Townsville

TOWNSVILLE CITY COUNCIL

ROSS CREEK FLOOD STUDY
BASE-LINE FLOODING ASSESSMENT

Volume 1

MAY 2013

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Quality Information

Prepared for:

Information

Prepared by:

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Document	Ross Creek Flood Study - Base-line Flooding Assessment
DW ID	s:\infrastructure planning\stormwater-flooding\projects\townsville flood constraints map\reports\rosscreek\rosscreek-baseline.doc
Date	1 May 2013

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
	6/3/2013	Draft for Internal review	Wesley Bailey	
	1/5/2013	Final Draft	Wesley Bailey	

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Executive Summary

The *Ross Creek Flood Study – Baseline Flooding Assessment* has been completed as a component of Townsville City Council's City Wide Flood Constraints project. This study has developed a detailed flood model for quantifying the flood risk on portions of the Townsville Floodplain that drains to Ross Creek including the suburbs of:

- Cranbrook;
- Aitkenvale;
- Heatley (parts of);
- Vincent (parts of);
- Gulliver;
- Mundingburra;
- Mysterton;
- Pimlico;
- Currajong;
- Garbutt (parts of);
- West End (parts of);
- Hyde Park;
- Hermit Park;
- Railway Estate (parts of);
- Townsville City; and
- South Townsville (parts of).

The study developed and calibrated a MIKE FLOOD coupled two-dimensional / one-dimensional hydraulic model. The model represents in fine-scale resolution the topography and drainage systems of the Ross Creek catchment, including:

- a digital elevation model resolved to a 10m grid;
- the larger components of the underground drainage network (greater than 900 mm diameter equivalent diameter);
- open drains narrower than the 10m grid resolution using one-dimensional branches; and
- application of rainfall directly onto the model grid.

The calibrated flood model has been used to assess design storm flood events for the 2, 5, 10, 20, 50, 100, 200 and 500 Year Average Recurrence Intervals (ARI) as well as the Probable Maximum Precipitation flood event. The design storm events have been assessed for a range of storm durations so that the critical duration event has been evaluated at all points of the floodplain.

The flood model results for the design storm events have been used to:

- quantify the floodplain hydraulic response with hydraulic grade lines and flow distributions;
- evaluate the potential impact on residential properties;
- identify flood hazard zones on the floodplain;
- inform flood overlay development for the new City Plan; and
- identify emergency management considerations.

Table EX-1 provides a summary of the flooding results for the Ross Creek study area. Within Table EX-1 indicative rainfalls for the design events have been provided so that real events can be easily evaluated against the results of this study.

A sensitivity assessment of the impacts of flooding with coincident Highest Astronomical Tide (HAT) was also completed. The assessment showed that increases in flood levels associated with the higher tide levels are observed as far upstream in the system to Balls Lane crossing of Mindham Park Drain.

An assessment for the potential for climate change to impact on flooding has been undertaken, accounting for a 0.8m sea level rise and 15% increase in rainfall intensities. The results of the modelling indicate increases in flood levels in a majority of the urban area either in the order of 50mm for the 50 and 100 Year ARI floods. The results also show that areas likely to experience significant impacts on flooding associated with climate change are Rosslea, Hermit Park, Railway Estate, northern Pimlico and northern Hyde Park.

Table EX1 - Summary of Ross Creek Flooding Results

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues	Flooding Description
2 Y ARI	54mm in 1 hour 63mm in 1.5 hour 71mm in 2 hours 83mm in 3 hours 109mm in 6 hours 143mm in 12 hours 168mm in 18 hours 189mm in 24 hours 277mm in 72 hours	580	Railway Avenue - Ninth Street Railway Avenue- Doorey Street Bowen Road - Rosslea Drain Woolcock Street - Kings Road Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central	**Railway Estate community centre and mental health nursing home (Vincent) inundated.**	Flows largely contained to drainage reserves and roads, with some inundation of lots, particularly in Mundingburra, Vincent, Heatley, Railway Estate, South Townsville, Hermit Park, Currajong and Aitkenvale. Overflow bypassing Lakes I through northern Pimlico is formed.
5 Y ARI	70mm in 1 hour 83mm in 1.5 hour 93mm in 2 hours 110mm in 3 hours 144mm in 6 hours 189mm in 12 hours 226mm in 18 hours 256mm in 24 hours 392mm in 72 hours	970	Railway Avenue - Ninth Street Railway Avenue- Doorey Street Bowen Road - Rosslea Drain Woolcock Street - Kings Road Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central **Ross River Road - Indigenous Reserve**	Railway Estate community centre and mental health nursing home (Vincent) inundated.	Flows becoming more widespread through lots, particularly in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Currajong, Aitkenvale and Cranbrook. Minor overflows from Gulliver flow path into Pimlico Drain system.
10 Y ARI	81mm in 1 hour 95mm in 1.5 hour 107mm in 2 hours 125mm in 3 hours 165mm in 6 hours 216mm in 12 hours 261mm in 18 hours 298mm in 24 hours 467mm in 72 hours	1260	Railway Avenue - Ninth Street Railway Avenue- Doorey Street Bowen Road - Rosslea Drain Woolcock Street - Kings Road Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve **Flinders Street - Morris Street** **Woolcock Street - Lakes I** **Ross River Road - Crete Street**	Railway Estate community centre, mental health nursing home (Vincent) and **Villa McAulay Retirement Village** inundated.	Flooded areas becoming more widespread and connected, with significant inundation of lots in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Currajong, Aitkenvale, Cranbrook, Mysterton and West End.
20 Y ARI	94mm in 1 hour 111mm in 1.5 hour 125mm in 2 hours 146mm in 3 hours	1695	Railway Avenue - Ninth Street Railway Avenue- Doorey Street Bowen Road - Rosslea Drain Woolcock Street - Kings Road	Railway Estate community centre, mental health nursing home (Vincent) and Villa McAulay Retirement Village inundated.	Widespread areas of interconnected flooding, with significant depths on Lots in Mundingburra Vincent and Hermit Park. Backwater from Ross River impacting properties in Rosslea.

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues	Flooding Description
	192mm in 6 hours 252mm in 12 hours 307mm in 18 hours 351mm in 24 hours 562mm in 72 hours		Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street **Charters Towers Road - Hermit Park Drain** **Ross River Road - Nathan Street**		Significant number of lots inundated in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Pimlico Currajong, Gulliver, Aitkenvale, Cranbrook, Mysterton and West End
50 Y ARI	111mm in 1 hour 132mm in 1.5 hour 148mm in 2 hours 174mm in 3 hours 229mm in 6 hours 301mm in 12 hours 368mm in 18 hours 424mm in 24 hours 692mm in 72 hours	2120	Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street Charters Towers Road - Hermit Park Drain Ross River Road - Nathan Street **Woolcock Street - Mindham Park Drain** **Percy Street - Harold Street**	Railway Estate community centre, mental health nursing home (Vincent), Villa McAulay Retirement Village, **Townsville Railway Station and church of Jesus Christ of latter day saints** inundated.	Overflows from Mindham Park Drain through northern Hyde Park to Woolcock Canal are formed. Overflows from northern Cranbrook into Heatley via Fulham Road are formed. Widespread areas of interconnected flooding, with significant depths on lots in Mundingburra, Pimlico, Vincent and Hermit Park. Significant number of lots inundated in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Pimlico Currajong, Gulliver, Aitkenvale, Cranbrook, Mysterton and West End
100 Y ARI	125mm in 1 hour 148mm in 1.5 hour 166mm in 2 hours 195mm in 3 hours 257mm in 6 hours 338mm in 12 hours 416mm in 18 hours 481mm in 24 hours 796mm in 72 hours	2605	Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street Charters Towers Road - Hermit Park Drain Ross River Road - Nathan Street Woolcock Street - Mindham Park Drain Percy Street - Harold Street **Charter Towers Road - Boundary Street**	Railway Estate community centre, mental health nursing home (Vincent), Villa McAulay Retirement Village, Townsville Railway Station, church of Jesus Christ of latter day saints, **Townsville Water Police and Cranbrae no. 4 Retirement Village** inundated.	Widespread areas of interconnected flooding, with significant depths on lots in Mundingburra, Aitkenvale, Pimlico, Vincent and Hermit Park. Significant number of lots inundated in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Pimlico Currajong, Gulliver, Aitkenvale, Cranbrook, Mysterton and West End

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues	Flooding Description
200 Y ARI	139mm in 1 hour 165mm in 1.5 hour 185mm in 2 hours 217mm in 3 hours 286mm in 6 hours 377mm in 12 hours 466mm in 18 hours 540mm in 24 hours 905mm in 72 hours	3100	Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street Charters Towers Road - Hermit Park Drain Ross River Road - Nathan Street Woolcock Street - Mindham Park Drain Percy Street - Harold Street Charter Towers Road - Boundary Street **Percy Street - Ralston Street** **Ross River Road - Wood Street**	Railway Estate community centre, mental health nursing home (Vincent), Villa McAulay Retirement Village, Townsville Railway Station, church of Jesus Christ of latter day saints, Townsville Water Police, Cranbrae no. 4 Retirement Village , **Cranbrae no. 1 Retirement Village and Cranbrae no. 3 Retirement Village** inundated.	Backwater from Ross River in Rosslea and Hermit Park becoming significant. Widespread areas of interconnected flooding, with significant depths on lots in Mundingburra, Aitkenvale, Rosslea, Pimlico, Vincent and Hermit Park. Significant number of lots inundated in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Pimlico Currajong, Gulliver, Rosslea, Aitkenvale, Cranbrook, Mysterton and West End
500 Y ARI	158mm in 1 hour 187mm in 1.5 hour 210mm in 2 hours 248mm in 3 hours 326mm in 6 hours 430mm in 12 hours 534mm in 18 hours 621mm in 24 hours 1058mm in 72 hours	4200	Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street Charters Towers Road - Hermit Park Drain Ross River Road - Nathan Street Woolcock Street - Mindham Park Drain Percy Street - Harold Street Charter Towers Road - Boundary Street Percy Street - Ralston Street Ross River Road - Wood Street **Charters Towers Road - Yeatman Street** **Bowen Road - Benson Street**	Railway Estate community centre, mental health nursing home (Vincent), Villa McAulay Retirement Village, Townsville Railway Station, church of Jesus Christ of latter day saints, Townsville Water Police, Cranbrae no. 1, 3 & 4 Retirement Villages, **South Townsville Fire and Rescue and Townsville Show Grounds** inundated.	Overflows from Ross River flow through Rosslea and Hermit Park into Hermit Park Drain. Widespread areas of interconnected flooding, with significant depths on lots in Mundingburra, Aitkenvale, Rosslea, Pimlico, Vincent and Hermit Park. Significant number of lots inundated in Mundingburra, Hermit Park, Vincent, Heatley, Railway Estate, South Townsville, Pimlico Currajong, Gulliver, Rosslea, Aitkenvale, Cranbrook, Mysterton and West End
PMP	610mm in 2 hours 1570mm in 24 hours 2840mm in 72 hours	11390	Hugh Street - Woolcock Street Woolcock Street - Pilkington Street Ross River Road - Vale Hotel Nathan Street- Albert Street Nathan Street - Charles Street	Railway Estate community centre, mental health nursing home (Vincent), Villa McAulay Retirement Village, Townsville Railway Station, church of Jesus Christ of latter day saints,	Significant widespread flooding with most flows running north-eastward irrespective of local topography. Portions of West End and Townsville City remain flood free around Castle Hill. Isolated flood islands in

Event	Indicative Rainfall	Properties Inundated[1]	Major Evacuation Route Closures	Emergency Management Issues	Flooding Description
			Nathan Street - Domain Central Ross River Road - Indigenous Reserve Flinders Street - Morris Street Woolcock Street - Lakes I Ross River Road - Crete Street Charters Towers Road - Hermit Park Drain Ross River Road - Nathan Street Woolcock Street - Mindham Park Drain Percy Street - Harold Street Charter Towers Road - Boundary Street Percy Street - Ralston Street Ross River Road - Wood Street Charters Towers Road - Yeatman Street Bowen Road - Benson Street **Railway Avenue - Seventh Street** **Ross River Road - Cathedral School**	Townsville Water Police, Cranbrae no. 1, 2, 3 & 4 Retirement Villages, South Townsville Fire and Rescue, Townsville Show Grounds, **Ignatius Park College, Wesley park Haven Hospital, Villa Vincent Nursing Home, Park Services Depot - Railway Estate, Infrastructure Services Depot, Garbutt Operations Centre, Currajong Ambulance, Cranbrook Suites Retirement Village, Wellington Street Depot, Reid Park Facility, Stockland Police Beat, Aitkenvale PCYC, Civic Theatre and Fit for Life centre** are inundated.	• Eastern South Townsville; • Bicentennial Park; • Southern Hyde Park; • South-western Hermit Park; • Southern Pimlico; • Western Mysterton; • Northern Vincent; • Various areas in Heatley; • North-western and south-western Cranbrook; • Southern Aitkenvale; and • Eastern, Central and Western Mundingburra.

Glossary

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
AVM	Average Variability Method
BoM	Bureau of Meteorology
DEM	Digital Elevation Model
DERM	Department of Environment and Resource Management
DFE	Defined Flood Event
DoIP	Department of Infrastructure and Planning (now Department of Local Government and Planning)
FSL	Full Supply Level
GTSMR	Generalised Tropical Storm Method Revised – Methodology for estimating the PMP
HAT	Highest Astronomical Tide – The highest level of water which can be predicted to occur under any combination of astronomical conditions.
HEC-RAS	A steady state 1D hydraulic model
Hydraulic model	A model used for assessing flood levels and velocities from inflows and topography
Hydrologic model	A model used for assessing catchment outflows from rainfall and catchment conditions
IFD	Intensity–Frequency-Duration
LiDAR	Light Detection and Ranging (Aerial Laser Survey)
LGAQ	Local Government Association of Queensland
MHWS	Mean High Water Springs – the average height of the high waters of spring tides
MIKE11	Fully dynamic 1D hydraulic model
MIKE21	Fully dynamic 2D hydraulic model
MIKE FLOOD	Coupled 2D/1D hydraulic model combining MIKE11 and MIKE21

Pluviometer	Automated sampling device for measuring rainfall variability in short time periods
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QUDM	Queensland Urban Drainage Manual
RORB	A rural runoff-routing hydrologic model
TFHAS	Townsville Flood Hazard Assessment Study (Maunsell, 2005)
RRHS	Ross River Hydraulic Study (Maunsell, 2001)
XP-RAFTS	An urban and rural runoff-routing hydrologic model

1.0 Introduction

1.1 Overview

The *Ross Creek Flood Study – Baseline Flooding Assessment* has been undertaken as part of Townsville City Council's City Wide Flood Constraints Project. The project seeks to develop up to date flood models for the city of Townsville at scales suitable for:

- defining flood levels for most urban properties;
- identifying the flood hazard overlay for the planning scheme;
- evaluating future flood mitigation projects; and
- assisting the disaster management process.

This study builds on previous hydrologic and hydraulic analysis projects for the former Townsville Local Government Area (LGA) and incorporates the latest Light Detection and Ranging (LiDAR) topographic data as well as recent hydrographic survey to form up to date hydrologic and hydraulic flood models for Ross Creek. The *Ross Creek Flood Study* builds on the previous *Ross River Flood Study – Baseline Flooding Assessment* to provide detailed hydrological and hydraulic models for urban areas of Townsville within the Ross Creek catchment. A majority of the older urban areas of the city with known flooding and drainage problems fall within the study area.

1.2 Study Area

Ross Creek is a relatively short watercourse that drains much of the urban area of Townsville. Presently the mouth of the creek is at the Port of Townsville Inner Harbour, while the upper extent of the watercourse terminates at Bicentennial Park in Hermit Park and Railway Estate. Historically, the upper end of Ross Creek was connected to Ross River, forming Ross Island, consisting of Railway Estate and South Townsville. Bicentennial Park is a closed landfill that stopped the connection between Ross River and Ross Creek.

Ross Creek drains the suburbs of:

- Cranbrook;
- Aitkenvale;
- Heatley (parts of);
- Vincent (parts of);
- Gulliver;
- Mundingburra;
- Mysterton;
- Pimlico;
- Currajong;
- Garbutt (parts of);
- West End (parts of);
- Hyde Park;
- Hermit Park;
- Railway Estate (parts of);
- Townsville City; and
- South Townsville (parts of).

The entire catchment is urbanised, apart from some minor areas on the slopes of Castle Hill within West End. Much of the urbanised areas are residential with some commercial and light industry in Garbutt, Currajong, West End and Hyde Park; and significant high density commercial and business within Townsville City.

Within Currajong and West End, “The Lakes” system has been constructed, consisting of Currlea Lake (Lake 1) and Keyatta Lake (Lake 2). The lakes system drains into Woolcock Canal at Kings Road, which ultimately discharges into Ross Creek downstream of Charters Towers Road.

Mindham Park drain system is the significant drainage path within Ross Creek catchment. The drainage path is maintained though the linear parks of Mindham Park, Anderson Park and Aitkenvale Park

The study area is shown in **Figure 1-1**.

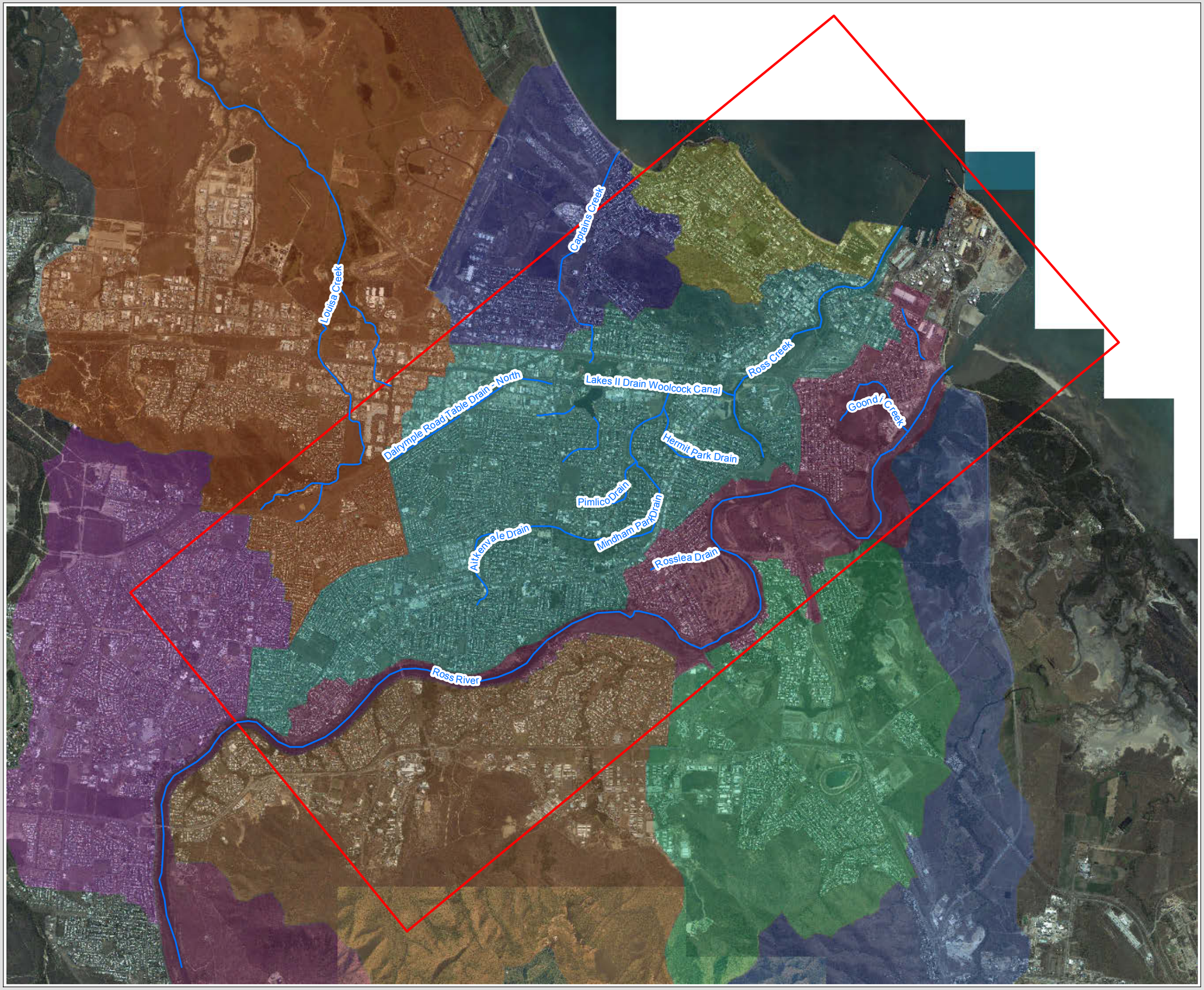
1.3 Scope of Works

The scope of works for this *Baseline Flooding Assessment* includes:

- review of previous engineering reports and data;
- collation of relevant data including rainfall, stream gauging, construction drawings, topographic survey and hydrographic survey;
- identification of a suitable approach for hydrologic and hydraulic modelling;
- development and calibration of Ross Creek hydrologic and hydraulic models; and
- review and detailing the base-line flooding determined for the study area.

ROSS CREEK FLOOD STUDY STUDY AREA

Figure 1-1



LEGEND

- Hydraulic Model Extent

Major Sub-Catchments

- Annandale/Douglas
- Captains Creek
- Gordon Creek
- Louisa Creek
- Lower Ross River
- North Ward
- Ross Creek
- Stuart Creek
- Tchooratippa Creek

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SCALE: 1:50,000 @A3

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STRATEGIC PLANNING
Planning and Development

DATE: 25/07/2012

DATE PRINTED: 8/08/2012

DRAWN BY: WBB

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1.4 Study Approach

This *Baseline Flooding Assessment* builds on the recently completed *Ross River Flood Study* and numerous previous projects. The flood models developed from this study take the broader boundary flows established from the Ross River Flood Study into a finer scale representation of the study area topography and drainage infrastructure.

Several hydrologic models have been developed to represent the flows from the catchments draining into the study area in combination with a “Rain on Grid” approach to represent a majority of the local rain within the bounds of the hydraulic model. Ross River Flows from upstream of the study area (including upstream of the Ross River Dam) have been taken directly from the hydraulic models developed for the *Ross River Flood Study*. Other catchments that were represented through XP-RAFTS hydrological models for this study are:

- Ross Creek;
- Ross River Downstream;
- Annandale/Douglas;
- Gordon Creek;
- Stuart Creek;
- Louisa Creek; and
- Captains Creek.

Details of the development Ross Creek XP-RAFTS model and how the “Rain on Grid” approach has been applied are provided in this report, while the development and calibration of Ross River Downstream model described in the *Ross River Flood Study – Base-line Flooding Assessment*. Descriptions of the development and calibration of the other XP-RAFTS models will be provided in subsequent reports for the City Wide Flood Constraints Project.

The hydraulic model is a new fine-scale model based on the latest LiDAR and survey. The hydraulic model is a three-way coupled MIKE FLOOD model, representing two-dimensional floodplain topography, one-dimensional flow paths and structures and trunk underground drainage. Results of the model are intended to be used for floodplain planning and evaluation of flood mitigation works for future investigations.

The report has been prepared in two volumes:

- Volume 1 (this Volume) – provides the majority of the report including methodology and discussion of results;
- Volume 2 – provides the flood map results from the study.

2.0 Available Data

2.1 Historical Rainfall Records

Historical rainfall records have been sourced for the purpose of calibrating the hydrological models developed for the study. Within the immediate area of Townsville, there are a range of gauges including daily rainfall gauges, meteorological pluviometers and flood alert pluviometers. Due to the fine-scale of the Ross Creek catchment relative the extent of all rainfall gauges most of the historical rainfall records came only from nearby meteorological pluviometers or the flood alert pluviometers. Details of these gauges are provided in **Table 2-1** and **Table 2-2** respectively.

Table 2-1 - Meteorological Rainfall Pluviometers

Station Number	Location	Start of Record	End of Record
032040	Townsville Aero	3/03/1953	31/12/2009
032050	Yabulu Qld Nickel	11/1/1990	31/12/2009

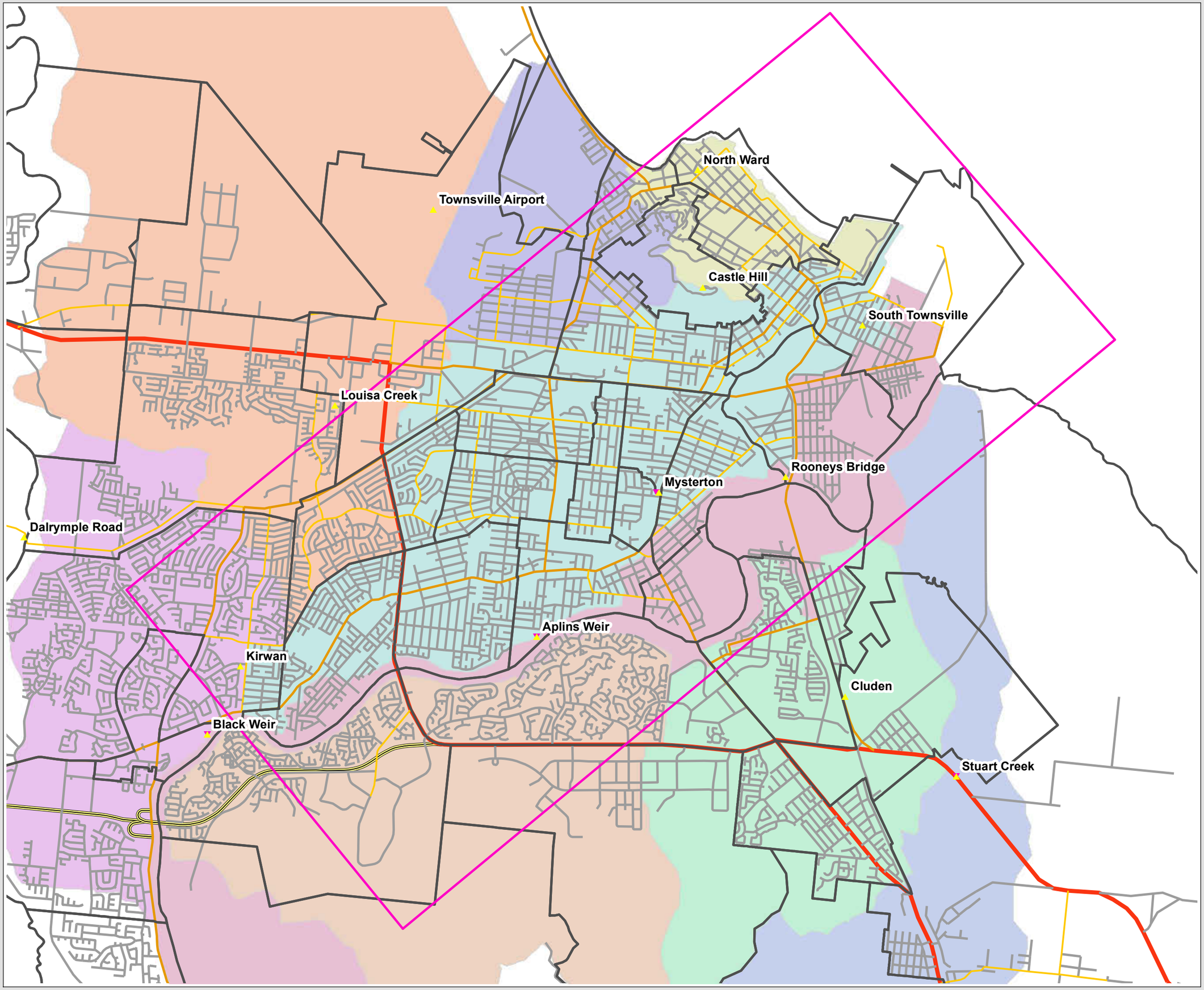
The locations of the flood alert pluviometers are shown in **Figure 2-1**. There are numerous rain gauges around Townsville; however few have records prior to 1998.

Table 2-2 - Flood Alert Pluviometers

Station Number	Location	Start of Record	End of Record
532034	Alligator Creek	11/08/2000	21/02/2011
532029	Aplins Weir	13/08/2000	21/02/2011
532046	Black River	11/08/2000	21/02/2011
532030	Blacks Weir	10/11/2000	21/02/2011
532048	Bluewater	12/08/2000	21/02/2011
532043	Bohle River	11/08/2000	21/02/2011
533007	Brabons	7/01/1997	21/02/2011
533070	Calcium	2/01/2001	21/02/2011
533045	Cormacks	5/01/1998	21/02/2011
532054	Deeragun	8/12/2000	21/02/2011
532040	Gleesons Mill	11/08/2000	21/02/2011
532039	Kirwan	4/01/2001	21/02/2011
532044	Little Bohle River	11/08/2001	21/02/2011
532032	Louisa Ck	4/10/2000	21/02/2011
533044	McDonalds	7/01/1998	21/02/2011
532053	Mount Bohle	11/08/2000	21/02/2011
532042	Mount Margaret	5/09/2000	21/02/2011
532037	Mysterton	1/09/2000	21/02/2011
533043	Nettlefield	1/01/1998	21/02/2011
532088	Rooney's Bridge	1/11/2010	21/02/2011
532020	Ross River Dam	1/12/1998	21/02/2011
532077	South Townsville	1/11/2010	21/02/2011
532036	Stuart	26/12/2000	21/02/2011
532035	Stuart Creek	28/08/2000	21/02/2011
532041	The Pinnacles	11/08/2000	21/02/2011
532031	Townsville Airport	25/08/2000	21/02/2011
532045	Upper Black River	5/09/2000	21/02/2011
532047	Upper Bluewater	7/09/2000	21/02/2011
533022	Woodlands	9/09/1999	21/02/2011

ROSS CREEK FLOOD STUDY GAUGING STATIONS

Figure 2-1



LEGEND

- Rain Alerts
- Level Alerts
- Hydraulic Model Extent

Major-Catchments

- Annandale/Douglas
- Captains Creek
- Gordon Creek
- Louisa Creek
- Lower Ross River
- North Ward
- Ross Creek
- Stuart Creek
- Tchooratippa Creek

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STRATEGIC PLANNING
Planning and Development

DATE: 25/07/2012

DATE PRINTED: 9/08/2012

DRAWN BY: WBB

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2.2 Stream Gauging Records

Stream gauging records for Ross Creek study area have been used for the purpose of calibrating the hydrologic and hydraulic models. The Ross Creek catchment is far too small to have monitoring stations operated by the Department of Environment and Resource Management (DERM); however, there are stream level alert gauges relevant to the current study on both Ross Creek and Ross River. These include:

Table 2-3 - Ross Creek Stream Gauging

Station Number	Location	Agency	Start of Record	End of Record
532037	Mysterton Alert	BoM	05/10/2000	21/2/2011
532033	Townsville Harbour	DERM	11/3/1975	21/2/2011
532029	Aplins Weir	BoM	8/2/2001	21/2/2011
532088	Rooney's Bridge	BoM	1/11/2010	21/2/2011

Only the Mysterton Alert gauge provides an opportunity to match historical flood levels within the Ross Creek catchment, while the Aplins Weir Alert gauge provides an opportunity to match historical flood levels on Ross River within the Study area. The Townsville Harbour gauge is at the outlet of the catchment and is influenced by tidal levels. The period of record on the Rooney's Bridge gauge is quite short and did not provide any data for the calibration events assessed.

2.3 Topographic Data

Topographic data has been used from numerous sources to ensure appropriate representation of ground relief. The main datasets and sources are:

- Townsville City Council LiDAR obtained from a joint government agency project, with capture around September/October 2009;
- Hydrographic survey of the freshwater reaches of Ross River obtained as part of the Ross River Hydraulic Study, 2001;
- Hydrographic survey of the lower estuarine reaches of Ross River obtained from Port of Townsville and AquaMap, 2010;
- Hydrographic survey of Ross Creek downstream of Denham Street obtained from the Port of Townsville and AquaMap, 2010; and
- Hydrographic survey of Ross Creek between Boundary Street/Charters Towers Road and Denham Street undertaken by AquaMap for the purpose of this project, 2011.

Figure 2-2 shows the extent of the topographic datasets.

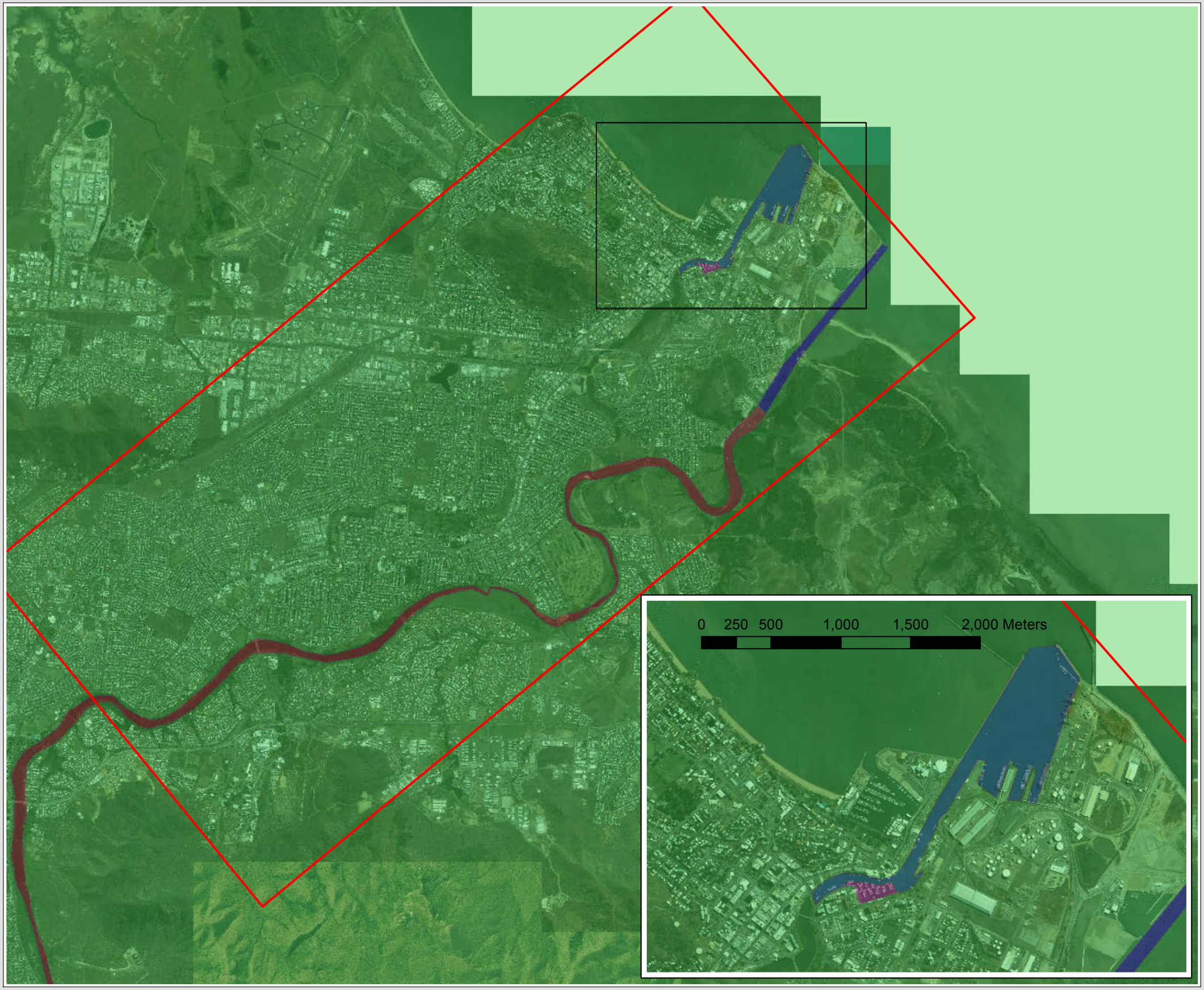
2.4 Surveyed Historical Flood Levels

Townsville City Council's surveyors have endeavoured to survey debris marks and peak flood levels during major flood events. The largest flood event in recent history for the Ross Creek catchment was the January 1998 flood event. This is the only flood event with a significant surveyed dataset held by Council. These surveyed flood levels have been used to calibrate the hydraulic model for this study.

