2.14**)	2.17/**2.17** (**2.41**)	2.42/**2.42** (**2.49**)	~~8.59~~
N3	3.79/**3.68** (**4.24**)	4.58/**4.40** (**5.09**)	5.65/**5.38** (**6.12**)	6.56/**6.29** (**7.20**)	7.44/**7.25** (**8.13**)	~~18.86~~ 37.02
N4	4.43/**4.17** (**4.81**)	5.35/**5.01** (**5.79**)	6.61/**6.13** (**7.15**)	7.71/**7.35** (**8.45**)	8.73/**8.51** (**9.59**)	~~23.69~~ 50.3
N5	4.72/**4.32** (**4.97**)	5.68/**5.18** (**6.07**)	7.03/**6.47** (**7.54**)	8.19/**7.75** (**8.88**)	9.32/**8.95** (**10.06**)	~~25.89~~ 56.05
S5,S5RD+N6	9.46/**8.89** (**10.19**)	11.24/**10.59** (**12.29**)	13.79/**13.04** (**14.93**)	16.09/**15.27** (**17.36**)	18.32/**17.48** (**19.52**)	~~54.62~~ 121.9
S6	9.94/**9.23** (**10.73**)	11.85/**11.18** (**12.95**)	14.63/**13.76** (**15.73**)	17.07/**16.09** (**18.48**)	19.45/**18.63** (**20.9**)	~~59.47~~ 135
E1	0.58/**0.60** (**0.68**)	0.70/**0.71** (**0.81**)	0.86/**0.86** (**0.97**)	0.98/**0.99** (**1.12**)	1.1/**1.13** (**1.28**)	~~3.58~~ 8.90
E2	0.79/**1.33** (**1.47**)	1.01/**1.53** (**1.70**)	1.27/**1.79** (**2.01**)	1.50/**2.01** (**2.21**)	1.72/**2.25** (**2.49**)	~~5.70~~ 15.44
E3	0.28/**0.39** (**0.43**)	0.34/**0.45** (**0.50**)	0.42/**0.52** (**0.58**)	0.48/**0.58** (**0.64**)	0.55/**0.65** (**0.71**)	~~1.68~~ 4.17

Figures for catchments S1 to S6 indicate the flows through the site including Narellan Road upgrade works. Figures in Bold are for the developed site with no OSD. Figures in () indicate developed flows with Climate Change increase.

Table 5.4 – Indicative detention basin sizes for Catchments E1 to E3

Catchment	Approx. Basin Area (m^2)	Approx. Basin Volume (m^3)
E1	1450	1430
E2	1970	2080
E3	770	670

6. NSW Office of Water Riparian Zones

JMD have been provided with a sketch showing the indicative "riparian corridor constraints as advised by NSW Office of Water". It is understood that the indicated riparian zones have been developed in consultation with the NSW Office of Water and will be applied to the site when the proposed development of the site proceeds. This sketch is reproduced at Figure 6.1. The indicated riparian buffer zone limits have been interpreted by JMD and are indicated in the Catchment Plan provided at Appendix B.

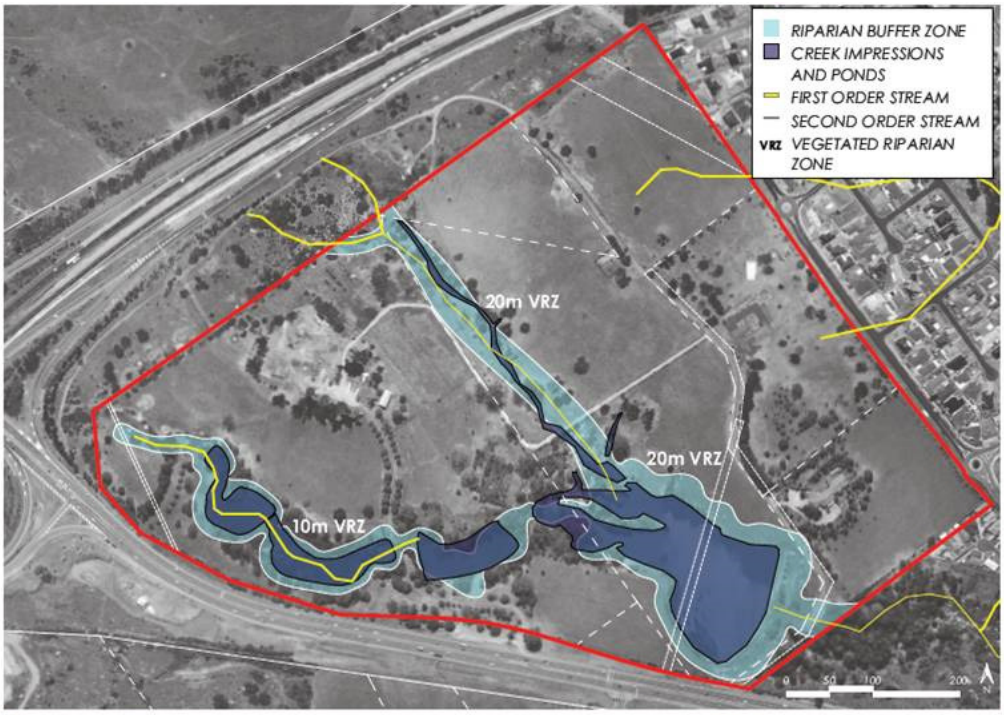

Figure 6.1 – Riparian Corridor Constraints

7. Flood Impact Assessment

The results of the HEC-Ras modelling completed for this assessment has been examined as to flood impacts. Following is a commentary on these impacts.

a. South Arm station 850 to station 645

This reach of the southern arm of Tributary 1 remains largely untouched by the proposed development of the site. Flow depths in the creek vary from approx. 0.7m in the 5 year ARI event, 0.8m in the 100 year event, and up to 1.2m in the PMF. The lower end of this reach is affected by a dam with an access track across the top of the dam wall (approx. RL95.6). As discussed in Appendix A, a piped outlet was not observed for this dam and so it is assumed that flows overtop the dam wall.

The depths of flow over the dam wall vary from 120mm in the 5 year ARI event to 180mm in the 100 year Ari event and 0.36m in the PMF. The velocity of flow over the dam wall will vary from 0.3m/s to 0.5m/s at the top of wall and from 1.22m/s to 1.5m/s immediately downstream if the wall (5 year ARI to 100 Year ARI events). Across the existing track then the velocity depth product would be significantly less than 0.4 and so the track would be safe for passage of vehicles in all storm events up to the 100 year ARI event.

The velocity of flow over the wall in the PMF event varies from 0.9m/s at top of wall to 2m/s immediately downstream of the wall. The flows in the PMF peak storm then is close to the safety limit of velocity depth product recognised in the Floodplain Development Manual (April 2005).

No assessment has been made as to the structural integrity of the dam wall nor the ability of the wall to withstand inundation during any storm event.

The flows in the creek in this reach of the creek are generally contained within the identified riparian buffer zones and do not impact on the proposed development sites.

b. South Arm station 645 to station 430

This reach of the southern arm of Tributary 1 will be affected by the proposed development of the site. Flow depths in the creek vary from approx. 0.8m in the 5 year ARI event, 0.9m in the 100 year event, and up to 1.5m in the PMF. The lower end of this reach is affected by a dam with a sealed access track across the top of the dam wall (approx. RL92.0). The water level in the dam is maintained by a concrete weir draining to a pipe laid through the dam wall. The modelling has revealed that the pipe has insufficient capacity for peak storm flows in all storm events resulting in flow overtopping the access track in all modelled storm events.

The depths of flow over the dam wall vary from 60mm in the 5 year ARI event to 130mm in the 100 year Ari event and 0.32m in the PMF. The velocity of flow over the dam wall is very low (less than 0.2m/s. the modelling indicates that the flows immediately downstream of the access track remain low as the creek is "drowned" by the backwater effects from the downstream dam. Across the existing track then the velocity depth product would be significantly less than 0.4 and so the track would be safe for passage of vehicles in all storm events up to the 100 year ARI event.

The velocity of flow over the wall in the PMF event varies but does not exceed 0.6m/s resulting in the velocity depth product for the PMF peak storm being well below the 0.4 safe limit recognised in the Floodplain Development Manual.

No assessment has been made as to the structural integrity of the dam wall nor the ability of the wall to withstand inundation during any storm event.

The flows in the creek in this reach of the creek are generally contained within the identified riparian zones on the south side of the creek except for in the vicinity of the dam wall where the overtopping of the wall causes the width of flow to exceed the indicated riparian buffer zone width. The modelling indicates that the 100 year and PMF flood lines will exceed the width of the riparian buffer zone on the north side of the creek. The planning proposal detailed at Figure 5.1 was found to be marginally affected by stormwater flows in the creek during the peak 1 in 100 year design storm. The August 2015 planning proposal indicated at Figure 5.2 has the development areas adjusted to remove the minor affectation and so all residential areas in the August 2015 Planning Proposal will be above the 1 in 100 year flood line.

The development proposal indicates that the current sealed access will be replaced by a public road providing access to the proposed seniors living area. In accordance with the requirements of Council's design specification, this road will need to be flood free in the 100 year ARI flood event and passable in the PMF. It is understood that the existing dam water levels are to be retained to retain the current ecology of the area. The public road will therefore need to be raised to provide for the necessary culverts to be constructed under the road while maintaining the existing upstream water level. The culverts will need to be designed to convey the 100 year ARI flood flow (8.47m^3/s) plus allowance for 50% blockage.

c. South Arm station 430 to station 274

This reach of the southern arm of Tributary 1 may be affected by the proposed development of the site. Flow depths in the creek are not know in this reach of the creek as the reach is affected by an existing dam of unknown depth.

Velocities along the reach are low and the width and depth of flow is controlled by the dam wall at station 320. The 100 year ARI and PMF flood lines are generally consistent with the Riparian buffer zone on the south side of the creek but exceed the indicated width of the riparian buffer zones on the north side of the creek where the 100 year ARI flood line approximates the proposed Business Park

area as identified in the original Planning Proposal at Figure 5.1 but will be clear of the proposed Business Park area identified in the August 2015 Planning Proposal at Figure 5.2. The PMF flood line intrudes into to proposed Business Park area.

No assessment has been made as to the structural integrity of the dam wall nor the ability of the wall to withstand inundation during any storm event.

d. North Arm Station 560 to station 170

This reach is roughly linear in alignment. Flow depths vary from approx. 300mm in the 5 year Ari event to approx. 0.6m in the 100 year ARI event and 0.7m in the PMF. Velocities are generally in the vicinity of 0.8m/s to 1.2m/s and flows are generally sub-critical.

An existing access track has been built across the creek at station 225. The embankment associated with this access track is approx. 2.5m high with the creek drained through the embankment by twin 900mm dia pipes. These pipes have insufficient capacity to convey the 5 year ARI flows and so the embankment is overtopped in all storm events modelled.

Flood flows in this reach are generally contained within the proposed riparian buffer zones and so the flood flows are considered to have a low impact on the proposed development of the site.

The development proposal indicates that a cycleway connection will cross this reach at approximately station 330. The design requirements for such a crossing are not clearly stated in Council's design specification however the crossing will need to be designed to provide for the safe conveyance of flood flows.

The development proposal indicates that a public road will cross this reach at approximately station 200. In accordance with the requirements of Council's design specification, this road will need to be flood free in the 100 year ARI flood event and passable in the PMF. It is assumed that the existing access road embankment will be removed. The public road will need to be elevated above creek invert to provide for the necessary culverts to be constructed under the road. The culverts will need to be designed to convey the 100 year ARI flood flow (7.99m³/s) plus allowance for 50% blockage.

e. South Arm Station 274 to station 0

This reach represents the large dam at the south-east corner of the Maryfields Site. Flood flows are generally contained within the existing dam and its immediate surrounds with water levels governed directly by the outlet conditions. Under current conditions as modelled, flood flows in all storm events up to PMF are contained with the indicated riparian buffer zones.

The development proposal indicates that a public road will cross this reach at approximately station 170. In accordance with the requirements of Council's design specification, this road will need to be flood free in the 100 year ARI flood event and passable in the PMF. The public road will need to be elevated above dam surface to provide for the necessary culverts to be constructed under the road. The culverts will need to be designed to convey the 100 year ARI flood flow (21.3m³/s) plus allowance for 50% blockage.

8. Overall Flood Impact Assessment

This study has undertaken a comprehensive assessment of the flood impacts likely to result from the development of the site as indicated at Section 5. In general, flood flows will be contained within the proposed riparian buffer zones indicated in Figure 6.1 with no impacts on the proposed development

zones on the site as identified in the August 2015 Planning Proposal at Figure 5.2 in the peak 1 in 100 year flood. Proposed road crossings providing public access to the various development zones will need to be designed to cater for the indicated flood flows and provide safe passage in the design storm events.

Subject to the provision of suitable culvert/bridge crossings compliant with Council's design specification, the August 2015 development proposal will not have a significant impact on the riparian zones associated with the Tributary 1 traversing the Maryfields site.

The development proposal indicated for the site will not result in the need to provide stormwater detention on the Tributary 1 catchment. The development of the Tributary 1 catchment as indicated will result in a minor reduction in peak flows in the Tributary.

The northern portion of the Maryfields Site not draining to the Tributary 1 creek system will require the provision of stormwater detention systems to reduce developed flows to that which occur under current conditions. Alternatively, it may be possible to take advantage of the minor decrease in peak flows in Tributary 1 which will result from the development of the site and divert flows of part of the northern catchment to the tributary 1 catchment such that the developed flows to the north are reduced to current levels. The investigation of this alternative however is beyond the scope of this assessment.

9. Water Quality Issues

The development of the Maryfields Site will need to address water quality impacts resulting from the development of the site. At this preliminary stage of the development process, it is not possible to provide details of specific water quality measures required to address the impacts of the development proposal. Following however is a generic discussion of water quality issues and possible design solutions. The final treatment measures to be adopted for the site will need to be determined in consultation with Council and NSW Office of Water.

