Townsville

TOWNSVILLE CITY COUNCIL

ALTHAUS CREEK FLOOD STUDY
BASE-LINE FLOODING ASSESSMENT

Volume 1
FEBRUAY 2014

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Executive Summary

The *Althaus 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 for the Althaus Creek floodplain including the suburbs of Saunders Beach, Purono Park, Bluewater and Yabulu.

The study developed and calibrated a MIKE FLOOD coupled two-dimensional / one-dimensional hydraulic model. The model represents the topography and drainage systems of the Althaus Creek floodplain, including:

- a digital elevation model resolved to a 10m grid;
- representation of the influence of Bluewater Creek and Black River on flooding in the study area;
- open drains narrower than the 10m grid resolution using one-dimensional branches; and
- application of rainfall directly onto the model grid.

The flood model has been used to assess design storm flood events for the 2, 5, 10, 20, 50, 100 and 500 Year Average Recurrence Intervals (ARI) as well as the Probable Maximum Precipitation flood event. The 2 and 24 hour duration design storm events were determined to be critical duration across most of the 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 Althaus 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 some increases in the lower reaches of Alick Creek, with little impact on flood levels within Althaus Creek.

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 show increases in flood levels of between 100 mm and 300 mm around the study watercourses with localised increases above 500mm in Black River around the Bruce Highway. In areas of the study area subject to inundation from local runoff rather than floodplain inundation, increases in flood levels area generally below 50mm.

Table EX-1 – Summary of Althaus Creek Flooding Results

Event	Indicative Rainfall	Road Overtopping	Flooding Description
2 Year ARI	192mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road	Inundation contained to watercourses and lower floodplain around confluence of Healy Creek and Althaus Creek Significant ponding near Greenvale Rail line in Yabulu Some connectivity between Bluewater Creek and Althaus Creek in lower reaches
5 Year ARI	93mm in 2 hours 257mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road **Saunders Beach Road** **James Street, Western Gully**	Overbank flows forming around Althaus Creek Some inundation of lots in Purono Park from local runoff Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway Connectivity between Bluewater Creek and Althaus Creek in lower reaches
10 Year ARI	107mm in 2 hours 297mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully **Bruce Highway, Healy Creek Overflow**	Overbank around Althaus Creek becoming extensive with up to 1km of floodplain More inundation of lots in Purono Park from local runoff Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway Connectivity between Bluewater Creek and Althaus Creek in lower reaches
20 Year ARI	122mm in 2 hours 348mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully Bruce Highway, Healy Creek Overflow **McKinnon Road, Southern Crossing**	Overflow from Althaus Creek to Healy Creek forms immediately north of Purono Park Connectivity between Bluewater Creek and Healy Creek in lower reaches with inundation between Bluewater Drive and Saunders Beach Road. More inundation of lots in Purono Park from local runoff Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway with depths over 1m.
50 Year ARI	143mm in 2 hours 417mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully Bruce Highway, Healy Creek Overflow McKinnon Road, Southern Crossing **Bluewater Drive, Near James Street** **Purono Parkway near North Coast Rail-line**	Overflow from Althaus Creek to Healy Creek starts to flow through residential lots in Purono Park. Overflows from Bluewater Creek towards Althaus Creek with inundation of residential lots in Bluewater. Connectivity between Bluewater Creek and Healy Creek in lower reaches with inundation between Bluewater Drive and Saunders Beach Road. Flood flows through lower areas of Saunders Beach impacting residential lots. Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway with depths to 1.5m.
100 Year ARI	118mm in 1 hour 141mm in 1.5 hours 159mm in 2 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway	Overflow from Althaus Creek to Healy Creek is extensive with numerous residential lots inundated in Purono Park. Overflows from Bluewater Creek are extensive with inundation of most residential lots in

Event	Indicative Rainfall	Road Overtopping	Flooding Description
	189mm in 3 hours 253mm in 6 hours 340mm in 12 hours 412mm in 18 hours 470mm in 24 hours 637mm in 48 hours	Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully Bruce Highway, Healy Creek Overflow McKinnon Road, Southern Crossing Bluewater Drive, Near James Street Purono Parkway near North Coast Rail-line **Percheron Place**	Bluewater. Connectivity between Bluewater Creek and Healy Creek in lower reaches with inundation between Bluewater Drive to east of Saunders Beach Road. Flood flows through lower areas of Saunders Beach impacting residential lots. Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway with depths greater than 1.5m.
500 Year ARI	207mm in 2 hours 801mm in 24hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully Bruce Highway, Healy Creek Overflow McKinnon Road, Southern Crossing Bluewater Drive, Near James Street Purono Parkway near North Coast Rail-line Percheron Place **McKinnon Road, Northern Crossing** **Bruce Highway, Althaus Creek**	Overflow from Althaus Creek to Healy Creek is extensive with all residential lots north of the Rail line in Purono Park inundated. Overflows from Bluewater Creek are extensive with inundation of all residential lots in Bluewater. Extensive Connectivity between Bluewater Creek and Healy Creek in lower reaches with inundation between Bluewater Drive to east of Saunders Beach Road. Flood flows through lower areas of Saunders Beach impacting residential lots. Significant ponding near Greenvale Rail line in Yabulu and upstream of Bruce Highway with depths to 2.0m. Overflows from Black River into Alick Creek, with substantial inundation north of Bruce Highway.
PMF	520mm in 2 hours 1700mm in 24 hours	Black River Road – Aurora Drive Causeway Black River Road, Northern Causeway Purono Parkway Mill Road, Healy Creek Bruce Highway, Greenvale Rail McKinnon Road, Near Black River Road Saunders Beach Road James Street, Western Gully Bruce Highway, Healy Creek Overflow McKinnon Road, Southern Crossing Bluewater Drive, Near James Street Purono Parkway near North Coast Rail-line Percheron Place McKinnon Road, Northern Crossing Bruce Highway, Althaus Creek	50% of lots in Saunders Beach Extensive flooding between Bluewater Creek and ridge line with Nickel Refinery. All residential lots impacted in Purono Park with flooding depths up to 2m. Some impact of Alick Creek floodplain inundation encroaching Nickel Refinery.

Glossary

AEP	Annual Exceedance Proability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
AVM	Average Variability Method
BoM	Bureau of Meteorology
CL	Continuing Loss
DEM	Digital Elevation Model
DEHP	Department of Environment and Heritage Protection
DFE	Defined Flood Event
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
IL	Initial Loss
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
XP-RAFTS	An urban and rural runoff-routing hydrologic model

1.0 Introduction

1.1 Overview

The *Althaus 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 Bluewater and Black River areas, 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 floodplain area between Black River and Bluewater Creek.

1.2 Study Area

The Althaus Creek catchment is 101 km^2 in size and is located approximately 25 km north of Townsville. In the late nineteenth century the site was described by surveyors as inferior grazing country with poor sandy soil covered by tea trees, wattle, bloodwood and ironbark. Today the site exhibits much similar bushland, however is home to small residential developments of Purono Parkway, Yabulu, Saunders Beach and Bluewater. A key feature of the study area is the Yabulu Nickel Refinery.

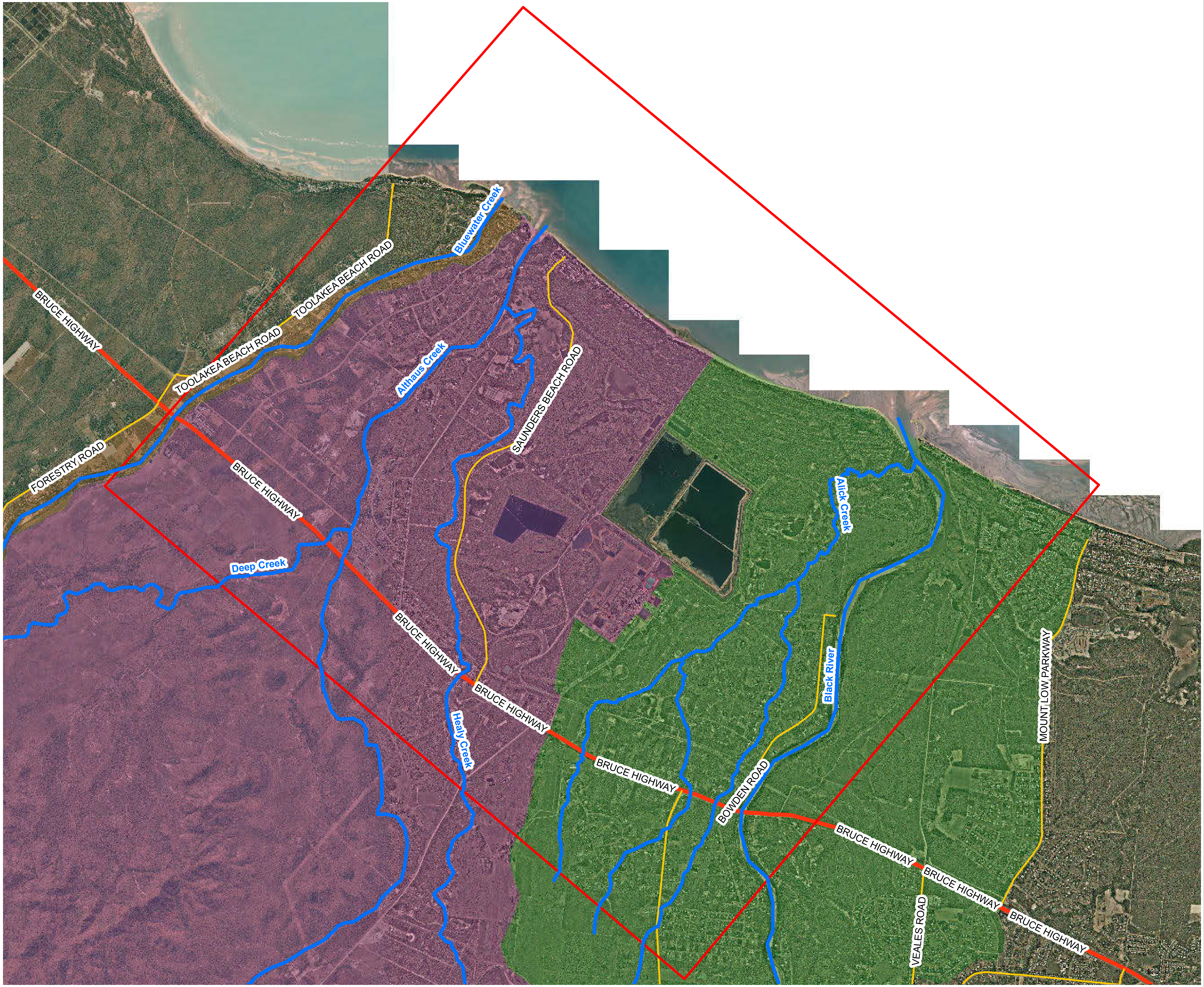
The headwaters of the creek are within the suburbs of Lynam and Black River. Althaus Creek and its main two tributaries of Deep Creek and Healy Creek separate the suburbs of Yabulu, Bluewater and Saunders Beach. Althaus Creek discharges to the coastal waters of Halifax Bay approximately 750 m south-east of the mouth of Bluewater Creek. Topography across the study area varies significantly, with mountainous ranges up to 600 m AHD in the headwaters and extensive low lying salt-plains near the coast.

The North Coast Rail Line crossing of Althaus Creek is 5.7 km upstream of the mouth. The Bruce Highway bridge crossing is a further 450 m upstream of the Rail bridge. There is also a highway bridge at Deep Creek about the same distance upstream of the rail bridge as the Althaus Creek highway crossing. There is both a rail bridge and highway bridge across Healy Creek.

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

ALTHAUS CREEK FLOOD STUDY STUDY AREA

Figure 1-1



LEGEND

- Waterways
- MIKE FLOOD Model Extent

Major Sub-Catchments

- Althaus Creek
- Black River
- Bluewater Creek

N

City of Townsville

SCALE: 1:50,000 @A3

400200 0 400 800 Metres

DISCLAIMER

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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;
- verification of the hydrologic model of Althaus Creek;
- development and verification of Althaus Creek hydraulic model; and
- reporting the base-line flooding determined for Atlthaus Creek.

1.4 Study Approach

This *Baseline Flooding Assessment* has been prepared from raw data, as well as previous flood studies including the Bluewater Creek Flood Study and Black River Flood Study.

The hydrologic approach employed a combination of rainfall runoff modelling (XP-RAFTS) and 'Rain on Grid' to represent runoff within the study area. XP-RAFTS hydrographs for upstream catchments were used as boundary inflows for the 'Rain-on-grid' model within the MIKE FLOOD software package. Within portions of the MIKE FLOOD model with steep grades, source point inflows representing runoff from sub-catchments within the XP-RAFTS model were applied to prevent model instabilities with the 'Rain on Grid' approach.

The Althaus Creek hydraulic model is a two-way coupled MIKE FLOOD model representing two-dimensional floodplain topography using MIKE21 and one-dimensional narrow flow paths and structures using MIKE11.

Calibration of the Althaus Creek model was not undertaken as there is no stream gauging available on the Althaus Creek system. Instead flood levels along reaches of Black River and Bluewater Creek represented in the Althaus Creek model were matched to previous calibrated flood model results. Furthermore head-loss checks for the major waterway crossings were completed using HEC-RAS.

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 Stream and Rainfall Records

There are significant historical rainfall records for gauges in and around the Althaus Creek catchment. Without the stream gauges for a calibration match against real flood events, there is no need for sourcing historical rainfall gauges as part of the flood study. While the rainfall records have been sourced for interest, they have no bearing on the flood study and have not been presented here. The largest rainfall event on record in the area is the January 1998 event, consistent with what was identified in the Bluewater Creek and Black River Flood Studies.

2.2 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;
- Thuringowa City Council photogrammetry obtained around 2001 was used to supplement the 2009 LiDAR in areas around watercourses.
- Hydrographic survey of the Black River Estuary obtained by Townsville City Council Surveyors; and
- Cross-sectional survey of Bluewater Creek obtained as part of the 2001 Bluewater Creek Flood Study; and
- Bathymetric data compiled by the Great Barrier Reef Marine Park Authority for the Queensland Basin (e-atlas.org.au) .

Broad-scale contours over the study area digitised from 1:100,000 series topographic maps have also been used.

2.3 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 5th July 2013.

2.4 Structure Design Drawings

Drawings have been sourced for the bridge and culvert crossing from Transport and Main Roads (TMR), Queensland Rail (QR) or council records 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. Details of the culverts and bridges include in the MIKE FLOOD model are provided in **Table 2-1**.

Table 2-1 Hydraulic Model Structures

Structure Name	Description	Upstream Invert (m AHD)	Downstream Invert (m AHD)
AlickCk_Rail	Railway Bridge	9.29	
Alick_Trib1Rail	Railway Bridge	11.11	
Alick_Trib2Rail	Railway Bridge	8.84	
Alick_Trib3Rail	Railway Bridge	9.06	
Alt_Trib1Rail	Railway Bridge	7.30	
AlthausHwy	Bruce Highway Bridge	4.50	
AlthausRail	Railway Bridge	3.31	
BlackR_Hwy	Bruce Highway Bridge	4.97	
BlackR_Rail	Railway Bridge	4.44	
Bluewater_Ped	Pedestrian Bridge	8.16	
BluewaterCk_Hwy	Bruce Highway Bridge	8.00	
BluewaterCk_Rail	Railway Bridge	7.76	
DeepHwy	Bruce Highway Bridge	5.19	
Healy_Hwy	Bruce Highway Bridge	8.40	
Healy_Rail	Railway Bridge	7.87	
Alick_Trib1Hwy	4/3000 x 1500 RCBC – Bruce Hwy	13.42	13.38
Alick_Trib1McKinnon	2/1200 dia RCP – McKinnon Rd	14.92	14.85
Alick_Trib2Hwy	3/1200 dia RCP – Bruce Hwy	13.7	13.4
Alick_Trib3aHwy	3/1675 dia RCP – Bruce Hwy	11.87	11.6
Alick_Trib3aMcKinnon	4/1200 x 300 RCBC – McKinnon Rd	17.54	17.44
Alick_Trib3aMoree	4/1200 x 450 RCBC – Moree Rd	15.56	15.51
Alick_Trib3bBRRoad	2/1800 x 1200 RCBC – Black River Rd	12.37	12.25
Alick_Trib3bHwy	5/1500 dia RCP – Bruce Hwy	11.6	11.3
Alick_Trib3bMcKinnon	3/1050 dia RCP – McKinnon Rd	15.84	15.54
Alick_Trib4Percheron	2/1200 x 600 RCBC – Percheron Pl	9.68	9.5
Alick_Trib5Clydesdale	2/1200 dia RCP – Clydesdale Pl	3.865	3.77
AlickCk_BRRoad	2/1800 x 1200 RCBC – Black River Rd	16.79	16.71
AlickCk_Hwy	7/2100 x 2100 RCBC – Bruce Hwy	11.3	11.2
AlickCk_Percheron	1800 dia RCP – Percheron Pl	7.453	7.361
Alt_Trib1aHwy	3/375 dia RCP – Bruce Hwy	11.4	11.1
Alt_Trib1Hwy	2/750 dia RCP – Bruce Hwy	10.31	10.29
Alt_Trib1Hwy	2/375 dia RCP – Bruce Hwy	10.31	10.29
Alt_Trib2aHwy	450 dia RCP – Bruce Hwy	13.08	13.02
Alt_Trib2b1Rail	1200 x 450 RCBC - Railway	10.82	10.75
Alt_Trib2bHwy	2/450 dia RCP – Bruce Hwy	12.35	12
Alt_Trib2Bluewater	9/1200 x 450 RCBC – Bluewater Dr	12.76	12.73
Alt_Trib2bRail	2/750 x 450 RCBC – Railway	10.79	10.65
Alt_Trib2c1Rail	2/900 x 450 RCBC – Railway	10.7	10.45
Alt_Trib2c2Rail	1200 x 450 RCBC – Railway	10.45	10.2
Alt_Trib2cHwy	375 dia RCP– Bruce Hwy	11.45	11.42
Alt_Trib2cRail	2/900 x 450 RCBC – Railway	10.9	10.7
Alt_Trib2James	3/1500 x 900 RCBC – James St	7.94	7.87
Alt_Trib2King	2/1200 dia RCP – Kings St	5.2	5.13
Alt_Trib2Rail	1500 x 600 RCBC – Railway	12.11	11.95
Alt_Trib3Bluewater	2/1500 x 900 RCBC – Bluewater Dr	5.806	5.686

Alt_Trib3James	4/1200 x 900 RCBC – James St	9.38	9.35
Alt_Trib4Bluewater	3/1200 x 300 RCBC – Bluewater Dv	2.89	2.706
Alt_Trib5Jaloonda	1200 x 300 RCBC – Jaloonda Rd	1.76	1.75
Alt_TribPur2Hwy	1050 dia RCP – Bruce Hwy	7.78	7.68
Alt_TribPurHwy	750 dia RCP – Bruce Hwy	9.42	9.14
AltPde1_Clifford	2/600 x 300 RCBC – Clifford Av	7.6	7.55
AltPde2_Clifford	1200 x 600 RCBC – Clifford Av	7.61	7.57
Anita_BOLClifford	5/600 300 RCBC – Anita/Clifford Av	7.49	7.25
Anita1_Clifford	2/600 x 300 RCBC Clifford Av	7.45	7.3
Anita2_Clifford	2/600 x 300 RCBC Clifford Av	7.6	7.42
ArabianPl_Culv	3/1200 x 300 RCBC – Arabian Pl	8.28	8
Black_LOBHwy	2/1500 dia RCP – Bruce Hwy	12.2	12.1
Black_Trib2Church	1200 dia RCP – Church Rd	13.91	13.091
Black_Trib3Church	2/750 dia RCP – Church Rd	15.1	15.04
BlackR_Trib1Church	2100 dia RCP – Church Rd	10.76	10.75
Blue_Rail	2/1500 x 900 RCBC - Railway	12.15	11.89
Bluewater1_Hwy	6/375 dia RCP – Bruce Hwy	12.82	12.79
Bluewater2_Hwy	375 dia RCP – Bruce Hwy	13.02	12.97
Bluewater3_Hwy	450 dia RCP – Bruce Hwy	13.08	12.98
Bluewater4_Hwy	2/900 x 450 RCBC – Bruce Hwy	14.38	14.21
Bluewater5_Hwy	8/750 x 450 RCBC – Bruce Hwy	14.44	14.14
Bluewater6_Hwy	2/900 x 450 RCBC – Bruce Hwy	14.76	14.54
Deep_Trib1Hwy	1200 x 450 RCBC – Bruce Hwy	10.95	10.84
Hea_Car1Hwy	2/450 dia RCP – Bruce Hwy	10.55	10.33
Hea_Car2Hwy	900 dia RCP – Bruce Hwy	10.38	9.9
Hea_Car3Hwy	2/1200 x 450 RCBC – Bruce Hwy	11.57	11.49
Hea_CarCarmen	1200 x 300 RCBC – Carmen Cl	10.92	10.82
Hea_CarRail	1050 dia RCP - Railway	9.65	9.4
Hea_Dunes1SBRoad	450 dia RCP – Saunders Beach Rd	2.64	2.62
Hea_Dunes2SBRoad	375 dia RCP – Saunders Beach Rd	3	2.95
Hea_Flats1SBRoad	1200 x 450 RCBC – Saunders Beach Rd	2.88	2.74
Hea_Flats2SBRoad	2/1200 x 450 RCBC – Saunders Beach Rd	2.95	2.78
Hea_Flats3SBRoad	2/600 dia RCP – Saunders Beach Rd	1.66	1.64
Hea_Pur1Rail	600 x 450 RCBC – Railway	10.95	10.73
Hea_Pur2Rail	1200 x 450 RCBC – Railway	11.27	11.05
Hea_Pur3Rail	1200 x 450 RCBC – Railway	11.06	10.99
Hea_Pur4Rail	1200 x 450 RCBC – Railway	11.51	11.36
Hea_PurHwy	2/1200 x 450 RCBC – Bruce Hwy	11.41	11.29
Hea_PurRail	3/1200 x 900 RCBC – Railway	9.92	9.73
Hea_Trib1aNCRail	2/1200 x 1200 RCBC – Railway	11.3	11.24
Hea_Trib1aNCRail1	2/1700 x 850 RCBC – Railway	11.37	11.3
Hea_Trib1aRail	4/900 dia RCP – Railway	10.3	10.12
Hea_Trib1aSBRoad	1200 dia RCP – Saunders Beach Rd	9.93	9.91
Hea_Trib1bSBRoad	525 dia RCP – Saunders Beach Rd	10.39	10.27
Hea_Trib1cSBRoad	900 dia RCP – Saunders Beach Rd	9.99	9.69
Hea_Trib1dSBRoad	450 dia RCP – Saunders Beach Rd	10.79	10.35
Hea_Trib1Hwy	3/1800 dia RCP – Bruce Hwy	11.15	10.8
Hea_Trib1Rail	7/1800 x 1200 RCBC – Railway	10.2	10.05
Hea_Trib1Rail	2/1200 x 1200 RCBC – Railway	10.2	10.05

Hea_Trib1SBRoad	3/1800 dia RCP – Saunders Beach Rd	10.09	10.04
Hea_Trib2SBRoad	2/1050 dia RCP – Saunders Beach Rd	11.69	11.6
Hea_Trib3aSBRoad	750 dia RCP – Saunders Beach Rd	10.94	10.85
Hea_Trib3bSBRoad	600 dia RCP – Saunders Beach Rd	11.39	11.09
Hea_Trib4aSBRoad	2/450 dia RCP – Saunders Beach Rd	12.17	11.98
Hea_Trib4bSBRoad	450 dia RCP – Saunders Beach Rd	12.23	12.14
Hea_Trib5SBRoad	1200 dia RCP – Saunders Beach Rd	10.88	10.48
Hea_Trib6SBRoad	600 dia RCP – Saunders Beach Rd	10.3	9.95
Hea_Trib7SBRoad	1200 dia RCP – Saunders Beach Rd	8.7	8.4
Hea_Trib8SBRoad	1200 dia RCP – Saunders Beach Rd	6.47	6.1
Hea_Trib9aSBRoad	600 dia RCP – Saunders Beach Rd	3.2	2.8
Hea_Trib9SBRoad	3/1800 dia RCP – Saunders Beach Rd	2.45	2.15
Healy_Mill	3/525 dia RCP – Mill Rd	12.15	12.09
HeaPur_Carmen	3/1200 x 300 RCBC – Carmen Cl	11.03	10.95
Holstein_Culv1	2/1200 x 300 RCBC – Holstein Pl	9.96	9.75
Pur1_Clifford	1200 x 300 RCBC – Clifford Av	6.76	6.72
Pur1_Hwy	2/1200 x 450 RCBC – Bruce Hwy	11.22	11.18
Pur1_Purono	2/1200 x 300 RCBC – Purono Pkwy	9.65	9.58
Pur2_Hwy	2/1200 x 450 RCBC – Bruce Hwy	11.35	11.33
Pur2_Purono	2/600 x 300 RCBC – Purono Pkwy	6.76	6.72
Pur3_Hwy	2/1200 x 450 RCBC – Bruce Hwy	11.45	11.28
Pur4_Hwy	2/1200 x 450 RCBC – Bruce Hwy	11.17	11.13
Purono_BOLClifford	7/600 x 300 RCBC – Clifford Av	7.15	6.98
Purono_Culv1	375 dia RCP – Purono Pkwy	4.74	4.74
PuronoBackLot	2/1200 x 450 RCBC – Althaus Parade	9.48	9.42
PuronoBackLot	2/1200 x 300 RCBC – Althuas Parade	7.787	7.731
SBDunes_Atoll	450 dia RCP – Atoll Street	2.9	2.8
Yab_GRail	3/750 dia RCP – Railway	12.85	12.2
Yab1_Hwy	900 dia RCP – Bruce Hwy	14	13.7
Yab1_Rail	900 x 450 RCBC – Railway	12.85	12.85
Yab2_Hwy	900 dia RCP – Bruce Hwy	14.55	14.53
Yab2Rail	1200 x 450 RCBC – Railway	12.85	12.85
Yab3_Hwy	2/450 dia RCP – Bruce Hwy	14.96	14.92
Yab3_Rail	900 x 600 RCBC – Railway	13.059	13.04
Yab5_Hwy	3/675 dia RCP – Bruce Hwy	13.91	13.88

2.5 Previous Engineering Reports

While the Althaus Creek catchment has not previously been modelled in detail, there are adjacent studies that are relevant to this study. The relevance of the previous studies is specific to previous hydrology (design rainfall), boundary conditions and model verification.