Figure 2-3 shows the surveyed flood levels from the January 1998 event.

ROSS CREEK FLOOD STUDY TOPOGRAPHIC DATA

Figure 2-2



LEGEND

- Hydraulic Model Extent

Dataset

- LiDAR
- Ross Creek Hydrographic
- Ross River Hydrographic
- TFHAS Survey
- Yacht Club Hydrographic

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City of Townsville

SCALE: 1:50,000 @A3

400 200 0 400 800 1,200 1,600 Metres

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DATE: 25/07/2012

DATE PRINTED: 9/08/2012

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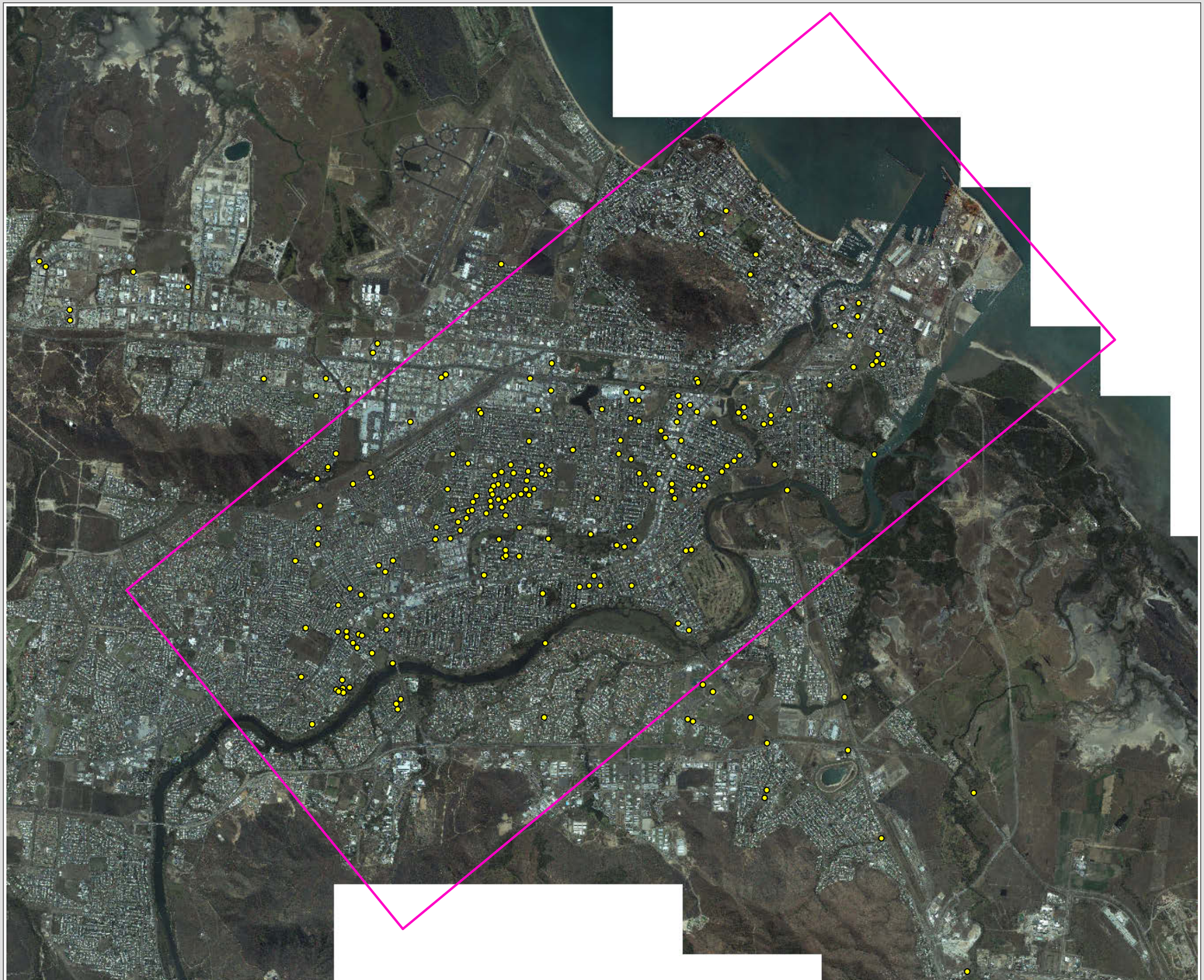
ROSS CREEK FLOOD STUDY JANUARY 1998 SURVEY

Figure 2-3



LEGEND

- Survey Points
- Hydraulic Model Extent

N

City of Townsville

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400200 0 400 800 Metres

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2.5 Cadastral Data

Cadastral data from the study areas has been used for evaluating catchment and floodplain parameters as part of the hydrological and hydraulic modelling. The Cadastral information was used as at 30th September 2010. There has not been significant greenfield development within the study area that has occurred since this date.

2.6 Structure Design Drawings

Drawings have been sourced for the bridge and culvert structures within the Study Area, to provide details for the hydraulic modelling. Where design drawings have not been available, site observations and survey have been used to determine geometrical parameters for the bridges.

2.7 Aerial Photography

Townsville City Council's aerial photography captured in July 2009 was used for assigning fraction impervious and hydraulic roughness within the flood models.

2.8 Previous Flooding Reports

Townsville Flood Hazard Assessment Study
Townsville City Council commissioned Maunsell to undertake the *Townsville Flood Hazard Assessment Study* as part of the Natural Disaster Risk Management Studies Program. The Study was completed in 2005 and involved 3 phases:

- Phase 1 – Data Acquisition;
- Phase 2 – Flood Hazard Assessment; and
- Phase 3 – Vulnerability Assessment and Risk Analysis.

The flood modelling was completed for Phase 2 of the report. The hydrological assessment focused on the Ross Creek catchment. The study did not did not account for flows over the Ross River Dam spillway from the upstream catchment. The hydraulic assessment developed a MIKE11 model for flood events up to the 20 Year ARI, while a MIKE21 model was developed for the flood events greater than and including the 50 Year ARI. To simplify the computational requirements of the project, only the 2 hour and 6 hour storm durations were assessed.

Data acquired for the *Townsville Flood Hazard Assessment Study* was used in the development of the hydrological and hydraulic models for the present study. Results of the *Townsville Flood Hazard Assessment Study* were also used for comparison of results.

Ross River Flood Study – Base Line Flooding Assessment
Townsville City Council completed the Ross River Flood Study as an early component of the City Wide Flood Constraints Project. The flood study examined both the catchments upstream and downstream of Ross River dam. A 30 m grid MIKE FLOOD model was developed for the River which allowed efficient representation of the broad-

scale flood flow paths associated with Ross River. Flows from the Ross River model were used as boundary conditions to the Ross Creek model developed for this study.

Garbutt Drainage Investigation

The Garbutt Drainage Investigation was completed by Maunsell AECOM in 2008. The investigation developed a MIKE FLOOD model with a 5m grid of the Captains Creek floodplain including Garbutt. The flood model had some allowance for overflows from Lakes II; however these flows were only provided from the Townsville Flood Hazard Assessment Study and were limited to the 6 hour duration event.

The MIKE FLOOD model that was developed for the Garbutt Drainage Investigation was used to evaluate flood mitigation options for Garbutt and the broader catchment. To date, none of the mitigation works identified from the report have been constructed.

Ultimately flows from the Ross Creek flood model will be able to be applied to the model for Captains Creek (Garbutt) to represent the overflows from Lakes II. The results from the Garbutt Drainage Investigation have been compared when reviewing the results of this study.

3.0 Hydrological Assessment

3.1 Catchment Overview

The Ross Creek catchment is a highly urbanised catchment, draining much of the urban area of Townsville. With the exception of the southern slopes of Castle Hill, the Ross Creek catchment is very flat. In areas, it is difficult to determine exact catchment boundaries, particularly at the boundaries with:

- Captains Creek;
- Louisa Creek; and
- Ross River Downstream

These uncertainties can be overcome, in a modelling sense, through calculating the flows for relevant areas of the adjacent catchments then applying these flows to a two-dimensional hydraulic model with appropriate underground drainage represented. The application of the “Rain on Grid” approach to local runoff means that accuracy of flood levels is less dependent on the uncertainties associated with inconspicuous catchment boundaries.

The area of the Ross Creek catchment is approximately 26.1 km^2 based on catchment used for this investigation. The creek drains to the Inner Harbour of the Port of Townsville. The water courses within the catchment are considered heavily disturbed and in most instances are completely artificial. The two primary tributaries for the catchment are the Mindham Park System and the Lakes System, which both drain into Woolcock Canal and ultimately Ross Creek.

The upper most portion of the catchment is the suburb of Cranbrook, which drains through Aitkenvale and into the Mindham Park System. The Mindham Park system also drains Mundingburra, parts of Gulliver, Mysterton, parts of Pimlico, Hermit Park and parts of Hyde Park. Suburbs draining to the Lake system tend to drain via individual flow paths for each suburb. The suburbs of West End, parts of Garbutt, Currajong, parts of Gulliver, parts of Pimlico and parts of Hyde Park all generally drain directly to the Lakes. Downstream of the confluence of Woolcock Canal and Ross Creek, portions of the suburbs of Railway Estate and South Townsville drain to the Creek.

While a majority of the catchment is urbanised, there are pockets of parkland such as Gill Park, Aitkenvale Park and Anderson Gardens that provide some significant pervious areas within the catchment. Also the southern slopes of Castle Hill are too steep to develop and are in a natural state.

The urban development within the catchment varies. There is high density commercial within the Central Business District as well as Charters Towers Road and Aitkenvale. Light industrial areas are contained to Hyde Park, Currajong, West End and Garbutt, while the remainder of the urban development is residential of varying densities.

3.2 Hydrological Modelling Software

XP-RAFTS

The hydrologic modelling software XP-RAFTS calculates catchment flows from rainfall based on Laurenson's non-linear routing method. The model is able to predict flows for catchments containing both urban and rural land uses accounting for surface roughness, catchment slope, soil infiltration and depression storage losses. It is well suited to the study area due to the need for detailed sub-catchment definition and representation of both rural and urban areas combined.

XP-RAFTS has been used to simulate the hydrological response of Ross Creek catchment in addition to the other adjacent catchments:

- Ross River local watercourse catchments (Ross River Downstream);
- Annandale and Douglas areas;
- Gordon Creek; and
- Stuart Creek.

Details of the Ross Creek hydrological modelling are provided in this report. Details of the hydrological modelling of the other major sub-catchments will be provided in subsequent reports as part of the City Wide flood constraint project.

RORB

Within area of the Ross Creek Floodplain, flooding can also result from overbank flooding of Ross River flood events. This is particularly the case in longer duration rainfall events, where the total volume of rainfall is sufficient to fill Ross River Dam and drive outflows over the dam spillway.

To ensure all aspects of flooding in the Ross Creek floodplain are represented outflows from the Ross River Dam were also simulated. The RORB hydrological model of the Ross River Dam catchment, developed for the Ross River Flood Study (2012) was used for this study. For any storm evaluated on the local Ross Creek catchment the, same storm ARI and Duration was simulated for the Ross River Dam catchment, with the spillway flows applied to the Ross River Downstream hydrological model. The Ross River Dam RORB model used model parameters as per the Ross River Flood Study (TCC, 2012).

Rain on Grid Approach

The rain on grid approach involves directly applying rainfall excess to the two-dimensional grid of the MIKE-FLOOD model. Rainfall excess is the rainfall less initial and continuing losses associated with surface depression storage and infiltration.

3.3 Catchment Delineation

The Ross Creek catchment was divided into 553 sub-catchments. The sub-catchments were determined from the available topographic data and were cognisant of the trunk drainage infrastructure and the resolution required within the hydraulic model.

Figure 3-1 shows an overview of the sub-catchment delineation of Ross Creek adopted for this study. Within the catchment there were the following sub-catchment groupings:

- City (Cy);
- Railway Estate (RE)
- West End (WE);
- Hermit Park 1 (Hp);
- Hermit Park 2 (Hm);
- Hyde Park (Hy);
- Castletown (CT);
- Currajong (Cj);
- Dalrymple Road (Dm);
- Hopkins Street Drain (Hk);
- Mindham Drain (Mn);
- Pimlico Drain (Pm);
- Mundingburra (Md);
- Gulliver (Gu);
- Aitkenvale (Ak);
- Illich Park (IP);
- Cranbrook (Ck);

Detailed sub-catchment maps are provided in **Appendix A**.

3.4 Sub-Catchment Parameters

Sub-catchment parameters for the Ross Creek hydrological model were determined from topographic data, aerial photography, cadastral information and site observations. The adopted sub-catchment parameters are given in **Table A1** in **Appendix A**.

ROSS CREEK FLOOD STUDY CATCHMENT OVERVIEW

Figure 3-1

TOWN COMMON
ROWES BAY
BELGIAN GARDENS
NORTH WARD
North Ward
MOUNT ST JOHN
Captains Creek
CASTLE HILL
TOWNSVILLE CITY
GARBUTT
SOUTH TOWNSVILLE
WEST END
Louisa Creek
MOUNT LOUISA
CURRAJONG
HYDE PARK
RAILWAY ESTATE
PIMLICO
VINCENT
HERMIT PARK
GULLIVER
MYSTERTON
OONOONBA
Lower Ross River
Stuart Creek
STUART
HEATLEY
MUNDINGBURRA
ROSSLEA
AITKENVALE
Tchooratippa Creek
KIRWAN
CRANBROOK
IDALIA
ANNANDALE
Gordon Creek
CLUDEN
Annandale/Douglas
THURINGOWA CENTRAL
DOUGLAS
MURRAY
WULGURU

LEGEND

Major Sub-Catchments

- City
- Railway Estate
- West End
- Hyde Park
- Castletown
- Hermit Park 1
- Hermit Park 2
- Dalrymple Road
- Hopkins Drain
- Mindham Park
- Pimlico
- Currajong
- Illich Park
- Mundingburra
- Gulliver
- Aitkenvale
- Cranbrook

N

City of Townsville

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400 200 0 400 800 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development
DATE: 25/07/2012
DATE PRINTED: 8/08/2012
DRAWN BY: WBB
DIGITAL FILE: RossCreek_Fig3-1_SubCatch.mxd

3.5 Model Verification

Although local runoff for a majority of the study area has been represented using the "Rain on Grid" approach, the XP-RAFTS model is still useful for rapid assessment of major system flows and potential detention storage volumes. Given there are no stream flow gauges within the Ross Creek catchment, the hydrological model has been verified by comparing peak flow rates from the model with flows determined from Rational Method calculations.

For suitable sub-catchments in the Ross Creek catchment, Rational Method flows were determined using appropriate time of concentration calculation methods for the catchment and runoff coefficients as per the *Queensland Urban Drainage Methodology*. The potential for impact of partial area effects were also examined. A summary of the results is provided in **Table 3-1**. The result show good agreement between peak discharges from the XP-RAFTS model and the Rational Method.

Table 3-1 Ross Creek Hydrological Model Verification

			Peak Flow (m^3/s)	
Catchment	**Location**	**ARI (Years)**	**Rational Method**	**XP-RAFTS**
TCK-12.00	Corner Valencia Street & Ross River Road (Kirwan /Cranbrook)	50	26.2	23.3
TCK-12.00	Corner Valencia Street & Ross River Road (Kirwan /Cranbrook)	2	9.1	9.4
TIP-11.00	Corner Illoura Street & Charles Street (Cranbrook)	50	21.6	22.3
TIP-11.00	Corner Illoura Street & Charles Street (Cranbrook)	2	7.6	9.0
TAK-1.00.03	Blair Court u/s Aitkenvale Drain (Aitkenvale)	50	15.9	16.5
TAK-1.00.03	Blair Court u/s Aitkenvale Drain (Aitkenvale)	2	5.6	7.4
TGU-1.00.01	Gulliver Street, flowing north into Anderson Park Drain (Mundingburra)	50	9.6	10.4
TGU-1.00.01	Gulliver Street, flowing north into Anderson Park Drain (Mundingburra)	2	3.4	4.7
TMn-1.00	Corner Wood Street and Ross River Road (Mundingburra)	50	25.5	25.0
TMn-1.00	Corner Wood Street and Ross River Road (Mundingburra)	2	8.9	10.1
TPm-1.00	Purves Street u/s Mindham Park Drain (Pimlico)	50	29.1	27.0
TPm-1.00	Purves Street u/s Mindham Park Drain (Pimlico)	2	10.3	10.9
THk-3.00	Hopkins Street Drain u/s Corcoran Street (Currajong /Gulliver)	50	18.5	17.9
THk-3.00	Hopkins Street Drain u/s Corcoran Street (Currajong /Gulliver)	2	6.5	7.4
THm-5.00	Hermit Park Drain u/s Charters Towers Road (Hermit Park)	50	17.7	17.8
THm-5.00	Hermit Park Drain u/s Charters Towers Road (Hermit Park)	2	6.2	7.1
THp-1.00	Ross Creek u/s Boundary Street (Hermit Park /Railway Estate)	50	23.6	23.2
THp-1.00	Ross Creek u/s Boundary Street (Hermit Park /Railway Estate)	2	8.4	8.9
TDm-1.00	Dalrymple Road Drain u/s Hugh Street (Garbutt)	50	13.5	13.3
TDm-1.00	Dalrymple Road Drain u/s Hugh Street (Garbutt)	2	4.8	6.3

3.6 Design Rainfall

Design rainfall for the Ross Creek catchment was developed from the Intensity Frequency Duration (IFD) methods outlined in Australian Rainfall and Runoff (1998) using catchment specific IFD input parameters. The IFD input parameters adopted are provided in **Table 3-2**. The resulting IFD rainfall intensities for Ross Creek are provided in **Table 3-3**.

Table 3-2 Ross Creek IFD Input Data

Parameter	Value
Latitude	19.3 Deg S
Longitude	146.775 Deg E
2 Year, 1 Hour Intensity	53.82 mm/h
2 Year, 12 Hour Intensity	11.92 mm/h
2 Year, 72 Hour Intensity	3.87 mm/h
50 Year, 1 Hour Intensity	110.12 mm/h
50 Year, 12 Hour Intensity	24.8 mm/h
50 Year, 72 Hour Intensity	9.48 mm/h
Skewness (G)	0.05
Geographical Factor (F2)	3.93
Geographical Factor (F50)	17.08

Table 3-3 Ross Creek IFD Rainfall Data

Storm Duration	Rainfall Intensity (mm/h) for Given ARI								
	1Y	2Y	5Y	10Y	20Y	50Y	100Y	200Y	500Y
5 min	115.47	149.70	195.51	222.87	258.76	306.49	343.23	381.04	432.56
6 min	109.14	141.51	184.87	210.78	244.75	289.94	324.73	360.53	409.33
10 min	91.54	118.73	155.26	177.10	205.74	243.84	273.19	303.40	344.58
15 min	78.22	101.49	132.83	151.59	176.16	208.87	234.08	260.03	295.42
20 min	69.33	89.98	117.84	134.53	156.38	185.48	207.91	231.00	262.51
30 min	57.81	75.05	98.39	112.38	130.69	155.09	173.90	193.28	219.72
45 min	47.64	61.87	81.19	92.79	107.96	128.18	143.78	159.85	181.79
1 hour	41.28	53.64	70.44	80.54	93.74	111.34	124.92	138.91	158.02
1.5 hour	32.48	42.21	55.50	63.49	73.93	87.85	98.61	109.69	124.83
2 hour	27.30	35.49	46.69	53.44	62.25	74.01	83.08	92.45	105.24
3 hour	21.31	27.71	36.51	41.80	48.72	57.95	65.09	72.45	82.51
4.5 hour	16.61	21.62	28.51	32.66	38.09	45.33	50.93	56.71	64.61
6 hour	13.93	18.13	23.92	27.42	31.99	38.09	42.80	47.67	54.33
9 hour	10.87	14.15	18.70	21.45	25.03	29.82	33.53	37.35	42.59
12 hour	9.12	11.88	15.71	18.03	21.04	25.08	28.20	31.43	35.85
18 hour	7.14	9.35	12.54	14.50	17.04	20.45	23.11	25.87	29.66
24 hour	5.99	7.87	10.67	12.41	14.64	17.66	20.03	22.49	25.88
30 hour	5.21	6.87	9.39	10.96	12.99	15.73	17.88	20.13	23.24
36 hour	4.64	6.14	8.44	9.89	11.75	14.28	16.27	18.36	21.24
48 hour	3.84	5.10	7.09	8.36	9.98	12.19	13.95	15.79	18.35
72 hour	2.89	3.85	5.45	6.48	7.80	9.61	11.05	12.57	14.70

Probable Maximum Precipitation

Estimates of the Probable Maximum Precipitation (PMP) have been made for a range of storm durations. The Generalised Short Duration Method (GSDM) has been used for storm events up to 6 hours, while the Generalised Tropical Storm Method - Revised (GTSMR) has been used for storm events longer than 24 hours. The PMP rainfall depth estimates are provided in **Table 3-4**. Calculation sheets for the PMP rainfall estimates are provided in **Appendix G**.

Table 3-4 PMP Rainfall Depths

Duration (hours)	Method	PMP Rainfall Depth (mm)
1	GSDM	400
2	GSDM	645
3	GSDM	730
4	GSDM	830
5	GSDM	920
6	GSDM	980
12	Interpolated	1210
24	GTSMR	1570
36	GTSMR	1930
48	GTSMR	2260
72	GTSMR	2840
96	GTSMR	3180
120	GTSMR	3330

3.7 Rainfall Loss Values

Rainfall loss values for the design events were assigned based on results of the joint calibration with the hydraulic model and verification. A summary of the loss values determined from the joint calibration events for the Ross Creek models are in **Table 3-5**.

Table 3-5 Ross Creek Calibration Event Rainfall Losses

Event	Surface Type	Initial Loss	Continuing Loss
January 1998	Pervious	25 mm	2.5 mm/h
	Impervious	1 mm	0 mm/h
February 2002	Pervious	60 mm	3 mm/h
	Impervious	1 mm	0 mm/h
January 2009	Pervious	1 mm	2.5 mm/h
	Impervious	1 mm	0 mm/h

The February 2002 rainfall event followed an extended period without rain, as noted within the Townsville Flood Hazard Assessment Study. The losses adopted through the joint calibration process outlined in **Table 3-4**, reflect the dry antecedent conditions of the catchment. Likewise, the January 2009 rainfall event represented for the joint calibration was following a period of wet antecedent conditions. The rainfall losses adopted from the joint calibration reflect these wet antecedent conditions. Details of the joint calibration process are outlined in **Section 4.4**.

On the basis of these results the following rainfall losses were adopted for design events:

- Impervious – 1 mm IL and 0 mm CL;
- Pervious – 25 mm IL and 2.5 mm CL.

3.8 Design Flood Flows

Although the Ross Creek flood modelling has been completed using the MIKE FLOOD model with a majority of the catchment hydrology represented through the Rain on Grid approach, the XP-RAFTS model provides a useful tool evaluating indicative local catchment flows and providing initial estimates of detention storage requirements. A summary of the design flood flow results from the Ross Creek XP-RAFTS model are provided in **Table 3-6**.

Table 3-6 Ross Creek XP-RAFTS Design Flood Flows

Location	Peak Flood Flows (m^3/s)								
	2Y	**5Y**	**10Y**	**20Y**	**50Y**	**100Y**	**200Y**	**500Y**	**PMF**
Cranbrook (Ck-1.00)	14.5 (2h)	21.4 (2h)	26.2 (2h)	32.6 (2h)	39.9 (2h)	46.4 (2h)	51.9 (2h)	61.2 (2h)	195 (2h)
Aitkenvale (Ak-1.00)	24.0 (12h)	34.6 (12h)	41.0 (12h)	49.3 (12h)	56.0 (1h)	64.7 (3h)	74.3 (3h)	86.4 (12h)	275 (2h)
Gulliver (Gu-1.00)	41.0 (2h)	59.1 (2h)	68.7 (2h)	79.3 (2h)	94.6 (1h)	106.8 (1.5h)	120 (2h)	139 (2h)	436 (2h)
Currajong (Cj-1.00)	33.1 (2h)	48.5 (24h)	59.1 (24h)	70.5 (24h)	80.2 (2h)	91.9 (1.5h)	104 (2h)	122 (24h)	398 (2h)
Lake 1 South (Hk-1.00)	9.0 (1h)	13.0 (1.5h)	15.6 (1.5h)	19.1 (1.5h)	23.1 (1h)	27.0 (1h)	30.8 (1h)	33.8 (1.5h)	92 (2h)
Mundingburra (Mn-1.00)	9.0 (2h)	13.0 (2h)	15.6 (2h)	19.0 (2h)	22.9 (2h)	26.6 (2h)	30.2 (2h)	35.6 (1.5h)	116 (2h)
Pimlico (Pm-1.00)	9.9 (1h)	14.2 (1h)	16.8 (1h)	20.5 (2h)	25.1 (1h)	29.2 (1h)	33.1 (1h)	38.9 (1h)	104 (2h)
Hermit Park (Hm-1.00)	10.5 (2h)	15.5 (2h)	18.5 (2h)	22.8 (2h)	27.2 (2h)	31.6 (1.5h)	35.9 (1.5h)	42.5 (1.5h)	119 (2h)
Ross Creek – Boundary Street (Hp-1.00)	7.6 (1h)	11.4 (1h)	13.7 (1h)	17.2 (2h)	21.4 (1h)	25.2 (1h)	29.0 (1h)	34.5 (1h)	97 (2h)
Railway Estate (RE-1.00)	6.0 (2h)	8.8 (2h)	10.6 (2h)	13.1 (2h)	15.9 (2h)	18.3 (2h)	20.8 (2h)	24.2 (2h)	78 (2h)
Ross Creek – Outlet (Cy-1.00)	105 (24h)	155 (24h)	187 (24h)	224 (24h)	255 (24h)	292 (24h)	330 (24h)	387 (24h)	1080 (2h)

4.0 Hydraulic Assessment

4.1 Floodplain Overview

The Ross Creek floodplain comprises a majority of the older urban areas of Townsville on the northern side of Ross River. The left (northern) bank of Ross River is perched and overflows from the Ross River generally do not occur for flood events less than the 100 Year ARI (Ross River Flood Study 2012). The Ross Creek Floodplain drains north-east away from the perched bank of Ross River towards the Townsville Central Business District and Port of Townsville.

The floodplain is completely urbanised with many of the surface flow paths heavily constrained. The main surface flow paths that are dedicated to stormwater conveyance are:

- Mindham Park Drain;
- Hermit Park Drain;
- Pimlico Drain;
- Hopkins Street Drain;
- Woolcock Canal;
- Ross Creek; and
- Dalrymple Road Table Drains.

There are large areas of the suburbs of Vincent, Currajong and Gulliver that have no dedicated surface flow paths. Consequently these areas are subject to significant inundation within streets and across lots.

4.2 MIKE FLOOD

MIKE FLOOD is a dynamically linked 3-way hydraulic modelling package, which couples the 1D river hydraulics model, MIKE11 and the 1D sub-surface drainage model, MIKE URBAN with the 2D surface water model, MIKE21. MIKE FLOOD can be used to simulate:

- coincident river and storm surge flooding in coastal areas;
- the detailed flooding patterns on floodplains in terms of flow velocities and water levels;
- water exchange between channels, canals, sub-surface drainage and adjacent floodplains, ponds, reservoirs, etc.; and
- flood waves in channels and on flood plains associated with a dam failure.

The MIKE21 2D component of the MIKE FLOOD model has been used to adequately represent the complex two dimensional hydraulics of the Ross Creek floodplain. The MIKE11 1D component of the MIKE FLOOD model was required to provide a more accurate representation of the hydraulics of structures (such as culverts and bridges) and narrow open channels. The MIKE URBAN 1D component of the MIKE FLOOD model was required to represent sub-surface drainage that has the potential to impact on flood levels. Sub-surface drainage generally larger than or equal to the equivalent waterway area of 900 mm diameter pipe were considered to have the potential to impact on flood levels.

4.3 Model Setup

Topographic Grid

The MIKE FLOOD model developed for the Study is based on a rotated 10 m topographic grid covering an area of 13.26 km by 6.22 km. The rotation of the grid was aligned to the general orientation of the Ross Creek floodplain. The model set-up is shown in **Figure 4-1**. The topographic grid is based on the LiDAR obtained in 2009 for a majority of the floodplain. Within the estuary reaches of Ross River, recent hydrographic survey obtained from Port of Townsville and AquaMap has been used to specify the underwater areas of the grid. In the upper freshwater reaches of Ross River, underwater survey obtained as part of the *Townsville Flood Hazard Assessment Study* and *Ross River Hydraulic Study* has been used to specify the underwater areas of the grid. Hydrographic survey of the lower reaches Ross Creek completed by AquaMap specifically for this project, was also incorporated into the Topographic grid.

Boundary Conditions

Boundary conditions of the model are specified as either upstream inflows or downstream water levels. The base-line flooding assessment of design flood events has used downstream water levels set to a fixed level of the Mean High Water Springs (MHWS) tide. A sensitivity assessment has also evaluated the impact of increase to Highest Astronomical Tide (HAT) as a tail water condition as well as the potential impact of sea level rise. Within the calibration events, downstream water level boundaries were set to recorded water levels from the Townsville Harbour gauge, appropriate for the event.

The key boundaries for the model are:

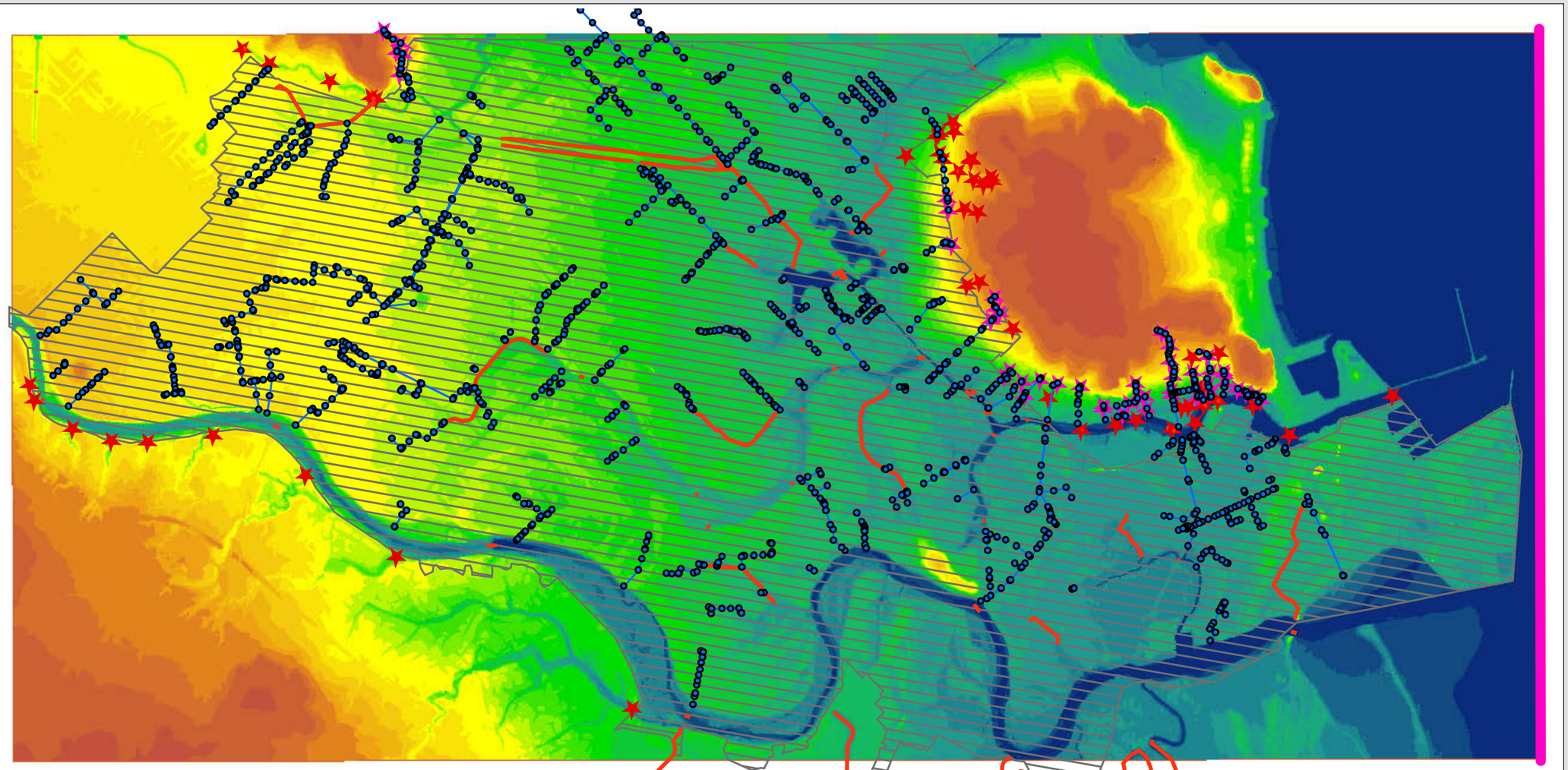
- Ross River Flows (inflow to the model just upstream of Gleesons Weir);
- Cleveland Bay Ocean Boundary
- Captains Creek Outflow Boundary
- Meenan Street Garbutt Boundary
- Peewee Creek Outflow Boundary
- Louisa Creek Outflow; and
- Sandfly Creek Outflow Boundary.