Council's Design Specification describes the following generic treatment targets for use where targets are not provided in the site specific Stormwater Management Plans.

Campbelltown City Council Generic Stormwater Quality Objectives

Parameter	Criteria
Total Phosphorus (TP)	45% retention of average annual load
Total Nitrogen (TN)	45% retention of average annual load
Total Suspended Solids (TSS)	80% retention of average annual load

Water Quality is a developing area of engineering and the above targets detailed in Council's design specification are outdated. More recent development proposals such as that at Oran Park are required to meet the following higher targets:-

Oran Park DCP Stormwater Quality Objectives

Parameter	Criteria
Total Phosphorus (TP)	65% retention of average annual load
Total Nitrogen (TN)	45% retention of average annual load
Total Suspended Solids (TSS)	85% retention of average annual load

Typically water quality measures are designed using the MUSIC computer program developed by eWater. This program has become the industry standard for this type of modelling and has been adopted by a number of Councils and Government agencies. The program requires the site to be

modelled using input nodes to represent the site conditions and treatment nodes to represent the water quality treatment measures. The results are then generated generally as mean annual loads. The effectiveness of the proposed treatment measures can be ascertained by comparing results from a model with no treatment measures to that with treatment measures included.

One method of achieving water quality treatment targets is by diverting low flows off developed catchments through a gross pollutant trap (GPT) to a bio-retention basin where stormwater is detained and filtered through vegetated sandy filter beds prior to discharge. The MUSIC program enables the designer to determine the area of the bio-retention basin. Typically, the surface area of the filter media in a bio-retention basin needs to be between 1% and 1.5% of the contributing catchment area to achieve the required water quality outcomes. Generally, bio-retention basins are required to be located outside riparian buffer zones.

Recent experience has revealed a reluctance on the part of Campbelltown Council to adopt the use of bio-retention basins for water quality treatment if the basins are to become a public asset. An alternative treatment measure used by JMD on a number developments within the Campbelltown LGA has been to divert low flows from developed catchments to a GPT in tandem with a proprietary filter pit such as a “Jellyfish” treatment pit which is produced by Humes. Modelling completed by JMD has shown such filter pits to be effective for residential catchments (vacant lot development where surfaces are assumed to be 80% impervious) up to approximately 2ha.

10. Conclusion

JMD have been engaged by the Franciscan Friars to prepare a flood impact assessment to assist Council and other authorities in the consideration of the proposed future development of the Maryfields Development Site.

The Maryfields Site which measures some 43.4ha in area is located on the north-east corner of the intersection of Narellan Road with the Hume Motorway and is traversed by a creek system known as Tributary No.1 of Bow Bowing Creek.

The site is proposed to be developed for a number of uses including residential, business and senior living. The proposal has achieved NSW Gateway Consent and Campbelltown City Council endorsement to proceed to a future re-zoning of the Maryfields Site. This report details the findings of a flood assessment conducted by JMD, documents the likely impacts of flooding on the proposed development areas and provides preliminary flood extent mapping. Subject to the detailed design of road crossings and certification of the stability of existing dam structures (both issues are beyond the scope of this assessment), the development proposal has been found to be largely unaffected by flooding issues.

The assessment has found that the proposed development will not adversely impact on the existing creek system in the area. A portion of the site located along the northern boundary of the site does not currently drain to Tributary No.1. The development of these northern catchments will result in an increase stormwater flows which will need to be addressed by the provision of stormwater detention or other means. At this stage of the development process, it is not possible to provide detailed information of the design of the proposed detention systems but preliminary estimates of storage volumes have been documented.

The development of the site will need to include the provision of adequate measures to address water quality impacts resulting from the development. Again, at this stage of the development process, it is not possible to provide detailed information of the design of the proposed water quality measures however the report provides a preliminary discussion of the issues associated with water quality and options for the treatment of storm water flows which have been successfully used on other similar projects in the Campbelltown LGA.

Yours faithfully

.....

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CP Eng

Appendix A

A1 Notes and Assumptions adopted for site hydrology & hydraulic models

The catchment analysis has been competed using site survey data obtained between 2002 and 2014. While these surveys were not completed specifically for the purposes of this flood assessment the site has been inspected and compared to the site survey details available and the survey is considered to be an adequate representation of the site in its current condition.

External catchments have been estimated using topographical information obtained from LPI (information depicted in catchment plan). Catchments have been compared to information contained in the reports by Rust PPK and Lyle and Associates P/L referred to in this report and found to be consistent.

Catchment S1

- Catchment has been measured at 15.53ha in area.
- Catchment contains existing road pavement areas associated with the Hume Motorway and Narellan Area. The area of pavement under current conditions has been estimated at 1.6ha (10.3% of catchment)
- The proposed Narellan Rd upgrade works are estimated to result in an increase in the impervious area by some 3560m² (total impervious area 12.6% of catchment).
- The catchment is otherwise steep with an average slope of 13.9% and ground cover of grass with some trees nearer the Hume Motorway. A surface roughness 'n' of 0.033 was considered suitable for the hydrology of this catchment.
- Catchment drains via 1200mm pipe inv upstream approx. 109 inv d/stream approx. 100 length approx. 315m grade assumed at 2.9%. Level of Motorway approx. RL114
- Basin volumes interpreted from Catchment contours as follows:-

RL	Area	Vol
109	0	0
110	340	113
112	2915	3368
114	8389	14672

- Pipe flow calculated using orifice eqn Q=0.6A(2gh)^0.5 Catchment flows found not to exceed pipe capacity. Basin does not overflow.

Catchment S2

- Catchment 5.55ha in area.
- Catchment contains a large dame approx. 4000m² in area (7.2% of catchment) which for the purposes of this assessment has been assumed to be impervious area.
- The dam wall (creek station 638) has a dirt track across the top at approx. RL95.6. This has been modelled in HEC-Ras as a deck/roadway. An outlet pipe was not observed on site but a nominal low flow pipe (150mm dia) has been added into the Hec-Ras model to avoid run errors. This pipe will not impact on model results.
- Ground slopes from top of catchment to creek have been measured at 10% with creek bed average slope in reach 1.9% and length of 220m.
- The catchment is largely grassed with a scattering of trees. The localised linear creek environ is reasonably timbered. A surface roughness 'n' of 0.04 is considered reasonable for the catchment hydrology and 0.045 for creek bed hydraulics with overbank areas 0.033.

Catchment S3

- Catchment is 4.21 ha in area.
- Catchment contains a large dam approx. 3500m² in area (8.3% of catchment)
- Catchment contains an sealed access track to a dwelling approx. 870m² in area and approx. 400m² of area associated with the dwelling which would be considered impervious. Total impervious area for catchment then is 4770m² (11.3% of catchment).
- The dam wall (creek station 433) has been constructed with a weir and 600mm dia low flow pipe under the sealed road on top of the dam wall. Top of dam wall is approx. RL92.0 and pipe invert is approx. RL91.0 but has been modelled with an upstream invert of RL91.4 to replicate the operation of the concrete weir which controls water level in the dam to RL91.4.
- Ground slopes from top of catchment to creek have been measured at 8% with creek bed average slope in reach 2% and length of 210m.
- The upper northern portion of the catchment is grassed. The lower portion of the catchment and creek environ is timbered. A surface roughness 'n' of 0.04 is considered reasonable for the catchment hydrology and 0.05 for creek bed hydraulics with overbank areas 0.04.

Catchment S4

- Catchment is 3.26ha in area.
- Catchment contains a large dam approx. 5,300m² in area (16.3% of catchment)
- Catchment contains part of the sealed access track to the dwelling referred to in Catchment S3 above approx. 130m² in area. Total impervious area for catchment then is 5430m² (16.7% of catchment).
- The dam (creek station 320) was observed to be a simple farm dam with no visible low flow pipe (wall is overgrown) but a nominal low flow pipe (150mm dia) has been added into the Hec-Ras model to avoid run errors. This pipe will not impact on model results. Based on site survey, the top of wall has been entered into model at RL90.0
- Ground slopes from top of catchment to creek have been measured at 6.5% with creek bed average slope in reach 2% and length of 90m.
- The catchment is grassed with a scattering of trees. The creek portion of this catchment is primarily dam lined with trees. A surface roughness 'n' of 0.04 is considered reasonable for the catchment hydrology and 0.04 for creek bed hydraulics with overbank areas 0.04.

Catchment N1

- Catchment has been measured at 6.67ha in area.
- Catchment does not include any road pavement areas associated with the Hume Motorway. The catchment analysis conducted by Lyall and Associates and confirmed by JMD indicates that the pavement area of the Hume Motorway adjacent to this catchment drains to the north away from the Maryfield Site.
- The catchment is steep with an average slope of 11% and ground cover of grass with some trees nearer the Hume Motorway. A surface roughness 'n' of 0.033 was considered suitable for the hydrology of this catchment.
- Catchment drains via 1200mm pipe inv upstream approx. 101.5 inv d/stream approx. 96 length approx. 155m grade assumed at 3.5%. Level of Motorway approx. RL106
- Basin volumes interpreted from Catchment contours as follows:-

RL	Area	Vol
101.5	0	0
102	40	6
104	483	526
106	2648	3657

- Pipe flow calculated using orifice eqn Q=0.6A(2gh)^0.5 Catchment flows found to exceed pipe capacity in some storm events. Basin overflows diverted out of system (to dummy node "Out")

via diversion link with bypass threshold set at 5.9m³/s (capacity of pipe inlet with water level at RL106)

-

Catchment N2

- Catchment has been measured at 7.47ha in area.
- Catchment does not include any road pavement areas associated with the Hume Motorway. The catchment analysis conducted by Lyall and Associates and confirmed by JMD indicates that the pavement area of the Hume Motorway adjacent to this catchment drains to the north away from the Maryfield Site.
- The catchment is steep with an average slope of 12.8% and ground cover of grass with some trees nearer the Hume Motorway. A surface roughness 'n' of 0.033 was considered suitable for the hydrology of this catchment.
- Catchment drains via 900mm pipe inv upstream approx. 101.5 inv d/stream approx. 98 length approx. 167m grade assumed at 2%. Level of Motorway approx. RL106
- Basin volumes interpreted from Catchment contours as follows:-

RL	Area	Vol
101.5	0	0
102	22	4
104	338	364
106	1491	2193

- Pipe flow calculated using orifice eqn Q=0.6A(2gh)^0.5 Catchment flows found to exceed pipe capacity in some storm events. Basin overflows diverted to Node N1 via diversion link with bypass threshold set at 3.4m³/s (capacity of pipe inlet with water level at RL106)

Catchment N3

- Catchment 9.17ha in area.
- Catchment contains 150m of unsealed access track which has been assumed to be impervious (adopted area 450m² = 0.5% of catchment)
- Ground slopes from top of catchment to creek have been measured at 10% with creek bed average slope in reach 2.6% and length of 200m.
- The catchment is largely grassed with a scattering of trees. The localised linear creek environ is reasonably timbered. A surface roughness 'n' of 0.04 is considered reasonable for the catchment hydrology and 0.045 for creek bed hydraulics with overbank areas 0.04.

Catchment N4

- Catchment 4.38ha in area.
- Catchment contains 310m of access track which has been assumed to be impervious (adopted area 930m² = 2.1% of catchment)
- The access track across the creek has been built up to form an embankment with twin 900mm pipes allowing the passage of water. Top of embankment is approx. RL87.7
- Ground slopes from top of catchment to creek have been measured at 10% south and 7% north. Average slope adopted was 8.5% with creek bed average slope in reach 2.4% and length of 138m.
- The catchment is largely grassed with only some of trees. The localised linear creek environ is only lightly timbered. A surface roughness 'n' of 0.035 is considered reasonable for the catchment hydrology and 0.04 for creek bed hydraulics with overbank areas 0.035.

Catchment N5

- Catchment has been measured at 2ha in area.
- Catchment is not affected by any impervious surfaces
- The catchment is largely grassed with a scattering of trees. The localised linear creek environ is lightly timbered. A surface roughness 'n' of 0.04 is considered reasonable for the catchment hydrology and 0.035 for creek bed hydraulics with overbank areas 0.04.

Catchments S5 & N6

- These catchments discharge directly to the large dam at the south-west corner of the site and measure 3.91ha and 4.95ha in area.
- The catchment includes the large dam which measures some 2.4ha in area and 245m of access road total combined impervious area adopted then is 2.47ha (27.9% of catchment).
- The catchment is largely grassed with few trees. The localised creek environ the large dam. A surface roughness 'n' of 0.033 is considered reasonable for the catchment hydrology.
- Ground slopes from top of catchment to creek have been measured at 9% but the dam is flat therefore average slope of 4.5% was adopted
- Catchment S5 RD with a total area of 1.13ha which represents the northern side of Narellan Rd drains into this catchment. Approximately 81% of this catchment is sealed and it is understood that the % impervious in this catchment will rise to 96% after the completion of the Narellan Rd upgrade works.

Catchment S6

- Catchment has been measured at 4.38ha in area.
- The catchment includes 235m of access road. Total impervious area adopted then is 705m² (1.6% of catchment).
- Ground slopes from top of catchment to creek have been measured at 10.9%
- The catchment is largely grassed with a scattering of trees. The creek environ as such is largely non-existent in this portion of the site as the area has been maintained over the years as a grassed area. Stormwater flows from the dam discharge into the downstream property via 4 900mm diameter pipes under the existing access road. A surface roughness 'n' of 0.033 is considered reasonable for the catchment hydrology.

Links

Each catchment node in the XP-Rafts model was connected using links. Long section inputs for each link consisting of length of flow and grade were input using the data described above. A generic Rafts section was used to approximate the creek profile. This section is a trapezoidal section 12m wide at the base with 1 in 4 banks 0.5m high with 10m wide overbank flow paths. Roughness factors for each link were adopted from the above assessment. The use of the generic section was checked for suitability by comparing velocities in the XP-Rafts output against those generated in the HEC-Ras hydraulic model. The two programs are indicating similar flow velocities and so the flow estimates generated in the XP-Rafts model are considered to be a reliable model of the site.

