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Bowen Local Drainage Study
Whitsunday Regional Council
13-Feb-2015

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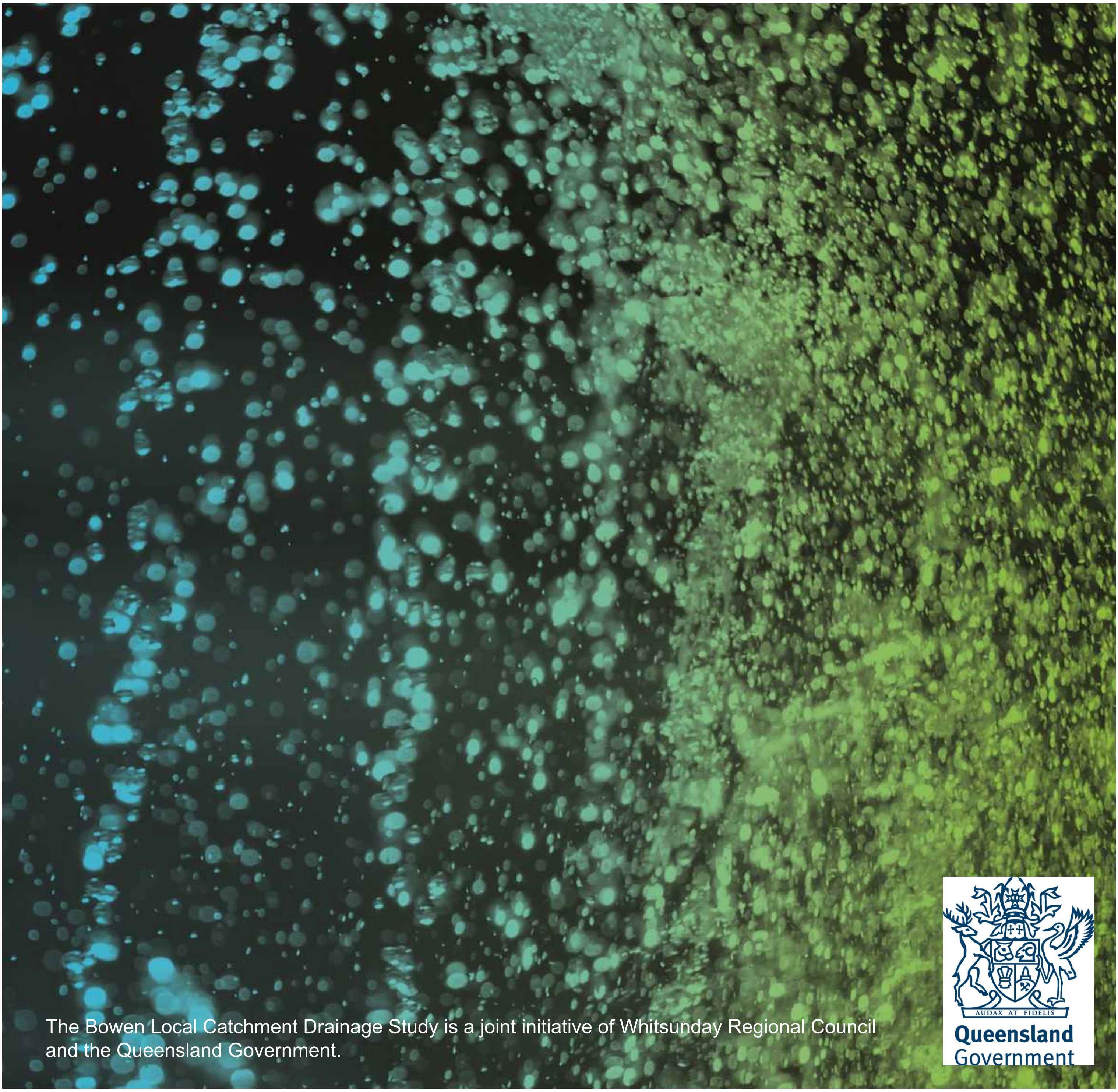
Bowen Local Catchment Flood Study

Baseline Flood Assessment



The Bowen Local Catchment Drainage Study is a joint initiative of Whitsunday Regional Council and the Queensland Government.

Queensland Government

Bowen Local Catchment Flood Study

Baseline Flood Assessment

Client: Whitsunday Regional Council

ABN: 63 291 580 128

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Quality Information

Document	Bowen Local Catchment Flood Study
Ref	60332898 j:\60332898\8. issued docs\8.1 reports\rev a\bowen local drainage study_final_reva.docx
Date	13-Feb-2015
Prepared by	Amanda Mulligan / Ben McMaster
Reviewed by	Melanie Collett

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	16-Jan-2015	Draft for Client Review	Brian Wright Industry Director - Water Infrastructure Services	Original Signed
A	13-Feb-2015	Final Issue	Brian Wright Industry Director - Water Infrastructure Services	Original Signed

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Glossary / Abbreviations

1D	One Dimensional
2D	Two Dimensional
AECOM	AECOM Australia Pty Ltd
AHD	Australian Height Datum
AEP	Annual Exceedence Probability
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DNRM	Queensland Department of Natural Resources and Mines
DEM	Digital Elevation Model
DFE	Defined Flood Event
DTM	Digital Terrain Model
EY	Exceedance per Year
GIS	Geographical Information Systems
GSDM	Generalised Short Duration Method
HAT	Highest Astronomical Tide
IFD	Intensity Frequency Duration
LAT	Lowest Astronomical Tide
LiDAR	Light Detecting and Ranging
LDMG	Local Disaster Management Group
MAF	Moisture Adjustment Factor
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
MIKE FLOOD	1D / 2D hydraulic modelling software
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
QUDM	Queensland Urban Drainage Manual
RCP	Reinforced Concrete Pipe
RCBC	Reinforced Concrete Box Culvert
SES	State Emergency Service
SRTM	Shuttle Radar Topography Mission
TAF	Topographic Adjustment Factor
WRC	Whitsunday Regional Council
XP-RAFTS	Rainfall runoff routing (hydrologic) modelling software