Ross River Inflows to the Ross Creek model were determined from simulations using the broader Ross River flood model developed as part of the Ross River Flood Study. The Sandfly Creek overflow is a downstream ocean boundary to one of the MIKE 11 branches within the lower Ross River Floodplain.

The locations of the model boundaries can be seen in **Figure 4-1**.

ROSS CREEK FLOOD STUDY HYDRAULIC MODEL

Figure 4-1



LEGEND

- Ocean Boundaries
- MIKE Urban Nodes
- MIKE Urban Links
- MIKE11 BRanches
- MIKE21 Source Points
- MIKE URBAN Source Points
- Rain on Grid Extent

MIKE21 Topographic Grid

Surface Elevation (m AHD)

< -1	8 - 9
-1 - 0	9 - 10
0 - 1	10 - 12
1 - 2	12 - 14
2 - 3	14 - 16
3 - 4	16 - 18
4 - 5	18 - 20
5 - 6	20 - 30
6 - 7	30 - 40
7 - 8	40 - 100
	> 100

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Rain on Grid
The application of rainfall excess directly to the MIKE FLOOD 2D grid was limited to flat portions of the study area to ensure model stability. The extent of the "Rain on Grid" area is shown in **Figure 4-1**. The rainfall excess was applied to the MIKE FLOOD 2D grid with a spatial distribution representing the impervious areas within study area. The impervious areas were identified from detailed review of aerial photography and zoning information. The spatial distribution of impervious areas is shown in **Figure 4-2**.

Rainfall loss values were determined from the review of rainfall losses determined from the model calibration (refer to **Section 4.4**). The loss values adopted for the design flood events were:

- initial loss - 25mm; and
- continuing loss 2.5 mm/h.

For the calibration events the spatial distribution of rainfall applied to the grid also accounted for the spatial rainfall distribution determined from the recorded rainfall records (refer to **Section 4.4**).

The derivation of the design rainfall applied using "Rain on Grid" is provided in **Section 3.6**.

Source Points
Source points representing sub-catchment inflows are applied to the MIKE FLOOD model for those areas outside of the "Rain on Grid" area, as shown in **Figure 4-1**. Sub-catchments represented by these source-points include:

- Douglas/Annandale;
- Gordon Creek;
- Stuart Creek;
- portions of Ross Creek;
- portions of Captains Creek; and
- portions of Louisa Creek.

Flows for these sources points were determined by applying rainfall to the XP-RAFTS models developed for these catchments.

ROSS CREEK FLOOD STUDY FRACTION IMPERVIOUS

Figure 4-2

LEGEND

Impervious Assignment

- Pervious
- Impervious

N

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Hydraulic Structures
Major structures on Ross River have been represented as one-dimensional elements in the model by either:

- representing the structure as an implicit coupled structure;
- representing the structure as an explicit coupled structure (for branches longer than the cell width – 10m); or
- representing the structure within a 1-dimensional branch that was laterally coupled immediately upstream and downstream of the structure.

The major structures represented include:

- Port Access Road Bridge over Ross River;
- Abbott Street Bridges over Ross River (rail, pedestrian and road);
- Bowen Road Bridge over Ross River;
- Aplins Weir (and pedestrian bridge);
- Nathan Street Bridge over Ross River;
- Gleesons Weir; and
- Denham Street Bridge over Ross Creek;
- Victoria Bridge over Ross Creek;
- Lowths Bridge over Ross Creek;
- the abandoned Rail Bridge immediately upstream of Lowths Bridge on Ross Creek;
- The abandoned Rail Bridge adjacent to Little Fletcher Street on Ross Creek;
- Railway Station Bridge over Ross Creek;
- V8 supercar bridge over Ross Creek;
- Boundary Street culvert over Ross Creek;
- Flower Street / Queens Road culverts over Ross Creek;
- both Charters Towers Road culverts over Woolcock Canal;
- both Sturt Street culverts over Woolcock Canal;
- Woolcock Street culverts at the lower Mindham Park Drain;
- Kings Road culverts over Woolcock Canal;
- three culverts under Woolcock Street connecting Lakes 1 and 2;
- Bayswater Road culvert over Mindham Park Drain;
- Bayswater Road culvert over Hermit Park Drain;
- Charters Towers Road culvert over Hermit Park Drain
- Bayswater Terrace culvert over Mindham Park Drain;
- Townsend Street culvert over Mindham Park Drain;
- Balls Lane culvert downstream of Anderson Gardens;
- Balls Lane culvert between Marron Crescent and Ross River Road;
- Gulliver Street culvert upstream of Anderson Gardens;
- Ross River Road extended culverts over Aitkenvale Drain;
- Samphire Drive bridge over Goondi Creek;
- Dearness Street culverts over Melrose Park Drainage reserve.

Details of the culverts and bridges represented within the Ross Creek model are provided in **Appendix B**.

Narrow Flow Paths
Surface flow paths that are too narrow to be represented with the MIKE21 topographic grid component of the MIKE FLOOD model were represented using MIKE11 branches. Overflows from the MIKE11 branches are transferred to the MIKE21 topographic grid of the broader floodplain via lateral couples. The narrow flow paths represented by MIKE11 branches were:

- Rosslea drain;
- Pimlico drain;
- Hermit Park drain;
- Currajong drain;
- Lakes overflow drain (to Captains Creek);
- Woolcock Street table drain;
- Brooks Street drain (Railway Estate);
- Boundary Street drain (near Samphire Drive);
- South Townsville drain (within the Port buffer parkland);
- Dalrymple Road table drain (northern side);
- Dalrymple Road table drain (southern side – adjacent to Vincent);
- Dalrymple Road table drain (southern side – adjacent to Currajong);
- Aitkenvale drain; and
- North Kirwan drain (draining Eckhoff Street area to Louisa Creek).

Cross sections for the narrow flow path drains were digitised from the LiDAR survey, which has elevation points identified at 1m centres. The locations of the narrow flow path branches represented within MIKE11 are shown in **Figure 4-1**.

Underground Drainage
Components of the underground drainage network that have potential to impact on surface flood levels have been represented using the MIKE URBAN component of the MIKE FLOOD model. Following an assessment of the conveyance within a typical street cross-section, with typical grades experienced in Townsville, it was identified that underground drainage with a cross-sectional area equal to a 900mm diameter pipe or greater was able to impact flood levels within the street cross-section by 10mm or greater. Generally only sections of the underground drainage, where the pipe cross-sectional area is greater than the equivalent of a 900mm pipe have been represented. In some areas smaller pipes have been represented, when they:

- are downstream of larger pipes;
- are part of a parallel set of pipes that would have an area greater than the equivalent of 900mm diameter pipe; or
- drain a trap low-point.

Figure 4-1 shows the general layout of the underground drainage network represented in the MIKE FLOOD model. Details of the underground drainage network represented in the MIKE FLOOD model are provided in **Appendix C** as small-scale layout plans and tabulated details of the network. Information to specify levels and dimensions of the network was sourced from Council's corporate GIS database, along with survey undertaken by Brazier Motti in 2010. Additionally, details were obtained from as-constructed or design plans for new drainage infrastructure including:

- drainage infrastructure associated with the Flinders Street upgrade project;

- drainage infrastructure associated with the re-development of the Stockland shopping centre;
- Barryman Street Pump Station and associated infrastructure;
- Albany Road Pump Station and associated infrastructure; and
- Campbell Street Pump Station and associated infrastructure.

Lower Ross River Floodplain

Much of the overbank area of the southern side of Ross River is inundated in larger flood events. To ensure that the flows within Ross River could be represented accurately while still having sufficient detail across the Ross Creek floodplain, it was necessary to represent flows on the southern overbank of Ross River using MIKE11 branches. The MIKE11 branches represented large areas that are major flow paths within the floodplain. The branches used to represent these flood plain flows included:

- Stuart Creek;
- Gordon Creek;
- Fairfield Waters Lake System;
- Overflow path through Murray
- Sandfly Creek;
- Sandfly Creek – second outlet;
- Cluden Creek;
- Floodplain flows between Gordon and Stuart Creeks; and
- Floodplain flows between Stuart and Sandfly Creeks.

These branches are shown in **Figure 4-1**.

Hydraulic Roughness

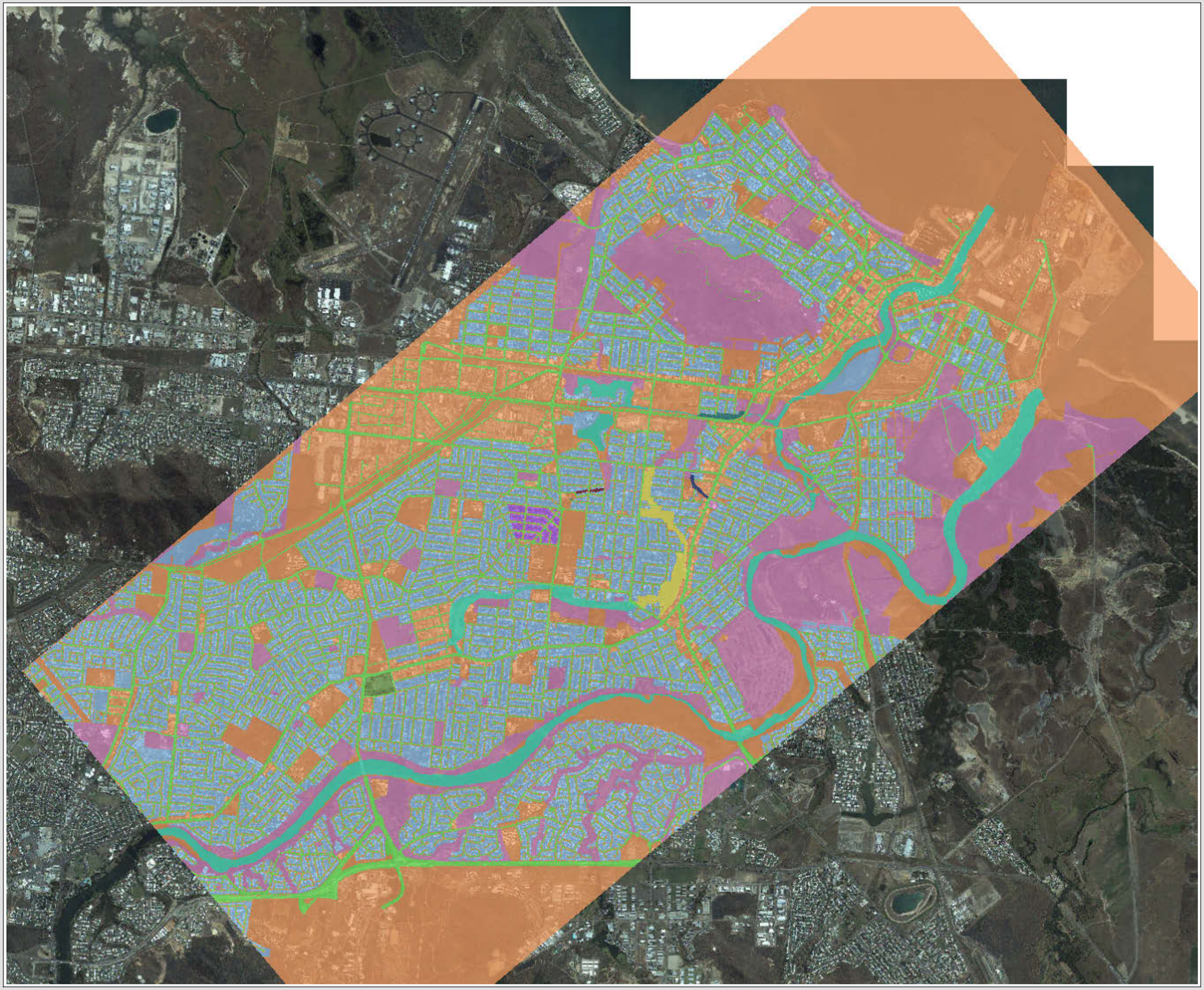
Hydraulic roughness within the model is specified as Manning's n values and was determined from review of land-use data, aerial photography and site assessment. The joint calibration of the model to recorded water levels (refer to **Section 4.6**) has confirmed the selection of the Manning's n values.

The roughness values adopted within the MIKE21 component of the MIKE FLOOD model are shown in **Figure 4-3**. Details of the roughness values adopted in the underground drainage (MIKE URBAN) of the MIKE FLOOD model are provided in **Appendix C**. The open channels represented with the MIKE11 component of the MIKE FLOOD were generally represented with Manning's n values of 0.033; however the following predominantly concrete drains had different values applied:

- Hermit Park drain – 0.015; and
- Woolcock Street drain – 0.025.

ROSS CREEK FLOOD STUDY MIKE21 ROUGHNESS

Figure 4-3



LEGEND

Manning's n

- 0.015
- 0.018
- 0.02
- 0.025
- 0.03
- 0.05
- 0.06
- 0.08
- 0.1
- 0.12
- 0.2

N

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Flow Couples

To allow the MIKE FLOOD to simultaneously represent 2D floodplain flows with, 1D channel flows and 1D pipe flows, the methodology for transferring flow between models must be specified. The following is a general description of the couple types adopted within the MIKE FLOOD model setup:

- *Standard Couple* – representing flow transfer between MIKE21 and MIKE11 where one or more MIKE21 cells are linked to the end of a MIKE11 branch (either upstream or downstream end). This type of couple is useful for connecting a detailed MIKE21 grid into a broader MIKE 11 network, or to connect an internal MIKE11 branch/structure (with an extent of more than a grid cell) inside the MIKE 21 grid.
- *Lateral Couple* – representing flow transfer between MIKE21 and MIKE11 where a string of MIKE21 cells are laterally linked to MIKE11 for either a section of a branch or an entire branch. This type of couple is useful for simulating overflow from a channel onto a flood plain.
- *Structure Couple* – representing flow transfer between MIKE21 and MIKE11 where a structure is represented in MIKE11. The structure couple takes the flow terms from a structure in MIKE11 and inserts them directly into the momentum equations of MIKE21.
- *Zero Flow Couple* – prevent flow through a series of MIKE21 cells. These zero flow couples have been used in conjunction with standard couples, when the standard couples are used for structure branches. These couples ensure all flow travels through the MIKE11 branch.
- *River / Urban Couple* – representing flow transfer between MIKE11 and MIKE URBAN where a chainage in MIKE11 and a Node in MIKE URBAN are linked. This kind of couple is used for representing outlets from the underground drainage network. Flow can travel both ways through this couple depending on the head difference in MIKE11 and MIKE URBAN.
- *Urban Outlet Couple* – representing flow transfer between MIKE21 and MIKE URBAN where a MIKE21 cell and a Node in MIKE URBAN are linked. This kind of couple is used for representing outlets from the underground drainage network. Flow can travel both ways through this couple depending on the head difference in MIKE21 and MIKE URBAN.
- *Urban Inlet Couple* – representing flow transfer between MIKE21 and MIKE URBAN where a MIKE21 cell and a Node in MIKE URBAN are linked. This kind of couple is used for representing inlets to the underground drainage network. Flow can travel both ways through this couple depending on the head difference in MIKE21 and MIKE URBAN.

The Ross River MIKE FLOOD model has a total 1251 couples comprising:

- 99 standard couples;
- 43 lateral couples;
- 8 structure couples;
- 44 zero flow couples;
- 14 river/urban couples; and
- 1043 urban inlet/outlet couples.

4.4 Model Calibration

The MIKE FLOOD model was calibrated to 3 representative historical events on the following basis:

- **January 1998** – was a large flood event resulting from rainfall directly on the Ross Creek catchment and a large peak water level data set was obtained;
- **February 2002** – was a moderate flood event resulting from rainfall directly on the Ross Creek catchment and had records at the Mysterton stream gauge; and
- **January 2009** – was a moderate flood resulting from a combination of local rainfall and Ross River flows and stream gauging records at Mysterton and Aplins Weir.

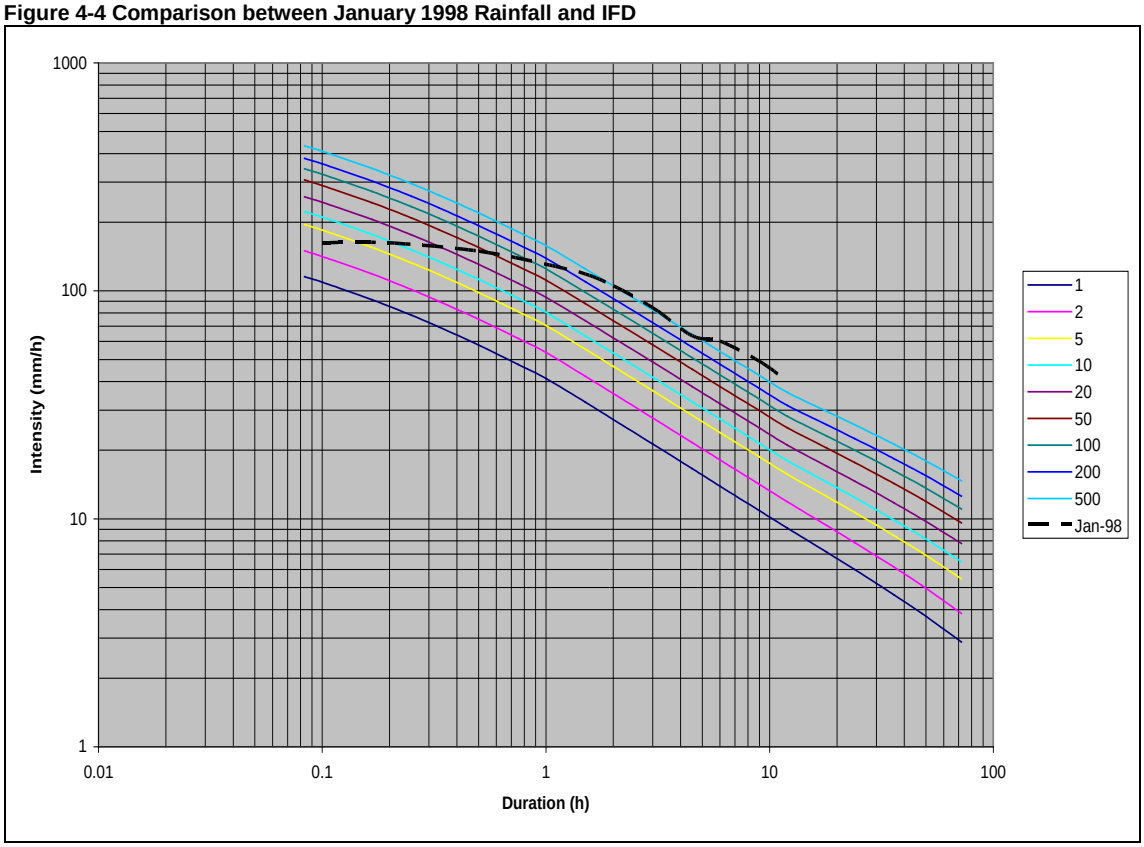
Water levels from the Townsville Harbour tide level gauge were used to specify downstream water level boundaries for the model. Local catchment runoff were represented by the "Rain on Grid" approach or local XP-RAFTS models and applied as source-points to the model. Flows from the Ross River dam were obtained from the RORB model developed from the *Ross River Flood Study* (TCC, 2012).

Specific details of the calibration for each event are provided in the sections below.

January 1998

The January 1998 event was a large rainfall event that occurred between 5pm on the 10th of January 1998 and 8am on the 11th of January 1998. Approximately 510 mm of rain was recorded at the Townsville Airport Gauge during this period. A comparison between the recorded rainfall at the airport gauge and the IFD relationship for Ross Creek (refer to **Figure 4-4**), shows that the event was in excess of a 500 Year ARI rainfall event particularly for durations beyond 6 hours.

Figure 4-4 Comparison between January 1998 Rainfall and IFD



The large peak water level surveyed dataset from the January 1998 event meant that calibrating the MIKE FLOOD model to the event would provide confidence in the spatial distribution of flood levels within the model. The surveyed dataset had been obtained by Townsville City Council surveyors in the immediate aftermath of the event. The locations of the data points are shown in **Figure 2-3**.

During the January 1998 event the only pluviometer close to the Ross Creek catchment was the Townsville Airport Gauge. There was however daily rainfall gauges that could be used to infer details of the spatial distribution of rainfall about the catchment. **Figure 4-5** shows the daily rainfall depths to 9am January 11 and the Thiessens polygons used in assigning rainfall to the model. A hyetograph based on the rainfall at the Townsville Aero gauge was applied across all Thiessens polygons with the polygon rainfall depth scaled from the daily rainfall depth.

Rainfall excess was applied to the MIKE FLOOD model by applying rainfall losses to the rainfall hyetographs. The losses adopted were as follows:

Table 4-1 January 1998 Rainfall Losses

Loss Type	Pervious	Impervious
Initial	25mm	1mm
Continuing	2.5mm/h	0mm/h

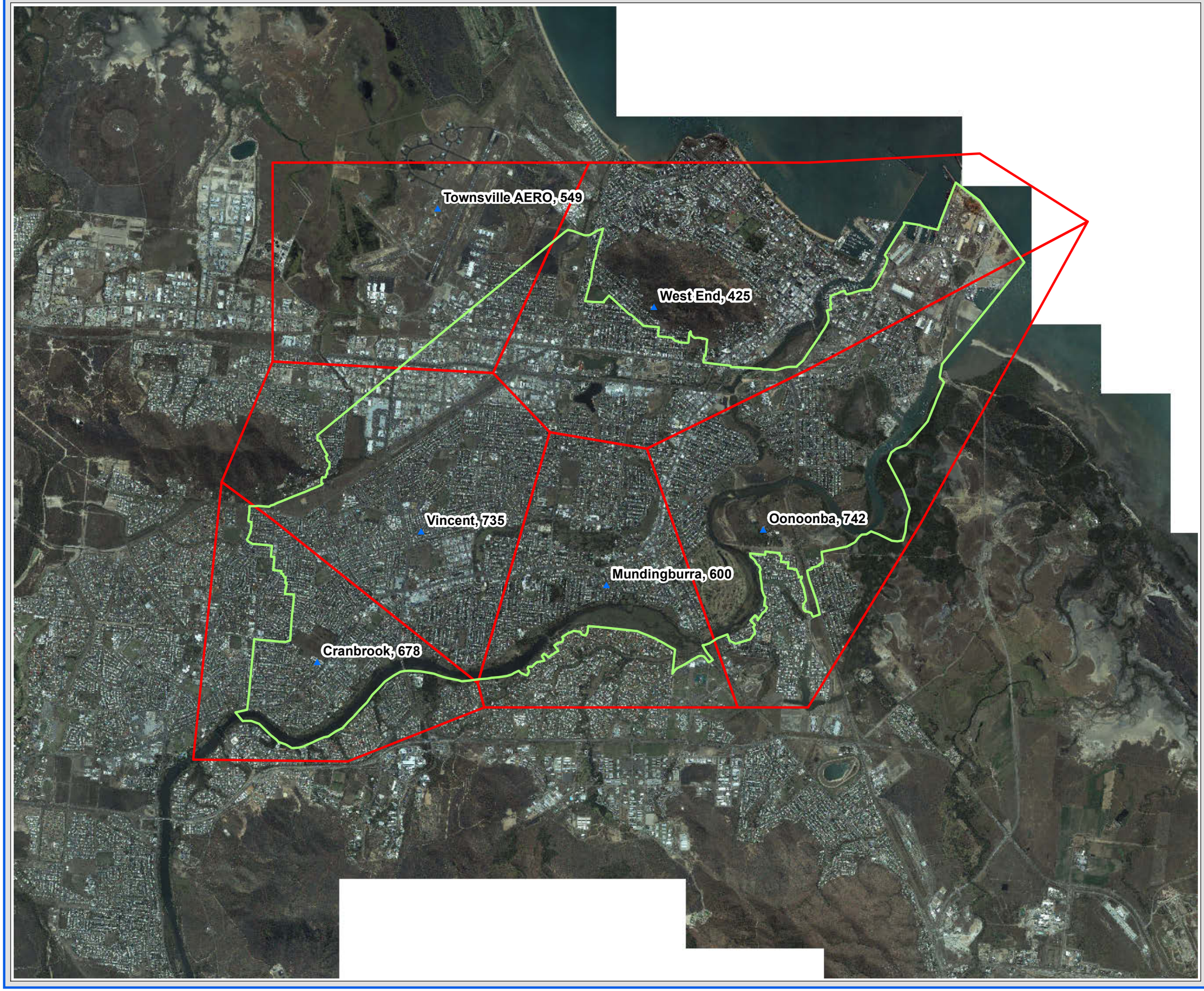
The topography of the model was adjusted to reflect the state of the floodplain during the January 1998 event. In particular drainage and bridge upgrades, since the January 1998 event were removed from the base-line model:

- Woolcock Canal widening in the lower reaches;
- additional culvert between Lakes I and Lakes II under Woolcock Street;
- new culverts under Bayswater Road on the Mindham Park Drain;
- new culverts under Gulliver Street on the Anderson Park Drain;
- Barryman Street stormwater pump station;
- Albany Road stormwater pump station;
- Campbell Street stormwater pump station; and
- the V8 supercar bridge and track facilities.

Figure 4-6 shows the results of the January 1998 calibration event as a comparison between the surveyed flood levels and the model results. The blue triangles represent locations where the model is lower than the surveyed flood levels, while the red triangles represent locations where the model is higher than the surveyed flood levels. The comparison of results shows that generally the flood levels determined fromm the model are within ±0.3m of the surveyed flood levels. The comparison of results also shows are reasonable spread of points where model flood levels and survey flood levels are close.

ROSS CREEK FLOOD STUDY JAN 1998 RAINFALL

Figure 4-5



LEGEND

- Rain on Grid Extent
- Daily Rain Gauges
- Thiessen Polygons

N

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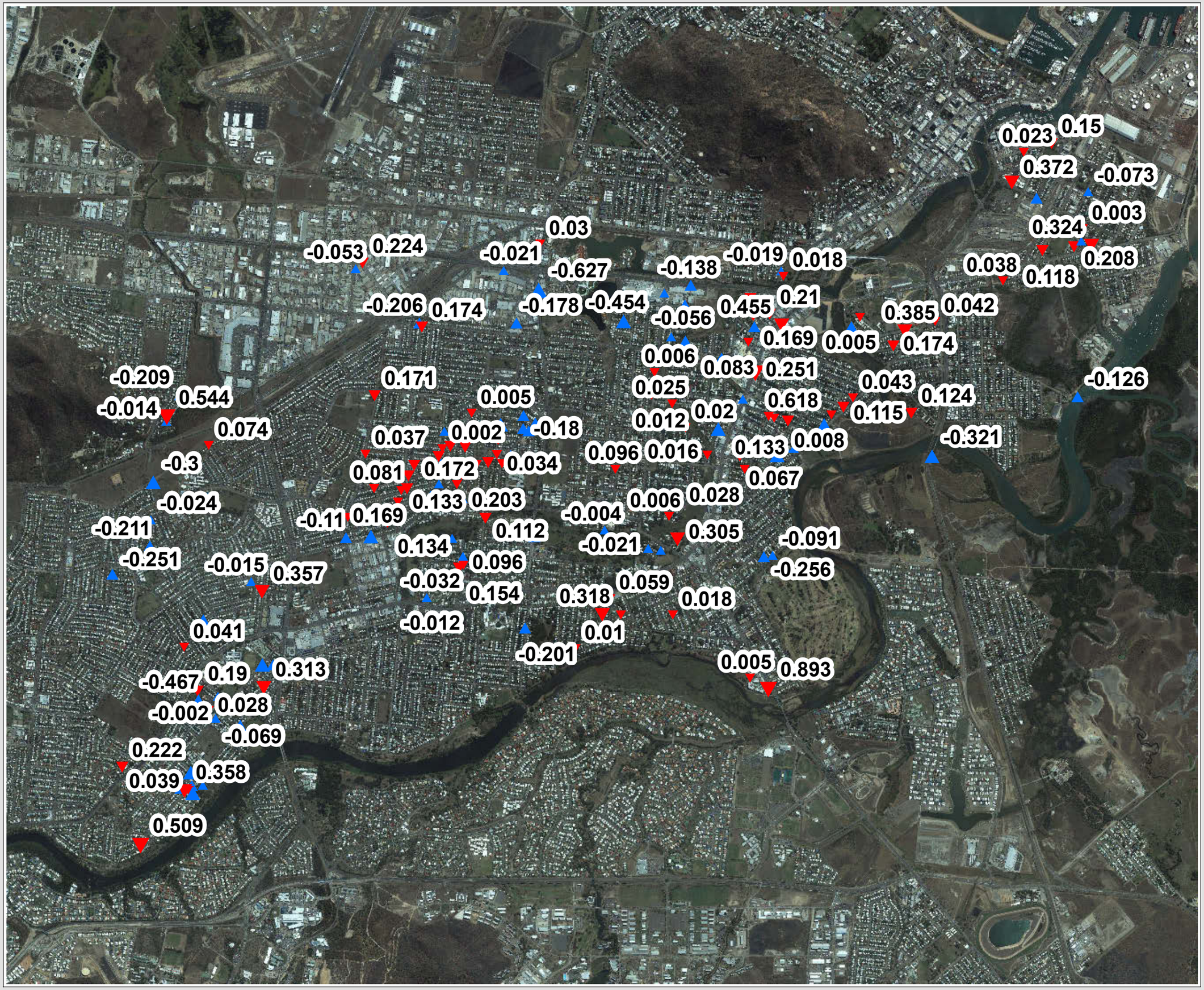
ROSS CREEK FLOOD STUDY JAN 1998 CALIBRATION

Figure 4-6



LEGEND

Results Comparison

- < -1
- -1- -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.3
- 0.3- 0.5
- 0.5 - 1
- > 1

N

City of Townsville

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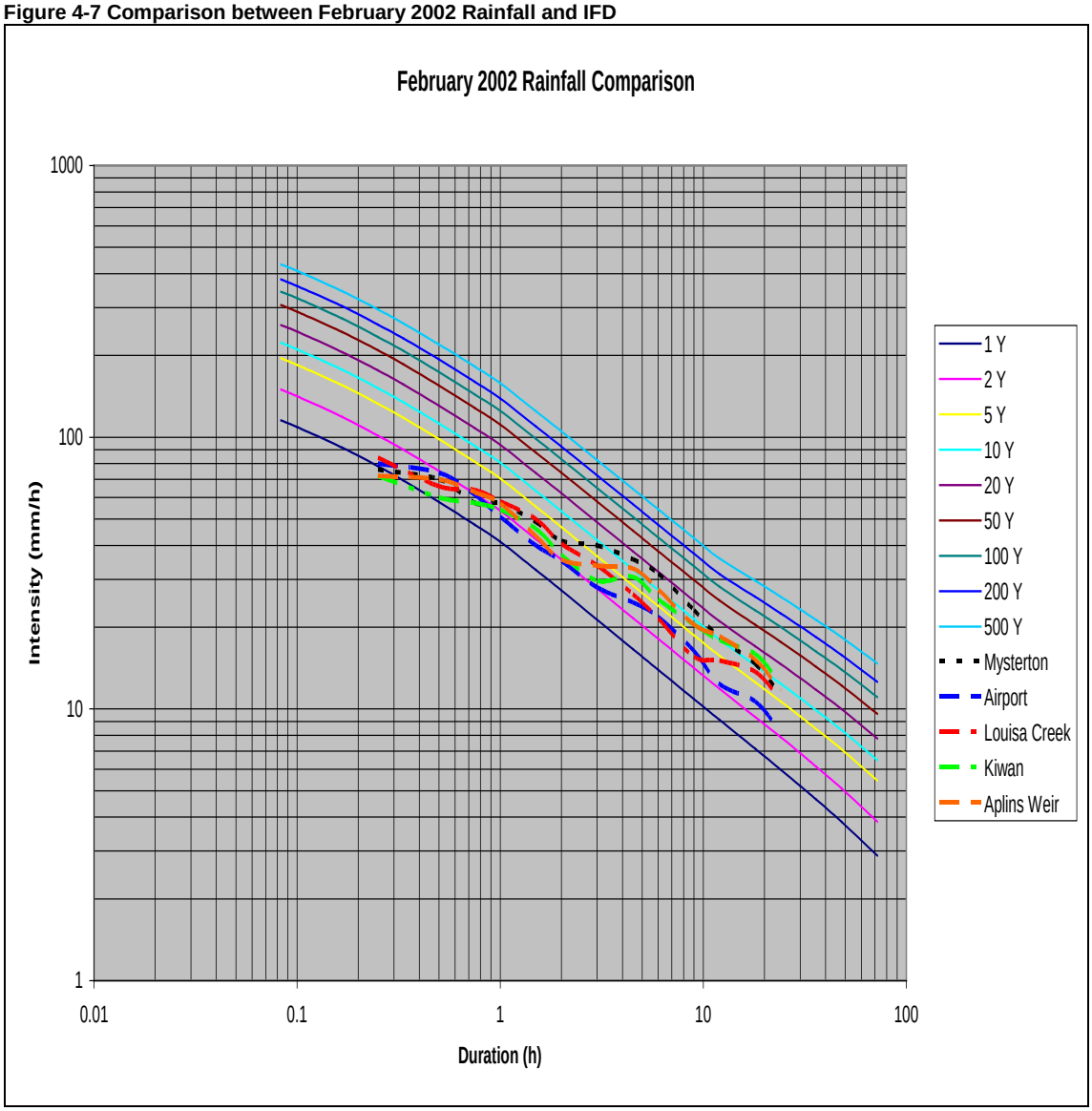
February 2002

The February 2002 event was a moderate rainfall event that occurred over the 13th, 14th and 15th of February 2002. Between 300mm and 450mm of rainfall fell at various rainfall alert stations throughout the Townsville area. The rainfall alert gauges relevant to the Ross Creek catchment that recorded data during the event were Mysterton, Townsville Airport, Louisa Creek, Kirwan and Aplins Weir. A comparison between the recorded rainfall at the various gauges and the IFD relationship for Ross Creek (refer to **Figure 4-7**), shows that the event was up to a 20 Year ARI rainfall event, particularly for the 6 hour duration event.