Table A1 below is a summary of the above details.

MARYFIELDS SITE					
CATCHMENT SUMMARY					
EXISTING CONDITIONS - PRIOR TO NARELLAN RD WORKS					
CATCH	AREA	% IMPERV.	AREA IMPERVIOUS (ha)	AREA PERVIOUS (ha)	CHECK TOTAL AREA (ha)
S1	15.53	10.30%	1.60	13.93	15.53
S2	5.55	7.20%	0.40	5.15	5.55
S3	4.21	11.30%	0.48	3.73	4.21
S4	3.26	16.70%	0.54	2.72	3.26
S5	3.91	27.90%	1.09	2.82	3.91
S5RD	1.13	81.00%	0.92	0.21	1.13
N1	6.67	0.00%	0.00	6.67	6.67
N2	7.47	0.00%	0.00	7.47	7.47
N3	9.17	0.50%	0.05	9.12	9.17
N4	4.38	2.10%	0.09	4.29	4.38
N5	2	0.00%	0.00	2.00	2
N6	4.95	27.90%	1.38	3.57	4.95
DAM	0	0.00%	0.00	0.00	0
S6	4.38	1.60%	0.07	4.31	4.38
Totals	72.61		6.61	66.00	72.61
POST NARELLAN RD WORKS					
CATCH	AREA	% IMPERV.	Exist AREA IMPERVIOUS (ha)	Exist AREA PERVIOUS (ha)	CHECK TOTAL AREA (ha)
S1	15.53	12.60%	1.96	13.57	15.53
S2	5.55	7.20%	0.40	5.15	5.55
S3	4.21	11.30%	0.48	3.73	4.21
S4	3.26	16.70%	0.54	2.72	3.26
S5	3.91	27.90%	1.09	2.82	3.91
S5RD	1.13	96.00%	1.08	0.05	1.13
N1	6.67	0.00%	0.00	6.67	6.67
N2	7.47	0.00%	0.00	7.47	7.47
N3	9.17	0.50%	0.05	9.12	9.17
N4	4.38	2.10%	0.09	4.29	4.38
N5	2	0.00%	0.00	2.00	2
N6	4.95	27.90%	1.38	3.57	4.95
DAM	0	0.00%	0.00	0.00	0
S6	4.38	1.60%	0.07	4.31	4.38
	72.61		7.14	65.47	72.61
E1	2.88	0%	0.00	2.88	2.88

The HEC-Ras computer hydraulic model was setup as described in section 4. The large dam does not at present have any significant overflow structure. For the purpose of this assessment, it has been assumed that any flows which escape the large dam flow over the wall. For the purpose of setting downstream water levels, the wall has been assumed to be a control with the depth of water over the wall being estimated by the use of the generic weir equation:-

Q = 1.7Ld^1.5	Q	= flow over weir (m^3/s)
	L	= length of weir (m)
	d	= depth of flow over weir

The wall is approximately 148m wide with a top of bank level of approx. RL84.4m resulting in the following starting water levels assuming the large dam is full at the start of the peak flow events:-

Event ARI	Flow (m^3/s)	d(m)	Top water Level(m)
5	10.11	0.12	84.52
10	12.48	0.14	84.54
20	15.76	0.16	84.56
50	18.54	0.18	84.58
100	21.3	0.19	84.59
PMF	75.13	0.45	84.85

A2 External Catchments

There are three catchments along the northern boundary of the Maryfields Site which discharge to the north away from the central creek section. These have been denoted catchments E1, E2 and E3.

Catchment E1

- This catchment is 2.88ha in area and includes a portion of the Hume Motorway land.
- Catchment falls at 10% grade to a gully along the southern side of the Hume Motorway.
- The catchment is grassed A surface roughness ‘n’ of 0.033 is considered reasonable for the catchment hydrology.

Catchment E2

- This catchment is 4.87ha in area.
- The catchment has a small % impervious (4%) associated with the existing building at the top of the catchment.
- Catchment falls at 8% grade to the bend in Maryfields Drive north of the intersection with the northern leg of Gabriel Cct.
- The catchment is grassed A surface roughness ‘n’ of 0.033 is considered reasonable for the catchment hydrology.

Catchment E3

- This catchment is 1.29ha in area.
- The catchment has a small % impervious (9%) associated with the existing building at the top of the catchment.
- Catchment falls at 9% grade to Maryfields Drive at the intersection with the southern leg of Gabriel Cct.
- The catchment is grassed A surface roughness ‘n’ of 0.033 is considered reasonable for the catchment hydrology.

A3 Comparison of JMD XP-Rafts outputs

JMD results

The above parameters were input modelled using the XP-Rafts computer program and analysed for 5, 10, 20, 50 and 100 year storm events ranging from 25 minutes to 270 minutes.

The following rainfall losses as specified in Council's design specification were adopted.

Impervious areas 1.5mm initial loss, 0mm continuing loss
Pervious areas 15mm initial loss, 2.5mm continuing loss

IFD data for the Campbelltown catchment identified in the Council Design Specification was input into the model and standard rainfall storm events were generated using standard Aust. Rainfall and Runoff inputs provided in the program.

~~For the purposes of analysing the model under the effects of an extreme storm event the extreme storm event was considered as a flood resulting from a 2 hour rainfall with a rainfall intensity 3 times the 100 year ARI rainfall intensity. The flows resulting from such an event can be considered as an approximation of an extreme flood instead of a PMF.~~ An initial review of this report by Campbelltown Council noted that the intensity adopted for the extreme event previously adopted could be out by a factor of 3. In order to address Council's concerns, the PMF has been assessed by estimating the PMP using the Bureau of Meteorology Bulletin 53 method and routing the PMP through the XP-Rafts model assuming a 0mm initial loss and 1mm continuing loss as recommended in Australian Rainfall and Runoff. The figures below detail the resultant flows.

The storage Coefficient Multiplication Factor was set to 1 as required by Council.

The results of peak flows from the model are as follows:-

Catchment	Peak Flow for Storm Event Average Recurrence Interval (m^3)					
	5	10	20	50	100	PMF
S1	2.63/2.67	3.25/3.29	4.11/4.14	4.82/4.84	5.52/5.53	~~18.23~~
S2	3.48/3.49	4.28/4.32	5.40/5.42	6.31/6.31	7.25/7.26	~~24.61~~
S3	4.08/4.10	5.02/5.06	6.29/6.30	7.39/7.40	8.46/8.47	~~29.23~~
S4	4.51/4.53	5.57/5.60	6.98/7.0	8.16/8.18	9.4/9.41	~~32.79/32.83~~
N1	1.21	1.49	1.85	2.14	2.42	
N2	1.41	1.73	2.13	2.44	2.75	
N3	3.92	4.83	6.06	7.05	7.99	~~27.38~~
N4	4.63	5.68	7.12	8.26	9.41	~~32.50~~
N5	4.92	6.03	7.56	8.81	10.03	~~34.74~~
S5,S5RD+N6	10.09/10.11	12.45/12.48	15.73/15.76	18.5/18.54	21.28 /21.3	~~75.04/75.13~~
S6	10.6/10.62	13.13/13.17	16.6/16.63	19.52/19.56	22.45 /22.47	~~79.88/79.99~~

The second set of figures for catchments S1 to S6 indicate the change in flows through the site as a result of the Narellan Road upgrade works. The changes in flows resulting from these works are not considered significant.

The above results detail the results of initial modelling completed prior to discussions with Council. The modelling of catchments S1, N1 and N2 was discussed and Council's officer requested that the detention effects of the Hume Motorway Embankment be accounted for. The model has now been

adjusted to account for the detention effects as discussed in Section A1 above and the resultant flows are adjusted as follows:-

Catchment	Peak Flow for Storm Event Average Recurrence Interval (m^3)					
	5	10	20	50	100	PMF
S1	2.17/**2.17** **(2.37)**	2.46/**2.46** **(2.74)**	2.87/**2.87** **(3.12)**	3.17/**3.17** **(3.46)**	3.48/**3.48** **(3.76)**	
S2	2.93/**2.93** **(3.24)**	3.34/**3.33** **(3.74)**	3.94/**3.93** **(4.33)**	4.41/**4.40** **(4.82)**	4.86/**4.85** **(5.31)**	~~11.85~~ 22.64
S3	3.49/**3.40** **(3.78)**	4.02/**3.89** **(4.37)**	4.76/**4.60** **(5.13)**	5.39/**5.21** **(5.76)**	6.03/**5.79** **(6.48)**	~~16.47~~ 34.21
S4	3.92/**3.83** **(4.27)**	4.53/**4.39** **(4.96)**	5.40/**5.21** **(5.86)**	6.17/**5.99** **(6.73)**	6.93/**6.77** **(7.58)**	~~20.05~~ 43.41
N1	1.16/**1.16** **(1.34)**	1.40/**1.40** **(1.62)**	1.73/**1.73** **(1.99)**	2.02/**2.02** **(2.28)**	2.29/**2.29** **(2.56)**	~~7.55~~
N2	1.32/**1.32** **(1.51)**	1.57/**1.57** **(1.80)**	1.90/**1.90** **(2.14)**	2.17/**2.17** **(2.41)**	2.42/**2.42** **(2.49)**	~~8.59~~
N3	3.79/**3.68** **(4.24)**	4.58/**4.40** **(5.09)**	5.65/**5.38** **(6.12)**	6.56/**6.29** **(7.20)**	7.44/**7.25** **(8.13)**	~~18.86~~ 37.02
N4	4.43/**4.17** **(4.81)**	5.35/**5.01** **(5.79)**	6.61/**6.13** **(7.15)**	7.71/**7.35** **(8.45)**	8.73/**8.51** **(9.59)**	~~23.69~~ 50.3
N5	4.72/**4.32** **(4.97)**	5.68/**5.18** **(6.07)**	7.03/**6.47** **(7.54)**	8.19/**7.75** **(8.88)**	9.32/**8.95** **(10.06)**	~~25.89~~ 56.05
S5,S5RD+N6	9.46/**8.89** **(10.19)**	11.24/**10.59** **(12.29)**	13.79/**13.04** **(14.93)**	16.09/**15.27** **(17.36)**	18.32/**17.48** **(19.52)**	~~54.62~~ 121.9
S6	9.94/**9.23** **(10.73)**	11.85/**11.18** **(12.95)**	14.63/**13.76** **(15.73)**	17.07/**16.09** **(18.48)**	19.45/**18.63** **(20.9)**	~~59.47~~ 135
E1	0.58/**0.60** **(0.68)**	0.70/**0.71** **(0.81)**	0.86/**0.86** **(0.97)**	0.98/**0.99** **(1.12)**	1.1/**1.13** **(1.28)**	~~3.58~~ 8.90
E2	0.79/**1.33** **(1.47)**	1.01/**1.53** **(1.70)**	1.27/**1.79** **(2.01)**	1.50/**2.01** **(2.21)**	1.72/**2.25** **(2.49)**	~~5.70~~ 15.44
E3	0.28/**0.39** **(0.43)**	0.34/**0.45** **(0.50)**	0.42/**0.52** **(0.58)**	0.48/**0.58** **(0.64)**	0.55/**0.65** **(0.71)**	~~1.68~~ 4.17

Figures for catchments S1 to S6 indicate the flows through the site including Narellan Road upgrade works. Figures in Bold are for the developed site with no OSD. Figures in () indicate developed flows with Climate Change increase.

The flood mapping detailed at Appendix B indicates the flood lines for the 1 in 100 flood and the PMF event. It is noted that the PMF line was generated based on the flows detailed on page 26 of this report (ie: prior to adjustment for highway culverts). The flow depths generated from these flows are very similar to that generated by the updated PMF flows and so the PMF flood line on the mapping does not change.

Lyall Results

The JMD results were compared to the results from the Lyall and Associates report. Unfortunately, that report did not detail flows entering the site other than for Catchment S1 (Lyall catchment C11 discharging at Structure F13). Catchments discharging to structures F14 and F15 equivalent to the JMD catchments N1 and N2 were identified in the Lyall Report but no flow details were reported.

The Lyall results for the Lyall Catchment C11 discharging to Structure F13 are reported at Table 5.2 of the Lyall report as 2.71m³/s in the 5 yr event, 4.16m³/s in the 20 year event and 5.66m³/s in the 100 year event. These figures correspond to the initial JMD results for JMD Catchment S1.

Rust PPK Results

The Rust PPK report does not detail the catchment areas used to estimate the peak flow. The total area draining to the south-east boundary of the Maryfields Site as estimated by JMD is 72.61ha. Adopting the Rural Rational method as recommended in Australian Rainfall and Runoff,

t'c = 0.76A^0.38 A-catchment area in sq.km (0.7261km²)
= 40 minutes

I100 = 87mm/hr

C10 =0.6

FF100 =1.38

Q =fCIA
= 0.6 x 1.38 x 87 x 72.61 / 360
= 14.53m³/s

If the external catchments are excluded (JMD catchments S1, N1, N2 and S5RD) the catchment area becomes 41.8ha and the resulting t'c = 33mins I100 = 97mm/h and the peak 100 year flow is 9.33m³/s. It would seem then that the Rust PPK report only considered the flows off the local site and ignored the flows off the external catchment.

The difference between the JMD flow peak 100 year flow (22.45m³/s) detailed above and the 14.53m³/s peak rational method flow of the combined catchment area in the above calculation results from the use of more detailed site specific input data. The Rational Method is a generic flow estimation only and is based on gross data and does not consider factors such as surface slope and roughness, and catchment characteristics.

The Lyall calculations were undertaken using the DRAINS unit hydrograph type hydrological model similar to the XP-Rafts model used by JMD and have achieved similar results.