Executive Summary

Whitsunday Regional Council (WRC) commissioned AECOM Australia Pty Ltd (AECOM) to carry out a flood study of the greater Bowen area in order to assess baseline flood characteristics associated with local rainfall events and to confirm the efficiency of the existing drainage infrastructure

This study has only assessed the existing flood risk imposed by local catchment events. It does not include the assessment of flood impacts due to riverine flood events (i.e. Don River and Euri Creek) and storm surge. These have been the subject of separate studies carried out for WRC.

The scope of work undertaken in this study included the development of an XP-RAFTS hydrologic model to estimate flood discharge hydrographs for a portion of the Doughty Creek catchment which was outside the hydraulic model extent. The remainder of the catchments within the study area were simulated using a direct rainfall approach. A MIKE FLOOD two dimensional hydraulic model was developed for the study area which included MIKE 21, MIKE 11 and MIKE URBAN components. Uncertainties were evident in developing the hydraulic model. These included:

- Uncertainties from the hydrologic assessment as no gauges exist within the study area.
- Lack of flood height records associated with the local catchment events.

Design event modelling was carried out for the 50%, 20%, 10% AEP, 2% AEP, 1% AEP and the Probable Maximum Flood (PMF) event. The MIKE FLOOD model results were analysed and a series of maps were developed to present the results for each modelled flood event.

Maps were produced including:

- Peak water surface levels.
- Peak depths.
- Peak velocities.
- Peak hazard.

Given the uncertainty in climate change and sea level rise projections, particularly with respect to changes in rainfall intensity, climate change sensitivity has been undertaken as part pf this study. The hydrologic and hydraulic models have been used to assess the impact of climate change that would be expected to occur in year 2100 for the 1% AEP design event.

The following uncertainties also required consideration in respect to sensitivity in the hydraulic model:

- Parameter uncertainty in the hydraulic model (roughness).
- Uncertainty in respect of downstream boundary conditions.

In consideration of the results of the sensitivity tests, and lack of data on which to base model calibration, it is recommended that a freeboard of 0.3m be applied to the model results in using them for development control purposes.

Whilst not specifically requested in the scope, several recommendations have been provided on non-structural flood mitigation measures which could be addressed following completion of this study. Specific information has been provided on Emergency Management Planning, Community Awareness and Development Planning.

A number of other recommendations have been identified throughout the course of this assessment. These additional studies / investigations would reduce uncertainties, provide additional information to Council and provide a better understanding of flooding in the Bowen region. A summary is below:

- Collation of records for future flood events to allow additional model calibration.
- Development of Standards for Modelling Methodologies and Management.
- Modelling of concurrent riverine and local catchment events.

1.0 Introduction

1.1 Study Background and Objectives

In 2014, Whitsunday Regional Council (WRC) received partial funding from the Department of Local Government to carry out a flood study of the greater Bowen area, in order to assess baseline flood characteristics associated with local rainfall events and to confirm the efficiency of the existing drainage infrastructure. AECOM Australia Pty Ltd (AECOM) was subsequently commissioned by Council to assess and quantify the potential flood risk posed by local rainfall events over a range of annual exceedance probability (AEP) events and determine areas of the existing stormwater drainage network that may require upgrading.

Flooding in Bowen and surrounding area can occur as a result of three different flood mechanism (or a combination) as described below:

- Flooding due to rainfall over the Don River and Euri Creek catchments.
- Inundation as a result of storm surge.
- Flooding due to rainfall over the local catchments around Bowen.

This study is focussed on existing flood risk posed by rainfall events of the local catchments around Bowen. This study does not assess the flood risk posed by the other two flood mechanism as these have been investigated and reported separately.

The key objectives of the study are:

- The development of detailed hydrologic and hydraulic modelling tools based on current best practice procedures, capable of adequately simulating the flood characteristics and behaviour of the local catchments.
- The assessment of existing flood risk within the study area (refer to Figure 1). It is expected that these results will be used to inform future emergency planning and floodplain management – particularly through the incorporation of key outputs into Council's updated planning scheme.
- The development of clear and easy to understand flood mapping products for use in future community education and awareness campaigns.
- Selection of priority areas within the existing stormwater network where upgrades should be further investigated and considered in Council's capital works program.

Minimising flood damage through more informed and reliable planning, appropriate mitigation, education, and disaster response is the key to developing more resilient communities which will ultimately result in future growth and prosperity. The overall objective of this study is to minimise loss, disruption and social anxiety; for both existing and future floodplain occupants.

1.2 Bowen Township

The township of Bowen is situated on the eastern bank of the Don River, on the northern side of Port Denison and has an estimated population of 10,300 (2011 census data). The landform over the urban area varies between elevated land of RL 50.0m AHD to the low lying coastal foreshore with levels around RL 1.0m AHD.

Bowen is the site of diverse horticultural and agricultural industries which underpin the economic stability of the district along with tourism, fishing and mining. The major area for agriculture lies on the Don River floodplain due to the nature of the alluvial soils deposited by the river.

The proposed study area covers approximately 3,200 hectares which is broadly defined by Queens Beach to the north, the right bank of the Don River to the west, the Bruce Highway to the south and Edgecombe Bay to the east. The study area includes the central business area and urban areas of the town of Bowen.