Figure 4-7 Comparison between February 2002 Rainfall and IFD

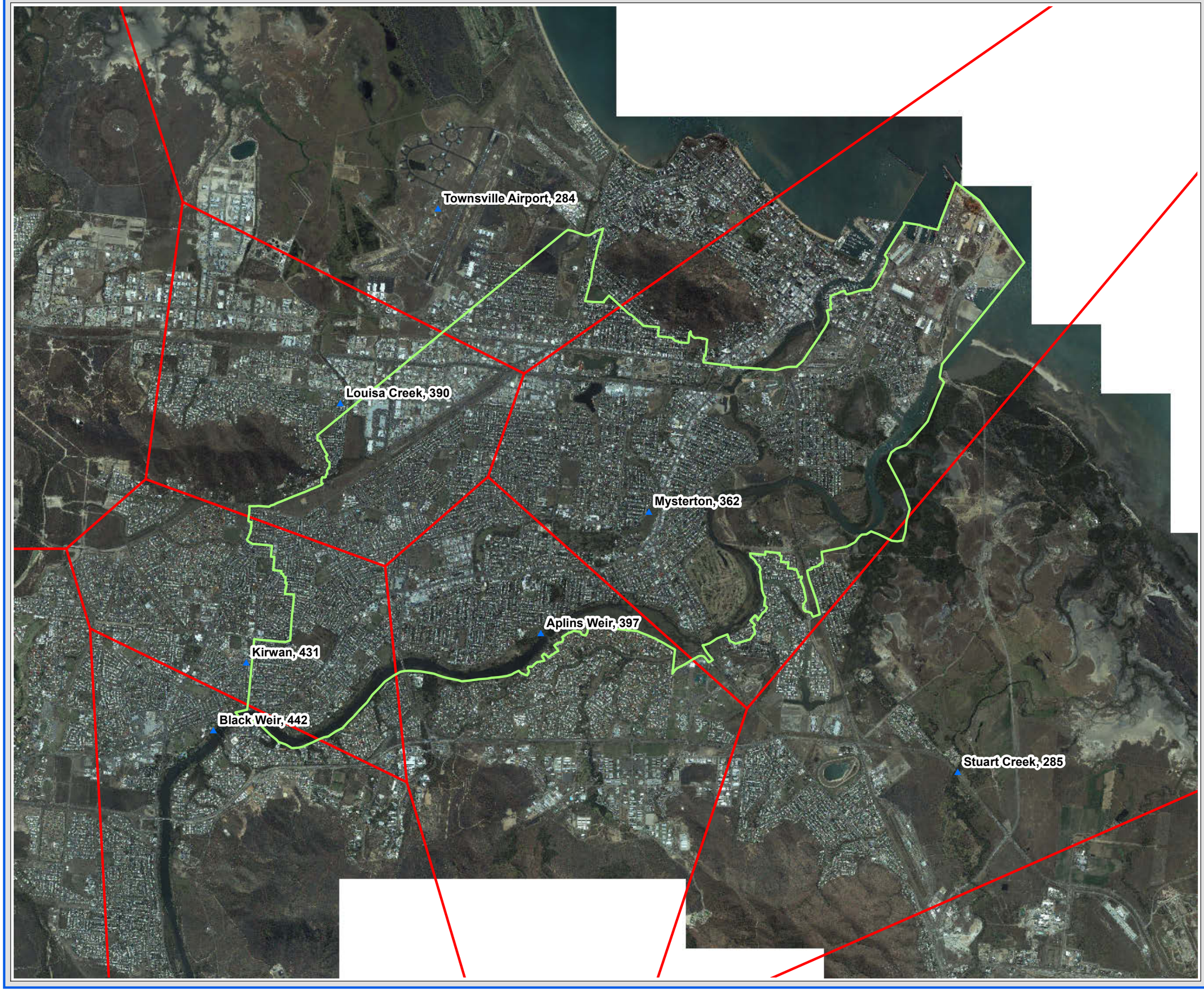


The only recorded water levels applicable to the model for this event were the water levels recorded by the flood level alert gauge at Mysterton on the Mindham Park Drain. Water levels from the model at this location were compared to the recorded water levels from the Mysterton Gauge to provide confidence in the ability of the model to reproduce flood timing.

As identified above there were several pluviometers that recorded rainfall data for the February 2002 event. **Figure 4-8** shows the total rainfall depths for the event and the Thiessens polygons used in assigning rainfall to the model.

ROSS CREEK FLOOD STUDY FEB 2002 RAINFALL

Figure 4-8



LEGEND

- Rain on Grid Extent
- Rainfall Gauges
- Thiessen Polygons

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Rainfall excess was applied to the MIKE FLOOD model by applying rainfall losses to the rainfall hyetographs. The losses adopted are shown in **Table 4-2**. The rainfall losses applied for the February 2002 event are greater than those applied for January 1998 event. Antecedent conditions prior to the February 2002 event were quite dry. In the calibration of the February 2002 within the *Townsville Flood Hazard Assessment Study* (Maunsell, 2005), the event was described as a "drought-breaking" event, with higher loss values adopted than in other calibration events.

Table 4-2 February 2002 Rainfall Losses

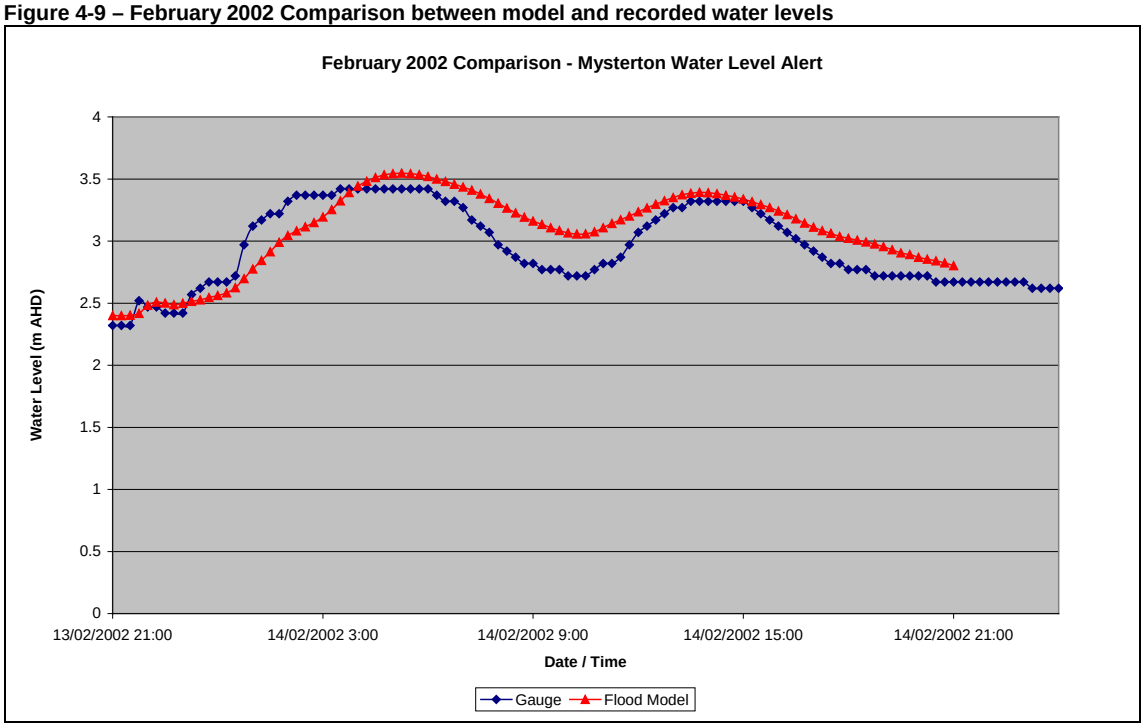
Loss Type	Pervious	Impervious
Initial	60mm	1mm
Continuing	3mm/h	0mm/h

Again, the topography of the model was adjusted to reflect the state of the floodplain during the February 2002 event. In particular drainage and bridge upgrades, since the February 2002 event were removed from the base-line model:

- Woolcock Canal widening in the lower reaches;
- additional culvert between Lakes I and Lakes II under Woolcock Street;
- new culverts under Bayswater Road on the Mindham Park Drain;
- new culverts under Gulliver Street on the Anderson Park Drain;
- Barryman Street stormwater pump station;
- Albany Road stormwater pump station;
- Campbell Street stormwater pump station; and
- the V8 supercar bridge and track facilities.

Figure 4-9 shows the results of the February 2002 calibration event as a time series comparison of the Mysterton gauge flood levels and the model results. The comparison of results shows good agreement in peak water levels and timing, within the limitations of the available rainfall data.

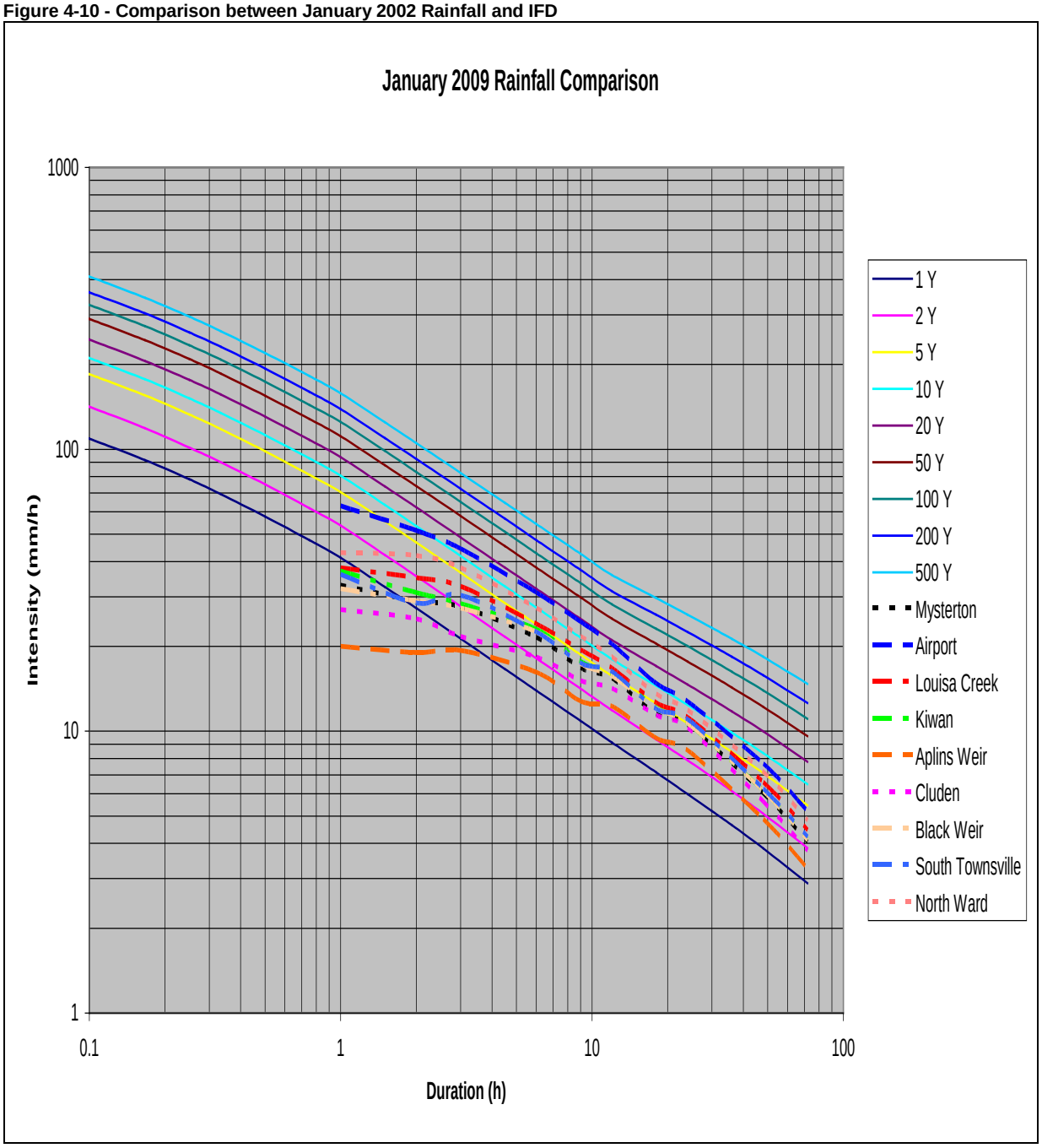
Figure 4-9 – February 2002 Comparison between model and recorded water levels



January 2009

The January 2009 event was a moderate event that involved flows in Ross River with rainfall on the local Ross Creek catchment. Flows over the Ross River Dam spillway started on the 29th of January 2009 and continued until the 16th of February 2009. Over this time there was also a significant rainfall event on the Ross Creek catchment between the 2nd of February and the 6th of February. The rainfall alert gauges relevant to the Ross Creek catchment that recorded data during the event were Mysterton, Townsville Airport, Louisa Creek, Kirwan, Aplins Weir, Cluden, Black Weir, South Townsville and North Ward. A comparison between the recorded rainfall at the various gauges and the IFD relationship for Ross Creek (refer to **Figure 4-10**), shows that the event was between a 2 and 20 Year ARI rainfall event with most gauges showing the event to be slightly higher than a 5 Year ARI particularly for the 12 hour duration event.

Figure 4-10 - Comparison between January 2002 Rainfall and IFD



As identified above there were several pluviometers that recorded rainfall data for the January 2009 event. **Figure 4-11** shows the total rainfall depths for the event and the Thiessens polygons used in assigning rainfall to the model.

Rainfall excess was applied to the MIKE FLOOD model by applying rainfall losses to the rainfall hyetographs. The losses adopted are shown in **Table 4-3**. The initial loss applied for the January 2009 event is less than those applied for January 1998 or February 2002 events. Given that the MIKE FLOOD simulation for January 2009 represents a sub-set of the longer wet period between late January and mid February, it is reasonable to have a small initial loss value. The continuing loss value adopted is the same as the January 1998 value.

Table 4-3 January 2009 Rainfall Losses

Loss Type	Pervious	Impervious
Initial	1mm	1mm
Continuing	2.5mm/h	0mm/h

Recorded water levels for the January 2009 event were available at the Mysterton alert gauge and Aplins Weir. Both local runoff and flows from Ross River dam were applied to the MIKE FLOOD model to confirm the models ability to replicate flood levels from local runoff and flood levels within Ross River.

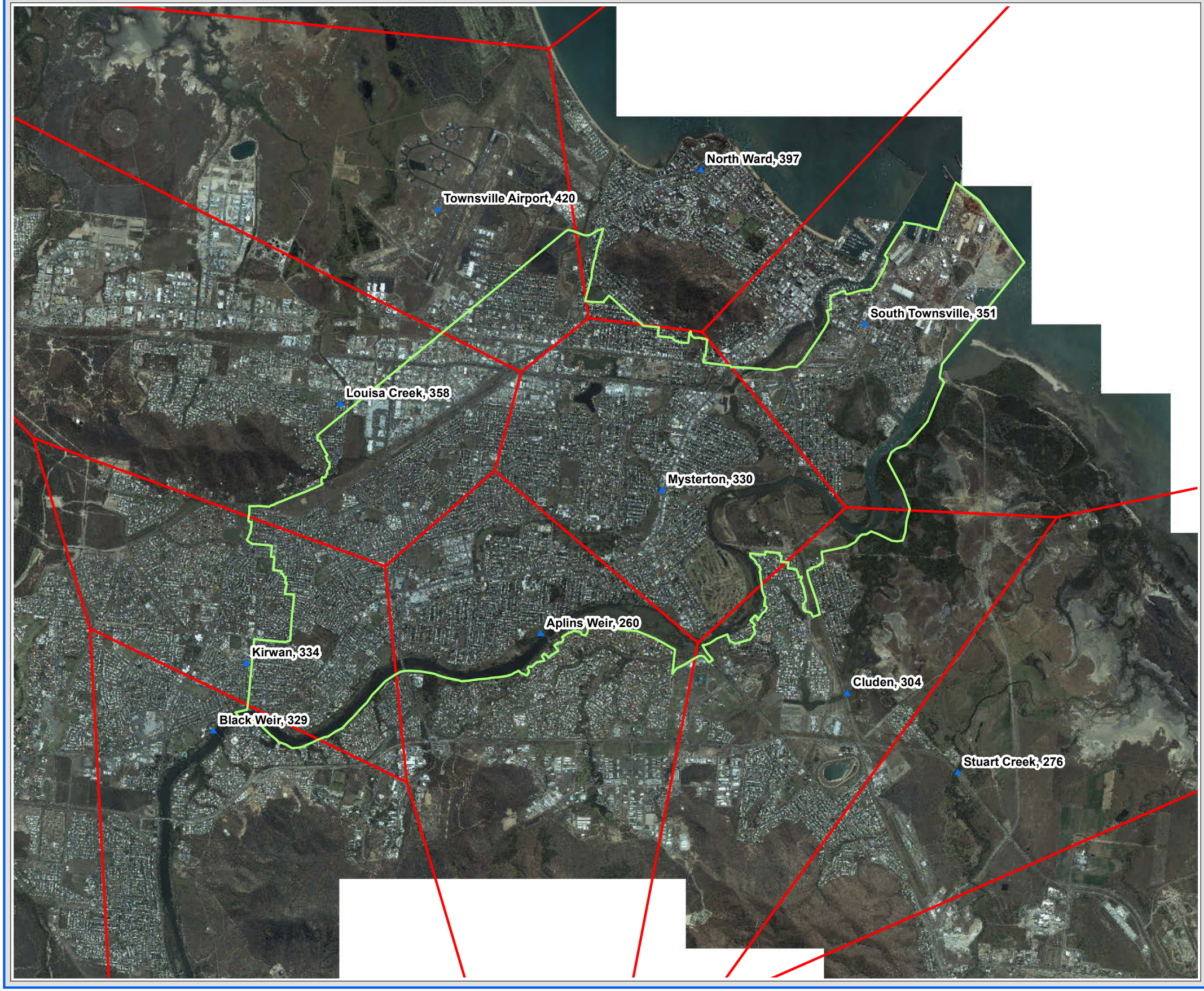
The topography of the floodplain during January 2009 event is essentially similar to that of 2012 conditions. The following drainage and bridge upgrades were included into the model relative to the previous calibration events:

- Woolcock Canal widening in the lower reaches;
- Removal of the Church Street bridge over Woolcock Canal;
- additional culvert between Lakes I and Lakes II under Woolcock Street;
- new culverts under Bayswater Road on the Mindham Park Drain;
- new culverts under Gulliver Street on the Anderson Park Drain;
- Barryman Street stormwater pump station;
- Albany Road stormwater pump station;
- Campbell Street stormwater pump station; and
- the V8 supercar bridge and track facilities.

Figure 4-12 shows the results of the January 2009 calibration event as a time series comparison of the Mysterton gauge flood levels and the model results. **Figure 4-13** shows the results of the January 2009 calibration event as a time series comparison of the Aplins Weir gauge flood levels and the model results. The comparison of results at both locations shows good agreement in peak water levels and timing.

ROSS CREEK FLOOD STUDY JAN 2009 RAINFALL

Figure 4-11



LEGEND

- Rain on Grid Extent
- Rainfall Gauges
- Thiessens Polygons

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Figure 4-12 January 2009 Comparison between model and recorded water levels - Mysterton

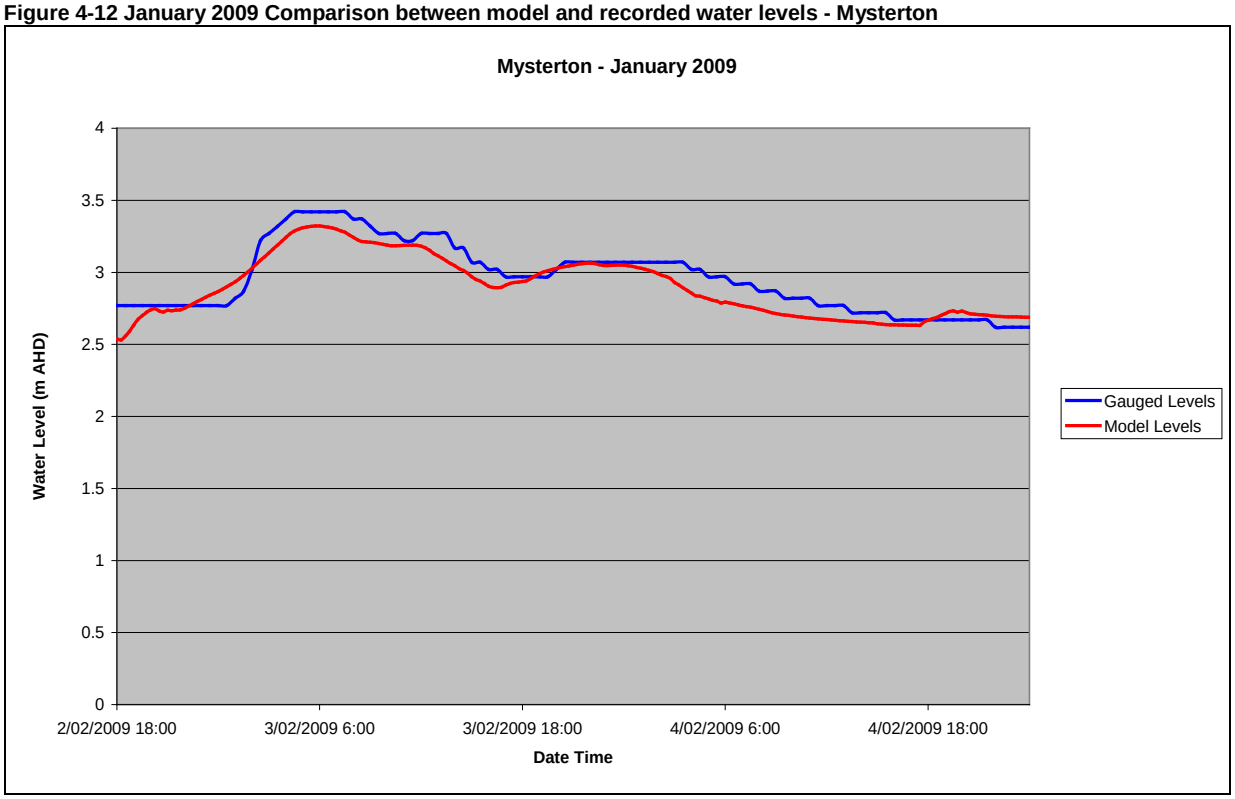
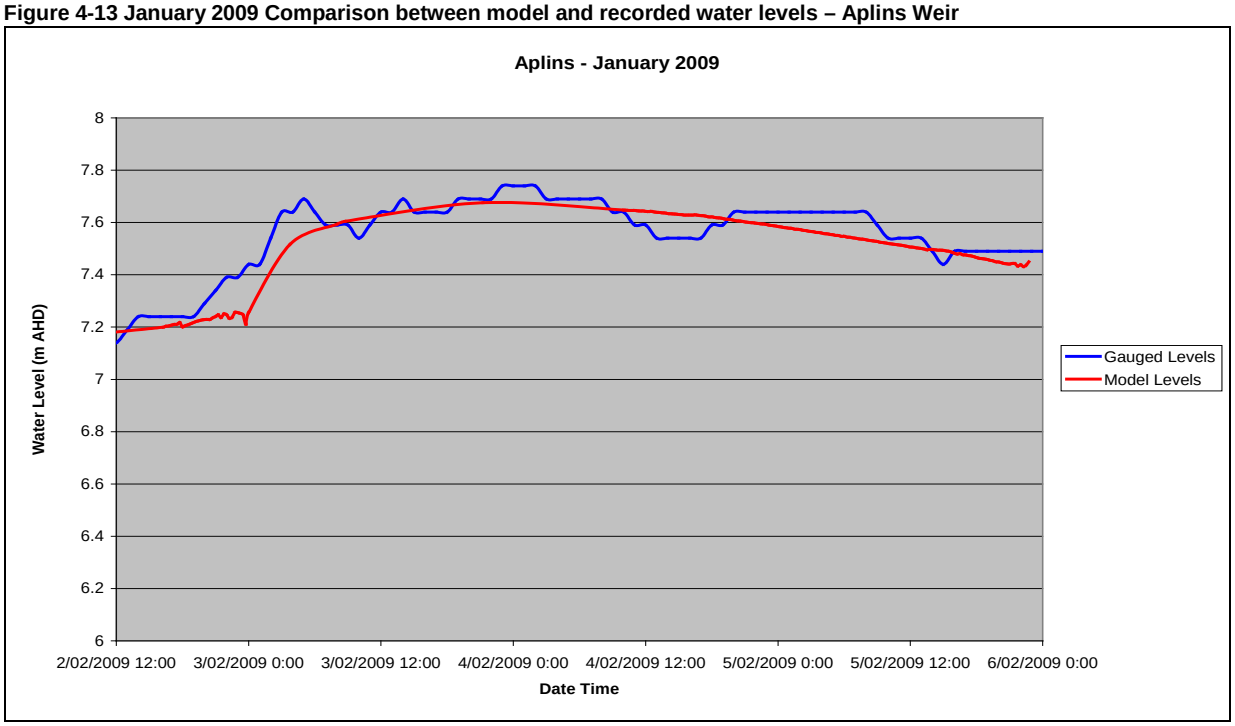


Figure 4-13 January 2009 Comparison between model and recorded water levels – Aplins Weir



4.5 Design Flood Assessment

Following calibration of the hydraulic model, the model was updated to represent design flood events, by ensuring the topography and underground network represent 2011 conditions.

Initially the 50 Year ARI and 100 Year ARI were run for a range of event durations to establish the critical durations across the floodplain. The results demonstrated that there is no clear critical duration across the floodplain, however it was identified that the 48 hour storm was not critical anywhere. For the remainder of the storm frequencies up to the 500 Year ARI, a range of storm durations between 1 hour and 72 hours (excluding the 48 hour storm) have been evaluated for the design events. Only the 2 hour, 24 hour and 72 hour duration events were evaluated for the Probable Maximum Flood.

Flood map results are provided in **Appendix D**, for water depths, flood levels and flow velocities as well as critical duration. For all storm frequencies the flood map results are based on the critical flood envelope from all storm durations. Given the “Rain on Grid” approach has all cells within the model wet; areas with depths of less than 0.1m have not been shown as inundated.

Detailed discussion of the flood model results are provided in subsequent chapters.

4.6 Comparison with Townsville Flood Hazard Assessment Study

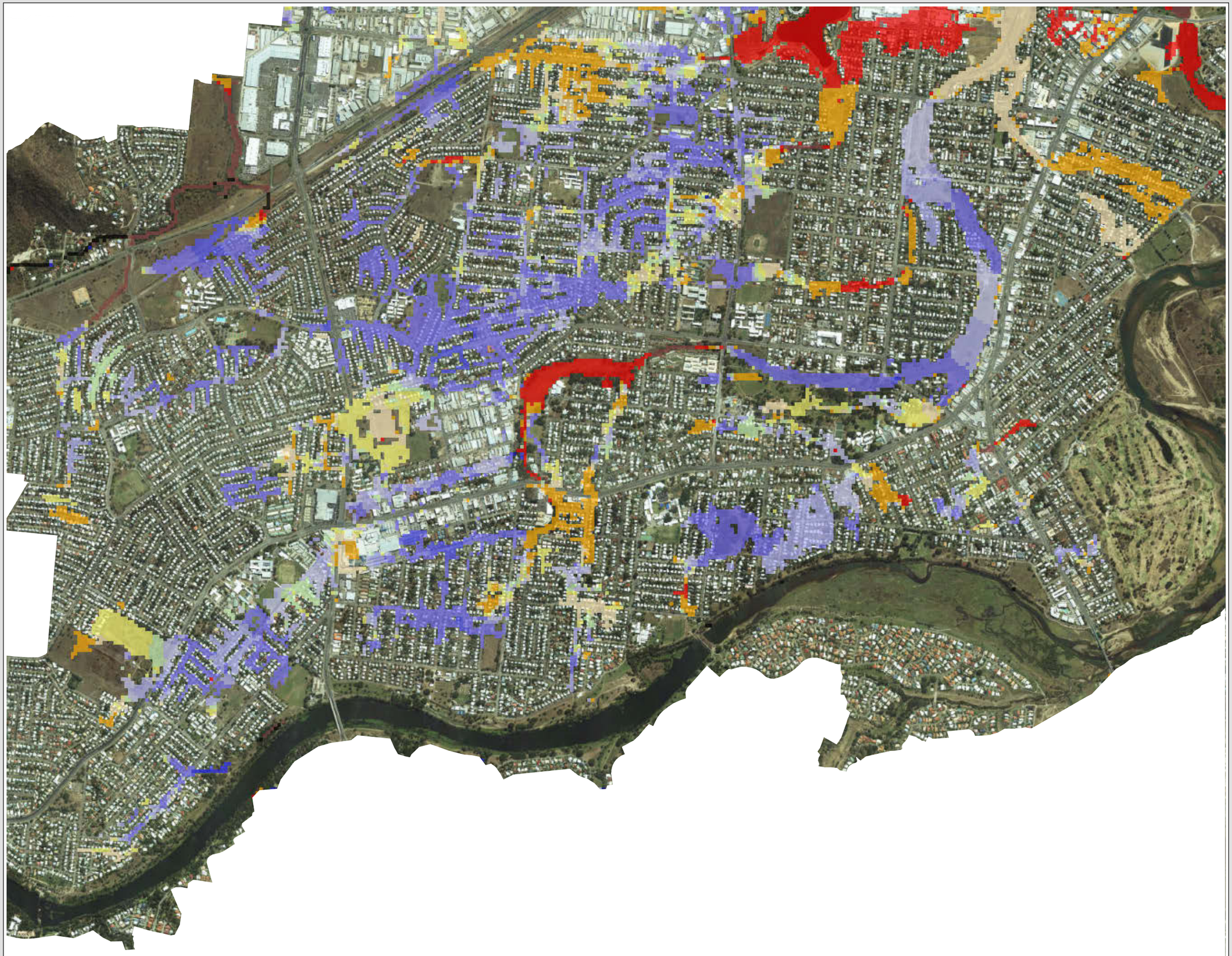
Prior to this study, the Townsville Flood Hazard Assessment Study (Maunsell, 2005) was the most recent flood study within the study area. There are numerous changes and improvements to the methodology in the present study; however a comparison with the previous results has been undertaken to give an indication of the changes in flood levels. **Figure 4-14** shows the difference in flood levels for 50 Year ARI flood compared to those previously determined from the Townsville Flood Hazard Assessment Study (TFHAS). The 50 Year ARI has been chosen as it is the present Defined Flood Event for Townsville.

Review of the results shows:

- Flood levels are generally higher in the major flow paths of Ross Creek, Woolcock Canal, Hermit Park Drain and Aitkenvale Drain as a result of larger flows/flood volumes because the critical duration event has been determined from assessing a range of storm durations rather than just the 6 hour duration storm;
- Flood levels are generally lower in the flood plain areas because the rain on grid approach spreads catchment flows across the catchment rather than concentrating catchment flows at a single source point location;
- Flood levels are higher near major storage areas such as The Lakes and the Illich Park Detention basin as a result of larger flood volumes because the critical duration event has been determined from assessing a range of storm durations rather than just the 6 hour duration storm;
- Flood levels are lower in Mindham Park upstream of Bayswater Road. The critical duration event in this location is the 6 hour event, which is the same critical duration as the TFHAS. The more refined definition of the 10m grid allows for a better representation of the conveyance of the flow path in this area.

ROSS CREEK FLOOD STUDY COMPARISON - TFHAS 50 Y ARI

Figure 4-14a



LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

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DATE PRINTED: 5/03/2013

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig4-14_compTFHAS

ROSS CREEK FLOOD STUDY COMPARISON - TFHAS 50 Y ARI

Figure 4-14b

LEGEND

Water Level Difference (m)

- Previously Inundated
- < -1
- -1 - -0.5
- -0.5 - -0.3
- -0.3 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 1
- > 1
- Now Inundated

N

City of Townsville

SCALE: 1:20,000 @A3

200 100 0 200 400 600 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 09/08/2012

DATE PRINTED: 5/03/2013

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DIGITAL FILE: RossCreek_Fig4-14_compTFHAS

5.0 Baseline Flooding Summary

5.1 Description of Flooding Results

Base-line flood maps for the design floods are provided in **Appendix D**. These maps are provided for water depths, flood levels and flow velocities of the:

- 2 Year ARI;
- 5 Year ARI;
- 10 Year ARI;
- 20 Year ARI;
- 50 Year ARI;
- 100 Year ARI;
- 200 Year ARI;
- 500 Year ARI; and
- Probable Maximum Flood.

Descriptions of the flooding for the various design events are provided in the following sections for discrete areas of the floodplain. Where numbers of inundated residential properties are provided, they are on the basis of 0.20 m water depth within the lot, which does not mean floor levels are exceeded (though in some cases they may be when floor levels are less 0.20 m above the ground). To undertake a comparison to floor levels would require survey of all floor levels within the study area.

Cranbrook
Figure 5-1 outlines the key drainage features within Cranbrook. There are 3 major flow paths out of Cranbrook:

- The Cranbrook drain, adjacent to Ansell and Kirrang Courts, which discharges to Ross River;
- Surface flows along Killara and Albert Streets that flow over Nathan Street, through the Stockland Shopping Centre, then along Alfred Street before discharging into the Aitkenvale Drain; and
- Surface flows that flow through the Brampton Avenue area then along Charles Street and into the Illich Park System.

Additionally for events 50 Year ARI or greater there is an overflow from northern Cranbrook that crosses Charles Street and flows northwards along Fulham Road.