Appendix B

Catchment Plan

50 20 0 40 80 120 160 200
1 : 2000

MGA

CATCHMENT 'N1'
6.67ha

CATCHMENT 'N2'
7.47ha

1
DP 1136070

CATCHMENT 'S1'
15.53ha

HUME MOTORWAY

ST STEPHEN RD

EASEMENT FOR TRANSMISSION LINE 40 METRES WIDE (VIDE BK 3241 No 396)

CATCHMENT 'E1'
2.88ha

2
D.P. 569795
1964ha vide
Title Diagram

CATCHMENT 'E2'
4.87ha

GABRIEL CCT

EXISTING SUBDIVISION

MARYFIELDS DR

12
D.P. 829093

BETHLEHEM MONASTERY

CATCHMENT 'N3'
9.17ha

NORTH CREEK

CATCHMENT 'N4'
4.38ha

CATCHMENT 'N5'
2.00ha

CATCHMENT 'E3'
1.29ha

CATCHMENT 'S2'
5.55ha

1
D.P.247902
17.11 ha vide
Title Diagram

1
DP 1136995
16.28 ha vide
Calculation

CATCHMENT 'N6'
4.95ha

MARYFIELDS FRIARY

13
D.P. 1034409

SOUTH CREEK

DAM No.4

CATCHMENT 'S3'
4.21ha

EASEMENT FOR WATER SUPPLY 3.66 WIDE (J107955)

MARSH

DAM No.3

DAM No.2

CATCHMENT 'S4'
3.26ha

CATCHMENT 'S5'
3.91ha

DAM No.1

EASEMENT FOR ELECTRICITY PURPOSES 45.105 WIDE (DP 829093)

CATCHMENT 'S6'
4.38ha

RIGHT OF CAI
10.06 WIDE & VA
(VIDE BK 28

1
D.P. 575729
4856m vide
Title Diagram

NARELLAN ROAD

CATCHMENT 'S5' RD
1.13ha

63
DP 1104456

4
DP 247902

63
DP 1104456

5
DP 253700

845
DP 1024090

LEGEND

- DENOTES CATCHMENT BOUNDARY
- CATCHMENT 'S2' 5.55ha — DENOTES CATCHMENT NAME & CATCHMENT AREA
- 397.009 — DENOTES CREEK SET OUT (STATION 397.009)
- DENOTES POSSIBLE MAXIMUM FLOOD LINE (PMF)
- DENOTES 100 YEAR FLOOD LINE
- DENOTES RIPARIAN BUFFER ZONE AS DETERMINED BY THE OFFICE OF WATER

Issue	App	Date	Description
A	T.H.	26-03-2015	ORIGINAL ISSUE

Client: FRANCISCA PROVISIONAL OFFICE

Designed by : T.H.

Date of Drawing : 26-03-2015

Ratio (A1) : 1:2000

Datum : AHD

Origin of Levels : SSM40186
RL101.917 VIDE
SCIMS 12-09-1990

Date of Survey : 09-09-2002

JMD Development Consultants

John M. Daly & Associates PTY LTD
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Surveying
Engineering
Project Management
Licensed Water Service Co ordinators
32 Iolanthe Street
P.O. BOX 25
CAMPBELLTOWN N.S.W. 2560
PH. (02) 4625 5055
FAX (02) 4628 2013
email: admin@jmd.com.au

Project : MARYFIELDS, NARELLAN ROAD, CAMPBELLTOWN

Sheet 1 of 2 sheets

CATCHMENT PLAN

Ref: 12100E1

Locality : CAMPBELLTOWN

L.G.A. : CAMPBELLTOWN

CAD Ref: S:\DATA\12\12100\ENG\CAD\E1-FLOOD\12100E1-CATCH

LEGEND

- DENOTES CATCHMENT BOUNDARY
- CATCHMENT 'S2' 5.55ha — DENOTES CATCHMENT NAME
- 397.009 — DENOTES CREEK SET OUT (STATION 397.009)
- DENOTES POSSIBLE MAXIMUM FLOOD LINE (PMF)
- DENOTES 100 YEAR FLOOD LINE
- DENOTES RIPARIAN BUFFER ZONE AS DETERMINED BY THE OFFICE OF WATER
- DENOTES SENIORS LIVING
- DENOTES BUSINESS PARK
- DENOTES LOW DENSITY RESIDENTIAL
- DENOTES MEDIUM DENSITY RESIDENTIAL

50 20 0 40 80 120 160 200
1 : 2000

MGA

CATCHMENT 'N1'
CATCHMENT 'E1'
CATCHMENT 'E2'
CATCHMENT 'E3'
CATCHMENT 'N3'
CATCHMENT 'N4'
CATCHMENT 'N5'
CATCHMENT 'N6'
CATCHMENT 'S2'
CATCHMENT 'S3'
CATCHMENT 'S4'
CATCHMENT 'S5'
CATCHMENT 'S5' RD
CATCHMENT 'S6'
ENT 'S1'

MOTORWAY
HUME
ST STEPHEN RD
GABRIEL CCT
MARYFIELDS DR
THE KRAAL DRIVE
NARELLAN ROAD

EASEMENT FOR TRANSMISSION LINE 40 METRES WIDE (VIDE BK 3247 NO 396)
EXISTING SUBDIVISION
BETHLEHEM MONASTERY
MARYFIELDS FRIARY
RIGHT OF CARRIAGEWAY 10.06 WIDE & VARIABLE WIDTH (VIDE BK 2825 No 419)
EASEMENT FOR WATER SUPPLY 3.66 WIDE (D107953)
EASEMENT FOR ELECTRICITY PURPOSES 45 WIDE (D829093)
NORTH CREEK
SOUTH CREEK
LARGE DAM
MARSH

1 DP 1136070
2 D.P. 569795 1.964ha vide Title Diagram
12 D.P. 829093
1 DP 1136995 16.28 ha vide Calculation
1 D.P.247902 17.11 ha vide Title Diagram
13 D.P. 1034409
1 D.P. 575729 4856m vide Title Diagram
63 DP 1104456
4 DP 247902
63 DP 1104456
5 DP 253700
843 DP 1024090

Issue	App	Date	Description
A	T.H.	26-03-2015	ORIGINAL ISSUE

Client: FRANCISCA PROVISIONAL OFFICE
Designed by : T.H.
Date of Drawing : 26-03-2015
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email: admin@jmd.com.au

Project : MARYFIELDS, NARELLAN ROAD, CAMPBELLTOWN
Sheet 2 of 2 sheets
CATCHMENT PLAN OVERLAID WITH PROPOSED DEVELOPMENT AREAS
Ref: 12100E1
Locality : CAMPBELLTOWN
L.G.A. : CAMPBELLTOWN
CAD Ref: S:\DATA\12\12100\ENG\CAD\E1-FLOOD\12100E1-CATCH