Bluewater Creek Flood Study (Engeny, 2013)

The Bluewater Creek Flood Study was completed by Engeny Management in June 2013. The project developed and calibrated a hydrologic and hydraulic model of Bluewater Creek including the northern bank overflow area of Toolakea. A MIKE FLOOD model was developed that employed the ‘Rain on Grid’ approach, however inflows to the model for a large portion of the upper catchment were determined from an XP-RAFTS model. The Bluewater Creek Flood Study calibrated the flood model to the January 1998 and March 2011 flood events.

Design rainfall from the Bluewater Creek Study was determined as follows:

- Rainfall up to the 100 Year ARI was based on the Intensity-Frequency-Duration (IFD) relationships of Australian Rainfall and Runoff (AR&R 1987);
- Rainfall for the 500 Year ARI was determined from an adjusted CRC-FORGE approach, where the ratio of rainfall depths between the 100 Year ARI and 500 Year ARI events from the CRC-FORGE approach, were used to scale the 500 Year ARI rainfall from the 100 Year ARI rainfall based on IFD; and
- Rainfall for the Probable Maximum Precipitation (PMP) were based on the Generalised Short Duration Method (GSDM) and the Generalised Tropical Storm Method Revised (GTSMR) depending on the storm duration.

The design rainfall approach from the Bluewater Creek Flood Study was considered as part of developing the design rainfall for this study (refer to **Section 3.6**). Flows from the Bluewater Creek Flood Study were used as boundary conditions for this study (refer to **Section 4.3**), while the flood levels in the lower reaches of Bluewater Creek were used to verify the model from this study (refer to **Section 4.5**).

Bohle Plains Flood Planning Report (AECOM, 2010)

The Bohle Plains Flood Planning report developed hydrologic and hydraulic flood models of Bohle River, Saunders Creek, Stony Creek and Black River. The work completed on Black River is of particular relevance to the present study. An XP-RAFTS hydrologic model and MIKE FLOOD hydraulic model were developed and calibrated for Black River. Flows from the Black River hydrologic model were used as boundary conditions for the present study (refer to **Section 4.3**) while the flood levels in the lower reaches of the Black River were considered as part of the model verification (refer to **Section 4.5**)

Black River Flood Study (AECOM, present)

Townsville City Council has engaged AECOM to update the previous Black River Flood model to include LiDAR captured in 2009/2012 as well as utilise a ‘Rain on Grid’ approach for key urban areas. Flood levels within the lower reaches of the Black River were considered as part of the model verification (refer to **Section 4.5**).

3.0 Hydrological Assessment

3.1 Catchment Overview

The catchment comprises steep upper areas around the foothills of Hervey Range and Mount Halifax and a flat coastal plain to the outlet with Halifax Bay. Upstream of the highway much of the catchment is either natural or rural, with almost no development. Downstream of the highway the land use becomes rural-residential with the heavy industry precinct of Yabulu Nickel Refinery. The density of rural residential lots increases around Purono Parkway. Residential lot sizes are even smaller again in Saunders Beach which is traditional residential.

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.

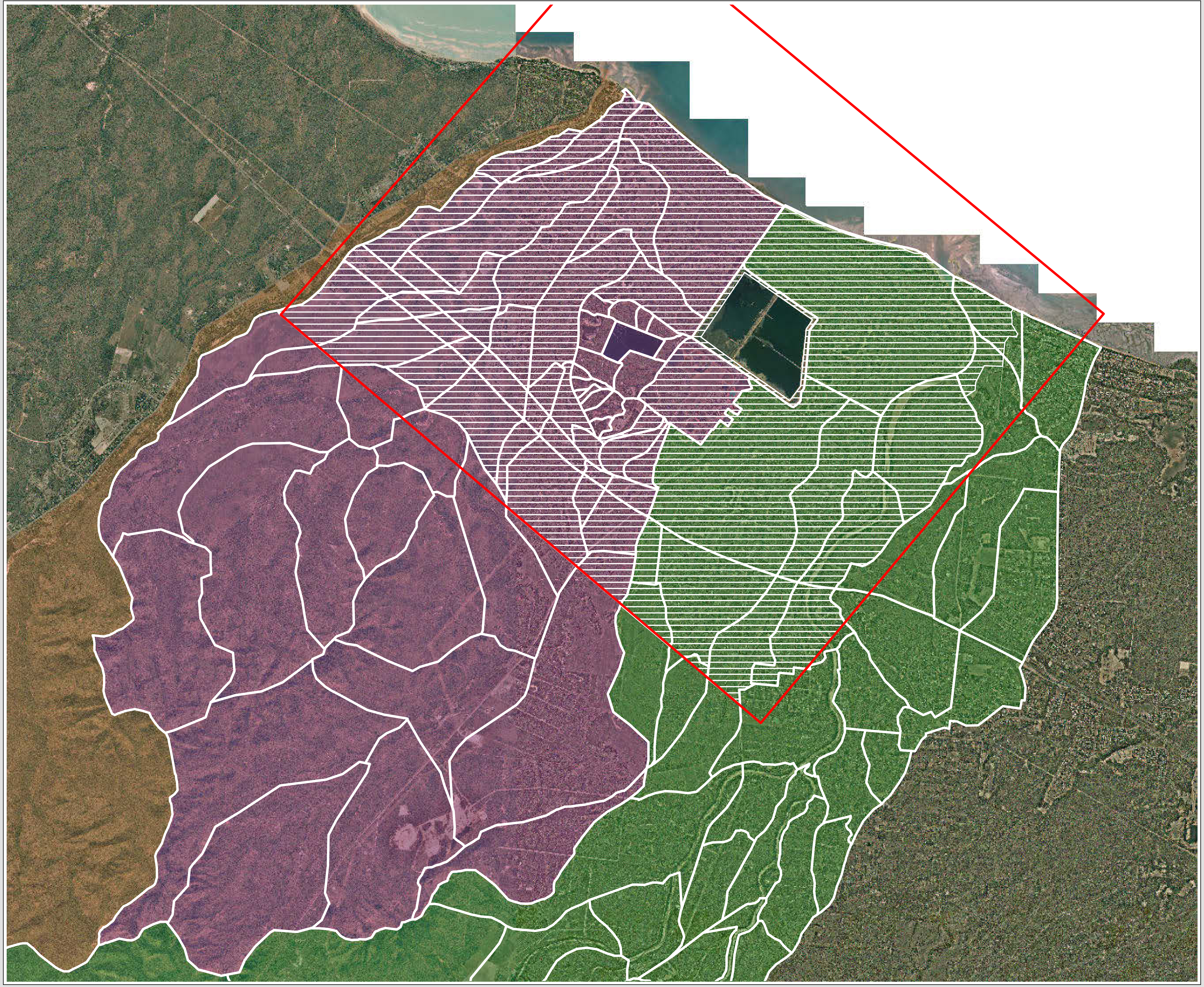
XP-RAFTS has been used to simulate the hydrological response of the sub-catchment area upstream of the MIKE FLOOD as well as within steep parts of the MIKE FLOOD model domain. XP-RAFTS models were previously also developed for Black River and Bluewater Creek.

Details of the Althaus Creek hydrological modelling are provided in this report. Details of the hydrological modelling of the other major sub-catchments are within other reports of the City Wide Flood Constraints project.

3.3 Catchment Delineation

Sub-catchments for the Althaus Creek XP-RAFTS model were delineated based on 2009 LiDAR data and 1:100,000 topographic map series. Sub-catchments were delineated to ensure boundary flows for the MIKE FLOOD model would not duplicate runoff from within the 'Rain on Grid' area.

The sub-catchment delineation is shown in **Figure 3-1**.



ALTHAUS CREEK FLOOD STUDY SUBCATCHMENT DELINEATION

Figure 3-1

LEGEND

- MIKE FLOOD Model Extent
- Rain on Grid Extent
- Sub-Catchment Boundaries

Major Sub-Catchments

- Althaus Creek
- Black River
- Bluewater Creek

N

SCALE: 1:60,000 @A3

500 250 0 500 1,000 1,500 Metres

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3.4 Sub-Catchment Parameters

Sub-catchment parameters for the Althaus Creek XP-RAFTS model were determined from topographic data, aerial photography and zoning information. The adopted sub-catchment parameters are given in **Table 3-1**.

Table 3-1 Althaus Creek Sub-Catchment Parameters

Sub-Catchment	Area (ha)	Slope (%)	Fraction Impervious (%)	Surface Retardance (n*)	
				Pervious	Impervious
A1a	59	3.6	2	0.06	0.025
A1b	832.5	3.6	0.5	0.06	0.025
A1c	283.394	5	0.5	0.06	0.025
A2a	49	0.5	0.1	0.06	0.025
A2b	186.6	0.5	0.1	0.06	0.025
A3	15.21	0.5	50	0.06	0.015
B1	87.06	0.5	7.5	0.06	0.025
B2	24.57	5.6	30	0.06	0.015
B2a	31.43	5	10	0.05	0.025
B2b	47.2	0.5	0	0.05	0.025
B2c	19.2	0.35	0	0.05	0.025
B2d	24.1	15.8	0	0.06	0.025
B2e	8.6	5	0	0.04	0.025
B2f	19.6	12	0	0.05	0.025
B2g	10.9	14.2	0	0.05	0.025
B2h	4.3	14	0	0.05	0.025
B2i	2	4.7	0	0.04	0.025
B2j	9.8	10	0	0.05	0.025
B2k	5.94	11.3	0	0.04	0.025
B2l	43.5	3	0	0.05	0.025
B3a	196.07	1.5	0	0.05	0.025
B3b	45.8	11	0	0.05	0.025
B3c	30.3	8	0	0.05	0.025
B3d	34.8	9	0	0.05	0.025
B3f	12.7	14	0	0.05	0.025
B3g	12.5	8	0	0.05	0.025
B3h	9	6	0	0.04	0.025
B3i	17.8	6	0	0.05	0.025
B3j	13.7	10	0	0.04	0.025
B3k	106.4	0.5	0	0.05	0.025
B3l	196.7	0.5	0	0.05	0.025
B4	160.8	0.5	0.1	0.08	0.025
C1	647.33	4.27	0.1	0.1	0.025
C2a	508.02	6.29	0.1	0.1	0.025
C2b	840.36	6.6	0.1	0.1	0.025
C3	447.682	3.07	0.1	0.1	0.025
C4	320.49	0.72	0.1	0.06	0.025
C5a	92.3	0.5	2	0.06	0.025
C5b	38.9	0.5	2	0.06	0.025

Sub-Catchment	Area (ha)	Slope (%)	Fraction Impervious (%)	Surface Retardance (n*)	
				Pervious	Impervious
C6	23.63	0.5	50	0.06	0.015
C7	38.35	1.06	48	0.06	0.015
C8	175.2	0.5	1	0.08	0.025
D1	443.35	2.7	0.1	0.06	0.025
E1	188.09	4.69	0.1	0.06	0.025
F1	145.73	2.9	0.1	0.06	0.025
G1	694.1	3.54	0.1	0.1	0.025
G2	327.4	6.9	0.1	0.1	0.025
H1	546.6	7.6	0.1	0.1	0.025
H2	504.43	0.5	0.1	0.06	0.025
H3	145.7	0.56	0.1	0.06	0.025
H4	72.82	0.5	2	0.06	0.025
H5	17.7	0.5	5	0.06	0.025
I1a	46	0.5	2	0.06	0.025
I1b	122.3	0.5	2	0.06	0.025
I2	26.51	0.5	5	0.06	0.025
J1	32.41	0.69	5	0.06	0.025
K1	23.36	0.5	2	0.06	0.025
K2	23.3	0.5	5	0.06	0.025
K3	63.5	0.6	5	0.06	0.025
L1a	150.46	0.5	0.1	0.06	0.025
L1b	127.15	0.5	0.1	0.06	0.025
L2	44.87	0.5	10	0.06	0.025
L3	37.72	0.5	2	0.06	0.025
L4	295.95	0.5	5	0.08	0.025
L4a	111.16	0.5	5	0.08	0.025
L4b	58.27	0.5	5	0.08	0.025
M1	96.37	0.5	5	0.08	0.025
N1	449.9	0.5	5	0.08	0.025
O1	26.02	0.5	5	0.06	0.025
O2	5.73	0.5	50	0.06	0.015
O3	23.1	0.52	1	0.06	0.025
P1	35.3	0.5	2	0.06	0.025
P2	8.5	0.5	50	0.06	0.015
P3	28.27	0.5	2	0.06	0.025

3.5 Model Verification

To verify the performance of the hydrological models, their ability to replicate flow conditions was benchmarked. Peak flow rates determined from the model were compared to results of Rational Method calculations. Unfortunately due to the lack of stream gauging on the Althaus Creek system, there is no ability to calibrate the hydrologic model or compare the results of design events to flood frequency assessment.

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 3-2**. The result show good agreement between peak discharges from the XP-RAFTS model and the Rational Method.

Table 3-2 Althaus Creek XP-RAFTS Model Verification

Catchment	Location	ARI (Years)	Peak Flow (m^3/s)	
			Rational Method	XP-RAFTS
A Total (A1c, A1b, A1a, A2a, A2b, A3)	Healy Creek	50	105.8	113.5
		2	36.1	46.0
B2d	Yabulu Refinery	50	6.3	6.1
		2	2.3	2.2
B2e	Yabulu Refinery	50	3.8	2.2
		2	1.4	0.8
B2f	Yabulu Refinery	50	6.9	5.1
		2	2.6	1.8
B2g	Yabulu Refinery	50	4.2	3.4
		2	1.6	1.1
B2h	Yabulu Refinery	50	1.8	1.5
		2	0.7	0.4
B2i	Yabulu Refinery	50	1.1	0.7
		2	0.4	0.2
B2j	Yabulu Refinery	50	3.5	2.7
		2	1.3	0.9
B2k	Yabulu Refinery	50	2.7	2.1
		2	1.0	0.6
B3b	Yabulu Refinery	50	13.3	10.9
		2	4.9	3.8
B3c	Yabulu Refinery	50	8.4	6.8
		2	3.1	2.4
B3d	Yabulu Refinery	50	9.6	8.1
		2	3.6	2.8
B3f	Yabulu Refinery	50	4.0	3.8
		2	1.5	1.2
B3g	Yabulu Refinery	50	4.6	3.2
		2	1.7	1.1
B3h	Yabulu Refinery	50	3.6	2.4
		2	1.3	0.8
B3i	Yabulu Refinery	50	6.4	4.0
		2	3.0	1.4
B3j	Yabulu Refinery	50	6.4	4.1
		2	2.4	1.3
C Total (C1, C2a, C2b, C3, C4)	Althaus Creek	50	222.8	251.3
		2	76.5	72.0
D Total	Althaus Creek Tributary	50	96.2	73.4
(D1, E1)		2	34.6	21.3
H Total	Deep Creek	50	194.5	183.1
(G1a, G1b, H1,		2	67.1	58.1

3.6 Design Rainfall

Design rainfall was developed with an approach consistent to the Bluewater Creek Flood Study (Engeny 2013). Essentially, design rainfall intensities for all events up to and including the 100 Year ARI were developed based on methods outlined in the Australian Rainfall & Runoff (AR&R) using the IFD approach. A summary of the IFD input parameters is provided in provided in **Table 3-3** below. The resulting rainfall IFD values are provided in **Table 3-4**.

Table 3-3 Input IFD parameters

Parameter	Value
2 Year, 1 hour Intensity	55 mm/h
2 Year 12 hour Intensity	12 mm/h
2 Year, 72 hour intensity	4 mm/h
50 Year, 1 hour Intensity	105 mm/h
50 Year 12 hour Intensity	25 mm/h
50 Year, 72 hour intensity	9 mm/h
Skew (G)	0.04
Geographical Factor (f2)	3.93
Geographical Factor (f50)	17

Table 3-4 Althaus Creek IFD Values

	ARI (Years)						
Duration	**1**	**2**	**5**	**10**	**20**	**50**	**100**
5min	118.83	152.76	195.20	219.89	252.74	295.91	328.79
6min	112.35	144.42	184.53	207.86	238.90	279.70	310.76
10min	94.31	121.22	154.84	174.39	200.42	234.61	260.64
15min	80.66	103.66	132.37	149.07	171.30	200.49	222.72
20min	71.53	91.93	117.37	132.16	151.85	177.72	197.41
30min	59.70	76.71	97.91	110.23	126.64	148.20	164.60
45min	49.24	63.26	80.73	90.87	104.38	122.13	135.64
1hour	42.70	54.86	69.99	78.78	90.48	105.85	117.55
1.5hour	33.45	43.07	55.26	62.39	71.84	84.28	93.77
2hour	28.03	36.15	46.57	52.69	60.78	71.46	79.61
3hour	21.79	28.16	36.49	41.42	47.90	56.48	63.04
4.5hour	16.91	21.91	28.56	32.52	37.70	44.59	49.87
6hour	14.14	18.34	24.01	27.39	31.82	37.71	42.24
9hour	10.99	14.28	18.81	21.53	25.08	29.80	33.44
12hour	9.19	11.97	15.83	18.15	21.18	25.23	28.35
18hour	7.26	9.47	12.61	14.52	16.99	20.31	22.87
24hour	6.12	8.01	10.72	12.37	14.50	17.37	19.60
30hour	5.36	7.01	9.42	10.89	12.80	15.36	17.35
36hour	4.79	6.28	8.46	9.80	11.53	13.86	15.67
48hour	3.99	5.24	7.10	8.24	9.72	11.71	13.27
72hour	3.03	3.99	5.44	6.35	7.51	9.09	10.32

Similar to the Bluewater Creek Flood Study (Engeny 2013) the 500 Year ARI rainfall intensities were scaled from the 100 Year ARI rainfall intensities above using the ratio of the 500 and 100 Year ARI rainfall intensities from the CRC-FORGE method developed by Hargraves (2004). Temporal Patterns for the rainfall events up to 500 Year ARI were based on the unit temporal patterns for AR&R zone 3.

Probable Maximum Precipitation (PMP) estimates were derived using the Generalised Short Duration Method (BoM, June 2003) for storm durations up to 6 hours and the Generalised Tropical Storm Method Revised (BoM, Aug 2003) for storm durations equal to or greater than 24 hours. The PMP rainfall depths are provided in **Table 3-5**.

Table 3-5 Althaus Creek PMP rainfall depths

Duration (hours)	Rainfall Depth (mm)
1	350
2	520
3	630
4	710
5	780
6	830
12	1190
24	1700
36	2070
48	2420
72	3050
96	3420
120	3580

3.7 Rainfall Loss Values

Rainfall losses were determined from the model verification (**Sections 3.5** and **4.5**) through comparison of the model results to previously calibrated models that cover parts of the study area. The Rainfall loss values adopted for design events were:

- Impervious – 1 mm IL and 0 mm CL;
- Pervious – 50 mm IL and 2.5 mm CL.

A sensitivity assessment to the rainfall loss values was also completed as outlined in **Section 4.6**.

3.8 Design Flood Flows

Design flows derived from hydrological assessment were supplied as boundary conditions to the MIKE FLOOD hydraulic model. Flows were taken directly from the Althaus Creek and Black River XP-RAFTS models. Boundary flows were also taken from the Bluewater Creek MIKE FLOOD developed as part of the Bluewater Creek Flood Study (Engeny 2013).

4.0 Hydraulic Assessment

4.1 Floodplain Overview

The Althaus Creek floodplain is a low lying area bounded by Black River, the Bruce Highway, Bluewater Creek and Halifax Bay. The general grade of the floodplain is towards the north east. The floodplain areas around Althaus Creek are generally lower than comparable areas around Bluewater Creek or Black River for the same distance upstream of the waterway mouth.

The Yabulu Nickel Refinery sits on a ridge-line dividing the Black River and Althaus Creek catchments. A small hill (Mount Healy) to the south of Saunders Beach Road also divides these catchments. There is an extensive sand-dune and swale network between Althaus Creek and Black River, towards the coast from Yabulu Nickel Refinery. The suburb of Saunders Beach is located on the western end of this sand dune system, near the mouth of Althaus Creek.

A majority of the floodplain area is rural particularly upstream of the Bruce Highway. Downstream of the highway land use becomes rural residential particularly between Healy Creek and Bluewater Creek. Yabulu Nickel Refinery sits between Alick Creek and Healy Creek however a majority of the site comprises open grasslands and woodlands.

4.2 MIKE FLOOD

MIKE FLOOD is a dynamically linked 1D and 2D hydraulic modelling package, which couples the 1D river hydraulics model, MIKE11 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 and adjacent floodplains, ponds, reservoirs, etc; and
- flood waves in channels and on flood plains associated with a dam failure.

The MIKE21 2D model has been used to adequately represent the complex two dimensional hydraulics of the Althaus Creek floodplain. The 1D component of MIKE FLOOD (MIKE11) was required to provide a more accurate representation of the hydraulics of structures (such as culverts and bridges). MIKE FLOOD has been used for the hydraulic model of Ross River.