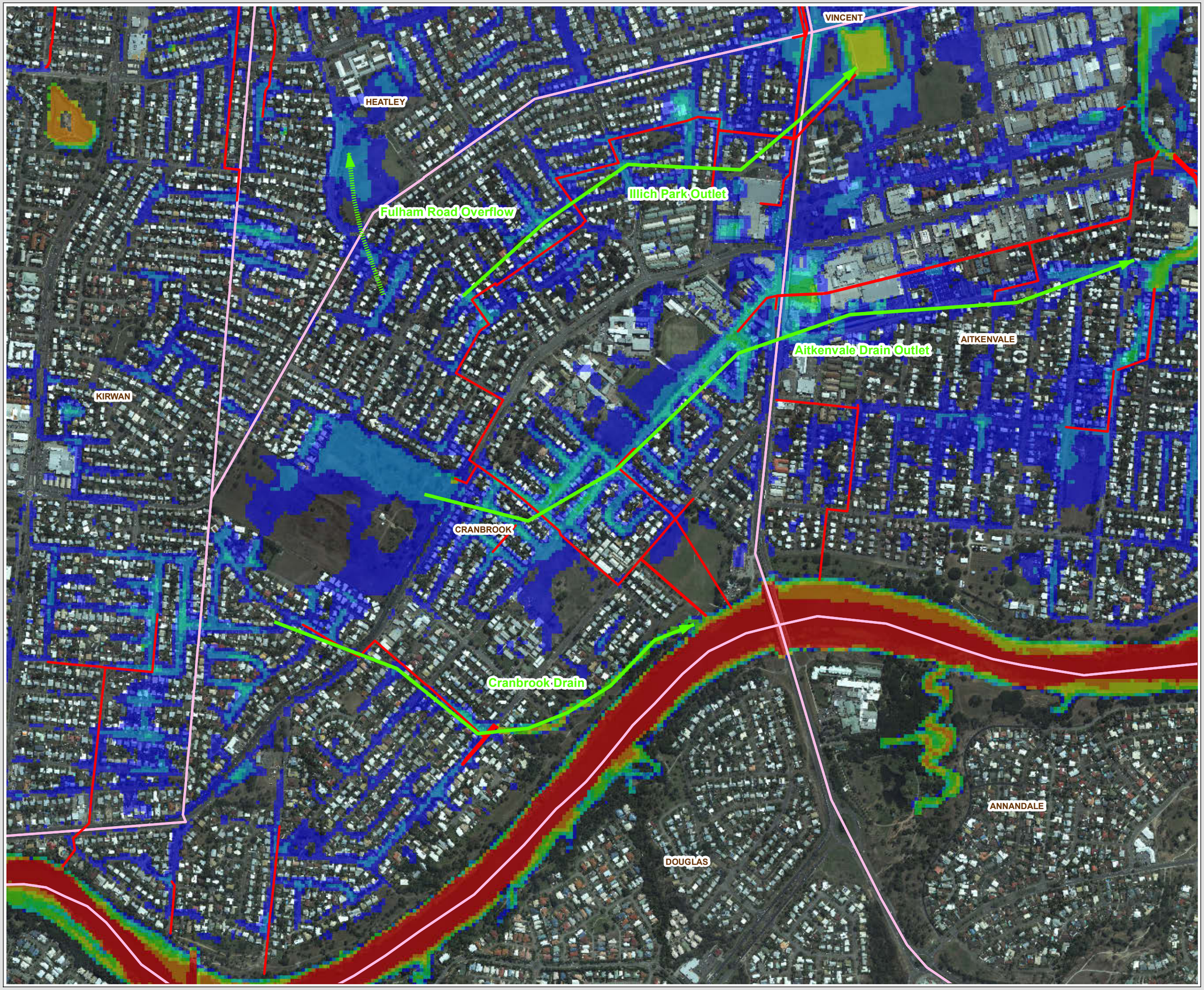
The Illich Park detention basin is connected to a large pipe system that runs north along Nathan Street and discharges to Louisa Creek. The pipe system consists of 2/1200 RCPs and a 1500 x 1500 RCBC that becomes 2/1500 RCPs and a 2700 x1800 RCBC north of Fulham Road. The 2/1500 RCPs become 2/1650 RCPs north of Riechelmann Street and the 2700 x 1800 RCBC becomes a 3600 x 1800 RCBC north of Dalrymple Service Road.

The area of south-eastern Kirwan (east of Bamford Lane) and south-western Cranbrook (south of Ross River Road) are drained by underground pipes to Ross River against the grade of the surface. Flows in excess of the underground drainage capacity within south-eastern Kirwan flow towards the Aitkenvale Drain Outlet. Flows in excess of the underground drainage capacity within south western Cranbrook flow towards the Cranbrook Drain.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-1

Cranbrook



LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 14/08/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-1_Cmbk.mxd

A summary of the key flooding issues within the Cranbrook area relative to the ARI of floods is provided in **Table 5-1** following inspection of the flood mapping as presented in **Appendix D**.

Table5-1 Cranbrook Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 1.5 to 2 hours for the Cranbrook Drain system; • 24 hours for the Aitkenvale Drain Outlet system; and • 24 hours for the Illich Park Outlet system. Flooding is largely contained to the road reserves except for approximately 10 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road. There is some inundation of major roads including: • 0.1m of water over Ross River Road near the Indigenous Reserve; • up to 0.3m of water on the north bound lane of Nathan Street upstream of the Stockland Shopping Centre; and • 0.15m of water over Charles Street near the intersection with Nathan Street. Flow velocities are generally under 0.5m/s, however there are higher velocities in Albert Street (~0.5m/s) and Bergin Road upstream of the Cranbrook Drain (~0.8m/s)
5 Year ARI	Generally the critical duration event is: • 1.5 to 2 hours for the Cranbrook Drain system; • 24 hours for the Aitkenvale Drain Outlet system; and • 24 hours for the downstream sections of Illich Park Outlet system and 1.5 to 2 hours for the upstream sections (West of Lindeman Avenue). Flooding is generally contained to the road reserves, however there are more lots inundated than in the 2 Year ARI with approximately 75 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road. Surface flows overtop Nathan Street near Charles Street and flow towards the Illich Park Detention Basin. Inundation of major roads includes: • 0.15m of water over Ross River Road near the Indigenous Reserve; • up to 0.4m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.3m of water over the intersection Charles Street and Nathan Street; • 0.15m of water on the west bound lanes Ross River Road near power substation. Flow velocities are generally under 0.5m/s, however there are higher velocities in Albert Street (~0.6m/s) and Bergin Road upstream of the Cranbrook Drain (~1.0m/s)
10 Year ARI	Generally the critical duration event is: • 1.5 to 2 hours for the Cranbrook Drain system; • 24 hours for the Aitkenvale Drain Outlet system; and • 24 hours for the downstream sections of Illich Park Outlet system and 1.5 to 2 hours for the upstream sections (West of Lindeman Avenue). Flooding becoming more widespread with approximately 120 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road as well as inundation around the car park of the offices on the south-eastern corner of Nathan Street and Ross River Road. Surface flows overtop Charles Street near Nathan Street and flow north wards along Nathan Street.

Event	Description
	Inundation of major roads includes: • 0.2m of water over Ross River Road near the Indigenous Reserve; • up to 0.45m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.5m of water over the intersection Charles Street and Nathan Street; • 0.2m of water on the west bound lanes Ross River Road near power substation. Flow velocities are generally under 0.5m/s, however there are higher velocities in Albert Street (~0.7m/s) and Bergin Road upstream of the Cranbrook Drain (~1.1m/s)
20 Year ARI	Generally the critical duration event is: • 1 to 1.5 hours for the Cranbrook Drain system; • 24 hours for the Aitkenvale Drain Outlet system; and • 24 hours for the downstream sections of Illich Park Outlet system and 1.5 to 3 hours for the upstream sections (West of Lindeman Avenue). Flooding becoming widespread, particularly within the Aitkenvale Drain Outlet system, with a total of approximately 175 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road as well as inundation of the offices on the south-eastern corner of Nathan Street and Ross River Road. There is also inundation of portions of the Ignatius Park Secondary College grounds. Surface flows overtop Nathan Street near intersection with Ross River Road and flow north-east over vacant land. Inundation of major roads includes: • 0.2m of water over Ross River Road near the Indigenous Reserve; • up to 0.50m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.55m of water over the intersection Charles Street and Nathan Street; • 0.3m of water on the west bound lanes Ross River Road near power substation. Flow velocities are generally under 0.5m/s, however there are higher velocities in Albert Street (~0.8m/s) and Bergin Road upstream of the Cranbrook Drain (~1.1m/s)
50 Year ARI	Generally the critical duration event is: • 1 to 1.5 hours for the Cranbrook Drain system; • 3 hours for the Aitkenvale Drain Outlet system; and • 1.5 to 3 hours for the Illich Park Outlet system. Flooding is widespread, particularly within the Aitkenvale Drain Outlet system, with a total of approximately 235 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road as well as inundation of the offices on the south-eastern corner of Nathan Street and Ross River Road. There is also inundation of portions of the Ignatius Park Secondary College grounds. Flows start to overtop Charles Street and run north along Fulham Road Inundation of major roads includes: • 0.25m of water over Ross River Road near the Indigenous Reserve; • up to 0.60m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.55m of water over the intersection Charles Street and Nathan Street; • 0.35m of water on the west bound lanes Ross River Road near power substation; • 0.1m of water over Charles Street near the intersection with Fulham Road Flow velocities are generally under 0.5m/s, however there are higher velocities in Albert Street (~0.9m/s) and Bergin Road upstream of the Cranbrook Drain (~1.3m/s).

Event	Description
100 Year ARI	Generally the critical duration event is: • 1 to 1.5 hours for the Cranbrook Drain system; • 3 hours for the Aitkenvale Drain Outlet system, however 24 hours downstream of Mathiesen Street and 2 hours upstream of the Indigenous Reserve; and • 1.5 to 3 hours for the Illich Park Outlet system. Flooding is widespread, particularly within the Aitkenvale Drain Outlet system, with a total of approximately 290 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road as well as inundation of the offices on the south-eastern corner of Nathan Street and Ross River Road. There is also inundation of portions of the Ignatius Park Secondary College grounds. Inundation of major roads includes: • 0.3m of water over Ross River Road near the Indigenous Reserve; • up to 0.65m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.55m of water over the intersection Charles Street and Nathan Street; • 0.35m of water on the west bound lanes Ross River Road near power substation; • 0.15m of water over Charles Street near the intersection with Fulham Road Flow velocities are generally under 0.5m/s; however there are higher velocities in Albert Street (~0.95m/s), Bergin Road upstream of the Cranbrook Drain (~1.4m/s), across the Nathan Street/Ross River Road Intersection (0.8m/s) and within Bauhinia and Carcoola Streets (~0.6m/s).
200 Year ARI	Generally the critical duration event is: • 1 to 1.5 hours for the Cranbrook Drain system; • 24 hours for the Aitkenvale Drain Outlet system, however 2 hours upstream of the Indigenous Reserve; and • 1.5 to 3 hours for the Illich Park Outlet system. Flooding is widespread, particularly within the Aitkenvale Drain Outlet system, with a total of approximately 330 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread inundation on the Indigenous Reserve on Ross River Road as well as inundation of the offices on the south-eastern corner of Nathan Street and Ross River Road. There is also inundation of portions of the Ignatius Park Secondary College, Holy Spirit Primary School and Cranbrook State School grounds. Inundation of major roads includes: • 0.3m of water over Ross River Road near the Indigenous Reserve; • up to 0.70m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.60m of water over the intersection Charles Street and Nathan Street; • 0.35m of water on the west bound lanes Ross River Road near power substation; • 0.20m of water over Charles Street near the intersection with Fulham Road Flow velocities are generally under 0.5m/s; however there are higher velocities in Albert Street (~1.0m/s), Bergin Road upstream of the Cranbrook Drain (~1.4m/s), across the Nathan Street/Ross River Road Intersection (0.9m/s) and within Bauhinia and Carcoola Streets (~0.6m/s).
500 Year ARI	Generally the critical duration event is: • 1 to 1.5 hours for the Cranbrook Drain system, however the lower reaches of the Cranbrook Drain are 72 hours (Ross River backwater); • 24 hours for the Aitkenvale Drain Outlet system, however 2 hours upstream of the Indigenous Reserve; and • 1 to 2 hours for the Illich Park Outlet system. Flooding is widespread, with a total of approximately 415 residential lots inundated and areas of Kmart Plaza and the Rossvale shops inundated. There is also wide spread

Event	Description
	inundation on the Indigenous Reserve on Ross River Road as well as inundation of the offices on the south-eastern corner of Nathan Street and Ross River Road. There is inundation of portions of the Ignatius Park Secondary College, Holy Spirit Primary School and Cranbrook State School grounds. The doctors' surgery on the corner of Charles Street and Illoura Street is inundated. Inundation of major roads includes: • 0.35m of water over Ross River Road near the Indigenous Reserve; • up to 0.75m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 0.65m of water over the intersection Charles Street and Nathan Street; • 0.40m of water on the west bound lanes Ross River Road near power substation; • 0.25m of water over Charles Street near the intersection with Fulham Road Flow velocities are generally under 0.5m/s; however there are higher velocities in Albert Street (~1.1m/s), Bergin Road upstream of the Cranbrook Drain (~1.5m/s), across the Nathan Street/Ross River Road Intersection (1.0m/s) and within Bauhinia and Carcoola Streets (~0.7m/s).
PMF	Generally the critical duration event is: • 2 hours for the Cranbrook Drain system, however the lower reaches of the Cranbrook Drain are 72 hours (Ross River backwater); • 24 hours for the Aitkenvale Drain Outlet system; and • 24 hours for the Illich Park Outlet system, however 2 hours upstream of Choonda Street. There is significant widespread flooding with depths up to 1.4m. A total of approximately 1080 residential properties are inundated. Numerous commercial premises, educational institutions and public utilities are also impacted. Inundation of major roads includes: • 0.75m of water over Ross River Road near the Indigenous Reserve; • up to 1.1m of water on the north bound lanes of Nathan Street upstream of the Stockland Shopping Centre; • 1.0m of water over the intersection Charles Street and Nathan Street; • 0.75m of water on the west bound lanes Ross River Road near power substation; • 0.35m of water over Charles Street near the intersection with Fulham Road Flow velocities are generally under 0.8m/s; however there are higher velocities in Albert Street (~1.1m/s), Bergin Road upstream of the Cranbrook Drain (~1.8m/s), across the Nathan Street/Ross River Road Intersection (1.5m/s) and within Bauhinia and Carcoola Streets (~0.9m/s).

Aitkenvale/Mundingburra

Figure 5-2 outlines the key drainage features of the Aitkenvale/ Mundingburra area. There are a series of major open drains and major flow paths for the area:

- Aitkenvale Drain which runs within the Parkland between Ross River Road and Armit Street and flows into Anderson Park Drain;
- Anderson Park Drain runs within Parkland between Armit Street and Balls Lane;
- a series of major surface flow paths through Aitkenvale that discharge to Aitkenvale Drain (identified as Aitkenvale North, Central, South and East in **Figure 5-2**);
- an overflow from the Aitkenvale Drain System upstream of Ross River Road adjacent to the Vale Hotel that crosses Ross River Road and flows through residential properties and streets to short circuit a majority of the Aitkenvale Drain;

- Mundingburra Drain which runs through Anderson Park to Balls Lane and ultimately discharges to Mindham Park Drain;
- the Harding Avenue Flowpath which drains areas of northwest Mundingburra to the Mundingburra Drain; and
- the Mundingburra South Flowpath, which drains southern areas of Mundingburra around Wood and Water Street towards the Mundingburra Drain.

In addition to the flow paths identified above there are areas of Mundingburra that are effectively hollows that have not been removed from the landscape when the area was developed. There are a series of pipe networks that drain these hollows back to Ross River; however it is only the system draining Arthur Fadden Park that is above 900mm diameter equivalent waterway area.

A summary of the key flooding issues within the Aitkenvale/Mundingburra area relative to the ARI of floods is provided in **Table 5-2** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-2

Aitkenvale/Mundingburra

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 15/08/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-2_Ak-Mn.mxd

Table 5-2 Aitkenvale/Mundingburra Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 6 hours in Aitkenvale Drain; • 24 hours in Anderson Park Drain; • 2 hours in the Aitkenvale North area; • 24 hours in the Aitkenvale South area, however 2 – 3 hours upstream of Henrietta Street; • 12 hours in the Aitkenvale East Area; • 18 hours in the Mundingburra Drain; • 18 hours in the Mundingburra South Flowpath area; • 18 – 72 hours in the Harding Avenue Flowpath area; and • 72 hours in eastern Mundingburra Hollows and 6 hour in the western Mundingburra Hollows draining through Arthur Fadden Park. Flooding is largely contained to road reserves, however there are portions where flooding is more widespread across residential areas around the Mundingburra Hollows. There are approximately 45 residential properties inundated in Aitkenvale and 150 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of the Cathedral School, Mundingburra State School and St Joseph's Primary School. In Aitkenvale portions of the Stockland shopping centre site are inundated as are portions of the Vale Hotel site. Inundation is close to impacting on some warehouses in the Aitkenvale North area and professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are close to being impacted by inundation. Inundation of major roads includes: • 0.15m of water on Ross River Road adjacent to Russel Street; • Up to 0.3m of water on the westbound lanes of Ross River Road near Wood Street; • 0.2m of water on Love Lane at the intersection with Trott Street; and • 0.15m of water over Balls Lane at the downstream end of Anderson Park Drain. Within residential and commercial areas flow velocities are generally under 0.3m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are closer to 1m/s. The overtopping velocities for Balls Lane are 0.9m/s.
5 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain; • 24 hours in Anderson Park Drain; • 1.5 - 2 hours in the Aitkenvale North area; • 24 hours in the Aitkenvale South area, however 1.5 – 3 hours upstream of Henrietta Street; • 24 hours in the Aitkenvale East Area; • 18 hours in the Mundingburra Drain; • 12 hours in the Mundingburra South Flowpath area; • 12 hours in the Harding Avenue Flowpath area; and • 18 hours in eastern Mundingburra Hollows and 24 hours in the western Mundingburra Hollows draining through Arthur Fadden Park. Flooding is largely contained to road reserves, however there are portions where flooding is more widespread across residential areas around the Mundingburra Hollows and Harding Avenue flowpath. There are approximately 75 residential properties inundated in Aitkenvale and 185 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of the Cathedral School, Mundingburra State School Aitkenvale State School and St Joseph's Primary School. In Aitkenvale portions of the Stockland shopping centre site are inundated as are portions of the Vale Hotel site. Inundation is impacting on some warehouses and workshops in the

Event	Description
	Aitkenvale North area and professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are close to being impacted by inundation. Inundation of major roads includes: • 0.2m of water on Ross River Road adjacent to Russel Street; • Up to 0.35m of water on the westbound lanes of Ross River Road near Wood Street; • 0.25m of water over Love Lane at the intersection with Trott Street; and • 0.2m of water over Balls Lane at the downstream end of Anderson Park Drain. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are closer to 1m/s. The overtopping velocities for Balls Lane are 1.1m/s.
10 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain; • 24 hours in Anderson Park Drain; • 1.5 - 2 hours in the Aitkenvale North area, however 24 hours around Elizabeth Street; • 24 hours in the Aitkenvale South area, however 1.5 – 3 hours upstream of Henrietta Street; • 24 hours in the Aitkenvale East Area; • 12 hours in the Mundingburra Drain; • 12 -24 hours in the Mundingburra South Flowpath area; • 12 hours in the Harding Avenue Flowpath area; and • 18 hours in Mundingburra Hollows area. Flooding is becoming more widespread and there are portions of significant flooding across residential areas around the Mundingburra Hollows and Harding Avenue flowpath. There are approximately 105 residential properties inundated in Aitkenvale and 205 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of the Cathedral School, Mundingburra State School Aitkenvale State School and St Joseph's Primary School. In Aitkenvale portions of the Stockland shopping centre site are inundated as are portions the car park around McDonalds. Much of the Vale Hotel site is impacted. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area and professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation as is the supermarket on Ross River Road near Wood Street. Inundation of major roads includes: • 0.25m of water on Ross River Road adjacent to Russel Street; • Up to 0.35m of water on the westbound lanes of Ross River Road near Wood Street; • 0.3m of water over Love Lane at the intersection with Trott Street; • 0.25m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.1m over Ross River Road at Crete Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are just over 1m/s at locations. The overtopping velocities for Balls Lane are 1.3m/s. Areas of Arthur Fadden Park have velocities above 0.6m/s.
20 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain; • 24 hours in Anderson Park Drain; • 1.5 - 2 hours in the Aitkenvale North area, however 24 hours upstream of Anne Street;

Event	Description
	• 24 hours in the Aitkenvale South area, however 1.5 – 2 hours upstream of Henrietta Street; • 24 hours in the Aitkenvale East Area; • 12 hours in the Mundingburra Drain; • 72 hours in the Mundingburra South Flowpath area; • 12 - 24 hours in the Harding Avenue Flowpath area; and • 72 hours in eastern Mundingburra Hollows and 12 hour in the western Mundingburra Hollows draining through Arthur Fadden Park. Flooding is becoming more widespread particularly in the Mundingburra Hollows, Aitkenvale East, Aitkenvale South and Aitkenvale Overflow areas. There are approximately 165 residential properties inundated in Aitkenvale and 235 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of the Cathedral School, Mundingburra State School and St Joseph's Primary School, with some building areas inundated in Aitkenvale State School. In Aitkenvale portions of the Stockland shopping centre site are inundated as is the adjacent McDonalds. Much of the Vale Hotel site is impacted and the Power Substation upstream of the Vale Hotel, on Charlotte Street is potentially inundated. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area and professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation. The supermarket on Ross River Road near Wood Street is inundated as are professional offices east of Wood Street on Ross River Road and professional offices opposite the Cathedral School on Ross River Road. Inundation of major roads includes: • 0.3m of water on Ross River Road adjacent to Russel Street; • Up to 0.40m of water on the westbound lanes of Ross River Road near Wood Street; • 0.3m of water over Love Lane at the intersection with Trott Street; • 0.2m of water over Love Lane at the intersection with Kelly Street; • 0.30m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.10m of water on the west bound lanes of Balls Lane at the downstream end of Mundingburra Drain; • 0.15m over Ross River Road at Crete Street; • 0.1m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are just over 1m/s at locations. The overtopping velocities for Balls Lane are 1.3m/s. Areas of Arthur Fadden Park have velocities above 0.7m/s.
50 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain, however 2 to 3 hours upstream of Ross River Road; • 24 hours in Anderson Park Drain; • 1.5 hours in the Aitkenvale North area, however 24 hours upstream of Anne Street; • 1.5 – 2 hours in the Aitkenvale South area • 2 – 3 hours in the Aitkenvale East Area; • 24 hours in the Mundingburra Drain, however 6 hours downstream of St Joseph's School; • 72 hours in the Mundingburra South Flowpath area, however 18 hours in area west of Wood Street; • 24 hours in the Harding Avenue Flowpath area; and • 18 hours in Mundingburra Hollows area. Flooding is widespread particularly in the Mundingburra Hollows, Aitkenvale East, Aitkenvale South and Aitkenvale Overflow areas. There are approximately 215 residential properties inundated in Aitkenvale and 275 residential properties inundated in

Event	Description
	Mundingburra. There are areas of inundation within the grounds of the Cathedral School, Mundingburra State School and St Joseph's Primary School, with some building areas inundated in Aitkenvale State School. In Aitkenvale portions of the Stockland shopping centre site are inundated as is the adjacent McDonalds. Much of the Vale Hotel site is impacted and the Power Substation upstream of the Vale Hotel, on Charlotte Street is potentially inundated. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area and professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation. The supermarket on Ross River Road near Wood Street is inundated as are professional offices east of Wood Street on Ross River Road and professional offices opposite the Cathedral School on Ross River Road. There is some inundation of the grounds of the Aged Persons Home on Gulliver Street. Inundation of major roads includes: • 0.35m of water on Ross River Road adjacent to Russel Street; • Up to 0.50m of water on the westbound lanes of Ross River Road near Wood Street; • 0.35m of water over Love Lane at the intersection with Trott Street; • 0.2m of water over Love Lane at the intersection with Kelly Street; • 0.35m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.15m of water on the west bound lanes of Balls Lane at the downstream end of Mundingburra Drain; • 0.2m over Ross River Road at Crete/Tulip Streets; • 0.1m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are up to 1.2m/s at locations. The overtopping velocities for Balls Lane are 1.5m/s. Areas of Arthur Fadden Park have velocities above 0.8m/s. Flows velocities within the Aitkenvale Overflow area are up to 0.8m/s in locations.
100 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain, however 2 to 3 hours upstream of Ross River Road; • 24 hours in Anderson Park Drain; • 1.5 hours in the Aitkenvale North area, however 24 hours upstream of Anne Street; • 1.5 – 2 hours in the Aitkenvale South area • 2 hours in the Aitkenvale East Area; • 24 hours in the Mundingburra Drain; • 72 hours in the Mundingburra South Flowpath area, however 18 hours in area west of Wood Street; • 24 hours in the Harding Avenue Flowpath area, however 1.5 hours west of Gulliver Street; and • 18 hours in Mundingburra Hollows area. Flooding is widespread particularly in the Mundingburra Hollows, Aitkenvale East, Aitkenvale South and Aitkenvale Overflow areas. There are approximately 270 residential properties inundated in Aitkenvale and 320 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of Mundingburra State School and St Joseph's Primary School, with some building areas inundated in Aitkenvale State School and the Cathedral School. In Aitkenvale portions of the Stockland shopping centre site are inundated as is the adjacent McDonalds. Much of the Vale Hotel site is impacted and the Power Substation upstream of the Vale Hotel, on Charlotte Street is potentially inundated. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area and

Event	Description
	professional offices on Ross River Road east of Charlotte Street. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation. The supermarket on Ross River Road near Wood Street is inundated as are professional offices east of Wood Street on Ross River Road and professional offices opposite the Cathedral School on Ross River Road. There is some inundation of the grounds of the Aged Persons Home on Gulliver Street. Inundation of major roads includes: • 0.40m of water on Ross River Road adjacent to Russel Street; • Up to 0.55m of water on the westbound lanes of Ross River Road near Wood Street; • 0.35m of water over Love Lane at the intersection with Trott Street; • 0.2m of water over Love Lane at the intersection with Kelly Street; • 0.40m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.20m of water on the west bound lanes of Balls Lane at the downstream end of Mundingburra Drain; • 0.25m over Ross River Road at Crete/Tulip Streets; • 0.2m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are over 1.3m/s at locations. The overtopping velocities for Balls Lane are 1.75m/s. Areas of Arthur Fadden Park have velocities above 0.8m/s. Flows velocities within the Aitkenvale Overflow area are up to 0.8m/s in locations.
200 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain, however 2 hours upstream of Ross River Road; • 24 hours in Anderson Park Drain; • 24 hours in the Aitkenvale North area; • 1.5 – 2 hours in the Aitkenvale South area • 2 hours in the Aitkenvale East Area; • 24 hours in the Mundingburra Drain; • 72 hours in the Mundingburra South Flowpath area, however 18 hours in area west of Wood Street; • 24 hours in the Harding Avenue Flowpath area, however 1.5 hours west of Gulliver Street; and • 18 hours in Mundingburra Hollows area and 24 hours in the western Mundingburra Hollows draining through Arthur Fadden Park. Flooding is widespread and there are approximately 325 residential properties inundated in Aitkenvale and 350 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of Mundingburra State School and St Joseph's Primary School, with some building areas inundated in Aitkenvale State School and the Cathedral School. In Aitkenvale portions of the Stockland shopping centre site are inundated as is the adjacent McDonalds. Much of the Vale Hotel site is impacted and the Power Substation upstream of the Vale Hotel, on Charlotte Street is inundated. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area. Professional offices are impacted opposite Stockland Shopping centre on Ross River Road as well east of Charlotte Street on Ross River Road. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation. The supermarket on Ross River Road near Wood Street is inundated as are professional offices east of Wood Street on Ross River Road and professional offices opposite the Cathedral School on Ross River Road. There is some inundation of the grounds of the Aged Persons Home on Gulliver Street and the Aged Persons Home on Fulham Road. Inundation of major roads includes: • 0.40m of water on Ross River Road adjacent to Russel Street; • Up to 0.60m of water on the westbound lanes of Ross River Road near Wood

Event	Description
	Street; • 0.40m of water over Love Lane at the intersection with Trott Street; • 0.25m of water over Love Lane at the intersection with Kelly Street; • 0.45m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.15m of water overtopping Balls Lane at the downstream end of Mundingburra Drain; • 0.30m over Ross River Road at Crete/Tulip Streets; • 0.25m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are over 1.3m/s at locations. The overtopping velocities for Balls Lane are 1.9m/s. Areas of Arthur Fadden Park have velocities above 0.8m/s. Flows velocities within the Aitkenvale Overflow area are up to 0.8m/s in locations.
500 Year ARI	Generally the critical duration event is: • 24 hours in Aitkenvale Drain, however 2 hours upstream of Ross River Road; • 24 hours in Anderson Park Drain; • 24 hours in the Aitkenvale North area; • 1.5 – 2 hours in the Aitkenvale South area • 2 hours in the Aitkenvale East Area; • 24 hours in the Mundingburra Drain; • 24 hours in the Mundingburra South Flowpath area; • 1 -1.5 hours in the Harding Avenue Flowpath area; and • 24 hours in Mundingburra Hollows area. Flooding is widespread and there are approximately 410 residential properties inundated in Aitkenvale and 400 residential properties inundated in Mundingburra. There are areas of inundation within the grounds of Mundingburra State School and St Joseph's Primary School, with some building areas inundated in Aitkenvale State School and the Cathedral School. In Aitkenvale a majority of the Stockland shopping centre site is inundated as is the adjacent McDonalds. Much of the Vale Hotel site is impacted and the Power Substation upstream of the Vale Hotel, on Charlotte Street is inundated. Inundation is impacting on some warehouses and workshops in the Aitkenvale North Area. Professional offices are impacted opposite Stockland Shopping centre on Ross River Road as well east of Charlotte Street on Ross River Road. In Mundingburra some of the commercial areas fronting Bowen Road are impacted by inundation. The supermarket on Ross River Road near Wood Street is inundated as are professional offices east of Wood Street on Ross River Road and professional offices opposite the Cathedral School on Ross River Road. There is some inundation of the grounds of the Aged Persons Home on Gulliver Street and the Aged Persons Home on Fulham Road. Inundation of major roads includes: • 0.40m of water on Ross River Road adjacent to Russel Street; • Up to 0.65m of water on the westbound lanes of Ross River Road near Wood Street; • 0.45m of water over Love Lane at the intersection with Trott Street; • 0.30m of water over Love Lane at the intersection with Kelly Street; • 0.50m of water over Balls Lane at the downstream end of Anderson Park Drain; • 0.20m of water overtopping Balls Lane at the downstream end of Mundingburra Drain; • 0.35m over Ross River Road at Crete Street/Tulip Streets; • 0.30m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are over 1.5m/s at locations. The overtopping velocities for Balls Lane are 2.0m/s. Areas of Arthur Fadden Park have velocities above 0.8m/s. Flows velocities within the Aitkenvale Overflow area are up to 0.85m/s in locations.

Event	Description
PMF	Generally the critical duration event is: • 24 hours in a majority of areas throughout Aitkenvale and Mundingburra; • 2 hours in eastern portions of Mundingburra; and • 72 hours adjacent to Aplins Weir. There is significant widespread flooding with depths up to 1.7m in Aitkenvale and 2.1m in Mundingburra. A total of approximately 1285 and 940 residential properties are inundated in Aitkenvale and Mundingburra. Numerous commercial premises, educational institutions professional offices, churches, doctors' surgeries and public utilities are also impacted. Inundation of major roads includes: • 0.60m of water on Ross River Road adjacent to Russel Street; • Up to 1.2m of water on the westbound lanes of Ross River Road near Wood Street; • 0.80m of water over Love Lane at the intersection with Trott Street; • 0.85m of water over Love Lane at the intersection with Kelly/Wood Streets; • 1.7m of water over Balls Lane at the downstream end of Anderson Park Drain; • 1.0m of water overtopping Balls Lane at the downstream end of Mundingburra Drain; • 0.90m over Ross River Road at Crete Street/Tulip Streets; • 0.55m over Ross River Road near the Cathedral School. Within residential and commercial areas flow velocities are generally under 0.6m/s. Flow velocities within Aitkenvale Drain and Anderson Drain are over 2.0m/s at locations. The overtopping velocities for Balls Lane are 2.5m/s. Areas of Wentworth Avenue and Brownhill Street upstream of Arthur Fadden Park have velocities above 1.2m/s leading to the Park. Flows velocities within the Aitkenvale Overflow area are up to 1.3m/s in locations. Flow velocities along Alfred Street are as high as 1.2m/s. Flow velocities overtopping Ross River Road adjacent to the Vale Hotel are up to 2.6m/s

Rosslea/Mysterton/Hermit Park

Figure 5-3 outlines the key drainage features of the Rosslea/Mysterton/Hermit Park area. There are a series of major open drains and major flow paths for the area:

- Mindham Park Drain, which runs between Mysterton and Hermit Park and conveys much of the flows from upstream suburbs including Cranbrook, Aitkenvale and Mundingburra towards Woolcock Canal and Ross Creek;
- Rosslea Drain, which conveys flows from eastern Mundingburra and Rosslea to Ross River via the Townsville Golf Course land;
- Hermit Park Drain, which drains the central parts of Hermit Park west across Charters Towers Road and into Mindham Park Drain; and
- Pimlico Drain, which conveys flows from upstream flows from Gulliver and Pimlico through Mysterton to Mindham Park Drain.

In addition to the flow paths identified above there are areas within Rosslea and Hermit Park that are not freely drained by major surface flow paths or are significantly impacted by backwater from Ross River:

- the Golf Course Overflow area is portions of the Townsville Golf Course that are impacted from Ross River backwater adjacent to the outlet of the Rosslea Drain. In larger Ross River floods, flows short circuit the bend between the Golf Course and Idalia by flowing through the Golf Course;
- the Sherriff Street Area is an area of Hermit Park/Rosslea that is impacted by backwater from Ross River flows. In larger Ross River floods, the Sherriff Street Area is one of the locations where overflows from Ross River through Hermit Park to Ross Creek occur;

- the Marks Street Sump is a low area around the intersection of Marks and Sturges Streets where there is no major surface flow path for stormwater. An underground stormwater pipe-network drains the area to both Mindham Park and Ross River; and
- the Campbell Street Sump is a low area around the intersection of Campbell Street and Queens Road where there is no major surface flow path for stormwater. There has been a recent upgrade to a stormwater pump station that increases the capacity of the underground stormwater pipe-network to discharge to Ross River.