Appendix C

Tributary 1 Water Surface Profiles for existing conditions

5 Year Event – Existing Conditions

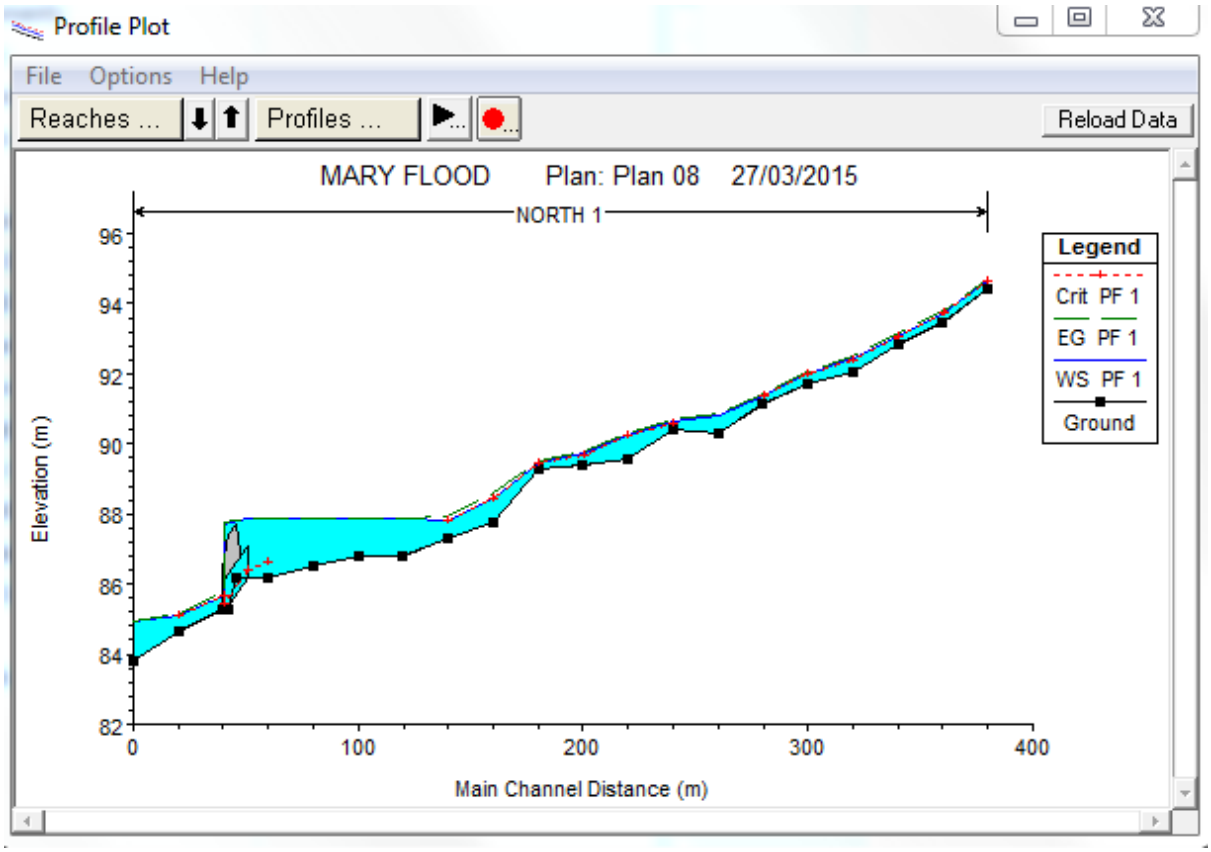

Figure C1 Typical profile plot of northern arm Tributary 1

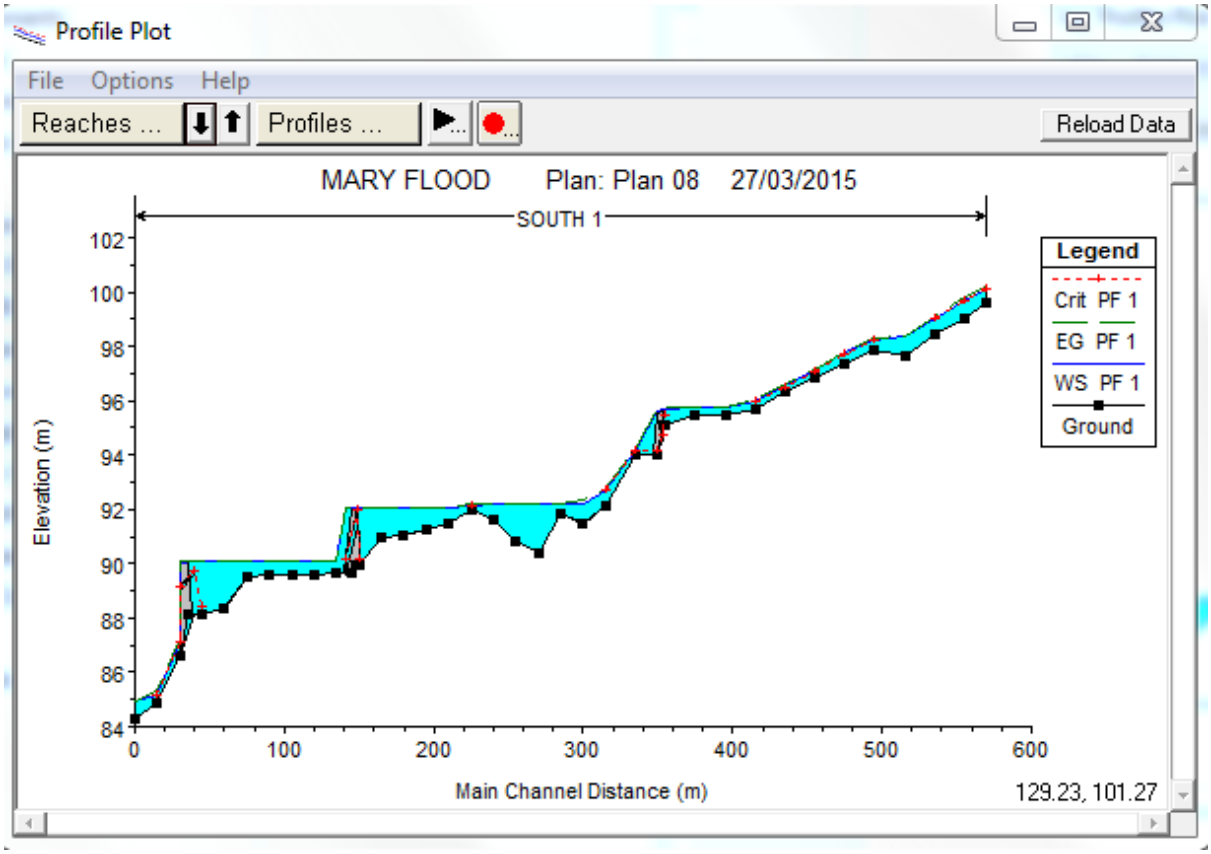

Figure C2 Typical profile plot of Upper reach of Southern arm Tributary 1

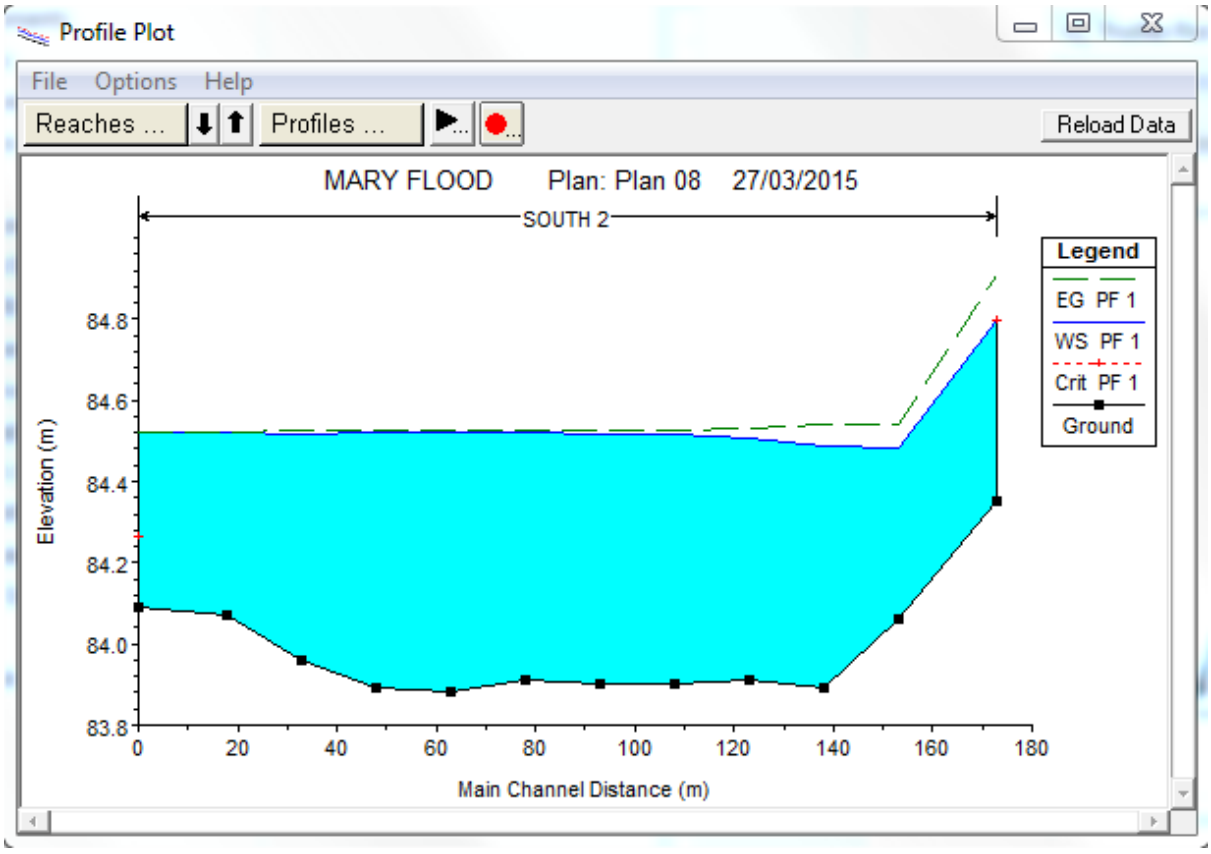

Figure C3 Typical profile plot of Lower Reach of Southern arm Tributary 1 (through Large Dam)

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	2.17	99.58	100.10	100.08	100.18	0.024093	1.48	1.90	9.47	0.77
SOUTH	1	840	PF 1	2.17	98.99	99.61	99.61	99.77	0.028946	1.81	1.30	4.43	0.88
SOUTH	1	820	PF 1	2.17	98.42	98.98	98.98	99.08	0.035304	1.49	1.63	8.20	0.91
SOUTH	1	800	PF 1	2.17	97.68	98.34		98.35	0.001984	0.36	6.11	24.81	0.23
SOUTH	1	780	PF 1	2.17	97.88	98.21	98.16	98.25	0.022286	0.92	2.44	15.40	0.71
SOUTH	1	760	PF 1	2.17	97.35	97.73	97.69	97.78	0.024636	1.03	2.11	11.14	0.76
SOUTH	1	740	PF 1	2.17	96.87	97.08	97.08	97.13	0.045626	0.92	2.36	23.60	0.93
SOUTH	1	720	PF 1	2.17	96.36	96.54	96.50	96.57	0.018400	0.74	2.95	21.11	0.63
SOUTH	1	700	PF 1	2.17	95.66	95.93	95.93	96.00	0.049171	1.17	1.85	13.65	1.01
SOUTH	1	680	PF 1	2.17	95.46	95.76		95.76	0.000833	0.22	10.28	47.80	0.14
SOUTH	1	660	PF 1	2.17	95.45	95.74		95.74	0.001158	0.21	10.22	59.03	0.16
SOUTH	1	640	PF 1	2.93	95.08	95.71	95.43	95.71	0.001642	0.31	11.09	72.15	0.20
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	2.93	93.99	94.16	94.16	94.23	0.048559	1.16	2.52	18.56	1.01
SOUTH	1	600	PF 1	2.93	92.12	92.65	92.65	92.77	0.040270	1.51	1.96	8.88	0.99
SOUTH	1	585	PF 1	2.93	91.48	92.20		92.29	0.017442	1.33	2.25	6.23	0.71
SOUTH	1	570	PF 1	2.93	91.85	92.19		92.20	0.002160	0.32	6.49	21.18	0.23
SOUTH	1	555	PF 1	2.93	90.39	92.19		92.19	0.000016	0.08	38.17	39.56	0.03
SOUTH	1	540	PF 1	2.93	90.84	92.19		92.19	0.000025	0.08	34.84	45.16	0.03
SOUTH	1	525	PF 1	2.93	91.64	92.19		92.19	0.000286	0.17	17.40	49.59	0.09
SOUTH	1	510	PF 1	2.93	92.02	92.14	92.14	92.17	0.061049	0.83	3.56	52.87	1.01
SOUTH	1	495	PF 1	2.93	91.51	92.08		92.08	0.000368	0.19	17.59	64.02	0.10
SOUTH	1	480	PF 1	2.93	91.24	92.08		92.08	0.000033	0.09	38.74	80.07	0.03
SOUTH	1	465	PF 1	2.93	91.06	92.08		92.08	0.000024	0.08	42.43	86.31	0.03
SOUTH	1	450	PF 1	2.93	90.95	92.08		92.08	0.000021	0.06	50.66	103.53	0.03
SOUTH	1	435	PF 1	3.49	89.98	92.08	90.16	92.08	0.000001	0.03	131.90	105.86	0.01
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	3.49	89.66	90.10		90.10	0.000255	0.17	21.42	63.24	0.09
SOUTH	1	405	PF 1	3.49	89.59	90.09		90.09	0.000204	0.15	23.64	63.93	0.08
SOUTH	1	390	PF 1	3.49	89.57	90.09		90.09	0.000238	0.17	21.81	62.77	0.08
SOUTH	1	375	PF 1	3.49	89.59	90.08		90.08	0.000560	0.20	17.09	60.81	0.12
SOUTH	1	360	PF 1	3.49	89.54	90.07		90.07	0.000807	0.22	15.77	65.79	0.14
SOUTH	1	345	PF 1	3.49	88.35	90.07		90.07	0.000041	0.11	42.15	94.78	0.04
SOUTH	1	330	PF 1	3.49	88.11	90.07	88.38	90.07	0.000002	0.03	120.89	129.04	0.01
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	3.49	86.63	87.11	87.11	87.21	0.044002	1.43	2.43	12.04	1.02
SOUTH	1	300	PF 1	3.49	84.89	85.17	85.17	85.25	0.045934	1.29	2.70	16.29	1.01
SOUTH	1	285	PF 1	3.49	84.26	84.90		84.91	0.000564	0.26	13.31	32.65	0.13
SOUTH	2	274.9	PF 1	9.46	84.35	84.78	84.78	84.89	0.000000	1.48	6.39	29.53	1.02
SOUTH	2	255	PF 1	9.46	84.06	84.49		84.54	0.000000	1.00	9.42	38.92	0.65
SOUTH	2	240	PF 1	9.46	83.89	84.49		84.54	0.000000	0.90	10.52	45.74	0.60
SOUTH	2	225	PF 1	9.46	83.91	84.51		84.53	0.000000	0.63	17.37	60.01	0.37
SOUTH	2	210	PF 1	9.46	83.90	84.52		84.53	0.000000	0.40	24.12	61.48	0.20
SOUTH	2	195	PF 1	9.46	83.90	84.52		84.53	0.000000	0.44	22.18	60.62	0.22
SOUTH	2	180	PF 1	9.46	83.91	84.52		84.52	0.000000	0.32	30.43	78.77	0.16
SOUTH	2	165	PF 1	9.46	83.88	84.52		84.52	0.000000	0.28	34.25	80.86	0.14
SOUTH	2	150	PF 1	9.46	83.89	84.52		84.52	0.000000	0.25	38.28	85.13	0.12
SOUTH	2	135	PF 1	9.46	83.96	84.52		84.52	0.000000	0.31	34.90	83.41	0.14
SOUTH	2	120	PF 1	9.46	84.07	84.52		84.52	0.000000	0.22	47.44	125.49	0.11
SOUTH	2	102	PF 1	9.46	84.09	84.52	84.26	84.52	0.000000	0.21	45.87	142.53	0.12
NORTH	1	560	PF 1	2.48	94.41	94.62	94.62	94.68	0.032360	1.11	2.24	18.30	1.01
NORTH	1	540	PF 1	2.48	93.44	93.73	93.73	93.81	0.028969	1.29	1.94	12.16	1.01
NORTH	1	520	PF 1	2.48	92.83	93.08	93.08	93.16	0.029984	1.27	1.96	12.33	1.01
NORTH	1	500	PF 1	2.48	92.06	92.43	92.40	92.51	0.017511	1.24	2.00	8.58	0.82
NORTH	1	480	PF 1	2.48	91.70	91.97	91.97	92.06	0.029382	1.30	1.91	11.38	1.01
NORTH	1	460	PF 1	2.48	91.12	91.36	91.36	91.43	0.030230	1.23	2.02	13.44	1.01
NORTH	1	440	PF 1	2.48	90.30	90.82		90.85	0.006554	0.78	3.20	13.24	0.50
NORTH	1	420	PF 1	2.48	90.39	90.64	90.59	90.68	0.011457	0.86	2.87	15.66	0.64
NORTH	1	400	PF 1	2.48	89.59	90.24	90.24	90.31	0.032303	1.20	2.07	14.88	1.02
NORTH	1	380	PF 1	3.79	89.42	89.75	89.68	89.77	0.007304	0.71	5.36	28.14	0.52
NORTH	1	360	PF 1	3.79	89.27	89.44	89.44	89.50	0.031428	1.15	3.29	24.77	1.01
NORTH	1	340	PF 1	3.79	87.75	88.41	88.41	88.58	0.024240	1.82	2.08	6.29	1.01
NORTH	1	320	PF 1	3.79	87.31	87.82	87.82	87.92	0.024650	1.42	2.67	12.40	0.97
NORTH	1	300	PF 1	3.79	86.79	87.86		87.87	0.000191	0.30	12.54	14.95	0.11
NORTH	1	280	PF 1	3.79	86.82	87.86		87.86	0.000088	0.20	18.70	22.95	0.07
NORTH	1	260	PF 1	3.79	86.51	87.86		87.86	0.000025	0.12	32.84	39.05	0.04
NORTH	1	240	PF 1	3.79	86.18	87.86	86.64	87.86	0.000024	0.13	31.05	48.84	0.04
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	3.79	85.27	85.65	85.65	85.80	0.024806	1.68	2.25	7.94	1.01
NORTH	1	200	PF 1	3.79	84.66	85.07	85.07	85.14	0.034737	1.12	3.41	29.17	1.04
NORTH	1	180	PF 1	3.79	83.83	84.90		84.91	0.000394	0.28	13.38	30.62	0.14