Development of the floodplain north of the Bruce Highway is extensive. Grazing and agriculture are the primary land based pursuits, particularly in the area between the Don River and Mt Nutt Road. Urban development is the primary land use east of Mt Nutt Road. The most likely areas for future urban expansion of the Queens Beach area are infill developments east of Mt Nutt Road and some existing rural areas to the west of Mt Nutt Road.

The flooding problems in the Queens Beach, Bowen CBD and Don Street area have been well recognised and over past years a number of reports have been prepared that have examined the effects of flooding from both local catchments and the Don River outflow.

Bells Gully serves as an overflow channel for excessive discharges from the main channel of the Don River; as a drainage path for a small proportion of the floodplain flows between Bowen and Queens Beach; and as a surcharging flow path from Mullers Lagoon.

Queens Beach has been developed on an old dunal system with many of the natural drainage paths along the swale areas having been blocked over time. Furthermore, some of the major stormwater outlets are through the frontal dunes and these ocean outfalls pose an ongoing maintenance problem.

The Flemington Road and Don Street areas in the southern extents of the study area are typically flat and fall west to east, away from the right bank of the Don River. These areas receive flow from the local catchment bounded by the river to the west, Richmond Road to the north and the airport to the south. The prime land use in this area is rural residential. The catchment discharge location is across Don Street into the mangrove swamp adjacent to the old salt works. The Don Street area may also receive overflow from Bells Gully at times of high river flows.

The existing drainage paths in the Bowen CBD area are predominately characterised by open channel flow or above ground flows that may generally be divided into four catchment areas as follows:

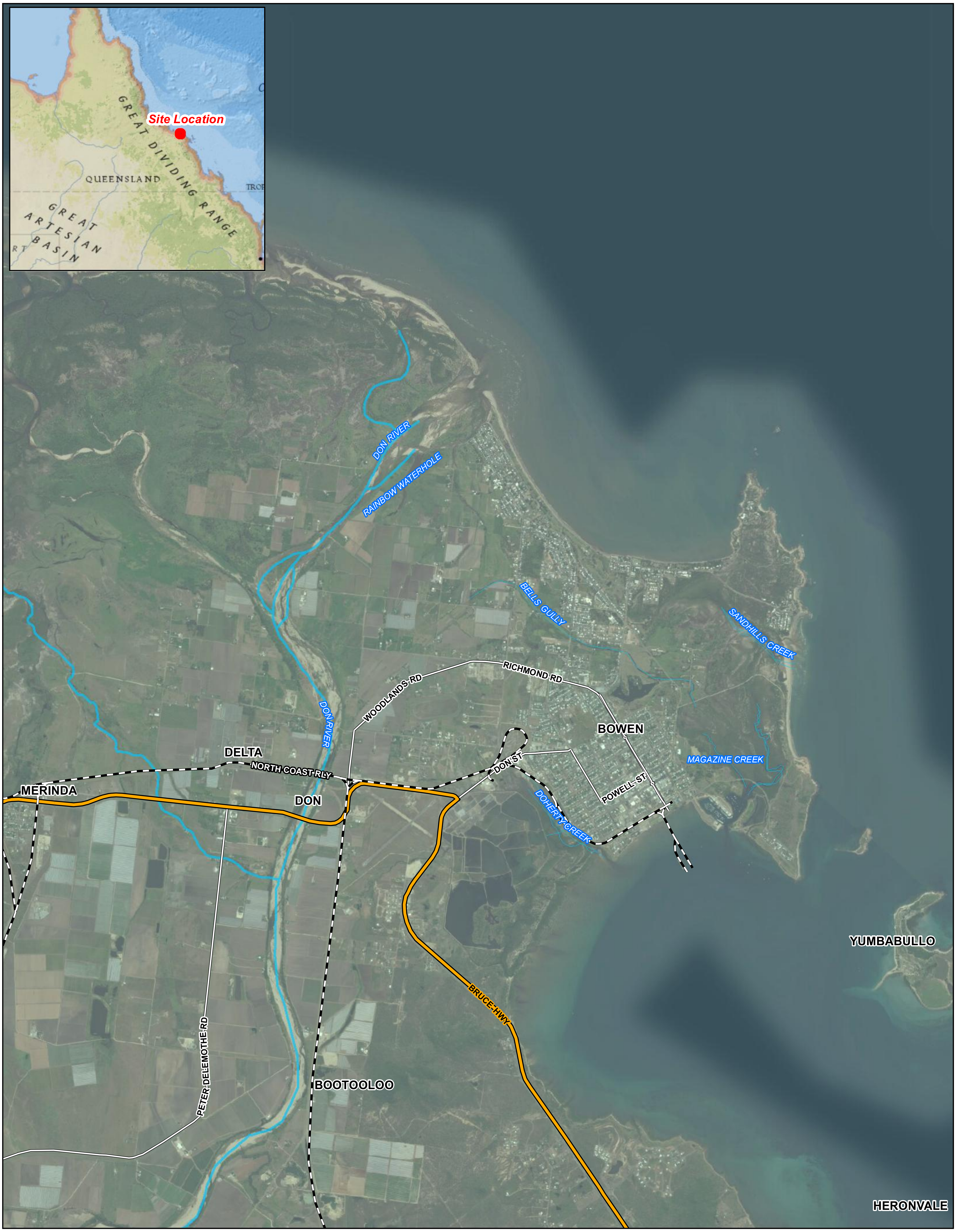
- Mullers lagoon catchment on the northern sector of the CBD.
- Brisbane Street that drains east to the front beach.
- Sinclair Street that drains east to the front beach.
- Don Street that drains south and west to the Don Street culverts.

