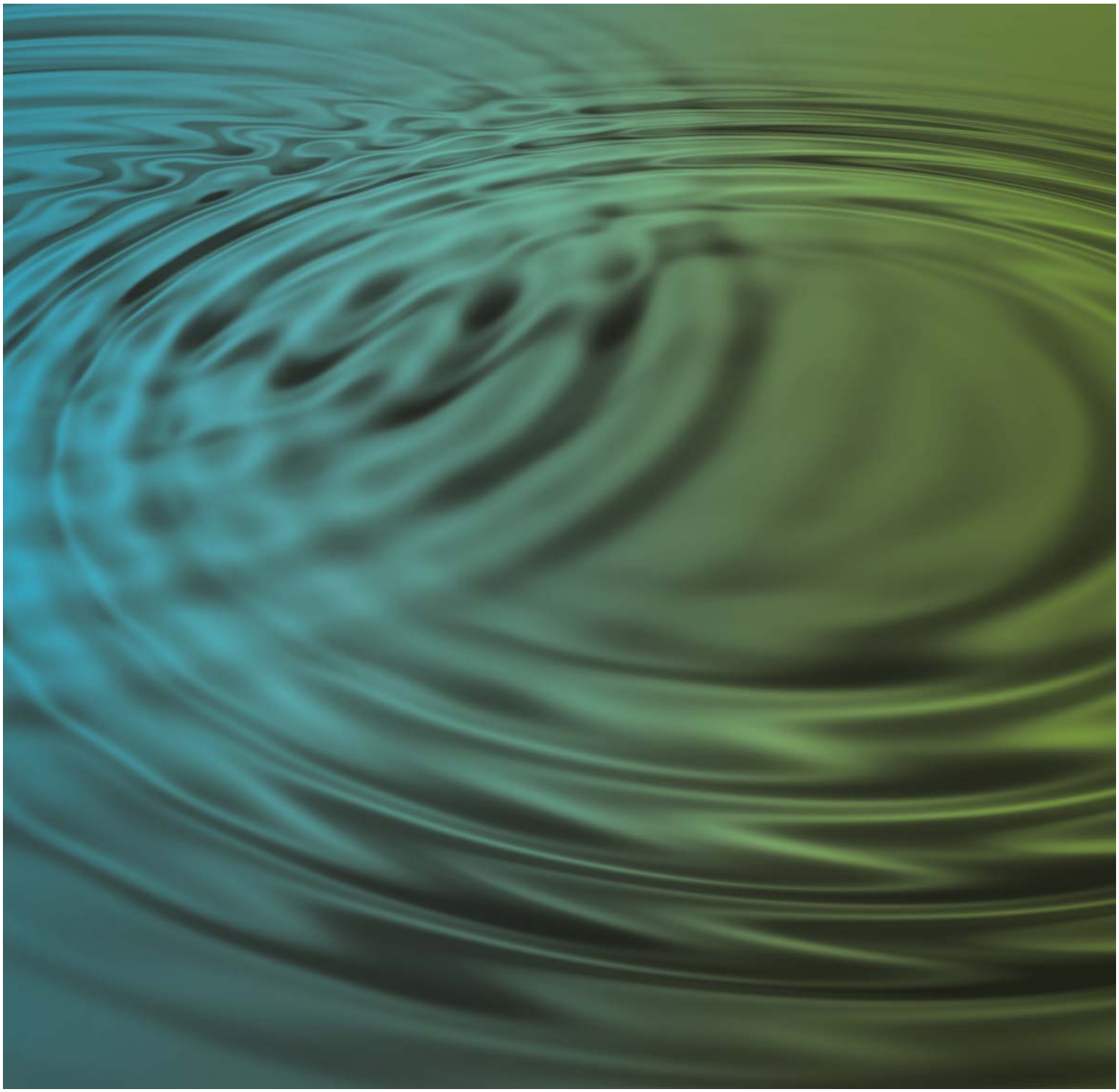
City Wide Flood Constraints Project
Townsville City Council
29-May-2014
Doc No. 60249277

# Lower Bohle/Stony Creek Flood Study

## Base-line Flooding Assessment



# Lower Bohle/Stony Creek Flood Study

Base-line Flooding Assessment

Client: Townsville City Council

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Prepared by

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# Quality Information

Document Lower Bohle/Stony Creek Flood Study

Ref 60249277

Date 29-May-2014

Prepared by Matilda Mathieu-Burry

Reviewed by Sally Williams

Revision History

| Revision | Revision Date | Details | Authorised | |
|---|---|---|---|---|
| | | | Name/Position | Signature |
| 0 | 15-May-2014 | Draft Copy | Brian Wright Industry Director – Water Infrastructure Services | |
| A | 29-May-2014 | Final Copy | Brian Wright Industry Director - Water Infrastructure Services |  |
| | | | | |

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# Executive Summary

AECOM Australia Pty Ltd (AECOM) was engaged by Townsville City Council (TCC) to develop hydrologic and hydraulic flood models for the lower reaches of the Bohle River area as part of the *Townsville City Wide Flood Constraints Project*.

For the purposes of this study, the area of interest was identified as the land to the west of the lower reaches of Bohle River and to the east of the lower reaches of the Black River. The lower reaches of the Black River were included in the model to facilitate the representation of overflows affecting the area of interest.

A dynamically coupled MIKE FLOOD hydraulic model comprising of a 10 m grid 2D overland flow component (MIKE21) linked to 1D elements (MIKE11 and MIKE URBAN) was developed. Base-line flooding conditions were determined for a range of design storm events.

No calibration or verification data was available for the study. Since the *Lower Bohle Flood Study (LBFS)* builds on several previous flood assessments carried out in the vicinity the model results were compared with the previous studies and found to be broadly consistent with overlapping and historical flood studies for the region.

Inflow boundary conditions were derived from XP-RAFTS hydrologic models as well as the *Black River Flood Study (2014)* and the *Middle Bohle Flood Study* (2014) which overlap the Lower Bohle model extents. Each of those models was independently calibrated and verified against previous flood events. The Rain-on-Grid method was adopted within the model extent to represent the localised runoff generated from the study area.