A summary of the key flooding issues within the Rosslea/Mysterton/Hermit Park area relative to the ARI of floods is provided in **Table 5-3** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-3

Rosslea/Mysterton/Hermit Park

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 23/08/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-3_Rs-My-HmP.mxd

Table 5-3 Rosslea/Mysterton/Hermit Park Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 72 hours within the Mysterton reaches of Mindham Park Drain; • 12 hours in the Rosslea Drain downstream of Bowen Road and 1.5 to 2 hours upstream of Bowen Road; • 72 hours in the Hermit Park Drain; • 12 to 18 hours in the Golf Course Overflow area; • 1.5 to 2 hours in the Sherriff Street Area; • 2 hours in the Marks Street Sump and; • 12 hours in the Campbell Street Sump; Flooding is quite isolated with most inundation contained to streets and major flow paths, with minor inundation of residential properties as follows: • 5 residential properties impacted in Rosslea; • 40 residential properties impacted in Hermit Park; and • 35 residential properties impacted in Mysterton (mainly in the northern portion of the suburb). There are some shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by minor localised flooding. Inundation of major roads includes: • 0.2 m of water on the east bound lanes of Queens Road adjacent to Campbell Street; • 0.15m of water over Ackers Street immediately east of Lily Street; • up to 0.15m of water over Charters Towers Road approaching Woolcock/Boundary Streets; and • 0.1m of water on the south bound lanes of Bowen Road around the Rosslea Drain. Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.3m/s.
5 Year ARI	Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1.5 to 2 hours upstream of Bowen Road; • 72 hours in the Hermit Park Drain; • 24 to 72 hours in the Golf Course Overflow area; • 1.5 hours in the Sherriff Street Area; • 3 hours in the Marks Street Sump and; • 24 hours in the Campbell Street Sump; Flooding is mostly contained to streets and major flow paths; however there is increased inundation of residential properties particularly within the Hermit Park Sumps. Residential property impacts are as follows: • 6 residential properties impacted in Rosslea; • 100 residential properties impacted in Hermit Park; and • 55 residential properties impacted in Mysterton. There are some shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by minor localised flooding. There is some inundation of the sub-station site adjacent to the Hermit Park Drain. Inundation of major roads includes: • 0.3 m of water over Queens Road adjacent to Campbell Street; • 0.2m of water over Ackers Street immediately east of Lily Street; • up to 0.15m of water over Charters Towers Road approaching Woolcock/Boundary Streets; • 0.2m of water over Charters Towers Road at the intersection with Bayswater Terrace; and • 0.15m of water on the south bound lanes of Bowen Road around the Rosslea Drain.

Event	Description
	Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.3m/s. Velocities up to 1m/s are present in the Rosslea Drain.
10 Year ARI	Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1.5 to 2 hours upstream of Bowen Road; • 72 hours in the Hermit Park Drain; • 24 to 72 hours in the Golf Course Overflow area; • 1.5 hours in the Sherriff Street Area; • 24 hours in the Marks Street Sump and; • 24 hours in the Campbell Street Sump; Flooding extents are increasing with inundation of residential properties as follows: • 10 residential properties impacted in Rosslea; • 130 residential properties impacted in Hermit Park; and • 65 residential properties impacted in Mysterton. There are some shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by minor localised flooding. There is some inundation of the sub-station site adjacent to the Hermit Park Drain. Inundation of major roads includes: • 0.45 m of water over Queens Road adjacent to Campbell Street; • 0.25m of water over Ackers Street immediately east of Lily Street; • up to 0.2m of water over Charters Towers Road approaching Woolcock/Boundary Streets; • 0.2m of water on the south bound lanes of Charters Towers Road near Carr Street; • 0.25m of water over Charters Towers Road at the intersection with Bayswater Terrace; • 0.2m of water on the south bound lanes of Bowen Road around the Rosslea Drain; • 0.15m of water on Bowen Road at the intersection with Inglis Smith Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.3m/s. Velocities up to 1m/s are present in the Rosslea Drain.
20 Year ARI	Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1.5 to 2 hours upstream of Bowen Road; • 72 hours in the Hermit Park Drain; • 72 hours in the Golf Course Overflow area; • 72 hours in the Sherriff Street Area (Ross River backwater); • 24 hours in the Marks Street Sump and; • 24 hours in the Campbell Street Sump; Flooding extents are increasing with inundation of residential properties as follows: • 20 residential properties impacted in Rosslea; • 200 residential properties impacted in Hermit Park; and • 75 residential properties impacted in Mysterton. There are some shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by flooding. There is some inundation of the sub-station site adjacent to the Hermit Park Drain. There is some inundation of the dental surgery on the corner of Charters Towers Road and Soule Street. Inundation of major roads includes: • 0.5 m of water over Queens Road adjacent to Campbell Street;

Event	Description
	• 0.25m of water over Ackers Street immediately east of Lily Street; • up to 0.2m of water over Charters Towers Road approaching Woolcock/Boundary Streets; • 0.25m of water on the south bound lanes of Charters Towers Road near Carr Street; • 0.25m of water over Charters Towers Road at the intersection with Bayswater Terrace; • 0.25m of water on the south bound lanes of Bowen Road around the Rosslea Drain; • 0.2m of water on Bowen Road at the intersection with Inglis Smith Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.3m/s. Velocities up to 1m/s are present in the Rosslea Drain and on other areas of the Golf Course.
50 Year ARI	Generally the critical duration event is: • 6 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1 to 1.5 hours upstream of Bowen Road; • 12 hours in the Hermit Park Drain; • 72 hours in the Golf Course Overflow area; • 72 hours in the Sherriff Street Area (Ross River backwater); • 2 hours in the Marks Street Sump and; • 24 hours in the Campbell Street Sump; Flooding becoming widespread particularly throughout Hermit Park and Mysterton with inundation of residential properties as follows: • 25 residential properties impacted in Rosslea; • 240 residential properties impacted in Hermit Park; and • 85 residential properties impacted in Mysterton. There are shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by flooding. There is greater inundation of the sub-station site adjacent to the Hermit Park Drain. There is some inundation of the dental surgery on the corner of Charters Towers Road and Soule Street. The Kindergarten on the corner of Campbell Street and Queens Road is inundated. Inundation of major roads includes: • 0.55 m of water over Queens Road adjacent to Campbell Street; • 0.30m of water over Ackers Street immediately east of Lily Street; • up to 0.25m of water over Charters Towers Road approaching Woolcock/Boundary Streets; • 0.30m of water on the south bound lanes of Charters Towers Road near Carr Street; • 0.30m of water over Charters Towers Road at the intersection with Bayswater Terrace; • 0.25m of water on the south bound lanes of Bowen Road around the Rosslea Drain; • 0.15m of water over the road on Bowen neat the intersection with Benson Street; • 0.2m of water on Bowen Road at the intersection with Inglis Smith Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.4m/s. Velocities up to 1m/s are present in the Rosslea Drain and on other areas of the Golf Course.
100 Year ARI	Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1 to 1.5 hours upstream of Bowen Road; • 12 hours in the Hermit Park Drain; • 72 hours in the Golf Course Overflow area;

Event	Description
	• 72 hours in the Sherriff Street Area (Ross River backwater); • 2 hours in the Marks Street Sump and; • 24 hours in the Campbell Street Sump; Flooding becoming widespread throughout all three suburbs with inundation of residential properties as follows: • 50 residential properties impacted in Rosslea; • 295 residential properties impacted in Hermit Park; and • 100 residential properties impacted in Mysterton. There are shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by flooding. The sub-station site adjacent to the Hermit Park Drain is completely inundated. There is some inundation of the dental surgery on the corner of Charters Towers Road and Soule Street. The Kindergarten on the corner of Campbell Street and Queens Road is inundated. Inundation of major roads includes: • 0.60 m of water over Queens Road adjacent to Campbell Street; • 0.30m of water over Ackers Street immediately east of Lily Street; • up to 0.30m of water over Charters Towers Road approaching Woolcock/Boundary Streets; • 0.1m of water over Charters Towers Road at Hermit Park Drain; • 0.30m of water on the south bound lanes of Charters Towers Road near Carr Street; • 0.30m of water over Charters Towers Road at the intersection with Bayswater Terrace; • 0.25m of water on the south bound lanes of Bowen Road around the Rosslea Drain; • 0.20m of water over the road on Bowen neat the intersection with Benson Street; • 0.25m of water on Bowen Road at the intersection with Inglis Smith Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.4m/s. Velocities up to 1.3m/s are present in the Rosslea Drain and on other areas of the Golf Course.
200 Year ARI	Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain downstream of Bowen Road (Ross River backwater) and 1 to 1.5 hours upstream of Bowen Road; • 12 hours in the Hermit Park Drain; • 72 hours in the Golf Course Overflow area; • 72 hours in the Sherriff Street Area (Ross River backwater); • 2 hours in the Marks Street Sump and; • 72 hours in the Campbell Street Sump; Widespread flooding from local rainfall and Ross River backwater with inundation of residential properties as follows: • 70 residential properties impacted in Rosslea; • 355 residential properties impacted in Hermit Park; and • 115 residential properties impacted in Mysterton. There are shops fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by flooding. There are also commercial properties fronting Bowen Road in Hermit Park and Rosslea that are impacted by flooding. The sub-station site adjacent to the Hermit Park Drain is completely inundated. There is inundation of the dental surgery on the corner of Charters Towers Road and Soule Street. The Kindergarten on the corner of Campbell Street and Queens Road is inundated. Inundation of major roads includes: • 0.80 m of water over Queens Road adjacent to Campbell Street; • 0.35m of water over Ackers Street immediately east of Lily Street; • up to 0.30m of water over Charters Towers Road approaching

Event	Description
	Woolcock/Boundary Streets; • 0.20m of water over Charters Towers Road at Hermit Park Drain; • 0.35m of water on the south bound lanes of Charters Towers Road near Carr Street; • 0.30m of water over Charters Towers Road at the intersection with Bayswater Terrace; • 0.30m of water on the south bound lanes of Bowen Road around the Rosslea Drain; • 0.20m of water over the road on Bowen neat the intersection with Benson Street; • 0.25m of water on Bowen Road at the intersection with Inglis Smith Street Within residential and commercial areas flow velocities are generally under 0.5m/s. Flow velocities within the Mysterton reaches of Mindham Park Drain are up to 1.5m/s. Velocities up to 1.3m/s are present in the Rosslea Drain and on other areas of the Golf Course.
500 Year ARI	The increase in flows within Ross River results in overflows running through the Golf Course Overflow area and through the Sherriff Street Area into Hermit Park. Much of Hermit Park south of Ahearne Street is inundated as is much of Rosslea east of Bowen Road. Generally the critical duration event is: • 24 hours within the Mysterton reaches of Mindham Park Drain; • 72 hours in the Rosslea Drain; • 72 hours in the Hermit Park Drain upstream of Charters Towers Road and 24 hours downstream of Charters Towers Road; • 72 hours in the Golf Course Overflow area; • 72 hours in the Sherriff Street Area; • 72 hours in the Marks Street Sump and; • 72 hours in the Campbell Street Sump; There is significant widespread flooding particularly within Rosslea and Hermit Park resulting from Ross River overflows with inundation of residential properties as follows: • 195 residential properties impacted in Rosslea; • 470 residential properties impacted in Hermit Park; and • 130 residential properties impacted in Mysterton. There are numerous commercial properties fronting Charters Towers Road in both Hermit Park and Mysterton that are impacted by flooding. There are also commercial properties fronting Bowen Road in Hermit Park and Rosslea that are impacted by flooding. The sub-station site adjacent to the Hermit Park Drain is inundated with depths up to 0.75m. The Kindergarten on the corner of Campbell Street and Queens Road is inundated with depths up to 1m. Inundation of major roads includes: • water over Queens Road between Goldring and Ahearne Streets with up to 1.50 m adjacent to Campbell Street; • 0.40m of water over Ackers Street immediately east of Lily Street; • water over Charters Towers Road between Somer Street and Woolcock/Boundary Streets with depths up to 0.35m; • water over Charters Towers Road between Roberts Street and Soule Street with a maximum water depth of 0.5m at the Hermit Park Drain; and • water over Bowen Road from Norris Street to Ross River with a maximum depth of 0.9m adjacent to the Rosslea Drain; Within residential and commercial areas flow velocities are generally under 0.5m/s with the following exceptions: • flow velocities within the Mysterton reach of Mindham Park Drain up to 2m/s; • flow velocities within the Hermit Park Drain up to 1.8m/s; • overtopping velocities for Charters Towers Road at the Hermit Park Drain of 1.5m/s; • flow velocities along Queens Road of up to 1.6m/s; • flows northwards through the residential streets of Hermit Park of up to 1m/s; • flows eastward along Benson Street and Inglis Smith Street up to 1m/s; and

Event	Description
	• flow velocities across the Golf Course Overflow up to 1.5 m/s.
PMF	There is widespread flooding across all areas of the three suburbs resulting from overflows from Ross River. Generally the critical duration event is: • 24 hours throughout Mysterton and Hermit Park; and • 2 hours throughout Rosslea. There is significant widespread flooding with inundation of residential properties as follows: • 345 residential properties impacted in Rosslea; • 1065 residential properties impacted in Hermit Park; and • 240 residential properties impacted in Mysterton. Almost all commercial areas of Hermit Park, Rosslea and Mysterton are impacted by inundation other than properties fronting Charters Towers Road around the intersection with Queens Road/ Ross River Road. Inundation of major roads includes: • water over Queens Road over the full length with a maximum of 2.5m adjacent to Campbell Street; • water over Ackers Street for the full length with a maximum of 1.8m immediately east of Lily Street; • water over Charters Towers Road between Goldring Street and Woolcock/Boundary Streets with a maximum water depth of 1.8m at the Hermit Park Drain; and • water over Bowen Road from Carmody Street to Ross River with a maximum depth of 1.5m adjacent to the Rosslea Drain; Within residential and commercial areas flow velocities are generally under 0.6m/s with the following exceptions: • flow velocities within the Mysterton reach of Mindham Park Drain up to 2.4m/s; • flow velocities within the Hermit Park Drain up to 2.0m/s; • overtopping velocities for Charters Towers Road at the Hermit Park Drain of 1.5m/s; • flow velocities along Queens Road of up to 2.0m/s; • flows northwards through the residential streets of Hermit Park of up to 1.2m/s; • flows eastward along Benson Street and Inglis Smith Street up to 1.7m/s; and

Railway Estate/South Townsville

Figure 5-4 outlines the key drainage features of the Railway Estate/South Townsville area. Railway Estate and South Townsville are on the northern banks of the lower reaches of the Ross River between Ross River and Ross Creek. In addition to flooding from local catchment flows and Ross River flows, there is also significant potential for coastal flooding from storm surge and sea level rise. In larger Ross River flow events, flood water overtops the northern Ross River bank around Rooney's bridge and flow north easterly across Railway Avenue through Railway Estate.

There are a series of local flow paths draining areas of Railway Estate and South Townsville to Ross River and Ross Creek:

- Goondi Creek is a natural, tidal creek that drains portions of South Townsville around Perkins and Tully Streets as well as much of Railway Estate east of Railway Avenue;
- Brooks Street Drain is an open drain that drains the south eastern area of Railway Estate which does not drain to Goondi Creek;

- the South Townsville drain is a combined open drain and underground pipe drain that drains areas to the east of the remnant sand dune in the area of Hubert Street;
- the Seventh Street Flow Path drains flows from north eastern Railway Estate to Goondi Creek; and
- the North Railway Estate Flow Path drains flows from north western Railway Estate through Reid Park to Ross Creek, mainly via underground pipes, however surface flows also direct this way once underground pipe capacity is exceeded.

There are also a series of trap-low points that are only drained by underground pipe drainage:

- the South Railway Estate Sump, which is west of Railway Avenue and south of Queens Road and is service by underground drainage to Ross Creek and underground drainage against the natural surface grades to Ross River;
- the Sixth Avenue Sump, which is generally south of Boundary Street between Fifth and Seventh Avenues. The sump is serviced by underground drainage to Ross River under the proposed location of the Townsville Boat Park Facility; and
- the Barlow Street Sump, which is located around Morey Street, Morehead Street and Barlow Streets. The sump is serviced by underground pipes under Dean Street that drain to Ross Creek.

A summary of the key flooding issues within the Railway Estate/South Townsville area relative to the ARI of floods is provided in **Table 5-4** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-4

Railway Estate / South Townsville

CASTLE HILL
TOWNSVILLE CITY
WEST END
RAILWAY ESTATE
SOUTH TOWNSVILLE
HERMIT PARK
OONOONBA
STUART
Ross Creek
Barlow Street Sump
South Townsville Drain
Sixth Avenue Sump
North Railway Estate Flow Path
Seventh Street Flow Path
Goondi Creek
South Railway Estate Sump
Ross River Overflow
Brooks Street Drain
Ross River

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 23/08/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-_RE-SthTsv.mxd

Table 5-4 Railway Estate / South Townsville Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 18 hours in Goondi Creek; • 24 hours in the Brooks Street Drain; • 18 hours in the South Townsville Drain; • 18 hours in the Seventh Avenue Flow Path; • 18 hours in the North Railway Estate Flow Path downstream of Boundary Street and 72 hours upstream of Boundary Street; • 2 hours in the South Railway Estate Sump; • 2 to 3 hours in the Sixth Avenue Sump; and • 72 hours in the Barlow Street Sump. There is minor flooding inundation of residential properties as follows: • 45 residential properties impacted in Railway Estate; • 40 residential properties impacted in South Townsville; There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. Inundation of major roads includes: • 0.2m of water over Archer Street upstream of the South Townsville Drain; • 0.2m of water over Boundary Street at the intersection with Benwell Road; • 0.1m of water over Boundary Street adjacent to Samphire Drive; • 0.2m of water on the south bound lanes of Railway Avenue at the intersection with Ninth Street; and • 0.25m of water on the south bound lanes of Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s.
5 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek (Ross River backwater); • 24 hours in the Brooks Street Drain ; • 24 hours in the South Townsville Drain; • 12 - 18 hours in the Seventh Avenue Flow Path; • 12 hours in the North Railway Estate Flow Path; • 2 hours in the South Railway Estate Sump; • 1.5 to 3 hours in the Sixth Avenue Sump; and • 24 hours in the Barlow Street Sump. There is minor flooding of residential properties as follows: • 60 residential properties impacted in Railway Estate; and • 80 residential properties impacted in South Townsville. There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • 0.35m of water over Archer Street upstream of the South Townsville Drain; • 0.3m of water over Boundary Street at the intersection with Benwell Road; • 0.15m of water over Boundary Street between Fourth and Fifth Avenues; • 0.1m of water over Boundary Street adjacent to Samphire Drive; • 0.25m of water over Railway Avenue at the intersection with Ninth Street; and • 0.3m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s.

Event	Description
10 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek downstream of Samphire Drive and 18 hours upstream of Samphire Drive; • 24 hours in the Brooks Street Drain ; • 24 hours in the South Townsville Drain; • 12 - 18 hours in the Seventh Avenue Flow Path; • 12 hours in the North Railway Estate Flow Path downstream of Boundary Street and 24 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 24 hours in the Sixth Avenue Sump; and • 24 hours in the Barlow Street Sump. Flooding is more widespread with inundation of residential properties as follows: • 75 residential properties impacted in Railway Estate; and • 95 residential properties impacted in South Townsville. There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • 0.4m of water over Archer Street upstream of the South Townsville Drain; • 0.35m of water over Boundary Street at the intersection with Benwell Road; • 0.20m of water over Boundary Street between Fourth and Fifth Avenues; • 0.15m of water over Boundary Street adjacent to Samphire Drive; • 0.30m of water over Railway Avenue at the intersection with Ninth Street; and • 0.35m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s.
20 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek downstream of Samphire Drive and 18 hours upstream of Samphire Drive; • 24 hours in the Brooks Street Drain ; • 24 hours in the South Townsville Drain; • 18 to 24 hours in the Seventh Avenue Flow Path; • 24 hours in the North Railway Estate Flow Path downstream of Boundary Street and 72 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 24 hours in the Sixth Avenue Sump; and • 24 hours in the Barlow Street Sump. Flooding is more widespread with inundation of residential properties as follows: • 100 residential properties impacted in Railway Estate; and • 110 residential properties impacted in South Townsville. There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • 0.45m of water over Archer Street upstream of the South Townsville Drain;

Event	Description
	• 0.35m of water over Boundary Street at the intersection with Benwell Road; • 0.20m of water over Boundary Street between Fourth and Fifth Avenues; • 0.2m of water over Boundary Street adjacent to Samphire Drive; • 0.30m of water over Railway Avenue at the intersection with Ninth Street; and • 0.35m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, except for the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 0.75m/s.
50 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek downstream of Samphire Drive and 18 hours upstream of Samphire Drive; • 1.5 hours in the Brooks Street Drain ; • 3 hours in the South Townsville Drain; • 12 to 18 hours in the Seventh Avenue Flow Path; • 2 hours in the North Railway Estate Flow Path downstream of Boundary Street and 72 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 3 hours in the Sixth Avenue Sump; and • 6 hours in the Barlow Street Sump. Flooding is widespread with inundation of residential properties as follows: • 125 residential properties impacted in Railway Estate; and • 130 residential properties impacted in South Townsville. There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • Archer Street is overtopped between Macrossan and Hubert Streets with a maximum depth of 0.55m upstream of the South Townsville Drain; • 0.50m of water over Boundary Street at the intersection with Benwell Road; • 0.15m of water over Boundary Street immediately east of Eighth Avenue; • 0.25m of water over Boundary Street between Fourth and Fifth Avenues; • 0.25m of water over Boundary Street adjacent to Samphire Drive; • 0.15m over Boundary Street around the intersection with Tenth Avenue; • 0.30m of water over Railway Avenue at the intersection with Ninth Street; and • 0.40m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, except for the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 0.9m/s.
100 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek; • 1.5 to 2 hours in the Brooks Street Drain ; • 3 hours in the South Townsville Drain; • 12 hours in the Seventh Avenue Flow Path upstream of Eleventh Avenue; • 1.5 hours in the North Railway Estate Flow Path downstream of Boundary Street and 72 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 3 hours in the Sixth Avenue Sump; and • 6 hours in the Barlow Street Sump. Flooding is widespread with inundation of residential properties as follows: • 140 residential properties impacted in Railway Estate; and • 150 residential properties impacted in South Townsville.

Event	Description
	There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • Archer Street is overtopped between Macrossan and Hubert Streets with a maximum depth of 0.60m upstream of the South Townsville Drain; • 0.50m of water over Boundary Street at the intersection with Benwell Road; • 0.2m of water over Boundary Street immediately east of Eighth Avenue; • 0.25m of water over Boundary Street between Fourth and Fifth Avenues; • 0.25m of water over Boundary Street adjacent to Samphire Drive; • 0.15m over Boundary Street around the intersection with Tenth Avenue; • 0.30m of water over Railway Avenue at the intersection with Ninth Street; and • 0.40m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, except for the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 1.1m/s.
200 Year ARI	Generally the critical duration event is: • 72 hours in Goondi Creek; • 72 hours in the Brooks Street Drain ; • 24 hours in the South Townsville Drain; • 24 hours in the Seventh Avenue Flow Path upstream of Eleventh Avenue; • 1.5 hours in the North Railway Estate Flow Path downstream of Boundary Street and 24 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 3 hours in the Sixth Avenue Sump; and • 24 hours in the Barlow Street Sump. Flooding is widespread with inundation of residential properties as follows: • 165 residential properties impacted in Railway Estate; and • 165 residential properties impacted in South Townsville. There are some commercial properties impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • Archer Street is overtopped between Macrossan and Hubert Streets with a maximum depth of 0.60m upstream of the South Townsville Drain; • 0.50m of water over Boundary Street at the intersection with Benwell Road; • 0.3m of water over Boundary Street immediately east of Eighth Avenue; • 0.3m of water over Boundary Street between Fourth and Fifth Avenues; • 0.3m of water over Boundary Street adjacent to Samphire Drive; • 0.15m over Boundary Street around the intersection with Tenth Avenue; • 0.30m of water over Railway Avenue at the intersection with Ninth Street; and • 0.45m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, except for the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 1.2m/s and the outlet to the open drain adjacent to Samphire Drive where velocities are around 1.0m/s.

Event	Description
500 Year ARI	As a result of larger flows within Ross River there is an overflow from Ross River around Rooney's bridge into the South Railway Estate Sump and the Brooks Drain area. Generally the critical duration event is: • 72 hours in Goondi Creek; • 72 hours in the Brooks Street Drain ; • 24 hours in the South Townsville Drain; • 24 hours in the Seventh Avenue Flow Path upstream of Eleventh Avenue; • 1.5 hours in the North Railway Estate Flow Path downstream of Boundary Street and 24 hours upstream of Boundary Street • 72 hours in the South Railway Estate Sump; • 3 hours in the Sixth Avenue Sump; and • 24 hours in the Barlow Street Sump. Flooding is widespread particularly within southern Railway Estate with inundation of residential properties as follows: • 425 residential properties impacted in Railway Estate; and • 190 residential properties impacted in South Townsville. Commercial properties are impacted between Boundary Street and Perkins Street West as well as commercial properties impacted around the Barlow Street Sump. Some of the commercial properties to the eastern end of Boundary Street are also impacted by inundation. There is also church land on Putt Street impacted by flooding. Portions of the sub-station site on Hubert Street are inundated. There is inundation of a majority of the fire station at the corner of Dean Street and Morey Street. The Railway Estate community centre on First Street is inundated. Inundation of major roads includes: • Archer Street is overtopped between Macrossan and Hubert Streets with a maximum depth of 0.65m upstream of the South Townsville Drain; • 0.50m of water over Boundary Street at the intersection with Benwell Road; • 0.35m of water over Boundary Street immediately east of Eighth Avenue; • 0.35m of water over Boundary Street between Fourth and Fifth Avenues; • 0.4m of water over Boundary Street adjacent to Samphire Drive; • 0.2m over Boundary Street around the intersection with Tenth Avenue; • 0.35m of water over Railway Avenue at the intersection with Ninth Street; and • 0.5m of water over Railway Avenue at the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 1.2m/s; • the outlet to the open drain adjacent to Samphire Drive where velocities are around 1.0m/s; • areas of Brooks Street where velocities are 0.8m/s; • the location where South Townsville Drain overflows flow into Ross River at 1m/s.
PMF	There is widespread flooding across both suburbs resulting from overflows from Ross River except for the remnant sand dune around Hubert Street in South Townsville. The critical duration event for all areas of South Townsville and Railway Estate is the 24 hour event. There is significant widespread flooding with inundation of residential properties as follows: • 1110 residential properties impacted in Railway Estate; and • 510 residential properties impacted in South Townsville. Almost all commercial areas of Railway Estate and South Townsville are impacted by inundation other than some properties on the block bounded by Palmer Street, Dean Street, McIllwrath Street and Plume Street. All Schools in these suburbs are impacted by flooding.

Event	Description
	Inundation of major roads includes: • Archer Street is overtopped between Macrossan and Benwell Road with a maximum depth of 1.0m upstream of the South Townsville Drain; • Boundary Street between the intersection with Benwell Road and Eighth Avenue with a maximum depth of 0.8m; • Boundary Street between Seventh Avenue and Railway Avenue with a maximum depth of 1.75m; • Dean Street between McIllwrath Street and Morey Street with a maximum depth of 1.0m; • Saunders Street between Rooney Street and the Rail Overpass with a maximum depth of 1.0m; and • Railway Avenue between Boundary Street and the Ross River with a maximum depth of 1.5m around the intersection with Doorey Street. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • the outlet for surface flows from Putt Street to Goondi Creek where velocities are around 1.7m/s; • the outlet to the open drain adjacent to Samphire Drive where velocities are around 1.4m/s; • areas of Brooks Street where velocities are 1.0m/s; • the location where South Townsville Drain overflows flow into Ross River at 2m/s; • areas around the intersection of Boundary Street and Railway Avenue where velocities are around 1.4m/s; and • many of the residential streets in Railway Estate west of Railway Avenue where velocities are generally above 0.6m/s.

Heatley/Vincent

Figure 5-5 outlines the key drainage features of the Heatley/Vincent area. Flows from this area are directed to both Ross Creek and Louisa Creek. In some instances, particularly within Vincent, underground drainage directs flows towards Louisa Creek while surface flows head north east towards the Lakes and ultimately Ross Creek. Heatley and Vincent, as with Gulliver and Currajong, have no significant open channels to convey major flows away from residential and commercial areas.

The key drainage flow paths within Heatley and Vincent are:

- Illich Park Overflow, where flows in excess of the capacity of Illich Park detention basin overflow into residential areas of southern Vincent and flow north easterly into Gulliver;
- Western Heatley, where flows generally head northward following Fulham Road, before heading through the Croft and Eckhoff Street areas and discharging into the Northern Kirwan Drain, that crosses through culverts diagonally under the intersection of Dalrymple Road and Banfield Drive to Louisa Creek;
- Northern Heatley where flows generally drain northward and converge at the intersection of Hutchins Street and Dalrymple Service before flowing under Dalrymple Road to Louisa Creek; and
- Nathan Street, which has significant underground pipe capacity on the western side of the roadway that is directed northwards into Louisa Creek.

One of the areas significantly impacted by inundation in all flood events is the area around Oliver Court to the south of Cambridge Park. This area is impacted by both local flows and Illich Park Overflows. There is some pipe drainage directed west back

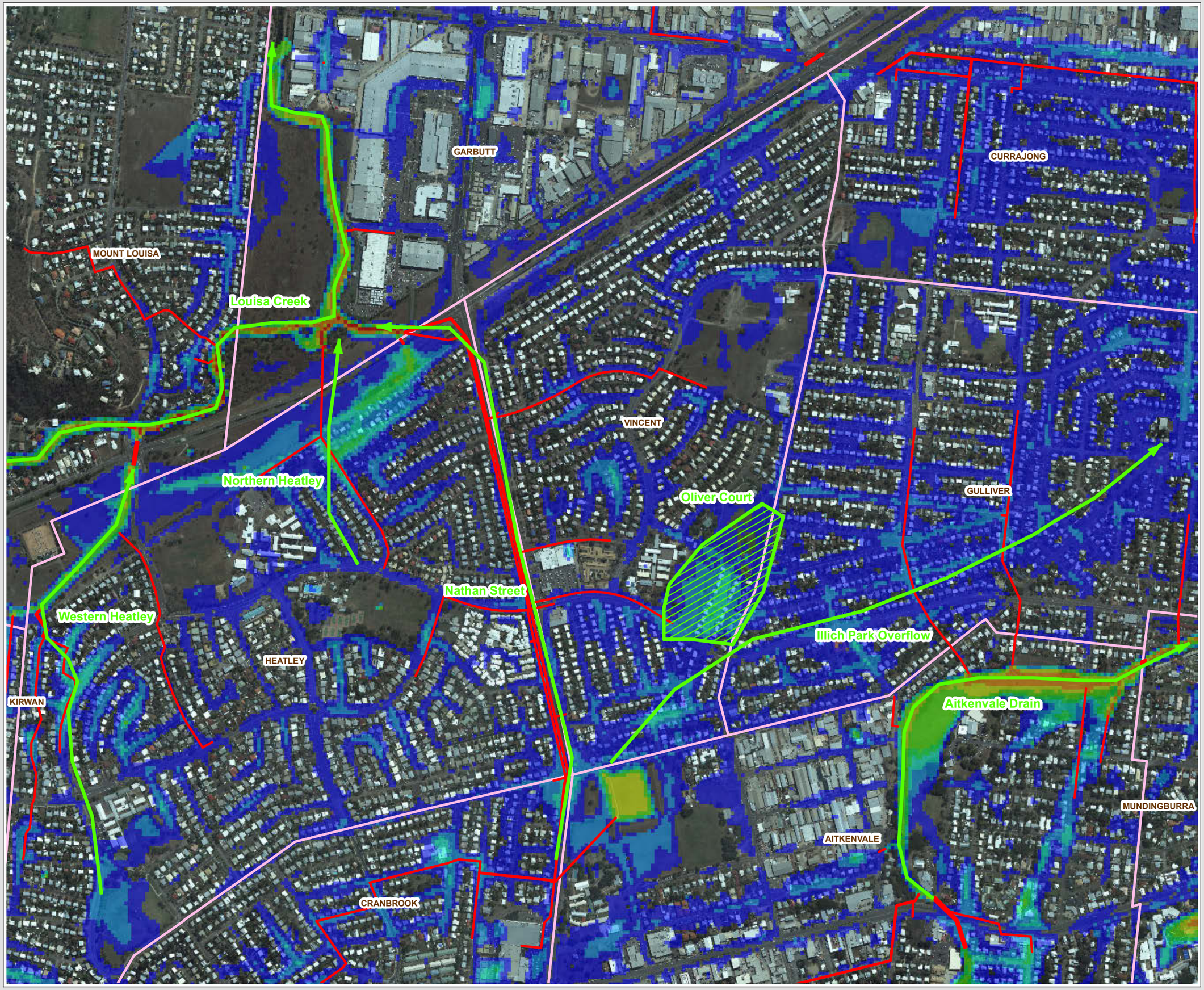
to the Nathan Street system from the area, however there is no open channel or other major flow path for flows through and out of this area.