10 Year Event – Existing Conditions

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	2.46	99.58	100.12	100.09	100.20	0.024004	1.53	2.11	10.04	0.77
SOUTH	1	840	PF 1	2.46	98.99	99.67	99.67	99.81	0.027395	1.74	1.56	5.40	0.86
SOUTH	1	820	PF 1	2.46	98.42	99.00	99.00	99.11	0.035404	1.53	1.80	8.74	0.92
SOUTH	1	800	PF 1	2.46	97.68	98.36		98.37	0.002004	0.38	6.58	25.08	0.23
SOUTH	1	780	PF 1	2.46	97.88	98.23	98.18	98.27	0.021557	0.92	2.76	16.77	0.70
SOUTH	1	760	PF 1	2.46	97.35	97.74	97.71	97.80	0.025451	1.08	2.29	11.60	0.78
SOUTH	1	740	PF 1	2.46	96.87	97.09	97.09	97.14	0.044587	0.93	2.63	25.34	0.92
SOUTH	1	720	PF 1	2.46	96.36	96.56	96.51	96.59	0.018415	0.77	3.21	21.78	0.63
SOUTH	1	700	PF 1	2.46	95.66	95.95	95.95	96.02	0.048358	1.20	2.05	14.35	1.01
SOUTH	1	680	PF 1	2.46	95.46	95.77		95.77	0.000897	0.23	10.87	48.20	0.15
SOUTH	1	660	PF 1	2.46	95.45	95.75		95.75	0.001216	0.23	10.87	59.27	0.17
SOUTH	1	640	PF 1	3.34	95.08	95.72	95.45	95.72	0.001853	0.33	11.67	72.52	0.22
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	3.34	93.99	94.17	94.17	94.25	0.046990	1.21	2.77	19.17	1.00
SOUTH	1	600	PF 1	3.34	92.12	92.68	92.68	92.79	0.039543	1.52	2.22	9.96	0.99
SOUTH	1	585	PF 1	3.34	91.48	92.22		92.32	0.020700	1.47	2.33	6.35	0.77
SOUTH	1	570	PF 1	3.34	91.85	92.20		92.21	0.002567	0.36	6.71	21.39	0.25
SOUTH	1	555	PF 1	3.34	90.39	92.20		92.21	0.000020	0.09	38.65	39.79	0.03
SOUTH	1	540	PF 1	3.34	90.84	92.20		92.20	0.000031	0.10	35.37	45.19	0.03
SOUTH	1	525	PF 1	3.34	91.64	92.20		92.20	0.000334	0.19	17.97	49.63	0.10
SOUTH	1	510	PF 1	3.34	92.02	92.15	92.15	92.18	0.057738	0.86	3.92	53.02	1.00
SOUTH	1	495	PF 1	3.34	91.51	92.09		92.09	0.000408	0.20	18.53	64.35	0.11
SOUTH	1	480	PF 1	3.34	91.24	92.09		92.09	0.000039	0.10	39.91	80.27	0.04
SOUTH	1	465	PF 1	3.34	91.06	92.09		92.09	0.000029	0.08	43.68	86.66	0.03
SOUTH	1	450	PF 1	3.34	90.95	92.09		92.09	0.000025	0.06	52.15	103.72	0.03
SOUTH	1	435	PF 1	4.53	89.98	92.09	90.18	92.09	0.000002	0.04	133.43	106.17	0.01
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	4.53	89.66	90.12		90.12	0.000350	0.21	22.92	64.38	0.10
SOUTH	1	405	PF 1	4.53	89.59	90.11		90.12	0.000290	0.18	25.07	65.01	0.09
SOUTH	1	390	PF 1	4.53	89.57	90.11		90.11	0.000336	0.21	23.11	63.75	0.10
SOUTH	1	375	PF 1	4.53	89.59	90.10		90.10	0.000777	0.25	18.21	61.76	0.15
SOUTH	1	360	PF 1	4.53	89.54	90.09		90.09	0.001157	0.27	16.69	67.20	0.17
SOUTH	1	345	PF 1	4.53	88.35	90.09		90.09	0.000064	0.13	43.45	95.88	0.05
SOUTH	1	330	PF 1	4.53	88.11	90.09	88.41	90.09	0.000003	0.04	122.68	130.12	0.01
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	4.53	86.63	87.15	87.15	87.27	0.042266	1.50	3.01	13.49	1.01
SOUTH	1	300	PF 1	4.53	84.89	85.20	85.20	85.30	0.042963	1.40	3.25	16.58	1.01
SOUTH	1	285	PF 1	4.53	84.26	84.94		84.94	0.000715	0.31	14.56	33.03	0.15
SOUTH	2	274.9	PF 1	11.24	84.35	84.81	84.81	84.93	0.000000	1.53	7.35	31.67	1.01
SOUTH	2	255	PF 1	11.24	84.06	84.50		84.56	0.000000	1.15	9.81	39.49	0.73
SOUTH	2	240	PF 1	11.24	83.89	84.51		84.56	0.000000	1.01	11.13	46.77	0.66
SOUTH	2	225	PF 1	11.24	83.91	84.53		84.55	0.000000	0.71	18.40	61.35	0.41
SOUTH	2	210	PF 1	11.24	83.90	84.54		84.55	0.000000	0.46	25.31	62.65	0.23
SOUTH	2	195	PF 1	11.24	83.90	84.53		84.55	0.000000	0.51	23.31	61.72	0.25
SOUTH	2	180	PF 1	11.24	83.91	84.54		84.54	0.000000	0.36	31.98	79.98	0.17
SOUTH	2	165	PF 1	11.24	83.88	84.54		84.54	0.000000	0.32	35.85	81.87	0.15
SOUTH	2	150	PF 1	11.24	83.89	84.54		84.54	0.000000	0.29	39.98	86.37	0.13
SOUTH	2	135	PF 1	11.24	83.96	84.54		84.54	0.000000	0.36	36.56	88.96	0.16
SOUTH	2	120	PF 1	11.24	84.07	84.54		84.54	0.000000	0.24	49.93	126.45	0.12
SOUTH	2	102	PF 1	11.24	84.09	84.54	84.27	84.54	0.000000	0.24	48.69	143.01	0.13
NORTH	1	560	PF 1	2.97	94.41	94.64	94.64	94.71	0.031588	1.15	2.58	19.46	1.01
NORTH	1	540	PF 1	2.97	93.44	93.75	93.75	93.85	0.027263	1.35	2.22	12.42	1.00
NORTH	1	520	PF 1	2.97	92.83	93.10	93.10	93.20	0.028840	1.34	2.22	12.44	1.01
NORTH	1	500	PF 1	2.97	92.06	92.45	92.42	92.54	0.018654	1.35	2.20	8.70	0.86
NORTH	1	480	PF 1	2.97	91.70	92.00	92.00	92.09	0.027807	1.37	2.17	11.52	1.01
NORTH	1	460	PF 1	2.97	91.12	91.38	91.38	91.46	0.029264	1.29	2.30	13.84	1.01
NORTH	1	440	PF 1	2.97	90.30	90.85		90.88	0.006831	0.82	3.61	14.07	0.52
NORTH	1	420	PF 1	2.97	90.39	90.66	90.61	90.71	0.011809	0.93	3.20	16.03	0.66
NORTH	1	400	PF 1	2.97	89.59	90.26	90.26	90.34	0.030834	1.25	2.37	15.34	1.02
NORTH	1	380	PF 1	4.58	89.42	89.77	89.69	89.80	0.007550	0.77	5.97	28.55	0.53
NORTH	1	360	PF 1	4.58	89.27	89.46	89.46	89.53	0.029518	1.21	3.77	25.11	1.00
NORTH	1	340	PF 1	4.58	87.75	88.47	88.47	88.65	0.023383	1.88	2.43	6.80	1.01
NORTH	1	320	PF 1	4.58	87.31	87.84	87.84	87.96	0.026495	1.56	2.95	12.61	1.02
NORTH	1	300	PF 1	4.58	86.79	87.88		87.89	0.000259	0.36	12.85	15.06	0.12
NORTH	1	280	PF 1	4.58	86.82	87.88		87.89	0.000119	0.24	19.18	23.09	0.08
NORTH	1	260	PF 1	4.58	86.51	87.88		87.88	0.000034	0.14	33.66	39.27	0.05
NORTH	1	240	PF 1	4.58	86.18	87.88	86.67	87.88	0.000033	0.15	32.08	50.26	0.05
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	4.58	85.27	85.69	85.69	85.85	0.024737	1.79	2.56	8.17	1.02
NORTH	1	200	PF 1	4.58	84.66	85.09	85.09	85.16	0.030909	1.16	3.97	29.49	1.00
NORTH	1	180	PF 1	4.58	83.83	84.94		84.94	0.000460	0.31	14.59	32.17	0.15

20 Year Event – Existing Conditions

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	2.87	99.58	100.16	100.12	100.23	0.022054	1.55	2.47	10.98	0.75
SOUTH	1	840	PF 1	2.87	98.99	99.71	99.71	99.85	0.028571	1.74	1.84	6.40	0.87
SOUTH	1	820	PF 1	2.87	98.42	99.03	99.03	99.14	0.034039	1.55	2.08	9.54	0.91
SOUTH	1	800	PF 1	2.87	97.68	98.38		98.39	0.002072	0.41	7.18	25.41	0.24
SOUTH	1	780	PF 1	2.87	97.88	98.25	98.20	98.30	0.020686	0.93	3.19	18.49	0.69
SOUTH	1	760	PF 1	2.87	97.35	97.76	97.73	97.83	0.026433	1.14	2.53	12.20	0.80
SOUTH	1	740	PF 1	2.87	96.87	97.11	97.10	97.15	0.043858	0.96	3.00	27.48	0.92
SOUTH	1	720	PF 1	2.87	96.36	96.57	96.52	96.60	0.018488	0.81	3.56	22.65	0.64
SOUTH	1	700	PF 1	2.87	95.66	95.96	95.96	96.04	0.047324	1.24	2.32	15.26	1.01
SOUTH	1	680	PF 1	2.87	95.46	95.79		95.79	0.000981	0.26	11.65	48.73	0.16
SOUTH	1	660	PF 1	2.87	95.45	95.77		95.77	0.001287	0.25	11.75	59.58	0.18
SOUTH	1	640	PF 1	3.94	95.08	95.73	95.47	95.73	0.002162	0.37	12.43	73.00	0.24
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	3.94	93.99	94.19	94.19	94.27	0.044981	1.26	3.14	20.02	1.00
SOUTH	1	600	PF 1	3.94	92.12	92.71	92.71	92.83	0.038549	1.54	2.60	11.33	0.98
SOUTH	1	585	PF 1	3.94	91.48	92.23		92.37	0.025599	1.65	2.44	6.51	0.86
SOUTH	1	570	PF 1	3.94	91.85	92.21		92.23	0.003161	0.42	7.03	21.69	0.28
SOUTH	1	555	PF 1	3.94	90.39	92.22		92.22	0.000026	0.10	39.33	40.12	0.03
SOUTH	1	540	PF 1	3.94	90.84	92.22		92.22	0.000040	0.11	36.14	45.24	0.04
SOUTH	1	525	PF 1	3.94	91.64	92.22		92.22	0.000402	0.21	18.77	49.68	0.11
SOUTH	1	510	PF 1	3.94	92.02	92.15	92.15	92.20	0.057217	0.91	4.35	53.20	1.01
SOUTH	1	495	PF 1	3.94	91.51	92.10		92.11	0.000500	0.23	19.31	64.72	0.12
SOUTH	1	480	PF 1	3.94	91.24	92.10		92.10	0.000050	0.12	40.87	80.44	0.04
SOUTH	1	465	PF 1	3.94	91.06	92.10		92.10	0.000037	0.10	44.71	86.94	0.04
SOUTH	1	450	PF 1	3.94	90.95	92.10		92.10	0.000033	0.07	53.37	103.87	0.03
SOUTH	1	435	PF 1	5.40	89.98	92.10	90.20	92.10	0.000003	0.05	134.67	106.41	0.01
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	5.40	89.66	90.14		90.14	0.000427	0.24	24.12	65.27	0.12
SOUTH	1	405	PF 1	5.40	89.59	90.13		90.13	0.000357	0.21	26.21	65.63	0.10
SOUTH	1	390	PF 1	5.40	89.57	90.13		90.13	0.000418	0.24	24.16	64.52	0.11
SOUTH	1	375	PF 1	5.40	89.59	90.11		90.12	0.000956	0.28	19.09	62.51	0.16
SOUTH	1	360	PF 1	5.40	89.54	90.10		90.10	0.001445	0.31	17.40	67.75	0.19
SOUTH	1	345	PF 1	5.40	88.35	90.10		90.10	0.000085	0.16	44.46	96.72	0.05
SOUTH	1	330	PF 1	5.40	88.11	90.10	88.43	90.10	0.000004	0.05	124.05	130.95	0.01
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	5.40	86.63	87.18	87.18	87.31	0.040577	1.55	3.47	14.32	1.01
SOUTH	1	300	PF 1	5.40	84.89	85.22	85.22	85.33	0.041512	1.47	3.67	16.81	1.01
SOUTH	1	285	PF 1	5.40	84.26	84.99		85.00	0.000722	0.33	16.23	33.53	0.15
SOUTH	2	274.9	PF 1	13.79	84.35	84.85	84.85	84.98	0.000000	1.59	8.65	34.36	1.01
SOUTH	2	255	PF 1	13.79	84.06	84.49	84.48	84.60	0.000000	1.42	9.72	39.36	0.91
SOUTH	2	240	PF 1	13.79	83.89	84.51		84.59	0.000000	1.21	11.43	47.27	0.78
SOUTH	2	225	PF 1	13.79	83.91	84.54		84.58	0.000000	0.83	19.33	62.61	0.47
SOUTH	2	210	PF 1	13.79	83.90	84.56		84.57	0.000000	0.54	26.50	63.82	0.26
SOUTH	2	195	PF 1	13.79	83.90	84.55		84.57	0.000000	0.60	24.41	63.07	0.29
SOUTH	2	180	PF 1	13.79	83.91	84.56		84.57	0.000000	0.42	33.55	81.20	0.20
SOUTH	2	165	PF 1	13.79	83.88	84.56		84.57	0.000000	0.37	37.48	82.34	0.17
SOUTH	2	150	PF 1	13.79	83.89	84.56		84.57	0.000000	0.34	41.73	87.63	0.15
SOUTH	2	135	PF 1	13.79	83.96	84.56		84.57	0.000000	0.42	38.30	94.47	0.18
SOUTH	2	120	PF 1	13.79	84.07	84.56		84.56	0.000000	0.29	52.47	127.42	0.14
SOUTH	2	102	PF 1	13.79	84.09	84.56	84.28	84.56	0.000000	0.28	51.58	143.49	0.15
NORTH	1	560	PF 1	3.63	94.41	94.66	94.66	94.73	0.030654	1.20	3.02	20.89	1.01
NORTH	1	540	PF 1	3.63	93.44	93.78	93.78	93.88	0.026238	1.44	2.56	12.72	1.00
NORTH	1	520	PF 1	3.63	92.83	93.13	93.13	93.23	0.027571	1.43	2.55	12.58	1.01
NORTH	1	500	PF 1	3.63	92.06	92.48	92.46	92.59	0.019489	1.47	2.46	8.86	0.89
NORTH	1	480	PF 1	3.63	91.70	92.02	92.02	92.13	0.027093	1.46	2.48	11.69	1.01
NORTH	1	460	PF 1	3.63	91.12	91.40	91.40	91.50	0.027717	1.36	2.68	14.36	1.00
NORTH	1	440	PF 1	3.63	90.30	90.88		90.92	0.007101	0.88	4.13	15.07	0.54
NORTH	1	420	PF 1	3.63	90.39	90.69	90.63	90.74	0.012387	1.01	3.60	16.47	0.69
NORTH	1	400	PF 1	3.63	89.59	90.29	90.29	90.37	0.028664	1.31	2.77	15.94	1.00
NORTH	1	380	PF 1	5.65	89.42	89.80		89.83	0.007583	0.83	6.82	29.11	0.55
NORTH	1	360	PF 1	5.65	89.27	89.48	89.48	89.57	0.028780	1.30	4.34	25.50	1.01
NORTH	1	340	PF 1	5.65	87.75	88.53	88.53	88.72	0.023041	1.97	2.86	7.37	1.01
NORTH	1	320	PF 1	5.65	87.31	87.88	87.88	88.02	0.025057	1.66	3.44	12.98	1.01
NORTH	1	300	PF 1	5.65	86.79	87.91		87.92	0.000361	0.43	13.24	15.19	0.15
NORTH	1	280	PF 1	5.65	86.82	87.91		87.91	0.000165	0.29	19.78	23.26	0.10
NORTH	1	260	PF 1	5.65	86.51	87.91		87.91	0.000047	0.17	34.68	39.53	0.05
NORTH	1	240	PF 1	5.65	86.18	87.91	86.72	87.91	0.000047	0.18	33.38	52.02	0.06
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	5.65	85.27	85.77	85.77	85.92	0.024108	1.71	3.31	11.17	1.00
NORTH	1	200	PF 1	5.65	84.66	85.11	85.11	85.19	0.031029	1.26	4.52	29.81	1.02
NORTH	1	180	PF 1	5.65	83.83	84.99		85.00	0.000532	0.35	16.23	34.15	0.16