The critical storm durations adopted for the area of interest were the 12 and 24 hour. These values were determined by assessing the full range of storm durations for the 100 year ARI storm event. For the 500 year ARI and PMP storm events, a critical duration of 3 hours was adopted to ensure consistency with previous studies completed as part of the *City Wide Flood Constraints Project*.

Mapping of the model outputs included water surface elevations, depth of flow and velocity and provided in Appendix A.

Sensitivity testing was undertaken for various parameters including roughness and hydrologic losses. It was found that the model is not sensitive to changes of the initial or continual losses but variations in the Manning's roughness coefficient produced changes of up to 0.25 m to modelled results. In addition to the sensitivity analysis, it is noted that residents' anecdotal accounts of flooding along Mount Low Parkway were generally consistent with the model estimates which confirmed that the parameters adopted for this study were reasonable.

The flood model results showed that some level of inundation was predicted at areas in the vicinity of Bushland Beach, Black River and Mount Low during all ARIs assessed with widespread flooding expected across Mount Low during the 500 year ARI and PMF event. Mount Low Parkway is estimated to have a level of flood immunity in excess of 100 year ARI whereas parts of North Shore Boulevard is estimated to have a level of flood immunity less than 50 year ARI.

The MIKE FLOOD hydraulic model is currently not calibrated or verified. It is recommended that calibration and verification is performed in the future when new flood survey levels or stream flow data become available. Opportunities to reduce the extent and consequences of flooding within the study area should be sought. This could include the introduction of flood mitigation measures at strategic locations. Furthermore, it is recommended that finished floor level survey for properties in areas deemed to be affected by flooding is carried out to facilitate the development of suitable flood risk management strategies by Council.

**Table Ex-1 – Summary of Lower Bohle/Stony Creek Flooding Results**

| Event | Indicative Rainfall | Properties Inundated[1] | Major Evacuation Route Closures | Flooding Description |
|---|---|---|---|---|
| 2 year ARI | 87 mm in 3h<br>116 mm in 6 h<br>138 mm in 9h<br>156 mm in 12h<br>182 mm in 18h | 128 | | - Overbank flow predicted for sections of the Bohle River and Stony Creek area.<br>- No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).<br>- Velocities of up to 0.75 m/s predicted at Bushland Beach. |
| 5 year ARI | 120 mm in 3h<br>153 mm in 6 h<br>183 mm in 9 h<br>206 mm in 12 h<br>245 mm in 28 h | 179 | | - Low Creek, tributary of the Black River, experiences overbank flow at the downstream end.<br>- No significant impact predicted for residential areas (i.e. water depth generally below 0.3 m).<br>- Velocities of up to 1 m/s predicted in Bushland Beach.<br>- High velocities (greater than 2 m/s) predicted in the Black River channel. |
| 10 year ARI | 141 mm in 3 h<br>175 mm in 6 h<br>210 m in 9h<br>239 mm in 12h<br>283 mm in 18h | 202 | | - No significant impact predicted for residential areas (i.e. water depth generally less than 0.3 m).<br>- Velocities of up to 1 m/s predicted at Bushland Beach. |
| 20 year ARI | 168 mm in 3 h<br>204 mm in 6 h<br>245 mm in 9h<br>280 mm in 12h<br>333 mm in 18h | 230 | | - No significant impact predicted for residential areas (i.e. water depth generally less than 0.3 m).<br>- Velocities of up to 1 m/s predicted at Bushland Beach. |
| 50 year ARI | 204 mm in 3 h<br>243 mm in 6 h<br>293 mm in 9 h<br>334 mm in 12 h<br>400 mm in 18 h | 228* | North Shore Boulevard | - No significant impact predicted for residential areas (i.e. water depth generally less than 0.3 m).<br>- Velocities of up to 1 m/s predicted at Bushland Beach.<br>- Velocities of up to 2 m/s predicted over Bruce Highway at Bohle River. |
| 100 year ARI | 231 mm in 3 h<br>273 mm in 6 h<br>329 mm in 9 h<br>377 mm in 12 h<br>452 mm in 18 h | 278 | North Shore Boulevard | - No significant impact predicted for residential areas (i.e. water depth generally less than 0.3 m).<br>- Velocities of up to 1.25 m/s predicted at Bushland Beach.<br>- Velocities of up to 2 m/s predicted over Bruce Highway at Bohle River. |

| Event | Indicative Rainfall | Properties Inundated[1] | Major Evacuation Route Closures | Flooding Description |
|---|---|---|---|---|
| 500 year ARI | 303 mm in 3 h<br>474 mm in 6 h<br>621 mm in 9 h<br>744 mm in 12 h<br>824 mm in 18 h | 545 | North Shore Boulevard<br>Bruce Highway at Saunders Creek | - No significant impact predicted for residential areas (i.e. water depth generally less than 0.3 m).<br>- Properties in Burdell near Saunders Creek inundated with water depths of up to 0.5 m.<br>- Velocities of up to 1.25 m/s predicted at Bushland Beach.<br>- Velocities of up to 1.75 m/s predicted across Bruce Highway at Black River.<br>- Velocities of up to 2 m/s predicted over Bruce Highway at Bohle River. |
| PMF | 561 mm in 3 h | 2298 | North Shore Boulevard<br>Bruce Highway at Saunders Creek<br>Bruce Highway at Stony Creek<br>Mount Low Parkway<br>Bruce Highway at Black River | - Properties in Burdell near Saunders Creek inundated with water depths of up to 2 m.<br>- Properties in Bushland Beach and Mount Low inundated with water depths of up to 0.75 m.<br>- Velocities of up to 1.25 m/s predicted at Bushland Beach.<br>- High velocities of greater than 2 m/s predicted over Bruce Highway at Bohle River and Black River. |

Notes:

1 Number of inundated properties is assessed based on a minimum of 200 mm water depth covering at least 15% of the lot size for the urban residential lots of the suburbs of Burdell and Bushland Beach only. This does not necessarily mean finished floor levels are exceeded and the building flooded as floor level data is not available for this study.