The existing drainage outlets along Queens Beach and the front beach of Bowen CBD are susceptible to sand build-up. The potential for sand build up at the beach outlet is both a maintenance and hydraulic challenge that will be considered as part of the proposed local catchment study.

1.3 Report Structure

This report is structured as follows:

- Section 2.0 describes the characteristics of the local catchments, including typical land use within the catchments.
- Section 3.0 describes the data available for the development of the hydrologic and hydraulic models.
- Section 4.0 outlines the hydrologic modelling approaches and presents the results of the modelling.
- Section 5.0 outlines the hydraulic modelling approaches.
- Section 6.0 presents the results of the investigation into the effect of climate change on flood discharges and extents.
- Section 7.0 presents the design flood depths, levels and extents for the study area.
- Section 8.0 summarises priority areas of the existing stormwater network which should be further investigated to confirm upgrades required to reduce flood impacts.
- Section 9.0, 10.0 and 11.0 provides recommendations and advice pertaining to Emergency Management Planning, Community Awareness and Development Planning, respectively.
- Section 12.0 provides a summary of the investigation and includes additional recommendations for Council’s consideration.
- Section 13.0 is a list of references.



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1:50,000 (when printed at A3)

0 0.5 1 2
Kilometers

Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

LEGEND
- Highways
- Main Road
- Railways Lines

BOWEN LOCAL CATCHMENT FLOOD STUDY

Locality Plan & Study Area

Figure 1

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2.0 Catchment Characteristics

2.1 General Description

Bowen has been subjected to flooding from both local catchment runoff and also from occasional outflows from the Don River. The flooding issues have been well recognised and have been investigated extensively over the past 30 years.

In Bowen, flooding due to local catchment runoff generally occurs in the flat and relatively low lying lands which surround the more elevated areas in the centre of the town. The existing drainage systems comprise underground piped systems, kerb and channelling and open drains. The flat low lying areas of the town have generally precluded the use of underground piped drainage systems and necessitated open channel drains and other special solution devised over time.

Queens Beach is an important developing urban neighbourhood of Bowen. Development has occurred along the frontal dunal system which is constrained in the northeast by the Don River, to the south by flooded lands associated with the Bells Gully overflow and to the east by low tidal lands. The dunal system is characterised by low sand ridges with intervening swale areas that have no well-defined natural drainage outlets. In some instances development has occurred across swale areas and has further restricted drainage paths. A number of outlets have been provided through the frontal dune and discharge onto the beach.

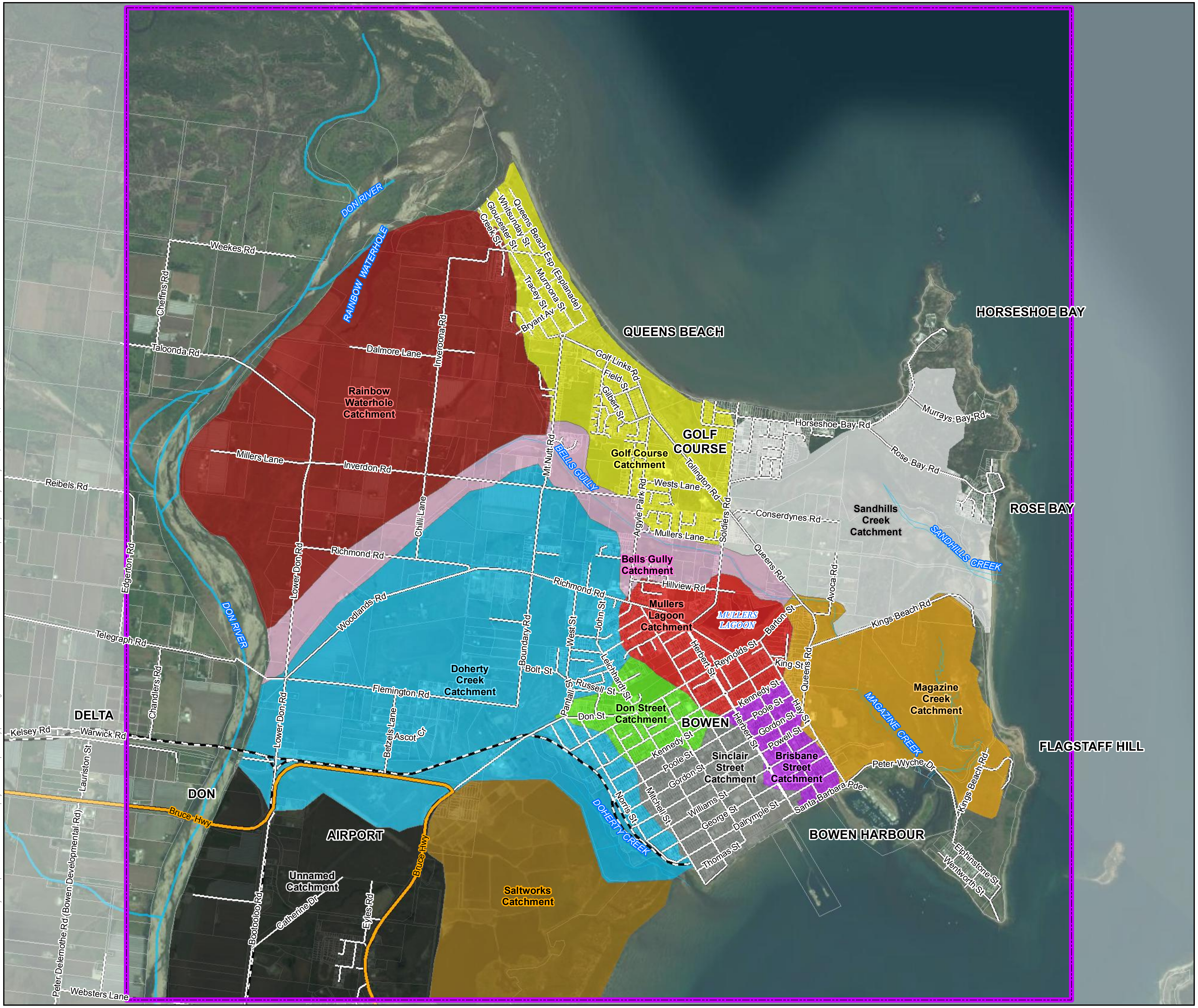
Major constraints affecting future drainage upgrades are:

- The flat low lying portions of the township preclude underground systems due to the practicalities associated with providing a suitable outfall.
- The lack of open areas for use as detention basins, particularly within the CBD area.
- The maintenance difficulties associated with current tidal outlets which make new outfalls potentially undesirable.

The study area can be divided into twelve principal catchment areas, as follows:

- Don Street Catchment.
- Sinclair Street Catchment.
- Brisbane Street Catchment.
- Mullers Lagoon.
- Doughty Creek.
- Saltworks Catchment.
- Unnamed Drainage Catchment.
- Bells Gully Local Catchment.
- Queens Beach / Golf Course Catchment.
- Sandhills Creek Catchment.
- Magazine Creek Catchment.
- Rainbow Waterhole / Eastern Channel Catchment.

Catchment extents are shown on Figure 2.



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BOWEN LOCAL CATCHMENT FLOOD STUDY

Catchment Areas

Figure 2

LEGEND

- Highways
- Roads
- Railway Lines
- Property Boundary
- Hydraulic Model

In Model

- Bells Gully
- Brisbane Street
- Doherty Creek
- Don Street
- Golf Course
- Magazine Creek
- Mullers Lagoon
- Rainbow Waterhole
- Saltworks
- Sandhills Creek
- Sinclair Street
- Unnamed Catchment

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

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2.2 Climate Characteristics

The study area is situated between latitudes of 19º 56´ and 19º 55´ south, about 400 km north of the Tropic of Capricorn. As a result, the catchment experiences a dry tropical maritime climate.

The climate is dominated by summer rainfalls with heavy falls likely from severe thunderstorms and occasionally from tropical cyclones. Heavy rainfall is most likely to occur between November and April with most of the flood events occurring in the months of December to March.

2.2.1 Rainfall Regime

Bowen has a mean annual rainfall between 900mm – 1000mm. The highest mean monthly rainfall of 225mm occurs in February. The highest and lowest annual rainfall recorded at the Bowen Airport is 2080mm (in 2010) and 370 mm (in 2001) which shows a significant variation in annual rainfall from year to year.

The highest monthly rainfall of 848mm was recorded in December 1990. Highest daily rainfall of 327mm was recorded on 31 December 1991. The following graph shows the distribution of the mean monthly rainfall throughout the year at the Bowen Airport.

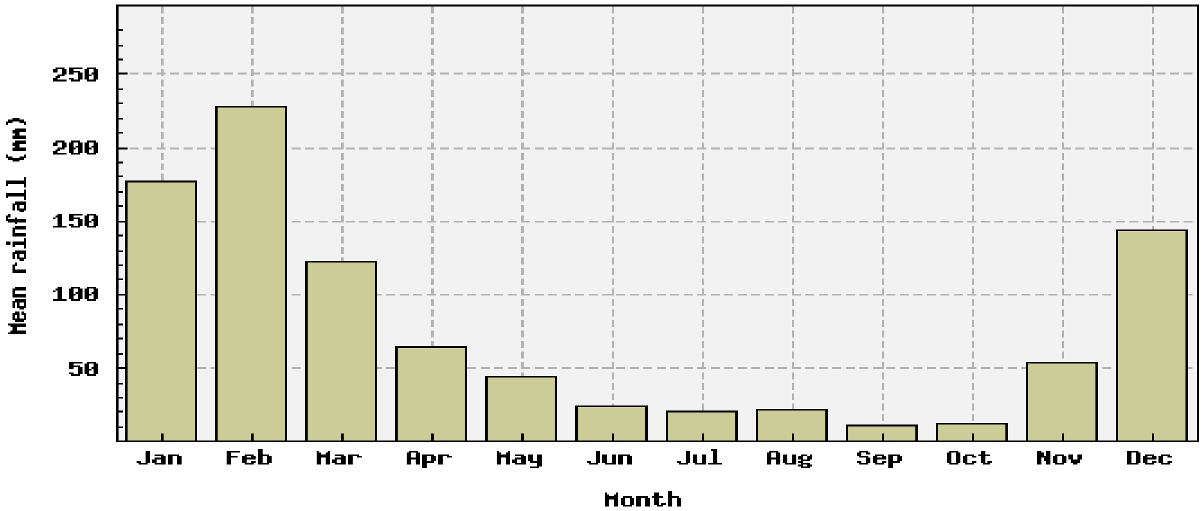


Figure 3 Mean Monthly Rainfall at the Bowen Airport Rainfall Station

3.0 Available Data

3.1 General

Available data for the development of the hydrologic and hydraulic models consisted of:

- Previous reports (refer to Section 3.2).
- Recorded rainfall and stream gauge data (refer to Section 3.3).
- Tidal data (refer to Section 3.5).
- Topographic data (refer to Section 3.6).
- Detailed survey (refer to Section 3.7).
- Details of hydraulic structures within the study area (refer to Section 3.7).
- Peak recorded water levels for the 2008 flood event (refer to Section 3.8).