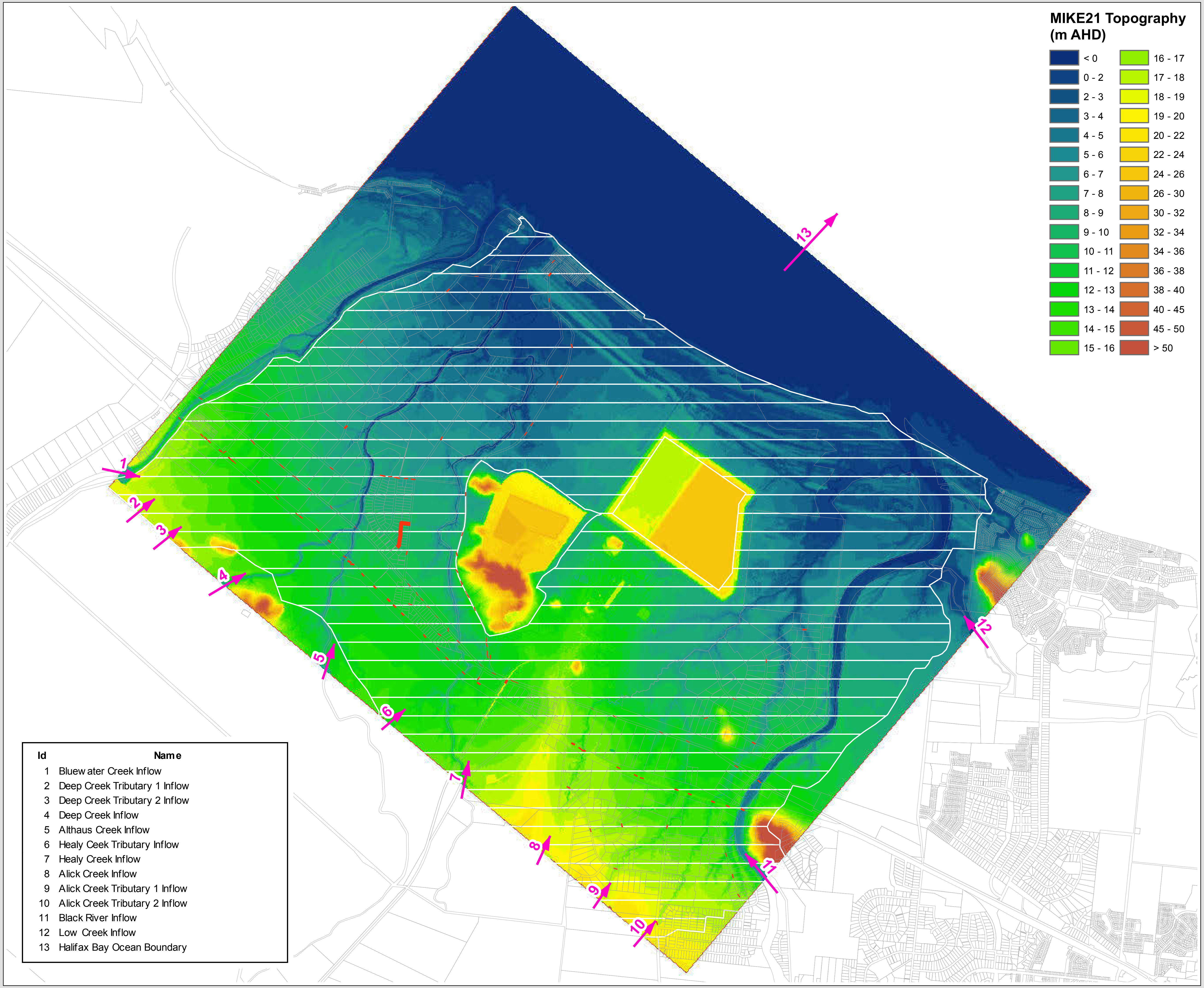
4.3 Model Setup

Topography

The MIKE FLOOD model developed for the Study is based on a 10 m topographic grid covering an area of 10.8 km by 9.0 km. The model set-up is shown in **Figure 4-1**. The topographic grid is based on the topographic datasets outlined in **Section 2.2**.

ALTHAUS CREEK FLOOD STUDY MIKE FLOOD MODEL SETUP

Figure 4-1



Id	Name
1	Bluewater Creek Inflow
2	Deep Creek Tributary 1 Inflow
3	Deep Creek Tributary 2 Inflow
4	Deep Creek Inflow
5	Althaus Creek Inflow
6	Healy Ceek Tributary Inflow
7	Healy Creek Inflow
8	Alick Creek Inflow
9	Alick Creek Tributary 1 Inflow
10	Alick Creek Tributary 2 Inflow
11	Black River Inflow
12	Low Creek Inflow
13	Halifax Bay Ocean Boundary

LEGEND

- Boundary Conditions
- MIKE11 Model
- Properties
- Rain on Grid Extent

City of Townsville

SCALE: 1:50,000 @A3

500 250 0 500 1,000 1,500 Metres

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Boundary Conditions
Boundary conditions of the model are specified as either upstream inflows or downstream water levels. The base-line flooding assessment 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 tailwater. The key boundaries for the model are:

- Bluewater Creek Inflow;
- Deep Creek Tributary 1 Inflow;
- Deep Creek Tributary 2 Inflow;
- Deep Creek Inflow;
- Althaus Creek Inflow;
- Healy Creek Tributary Inflow;
- Healy Creek Inflow;
- Alick Creek Inflow;
- Alick Creek Tributary 1 Inflow;
- Alick Creek Tributary 2 Inflow;
- Black River Inflow;
- Low Creek Inflow; and
- Halifax Bay Ocean Boundary.

Source Points
Source points representing sub-catchment inflows are applied to the model as follows:

- Cockatoo Creek / Bushland Beach Area; and
- Steep areas around Mount Healy.

Hydraulic Structures
Culvert and bridge structures within the study area have been represented as one-dimensional (MIKE11) elements in the model. **Table 2-1** outlines the bridges and culverts represented within the model.

The open channel behind lots on Purono Parkway (refer to **Figure 4-2**) has also been represented with a one-dimensional (MIKE11) element within the flood model. The branch representing the open channel was laterally coupled to the two-dimensional component of the model.

As part of verifying the model, the head loss across major bridge and culvert structures was checked against HEC-RAS models for the individual structures. This structure verification is outlined in **Section 4.4**.

Figure 4-2 Purono Parkway Open Drain

Hydraulic Roughness

Hydraulic roughness within the model is specified as Manning's n values and was determined from verification of the model (refer to **Section 4.5**). The distribution of roughness values are shown in **Figure 4-3**. Generally roughness values for land use / vegetation types were used as follows:

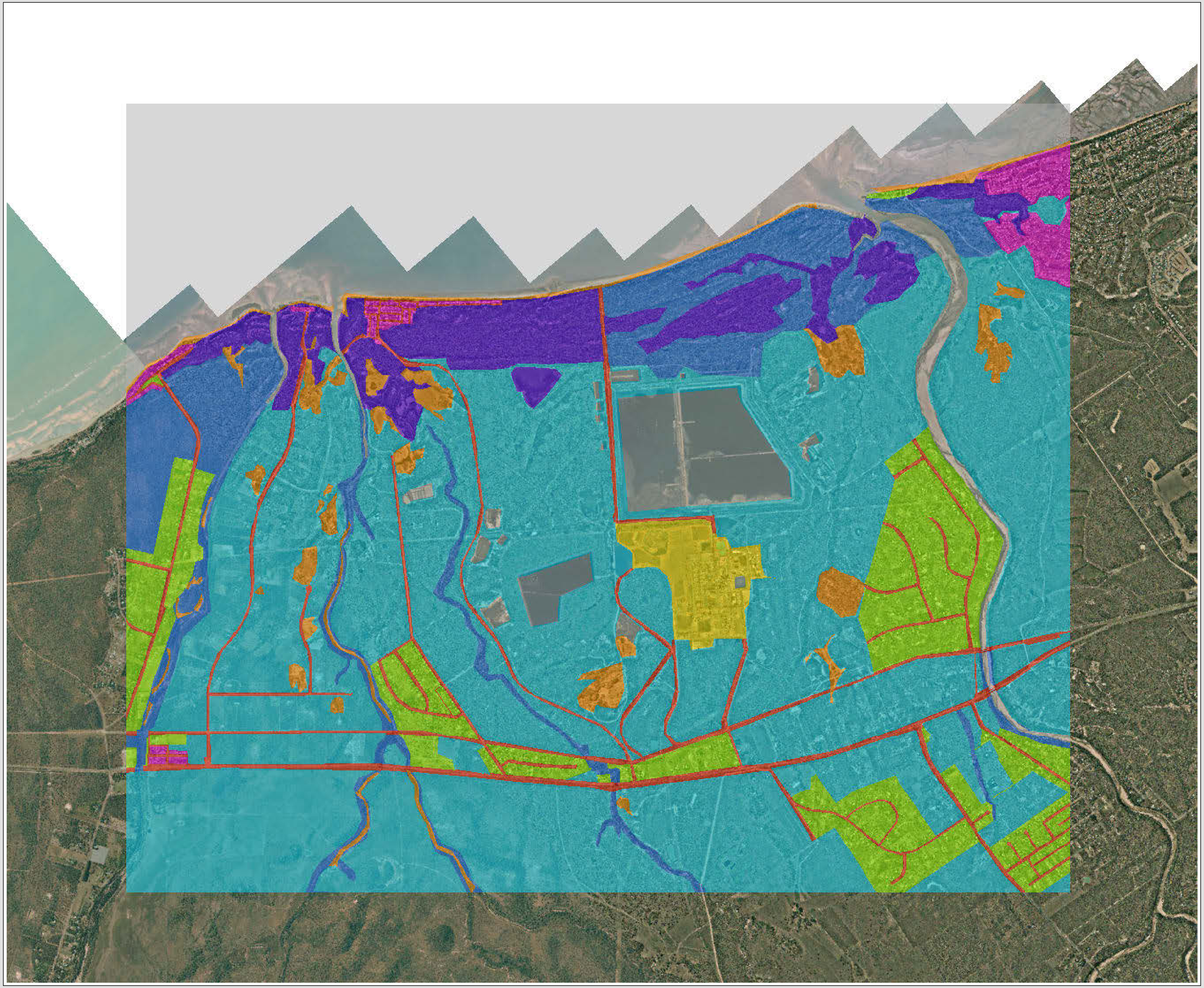
Table 4-1 Hydraulic Roughness Values

Land Use/Vegetation Type	Manning's n
Open water bodies / Watercourses	0.02
Roads	0.025
Bare earth / Salt Pan / Sand	0.035
Industrial Area	0.04
Rural Residential	0.055
Open Grassland / Sparse Woodland	0.06
Riparian Zones / Dense Woodlands	0.08
Mangrove Areas	0.1
Traditional Residential	0.15

Eddy Viscosity

A velocity based eddy viscosity was used with a distribution of eddy viscosity values about the model domain. Values adopted were as follows:

- $8m^2/s$ for a majority of the floodplain;
- $2m^2/s$ for the lower reaches of Bluewater Creek;
- $1m^2/s$ for upstream reaches of Black River ; and
- $16m^2/s$ around the Black River Highway and Rail bridges.



ALTHAUS CREEK FLOOD STUDY HYDRAULIC MODEL ROUGHNESS MAP

Figure 4-3

LEGEND

Manning's n

- 0.02
- 0.025
- 0.035
- 0.04
- 0.05
- 0.055
- 0.06
- 0.08
- 0.1
- 0.15
- 0.2

City of Townsville

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400 200 0 400 800 1,200 Metres

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4.4 Structure Verification

Head-losses across structures are critical for ensuring accurate prediction of flood levels within a flood model. To verify the head-losses across the structures, HEC-RAS models were set-up for key bridge structures to verify the calculated head-loss. HEC-RAS is considered to have better representation of the bridge hydraulics as it uses Bradley's Method and considers steady state conditions providing a simpler numerical solution.

Comparisons between the MIKE FLOOD model and HEC-RAS results at each of the major structures are provided in **Tables 4-2** to **4-6**. The results show good agreement between the models and confirm the head-losses represented within the MIKE FLOOD model.

Table 4-2 Comparison of Head-losses at Alick Creek Bridges

Location	Arriving Flow (m^3/s)	Water Level (m AHD)	
		MIKE FLOOD	HEC-RAS
D/S Bruce Hwy	24.1	13.30	13.30
U/S Bruce Hwy	24.1	13.51	13.52
D/S Rail	27.3	10.82	10.82
U/S Rail	27.3	11.58	11.58

Table 4-3 Comparison of Head-losses at Healy Creek Bridges

Location	Arriving Flow (m^3/s)	Water Level (m AHD)	
		MIKE FLOOD	HEC-RAS
D/S Bruce Hwy	133.69	12.41	12.41
U/S Bruce Hwy	133.69	12.70	12.68
D/S Rail	155.08	11.02	11.02
U/S Rail	155.08	11.53	11.51

Table 4-4 Comparison of Head-losses at Althaus Creek Bridges

Location	Arriving Flow (m^3/s)	Water Level (m AHD)	
		MIKE FLOOD	HEC-RAS
D/S Bruce Hwy	422.24	11.42	11.42
U/S Bruce Hwy	422.24	11.55	11.55
D/S Rail	655.86	10.02	10.02
U/S Rail	655.86	10.40	10.38

Table 4-5 Comparison of Head-losses at Deep Creek Bridge

Location	Arriving Flow (m^3/s)	Water Level (m AHD)	
		MIKE FLOOD	HEC-RAS
D/S Bruce Hwy	254.11	11.04	11.04
U/S Bruce Hwy	254.11	11.15	11.15

Table 4-6 Comparison of Head-losses at Bluewater Creek Bridges

Location	Arriving Flow (m^3/s)	Water Level (m AHD)	
		MIKE FLOOD	HEC-RAS
D/S Bruce Hwy	855.36	15.20	15.20
U/S Bruce Hwy	855.36	15.77	15.77
D/S Rail	886.48	13.62	13.62
U/S Rail	886.48	14.06	14.09

4.5 Model Verification

To verify the Althaus Creek flood model, results from the model were compared to overlapping areas of the previously calibrated Bluewater Creek and Black River models. Hydraulic grade-lines along the watercourses were used to verify the results and help to establish which flood model should be applicable where.

Comparisons to Bluewater Creek and Black River hydraulic grade lines are provided in **Figure 4-4** and **4-5** respectively. The Bluewater Creek comparison shows relatively good agreement (within 0.3m) between the models, particularly around the Bruce Highway and more densely populated area of the Bluewater suburb (within 0.1m). The Black River comparison shows good agreement particularly downstream of Bruce Highway (± 0.3m). Upstream of the Bruce Highway flows within the Black River hydraulic model have attenuated more than the flows within the Althaus Creek flood model as the upstream inflow boundary of the Black River Model is further 4.6 km upstream. Comparison between the Black River and Althaus Creek flood models revealed that flood levels within the Black River channel were quite sensitive to eddy viscosity values (refer to **Section 4.6**). Eddy viscosity values have been determined in combination with the calibration of the Black River flood model.

The differences in flood levels within the overlapping model areas are considered reasonable. Council will ultimately mesh adjacent flood study datasets together, with the divide between datasets chosen where flood levels are consistent between the study areas.

Figure 4-4 Bluewater Creek hydraulic grade line comparison

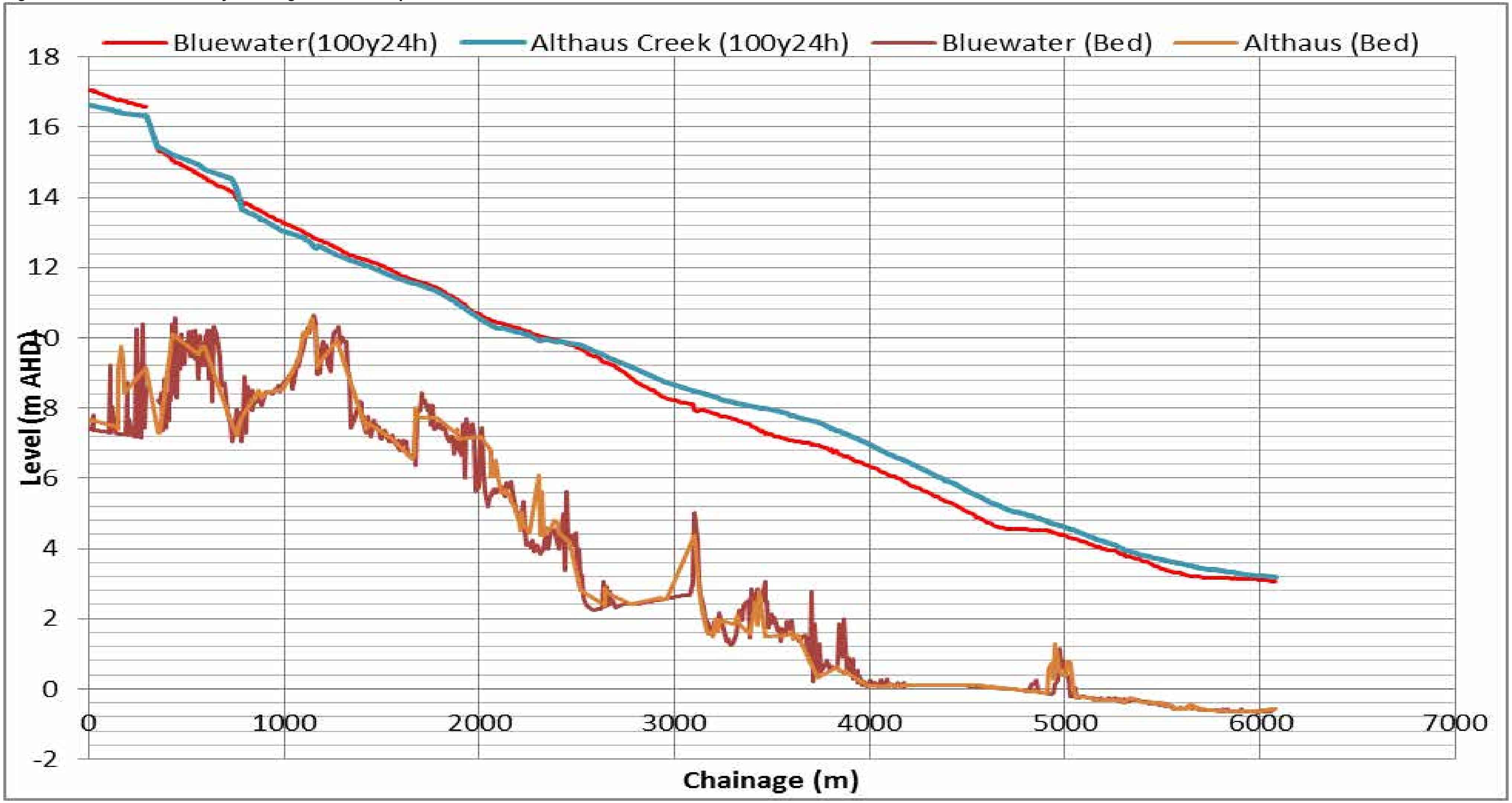


Figure 4-5 Black River hydraulic grade line comparison

4.6 Sensitivity Analysis

Sensitivity analysis was completed on the Althaus Creek MIKE FLOOD model. The sensitivity analysis provides insight to the model accuracy, particularly given there is no stream gauging available for calibration. The 100 Year ARI, 24 hour duration event was used to evaluate sensitivity to:

- Roughness (**Figure 4-6**);
- Initial and Continuing Losses (**Figure 4-7**); and
- Eddy Viscosity (**Figure 4-8**).

Roughness
The roughness sensitivity results show:

- the largest changes in flood levels (both increases and decreases) are around watercourses;
- little change in water levels in shallow parts of the study area where inundation is a result of local runoff rather than floodplain inundation;
- 20% decrease in roughness values results in water levels decreases around 100mm to 300mm near watercourses;
- 20% increase in roughness values results in water levels increases around 100mm to 300mm near watercourses;

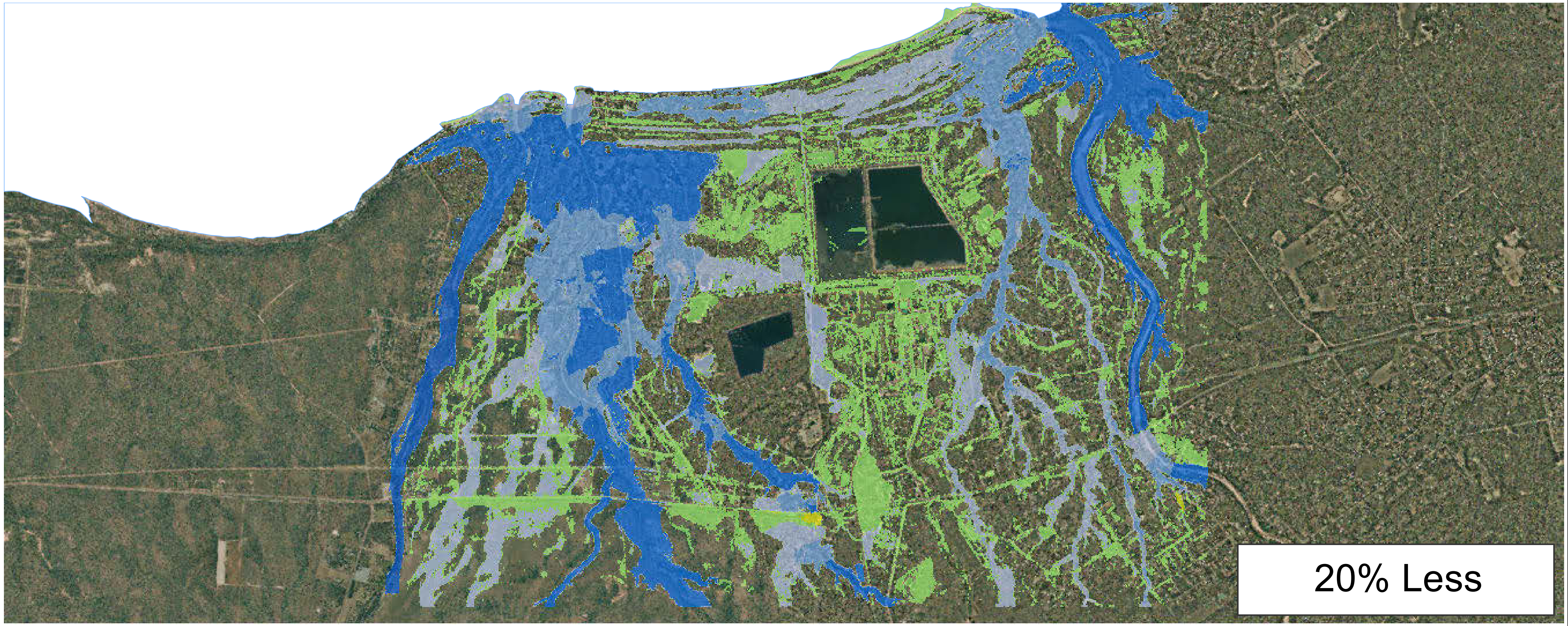
Initial and Continuing Loss
The rainfall loss sensitivity results show:

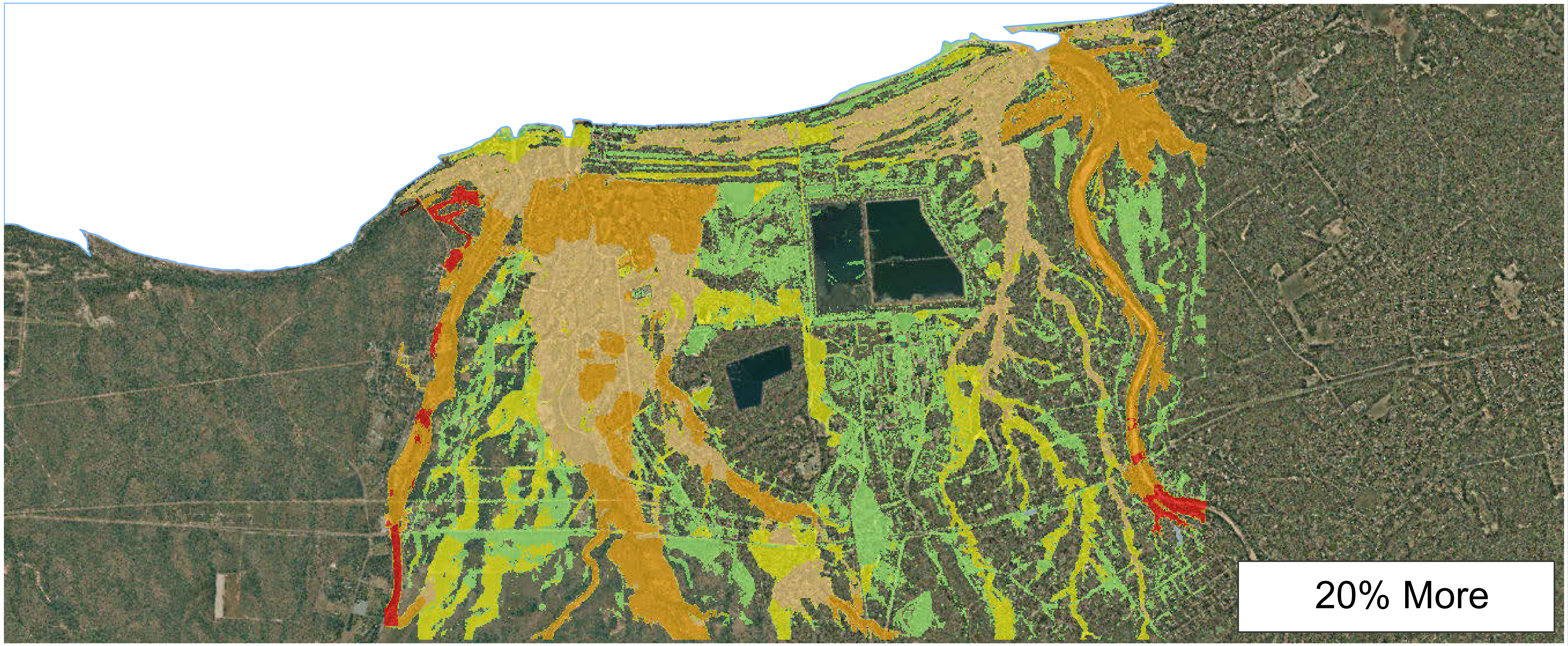
- the largest changes in flood levels (both increases and decreases) are around watercourses;
- little change in water levels in shallow parts of the study area where inundation is a result of local runoff rather than floodplain inundation;
- loss values of 10mm initial loss and 1mm/h continuing loss (compared with 50mm and 2.5mm/h in the base case) results in water levels increases around 150mm to 300mm near watercourses, however flood levels up to 1m higher are identified within Black River around the Bruce Highway. This substantial increase results in overflows to Alick Creek and results in levels over 500mm higher in Alick Creek downstream of the Highway.
- loss values of 70mm initial loss and 3mm/h continuing loss (compared with 50mm and 2.5mm/h in the base case) results in water levels decreases around 50mm to 150mm near watercourses;

The substantial increase in flows within Black River in the reduced rainfall loss scenario is particular to the 100 Year ARI, 24 hour storm event temporal pattern. With the lower initial loss there is approximately 45mm of rainfall in the first hour, while in the base case this is 26mm and in the high loss case 0mm. The steep upper reaches of the Black River catchment, mean this additional rainfall early in the storm can concentrate to the River channel towards the time of peak intensity in the temporal pattern.

Eddy Viscosity
The eddy viscosity sensitivity results show:

- the largest changes in flood levels (both increases and decreases) are confined to the larger watercourses of the study area (Althaus Creek, Bluewater Creek and Black River), where lower eddy viscosity can drive parabolic horizontal velocity profiles producing larger flows and lower water levels;
- little change in water levels in shallow parts of the study area where inundation is a result of local runoff rather than floodplain inundation;
- 20% decrease in eddy viscosity values results in water levels decreases around 50mm to 150mm in the major watercourses;
- 20% increase in eddy viscosity values results in water levels increases around 50mm to 200mm in the major watercourses;





ALTHAUS CREEK FLOOD STUDY SENSITIVITY ANALYSIS ROUGHNESS

Figure 4-6

LEGEND

Flood Level Difference (m)
100 Year ARI

- < -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

N

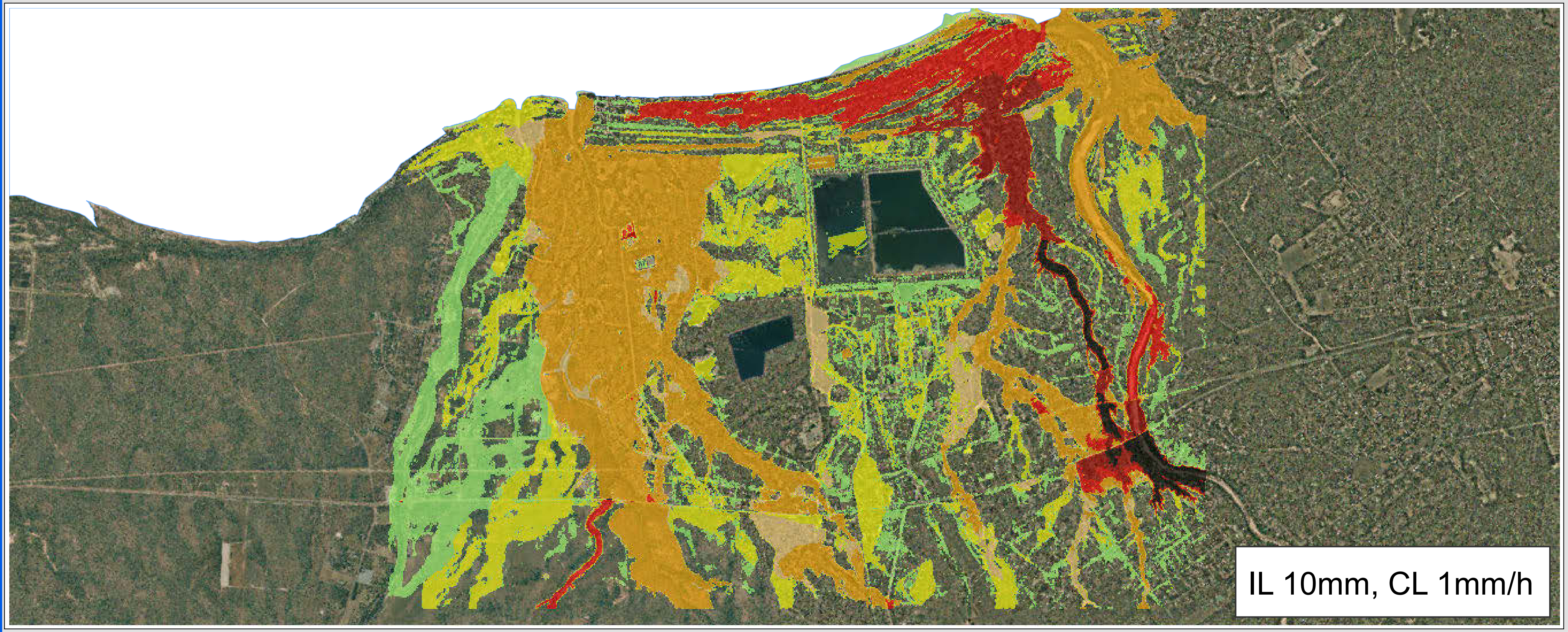
City of Townsville

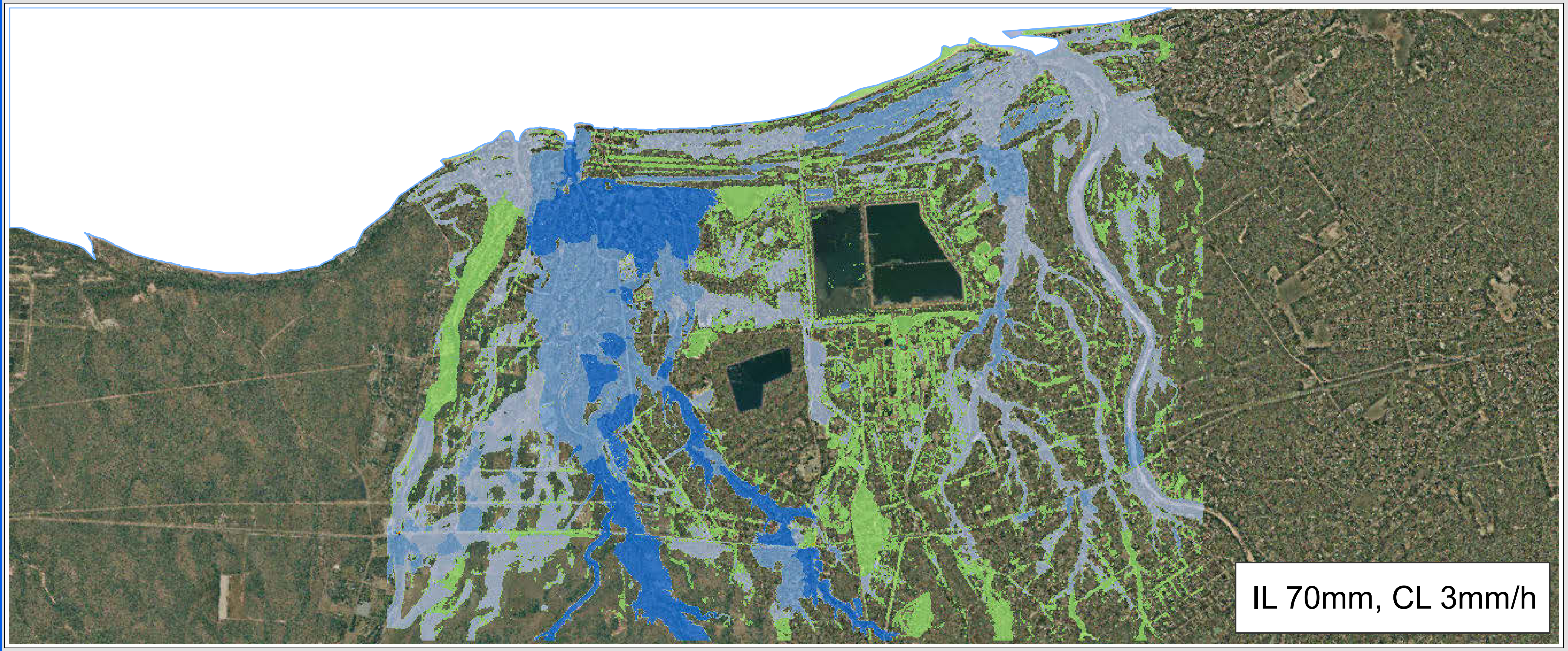
SCALE: 1:60,000 @A3

600 300 0 600 1,200 1,800 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 25/07/2012
DATE PRINTED: 4/02/2014
DRAWN BY: WBB
DIGITAL FILE: AlthausCk_Fig4-6_SensRough.mxd





ALTHAUS CREEK FLOOD STUDY SENSITIVITY ANALYSIS RAINFALL LOSSES

Figure 4-7

LEGEND

Flood Level Difference (m)
100 Year ARI

- < -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

City of Townsville

SCALE: 1:60,000 @A3

600 300 0 600 1,200 1,800 Metres

Produced by:
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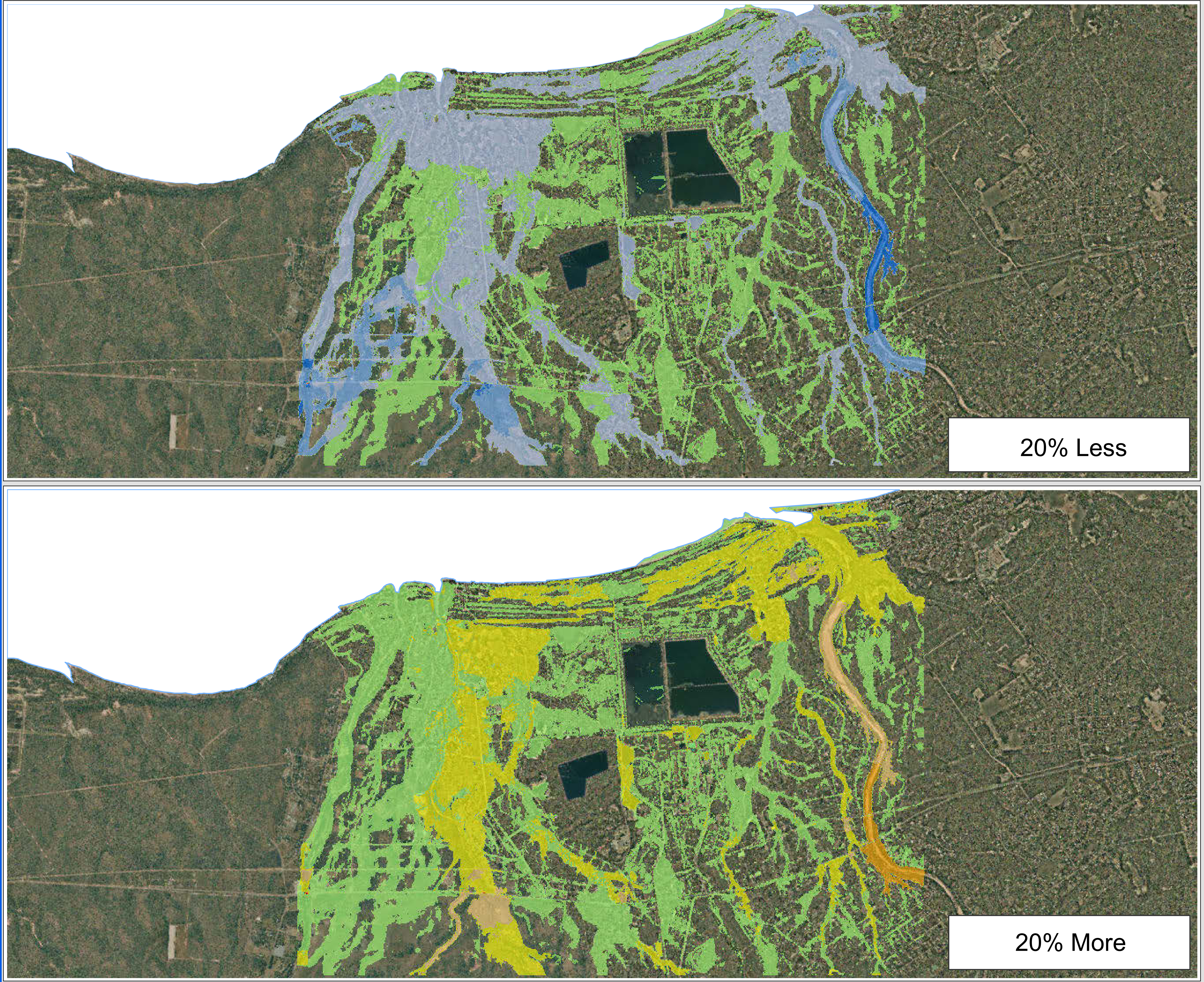
DIGITAL FILE: AlthausCk_Fig4-7_SensLoss.mxd

ALTHAUS CREEK FLOOD STUDY SENSITIVITY ANALYSIS EDDY VISCOSITY

Figure 4-8



LEGEND

Flood Level Difference (m) 100 Year ARI

- < -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

City of Townsville

SCALE: 1:60,000 @A3

600 300 0 600 1,200 1,800 Metres

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DATE: 25/07/2012

DATE PRINTED: 4/02/2014

DRAWN BY: WBB

DIGITAL FILE: AlthausCk_Fig4-8_SensEddy.mxd

4.7 Design Flood Assessment

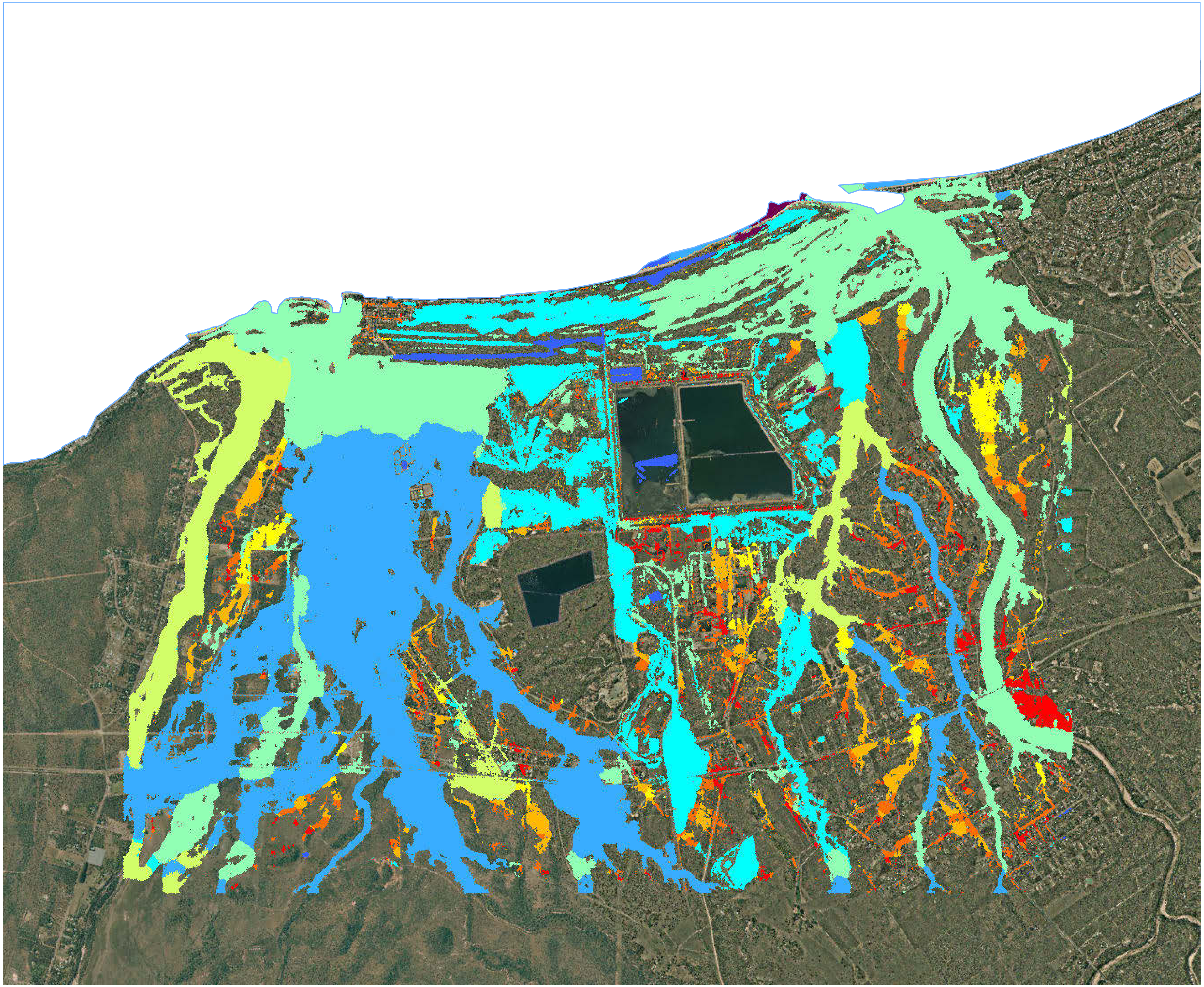
Following calibration of the hydraulic model, the model was updated to represent design flood events. Initially the 100 Year ARI was run for a range of event durations to establish the critical duration across the floodplain.

Figure 4-9 shows the critical flood durations for the 100 Year ARI event. The results demonstrate that there are a range of durations critical for flooding in the study area. Based on a closer examination of the flood levels the 2 hour and 24 hour storm durations were chosen as representative of the critical durations of flooding across the study area. Subsequent ARI events were represented for the 2 and 24 hour storm durations.

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

ALTHAUS CREEK FLOOD STUDY 100 YEAR ARI CRITICAL DURATION

Figure 4-9



LEGEND

Critical Duration

- 1h
- 1.5h
- 2h
- 3h
- 6h
- 12h
- 18h
- 24h
- 48h
- 72h

City of Townsville

SCALE: 1:40,000 @A3

400 200 0 400 800 1,200 Metres

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Planning and Development
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DATE PRINTED: 17/12/2013
DRAWN BY: WBB
DIGITAL FILE: AlthausCk_Fig4-9_CritDur.mxd

5.0 Baseline Flooding Summary

5.1 Flooding Results

Detailed flooding results are provided as flood maps in **Appendix B**. Flood maps are provided for flood depths, flood levels and flow velocities.

Detailed descriptions of the flooding for given ARIs are provided in **Table 5-1**. Descriptions are provided for each of the suburb areas within the study area.

Table 5-1 Description of Flooding

Event	Description
2 Year ARI	***Saunders Beach*** Inundation limited to local low points, floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders Beach. No overtopping of Saunders Beach Road Velocities of 0.8m/s in lower reaches of Althaus Creek. Floodplain velocities generally under 0.1m/s. ***Purono Park*** Inundation limited to table drains within the residential areas, creeks and hollows within the rural areas. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.3m. Velocities within Althaus Creek and Healy around 0.8m/s and 0.7m/s respectively. Velocities elsewhere generally less than 0.1m/s. ***Bluewater*** Inundation limited to table drains, gullies and hollows in rural areas. Areas of inundation upstream of Bruce Highway. Velocities in western and eastern James Street Gullies generally under 0.2m/s and 0.9m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line. Other inundation limited to creeks and table drains. Only minor impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line Floodplain velocities generally under 0.1m/s ***Black River*** Inundation mainly contained to creeks and table drains, with an area of inundation adjacent to the intersection of McKinnon Road and Black River Road. Overtopping of the Black River Road Northern Causeway by approximately 0.3m. Overtopping of McKinnon Road near Black River Road by approximately 0.1m. Velocities up to 0.4m/s in downstream of the Black River Road Northern Cause way.
5 Year ARI	***Saunders Beach*** Inundation limited to local low points. Increased inundation in floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders

Event	Description
	Beach. Overtopping of Saunders Beach Road by approximately 0.2m. Velocities of 2.0m/s in lower reaches of Althaus Creek and up to 0.7m/s in the lower reaches of Healy Creek. Floodplain velocities generally under 0.1m/s. ***Purono Park*** Inundation around table drains within the residential areas with some inundation of lots west of Purono Parkway near Bruce Highway and Althaus Parade. Inundation within creeks and hollows within the rural areas. There is an overflow from Althaus Creek towards Healy Creek to the north of the main residential area. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.45m. Velocities within Althaus Creek and Healy around 1.2m/s and 0.85m/s respectively. Velocities elsewhere generally less than 0.1m/s. ***Bluewater*** Inundation of table drains, gullies and hollows with floodplain inundation from gully overflows around King Street. Large areas of floodplain inundation adjacent to the lower reaches of Althaus Creek. Areas of inundation upstream of Bruce Highway. Overtopping of James Street at the Western Gully crossing by approximately 0.1m. Some Overtopping of Bruce Highway west of Deep Creek. Velocities in western and eastern James Street Gullies generally under 0.3m/s and 1.0m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1m. Other inundation around creeks and table drains. Only minor impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line Floodplain velocities generally under 0.1m/s, with velocities up to 0.8m/s in Healy Creek. ***Black River*** Inundation mainly contained to creeks and table drains, with an area of inundation adjacent to the intersection of McKinnon Road and Black River Road where depths are up to 0.6m. Other inundation upstream of roads. Overtopping of the Black River Road Northern Causeway by approximately 0.45m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.25m. Overtopping of McKinnon Road near Black River Road by approximately 0.1m. Velocities up to 0.6m/s in gullies.
10 Year ARI	***Saunders Beach*** Inundation limited to local low points within residential area. Increased inundation in floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders Beach. Overtopping of Saunders Beach Road by approximately 0.45m. Velocities of 2.1m/s in lower reaches of Althaus Creek and up to 0.9m/s in the lower reaches of Healy Creek. Floodplain velocities up to 0.5m/s around Althaus and Healy Creeks.