* A slight reduction in the flood extent and the predicted number of inundated properties was observed between the 20 year ARI and 50 year ARI 12 hour design storms in steep areas of Bushland Beach. The occurs due to the change in temporal pattern between the 20 year ARI and 50 year ARI design events. It is anticipated that if the critical duration storm for this localised area were to be assessed (the 1 hour event) a slight increase in the flood extent and number of properties inundated in this area would be predicted for this area.

# 1.0 Introduction

## 1.1 Overview

AECOM Australia Pty Ltd (AECOM) was engaged by Townsville City Council (TCC) to develop refined base-case hydrologic and hydraulic flood models for the Lower Bohle/Stony Creek area as part of the *City Wide Flood Constraints Project*.

The *City Wide Flood Constraints Project* seeks to develop flood models to:

- define flood levels for most urban properties
- identify strategies for trunk stormwater and flood mitigation infrastructure for future capital investment
- provide a means of evaluating the impacts of future flood mitigation and development projects
- assess escape routes and flooding along major arterial roads to assist in disaster management processes.

## 1.2 Study Area

The area of interest for this study is approximately 10 kilometres west of Townsville City as shown in Figure 1-1.

The principal focus area for this study was broadly considered to be the area north of the Bruce Highway/North Coast Railway line in between the Bohle River to the east and Mt Low Parkway to the west, however the model extends beyond this focus area.

Major transport corridors passing through the study area include the Bruce Highway, the North Coast Rail Line, Mount Low Parkway, and North Shore Boulevard. Urbanised residential areas within the study area include the suburbs of Burdell, Bushland Beach, Deeragun, Mount Low and Black River.

The study area includes the lower reaches of several major waterways including the Bohle River, Saunders Creek, Stony Creek, and the Black River as shown in Figure 1-1. To facilitate the representation of storage in the Town Common area affecting the area of interest, the lower reaches of Louisa Creek were also considered.

## 1.3 Scope of Works

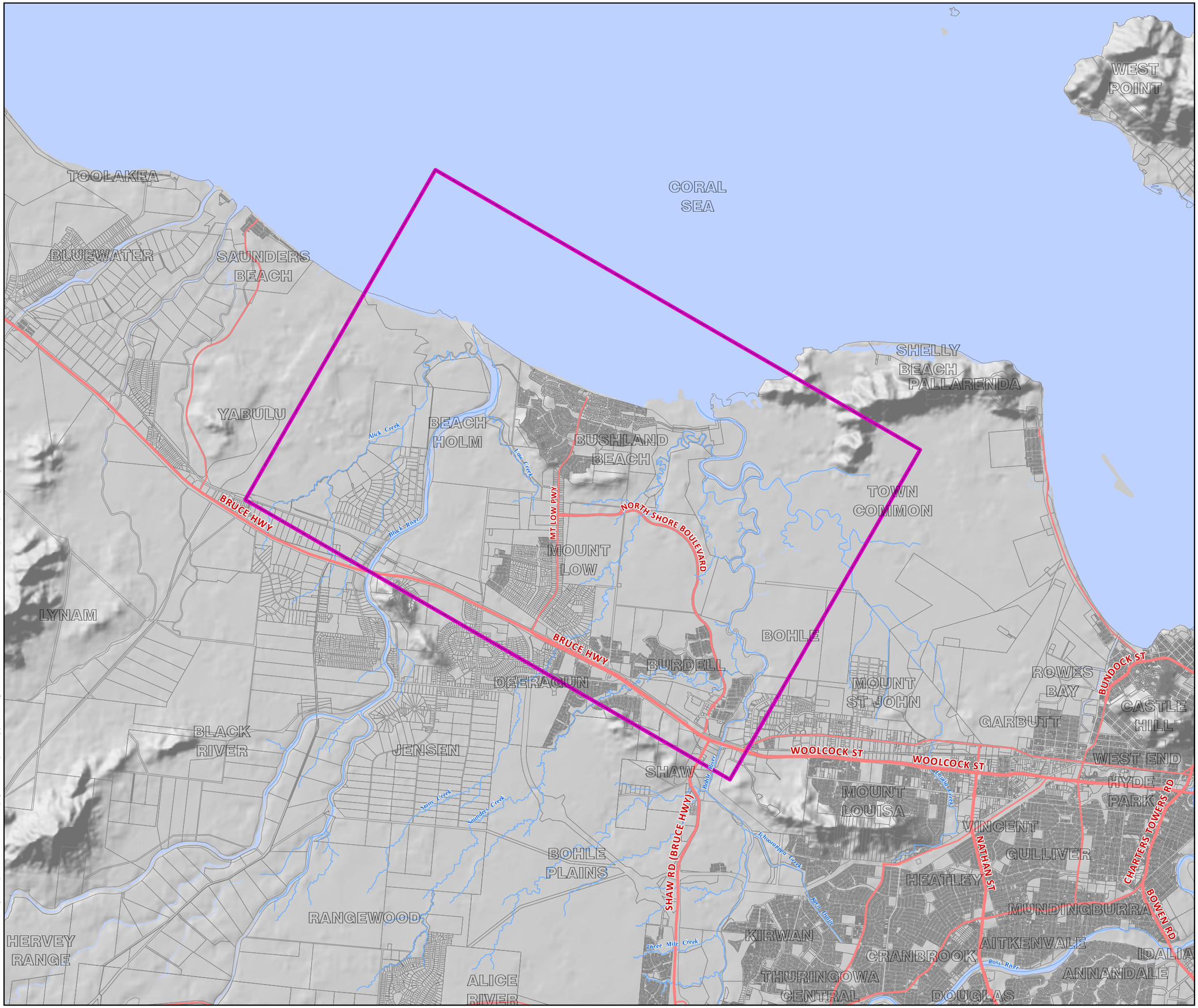
The scope of works for the *Lower Bohle/Stony Creek Flood Study* included:

- collation and review of available data including previous models relevant to the study
- assessment of the study area to confirm catchment parameters as well as gain an understanding of hydraulic controls and flow pathways
- developing topography using 2012 LiDAR data where possible within the model extent and incorporating bathymetric survey data provided by TCC for the lower reaches of Black River, Bohle River and Stony Creek
- developing roughness maps to account for development for floodplain conditions at the time the 2012 LiDAR data was flown (November 2012)
- developing fraction impervious mapping to account for floodplain conditions at the time the 2012 LiDAR data was flown (November 2012)
- define boundary conditions to account for storage within Town Common area and lower reaches of Louisa Creek at the eastern boundary
- incorporating major structures at various locations
- develop a MIKE FLOOD hydraulic model
- sensitivity assessment considering sensitivity to Manning's roughness
- critical duration assessment by running the 100 year ARI event for the 1, 2, 3, 4.5, 6, 9, 12, 18 and 24 hour durations. From this a maximum of two critical durations were adopted to assess the remaining ARI's.
- base case assessment based on two different critical durations for the 2, 5, 10, 20, 50 year events, and three durations for the 500 year event and one duration for the PMP event

- comparison with other studies by comparing the modelling results obtained for the 100 year ARI along the main watercourses to those obtained as part of other overlapping studies (i.e. Black River, Louisa Creek, Middle Bohle)
- reporting including mapping for all the design flood events assessed. Along with the long section comparisons, flood maps showing water depth, water level and velocity for all the cases assessed.

# TOWNSVILLE CITY COUNCIL
# LOWER BOHLE/STONY CREEK FLOOD STUDY
## Locality Plan

Figure 1-1




**Legend**

- Highways
- Main Roads
- Watercourse
- Property Boundaries
- Model Extent

0 1,000 2,000 4,000

Metres

1:80,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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## 1.4 Study Approach

The assessment of Lower Bohle/Stony Creek builds on a number of previous flood studies in the vicinity. Where possible, existing hydrologic and hydraulic models have been updated and refined to provide sufficient resolution according to the *Preparation of Flood Studies and Reports - Guidelines* (2010) developed by TCC.

Upstream boundary conditions were taken from the existing Middle Bohle River and Black River hydraulic models and previously developed XP-RAFTS models. Runoff generated within the localised catchments of the study area was simulated using the Rain-on-Grid method. Downstream boundary conditions for the ocean boundary were set to the mean high water springs tide level of 1.254 m Australia Height Datum (AHD).

## 1.5 Spatial Data

TCC provided the following data for the study:

- topography data in the form of contours and XYZ tiles at 1 metre (m) spacing based on 2009 LiDAR survey
- topography data in the form of contours and XYZ tiles at 1 metre (m) spacing based on 2012 LiDAR survey
- topography data in the form of contours and XYZ tiles at 1 metre (m) spacing based on 2013 LiDAR survey provided for Black River by TCC
- aerial photography flown in 2011 with pixel sizes of 0.125 m
- digital cadastral database containing property boundaries (TCC, October 2012)
- Mount Low Parkway development design drawings including road alignment and culvert information
- as built plans for the North Shore Boulevard road alignment as well as culvert information (provided by UDP)
- stormwater network for the existing developments (TCC, February 2012),
- bathymetric survey data for areas in the vicinity of Low Creek on the western side of the Mount Low Parkway and the lower reaches of Black River and Stony Creek.

Queensland Transport and Main Roads (TMR) provided the following data:

- bridge and culvert details along Bruce Highway within the model extent (TMR, May 2012).

Queensland Rail (QR) provided the following data:

- bridge and culvert details along North Coast Railway within the model extent.

## 1.6 Previous Reports

There are a number of previous flood / drainage assessments completed by AECOM and others within and around the study area as summarised below. Some of these studies have been used to inform our assessment.

- **Saunders Creek Flood Study (Kinhill, 1999)**

An investigation of the flooding behaviour of the Saunders Creek floodplain was undertaken by Kinhill Pty Ltd in 1999. The Saunders Creek Flood Study (SCFS) involved both hydrologic analysis (using a RORB model) and hydraulic analysis (using a MIKE11 model) to provide recommendations for flood mitigation in the area adjacent to Carinya Estate, immediately downstream of the Bruce Highway.

The XP-RAFTS hydrological model developed in this study was verified to the RORB model developed in the SCFS. Flood Levels established in this study were verified to flood levels defined in the SCFS.

- **Bohle River Floodplain Management Study (Maunsell McIntyre, 2001)**

The *Bohle River Floodplain Management Study* (*BRFMS*) project assessed the hydraulics and mapped the extents of the of the Bohle River floodplain from Kelso Drive to its outlet at Halifax Bay. RORB hydrologic and 1D MIKE 11 hydraulic models were developed to complete the flood extents analysis.

- **Black River Geomorphological and Stabilisation Study (Maunsell McIntyre, 2002)**

The *Black River Geomorphological and Stabilisation Study* was undertaken by Maunsell McIntyre to assess the impacts of sand and water extraction on the geomorphology of the Black River. The report also provided recommendations for rehabilitating the Black River channel and exclusion of development adjacent to the banks of the river on the basis of risk from erosion and risk from flooding, although no flood modelling work was completed. The report provided recommendations for revegetation of the Black River to help stabilise the channel and mitigate deterioration of the stream condition. The revegetated state of the channel has been modelled as the base-case for Black River so that the Defined Flood Event (DFE) accounts for the potential increases in flood levels associate with revegetation.

- **Saunders Creek SOBEK Modelling (Cardno Lawson Treloar, 2006)**

The report compiled by Cardno Lawson Treloar investigated the behaviour of the Saunders Creek floodplain using a 2D SOBEK model. There is overlap between the downstream reaches of the Summerville Gardens Maunsell MIKE11 model and the upstream portion of the SOBEK model. The fine scale survey used to develop the SOBEK model was used to develop a 2D component of a MIKE FLOOD model for this study. Flood levels established in this study were verified against flood levels defined in the SOBEK model.

- **Stony Creek Flooding Assessment (Maunsell, 2006)**

Maunsell has previously assessed flooding in Stony Creek as part of the *Stony Creek Flood Study*. The objectives of this study were to determine flood levels for design and planning purposes for the 50 year ARI event, including an assessment of the effects of development at North Shore and to determine preliminary sizing of the North Shore Boulevard Bridge.

An XP-RAFTS hydrologic model was developed for Stony Creek to provide inflow hydrographs to the MIKE FLOOD hydraulic model.

The Stony Creek MIKE FLOOD model used in Stony Creek Flood Study – Report was updated for this investigation to include the refined Stony Creek Bridge and cross drainage structures near the bridge.