Each of these a described in more detail in the following sections.

3.2 Previous Reports

There are a number of previous studies that have been closely reviewed to help inform various aspects of this investigation. These include:

- Queens Beach Flood Study (Ullman & Nolan, 1998).
- Bowen Stormwater Drainage Study (Ullman & Nolan, 2001).
- Queens Beach Drainage Study, Bells Gully (Cardno Ullman& Nolan, 2010).
- Queens Beach Drainage Study Addendum Report (Cardno, 2012).

A brief synopsis of these historical reports, and the relevant information gained from them, is given in the following subsections.

3.2.1 Queens Beach Flood Study (Ullman & Nolan, 1998)

The Queens Beach Flood Study has attempted to assess the risks to Queens Beach associated with the changes in the flooding regimes, as a result of the changes occurring in the Don River estuary. Structural mitigation works were proposed to mitigate the risks as much as possible. This report has provided a brief history of the breakouts which occur in Webster Browns, Bells Creek, 1946 mouth and Old Mouth.

The Queens Beach Flood Study provides useful information for the comparison of hydrologic and hydraulic modelling outputs. The study suggested mitigation works which were grouped into 'Upstream Works' and 'Downstream Works'. These are outlined below:

- Upstream Works:
    - Scheme 1 – Bank protection and embayment works upstream from Webster Brown to Council's Pump Station.
    - Scheme 2 – Bank protection works from Webster Brown to the Inverdon Bridge.
- Downstream Works:
    - Scheme 1 – Rock revetment works between Queens Beach and Rainbow waterhole.
    - Scheme 2 – Strengthening existing rockwork at the end of Creek and Gloucester Streets, Queens Beach.
    - Scheme 3 – Rock revetment to eastern bank of Rainbow waterhole.

3.2.2 Bowen Stormwater Drainage Study (Ullman & Nolan, 2001)

The Bowen Stormwater Drainage Study focused on the stormwater drainage of Bowen and Queens Beach. This report identified the deficiencies in the existing drainage system of Bowen and Queens Beach and provides augmentation options to improve the stormwater drainage system and provide greater local flooding immunity.

3.2.3 Queens Beach Drainage Study, Bells Gully (Cardno Ullman &Nolan, 2010)

The Queens Beach Drainage Study looked at the local drainage of Bells Gully and its potential coincidence with Don River outflows. The study provides useful information on the hydraulic capacity of the Bells Gully drainage system, estimated outflow from Don River at Bells Gully and existing structures along the gully. The principal conclusions reached in the study are summarised as follows:

- Bells Gully is subject to outflows from the Don River in extreme flood events. Previous studies have discussed preventing the outflows from the river and the impact of increased flows to other areas downstream of the Bells Gully overflow.
- Bells Gully is a series of parallel gullies with insufficient capacity to convey the 1% AEP event outflow from the Don River.
- The hydraulic capacity of Bells Gully downstream of Mt Nutt Road reduces from 70 m^3/s to approximately 20 m^3/s at Soldiers Road.
- Upstream of Mt Nutt Road the Don River outflows are directed approximately one-third to the north, one-third to the south and one-third to the east along Bells Gully.
- Downstream of Mt Nutt Road the Don River outflows discharge overbank to the north towards Brighton Road and Wests Lane, and to the south towards Richmond Road.

The report included a number of recommendations:

- That Council:
  - adopts the report as a basis for further analysis of trunk drainage strategies and stakeholder consultation to determine high flow drainage paths.
  - undertakes planning and design of high flow drainage paths including hydraulic design and investigation of easement creation or property acquisition, environmental impacts, costs and funding options.
  - acquires, either by way of development conditions or by purchase, drainage reserves necessary to ensure appropriate hydraulic conditions within the high flow drainage paths.

3.2.4 Queens Beach Drainage Study Addendum (Cardno, 2012)

Subsequent to the completion of the 2010 report, Council requested Cardno to prepare an addendum to the 2010 study which included revised modelling of 'Case 10'. The revisions included:

- The digital terrain model was derived from the 2009 LiDAR data. The 2009 data provided improved vertical accuracy to ±0.1m; closer point density to 1.0m average and current ground profile including recent land development areas.
- The downstream boundary conditions to be amended to include a 0.8m allowance above mean high water springs (MWHS) for climate change factors to 2100. The new downstream boundary conditions to be included in the model are RL 1.01 (AHD) + 0.8m = RL 1.81 AHD.
- The revised flows for the current conditions with a 1% AEP outflow event from the Don River has model outcomes at the following locations in Bells Gully as follows:
  - Peak flow at the Don River Bank – 350m^3/s
  - Peak flow mid-way between the Don River and Mt Nutt Road – 205 m^3/s
  - Peak flow at Mt Nutt Road – 88 m^3/s
  - Peak flow northward near Bryant Avenue – 76 m^3/s
  - Peak flow southward near Boundary Road – 87 m^3/s
  - Peak flow at Soldiers Road - 45 m^3/s

Subsequent to the 2010 interim report a number of mitigation and diversion scenarios were modelled to examine the impacts on Bells Gully and the adjacent areas. The modelling of a range of various scenarios developed the following broad parameters for any Bells Gully infrastructure enhancement:

- Bells Gully from Mt Nutt Road to Soldiers Road with an improved profile to have a maximum capacity of approximately 60 m^3/s.
- Bells Gully downstream of Soldiers Road to Kings Beach Road to have a trapezoidal profile with an increased maximum capacity of 40 m^3/s. Flows in excess of 40 m^3/s will follow existing flow patterns to the tidal areas east of Queens Road.
- A diversion of flows in excess of the nominal Bells Gully capacity. The diversion is best located to the west of Mt Nutt Road and may comprise a diversion to the north towards the Don River and/or a diversion to the south towards Don Street.
- The recommended infrastructure improvements for Bells Gully were:
  - A composite channel between Mt Nutt Road and Soldiers Road.
  - A trapezoidal channel from Soldiers Road to Kings Beach Road.
  - To restrict the flow through the Mt Nutt Road Bridge the following diversion and channel improvements to Bells Gully west of Mt Nutt Road are proposed:
    - A diversion channel northwards from Bells Gully commencing near Chilli Lane to discharge into the Don River.
    - A diversion channel eastwards and southwards from Bells Gully commencing near Chilli Lane to discharge into the tidal area downstream of Don Street.
    - Removal of the high ground in Bells Gully between Chilli Lane and Mt Nutt Road to eliminate divided flows in this section of Bells Gully.
    - Restriction of the profile of Bells Gully upstream of Mt Nutt Road to direct flows in excess of the nominated 60m^3/s to the diversion channels.

3.3 Rainfall Data

Historical rainfall data was acquired from the Bureau of Meteorology (BOM) in the form of daily rainfall data and pluviograph data. Data was obtained for rainfall gauging stations which were deemed to be relevant for the study area.

A list of the rainfall gauging stations, their locations, type of the data and length of the data is provided in Table 1 below. The available rainfall data provides a reasonable coverage of the local catchment rainfall event in 2008 which was used for model simulation.

Table 1 Summary of BOM Rainfall Stations used in the Study

Station Number	Site Name	Data Type Available	Start of Record	End of Record	2008 Flood Event
033094	Bowen Cheetham Salt	Daily Rainfall	November 1960	June 2012	✓
033257	Bowen Airport	Pluviograph	August 1987	September 2012	✓
033013	Collinsville Post Office	Pluviograph	June 1963	September 2010	✓

The daily rainfall records were analysed to determine the event durations associated with the 2008 flood event. Pluviograph data was then obtained from BOM for the identified event durations at the Bowen Airport.

3.4 Stream Gauging Data

Recorded water level data and/or discharge records are not available within the study area for local catchment events. A number of gauges are located on Don River and Euri Creek but this information was not applicable to local catchment flood events which are the subject of this report.

3.5 Tidal Data

A list of the tide gauging stations and the period of the required tidal data was submitted to Transport and Main Roads (TMR) – Maritime Branch. The location and period of the tidal data obtained is described in Table 2 below. Tidal date consisted of recorded water level.

Table 2 Tidal Data provided by TMR

Station ID	Station Name	Data Start date	Data End Date
033007A	Cape Ferguson Storm Surge	01/02/2008	28/02/2008
030003A	Shute Harbour Storm Surge	01/02/2008	28/02/2008
061007A	Bowen Storm Surge	01/02/2008	28/02/2008

3.6 Topographic Data

3.6.1 ALS Data

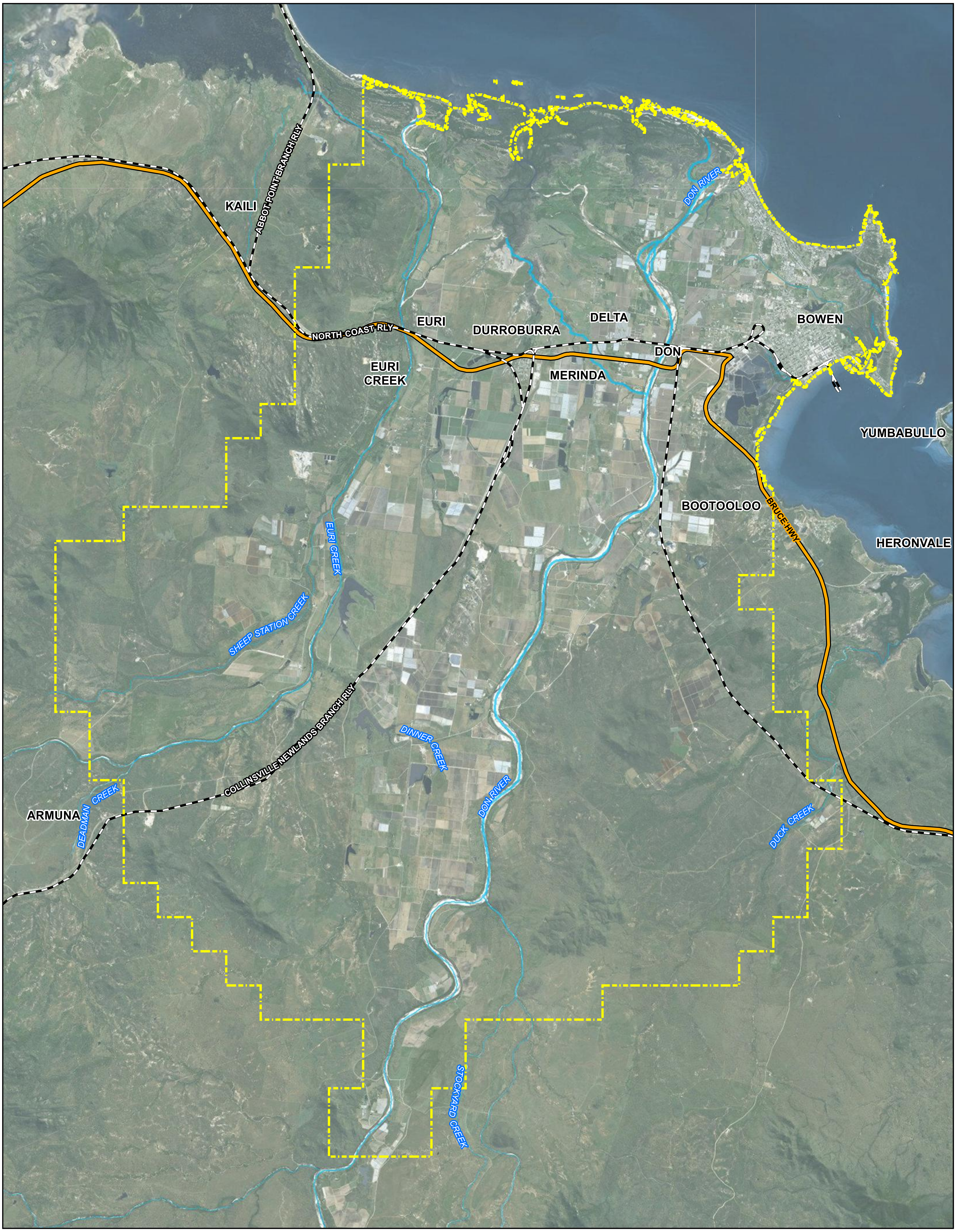
Topographical data was provided by WRC in the form of LiDAR survey undertaken in 2013. Figure 4 shows the extent of the LiDAR data sets made available.