Event	Description
	Purono Park Inundation around table drains within the residential areas with some inundation of lots west of Purono Parkway near Bruce Highway and Althaus Parade. Large areas of inundation within rural floodplain around Althaus Creek. There is an overflow from Althaus Creek towards Healy Creek to the north of the main residential area. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.4m. Velocities within Althaus Creek and Healy around 1.0m/s and 0.7m/s respectively. Velocities elsewhere generally less than 0.1m/s. ***Bluewater*** Inundation of table drains, gullies and hollows with floodplain inundation from gully overflows and Althaus Creek overbank flows around King Street. Large areas of floodplain inundation adjacent to the lower reaches of Althaus Creek. Areas of inundation upstream of Bruce Highway. Overtopping of James Street at the Western Gully crossing by approximately 0.2m. Some Overtopping of Bruce Highway west of Deep Creek and near intersection with Bluewater Drive. Minor overtopping of Bluewater Drive near James Street. Velocities in western and eastern James Street Gullies generally under 0.35m/s and 1.2m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1.2m. Inundation mainly around creeks and table drains with an overflow from Alick Creek towards the Nickel Refinery starting to form. Only minor impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 0.2m. Floodplain velocities generally under 0.2m/s, with velocities up to 0.9m/s in Healy Creek. ***Black River*** Inundation mainly contained to creeks and table drains, with an area of inundation adjacent to the intersection of McKinnon Road and Black River Road where depths are up to 0.65m. Other inundation upstream of roads. Overtopping of the Black River Road Northern Causeway by approximately 0.45m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.25m. Overtopping of McKinnon Road near Black River Road by approximately 0.15m. Velocities up to 0.9m/s in gullies.
20 Year ARI	***Saunders Beach*** Inundation within local low points within residential area including much of Lagoon Crescent. Increased inundation in floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders Beach. Overtopping of Saunders Beach Road by approximately 0.75m. Velocities of 2.2m/s in lower reaches of Althaus Creek and up to 1.1m/s in the lower reaches of Healy Creek. Floodplain velocities up to 0.6m/s around Althaus and Healy Creeks. ***Purono Park*** Inundation around table drains within the residential areas with more inundation of lots due to local runoff. Large areas of inundation within rural floodplain around Althaus Creek.

Event	Description
	There is more inundation of the rural area north of the main residential area associated with the overflow from Althaus Creek towards Healy Creek. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.5 m. Velocities within Althaus Creek and Healy around 1.5m/s and 1.0m/s respectively. Velocities within the overflows and overbank flows from Althaus Creek up to 0.5m/s. Velocities elsewhere generally less than 0.2m/s. ***Bluewater*** More widespread flooding between gullies upstream of James Street. Increased Floodplain inundation from gully overflows and Althaus Creek overbank flows around King Street. Large areas of floodplain inundation adjacent to the lower reaches of Althaus Creek. Areas of inundation upstream of Bruce Highway. Overtopping of James Street at the Western Gully crossing by approximately 0.3m. Longer stretches of overtopping of the Bruce Highway between Deep Creek and the intersection with Bluewater Drive. Minor overtopping of Bluewater Drive near James Street. Velocities in western and eastern James Street Gullies generally under 0.5m/s and 1.2m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1.3m. Inundation becoming more widespread including the overflow from Alick Creek towards the Nickel Refinery. Only minor impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 0.3m. Floodplain velocities generally under 0.3m/s, with velocities up to 1.1m/s in Healy Creek and 0.6m/s in an overflow to the west from Healy Creek. ***Black River*** Inundation of lots becoming more prevalent including inundation adjacent to the intersection of McKinnon Road and Black River Road and inundation upstream of Moree Road. Overtopping of the Black River Road Northern Causeway by approximately 0.6m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.3m. Overtopping of McKinnon Road near Black River Road by approximately 0.15m. Minor Overtopping of the McKinnon Road Northern Crossing and Percheron Place. Velocities up to 1.1m/s in gullies.
50 Year ARI	***Saunders Beach*** Inundation within local low points of the residential area including much of Lagoon Crescent. Increased inundation in floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders Beach. Overtopping of Saunders Beach Road by approximately 1.0m. Velocities of 2.2m/s in lower reaches of Althaus Creek and up to 1.2m/s in the lower reaches of Healy Creek. Floodplain velocities up to 0.7m/s around Althaus and Healy Creeks. ***Purono Park*** Inundation around table drains becoming more extensive within the residential areas with more inundation of lots due to local runoff. Large areas of inundation within rural floodplain around Althaus Creek. Large areas of inundation north of the main residential area associated with the overflow from Althaus Creek towards Healy Creek.

Event	Description
	There is another overflow from Althaus Creek flowing northward through the residential area. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.65m. Minor overtopping of Purono Parkway near the North Coast Rail-line. Velocities within Althaus Creek and Healy around 1.7m/s and 1.1m/s respectively. Velocities within the overflows and overbank flows from Althaus Creek up to 0.8m/s. Velocities up to 0.3m/s through the residential area. ***Bluewater*** More widespread flooding between gullies upstream of James Street. Increased Floodplain inundation from gully overflows and Althaus Creek overbank flows around King Street. Large areas of floodplain inundation adjacent to the lower reaches of Althaus Creek. Areas of inundation upstream of Bruce Highway. Overflows from Bluewater into the residential area of Bluewater. Overtopping of James Street at the Western Gully crossing by approximately 0.55m. Longer stretches of overtopping of the Bruce Highway between Deep Creek and the intersection with Bluewater Drive. Minor overtopping of Bluewater Drive near James Street. Velocities in western and eastern James Street Gullies generally under 0.7m/s and 1.3m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1.5m. Inundation becoming more widespread including the overflow from Alick Creek towards the Nickel Refinery, and more extensive inundation upstream of roads. Moderate impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 0.4m. Minor overtopping of the Bruce Highway at the Healy Creek Overflow. Floodplain velocities up to 0.7m/s, with velocities up to 1.2m/s in Healy Creek and 0.6m/s in an overflow to the west from Healy Creek. ***Black River*** Inundation of lots becoming more prevalent including inundation adjacent to the intersection of McKinnon Road and Black River Road and inundation upstream of Moree Road. Overtopping of the Black River Road Northern Causeway by approximately 0.65m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.35m. Overtopping of McKinnon Road near Black River Road by approximately 0.15m. Minor Overtopping of the McKinnon Road Northern Crossing and Percheron Place. Velocities up to 1.2m/s in gullies.
100 Year ARI	***Saunders Beach*** Inundation within local low points of the residential area including much of Lagoon Crescent. Increased inundation in floodplain areas in the lower reaches of Healy Creek and swales within the coastal dunes to the east of Saunders Beach. Overtopping of Saunders Beach Road by approximately 1.2m. Velocities of 2.2m/s in lower reaches of Althaus Creek and up to 1.2m/s in the lower reaches of Healy Creek. Floodplain velocities up to 0.7m/s around Althaus and Healy Creeks. ***Purono Park***

Event	Description
	Flooding within the main residential area is a combination of overflows from Althaus Creek and local inundation around table drains. Large areas of inundation north of the main residential area associated with the overflow from Althaus Creek towards Healy Creek. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 0.65m. Minor overtopping of Purono Parkway near the North Coast Rail-line. Velocities within Althaus Creek and Healy around 2.0m/s and 1.2m/s respectively. Velocities within the overflows and overbank flows from Althaus Creek up to 0.9m/s. Velocities up to 0.5m/s through the residential area. ***Bluewater*** More widespread flooding between gullies around James Street. Extensive floodplain inundation from gully overflows and Althaus Creek overbank flows around King Street. Large areas of floodplain inundation adjacent to the lower reaches of Althaus Creek. Areas of inundation upstream of Bruce Highway. Overflows from Bluewater into the residential area of Bluewater, with most residential properties and the school inundated. Overtopping of James Street at the Western Gully crossing by approximately 0.8m. Longer stretches of overtopping of the Bruce Highway between Deep Creek and the intersection with Bluewater Drive. Minor overtopping of Bluewater Drive near James Street. Velocities in western and eastern James Street Gullies generally under 0.8m/s and 1.3m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1.6m. Inundation becoming more widespread including the overflow from Alick Creek towards the Nickel Refinery, and more extensive inundation upstream of roads. Moderate impacts from local stormwater on Nickel Refinery site. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 0.5m. Overtopping of the Bruce Highway at the Healy Creek Overflow by approximately 0.25m. Floodplain velocities up to 0.7m/s, with velocities up to 1.3m/s in Healy Creek and 0.7m/s in an overflow to the west from Healy Creek. ***Black River*** Inundation of numerous lots with more cross flows between gullies.. Overtopping of the Black River Road Northern Causeway by approximately 0.8m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.35m. Overtopping of McKinnon Road near Black River Road by approximately 0.15m. Overtopping of the McKinnon Road Northern Crossing by approximately 0.1m. Overtopping of Percheron Place by approximately 0.25m. Minor overtopping of the McKinnon Road Southern Crossing. Velocities up to 1.25m/s in gullies.
500 Year ARI	***Saunders Beach*** Connection of the flooding within the dunes to the east of the Saunders Beach and Lower Althaus Creek to the west through Lagoon Crescent area. Overtopping of Saunders Beach Road by approximately 2.0m. Velocities of 2.2m/s in lower reaches of Althaus Creek and up to 1.2m/s in the lower reaches of Healy Creek. Floodplain velocities up to 0.7m/s around Althaus and Healy Creeks.

Event	Description
	Purono Park Nearly all of the residential area is flooded as a result of overflows from Althaus Creek except some lots in Carmen Close. Full inundation between Althaus Creek and Healy Creek downstream of the Bruce Highway. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 1.0m. Overtopping of Purono Parkway near the North Coast Rail-line by approximately 0.1m. Overtopping of the Bruce Highway for the entire study area west of Purono Parkway with approximately 0.5m over the Althaus Creek bridge. Velocities within Althaus Creek and Healy around 2.1m/s and 1.3m/s respectively. Velocities within the overflows and overbank flows from Althaus Creek up to 1.1m/s. Velocities up to 1.1m/s through the residential area. ***Bluewater*** Widespread inundation between Bluewater Drive and Althaus Creek downstream of the Bruce Highway. Overflows from Bluewater into the residential area of Bluewater, with all residential properties and the school inundated. Overtopping of the full length James Street with water approximately 1.05m deep at the Western Gully. Extensive of overtopping of Bluewater Drive with depths in the order of 0.3m. Velocities in western and eastern James Street Gullies generally under 1.1m/s and 1.4m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 1.6m. Inundation is widespread with extensive inundation in the floodplain around Alick Creek adjacent to the Nickel Refinery. Significant impacts from local stormwater on Nickel Refinery site, which is unable to drain due to elevated tail-water levels in Alick Creek. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 0.55m. Overtopping of the Bruce Highway at the Healy Creek Overflow by approximately 0. 5m. Floodplain velocities up to 0.8m/s, with velocities up to 1.4m/s in Healy Creek and 1.3m/s in an overflow to the west from Healy Creek. ***Black River*** Significant break-out from the Black River impacted on numerous lots east of Black River Road and north of the Bruce Highway. Overtopping of the Black River Road Northern Causeway by approximately 1.2m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.65m. Overtopping of McKinnon Road near Black River Road by approximately 0.2m. Overtopping of the McKinnon Road Northern Crossing by approximately 0.2m. Overtopping of Percheron Place by approximately 1.8m. Overtopping of the McKinnon Road Southern Crossing by Approximately 0.2m. Velocities in the Black River break-out up to 2.2m/s.
PMF	***Saunders Beach*** Significant number of residential properties inundated around, Lagoon Crescent, Coral Street, Reef Street, Atoll Street and Cay Street. Overtopping of Saunders Beach Road by approximately 3.2m. Velocities of 2.2m/s in lower reaches of Althaus Creek and up to 1.3m/s in the lower

Event	Description
	reaches of Healy Creek. Floodplain velocities up to 1.0m/s around Althaus and Healy Creeks. ***Purono Park*** Entire residential area is flooded as a result of overflows from Althaus Creek. Full inundation between Bluewater Creek and Healy Creek around the Bruce Highway. Overtopping of Purono Parkway at the causeway near 43 and 45 by approximately 1.8m. Overtopping of Purono Parkway near the North Coast Rail-line by approximately 0.6m. Overtopping of the Bruce Highway with approximately 1.1m over the Althaus Creek bridge. Velocities within Althaus Creek and Healy around 2.3m/s and 1.8m/s respectively. Velocities within the overflows and overbank flows from Althaus Creek up to 1.7m/s. Velocities up to 1.3m/s through the residential area. ***Bluewater*** Complete inundation between Bluewater Drive and Althaus Creek downstream of the Bruce Highway. Overflows from Bluewater into the residential area of Bluewater, with all residential properties and the school inundated. Overtopping of the full length James Street with water approximately 1.3m deep at the Western Gully. Extensive of overtopping of Bluewater Drive with depths in the order of 0.5m. Velocities in western and eastern James Street Gullies generally under 1.2m/s and 1.5m/s respectively. ***Yabulu*** Large area of inundation on the eastern side of the Greenvale Rail-line around Bruce Highway and North Coast Rail-line with depths up to 2.1m. Inundation is widespread with extensive inundation in the floodplain around Alick Creek impacting lower areas of the Nickel Refinery. Overtopping of Bruce Highway Near Greenvale Rail-line by approximately 1.2m. Overtopping of the Bruce Highway at the Healy Creek Overflow by approximately 0.7m. Floodplain velocities up to 1.3m/s, with velocities up to 1.8m/s in Healy Creek and 1.7 m/s in an overflow to the west from Healy Creek. ***Black River*** Extensive inundation impacting on numerous lots around Black River Road and the Bruce Highway. Overtopping of the Black River Road Northern Causeway by approximately 2.1m. Overtopping of Black River Road Aurora Drive Causeway by approximately 0.8m. Overtopping of McKinnon Road near Black River Road by approximately 0.3m. Overtopping of the McKinnon Road Northern Crossing by approximately 0.26m. Overtopping of Percheron Place by approximately 2.8m. Overtopping of the McKinnon Road Southern Crossing by Approximately 0.4m. Velocities in the Black River break-out up to 2.3m/s.

5.2 Hydraulic Grade Line

Hydraulic grade lines for key watercourses within the study area are provided in **Appendix A**. The key watercourses are shown in **Figure 5-1** and include:

- Althaus Creek;
- Healy Creek;
- Deep Creek;
- Alick Creek Tributary 1
- Alick Creek Tributary 2; and
- Alick Creek.

5.3 Flow Distributions

Results from the model in terms of flows are provided in **Table 5-2** for the locations given in **Figure 5-2**. **Appendix B** provides the flood map results that give an indication of how flow distribution changes spatially with increasing flood magnitude.

ALTHAUS CREEK FLOOD STUDY WATERCOURSE CHAINAGES

Figure 5-1

LEGEND

- Chainage Points
- Watercourse

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300 150 0 300 600 900 Metres

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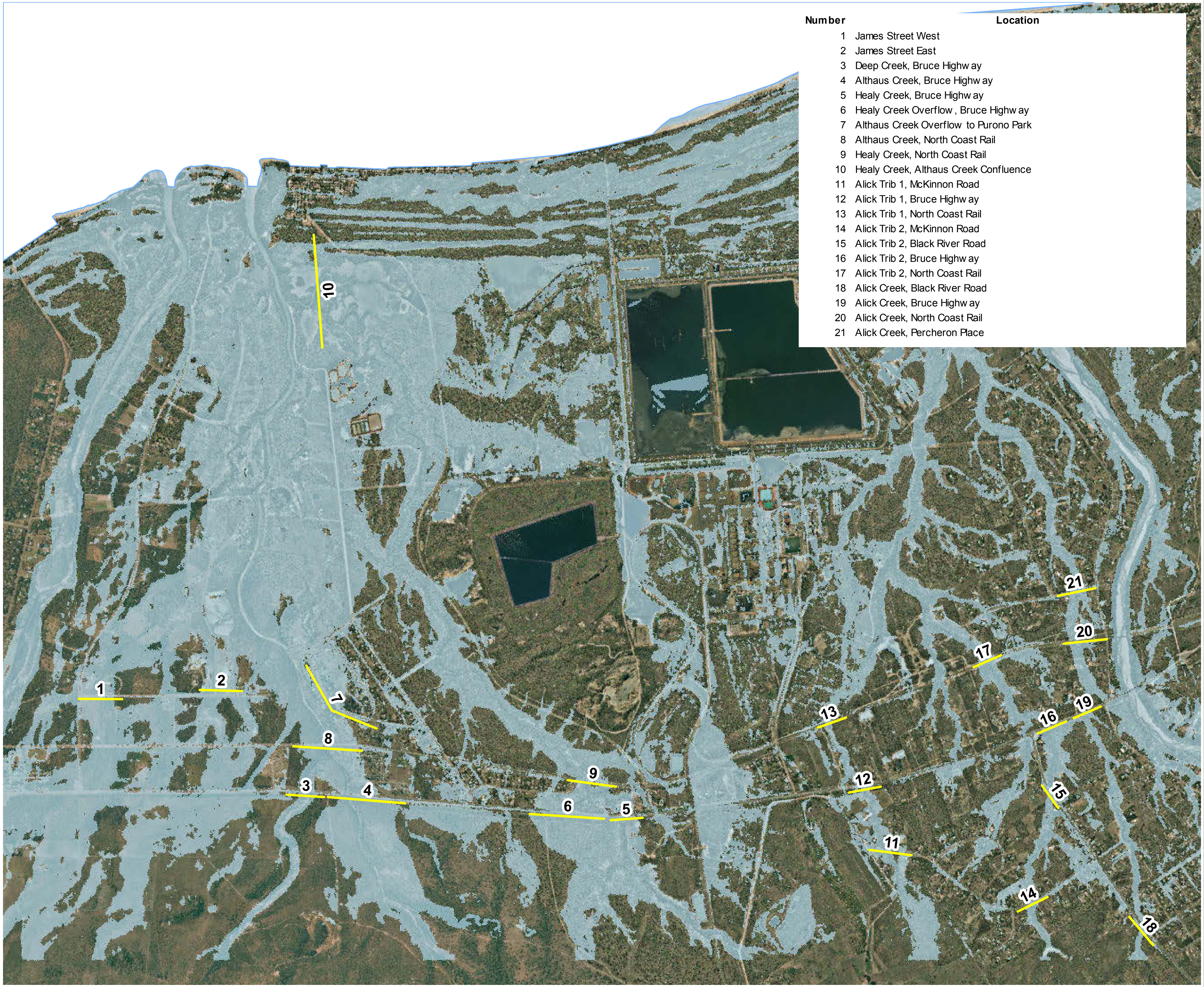
Table 5-2 Model Flow Results

Location	Description	Peak Flow (m^3/s)						
		2 Y ARI	5 Y ARI	10 Y ARI	20 Y ARI	50 Y ARI	100 Y ARI	500 Y ARI
1	James Street West	0.9	4.3	6.0	9.4	24.8	57.5	112.6
2	James Street East	1.1	4.8	6.8	9.9	15.2	28.4	95.4
3	Deep Creek, Bruce Highway	45.0	90.2	118.1	156.9	187.3	226.6	437.0
4	Althaus Creek, Bruce Highway	73.4	145.8	194.9	257.2	306.0	370.4	768.4
5	Healy Creek, Bruce Highway	33.2	61.7	77.0	92.0	100.2	107.7	160.1
6	Healy Creek Overflow, Bruce Highway	0.1	1.1	4.8	20.1	33.7	63.3	171.2
7	Althaus Creek Overflow to Purono Park	0	0	0	0	3.9	24.5	279.7
8	Althaus Creek, North Coast Rail	117.9	235.4	307.1	402.8	479.5	575.4	1057.8
9	Healy Creek, North Coast Rail	33.5	63.1	81.7	112.6	132.2	161.4	268.5
10	Healy Creek, Althaus Creek Confluence	-15.4	39.1	60.9	83.1	106.5	127.6	318.9
11	Alick Trib 1, McKinnon Road	1.9	5.2	7.5	10.7	14.9	18.1	34.5
12	Alick Trib 1, Bruce Highway	2.3	3.9	8.8	13.6	18.3	24.3	44.1
13	Alick Trib 1, North Coast Rail	4.0	7.2	10.0	13.9	18.8	24.5	44.7
14	Alick Trib 2, McKinnon Road	1.8	3.1	4.3	6.2	7.8	10.2	22.1
15	Alick Trib 2, Black River Road	3.8	7.8	11.1	16.0	20.1	25.3	43.8
16	Alick Trib 2, Bruce Highway	5.0	10.6	14.4	19.7	22.7	24.6	200.3
17	Alick Trib 2, North Coast Rail	7.1	14.0	18.4	28.3	32.3	37.0	330.0
18	Alick Creek, Black River Road	2.1	5.5	7.4	10.0	12.2	14.8	34.0
19	Alick Creek, Bruce Highway	1.9	7.8	11.5	15.5	16.0	23.2	356.4
20	Alick Creek, North Coast Rail	4.2	8.2	12.3	16.3	21.0	27.2	658.5
21	Alick Creek, Percheron Place	4.2	7.3	11.8	16.5	20.9	28.0	726.0

ALTHAUS CREEK FLOOD STUDY FLOW REPORTING LOCATIONS

Figure 5-2



Number	Location
1	James Street West
2	James Street East
3	Deep Creek, Bruce Highw ay
4	Althaus Creek, Bruce Highw ay
5	Healy Creek, Bruce Highw ay
6	Healy Creek Overflow , Bruce Highw ay
7	Althaus Creek Overflow to Purono Park
8	Althaus Creek, North Coast Rail
9	Healy Creek, North Coast Rail
10	Healy Creek, Althaus Creek Confluence
11	Alick Trib 1, McKinnon Road
12	Alick Trib 1, Bruce Highw ay
13	Alick Trib 1, North Coast Rail
14	Alick Trib 2, McKinnon Road
15	Alick Trib 2, Black River Road
16	Alick Trib 2, Bruce Highw ay
17	Alick Trib 2, North Coast Rail
18	Alick Creek, Black River Road
19	Alick Creek, Bruce Highw ay
20	Alick Creek, North Coast Rail
21	Alick Creek, Percheron Place

LEGEND

Flow Locations

100 Y ARI Flood Extent

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5.4 Floodplain Hazard

The safety of people and potential for damage to property is dependent on both the depth of inundation and the velocity of the flood waters. Floodwaters that flow deep and swift are obviously more hazardous than those areas where flows are shallow and slow.