- **Shaw Road Flooding Assessment, (Maunsell AECOM, 2007)**

Maunsell conducted a flooding assessment for a proposed light industrial subdivision on Shaw Road, Bohle by the Hansen Development Group. This study extended the MIKE FLOOD model developed for the *Gumlow Residential Development Assessment* north to include the development site. Surveyed cross sections of the Bohle River from the *BRFMS* were used to develop the underwater profile of the Bohle River. The study involved refinement of the original RORB model for the Bohle River 2 catchment to an XP-RAFTS model.

- **Lower Black River Flood Assessment (Maunsell AECOM, 2007)**

The *Lower Black River Flooding Assessment* undertaken by Maunsell AECOM comprised a flood study in the lower Black River as part of a development assessment for the Sunland Group. This investigation included assessment of baseline flood levels and flows within the lower Black River. An XP-RAFTS hydrological model

was developed for the Black River catchment. These flows were input into a MIKE-FLOOD hydraulic model extending from approximately 2.5 km upstream of the Bruce Highway to the mouth of the Black River.

The XP-RAFTS hydrological model was adapted and refined for use in this study. The MIKE FLOOD model was extended upstream for this study to incorporate the full extent of Black River covered by Councils topographic data.

- **Waterway Gardens Hydraulic Analysis (Maunsell AECOM, 2008)**

AECOM has previously completed a *flood analysis of the Waterway Gardens area as detailed in Waterway Gardens Hydraulic Analysis - Report (2008)*. The report presents the results of the flood assessment of the Bohle River and Saunders Creek at Waterway Gardens (now North Shore) for Stockland Developments. The study used RORB hydrological model and MIKE11 models to represent catchment hydrology with channel and floodplain hydraulics.

The Bohle River and Saunders Creek models developed were based on previous models from *BRFMS* and *SCFS* respectively. The *BRFMS* model was updated to include the Waterway Gardens development and survey data for the area.

The Saunders Creek MIKE11 model was used to assess the development including the North Shore Boulevard Bridge. The development fill and bridge were sized to ensure flood levels were not increased upstream of the boundary of North Shore with Carinya Estate. The MIKE11 model of Saunders Creek was used in developing the MIKE FLOOD model in this investigation.

- **Summerville Gardens Encroachment Modelling (Maunsell AECOM, 2007)**

Hydraulic modelling of Saunders Creek upstream of Deeragun was undertaken in the *Summerville Gardens Encroachment Modelling Study* by Maunsell in August 2007. The study reviewed the impact of Summerville Gardens up to Stage 4. The previously developed MIKE11 hydraulic model of Saunders Creek was refined by inclusion of additional surveyed cross sections. The model was verified to previous flood levels in the area.

Flood levels established in this study were verified against flood levels in the upper reach of Saunders Creek defined in the MIKE FLOOD model.

- **Stony Creek Hydraulics Assessment (Maunsell AECOM, 2008)**

The *Stony Creek Hydraulics Assessment* was undertaken by Maunsell AECOM to assess options for the proposed Woodlands to Veales upgrade of the Bruce Highway. The existing hydrologic and hydraulic models developed for the Stony Creek Flood Study were utilised in this investigation, including an extension of the MIKE FLOOD model approximately 1.5 km upstream of the Bruce Highway to include Geaney Lane. This previous investigation included detailed hydraulic analysis of Stony Creek for a 500 year ARI rainfall event.

In this investigation, the previous XP-RAFTS model was refined based on more accurate digital contour data available.

- **Bohle Plains Flood Planning Study (AECOM, 2010)**

The *Bohle Plains Flood Planning Study* (*BPFPS*) consolidated all modelling studies completed in the Bohle Plains area since the *BRFMS*. The assessment included hydrological and hydraulic modelling of the Bohle River, Saunders Creek, Stony Creek and Black River catchments for the 50 year ARI storm event.

- **Deeragun Flood Study (AECOM, 2012)**

The *Deeragun Flood Study (DFS)* assessed base case and urbanised scenarios flooding for the Deeragun area based on previously developed and calibrated models as part of the *City Wide Flood Constraints Project*. Hydrology models for the Black River, Bohle River 2, Bohle River 3, Saunders Creek and Stony Creek catchments were updated using TCC's LiDAR topography flown in 2009. A MIKE FLOOD hydraulic model was built based on the LiDAR topography with major culverts and large open channel drains within existing developments included in the model using the 1D MIKE 11 and MIKE URBAN elements. This hydraulic model was verified to the February 2008 storm event.

- **Upper and Middle Bohle Flood Study (April 2014)**

The *Upper & Middle Bohle Flood Study (UMBFS)* assessed base case flooding for the Upper and Middle Bohle areas building on a number of previous flood assessments carried out in the vicinity as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2012

and major culverts and open channel drains were included in the model using the 1D MIKE 11 and MIKE URBAN elements.

- **Black River Flood Study (In preparation)**

The *Black River Flood Study (BRFS)* assessed base case flooding for the Black River area as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2009 and 2012 and incorporates hydrographic survey of the lower reaches of Black River. Major culverts were included in the model using the 1D MIKE 11 elements.

- **Louisa Creek Flood Study (In preparation)**

The *Louisa Creek Flood Study (LCFS)* assessed base case flooding for the Louisa Creek area building on a number of previous flood assessments carried out in the vicinity as part of the *City Wide Flood Constraints Project*. A MIKE FLOOD hydraulic model was built based on TCC's LiDAR topography flown in 2009 and 2012 and incorporates hydrographic survey of the lower reaches of Bohle River. Major culverts and open channel drains were included in the model using the 1D MIKE11 and MIKE URBAN elements.

# 2.0 Hydrology Assessment

## 2.1 Overview

The hydrology for the Lower Bohle/Stony Creek Flood Study was obtained from recently completed assessments such as the *Black River Flood Study* (AECOM, 2014) and XP-RAFTS models developed for Louisa Creek (by TCC). No further refinement of hydrologic models was undertaken as part of this study. Figure 2-1 shows the location and extent of model catchments in relation to the study area.

Rainfall runoff generated within local catchments was represented using the Rain-on-Grid method.