50 Year Event – Existing Conditions

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	3.17	99.58	100.18	100.14	100.26	0.021061	1.57	2.72	11.58	0.74
SOUTH	1	840	PF 1	3.17	98.99	99.74	99.74	99.88	0.029224	1.75	2.02	6.98	0.89
SOUTH	1	820	PF 1	3.17	98.42	99.05	99.05	99.16	0.034019	1.58	2.26	10.01	0.91
SOUTH	1	800	PF 1	3.17	97.68	98.40		98.41	0.002102	0.42	7.61	25.65	0.24
SOUTH	1	780	PF 1	3.17	97.88	98.27	98.22	98.31	0.020189	0.94	3.49	19.61	0.68
SOUTH	1	760	PF 1	3.17	97.35	97.78	97.74	97.85	0.026907	1.17	2.71	12.63	0.81
SOUTH	1	740	PF 1	3.17	96.87	97.12	97.11	97.17	0.043610	0.97	3.25	28.87	0.93
SOUTH	1	720	PF 1	3.17	96.36	96.58	96.53	96.62	0.018548	0.84	3.81	23.25	0.65
SOUTH	1	700	PF 1	3.17	95.66	95.98	95.98	96.06	0.046789	1.26	2.51	15.88	1.01
SOUTH	1	680	PF 1	3.17	95.46	95.80		95.80	0.001019	0.27	12.26	49.13	0.16
SOUTH	1	660	PF 1	3.17	95.45	95.78		95.78	0.001308	0.26	12.42	59.83	0.18
SOUTH	1	640	PF 1	4.41	95.08	95.74	95.49	95.74	0.002366	0.40	13.04	73.39	0.25
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	4.41	93.99	94.21	94.21	94.29	0.043997	1.30	3.41	20.63	1.00
SOUTH	1	600	PF 1	4.41	92.12	92.76	92.74	92.86	0.031055	1.44	3.15	13.03	0.89
SOUTH	1	585	PF 1	4.41	91.48	92.24	92.21	92.40	0.029559	1.79	2.52	6.63	0.93
SOUTH	1	570	PF 1	4.41	91.85	92.22		92.24	0.003627	0.46	7.27	21.91	0.30
SOUTH	1	555	PF 1	4.41	90.39	92.23		92.23	0.000032	0.11	39.83	40.36	0.04
SOUTH	1	540	PF 1	4.41	90.84	92.23		92.23	0.000048	0.12	36.70	45.27	0.04
SOUTH	1	525	PF 1	4.41	91.64	92.23		92.23	0.000454	0.23	19.37	49.72	0.12
SOUTH	1	510	PF 1	4.41	92.02	92.16	92.16	92.21	0.055376	0.94	4.70	53.36	1.01
SOUTH	1	495	PF 1	4.41	91.51	92.10		92.11	0.000624	0.26	19.33	64.73	0.14
SOUTH	1	480	PF 1	4.41	91.24	92.10		92.10	0.000063	0.13	40.87	80.44	0.05
SOUTH	1	465	PF 1	4.41	91.06	92.10		92.10	0.000047	0.11	44.70	86.94	0.04
SOUTH	1	450	PF 1	4.41	90.95	92.10		92.10	0.000041	0.08	53.35	103.87	0.04
SOUTH	1	435	PF 1	6.17	89.98	92.10	90.21	92.10	0.000003	0.06	134.66	106.41	0.01
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	6.17	89.66	90.15		90.16	0.000491	0.26	25.14	66.03	0.12
SOUTH	1	405	PF 1	6.17	89.59	90.15		90.15	0.000413	0.23	27.19	66.05	0.11
SOUTH	1	390	PF 1	6.17	89.57	90.14		90.14	0.000489	0.26	25.05	65.17	0.12
SOUTH	1	375	PF 1	6.17	89.59	90.13		90.13	0.001109	0.31	19.84	63.13	0.18
SOUTH	1	360	PF 1	6.17	89.54	90.10		90.11	0.001700	0.35	18.00	68.20	0.21
SOUTH	1	345	PF 1	6.17	88.35	90.10		90.11	0.000106	0.17	45.30	97.42	0.06
SOUTH	1	330	PF 1	6.17	88.11	90.10	88.45	90.10	0.000005	0.06	125.20	131.64	0.02
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	6.17	86.63	87.21	87.21	87.34	0.039918	1.62	3.80	14.48	1.01
SOUTH	1	300	PF 1	6.17	84.89	85.24	85.24	85.36	0.040416	1.53	4.02	16.99	1.01
SOUTH	1	285	PF 1	6.17	84.26	85.03		85.04	0.000732	0.35	17.59	33.93	0.16
SOUTH	2	274.9	PF 1	16.09	84.35	84.89	84.89	85.02	0.000000	1.64	9.79	36.56	1.01
SOUTH	2	255	PF 1	16.09	84.06	84.50	84.50	84.63	0.000000	1.60	10.09	39.89	1.01
SOUTH	2	240	PF 1	16.09	83.89	84.52	84.49	84.62	0.000000	1.37	11.77	47.82	0.88
SOUTH	2	225	PF 1	16.09	83.91	84.56		84.60	0.000000	0.93	20.30	63.90	0.51
SOUTH	2	210	PF 1	16.09	83.90	84.57		84.59	0.000000	0.60	27.71	64.98	0.29
SOUTH	2	195	PF 1	16.09	83.90	84.57		84.59	0.000000	0.67	25.54	64.56	0.32
SOUTH	2	180	PF 1	16.09	83.91	84.58		84.59	0.000000	0.47	35.12	82.40	0.22
SOUTH	2	165	PF 1	16.09	83.88	84.58		84.59	0.000000	0.42	39.10	82.78	0.19
SOUTH	2	150	PF 1	16.09	83.89	84.58		84.59	0.000000	0.38	43.47	88.88	0.17
SOUTH	2	135	PF 1	16.09	83.96	84.58		84.59	0.000000	0.48	40.10	97.34	0.20
SOUTH	2	120	PF 1	16.09	84.07	84.58		84.58	0.000000	0.32	54.99	128.37	0.15
SOUTH	2	102	PF 1	16.09	84.09	84.58	84.30	84.58	0.000000	0.31	54.42	143.97	0.16
NORTH	1	560	PF 1	4.19	94.41	94.68	94.68	94.75	0.030062	1.24	3.39	22.23	1.01
NORTH	1	540	PF 1	4.19	93.44	93.80	93.80	93.92	0.024839	1.49	2.85	12.99	0.99
NORTH	1	520	PF 1	4.19	92.83	93.15	93.15	93.26	0.026771	1.49	2.81	12.69	1.01
NORTH	1	500	PF 1	4.19	92.06	92.50	92.48	92.63	0.020556	1.58	2.66	8.97	0.92
NORTH	1	480	PF 1	4.19	91.70	92.05	92.05	92.16	0.026094	1.52	2.75	11.83	1.01
NORTH	1	460	PF 1	4.19	91.12	91.42	91.42	91.52	0.027462	1.42	2.96	14.74	1.01
NORTH	1	440	PF 1	4.19	90.30	90.91		90.95	0.007334	0.92	4.55	15.81	0.55
NORTH	1	420	PF 1	4.19	90.39	90.71	90.65	90.76	0.012374	1.06	3.96	16.85	0.70
NORTH	1	400	PF 1	4.19	89.59	90.30	90.30	90.40	0.028783	1.37	3.05	16.34	1.01
NORTH	1	380	PF 1	6.56	89.42	89.82		89.86	0.007610	0.88	7.49	29.57	0.55
NORTH	1	360	PF 1	6.56	89.27	89.50	89.50	89.59	0.027840	1.36	4.82	25.82	1.01
NORTH	1	340	PF 1	6.56	87.75	88.57	88.57	88.78	0.022621	2.04	3.22	7.82	1.01
NORTH	1	320	PF 1	6.56	87.31	87.91	87.91	88.06	0.024195	1.73	3.83	13.26	1.01
NORTH	1	300	PF 1	6.56	86.79	87.93		87.94	0.000455	0.48	13.55	15.29	0.16
NORTH	1	280	PF 1	6.56	86.82	87.93		87.93	0.000207	0.32	20.25	23.39	0.11
NORTH	1	260	PF 1	6.56	86.51	87.93		87.93	0.000059	0.20	35.48	39.74	0.06
NORTH	1	240	PF 1	6.56	86.18	87.93	86.75	87.93	0.000059	0.21	34.42	53.38	0.06
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	6.56	85.27	85.82	85.82	85.96	0.024608	1.68	3.91	13.75	1.00
NORTH	1	200	PF 1	6.56	84.66	85.13	85.13	85.22	0.030931	1.33	4.96	30.06	1.04
NORTH	1	180	PF 1	6.56	83.83	85.03		85.04	0.000578	0.37	17.63	35.76	0.17