The degree of hazard varies across the floodplain in response to:

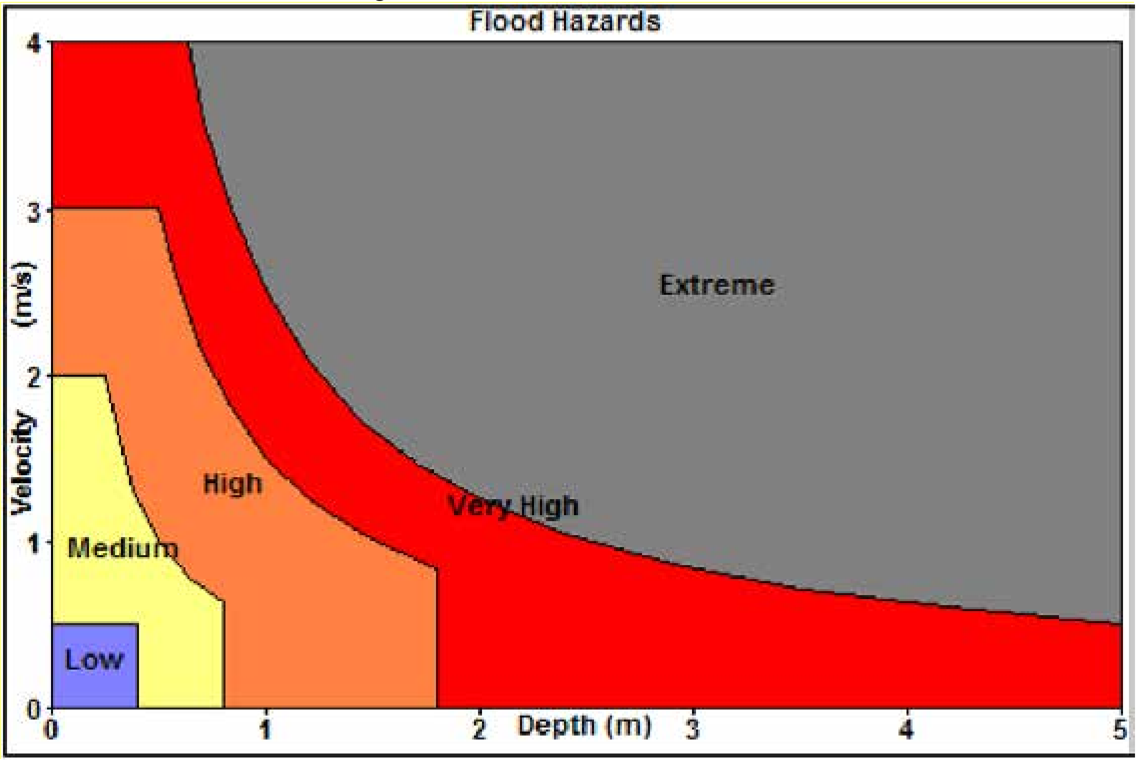
- flood severity;
- floodwater depth and velocity;
- rate of rise of floodwater;
- duration of flooding;
- evacuation capacity;
- population at risk;
- land-use;
- flood awareness; and
- warning time.

To assist with floodplain management it is necessary to determine the hazard and ensure land uses are suitably aligned. These hazard categories identified by McConnell and Low (2000) identify the following planning risks:

- **Low Hazard** – depth <0.4m and velocity <0.5m/s, suitable for cars;
- **Medium Hazard** – depth <0.8m, velocity <2m/s and velocity times depth <0.5, suitable for heavy vehicles and wading by able bodied adults;
- **High Hazard** – depth <1.8m, velocity <3m/s and velocity times depth <1.5, suitable for light construction (timber frame, brick veneer, etc.);
- **Very High Hazard** – velocity >0.5m/s and <4m/s with velocity times depth <2.5, suitable for heavy construction (steel frame, concrete, etc.); and
- **Extreme Hazard** – greater than very high, significant flow path development considered unsuitable and likely to significantly impact flood levels.

Prior to detailed assessment of floodplain hazard based on all the factors influencing hazard, preliminary assessment is often undertaken based on flood depth and velocity. **Figure 5-3** provides the basis for defining hazard as a function of depth and velocity as provided in McConnell and Low (2000).

Figure 5-3 Estimation of Flood Hazard



On the basis of the flood model results floodplain hazard has been mapped for the following events:

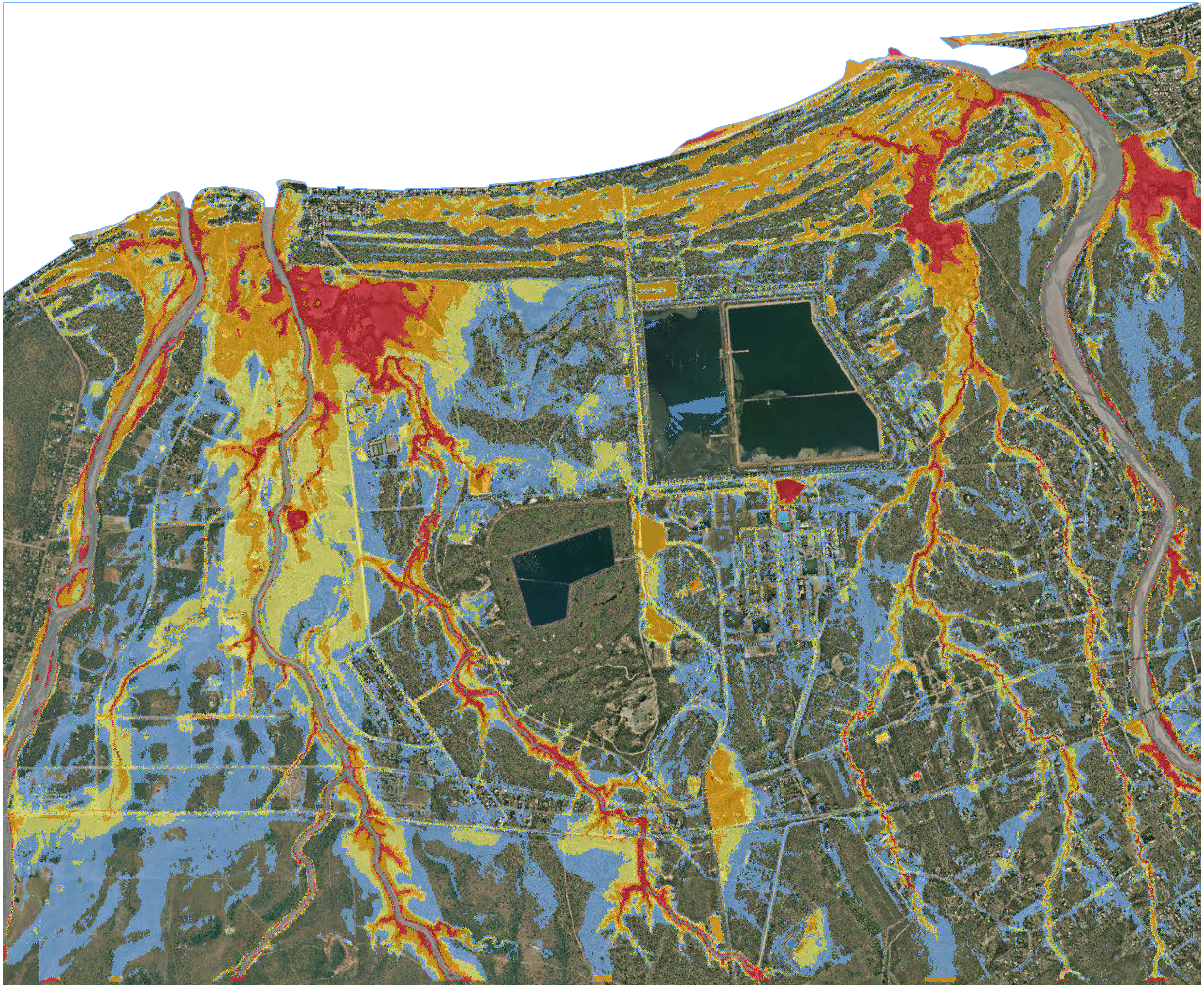
- **100 Year ARI** – representing the level of risk the *State Planning Policy* recommends for the Defined Flood Event;

- **500 Year ARI** – representing a rare event that is often used for design for critical infrastructure, and also the first event that modelled that has significant overflows into residential areas;

- **Probable Maximum Flood** – representing the extreme upper limit of flood hazard within the floodplain.

Figures 5-4, **5-5** and **5-6** show the resulting floodplain hazard maps for the 100 Year ARI, 500 Year ARI and Probable Maximum Floods respectively. Hazard mapping for the PMF provides an indication of ultimate potential hazard that could be anticipated at locations throughout the floodplain. The PMF hazard mapping reveals:

- Extereme hazard areas around the major watercourses and in the area of the overflow from Black River into Alick Creek;
- Saunders Beach is largely clear of flooding or has low flood hazard areas with some medium and high hazard areas within streets where there is inundation;
- Purono Park is mainly high and very high hazard areas;
- The area around Yabulu is generally either clear of flooding or has low hazard areas; and
- Bluewater is mainly medium and high flood hazard areas.



ALTHAUS CREEK FLOOD STUDY 100 YEAR ARI FLOOD HAZARD

Figure 5-4

LEGEND

Flood Hazard

- Low
- Medium
- High
- Very High
- Extreme

City of Townsville

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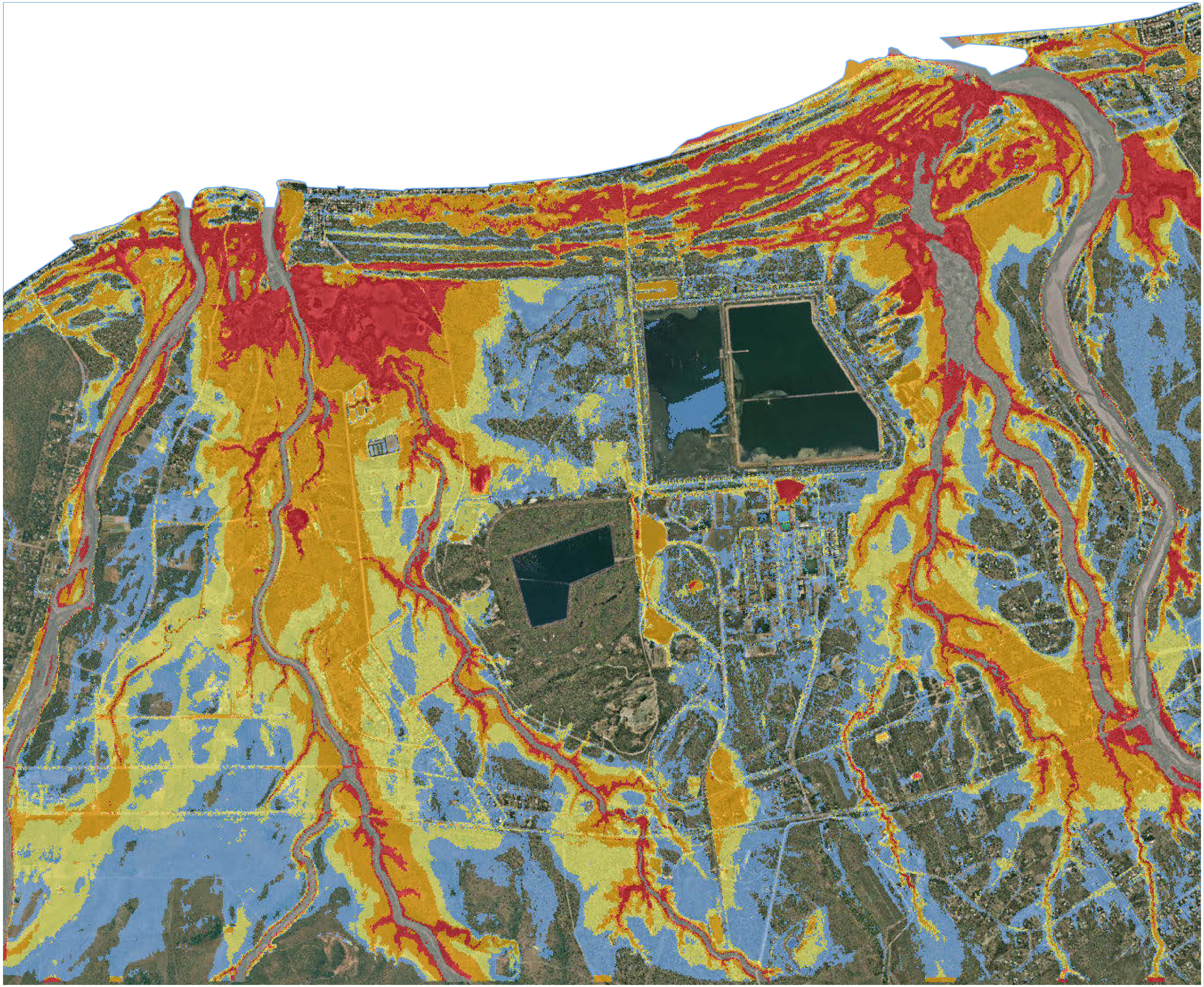

ALTHAUS CREEK FLOOD STUDY 500 YEAR ARI FLOOD HAZARD

Figure 5-5

LEGEND

Flood Hazard

- Low
- Medium
- High
- Very High
- Extreme

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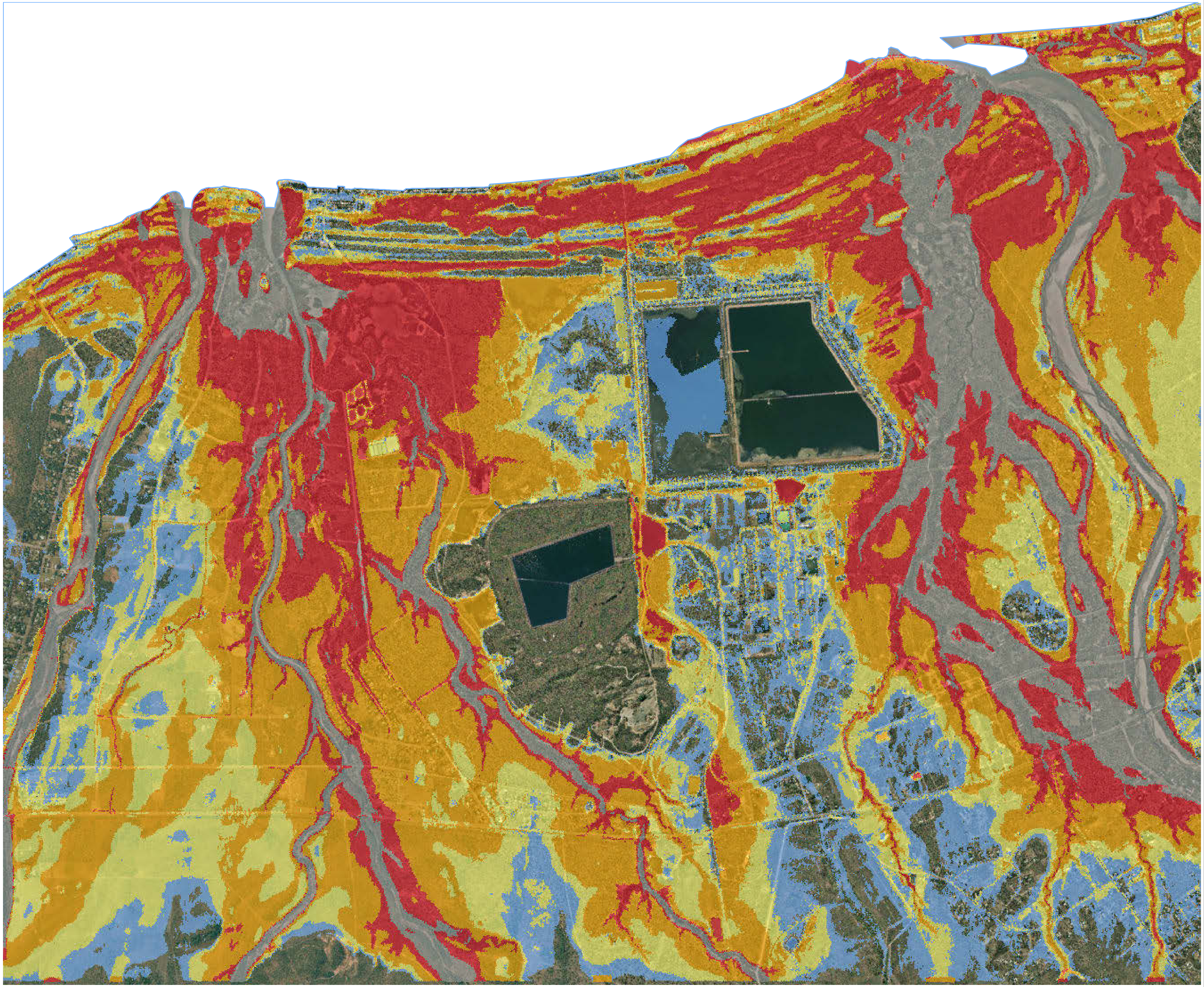

ALTHAUS CREEK FLOOD STUDY PMF FLOOD HAZARD

Figure 5-6

LEGEND

Flood Hazard

- Low
- Medium
- High
- Very High
- Extreme

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5.5 Floodplain Planning Considerations

Flood Hazard Overlay Mapping

The new City Plan for Townsville City Council is presently being drafted. The 100 Year ARI (1 % AEP) flood has been chosen as the Defined Flood Event (DFE) for establishing floor levels and providing planning controls for development. Maps for the Flood Hazard Overlay have utilised different zones for the overlay comprising:

- **Low flood hazard** – areas of residual flood risk beyond the 100 Year ARI;
- **Medium flood hazard** – areas of shallower and slower moving flood waters in the 100 Year ARI as per the criteria in **Figure 5-7**;
- **High flood Hazard** – areas of deeper and faster moving flood waters in the 100 Year ARI as per the criteria in **Figure 5-7.**

These hazard areas should not be confused with those provided in **Section 5.4**, which indicate the hazardous nature of the areas of the floodplain for specific probability floods.

Figure 5-7 – Flood Hazard Overlay Definitions (Medium and High Hazard)

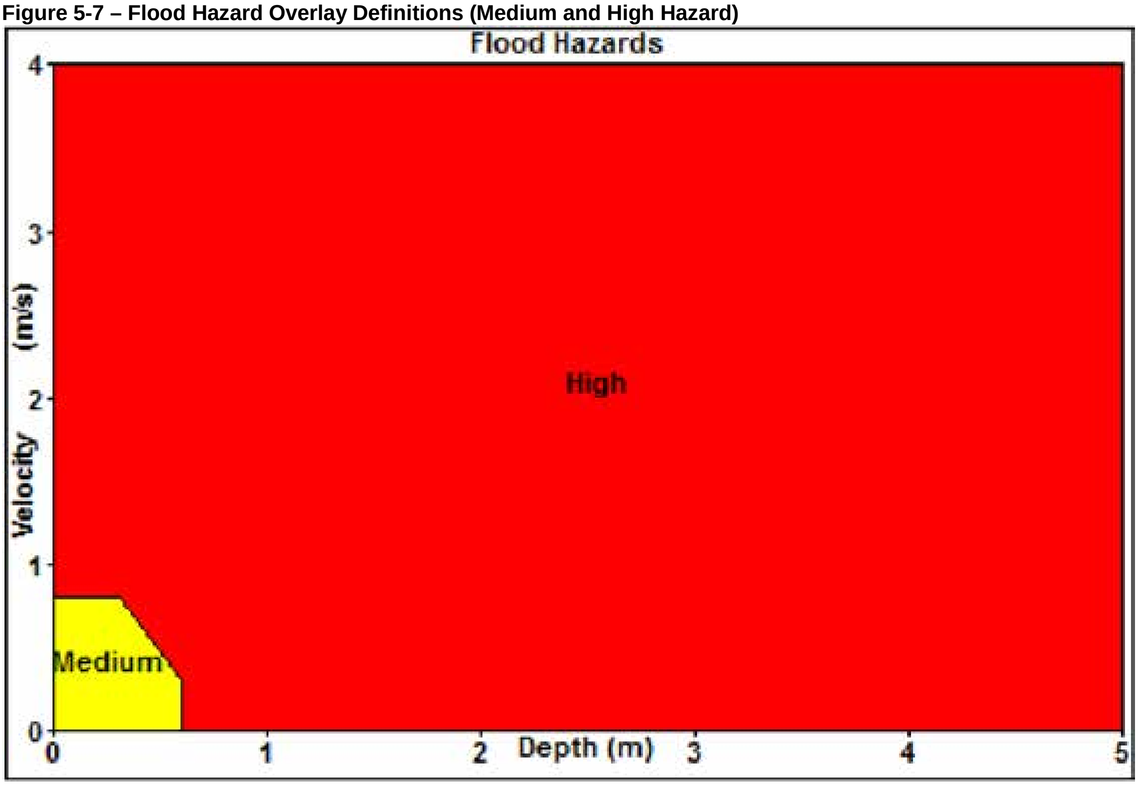
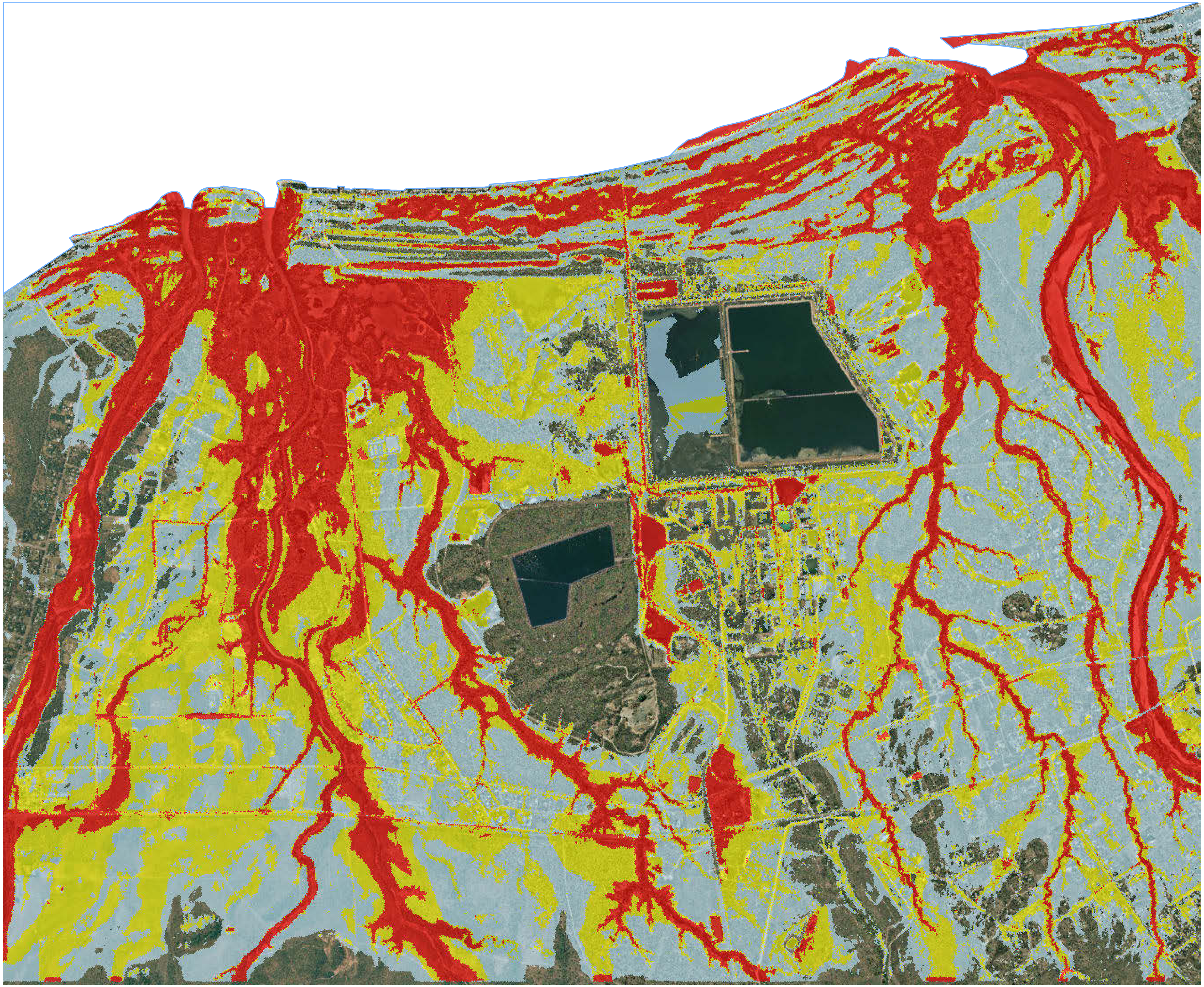


Figure 5-8 shows the proposed flood hazard overlay map for the Althaus Creek Study area based on the criteria above.