## 2.2 Design Rainfall

Intensity Frequency Duration (IFD) input parameters specific for the study area were determined from Volume 2 of the *Australian Rainfall and Runoff* report (ARR, 1987). The values are summarised in Table 2-1. Standard techniques from ARR were used to determine rainfall intensities for durations up to 72 hours and up to a 100 year ARI event. For the rainfall event greater than 100 year ARI but less than 1000 year ARI, extrapolation of AR&R has been undertaken. The values obtained are summarised in Table 2-2. The design rainfall intensities developed correlate with those established in the *UBFS* and *DFS.*

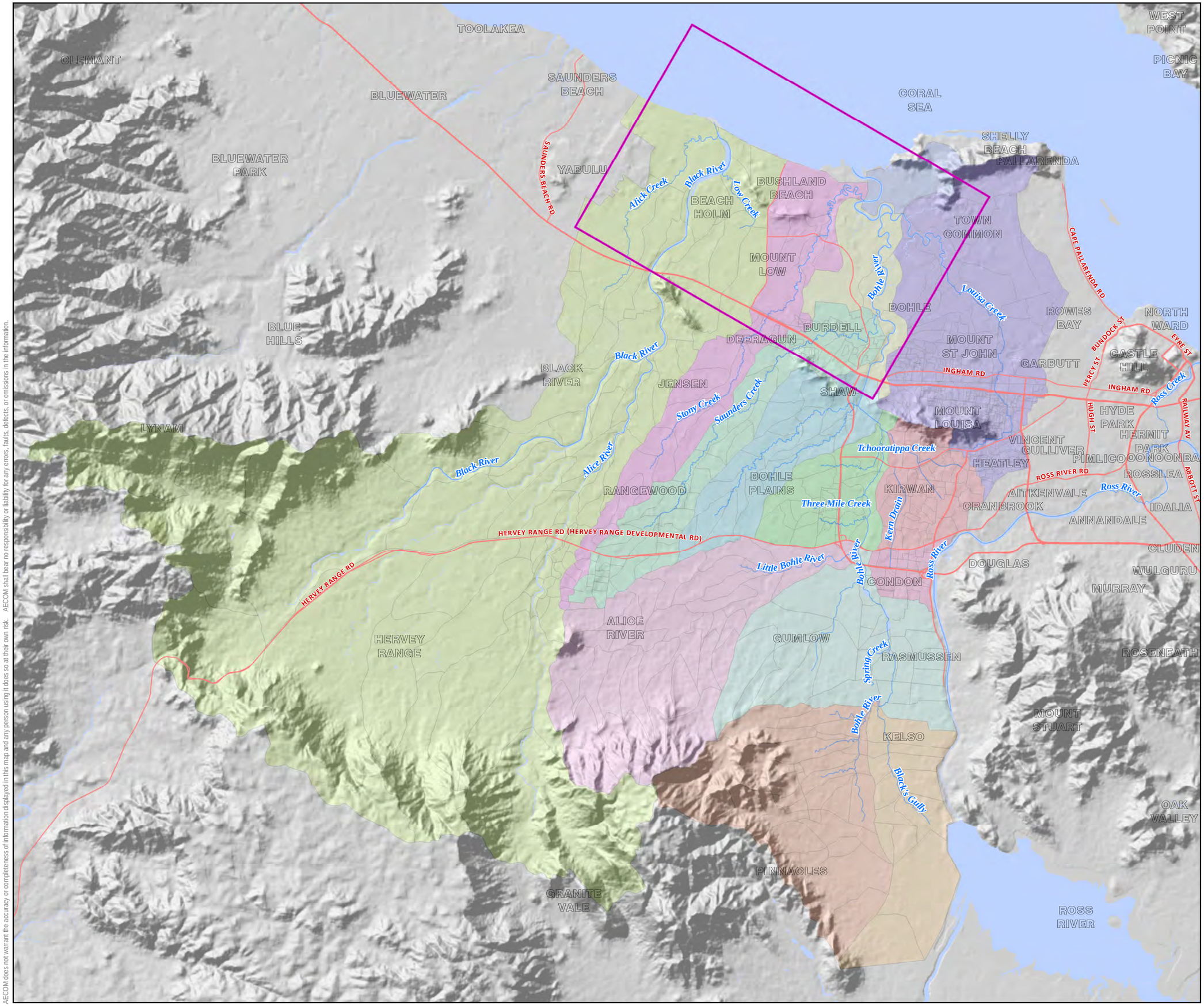
**Table 2-1 IFD Input Parameters**

| Parameters | Values |
|---|---|
| 2 year ARI, 1 hour duration (mm/h) | 55.0 |
| 2 year ARI, 12 hour duration (mm/h) | 13.0 |
| 2 year ARI, 72 hour duration (mm/h) | 4.0 |
| 50 year ARI, 1 hour duration (mm/h) | 105.0 |
| 50 year ARI, 12 hour duration (mm/h) | 27.5 |
| 50 year ARI, 72 hour duration (mm/h) | 9.5 |
| G | 0.05 |
| F2 | 3.93 |
| F50 | 17.0 |
| Zone | 3 |

**Table 2-2 Design Rainfall Intensities (mm/h)**

| Duration (h) | Average Recurrence Interval (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2 | 5 | 10 | 20 | 50 | 100 | 500 |
| 3 | 29.1 | 40.1 | 46.9 | 56 | 68 | 77 | 101 |
| 6 | 19.4 | 25.5 | 29.2 | 34 | 40.5 | 45.5 | 79 |
| 9 | 15.3 | 20.3 | 23.3 | 27.2 | 32.5 | 36.6 | 69 |
| 12 | 13 | 17.2 | 19.9 | 23.3 | 27.8 | 31.4 | 62 |
| 18 | 10.1 | 13.6 | 15.7 | 18.5 | 22.2 | 25.1 | 45.78 |

# TOWNSVILLE CITY COUNCIL
# LOWER BOHLE/STONY CREEK FLOOD STUDY
## Location and Extents of Model Catchments
## Figure 2-1




**Legend**

- Model Extent
- Watercourse
- Black River
- Black's Gully
- Bohle River 1
- Bohle River 2
- Bohle River 3
- Bohle River 4
- Condon
- Kirwan
- Little Bohle River
- Louisa Creek
- Middle Bohle River
- Saunders Creek
- Stony Creek
- Upper Bohle River

0 1,000 2,000 4,000

Metres

1:130,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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## 2.3 Probable Maximum Precipitation

Various methods can be used to estimate extreme rainfall and these have been considered for this study. The Generalised Short Duration Method (GSDM) and the Generalised Tropical Storm Method (GTSM) were used to estimate the Probable Maximum Precipitation (PMP) for this study. The rainfall intensities for the extreme (PMP) event assessed in this study are summarised in the tables below for the three different catchments assessed (Black River, Louisa Creek and Combined Catchments of Bohle River, Saunders Creek and Stony Creek).