100 Year Event – Existing Conditions

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	3.48	99.58	100.20	100.15	100.28	0.020169	1.58	2.98	12.16	0.73
SOUTH	1	840	PF 1	3.48	98.99	99.76	99.76	99.91	0.030011	1.77	2.19	7.49	0.90
SOUTH	1	820	PF 1	3.48	98.42	99.07	99.07	99.18	0.034152	1.61	2.44	10.46	0.91
SOUTH	1	800	PF 1	3.48	97.68	98.42		98.43	0.002137	0.44	8.03	25.88	0.25
SOUTH	1	780	PF 1	3.48	97.88	98.29	98.23	98.33	0.019659	0.94	3.81	20.71	0.68
SOUTH	1	760	PF 1	3.48	97.35	97.79	97.76	97.87	0.027313	1.21	2.89	13.04	0.82
SOUTH	1	740	PF 1	3.48	96.87	97.12	97.12	97.18	0.043915	1.00	3.49	30.12	0.93
SOUTH	1	720	PF 1	3.48	96.36	96.59	96.54	96.63	0.018421	0.86	4.08	23.86	0.65
SOUTH	1	700	PF 1	3.48	95.66	95.99	95.99	96.07	0.046181	1.29	2.70	16.48	1.01
SOUTH	1	680	PF 1	3.48	95.46	95.81		95.81	0.001070	0.28	12.81	49.50	0.17
SOUTH	1	660	PF 1	3.48	95.45	95.79		95.79	0.001348	0.27	13.04	60.05	0.18
SOUTH	1	640	PF 1	4.86	95.08	95.74	95.51	95.75	0.002525	0.42	13.65	73.77	0.26
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	4.86	93.99	94.22	94.22	94.31	0.042836	1.33	3.68	21.21	0.99
SOUTH	1	600	PF 1	4.86	92.12	92.80	92.76	92.89	0.026071	1.36	3.69	14.61	0.82
SOUTH	1	585	PF 1	4.86	91.48	92.26	92.24	92.44	0.033476	1.92	2.59	6.73	0.99
SOUTH	1	570	PF 1	4.86	91.85	92.23		92.26	0.004068	0.50	7.49	22.11	0.32
SOUTH	1	555	PF 1	4.86	90.39	92.25		92.25	0.000037	0.12	40.30	40.59	0.04
SOUTH	1	540	PF 1	4.86	90.84	92.25		92.25	0.000055	0.13	37.22	45.30	0.05
SOUTH	1	525	PF 1	4.86	91.64	92.24		92.24	0.000503	0.25	19.91	49.75	0.12
SOUTH	1	510	PF 1	4.86	92.02	92.17	92.17	92.21	0.054575	0.98	5.01	53.49	1.01
SOUTH	1	495	PF 1	4.86	91.51	92.10		92.10	0.000780	0.29	19.16	64.60	0.15
SOUTH	1	480	PF 1	4.86	91.24	92.10		92.10	0.000078	0.15	40.65	80.40	0.05
SOUTH	1	465	PF 1	4.86	91.06	92.10		92.10	0.000058	0.12	44.45	86.87	0.05
SOUTH	1	450	PF 1	4.86	90.95	92.10		92.10	0.000051	0.09	53.03	103.83	0.04
SOUTH	1	435	PF 1	6.03	89.98	92.10	90.21	92.10	0.000003	0.06	134.34	106.35	0.01
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	6.03	89.66	90.15		90.15	0.000480	0.26	24.96	65.89	0.12
SOUTH	1	405	PF 1	6.03	89.59	90.14		90.15	0.000403	0.22	27.01	65.98	0.11
SOUTH	1	390	PF 1	6.03	89.57	90.14		90.14	0.000477	0.26	24.88	65.05	0.12
SOUTH	1	375	PF 1	6.03	89.59	90.12		90.13	0.001082	0.31	19.70	63.02	0.17
SOUTH	1	360	PF 1	6.03	89.54	90.10		90.11	0.001656	0.34	17.89	68.11	0.21
SOUTH	1	345	PF 1	6.03	88.35	90.10		90.10	0.000102	0.17	45.14	97.29	0.06
SOUTH	1	330	PF 1	6.03	88.11	90.10	88.44	90.10	0.000005	0.06	124.98	131.51	0.01
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	6.03	86.63	87.20	87.20	87.33	0.040061	1.61	3.74	14.46	1.01
SOUTH	1	300	PF 1	6.03	84.89	85.24	85.24	85.36	0.041009	1.53	3.94	16.95	1.01
SOUTH	1	285	PF 1	6.03	84.26	85.07		85.07	0.000560	0.32	18.88	34.31	0.14
SOUTH	2	274.9	PF 1	18.32	84.35	84.91	84.91	85.06	0.000000	1.68	10.88	38.53	1.01
SOUTH	2	255	PF 1	18.32	84.06	84.53	84.53	84.67	0.000000	1.65	11.13	41.36	1.01
SOUTH	2	240	PF 1	18.32	83.89	84.53	84.52	84.64	0.000000	1.51	12.13	48.41	0.96
SOUTH	2	225	PF 1	18.32	83.91	84.57		84.62	0.000000	1.01	21.33	65.22	0.55
SOUTH	2	210	PF 1	18.32	83.90	84.59		84.61	0.000000	0.66	28.95	66.15	0.31
SOUTH	2	195	PF 1	18.32	83.90	84.59		84.61	0.000000	0.73	26.70	66.06	0.34
SOUTH	2	180	PF 1	18.32	83.91	84.60		84.61	0.000000	0.51	36.75	83.62	0.23
SOUTH	2	165	PF 1	18.32	83.88	84.60		84.61	0.000000	0.45	40.75	83.24	0.20
SOUTH	2	150	PF 1	18.32	83.89	84.60		84.61	0.000000	0.41	45.27	90.14	0.18
SOUTH	2	135	PF 1	18.32	83.96	84.59		84.61	0.000000	0.52	41.97	99.64	0.22
SOUTH	2	120	PF 1	18.32	84.07	84.60		84.61	0.000000	0.35	57.57	129.34	0.16
SOUTH	2	102	PF 1	18.32	84.09	84.60	84.31	84.61	0.000000	0.33	57.32	144.45	0.17
NORTH	1	560	PF 1	4.71	94.41	94.69	94.69	94.77	0.029643	1.26	3.73	23.37	1.01
NORTH	1	540	PF 1	4.71	93.44	93.82	93.82	93.94	0.024245	1.55	3.10	13.20	0.99
NORTH	1	520	PF 1	4.71	92.83	93.17	93.17	93.29	0.025831	1.54	3.06	12.79	1.01
NORTH	1	500	PF 1	4.71	92.06	92.52	92.51	92.66	0.021684	1.67	2.82	9.07	0.96
NORTH	1	480	PF 1	4.71	91.70	92.07	92.07	92.19	0.025210	1.57	3.00	11.95	1.00
NORTH	1	460	PF 1	4.71	91.12	91.44	91.44	91.55	0.026820	1.46	3.22	15.09	1.01
NORTH	1	440	PF 1	4.71	90.30	90.93		90.98	0.007504	0.96	4.92	16.45	0.56
NORTH	1	420	PF 1	4.71	90.39	90.73	90.67	90.79	0.012447	1.10	4.28	17.18	0.70
NORTH	1	400	PF 1	4.71	89.59	90.32	90.32	90.42	0.028462	1.42	3.31	16.71	1.02
NORTH	1	380	PF 1	7.44	89.42	89.84		89.89	0.007756	0.93	8.08	29.97	0.57
NORTH	1	360	PF 1	7.44	89.27	89.51	89.51	89.62	0.026970	1.41	5.27	26.12	1.00
NORTH	1	340	PF 1	7.44	87.75	88.61	88.61	88.84	0.023465	2.13	3.49	8.15	1.04
NORTH	1	320	PF 1	7.44	87.31	87.93	87.93	88.10	0.023501	1.79	4.20	13.52	1.01
NORTH	1	300	PF 1	7.44	86.79	87.95		87.96	0.000555	0.54	13.80	15.37	0.18
NORTH	1	280	PF 1	7.44	86.82	87.95		87.95	0.000252	0.36	20.62	23.50	0.12
NORTH	1	260	PF 1	7.44	86.51	87.95		87.95	0.000072	0.22	36.13	39.91	0.07
NORTH	1	240	PF 1	7.44	86.18	87.94	86.78	87.95	0.000073	0.23	35.34	63.00	0.07
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	7.44	85.27	85.86	85.86	86.00	0.024438	1.67	4.46	15.75	1.00
NORTH	1	200	PF 1	7.44	84.66	85.15	85.15	85.24	0.027741	1.35	5.55	30.39	1.00
NORTH	1	180	PF 1	7.44	83.83	85.06		85.07	0.000605	0.39	18.93	36.58	0.17

PMF Event

HEC-RAS Plan: Plan 07 Profile: PF 1

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
SOUTH	1	855	PF 1	18.23	99.58	100.70		100.81	0.014165	2.13	12.25	25.26	0.69
SOUTH	1	840	PF 1	18.23	98.99	100.25	100.25	100.50	0.031579	2.30	8.44	18.41	1.00
SOUTH	1	820	PF 1	18.23	98.42	99.49	99.49	99.69	0.026033	2.33	9.72	23.94	0.91
SOUTH	1	800	PF 1	18.23	97.68	98.81		98.86	0.003985	1.01	19.46	33.38	0.38
SOUTH	1	780	PF 1	18.23	97.88	98.65		98.73	0.011629	1.25	15.23	38.11	0.60
SOUTH	1	760	PF 1	18.23	97.35	98.14	98.14	98.34	0.034705	2.00	9.14	23.20	1.02
SOUTH	1	740	PF 1	18.23	96.87	97.35	97.32	97.45	0.025684	1.40	13.13	46.98	0.83
SOUTH	1	720	PF 1	18.23	96.36	96.87	96.81	97.00	0.020066	1.63	11.71	31.28	0.79
SOUTH	1	700	PF 1	18.23	95.66	96.30	96.30	96.46	0.037064	1.79	10.17	31.96	1.01
SOUTH	1	680	PF 1	18.23	95.46	96.10		96.13	0.002426	0.68	28.73	58.88	0.29
SOUTH	1	660	PF 1	18.23	95.45	96.06		96.08	0.002545	0.63	29.99	65.88	0.29
SOUTH	1	640	PF 1	24.61	95.08	95.96	95.80	95.99	0.005948	0.90	30.59	83.73	0.43
SOUTH	1	638		Culvert									
SOUTH	1	620	PF 1	24.61	93.99	94.55	94.55	94.73	0.030905	1.95	13.23	35.66	0.97
SOUTH	1	600	PF 1	24.61	92.12	93.43		93.50	0.007180	1.26	20.43	34.34	0.50
SOUTH	1	585	PF 1	24.61	91.48	92.95	92.95	93.29	0.027597	2.63	9.63	16.08	1.00
SOUTH	1	570	PF 1	24.61	91.85	92.50		92.65	0.016999	1.65	14.48	29.91	0.74
SOUTH	1	555	PF 1	24.61	90.39	92.58		92.59	0.000389	0.45	54.84	44.67	0.13
SOUTH	1	540	PF 1	24.61	90.84	92.57		92.58	0.000468	0.48	52.24	46.14	0.14
SOUTH	1	525	PF 1	24.61	91.64	92.55		92.57	0.001966	0.71	35.24	50.72	0.27
SOUTH	1	510	PF 1	24.61	92.02	92.37	92.35	92.49	0.028335	1.52	16.59	58.20	0.88
SOUTH	1	495	PF 1	24.61	91.51	92.34		92.36	0.002879	0.76	35.38	71.26	0.31
SOUTH	1	480	PF 1	24.61	91.24	92.33		92.34	0.000619	0.49	59.49	83.57	0.16
SOUTH	1	465	PF 1	24.61	91.06	92.32		92.33	0.000502	0.42	64.45	92.26	0.14
SOUTH	1	450	PF 1	24.61	90.95	92.32		92.32	0.000403	0.33	76.11	106.67	0.12
SOUTH	1	435	PF 1	29.23	89.98	92.32	90.49	92.32	0.000048	0.24	158.25	111.00	0.05
SOUTH	1	433		Culvert									
SOUTH	1	420	PF 1	29.23	89.66	90.48		90.50	0.001520	0.66	49.07	79.96	0.24
SOUTH	1	405	PF 1	29.23	89.59	90.46		90.47	0.001428	0.61	49.03	75.44	0.23
SOUTH	1	390	PF 1	29.23	89.57	90.43		90.45	0.001846	0.71	45.67	77.47	0.26
SOUTH	1	375	PF 1	29.23	89.59	90.38		90.41	0.003792	0.79	37.45	76.34	0.35
SOUTH	1	360	PF 1	29.23	89.54	90.29		90.33	0.007076	0.95	31.38	77.62	0.46
SOUTH	1	345	PF 1	29.23	88.35	90.28		90.29	0.000931	0.59	63.80	111.63	0.19
SOUTH	1	330	PF 1	29.23	88.11	90.29	88.76	90.29	0.000071	0.23	150.29	145.89	0.06
SOUTH	1	320		Culvert									
SOUTH	1	315	PF 1	29.23	86.63	87.70	87.70	87.99	0.025204	2.44	12.54	22.86	0.94
SOUTH	1	300	PF 1	29.23	84.89	85.68	85.68	85.97	0.030440	2.38	12.30	21.71	1.01
SOUTH	1	285	PF 1	29.23	84.26	85.71		85.73	0.001086	0.69	43.05	41.56	0.21
SOUTH	2	274.9	PF 1	75.13	84.35	85.35	85.35	85.70	0.000000	2.62	29.82	45.69	1.00
SOUTH	2	255	PF 1	75.13	84.06	84.95	84.95	85.18	0.000000	2.09	35.92	80.90	1.00
SOUTH	2	240	PF 1	75.13	83.89	84.90	84.90	85.13	0.000000	2.12	35.60	78.24	1.00
SOUTH	2	225	PF 1	75.13	83.91	84.83	84.83	85.08	0.000000	2.22	41.04	86.41	1.01
SOUTH	2	210	PF 1	75.13	83.90	84.89		85.01	0.000000	1.53	51.50	82.73	0.61
SOUTH	2	195	PF 1	75.13	83.90	84.71	84.71	84.99	0.000000	2.37	35.34	76.32	1.01
SOUTH	2	180	PF 1	75.13	83.91	84.83		84.94	0.000000	1.43	57.26	89.54	0.53
SOUTH	2	165	PF 1	75.13	83.88	84.85		84.93	0.000000	1.25	62.33	88.94	0.46
SOUTH	2	150	PF 1	75.13	83.89	84.86		84.92	0.000000	1.11	70.13	98.55	0.41
SOUTH	2	135	PF 1	75.13	83.96	84.78		84.92	0.000000	1.63	62.73	121.38	0.59
SOUTH	2	120	PF 1	75.13	84.07	84.84		84.89	0.000000	0.96	90.46	140.11	0.36
SOUTH	2	102	PF 1	75.13	84.09	84.85	84.51	84.89	0.000000	0.85	94.18	150.44	0.33
NORTH	1	560	PF 1	17.09	94.41	94.91	94.91	95.04	0.025123	1.62	10.57	40.93	1.01
NORTH	1	540	PF 1	17.09	93.44	94.16	94.16	94.31	0.012934	1.90	11.13	37.33	0.82
NORTH	1	520	PF 1	17.09	92.83	93.50	93.50	93.76	0.020267	2.27	7.52	14.52	1.01
NORTH	1	500	PF 1	17.09	92.06	92.92	92.92	93.24	0.019477	2.48	6.89	11.20	1.01
NORTH	1	480	PF 1	17.09	91.70	92.41	92.41	92.68	0.019997	2.29	7.45	14.07	1.01
NORTH	1	460	PF 1	17.09	91.12	91.74	91.74	91.95	0.018510	2.05	8.65	22.43	0.95
NORTH	1	440	PF 1	17.09	90.30	91.27		91.39	0.007739	1.49	11.50	20.22	0.63
NORTH	1	420	PF 1	17.09	90.39	90.99	90.94	91.17	0.015871	1.88	9.08	19.52	0.88
NORTH	1	400	PF 1	17.09	89.59	90.59	90.59	90.79	0.022071	2.00	8.56	21.43	1.01
NORTH	1	380	PF 1	27.38	89.42	90.15		90.27	0.008350	1.55	17.95	33.30	0.66
NORTH	1	360	PF 1	27.38	89.27	89.80	89.80	90.01	0.021027	2.06	13.30	30.97	1.00
NORTH	1	340	PF 1	27.38	87.75	89.02	89.02	89.26	0.020541	2.16	12.77	27.72	1.00
NORTH	1	320	PF 1	27.38	87.31	88.38	88.38	88.69	0.017526	2.53	11.15	17.75	0.98
NORTH	1	300	PF 1	27.38	86.79	88.17		88.29	0.003900	1.58	17.30	16.48	0.49
NORTH	1	280	PF 1	27.38	86.82	88.17		88.22	0.001713	1.05	25.99	24.95	0.33
NORTH	1	260	PF 1	27.38	86.51	88.18		88.20	0.000487	0.64	45.58	42.27	0.18
NORTH	1	240	PF 1	27.38	86.18	88.17	87.18	88.19	0.000445	0.63	53.50	84.00	0.18
NORTH	1	226		Culvert									
NORTH	1	220	PF 1	27.38	85.27	86.24	86.24	86.51	0.020376	2.33	11.77	21.82	1.01
NORTH	1	200	PF 1	27.38	84.66	85.71		85.77	0.003215	1.12	25.16	39.54	0.42
NORTH	1	180	PF 1	27.38	83.83	85.72		85.74	0.000588	0.59	46.08	46.64	0.19