ALTHAUS CREEK FLOOD STUDY PROPOSED FLOOD OVERLAY

Figure 5-8



LEGEND

Flood Hazard Overlay

- Low Flood Hazard
- Medium Flood Hazard
- High Flood Hazard

City of Townsville

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5.6 Emergency Management Considerations

Flood Warning and Prediction

The Althaus Creek flood model is presently not suitable for use as a real-time prediction flood model, because of long run-times. There is however a significant amount of GIS flood layers that have been developed from the study which could be imported into a post processing software package such as WaterRide to support flood extent prediction as part of emergency management planning.

Flood extent prediction will still require an understanding of what flood levels are expected at key locations in the Althaus Creek catchment based on Bureau of Meteorology rainfall predictions. The Bureau of Meteorology does not presently make any flood level estimates in the Althaus Creek catchment, as the catchment is much smaller than the typical river basin scale examined by the Bureau of Meteorology flood forecasting unit.

There is still significant work required to enable reasonable flood level prediction within the Althaus Creek catchment for input to emergency planning, including:

- commissioning additional flood level alert gauges on key water courses in the Althaus Creek catchment;
- re-calibrating the Althaus Creek hydraulic model against observed flood events at the new flood level alert gauges;
- developing suitable rating curves for locations corresponding to flood level alert gauges in the Althaus Creek catchment;
- calibrating the Althaus Creek hydrological model to observed flood events at the flood level alert gauges using the developed rating curves; and
- configuring the Althaus Creek hydrological model to be used as a flood forecasting tool with rainfall advice provided by the Bureau of Meteorology.

Road Closures

The only evacuation routes within the extent of the Althaus Creek Flood Study are Bruce Highway and Saunders Beach Road. Other local roads are also critical to the effective evacuation of residents in the event of large flooding or Storm Tide Event.

Because of limitations with flood warning and prediction identified above, it is difficult to provide any predictions of road closures based on rainfall predictions; however, the flood immunity of evacuation routes has been examined for the design flood events from the flood study.

Figure 5-9 shows the locations where the major evacuation routes are closed. Based on the flood study results the flood immunity of the evacuation routes is provided in **Table 5-3**.

Table 5-3 Road Overtopping Depths

Location	Road Level (m AHD)	Depth over Road (m)						
		2 Y ARI	5 Y ARI	10 Y ARI	20 Y ARI	50 Y ARI	100 Y ARI	500 Y ARI
Black River Road, Aurora Drive Causeway	18.2	0.07	0.09	0.1	0.12	0.13	0.15	0.32
Black River Road, Northern Causeway	14.08	0.34	0.47	0.55	0.64	0.69	0.75	1.21
McKinnon Road, Southern Crossing	17.3				0.04	0.07	0.1	0.21
McKinnon Road, Northern Crossing	16.87							0.02
Purono Parkway	8.52	0.3	0.38	0.44	0.5	0.57	0.61	1.07
Percheron Place	10.2				0	0	0.01	1.44
Mill Road, Healy Creek	13.05	1.44	1.96	2.24	2.55	2.73	2.96	3.72
Saunders Beach Road	2.7		0.19	0.47	0.76	0.99	1.2	2
Bruce Highway, Healy Creek Overflow	12			0.11	0.14	0.17	0.23	0.41
Bruce Highway, Althaus Creek	11.5							0.43
Bruce Highway, Greenvale Rail	14.1	0.08	0.11	0.19	0.32	0.43	0.53	0.58
James Street, Western Gully	10.96		0.08	0.18	0.3	0.53	0.79	1.02
Bluewater Drive, Near James Street	11.73					0.02	0.05	0.22
McKinnon Road, Near Black River Road	17.31	0.12	0.15	0.16	0.18	0.19	0.2	0.23
Purono Parkway near North Coast Rail-line	11.27					0.01	0.02	0.12

Of the two major evacuation routes in the study area:

- Bruce Highway is overtopped at the Greenvale Rail line in the 2 Year ARI event is unlikely to be trafficable in the 20 Year ARI event; and
- Saunders Beach Road is likely to be overtopped in the 5 Year ARI event and is unlikely to be trafficable in the 10 Year ARI event.

Given the overtopping level of 2.7 m AHD for Saunders Beach Road, inundation due to storm tide is also likely to occur.

ALTHAUS CREEK FLOOD STUDY ROAD CLOSURES

Figure 5-9

LEGEND

- Road Overtopping Location
- Major Evacuation Route

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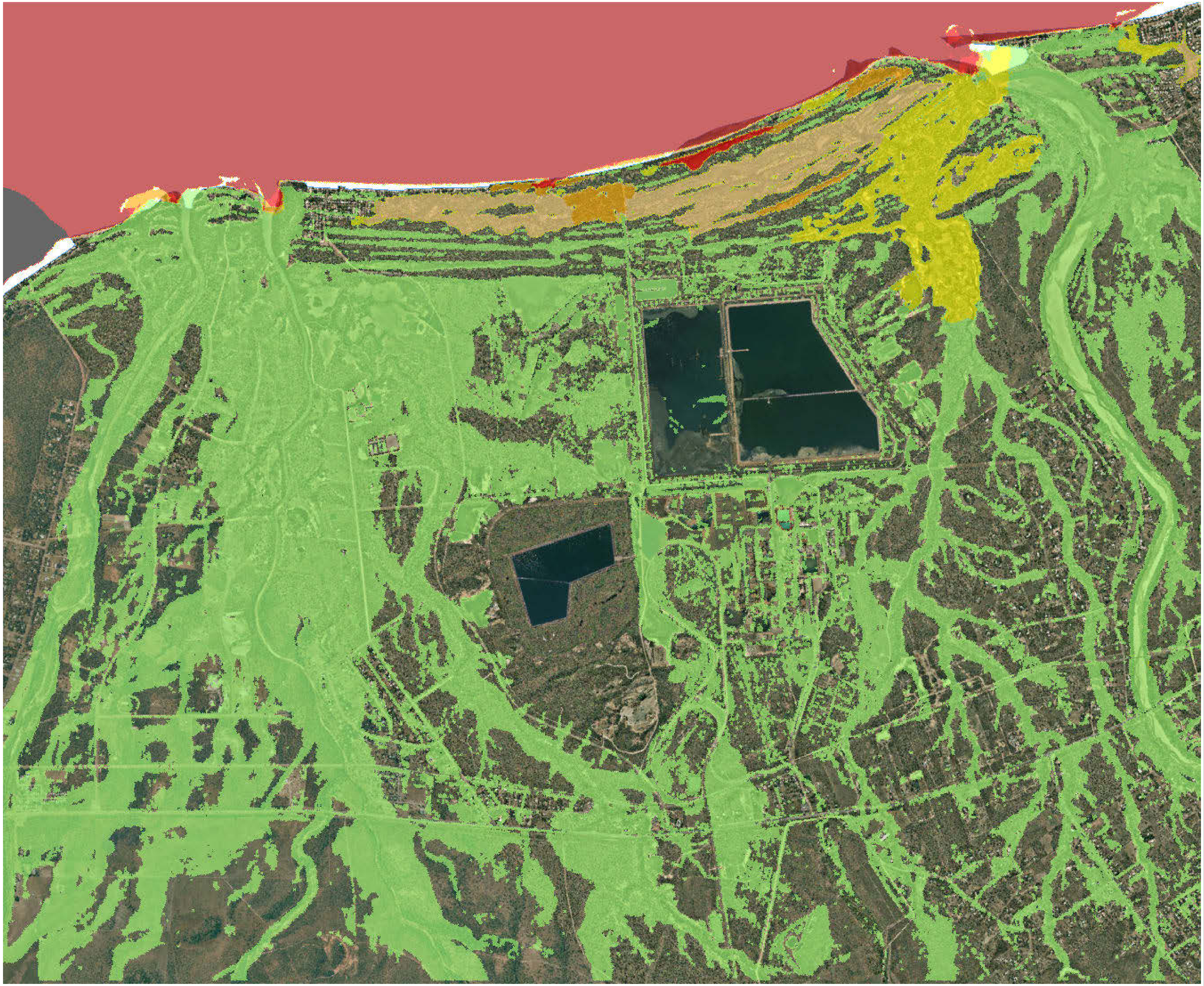
5.7 Tailwater Conditions

As indicated in **Section 4.3**, the MIKE FLOOD hydraulic model has represented design floods with a fixed tailwater condition at the MHWS tidal level (1.254 m AHD). This is considered somewhat conservative as the storm duration evaluated was 24 hours and there would be two semi-diurnal tidal cycles over this period.

There has also been an evaluation of adopting the Highest Astronomical Tide (HAT) level (2.25 m AHD) as the tailwater condition for the model. The 100 Year ARI flood was run with a tailwater condition equal to HAT. It should be noted that combining HAT with a design flood of a given frequency does not maintain the exceedance probability of the flood. Accordingly HAT in combination with a 100 Year ARI flood, should have a lower frequency (higher ARI). This issue of joint probability with respect to flooding and coastal processes is the subject of review of the forthcoming revision of *Australian Rainfall and Runoff*, due in 2015.

Figure 5-10 shows changes in flood levels for the 100 Year ARI flood as a result of the HAT tailwater condition. The results show increases in flood levels very localised to the mouth of Althaus Creek. Additionally there are increases in the order of 10-50mm in the lower reaches of Alick Creek and increases in flood levels between 50 and 100mm in the dune system to the east of Saunders Beach.



ALTHAUS CREEK FLOOD STUDY 100 YEAR ARI HAT IMPACTS

Figure 5-10

LEGEND

Flood Level Difference (m)

- < -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

City of Townsville

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6.0 Impact of Climate Change on Flooding

An evaluation of the potential impact of climate change on flooding has been undertaken. The two primary mechanisms considered for climate change to impact on flooding are sea level rise and changes in extreme rainfall intensities. The impact of sea-level rise and changes in extreme rainfall intensities were modelled concurrently using the MIKE FLOOD model.

While there is considerable consensus on the likelihood of sea-level rise resulting from climate change, the impacts on extreme rainfall is more contentious. The former Queensland Department of Environment and Resource Management (DERM) has released some interim guidance on the changes in extreme rainfall.

In a joint project between, DERM, the Department of Infrastructure and Planning (DoIP) and the Local Government Association of Queensland (LGAQ), a review of the potential for climate change to alter extreme rainfall intensities has been completed. *Increasing Queensland's resilience to inland flooding in a changing climate* (DERM, 2010) provides recommendation for extreme rainfall intensities in the interim until a new revision of *Australian Rainfall and Runoff* addresses the issue. From this project the Scientific Advisory Group (SAG) agreed that:

- an increase in rainfall intensity is likely;
- the available scientific literature indicates this increased rainfall intensity to be in the range of 3–10% per degree of global warming; and
- in the interim the SAG would consider a figure of a 5% increase in rainfall intensity per degree of global warming reasonable for informing policy development in the interim.

Review of the analysis completed to arrive at these conclusions, identifies that the increase in rainfall intensity is based on analysis of 1-day and 3 day rainfall (24 hour and 72 hour storms respectively). For the present study, the impact of climate change has been evaluated for the 100 Year ARI 24 hour duration storm.

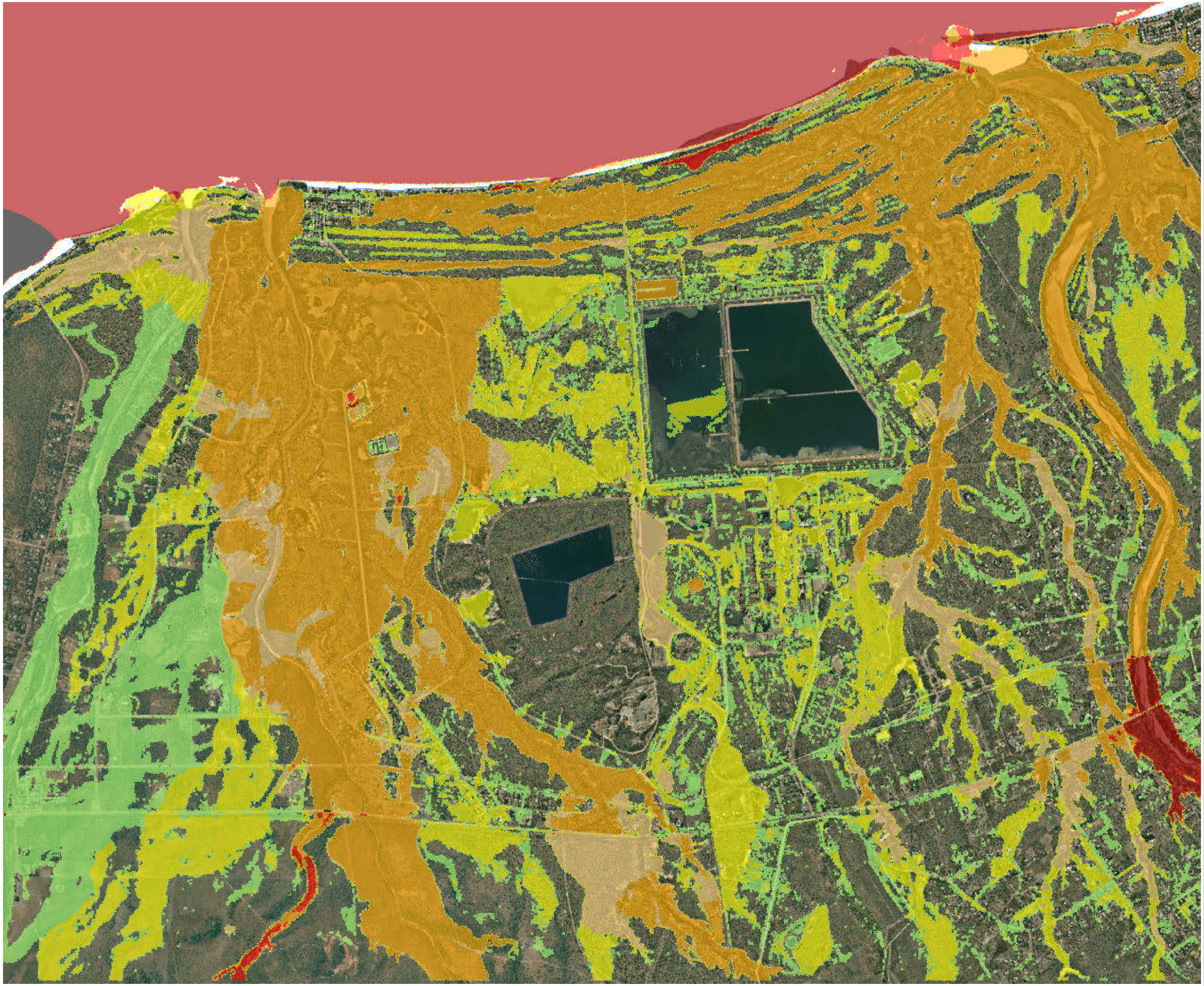
To evaluate the impact of sea-level rise and changes in extreme rainfall intensities on flooding, the modelling was updated by:

- increasing rainfall intensities by 15% allowing for a 3ºC rise in temperature to 2100 (based on local predictions from Hennesy et al 2008) ;
- re-calculating catchment runoff based on the new rainfall intensities;
- applying the revised flows as boundary conditions and source points to the MIKE FLOOD model; and
- updating the tailwater level to account for a 0.88 m rise in sea level to 2100.

It should be noted that the following assumptions are implied in this methodology:

- initial and continuing rainfall losses remain unchanged from present conditions;
- rainfall temporal patterns remain unchanged from present conditions;
- catchment surface retardances remain unchanged from present conditions;
- channel and floodplain hydraulic roughness remains unchanged from present conditions; and
- fraction impervious remains unchanged from present conditions.

Figure 6-1 shows the changes in flood levels for the 100 Year ARI flood. The results show increases in flood levels of between 100 mm and 300 m around the study watercourses with localised increases above 500mm in Black River around the Bruce Highway. In areas of the study area subject to inundation from local runoff rather than floodplain inundation, increases in flood levels are generally below 50mm.



ALTHAUS CREEK FLOOD STUDY 100 YEAR ARI CLIMATE CHANGE

Figure 6-1

LEGEND

Flood Level Difference (m)

- < -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

N

City of Townsville

SCALE: 1:30,000 @A3

300 150 0 300 600 900 Metres

Produced by:
STRATEGIC PLANNING
Planning and Development

DATE: 25/07/2012

DATE PRINTED: 4/02/2014

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7.0 Summary and Conclusions

The *Althaus Creek Flood Study – Baseline Flooding Assessment* is a component of the City Wide Flood Constraints project being completed by Townsville City Council. This study has developed hydrological and hydraulic models for quantifying the flood risk associated with flooding in the Althaus Creek are and will be used to inform floodplain planning, emergency management and infrastructure planning considerations. The analyses undertaken for the project builds on previous hydrological and hydraulic studies undertaken as part of the Bluewater Creek Flood Study (Engeny 2013) and Black River Flood Study (AECOM, in progress).

The hydrological analysis completed for the project has employed both runoff-routing and rain on grid approaches. The study evaluates the impacts of local rainfall events and broader river flooding events.

The MIKE FLOOD hydraulic model has been verified to previous flood models for the Black River and Bluewater Creek, with structure head-losses validated to HEC-RAS and sensitivity analysis completed for hydraulic roughness, rainfall losses and eddy viscosity.

The design storm frequencies assessed were the:

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

The modelling has been used to:

- determine floodplain hydraulic mechanisms;
- quantify flows about the floodplain for given frequency floods;
- categorise hazard zones within the floodplain;
- review floodplain planning considerations;
- identify issues for emergency management including flood warning and prediction and road closures;
- evaluate the impact on flooding of coincident Highest Astronomical Tide levels; and
- evaluate the impact on flooding of potential changes in sea-level and rainfall intensities associated with climate change.

7.1 Floodplain Hydraulic Mechanisms

Floodplain hydraulic mechanisms have been examined in detail in **Section 5.1**. The lower reaches of Healy and Althaus Creeks are quite low lying. In small flood events, there is overbank flooding in the area around the confluence of Healy and Althaus Creeks. With increasing flood magnitude there are overflows from Althaus Creek to Healy Creek, and in the 50 Year ARI there is an overflow running through Purono Park.

Overflows from Bluewater Creek into Althaus Creek also start to occur in the 50 Year ARI flood.

The Yabulu Nickel Refinery is located on a ridge that separates the Althaus Creek and Black River catchments. There is little interaction between flooding in Althaus Creek and Black River. During larger flood events there is some connection of the floodplains through the sand-dune areas of the lower reaches.

7.2 Inundation of Residential Properties

The primary residential areas of the Study area are Saunders Beach, Purono Park and Bluewater. Inundation within Saunders Beach is mainly the result of localised trap low points until the 50 Year ARI where there is some inundation of lots adjacent to floodplain areas. In the Probable Maximum Flood there are still approximately 50% of the residential lots clear of inundation, with flooding focussed around Lagoon Crescent, Coral Street, Reef Street, Atoll Street and Cay Street.

Inundation of residential lots within Purono Park is the result of local runoff until the 20 Year ARI event. In the 50 Year ARI event the overflows from Althaus Creek start to impact on lots around Althaus Parade. In the Probable Maximum Flood all residential lots in Purono Park are inundated.

The residential lots within Bluewater for the purpose of this discussion are those smaller lots immediately east of Bluewater Creek between the Bruce Highway and North Coast Rail. Inundation of residential lots within Bluewater is the result of local runoff until the 20 Year ARI event. In the 50 Year ARI event the overflows from Bluewater Creek impact on a majority of the lots. In the Probable Maximum Flood all residential lots in Bluewater are inundated.

7.3 Floodplain Hazard

Floodplain hazard has been characterised based on the function of velocity-depth product outlined in McConnell and Low (2000). The floodplain hazard was evaluated for the 100 Year ARI, 500 Year ARI and PMF events. Hazard mapping for the PMF provides an indication of ultimate potential hazard that could be anticipated at locations throughout the floodplain. The PMF hazard mapping reveals:

- Extreme hazard areas around the major watercourses and in the area of the overflow from Black River into Alick Creek;
- Saunders Beach is largely clear of flooding or has low flood hazard areas with some medium and high hazard areas within streets where there is inundation;
- Purono Park is mainly high and very high hazard areas;
- The area around Yabulu is generally either clear of flooding or has low hazard areas; and
- Bluewater is mainly medium and high flood hazard areas.

7.4 Floodplain Planning

The new City Plan for Townsville proposes to adopt the 100 Year ARI flood as the Defined Flood Event and will adopt a Flood Overlay map comprising three hazard ratings for flooding:

- Low flood hazard – areas of residual flood risk beyond the 100 Year ARI;
- Medium flood hazard – areas of shallower and slower moving flood waters in the 100 Year ARI; and
- High flood Hazard – areas of deeper and faster moving flood waters in the 100 Year ARI.

With larger lots like many of the rural lots within the study area, there are likely to be multiple flood hazard overlay ratings on individual lots. The spatial distribution of the overlay ratings will be able to guide appropriate uses across larger lots and the use on a particular lot will not be wholly limited by the highest hazard rating on the lot. Within the study area the flood hazard ratings for individual properties based on a majority of the individual lot are as follows:

- Low flood hazard rating – 1054 properties;
- Medium hazard rating – 282 properties
- High hazard rating – 108 properties

7.5 Emergency Management

The results of the flood modelling provide a useful tool for estimating flooding impacts throughout the Althaus Creek floodplain. Given the warning times available and the slow runtimes of the model, the model itself is not suitable for use as a real-time prediction tool.

The only evacuation routes within the extent of the Althaus Creek Flood Study are Bruce Highway and Saunders Beach Road. Other local roads are also critical to the effective evacuation of residents in the event of large flooding or Storm Tide Event. Of the two major evacuation routes in the study area:

- Bruce Highway is overtopped at the Greenvale Rail line in the 2 Year ARI event and is unlikely to be trafficable in the 20 Year ARI event; and
- Saunders Beach Road is likely to be overtopped in the 5 Year ARI event and is unlikely to be trafficable in the 10 Year A RI event.

Given the overtopping level of 2.7 m AHD for Saunders Beach Road, inundation due to storm tide is also likely to occur.

7.6 Impact of Higher Tides

A review of the potential for higher sea-levels to impact on flood levels was undertaken using the model. The tail water level was updated for sea level equal to Highest Astronomical Tide (2.25 m AHD). The results show some increases in the lower reaches of Alick Creek, with little impact on flood levels within Althaus Creek.

7.7 Impact of Climate Change

An assessment for the potential for climate change to impact on flooding has been undertaken. To account for climate change conditions in 2100, the model was updated to:

- include the sea level rise of 0.8 m on the Mean High Water Springs level to give a resulting sea level of 2.054 m AHD; and
- increase rainfall intensities by 15% in accordance with *Increasing Queensland's resilience to inland flooding in a changing climate* (DERM, 2010)

The results show increases in flood levels of between 100 mm and 300 m around the study watercourses with localised increases above 500mm in Black River around the Bruce Highway. In areas of the study area subject to inundation from local runoff rather than floodplain inundation, increases in flood levels are generally below 50mm.