A 3 hour critical duration was established in the *UBPFS* and subsequently adopted in the *DFS* for the extreme rainfall event upstream of the area of interest. To ensure consistency 3 hour was adopted for the PMP storm event as the critical storm duration. For the 500 year ARI storm event the 3, 12 and 24 hour durations were assessed.

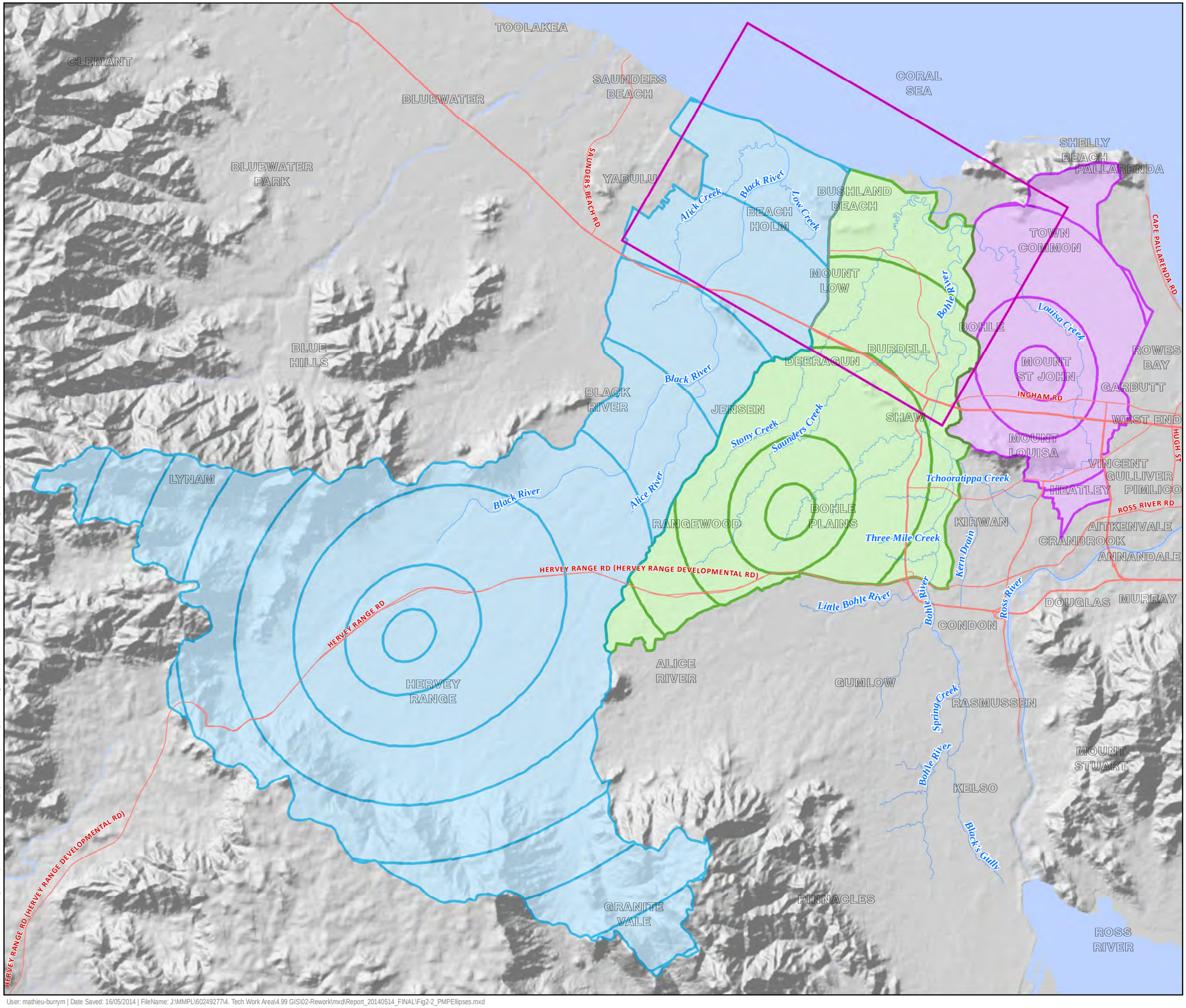
The sub-catchments were grouped to represent major tributaries within the catchment being assessed and to identify the one combination likely to generate the greatest rainfall for the PMP event across the wider catchment. This approach was based on the generally accepted premise that it is highly unlikely that PMP rainfall would fall across more than one of the main tributaries (all sub-catchments grouped) at the same time. The grouped catchments and their PMP ellipses are illustrated in Figure 2-2.

**Table 2-3 Extreme Rainfall Events Intensity (mm/h)**

| Duration (h) | Black River | Louisa Creek | Combined Catchments of Bohle River 1, 2 and 3, Stony Creek and Saunders Creek |
|---|---|---|---|
| | PMP | PMP | PMP |
| 3 | 167 | 190 | 187 |

TOWNSVILLE CITY COUNCIL
LOWER BOHLE/STONY CREEK
FLOOD STUDY
PMP Ellipses

Figure 2-2




**Legend**

- Model Extent
- Watercourse
- Black River Catchment - PMP Ellipses
- Merged Catchments (Bohle River 1, 2 and 3, Stony Creek and Saunders Creek - PMP Ellipses
- Louisa Creek Catchment - PMP Ellipses

0 1,000 2,000 4,000

Metres

1:120,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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## 2.4 Rain-on-Grid Method – Local Runoff

Rain-on-Grid is a method for assessing broad-scale flood risk for urban areas on a catchment scale. It involves applying rainfall directly on the two-dimensional grid which minimises the need for hydrologic models like XP-RAFTS, RORB, etc. This method is particularly advantageous in ungauged urban areas such as Lower Bohle/Stony Creek area and was applied within the model grid to simulate the local runoff generated.