A summary of the key flooding issues within the Heatley/Vincent area relative to the ARI of floods is provided in **Table 5-5** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-5

Heatley/Vincent



LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 27/08/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-5_Ht_Vn.mxd

Table 5-5 Heatley / Vincent Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 6 to 12 hours in the Illich Park Overflow area; • 12 hours in the Western Heatley area upstream of Mill Drive, 6 hours downstream of Mill Drive and 24 hours within the Northern Kirwan Drain; • 24 hours in the Northern Heatley area however 12 hours west of Hutchins Street; and • 6 hour in Oliver Court. Flooding is generally contained to road corridors, with the exception of areas around Oliver Court, Cuthbert Crescent and Riechelmann Street. Inundation of residential properties is as follows: • 50 residential properties impacted in Heatley; and • 40 residential properties impacted in Vincent. There is no significant inundation of commercial properties or community facilities. Inundation of major roads includes: • 0.15m of water over Fulham Road near Oliver Court; • 0.1m of water over Cambridge Street near Tyrrell Street; • 0.15m of over the intersection of Cambridge and Palmerston Streets; • 0.15m of water over Palmerston Street near Hodges Crescent; • 0.15m of water over the intersection of Fulham Road and Hanlon Street; • 0.3m of water over the intersection of Fulham Road and Croft Street; and • 0.3m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park. Within residential and commercial areas flow velocities are under 0.3m/s.
5 Year ARI	Generally the critical duration event is: • 24 hours in the Illich Park Overflow area; • 12 hours in the Western Heatley area upstream of Mill Drive, and 24 hours downstream of Mill Drive and within the Northern Kirwan Drain; • 24 hours in the Northern Heatley area however 2 hours within Pixley Crescent and Goldsworthy Street; and • 24 hour in Oliver Court. Flooding is less contained to road corridors with inundation of residential properties as follows: • 80 residential properties impacted in Heatley; and • 50 residential properties impacted in Vincent. There is no significant inundation of commercial properties. There is some inundation of the grounds of Vincent State School. Inundation of major roads includes: • 0.2m of water over Fulham Road near Oliver Court; • 0.25m of water over Cambridge Street near Tyrrell Street; • 0.2m of over the intersection of Cambridge and Palmerston Streets; • 0.15m of water over Palmerston Street near Hodges Crescent; • 0.25m of water over the intersection of Fulham Road and Hanlon Street; • 0.2m of water over the intersection of Fulham Road and Lindeman Avenue; • 0.5m of water over the intersection of Fulham Road and Croft Street; • 0.3m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park; and • Up to 0.25m of water over Charles Street between Nathan Street and Anne Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the exception of immediately north of the Illich Park detention basin where velocities are up to 0.6m/s.

Event	Description
10 Year ARI	Generally the critical duration event is: • 24 hours in the Illich Park Overflow area; • 24 hours in the Western Heatley, however 1.5 hours in Farrell Street; • 24 hours in the Northern Heatley area however 1.5 and 3 hours within Pixley Crescent and Goldsworthy Street respectively; and • 24 hour in Oliver Court. Flooding is becoming more widespread through properties with inundation of residential properties as follows: • 120 residential properties impacted in Heatley; and • 65 residential properties impacted in Vincent. There is no significant inundation of commercial properties. There is some inundation of the grounds of Vincent State School as well as some inundation of the Kindergarten on the corner of Nathan Street and Charles Street. Inundation of major roads includes: • 0.3m of water over Fulham Road near Oliver Court; • 0.3m of water over Cambridge Street near Tyrrell Street; • 0.25m of over the intersection of Cambridge and Palmerston Streets; • 0.15m of water over Palmerston Street near Hodges Crescent; • 0.3m of water over the intersection of Fulham Road and Hanlon Street; • 0.2m of water over the intersection of Fulham Road and Lindeman Avenue; • 0.65m of water over the intersection of Fulham Road and Croft Street; • 0.35m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park; and • Charles Street is inundated between Lindeman Avenue and Anne Street with a maximum depth of 0.4m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • immediately north of the Illich Park detention basin where velocities are up to 0.6m/s; • at the northern end of Lindeman Avenue where velocities are around 0.5m/s; and • at the northern end of Farrell Street where velocities are 0.5m/s.
20 Year ARI	Generally the critical duration event is: • 24 hours in the Illich Park Overflow area; • 24 hours in the Western Heatley, however 1.5 hours in Farrell Street; • 24 hours in the Northern Heatley area however 2 hours within Pixley Crescent and Goldsworthy Street; and • 24 hour in Oliver Court. Flooding is widespread through properties with inundation of residential properties as follows: • 160 residential properties impacted in Heatley; and • 90 residential properties impacted in Vincent. There is no significant inundation of commercial properties. There is some inundation of the grounds of Vincent State School, Heatley State School and Heatley Secondary School as well as some inundation of the Kindergarten on the corner of Nathan Street and Charles Street. Inundation of major roads includes: • 0.3m of water over Fulham Road near Oliver Court; • Cambridge Street is inundated between Fulham Road and Palmerston Street with a maximum of 0.35m of water over the road near Tyrrell Street; • 0.3m of water over Palmerston Street near the intersection with Cambridge Street; • 0.2m of water over Palmerston Street near Hodges Crescent; • Fulham Road is inundated between Hutchins Street and Marangi Street with a maximum water depth of 0.35m at the intersection with Hanlon Street;

Event	Description
	• 0.7m of water over the intersection of Fulham Road and Croft Street; • 0.35m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park; and • Charles Street is inundated between Lindeman Avenue and Anne Street with a maximum depth of 0.45m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • immediately north of the Illich Park detention basin where velocities are up to 0.65m/s; • at the northern end of Lindeman Avenue where velocities are around 0.6m/s; • at the northern end of Farrell Street where velocities are 0.6m/s; and • at the northern end of Eckhoff Street where velocities are up to 0.8m/s.
50 Year ARI	Generally the critical duration event is: • 3 hours in the Illich Park Overflow immediately north of Charles Street; • 3 hours in the Western Heatley with 1.5 hours in Farrell Street and 24 hours upstream of Fulham Road; • 1 to 3 hours in the Northern Heatley area; and • 24 hour in Oliver Court. Flooding is widespread through properties with inundation of residential properties as follows: • 195 residential properties impacted in Heatley; and • 110 residential properties impacted in Vincent. There is no significant inundation of commercial properties. There is some inundation of the grounds of Vincent State School as well as some inundation of the Kindergarten on the corner of Nathan Street and Charles Street. There is some inundation of the areas of buildings at Heatley State School and Heatley Secondary School. Inundation of major roads includes: • 0.35m of water over Fulham Road near Oliver Court; • Cambridge Street is inundated between Fulham Road and Palmerston Street with a maximum of 0.4m of water over the road near Tyrrell Street; • 0.3m of water over Palmerston Street near the intersection with Cambridge Street; • 0.2m of water over Palmerston Street near Hodges Crescent; • Fulham Road is inundated between Nathan Street and Marangi Street with a maximum water depth of 0.4m at the intersection with Hanlon Street; • 0.75m of water over the intersection of Fulham Road and Croft Street; • 0.40m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park; and • Charles Street is inundated between Lindeman Avenue and Anne Street with a maximum depth of 0.50m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • immediately north of the Illich Park detention basin where velocities are up to 0.7m/s; • in Fulham Road near Lindeman Avenue where velocities are around 0.8m/s; • at the northern end of Farrell Street where velocities are 0.6m/s; and • at the northern end of Eckhoff Street where velocities are up to 1.0m/s.
100 Year ARI	Generally the critical duration event is: • 3 hours in the Illich Park Overflow immediately north of Charles Street; • 24 hours in the Western Heatley with 1.5 hours in Farrell Street and 1.5 - 2 hours upstream of Mill Drive; • 2 hours in the Northern Heatley area; and • 24 hour in Oliver Court. There is significant flooding through properties with inundation of residential properties as follows:

Event	Description
	• 220 residential properties impacted in Heatley; and • 125 residential properties impacted in Vincent. There are additional overflows from Cranbrook near Wanda Avenue in to Fulham Road. There is no significant inundation of commercial properties. There is some inundation of the grounds of Vincent State School as well as some inundation of the Kindergarten on the corner of Nathan Street and Charles Street. There is some inundation of the areas of buildings at Heatley State School and Heatley Secondary School. Inundation of major roads includes: • Fulham Road is inundated between Nathan Street and Anne Street with a maximum depth of 0.40m near Ashton Street; • Cambridge Street is inundated between Fulham Road and Palmerston Street with a maximum of 0.4m of water over the road near Tyrrell Street; • 0.35m of water over Palmerston Street near the intersection with Cambridge Street; • 0.2m of water over Palmerston Street near Hodges Crescent; • Fulham Road is inundated between Nathan Street and Boyes Court with a maximum water depth of 0.4m at the intersection with Hanlon Street; • 0.8m of water over the intersection of Fulham Road and Croft Street; • 0.40m of water over Fulham Road adjacent to the Fulham Road / Charles Street Park; and • Charles Street is inundated between Lindeman Avenue and Anne Street with a maximum depth of 0.50m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • immediately north of the Illich Park detention basin where velocities are up to 0.9m/s; • in Fulham Road near Lindeman Avenue where velocities are around 0.8m/s; • at the northern end of Farrell Street where velocities are 0.7m/s; and • at the northern end of Eckhoff Street where velocities are up to 1.1m/s.
200 Year ARI	Generally the critical duration event is: • 3 hours in the Illich Park Overflow immediately north of Charles Street; • 24 hours in the Western Heatley with 1.5 hours in Farrell Street and 1.5 - 2 hours upstream of Mill Drive; • 2 hours in the Northern Heatley area; and • 24 hour in Oliver Court. There is significant flooding through properties with inundation of residential properties as follows: • 245 residential properties impacted in Heatley; and • 150 residential properties impacted in Vincent. There is some inundation of the service station and shopping centre carpark at the corner of Nathan Street and Fulham Roads. There is also some inundation of the grounds of Vincent State School as well as inundation of the Kindergarten on the corner of Nathan Street and Charles Street. There is some inundation of the areas of buildings at Heatley State School and Heatley Secondary School. Inundation of major roads includes: • Fulham Road is inundated between Nathan Street and Anne Street with a maximum depth of 0.50m near Ashton Street; • Cambridge Street is inundated between Fulham Road and Palmerston Street with a maximum of 0.45m of water over the road near Tyrrell Street; • 0.40m of water over Palmerston Street near the intersection with Cambridge Street; • 0.3m of water over Palmerston Street near Hodges Crescent; • Fulham Road is inundated between Nathan Street and Adams Street with a maximum water depth of 0.45m at the intersection with Hanlon Street; • Fulham Road is inundated between Charles Street and north of Croft Street with a maximum depth of 0.8m at the intersection of Fulham Road and Croft Street;

Event	Description
	and • Charles Street is inundated between O'Callaghan Street and Anne Street with a maximum depth of 0.55m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.4m/s, with the following exceptions: • immediately north of the Illich Park detention basin where velocities are up to 0.9m/s; • in Fulham Road near Lindeman Avenue where velocities are around 0.9m/s; • at the northern end of Farrell Street where velocities are 0.7m/s; and • at the northern end of Eckhoff Street where velocities are up to 1.1m/s.
500 Year ARI	Generally the critical duration event is: • 24 hours in the Illich Park Overflow; • 1 - 2 hours in the Western Heatley with 24 hours around the intersection of Fulham Road and Croft Streets; • 2 hours in the Northern Heatley area; and • 24 hour in Oliver Court. There is significant flooding through properties with inundation of residential properties as follows: • 290 residential properties impacted in Heatley; and • 190 residential properties impacted in Vincent. There is some inundation of the service station and shopping centre carpark at the corner of Nathan Street and Fulham Roads. There is also some inundation of the grounds of Vincent State School as well as inundation of the Kindergarten on the corner of Nathan Street and Charles Street. There is some inundation of the areas of buildings at Heatley State School and Heatley Secondary School. Inundation of major roads includes: • Fulham Road is inundated between Nathan Street and Anne Street with a maximum depth of 0.55m near Ashton Street; • Cambridge Street is inundated between Fulham Road and Palmerston Street with a maximum of 0.50m of water over the road near Tyrrell Street; • 0.45m of water over Palmerston Street near the intersection with Cambridge Street; • 0.3m of water over Palmerston Street near Hodges Crescent; • Fulham Road is inundated between Nathan Street and Adams Street with a maximum water depth of 0.55m at the intersection with Nathan Street; • Fulham Road is inundated between Charles Street and north of Croft Street with a maximum depth of 0.85m at the intersection of Fulham Road and Croft Street; and • Charles Street is inundated between O'Callaghan Street and Anne Street with a maximum depth of 0.60m at the intersection with Nathan Street. Within residential and commercial areas flow velocities are under 0.4m/s, with the following exceptions: • north of the Illich Park detention basin where velocities are up to 0.9m/s; • in Fulham Road near Lindeman Avenue where velocities are around 0.95m/s; • at the northern end of Farrell Street where velocities are 0.7m/s; and • at the northern end of Eckhoff Street where velocities are up to 1.1m/s.
PMF	Generally the critical duration event is: • 24 hours for a majority of Heatley and Vincent; • 2 hours around Angus Avenue; • 2 hours around the Fulham Road / Charles Street Park; • 72 hours around Eckhoff and Farrell Streets because of overflows from Ross River through Kirwan. There is significant widespread flooding with depths up to 1.7m in Heatley and 1.1m in Vincent over lots. Inundation of residential properties is as follows: • 730 residential properties impacted in Heatley; and

Event	Description
	• 575 residential properties impacted in Vincent. There is inundation of all commercial areas within Heatley and Vincent, as well as significant inundation of all schools and Kindergartens. The aged care facility at the corner of Fulham Road and Nathan Street is impacted, however there are areas of the site that appear free of inundation. The major roads of Nathan Street, Fulham Road, Charles Street, Palmerston Street and Cambridge Street are all inundated for almost the entire lengths within Heatley and Vincent. Within residential and commercial areas flow velocities are under 0.7m/s, however there are some key areas of higher velocities: • Lindeman Avenue, Fulham Road, Hanlon Street; • Fulham Road, Frank Street, Eckhoff Street; • Downstream of Illich Park detention basin; • Vincent State School and Cambridge Street; • Mill Drive, Fulham Road, Hutchins Street; and • Tregarkis Street, Palmerston Street.

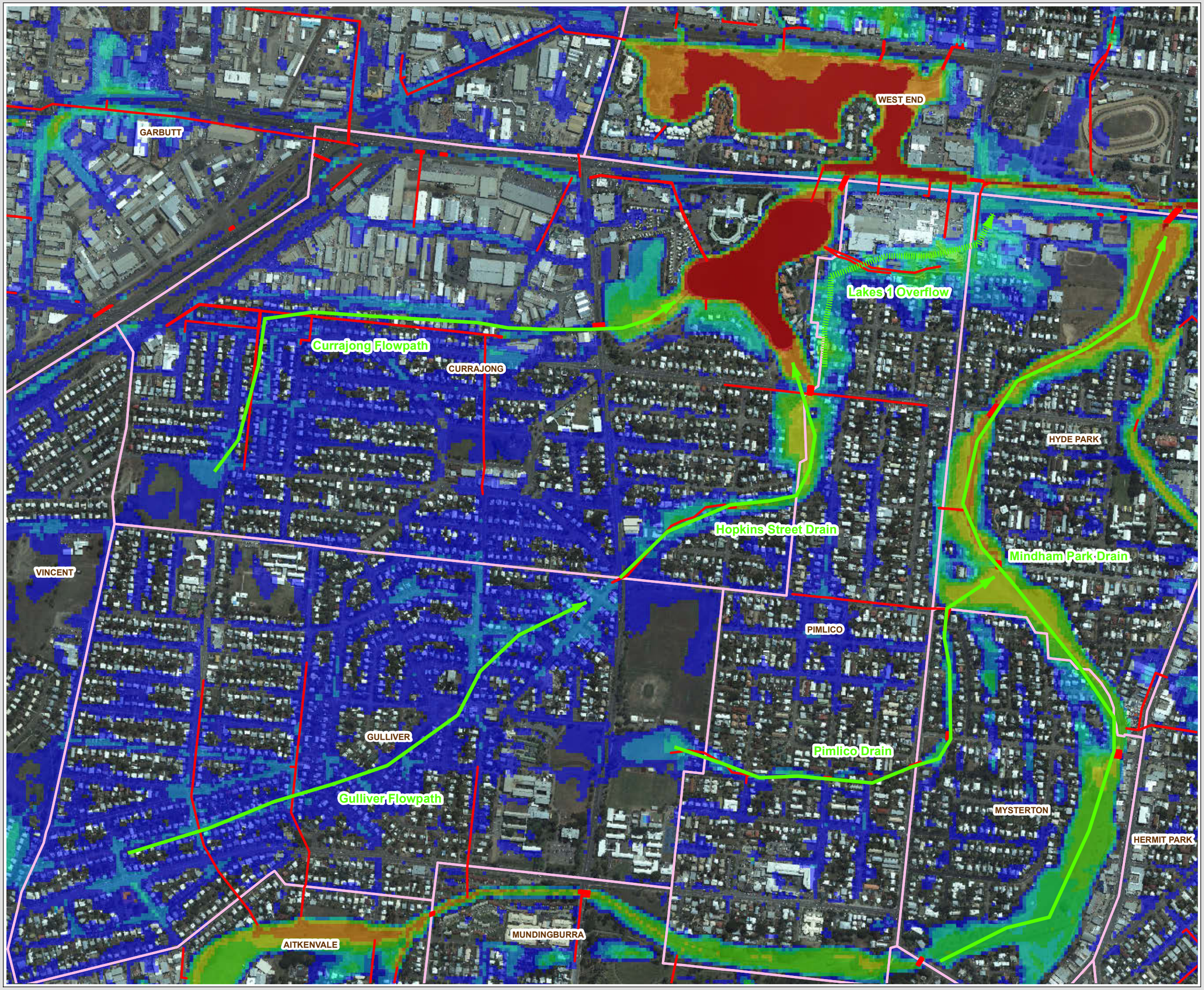
Gulliver/Currajong/Pimlico

Figure 5-6 outlines the key drainage features of the Gulliver/Currajong/Pimlico area. Flows from this area generally flow north east into Ross Creek via either the Lakes or Mindham Park Drain. In some locations within Gulliver underground drainage directs flows south towards Aitkenvale Drain. Gulliver and Currajong, as with Heatley and Vincent, have no significant open channels to convey major flows away from residential and commercial areas.

The key drainage flow paths within Gulliver, Currajong and Pimlico are:

- the Gulliver flowpath, which is a continuation of the Illich Park Overflows within Aitkenvale. Surface flows run generally north east through the streets of Gulliver towards the upstream end of Hopkins Street Drain at the intersection of Hugh Street and Palmerston Street;
- the Pimlico Drain which is an open channel that runs east through the southern portion of Pimlico before heading North through Mysterton and draining to Mindham Park Drain;
- the Currajong flowpath where surface flows generally run north through the streets of Currajong before heading east along Bayswater Road and Punari Street to Lakes 1;
- the Hopkins Street Drain, which is an open channel that runs north east from the around the Hugh Street/Palmerston Street intersection to the south arm of Lakes 1; and
- the Lakes 1 overflow where flows from Hopkins Street Drain divert east of Lake 1 at Bayswater Road through the northern portion of Pimlico then along Kings Road into Woolcock Canal.

A summary of the key flooding issues within the Gulliver/Currajong/Pimlico area relative to the ARI of floods is provided in **Table 5-6** following inspection of the flood mapping as presented in **Appendix D**.



ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-6

Gulliver/Currajong/Pimlico

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 13/09/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-6_Gu_Cj_Pm.mxd

Table 5-6 Gulliver / Currajong / Pimlico Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 24 hours in a majority of the Gulliver flow path area; • 24 hours in a majority of the Currajong flow path area; • 24 hours in the Hopkins Street Drain; • 1.5 to 3 hours in the Pimlico Drain; and • 72 hours in the Lakes 1 overflow area. Flooding is generally contained to road corridors, with the exception of areas in the north east of Gulliver, areas around the Hopkins Street drain and areas within the Lakes 1 overflow. Inundation of residential properties is as follows: • 8 residential properties impacted in Gulliver; • 45 residential properties impacted in Currajong; and • 20 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into some of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. Inundation of major roads includes: • 0.15m of water over Mooney Street at the intersection with Tyrell Street; • up to 0.2m of water over Mooney Street between Hammett Street and Bayswater Road; • 0.2m over Fulham Road at the intersection with Swanson Street; • 0.1m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • 0.15m of water over Palmerston Street near the intersection with McDougall Street; • 0.1m of water over Bayswater Road near Quandong Street; • up to 0.3m of water over Bayswater Road at the intersection with Reardon Street; • up to 0.15m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • 0.1m over Hugh Street at the intersection with Attlee Street; • 0.1m over Kings Road adjacent to Castletown Shopping centre; • up to 0.3m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.3m/s.
5 Year ARI	Generally the critical duration event is: • 24 hours in a majority of the Gulliver flow path area; • 24 hours in a majority of the Currajong flow path area; • 24 hours in the upstream of Grosvenor Street in Hopkins Street Drain and 12 hours between Grosvenor Street and Pegnall Street; • 24 hours for a majority of the Pimlico Drain then ; and • 72 hours in the Lakes 1 overflow area. Flooding is impacting more properties with inundation of residential properties as follows: • 15 residential properties impacted in Gulliver; • 60 residential properties impacted in Currajong; and • 40 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 10 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is inundation of the Townsville Museum within the Rotary Traffic Area park. Inundation of major roads includes: • 0.2m of water over Mooney Street at the intersection with Leeds and Tyrell

Event	Description
	Streets; • up to 0.25m of water over Mooney Street between Hammett Street and Bayswater Road; • 0.25m over Fulham Road at the intersection with Swanson Street; • Street; • 0.15m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • 0.2m of water over Palmerston Street near the intersection with McDougall Street; • 0.15m of water over Palmerston Street near Gill Park; • 0.2m of water over Palmerston Street at the intersection with Latchford Street; • up to 0.15m of water over Bayswater Road between Illuka and Warrina Streets; • 0.1m of water over Bayswater Road at the intersection with Ferguson Street; • up to 0.35m of water over Bayswater Road at the intersection with Reardon • water is just overtopping Bayswater Road at the upstream end of Lake 1 • up to 0.2m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • 0.1m of water over Hugh Street at the intersection with Corcoran Street; • 0.15m over Hugh Street at the intersection with Attlee Street; • 0.4m over Kings Road adjacent to Castletown Shopping centre; • up to 0.4m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.3m/s, with the exception of at the Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 0.9m/s.
10 Year ARI	Generally the critical duration event is: • 24 hours in a majority of the Gulliver flow path area; • 24 hours in a majority of the Currajong flow path area; • 24 hours upstream of Pegnall Street in the Hopkins Street Drain; • 24 hours for a majority of the Pimlico Drain; and • 72 hours in the Lakes 1 overflow area. Flooding is impacting more properties; however inundation of lots still appears to be backwater from streets rather than flows across lots, except in the Lakes 1 overflow area. The inundation of residential properties is as follows: • 40 residential properties impacted in Gulliver; • 75 residential properties impacted in Currajong; and • 50 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 13 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street. There is inundation of the Townsville Museum within the Rotary Traffic Area park. Inundation of major roads includes: • 0.25m of water over Mooney Street between Fulham Road and Brighton Street; • up to 0.3m of water over Mooney Street between Hammett Street and Bayswater Road; • 0.35m over Fulham Road at the intersection with Swanson Street; • Street; • 0.15m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • 0.25m of water over Palmerston Street near the intersection with McDougall Street; • 0.15m of water over Palmerston Street near Gill Park; • 0.25m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.4m.

Event	Description
	• 0.15m of water overtopping Bayswater Road at the upstream end of Lake 1; • 0.1m of water over Hugh Street between the TAFE and Pimlico High School; • up to 0.2m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • 0.15m of water over Hugh Street at the intersection with Corcoran Street; • 0.2m over Hugh Street at the intersection with Attlee Street; • up to 0.25m of water over Kings Road between Bayswater Terrace and Bayswater Road; • 0.55m over Kings Road adjacent to Castletown Shopping centre; • up to 0.55m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.0m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.1m/s; • within Harvey Street where velocities are up to 0.5m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 0.9m/s; • along Bayswater road within the Currajong flow path where velocities are up to 0.5m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 0.8m/s;
20 Year ARI	Generally the critical duration event is: • 24 hours in a majority of the Gulliver flow path area; • 24 hours in a majority of the Currajong flow path area; • 24 hours in the Hopkins Street Drain; • 24 hours for a majority of the Pimlico Drain; and • 72 hours in the Lakes 1 overflow area. Flooding is impacting more properties, with flows across lots becoming more prevalent. The inundation of residential properties is as follows: • 80 residential properties impacted in Gulliver; • 90 residential properties impacted in Currajong; and • 65 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 27 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street as well as inundation of the Kindergarten behind the Ambulance. There is inundation of the Townsville Museum within the Rotary Traffic Area park. Inundation of major roads includes: • 0.3m of water over Mooney Street between Fulham Road and Bristol Street; • up to 0.3m of water over Mooney Street between Goodwin Street and Bayswater Road; • 0.40m over Fulham Road at the intersection with Swanson Street; • Street; • 0.2m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • up to 0.3m of water over Palmerston Street between McDougall Street and Kent Street; • 0.15m of water over Palmerston Street near Gill Park; • 0.3m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.5m. • 0.25m of water overtopping Bayswater Road at the upstream end of Lake 1;

Event	Description
	• 0.1m of water over Hugh Street between the TAFE and Pimlico High School; • up to 0.2m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • 0.2m of water over Hugh Street at the intersection with Corcoran Street; • 0.25m over Hugh Street at the intersection with Attlee Street; • up to 0.45m of water over Kings Road between Palmerston Street and Bayswater Road; • 0.65m over Kings Road adjacent to Castletown Shopping centre; • up to 0.60m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.1m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.25m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 1.0m/s; • along Bayswater road within the Currajong flow path where velocities are up to 0.7m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 0.95m/s;
50 Year ARI	Generally the critical duration event is: • 24 hours in the Gulliver flow path area upstream of Mooney Street and 6 hours downstream of Mooney Street; • 2 to 3 hours in the Currajong flow path area; • 12 hours in the Hopkins Street Drain; • 2 hours for a majority of the Pimlico Drain; and • 18 hours in the Lakes 1 overflow area. Flooding is becoming wide spread with inundation of residential properties as follows: • 125 residential properties impacted in Gulliver; • 110 residential properties impacted in Currajong; and • 90 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 29 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street as well as inundation of the Kindergarten behind the Ambulance. There is inundation of the Townsville Museum within the Rotary Traffic Area park. There is inundation within Parks Street encroaching on the Mater Hospital. Inundation of major roads includes: • 0.35m of water over Mooney Street between Fulham Road and Bristol Street; • up to 0.35m of water over Mooney Street between Palmerston Street and Bayswater Road; • up to 0.45m over Fulham Road between Cambridge and Charles Streets; • Street; • 0.25m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • up to 0.3m of water over Palmerston Street between McDougall Street and Kent Street; • 0.20m of water over Palmerston Street near Gill Park; • 0.35m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.55m. • 0.30m of water overtopping Bayswater Road at the upstream end of Lake 1; • 0.1m of water over Hugh Street between the TAFE and Pimlico High School;

Event	Description
	• up to 0.25m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • 0.2m of water over Hugh Street at the intersection with Corcoran Street; • 0.3m over Hugh Street at the intersection with Attlee Street; • up to 0.65m of water over Kings Road between Palmerston Street and Bayswater Road; • 0.75m over Kings Road adjacent to Castletown Shopping centre; • up to 0.80m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.2m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.35m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 1.1m/s; • along Bayswater road within the Currajong flow path where velocities are up to 0.85m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 1.0m/s.
100 Year ARI	Generally the critical duration event is: • 24 hours in the Gulliver flow path; • 1.5 to 3 hours in the Currajong flow path area; • 24 hours in the Hopkins Street Drain; • 1.5 to 2 hours for the Pimlico Drain; and • 12 hours in the Lakes 1 overflow area. Flooding is wide spread with inundation of residential properties as follows: • 195 residential properties impacted in Gulliver; • 155 residential properties impacted in Currajong; and • 100 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 32 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street as well as inundation of the Kindergarten behind the Ambulance. There is inundation of the Townsville Museum within the Rotary Traffic Area park. There is inundation within Parks Street encroaching on the Mater Hospital. Inundation of major roads includes: • 0.35m of water over Mooney Street between Lonsdale Street and Tippett Street; • up to 0.35m of water over Mooney Street between Palmerston Street and Bayswater Road; • up to 0.50m over Fulham Road between Cambridge and Charles Streets; • Street; • 0.25m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • up to 0.3m of water over Palmerston Street between McDougall Street and Kent Street; • 0.20m of water over Palmerston Street near Gill Park; • 0.35m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.55m. • 0.55m of water overtopping Bayswater Road at the upstream end of Lake 1; • 0.1m of water over Hugh Street between the TAFE and Pimlico High School; • up to 0.25m of water on the northbound lanes of Hugh Street at the intersection

Event	Description
	with Palmerston Street; • up to 0.2m of water over Hugh Street between Corcoran Street and Palmerston Street; • 0.3m over Hugh Street at the intersection with Attlee Street; • up to 0.8m of water over Kings Road between Palmerston Street and Bayswater Road; • 0.9m over Kings Road adjacent to Castletown Shopping centre; • up to 1.1m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.3m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.4m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 1.1m/s; • along Bayswater road within the Currajong flow path where velocities are up to 0.9m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 1.2m/s; • at the intersection of McLean and Leeds Streets where velocities are up to 0.75m/s; and • within Harvey Street where velocities are around 0.6m/s.
200 Year ARI	Generally the critical duration event is: • 24 hours in the Gulliver flow path; • 1.5 to 2 hours in the Currajong flow path area; • 24 hours in the Hopkins Street Drain; • 1.5 to 2 hours for the Pimlico Drain; and • 12 hours in the Lakes 1 overflow area. There is significant wide spread flooding particularly through Gulliver and Currajong with inundation of residential properties as follows: • 270 residential properties impacted in Gulliver; • 200 residential properties impacted in Currajong; and • 120 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 32 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street as well as inundation of the Kindergarten behind the Ambulance. There is inundation of the Townsville Museum within the Rotary Traffic Area park. There is inundation within Parks Street encroaching on the Mater Hospital. Inundation of major roads includes: • 0.4m of water over Mooney Street between Lonsdale Street and Tippett Street; • up to 0.35m of water over Mooney Street between Palmerston Street and Bayswater Road; • up to 0.50m over Fulham Road between Cambridge and Charles Streets; • 0.25m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • up to 0.35m of water over Palmerston Street between McDougall Street and Kent Street; • 0.25m of water over Palmerston Street near Gill Park; • 0.35m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.55m. • 0.65m of water overtopping Bayswater Road at the upstream end of Lake 1;

Event	Description
	• 0.15m of water over Hugh Street between the TAFE and Pimlico High School; • up to 0.25m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • up to 0.2m of water over Hugh Street between Corcoran Street and Palmerston Street; • 0.35m over Hugh Street at the intersection with Attlee Street; • up to 0.9m of water over Kings Road between Palmerston Street and Bayswater Road; • 0.95m over Kings Road adjacent to Castletown Shopping centre; • up to 1.2m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.35m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.5m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 1.1m/s; • along Bayswater road within the Currajong flow path where velocities are up to 0.95m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 1.3m/s; • at the intersection of McLean and Leeds Streets where velocities are up to 0.8m/s; and • within Harvey Street where velocities are around 0.65m/s.
500 Year ARI	Generally the critical duration event is: • 24 hours in the Gulliver flow path; • 1.5 to 2 hours in the Currajong flow path area; • 24 hours in the Hopkins Street Drain; • 1.5 to 2 hours for the Pimlico Drain; and • 24 hours in the Lakes 1 overflow area. There is significant wide spread flooding with connectivity between the Gulliver and Currajong flow paths and overflows to the Pimlico Drain. Inundation of residential properties is as follows: • 385 residential properties impacted in Gulliver; • 260 residential properties impacted in Currajong; and • 140 residential properties impacted in Pimlico. There is inundation of areas of the Castletown site. There is also water that is encroaching into up to 38 of the commercial/industrial properties within northern Currajong from inundation within the streets. The entrance into the Mercure Inn and Lakes Caravan park are inundated along with about 20% of the Caravan Park site. The playing fields at the Rugby club on Hugh Street are inundated. Some of the grounds of Pimlico State High School are inundated. There is some inundation of portions of the Ambulance site on Hugh Street as well as inundation of the Kindergarten behind the Ambulance. There is inundation of the Townsville Museum within the Rotary Traffic Area park. There is inundation within Parks Street encroaching on the Mater Hospital. Some of the surgeries on Kings Road between Palmerston Street and Bayswater Road are inundated. Inundation of major roads includes: • 0.45m of water over Mooney Street between Lonsdale Street and Tippett Street; • up to 0.45m of water over Mooney Street between Palmerston Street and Bayswater Road; • up to 0.50m over Fulham Road between Cambridge and Charles Streets; • 0.25m of water over Palmerston Street near the intersection with Sussey Street and Tobruk Streets; • up to 0.35m of water over Palmerston Street between McDougall Street and Kent Street;

Event	Description
	• 0.3m of water over Palmerston Street near Gill Park; • 0.35m of water over Palmerston Street at the intersection with Latchford Street; • Bayswater Road is overtopped between Dalrymple and Reardon Street to a maximum depth of 0.6m. • 0.75m of water overtopping Bayswater Road at the upstream end of Lake 1; • 0.15m of water over Hugh Street between the TAFE and Pimlico High School; • up to 0.30m of water on the northbound lanes of Hugh Street at the intersection with Palmerston Street; • up to 0.25m of water over Hugh Street between Corcoran Street and Palmerston Street; • 0.40m over Hugh Street at the intersection with Attlee Street; • up to 1.1m of water over Kings Road between Palmerston Street and Bayswater Road; • 1.1m over Kings Road adjacent to Castletown Shopping centre; • up to 1.4m on the westbound lanes of Woolcock Street near Lakes 1 and Mercure Inn. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • Bayswater Road crossing upstream of Lakes 1, where velocities downstream of the culvert are up to 1.4m/s; • the Diprose Street crossing of the Pimlico Drain where velocities are up to 1.6m/s; • the Grosvenor Street crossing of Hopkins Street Drain where velocities are up to 1.1m/s; • along Bayswater road within the Currajong flow path where velocities are up to 1.0m/s; • in the vicinity of Reardon Street, upstream of the open channel in the Currajong flow path where velocities are up to 1.4m/s; • at the intersection of McLean and Leeds Streets where velocities are up to 0.9m/s; and • within Harvey Street where velocities are up to 0.75m/s.
PMF	Generally the critical duration event is 24 hours throughout Gulliver, Currajong and Pimlico except for some parts of southern Pimlico where the critical duration is 2 hours. There is significant widespread flooding with depths up to 1.0m in Gulliver, 2.3m in Currajong and 2.3m in Pimlico over lots. There are areas of southern Pimlico that remain clear of inundation. Inundation of residential properties is as follows: • 1165 residential properties impacted in Gulliver; • 1000 residential properties impacted in Currajong; and • 490 residential properties impacted in Pimlico. There is inundation of all commercial areas within Gulliver and Currajong, as well as significant inundation of all Kindergartens and most schools. Most of the buildings within the TAFE and Pimlico State High School are clear of inundation. The medical precinct around the Mater Hospital is free from significant inundation. The major roads of Mooney Street, Palmerston Street, Bayswater Road and Woolcock Street are all inundated for almost the entire lengths within Gulliver, Currajong and Pimlico. Some of the southern sections of Hugh Street and Kings Road as well as the eastern portion Fulham Road are clear of inundation. Within residential and commercial areas flow velocities are under 0.7m/s, however there are some key areas of higher velocities: • Western Fulham Road; • Parsons Street; • Harvey Street; • Hopkins Street; • The intersection of Vivian and Diprose Streets; • Gerard Street; • Corcoran Street; • Bayswater Road;

Event	Description
	• Sussey and Scott Streets • The intersection of Punari and Reardon Streets • Hugh Street at the crossing of the Currajong Open Drain; and • The intersection of Kings Road and Palmerston Street.