8.0 References

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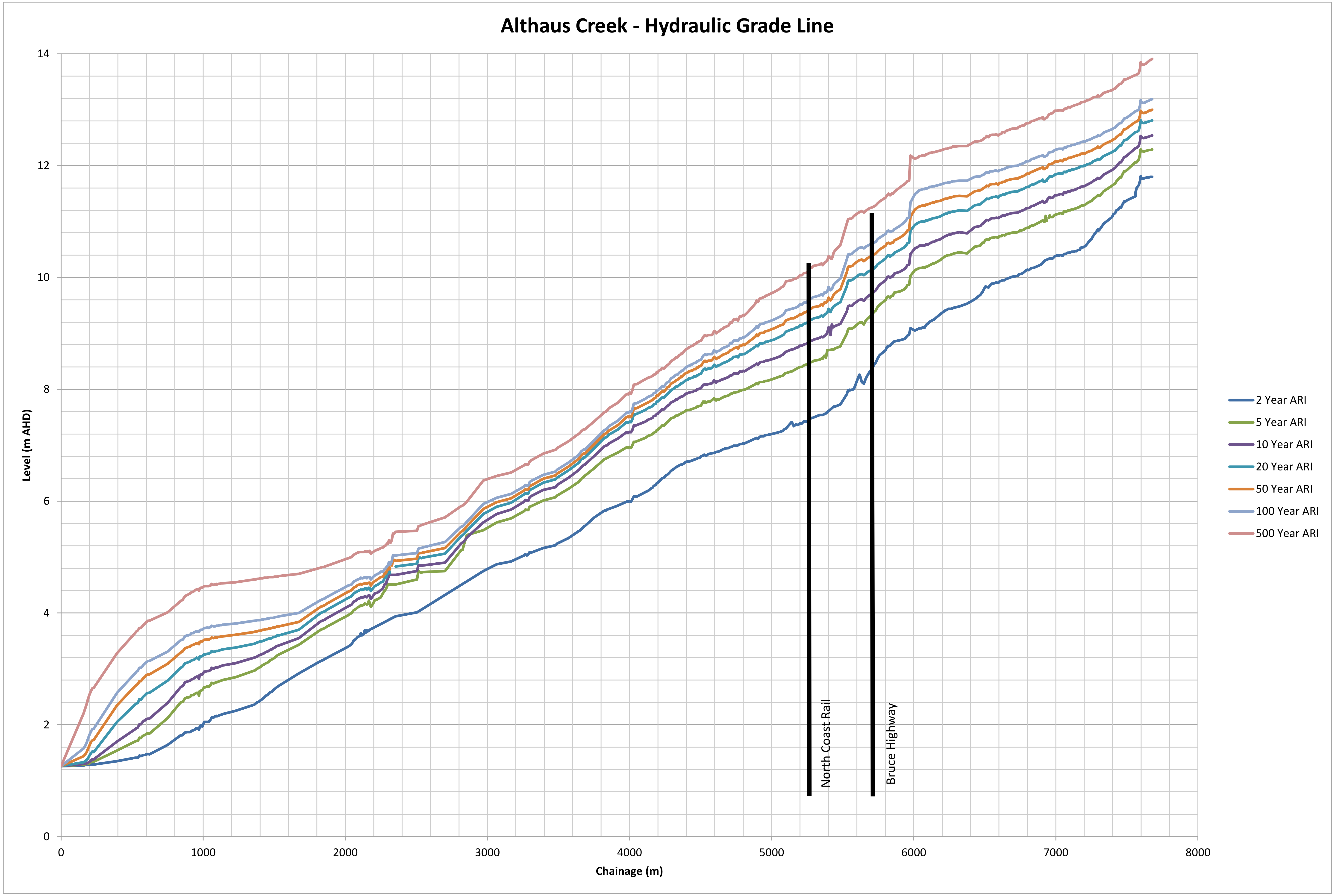
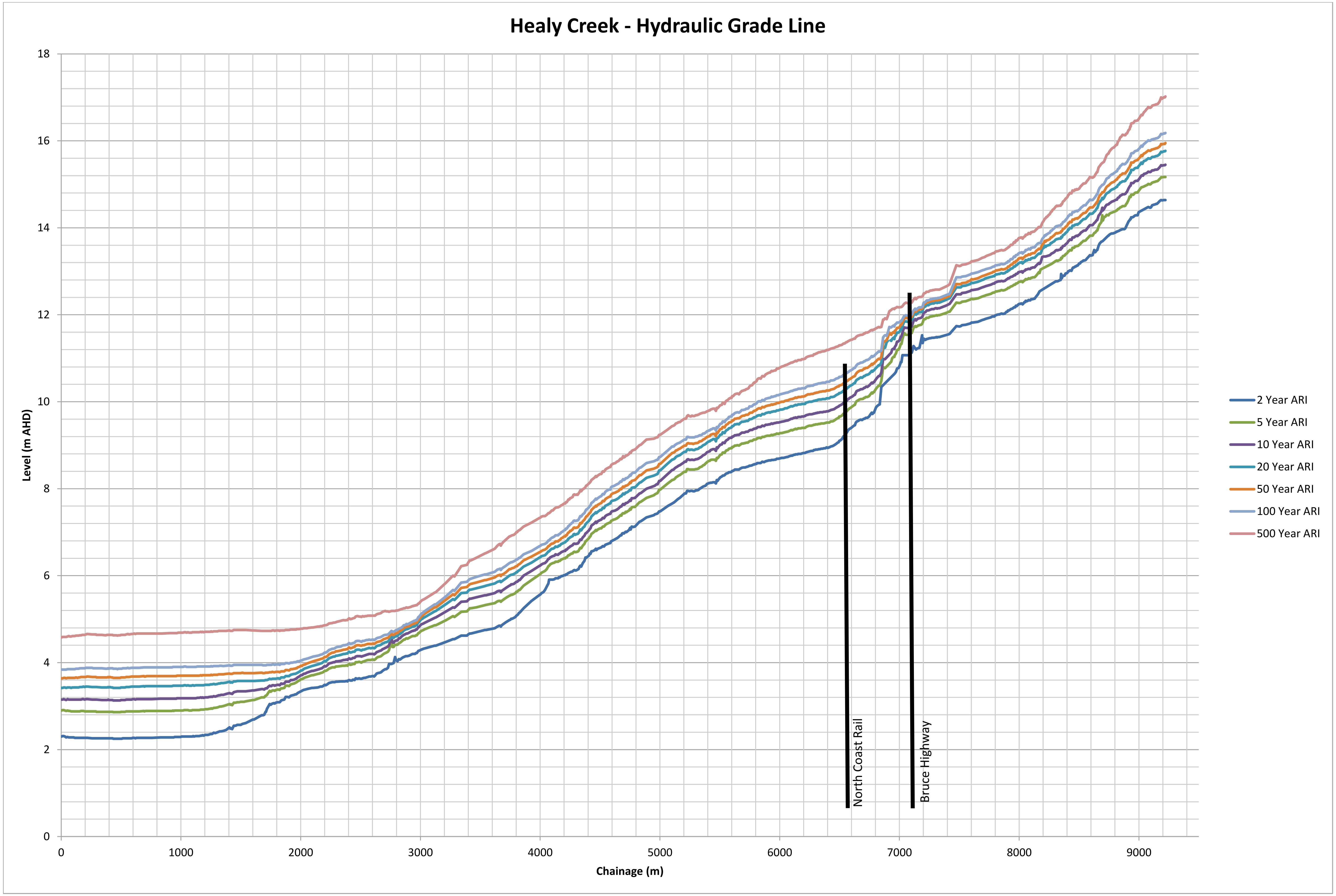
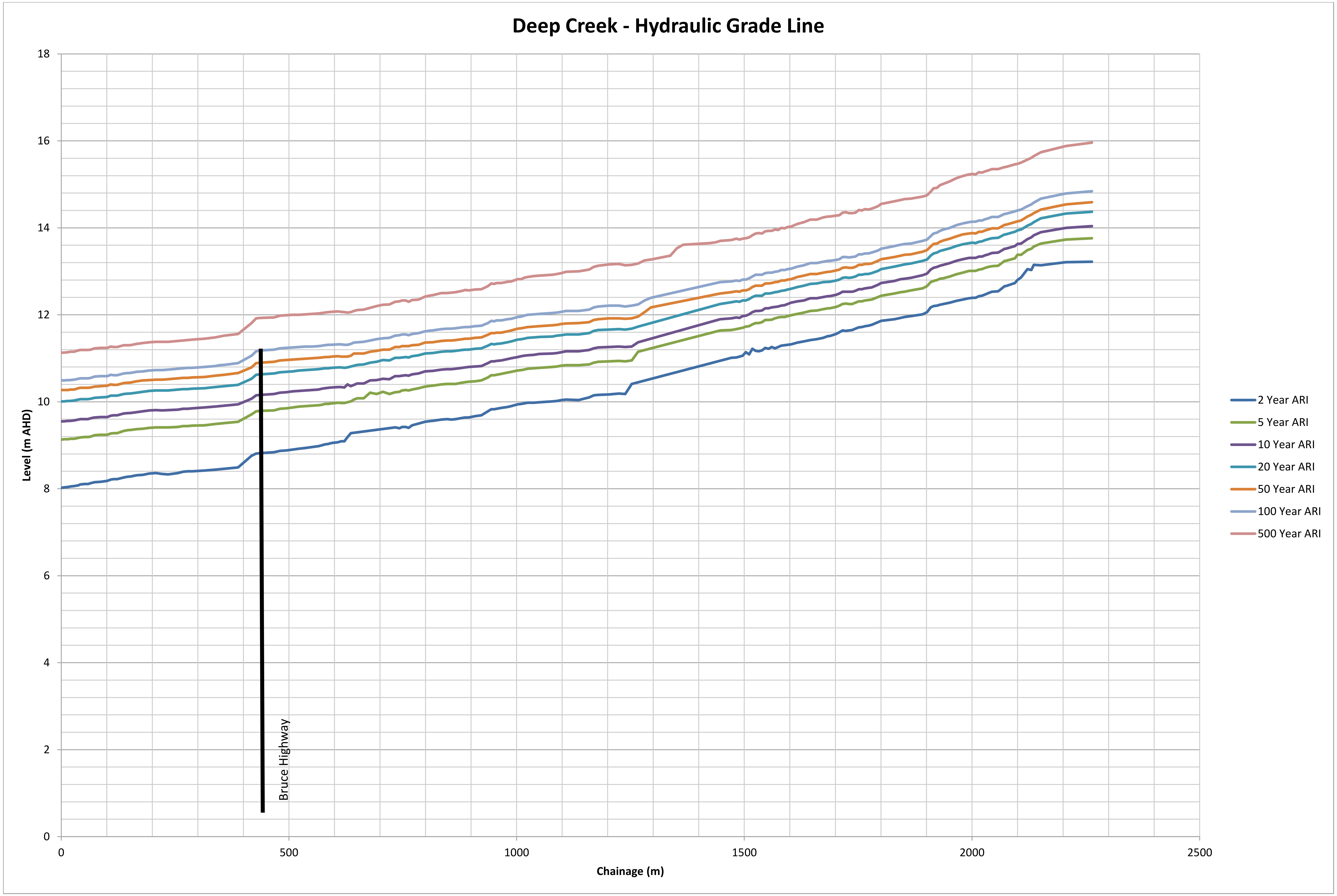
Appendix A – Hydraulic Grade Lines

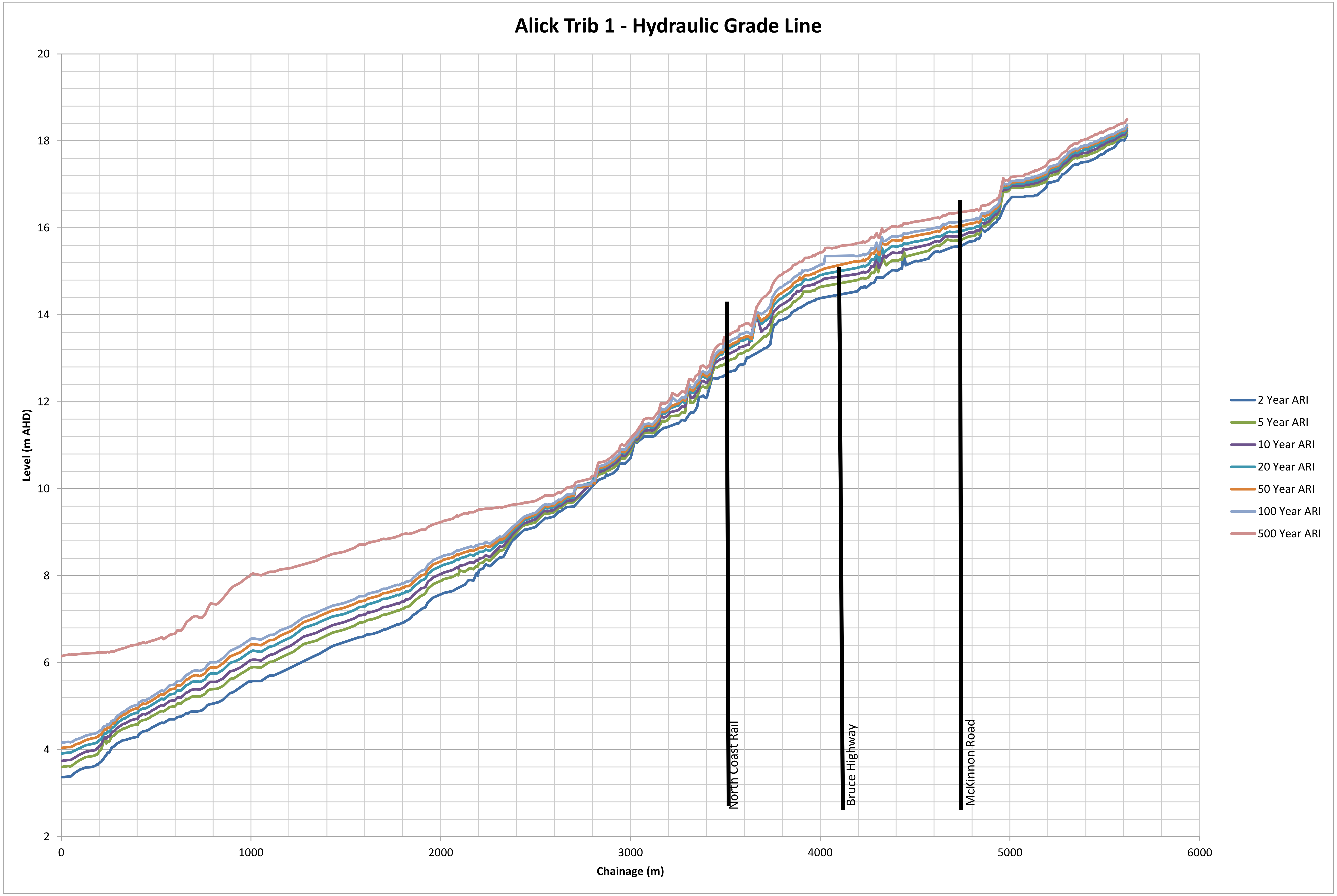


Althaus Creek - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
0
2
4
6
8
10
12
14
0
1000
2000
3000
4000
5000
6000
7000
8000
North Coast Rail
Bruce Highway
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI

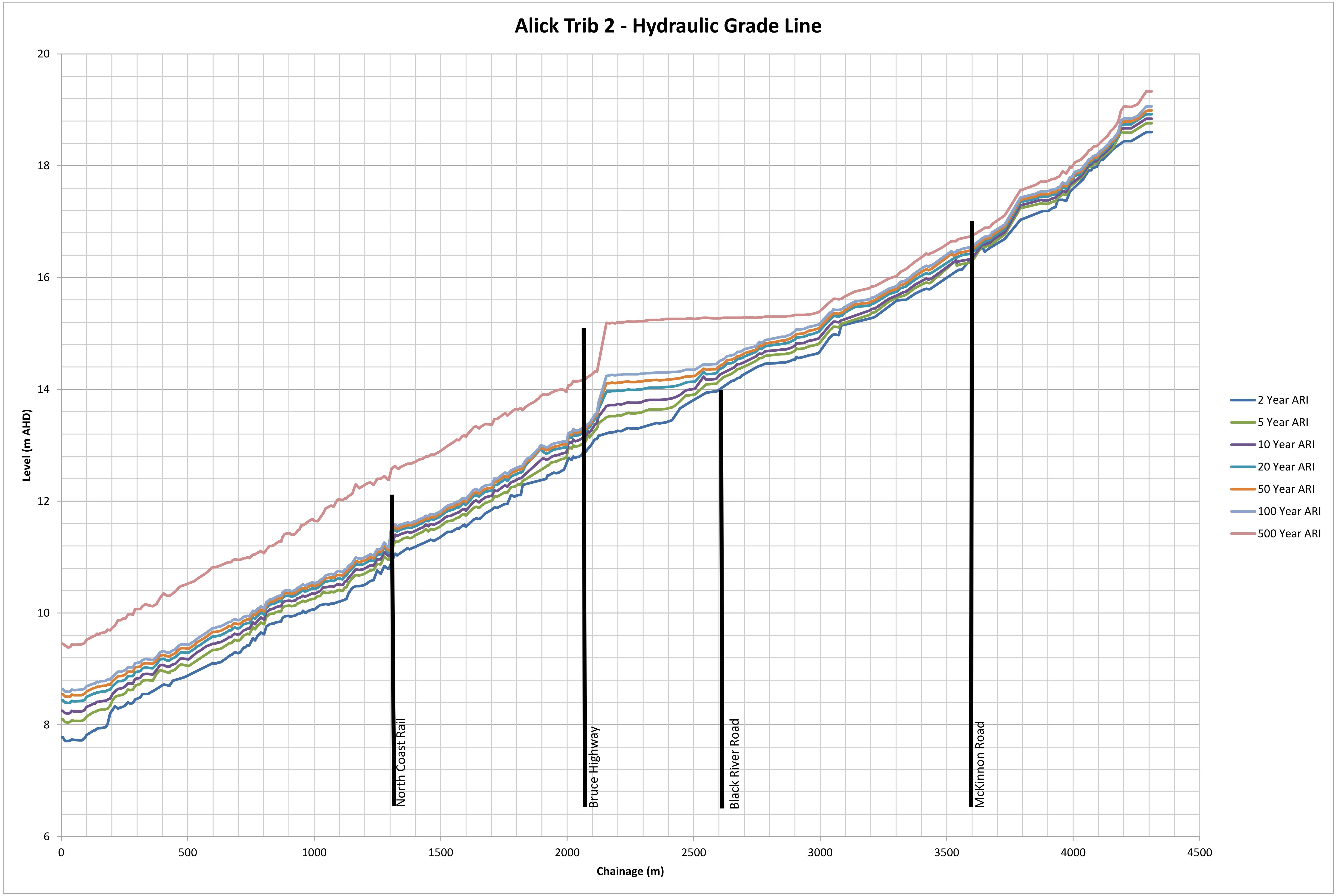


Healy Creek - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
0
2
4
6
8
10
12
14
16
18
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
North Coast Rail
Bruce Highway
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI

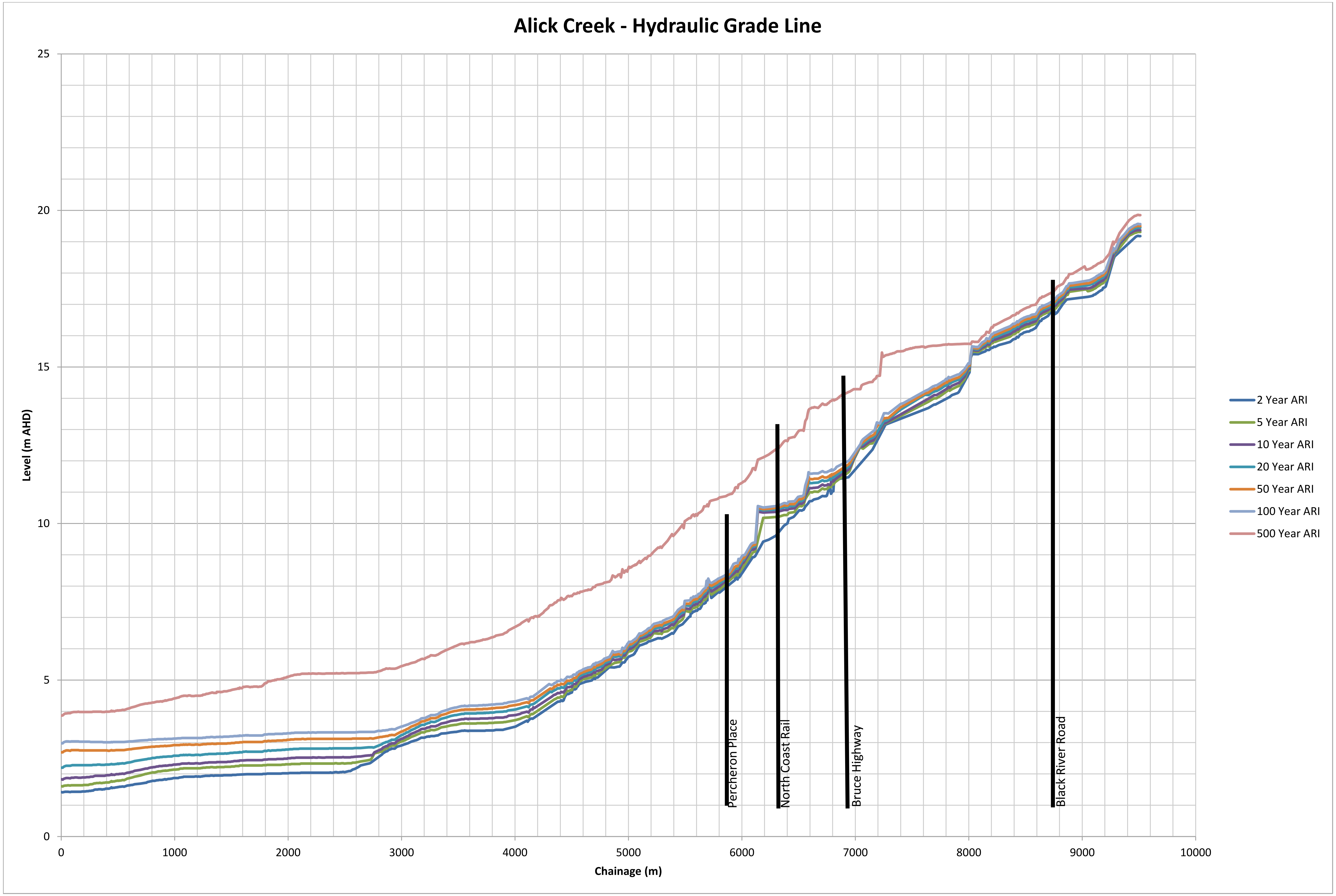

Deep Creek - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
Bruce Highway
0
2
4
6
8
10
12
14
16
18
0
500
1000
1500
2000
2500
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI



Alick Trib 1 - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
North Coast Rail
Bruce Highway
McKinnon Road
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI



Alick Trib 2 - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
20
18
16
14
12
10
8
6
0
500
1000
1500
2000
2500
3000
3500
4000
4500
North Coast Rail
Bruce Highway
Black River Road
McKinnon Road
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI


Alick Creek - Hydraulic Grade Line
Level (m AHD)
Chainage (m)
0
5
10
15
20
25
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Percheron Place
North Coast Rail
Bruce Highway
Black River Road
2 Year ARI
5 Year ARI
10 Year ARI
20 Year ARI
50 Year ARI
100 Year ARI
500 Year ARI

Appendix B – Flood Maps

(Refer to Volume 2)