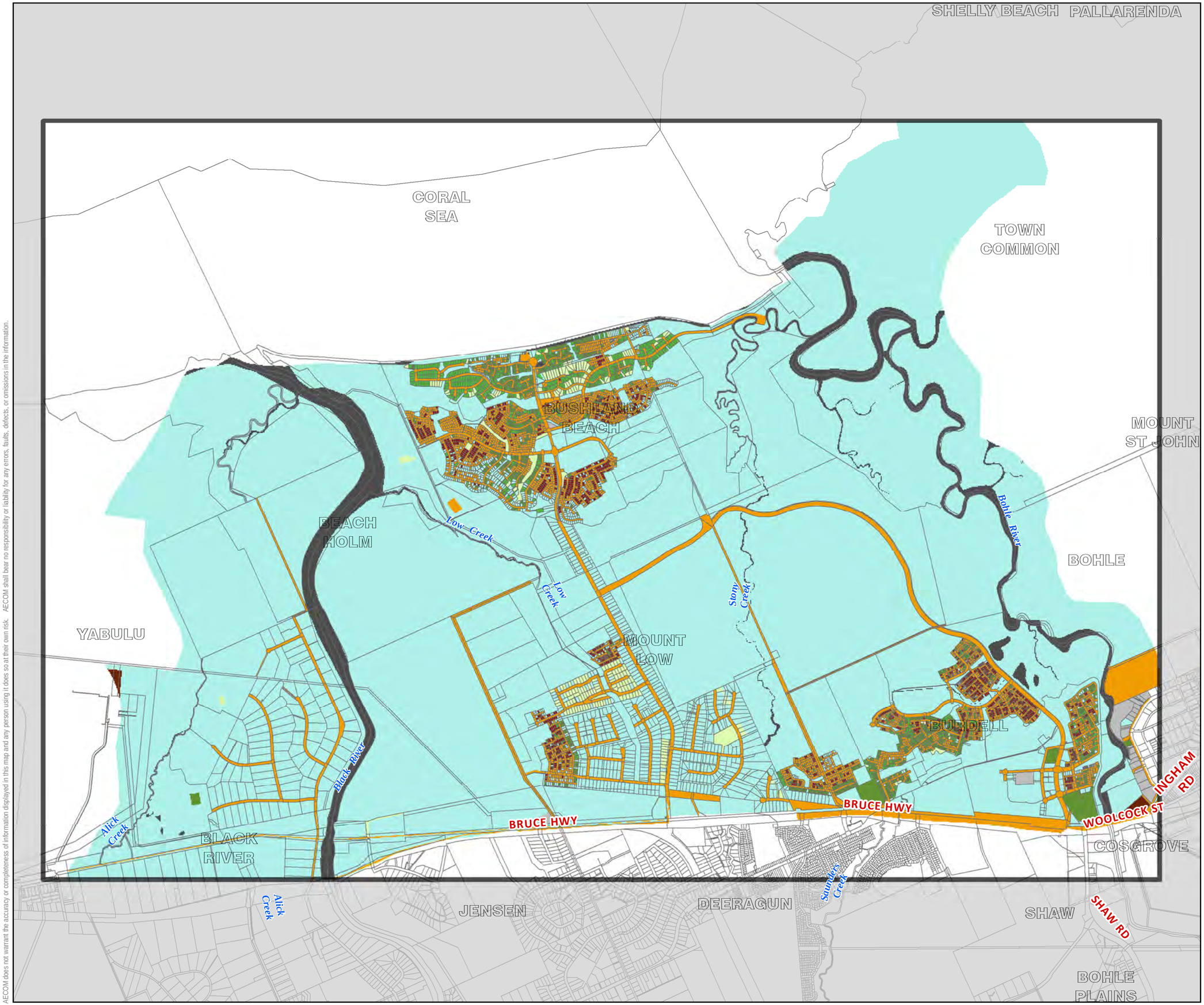
Two-dimensional rainfall excess time series for each ARI and duration were created to represent the local net precipitation for the study area. This rainfall excess is calculated by applying initial and continuous losses to the designed rainfall for two extreme scenarios (i.e. pervious and impervious). As outlined in ARR Volume 1 initial and continuous loss values represent infiltration and storage of runoff in surface depressions. Initial and continuous loss values of 24 mm / 2.5 mm/h and 0 mm / 1 mm/h were applied to the pervious and impervious areas respectively.

The time series for each of the pervious and impervious areas were developed by applying a temporal pattern in accordance with ARR Volume 2 for ARI storm events up to the 100 year event. For the 500 year ARI and PMP, the GSDM Manual recommended temporal pattern was used.

An imperviousness map for the base case scenario was created using TCC's property boundary dataset (Figure 2-3). This dataset contains suitable descriptors that allow the separation between vacant lands, vacant land intended for residential use, residential dwelling, parks, etc. The fraction impervious map used in the Lower Bohle Flood Study was refined to account for development included in the 2012 LiDAR data. To determine the imperviousness percentage, an average house size to land parcel ratio was used. For all other parcels such as parks, crown land, etc., an imperviousness of zero was applied. For river channels and bodies of water, an imperviousness percentage of 100% was used. This process of creating the imperviousness map was performed using the ArcGIS software package.

# TOWNSVILLE CITY COUNCIL
# LOWER BOHLE/STONY CREEK FLOOD STUDY
## Imperviousness Map

Figure 2-3




**Legend**

- 0 - 10% Impervious
- 10 - 20% Impervious
- 20 - 30% Impervious
- 30 - 40% Impervious
- 40 - 50% Impervious
- 50 - 60% Impervious
- 60 - 70% Impervious
- 70 - 80% Impervious
- 80 - 90% Impervious
- 90 - 100% Impervious

0 500 1,000 2,000

Metres

1:40,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Roads © 2012 (StreetPro)
Localities © 2012 (Queensland Govt)

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