West End/Hyde Park

Figure 5-7 outlines the key drainage features of the West End/Hyde Park area. Flows from this area generally converge into the Lakes or Woolcock Canal before flowing eastward into Ross Creek. West End and Hyde Park are in the lower reaches of the Ross Creek catchment; however there are portions of West End with only local catchments on Castle Hill, upstream of the urban area.

The key drainage flow paths within West End and Hyde Park are:

- Mindham Park Drain which conveys upstream flow from the suburbs of Mysterton, Pimlico, Mundingburra, Aitkenvale and Cranbrook to Woolcock Canal;
- Hermit Park Drain which conveys upstream flow from Hermit Park Mindham Park Drain;
- The Quarry flow path which conveys water from Castle Hill, through a disused quarry along Margaret and Echlin Streets then across the show grounds to Woolcock Canal;
- Ross Creek, which flows North East through the CBD and Port of Townsville before discharging to Cleveland Bay;
- Cutheringa Park Drain, which conveys water from Castle Hill past the Green Street SES headquarters, through the north western area of West End, through Cutheringa Park before crossing Percy Street and discharging to Captains Creek.

Lake 1 acts as a detention basin for much of the stormwater flowing from the upstream catchments of Currajong, Gulliver, Pimlico, Vincent and Heatley. Outflows from Lake 1 flow into Woolcock Canal.

Lake 2 acts as additional detention storage in the upper reaches of Woolcock Canal. There are also some local catchments from West End that drain to Lake 2. When water levels within Lake 2 are high enough, there is an overflow back along an open drain in the south western section of West End and into Captains Creek.

With much of West End to the north of Ingham Road, the general grade of the land is south, away from Castle Hill. Ingham Road is much higher than land immediately to the north, and in this area there is a significant sump where flows cannot easily reach Lake 2.

A summary of the key flooding issues within the West End/Hyde Park area relative to the ARI of floods is provided in **Table 5-7** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-7

West End/Hyde Park

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 19/09/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-7_WE_HdP.mxd

Table 5-7 West End / Hyde Park Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • 72 hours in Lake 2 • 72 hours in Mindham Park Drain; • 72 hours in Hermit Park Drain; • 72 hours in Woolcock Canal; • 3 hours in Ross Creek; • 24 hours in the Quarry flow path; • 24 hours in the Cutheringa Park Drain; and • 24 to 72 hours in the Ingham Road sump. Flooding is mainly contained to road corridors and drainage paths with the exception of the Ingham Road sump. Inundation of residential properties is as follows: • 35 residential properties impacted in West End; and • 15 residential properties impacted in Hyde Park. There is minimal inundation of commercial/ industrial properties other than: • some lots backing on to the Quarry flow path; • some lots on Ingham Road backing on to the Ingham Road sump; and • some lots fronting Charters Towers Road impacted by localised ponding. Inundation of major roads includes: • minimal water on both eastbound and westbound lanes of Woolcock Street around the Hyde Park Centre; • 0.25m of water over Kings Road between Woolcock Street and Ingham Road; • minimal water on the southbound lanes of Percy Street near the intersection with Ralston Street; Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • velocities of up to 1 m/s in Mindham Park Drain; • velocities of up to 1.1m/s in Woolcock Canal; • velocities of up to 1.2m/s in the Quarry flow path; and • velocities of up to 1.5m/s in the Cutheringa Park drain.
5 Year ARI	Generally the critical duration event is: • 72 hours in Lake 2 • 72 hours in Mindham Park Drain; • 72 hours in Hermit Park Drain; • 72 hours in Woolcock Canal; • 2 hours in Ross Creek; • 1.5 hours in the Quarry flow path; • 1.5 to 2 hours in the Cutheringa Park Drain; and • 72 hours in a majority of the Ingham Road sump area. Flooding is extending beyond the road corridors and drainage paths with inundation of residential properties as follows: • 55 residential properties impacted in West End; and • 35 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots in the industrial area in northern Hyde Park; and • some lots around the Hyde Park Centre. Inundation of major roads includes: • up to 0.25m of water over Woolcock Street near the Hyde Park Centre; • 0.35m of water over Kings Road between Woolcock Street and Ingham Road; • 0.35 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; and • 0.2m of water on the southbound lanes of Percy Street near the intersection with

Event	Description
	Ralston Street. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • velocities of up to 1.1 m/s in Mindham Park Drain; • velocities of up to 1.1m/s in Woolcock Canal; • velocities of up to 1.35m/s in the Quarry flow path; and • velocities of up to 1.8m/s in the Cutheringa Park drain.
10 Year ARI	Generally the critical duration event is: • 72 hours in Lake 2 • 72 hours in Mindham Park Drain; • 72 hours in Hermit Park Drain; • 72 hours in Woolcock Canal; • 2 hours in Ross Creek; • 1.5 hours in the Quarry flow path; • 1.5 hours in the Cutheringa Park Drain; and • 18 hours in a majority of the Ingham Road sump area. Flooding with inundation of residential properties as follows: • 60 residential properties impacted in West End; and • 45 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots in the industrial area in northern Hyde Park; and • some lots around the Hyde Park Centre. Inundation of major roads includes: • up to 0.3m of water over Woolcock Street near the Hyde Park Centre; • 0.4m of water over Kings Road between Woolcock Street and Ingham Road; • 0.35 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.25m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 0.15m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.1m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • velocities of up to 1.15 m/s in Mindham Park Drain; • velocities of up to 1.1m/s in Woolcock Canal; • velocities of up to 1.4m/s in the Quarry flow path; and • velocities of up to 1.9m/s in the Cutheringa Park drain.
20 Year ARI	Generally the critical duration event is: • 72 hours in Lake 2 • 72 hours in Mindham Park Drain; • 72 hours in Hermit Park Drain; • 72 hours in Woolcock Canal upstream of Church Street and 12 hours downstream of Church Street; • 1.5 hours in Ross Creek; • 1.5 to 2 hours in the Quarry flow path; • 1.5 to 2 hours in the Cutheringa Park Drain; and • 18 hours in a majority of the Ingham Road sump area. Flooding with inundation of residential properties as follows: • 70 residential properties impacted in West End; and • 60 residential properties impacted in Hyde Park.

Event	Description
	There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots in the industrial area in northern Hyde Park; and • some lots around the Hyde Park Centre. Inundation of major roads includes: • up to 0.35m of water over Woolcock Street near the Hyde Park Centre; • 0.45m of water over Kings Road between Woolcock Street and Ingham Road; • 0.55 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.30m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 0.25m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.15m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • velocities of up to 1.25 m/s in Mindham Park Drain; • velocities of up to 1.2m/s in Woolcock Canal; • velocities of up to 1.5m/s in the Quarry flow path; and • velocities of up to 2.2m/s in the Cutheringa Park drain.
50 Year ARI	Generally the critical duration event is: • 18 hours in Lake 2 • 6 hours in Mindham Park Drain upstream of Bayswater Road and 12 hours downstream of Bayswater Road; • 12 hours in Hermit Park Drain; • 18 hours in Woolcock Canal upstream of Parkes Street and 12 hours downstream of Parkes Street; • 12 hours in Ross Creek; • 1 to 2 hours in the Quarry flow path; • 1 to 1.5 hours in the Cutheringa Park Drain; and • 18 hours in a majority of the Ingham Road sump area. Flooding becoming widespread with inundation of residential properties as follows: • 80 residential properties impacted in West End; and • 80 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots in the industrial area in northern Hyde Park; • some lots along Kings Road between Woolcock Street and Ingham; and • some lots around the Hyde Park Centre. There is some inundation of the grounds of Hermit Park State School. Inundation of major roads includes: • up to 0.5m of water over Woolcock Street near the Hyde Park Centre; • 0.55m of water over Kings Road between Woolcock Street and Ingham Road; • 0.55 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.50m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 0.50m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.2m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.5m/s, with the

Event	Description
	following exceptions: • velocities of up to 1.25 m/s in Mindham Park Drain; • velocities of up to 1.3m/s in Woolcock Canal; • velocities of up to 1.75m/s in the Quarry flow path; and • velocities of up to 2.4m/s in the Cutheringa Park drain.
100 Year ARI	Generally the critical duration event is: • 18 hours in Lake 2 • 24 hours in Mindham Park Drain upstream of Bayswater Road and 12 hours downstream of Bayswater Road; • 12 hours in Hermit Park Drain; • 12 hours in Woolcock Canal; • 12 hours in Ross Creek; • 1 to 1.5 hours in the Quarry flow path; • 1 hour in the Cutheringa Park Drain; and • 18 hours in a majority of the Ingham Road sump area. Flooding becoming more widespread with inundation of residential properties as follows: • 95 residential properties impacted in West End; and • 100 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path including the Showgrounds; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots adjacent to Hermit Park Drain fronting Charters Towers Road; • some lots in the industrial area in northern Hyde Park; • some lots along Kings Road between Woolcock Street and Ingham; • some lots around the Hyde Park Centre; and • some lots on Ingham Road between Sturt Street and Charters Towers Road. There is some inundation of the grounds of Hermit Park State School. Inundation of major roads includes: • up to 0.55m of water over Woolcock Street near the Hyde Park Centre; • 0.6m of water over Kings Road between Woolcock Street and Ingham Road; • 0.6 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.50m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 0.70m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.3m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • velocities of up to 1.25 m/s in Mindham Park Drain; • velocities of up to 1.5m/s in Woolcock Canal; • velocities of up to 1.8m/s in the Quarry flow path; and • velocities of up to 2.6m/s in the Cutheringa Park drain.
200 Year ARI	Generally the critical duration event is: • 12 hours in Lake 2 • 24 hours in Mindham Park Drain upstream of Albany Road and 12 hours downstream of Albany Road; • 12 hours in Hermit Park Drain; • 12 hours in Woolcock Canal; • 12 hours in Ross Creek; • 1 hour in the Quarry flow path; • 1 to 2 hours in the Cutheringa Park Drain; and • 18 hours in a majority of the Ingham Road sump area.

Event	Description
	Flooding is widespread in south-west West End and northern Hyde Park with inundation of residential properties as follows: • 115 residential properties impacted in West End; and • 125 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path including the Showgrounds; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots adjacent to Hermit Park Drain fronting Charters Towers Road; • most lots in the industrial area in northern Hyde Park; • some lots along Kings Road between Woolcock Street and Ingham; • some lots around the Hyde Park Centre; and • some lots on Ingham Road between Sturt Street and Charters Towers Road. There is some inundation of the grounds of Hermit Park State School. Inundation of major roads includes: • up to 0.6m of water over Woolcock Street near the Hyde Park Centre; • 0.65m of water over Kings Road between Woolcock Street and Ingham Road; • 0.65 m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.50m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 0.85m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.35m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.5m/s, with the following exceptions: • velocities of up to 1.35 m/s in Mindham Park Drain; • velocities of up to 1.5m/s in Woolcock Canal; • velocities of up to 1.9m/s in the Quarry flow path; and • velocities of up to 2.6m/s in the Cutheringa Park drain.
500 Year ARI	Generally the critical duration event is: • 24 hours in Lake 2 • 24 hours in Mindham Park Drain; • 24 hours in Hermit Park Drain; • 24 hours in Woolcock Canal; • 12 hours in Ross Creek; • 1 hour in the Quarry flow path; • 1 to 2 hours in the Cutheringa Park Drain; and • 2 hours in a majority of the Ingham Road sump area. Flooding is widespread in south-west West End, south-eastern West End around Woolcock Canal and northern Hyde Park with inundation of residential properties as follows: • 135 residential properties impacted in West End; and • 165 residential properties impacted in Hyde Park. There is the following inundation of commercial/ industrial properties: • some lots backing on to the Quarry flow path including the Showgrounds; • some lots on Ingham Road backing on to the Ingham Road sump; • some lots fronting Charters Towers Road impacted by localised ponding; • some lots adjacent to Hermit Park Drain fronting Charters Towers Road; • most lots in the industrial area in northern Hyde Park; • some lots along Kings Road between Woolcock Street and Ingham; • some lots around the Hyde Park Centre; and • some lots on Ingham Road between Sturt Street and Charters Towers Road. There is some inundation of the grounds of Hermit Park State School.

Event	Description
	Inundation of major roads includes: • up to 0.9m of water over Woolcock Street near the Hyde Park Centre; • 0.7m of water over Kings Road between Woolcock Street and Ingham Road; • 0.7m of water over the northbound lanes of Charters Towers Road at the intersection with Yeatman Street; • 0.50m of water on the southbound lanes of Percy Street near the intersection with Ralston Street; • 1.0m of water over Bayswater Road at the crossing of the Hermit Park Drain; and • 0.35m of water over Echlin Street near the intersection with Ingham Road. Within residential and commercial areas flow velocities are under 0.3m/s, with the following exceptions: • velocities of up to 1.6m/s in Mindham Park Drain; • velocities of up to 1.7m/s in Woolcock Canal; • velocities of up to 1.0m/s in the Quarry flow path; and • velocities of up to 2.7m/s in the Cutheringa Park drain.
PMF	Generally the critical duration event is 24 hours everywhere, except in the upper reaches of flow paths from Castle Hill. There is significant widespread flooding with inundation of residential as follows: • 435 residential properties impacted in West End; and • 420 residential properties impacted in Hyde Park. Almost all commercial properties within Hyde Park are impacted by inundation. Commercial properties are generally impact, west of Cowley Street/Kings Road or South of Ingham Road. Many of the buildings within Hermit Park State School are impacted by inundation. The Major Roads of Charters Towers Road, Woolcock Street and Percy Street are inundated for their entire length within West End and Hyde Park. Within residential and commercial areas flow velocities are under 0.7m/s, however there are some key areas of higher velocities: • Mindham Park Drain; • Woolcock Canal; • The Quarry flow path; • the area of Ingham Road / Leigh Street intersection; • Cutheringa Park Drain; • The area of Cowley Street / Francis Street intersection.

Townsville City

Figure 5-8 outlines the key drainage features of the Townsville City area. The estuary of Ross Creek traverses through Townsville City before discharging to Cleveland Bay. In the lower reaches, tail water levels become the dominant influence on flood levels and Storm Tides independent of flooding are likely to produce higher water levels. The central business district is on the north-western bank of Ross Creek and back up the slopes Castle Hill, Stanton Hill and Melton Hill. Local catchments from the CBD are steep and generally have short response times.

A summary of the key flooding issues within the Townsville City area relative to the ARI of floods is provided in **Table 5-8** following inspection of the flood mapping as presented in **Appendix D**.

ROSS CREEK FLOOD STUDY KEY FEATURES

Figure 5-8

Townsville City

LEGEND

Major Underground Drainage

- Underground Stormwater
- Suburbs

100 Y ARI Water Depth (m)

- 0.01 - 0.3
- 0.3 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 3
- 3 - 25

N

City of Townsville

SCALE: 1:10,000 @A3

100 50 0 100 200 300 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 14/08/2012

DATE PRINTED: 24/09/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-8_City.mxd

Table 5-8 Townsville City Area Flooding Issues

Event	Description
2 Year ARI	Generally the critical duration event is: • Between 18 and 72 hours in Ross Creek; • 72 hours in the Barlow Street Sump; and • 18 hours in the Morehead Street Sump. The only areas impacted by inundation within Townsville City will be some car parks and the low lying areas around Ogden and Hanran Streets. There is no inundation of major roads. Velocities within Ross Creek are reaching 0.5m/s.
5 Year ARI	Generally the critical duration event is: • Between 18 and 24 hours in Ross Creek; • 24 hours in the Barlow Street Sump; and • 12 hours in the Morehead Street Sump. The only areas impacted by inundation within Townsville City will be some car parks and the low lying areas around Ogden and Hanran Streets. There is no significant inundation of major roads. Velocities within Ross Creek are reaching 0.6m/s.
10 Year ARI	Generally the critical duration event is: • either 2 or 24 hours in Ross Creek; • 24 hours in the Barlow Street Sump; and • 12 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; and • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.2m of water over the eastbound lanes of Flinders Street West near Knapp Street; and • 0.2m of water over the westbound lanes of Flinders Street West near Morris Street. Velocities within Ross Creek are reaching 0.6m/s.
20 Year ARI	Generally the critical duration event is: • either 2, 12 or 24 hours in Ross Creek; • 24 hours in the Barlow Street Sump; and • 24 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.2m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.2m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.15m of water over the eastbound lanes of Sturt Street near Fletcher Street; • 0.15m of water over the eastbound lanes of Sturt Street between Stanley and Stokes Streets; and • 0.15m of water over the eastbound lanes of Flinders Street East near Denham Street. Velocities within Ross Creek are reaching 0.8m/s.

Event	Description
50 Year ARI	Generally the critical duration event is: • 12 hours in Ross Creek; • 6 hours in the Barlow Street Sump; and • 2 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; and • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.2m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.2m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.15m of water over the eastbound lanes of Sturt Street near Fletcher Street; • 0.2m of water over the eastbound lanes of Sturt Street between Stanley and Stokes Streets; and • 0.15m of water over the eastbound lanes of Flinders Street East near Denham Street. Velocities within Ross Creek are reaching 1.0m/s.
100 Year ARI	Generally the critical duration event is: • 2 or 18 hours in Ross Creek; • 6 hours in the Barlow Street Sump; and • 2 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; • some properties along Stanley Street, between Sturt and Flinders Street; and • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.2m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.25m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.15m of water over the eastbound lanes of Sturt Street near Fletcher Street; • 0.2m of water over Sturt Street between Stanley and Stokes Streets; and • 0.15m of water over the eastbound lanes of Flinders Street East near Denham Street. Velocities within Ross Creek are reaching 1.2m/s.
200 Year ARI	Generally the critical duration event is: • 18 or 24 hours in Ross Creek; • 24 hours in the Barlow Street Sump; and • 1.5 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; • some properties along Stanley Street, between Sturt and Flinders Street; • properties around Flinders Street East near Denham Street; and • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.2m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.25m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.15m of water over the eastbound lanes of Sturt Street near Fletcher Street; • 0.25m of water over Sturt Street between Stanley and Stokes Streets; and • 0.15m of water over the eastbound lanes of Flinders Street East near Denham

Event	Description
	Street. Velocities within Ross Creek are reaching 1.5m/s.
500 Year ARI	Generally the critical duration event is: • 2, 12 or 18 hours in Ross Creek; • 24 hours in the Barlow Street Sump; and • 1.5 hours in the Morehead Street Sump. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; • some properties along Stanley Street, between Sturt and Flinders Street; • properties around Flinders Street East near Denham Street; and • immediately north of the rail-line near Flinders Street. Inundation of major Roads includes: • 0.25m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.30m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.15m of water over the eastbound lanes of Sturt Street near Fletcher Street; • 0.25m of water over Sturt Street between Stanley and Stokes Streets; and • 0.2m of water over the eastbound lanes of Flinders Street East near Denham Street. Velocities within Ross Creek are reaching 1.6m/s.
PMF	Generally the critical duration event is 24 hours in low-lying areas and 2 hours in the areas back up through the CBD. The areas impacted by inundation within Townsville City are: • low lying areas around Ogden and Hanran Streets; • properties along Stanley Street, between Sturt and Flinders Street; • properties around Flinders Street East near Denham Street; • Properties along a flow path between Denham and Stokes Streets; • immediately north of the rail-line near Flinders Street; and • the area between Knapp and Fletcher Streets, upstream to Sturt Street. Inundation of major Roads includes: • 0.3m of water over the eastbound lanes of Flinders Street West near Knapp Street; • 0.50m of water over the westbound lanes of Flinders Street West near Morris Street; • 0.3m of water over Sturt Street near Fletcher Street; • 0.25m of water over Sturt Street near Knapp Street; • 0.4m of water over Sturt Street between Stanley and Stokes Streets; • 0.15m of water over Sturt Street between Stokes and Denham Streets; and • 0.25m of water over the eastbound lanes of Flinders Street East near Denham Street. Velocities within Ross Creek are over 2.4m/s.

5.2 Hydraulic Grade Line

Results of the flood modelling have been used to derive hydraulic grade lines for the major open channels within the study area. Long-sections showing these hydraulic grade lines are provided in **Appendix E**. The locations of flow paths for the hydraulic grade lines are provided in **Figure 5-9**. Note that the chainages for all flow paths start at the downstream end of the branches shown in **Figure 5-9**.

Review of the hydraulic grade-line results identifies the following issues:

Ross Creek
The greatest head-losses are across:

- Denham Street;
- Lowths Bridge;
- The Railway Station; and
- Boundary Street.

All bridges downstream of Boundary Street have greater than 500 Year ARI immunity.

Goondi Creek
There are minimal head-losses across Samphire Drive. Samphire Drive has greater than 50 Year ARI immunity.

Woolcock Canal
There are significant head-losses across both Charters Towers Road and Sturt Street. Kings Road has less than 2 Year ARI immunity and both Charters Towers Road and Sturt Street have greater than 500 Year ARI immunity at the crossings.

Mindham Park Drain
The greatest head-losses are across:

- Bayswater Road; and
- Townsend Street.

Flood immunities of the major crossings are:

- Bayswater Road - 20 Year ARI;
- Bayswater Terrace - 2 Year ARI; and
- Townsend Street - less than 2 Year ARI.

Anderson Park Drain
There is significant head-loss Gulliver Street. Flood immunities of the major crossings are:

- Balls Lane- 5 Year ARI; and
- Gulliver Street - 100 Year ARI.

Aitkenvale Drain
There is a significant head-loss through the pipe system under the Vale hotel and Ross River Road. Flood immunities of the major crossings are:

- Armit Street- 2 Year ARI; and
- Ross River Road - 5 Year ARI.

Hopkins Street Drain
Grosvenor Street has less than 2 Year ARI immunity.

Hermit Park Drain
The hydraulic grade-lines in the Hermit Park Drain show three distinct phases on flooding:

- Backwater flooding (up to 200 Year ARI), where flood levels are controlled from tail-water levels in Mindham Park Drain with very little change in hydraulic grade back up the system;
- Ross River flooding (500 Year ARI and above), where overflows from the Ross River flow into Hermit Park elevating flood levels above those of the Mindham Park tail-water levels; and
- Catchment surcharge conditions (observed in the PMP), where the lowest flood levels in the drain are around Charters Towers Road as floodwaters surcharge out of the Hermit Park Drain northwards along Charters Towers Road.

Flood immunities of the major crossings are:

- Bayswater Road - less than 2 Year ARI;
- Charters Towers Road - 10 Year ARI; and
- Marks Street / Roberts Street intersection - less than 2 Year ARI.

Rosslea Drain
For events greater than and equal to the 10 Year ARI, flood levels downstream of Bowen Road are generally controlled by Ross River tail-water level. There is significant head-loss across Bowen Road for all events up to the 500 Year AR when Ross River tail-water levels drown out the effect of the crossing.

Flood immunities of the major crossings are:

- Lindsay Street - 2 Year ARI;
- Hodel Street - less than 2 Year ARI; and
- Bowen Road - 200 Year ARI.

Pimlico Drain
Within Pimlico Drain, there is typically 300mm increase in water levels between design floods up to the 20 Year ARI. Beyond the 20 Year ARI, there is notably less increase in flood level within increasing flood magnitude. Almost all crossing have significant head-losses other than low immunity crossing of Park Street.

Flood immunities of the major crossings are:

- Mindham Street - 10 Year ARI;
- Townsend Street - 100 Year ARI;
- Kings Road - 20 Year ARI;
- Cheynne Street - 10 Year ARI;
- Park Street - 5 Year ARI; and
- Diprose Street - 5 Year ARI.

Currajong Drain
There is significant head-loss across Hugh Street.

Lakes II Overflow
Hydraulic grade lines along the Lakes II Overflow are flat and result from flood levels in Lake II. There is head-loss across both Ingham Road and Tuffley Street for events greater than 20 Year ARI.

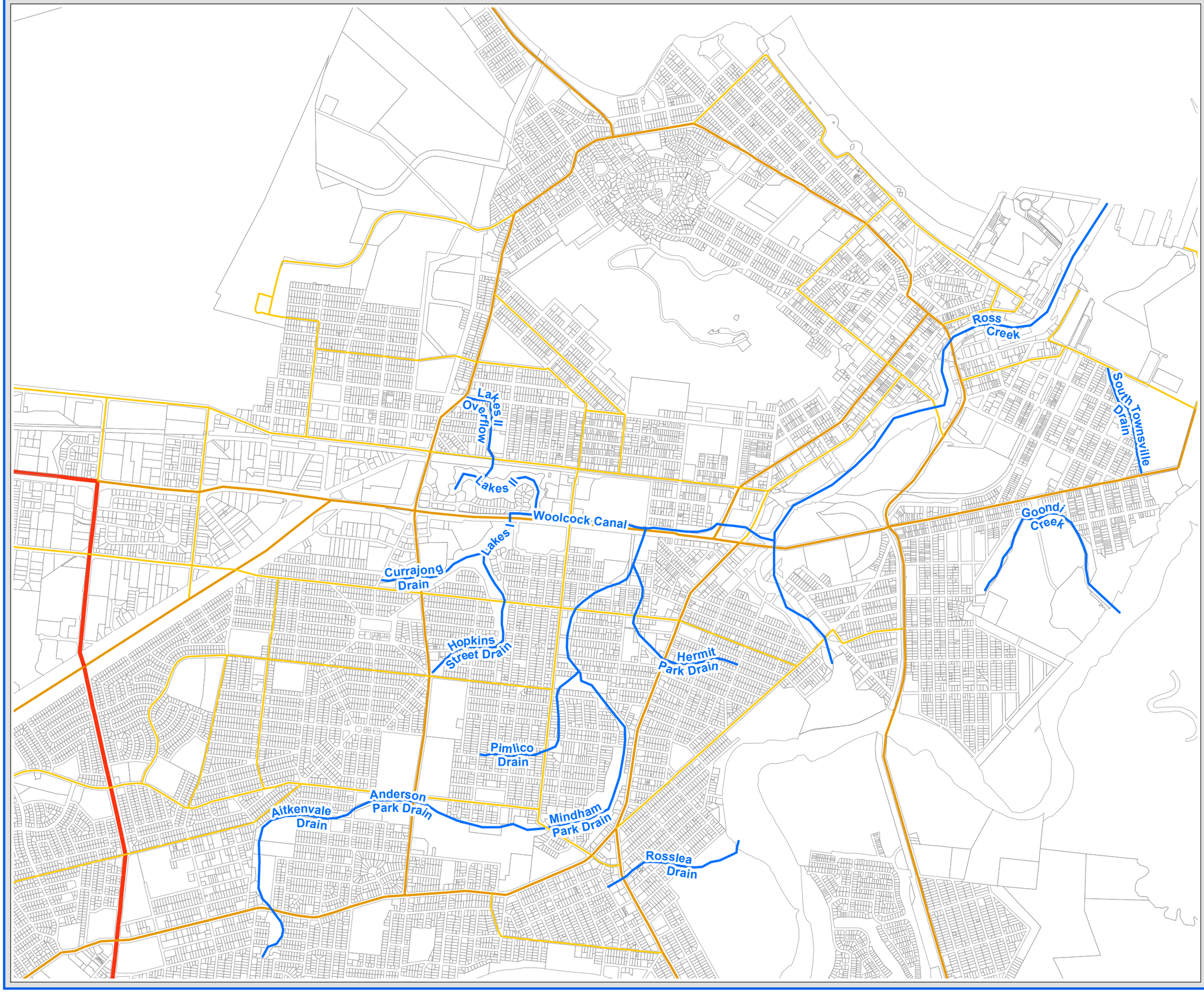
Flood immunities of the major crossings are:

- Ingham Road - greater than 500 Year ARI; and
- Tuffley Street - 50 Year ARI.

Northern Kirwan Drain
The hydraulic grade line upstream of Dalrymple Road is quite flat. The intersection of Dalrymple Road and Banfield Drive has high flood immunity.

ROSS CREEK FLOOD STUDY HGL LOCATIONS

Figure 5-9



LEGEND

Hydraulic Grade Line Locations

N

City of Townsville

SCALE: 1:25,000 @A3

400 200 0 400 800 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 08/10/2012

DATE PRINTED: 8/10/2012

DRAWN BY: WBB

DIGITAL FILE: RossCreek_Fig5-9_HGLLocations

5.3 Flow Distributions

Flows about the Ross Creek floodplain have been determined from the results of the Ross Creek flood model. Maximum flows for given ARIs are provided in **Table 5-9** for the locations shown in **Figure 5-10**. Note that the maximum flows provided are the maximum of the peak flows for all duration storm events for the given ARIs. The peak flows for all storm durations are given in **Appendix F**.

Table 5-9 - Peak Flow Distribution Results

	Peak Flow (m^3/s)								
Location	**2 Year ARI**	**5 Year ARI**	**10 Year ARI**	**20 Year ARI**	**50 Year ARI**	**100 Year ARI**	**200 Year ARI**	**500 Year ARI**	**PMF**
1	0.1	2.1	4	6.7	8.9	11.5	14.5	18.7	97.3
2	4.6	7.1	8.5	10.5	13.3	15.8	18.5	22.4	57.1
3	0.6	2.8	4.2	6.6	8.6	11.2	14	17.9	93.9
4	0.01	1.7	3.8	6.3	8.5	11.2	14.4	18.4	92.8
5	0	0.8	2	3.8	5.1	6.8	8.8	11.5	75.5
6	13.8	19.9	24.2	30.6	35.5	42	49	59	279.1
7	0	0	0	0.2	1.2	2.3	3.4	5.4	52.1
8	0	0.1	0.1	0.3	0.5	0.6	1	2.5	110.6
9	0.3	0.4	0.3	0.4	0.4	0.4	9.1	38.3	590.3
10	14	20	24.3	30.5	35.5	42	49	59	216.3
11	19	24.6	28.2	33	38.2	45.1	52.4	61.6	333.8
12	1.8	2.4	2.8	3.7	4.5	5.5	8	13	166.1
13	20.4	27.1	31.7	37.9	44	51.7	61.6	75.6	498
14	16.5	25.3	31.2	38.8	47.2	57.5	69.4	86.5	431

Location	Peak Flow (m^3/s)								
	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMF
15	24.1	31.7	35.9	41.3	49.1	59.3	71.1	88.2	316.5
16	27.8	34.5	39	43.5	52.1	58.5	64.6	72.4	195.6
17	6.6	7.2	7.2	7.6	7.9	9.2	11.5	27.4	98.3
18	55.4	75.3	82.9	96.5	110.2	139.8	149.4	192.4	569.3
19	57.3	75.9	85.7	101	118.7	141.5	157.2	199.6	758
20	59	79.8	88.4	102.3	119.6	140.6	158.4	199.6	979.6
21	0.6	2.8	5.7	9.2	11.9	14.7	17.5	21.3	90.4
22	4.5	7.7	9.9	12.6	16.2	19.2	23.2	29.2	188.1
23	4	6.6	8.2	10.6	12.8	15.9	19.5	24	79.5
24	1.9	3.7	4.9	6.4	8.1	10.6	12.9	15.7	65.4
25	1.7	3.1	4	5.3	7.1	9	10.6	12.2	38.2
26	1.8	2.6	3.2	4.5	6.3	8.4	10.7	14.1	103.3
27	1.6	2.5	3.1	4	4.8	5.6	6.5	7.8	26.2
28	2.1	3.8	6.4	9.9	12.6	16	19.4	24.1	118.2
29	8.7	13.3	16.4	20.3	23.6	26.9	29.4	33.3	106.3
30	1.2	2	2.7	3.9	5.7	7.8	10.4	14.4	134.8
31	15.1	20.8	24.5	29.7	35.3	39.1	44.5	51.1	116.7

Location	Peak Flow (m^3/s)								
	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMF
32	44.4	58.4	66.6	76.8	91.1	107.9	124.9	135.3	309.8
33	0	0	0	0.8	1.9	3.3	4.6	27.1	84
34	0.2	0.7	1.1	1.6	2.8	4.5	6.3	32.4	165.7
35	2.8	6.3	8.6	11.6	14.1	17	19.9	23.8	105.3
36	7.5	12.4	14.9	20.5	24.7	30.2	36.3	44.6	121.9
37	1.7	5.2	7.4	12.6	16.5	21.9	28	36.4	149.2
38	0	0.2	1.9	4.8	8.1	11.8	16	21.7	132.2
39	0.4	0.6	1.3	2.4	3.3	4.4	5.6	7.4	43.7
40	1.3	2.5	3.5	4.7	5.9	7.2	8.6	10.3	35.1
41	1.6	2.7	3.5	4.5	5.5	6.6	7.8	9.4	87.6
42	1.1	2.6	3.9	5.4	7.1	8.9	10.7	13.1	51.6
43	0.9	2.1	2.9	3.9	5	6.3	7.7	10.2	59.1
44	1.5	2.4	3	3.7	4.6	5.5	6.4	7.7	40.4
45	1.7	2.7	3.4	4.3	5.4	6.5	7.6	9.2	119.3
46	1.7	2.2	2.7	3.4	4.1	4.8	5.6	6.6	176.5
47	0.8	1.3	1.7	2.5	3	3.8	4.5	5.8	113.6
48	2.4	4.7	4.7	7.6	10.9	9.9	12.4	12.4	53.7
49	4.4	6.9	8.6	10.9	13.2	17.6	17.7	21	43.9

Location	Peak Flow (m^3/s)								
	2 Year ARI	5 Year ARI	10 Year ARI	20 Year ARI	50 Year ARI	100 Year ARI	200 Year ARI	500 Year ARI	PMF
50	7.9	7.9	10.3	12.9	15.6	19.4	20.2	23.3	58.1
51	2.8	4.1	4.9	7.3	9.4	12	14.9	18.9	72.3