The LiDAR points were used by DNRM to generate a 'bare earth' Digital Elevation Model (DEM) with a grid spacing of 1m. DNRM state that the DEM represents the ground with vertical accuracy of ±0.15 meter on clear, hard surfaces at the 1 sigma confidence level. The absolute horizontal accuracy will be ±0.45 meter at the 1 sigma confidence level.

A base DEM was prepared using the available data set. In order to improve data size and manageability, the LiDAR DEM was filtered to produce a 5 meter Digital Terrain Model (DTM). The extent of the DTM was then 'trimmed' to match the extent of the hydraulic model.

The following additional changes were made to the DTM:

- Road Crown Levels provided by surveyors for the local road network were checked against levels from the LiDAR and some minor alterations were made to the DTM to match these levels.
- Surveyed open drain inverts were checked against levels from the LiDAR and some minor alterations were made to the DTM to match these levels.



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Kilometers

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

LEGEND

2013 Lidar Extent

BOWEN LOCAL CATCHMENT FLOOD STUDY

Extent of LiDAR

Figure 4

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3.7 Detailed Survey

As part of the study, WRC commissioned detailed survey of the Bowen drainage system, including the underground stormwater infrastructure. The survey data was supplied by WSG Whitsunday Surveyors at the commencement of the study (2014).

The first data file (provided in MapInfo format) contained 2,407 entries which encompassed pipes, pits, surveyed cross-sections and channels. The MapInfo file had 741 blank entries. Some of these were deleted as a result of being double-up structures or 'decorative' features, and the remaining 615 were manually entered by the project team from AutoCAD files also provided by the surveyors. This included 27 pits, 280 kerb inlets, 59 pipes, 35 box culverts and 214 lines representing other structures such as culverts and channels.

After assessing against the AutoCAD file, the following issues were addressed:

- 32 of 445 pits had no dimensions, so measurements were made based on the aerial imagery, LiDAR and pipe inverts.
- 69 of 1044 pipes had missing inverts and/or lengths, which were assumed using LiDAR, adjoining pipes, or assuming cover and/or grades to calculate values.
- Some of the urban network pipes required splitting into multiple sections so inlets could be inserted. Intermediate inverts were assumed using LiDAR, adjoining pipes, or assuming cover and/or grades.

Additional structures were included in the model, which were not picked up in the survey. For the urban network, data was assumed based on aerial imagery, LiDAR and pipe inverts. In the case of other 'above ground' structures, assumptions were made based on LiDAR and field inspections undertaken on 26 December 2014.

These structures included:

- Culvert #3001 through an open channel adjacent to Bell's Gully in the vicinity of Mt Nutt Road.
- Culvert #3002 through the Golf Course.
- Culvert #3003 under the access road to the Golf Course club house.
- Culvert #3004 under Bootooloo Road.
- Culvert #3005 under Rose Bay Road.
- Grated pit in the vicinity of Silk Road.
- Two Kerb inlets along Gregory Street (between Carleton Street and McDougal Street) which are visible in the aerial imagery and Google Street View.
- Kerb inlet on Bunting Street which is visible in Google Street View.
- Kerb inlet at the intersection of Leichhardt Street and George Street which is visible in the aerial imagery.
- Kerb inlet at the intersection of Sinclair Street and Dalrymple Street.

Appendix A shows the list of bridge and culvert structures which were modelled as MIKE11 structures. The underground network was simulated in MIKE URBAN. A summarised list of MIKE URBAN components is included in Appendix B.

3.8 Recorded Data

3.8.1 Rainfall and Streamflow Data

Sections 3.3 describes the collation of rainfall gauging data from BOM which was subsequently used for model calibration.

3.8.2 Anecdotal Data

Fifty-five peak flood heights were obtained on 11 February 2008 and provided by WRC for this study. This was also supplemented by photos and videos compiled by the Don River Improvement Trust (DRIT) and other members of the public.

3.9 GIS Data

GIS data provided by WRC included cadastral boundaries, aerial imagery and planning zones. This information was provided on September 2013.

4.0 Hydrologic Assessment

4.1 Overview

In order to estimate flood levels, flood extents and flood hazard across the study area, a hydrologic assessment was undertaken to estimate flood flows resulting from local catchment design rainfall events.

The study area covers approximately 3,200 hectares. Land use within the study areas is predominantly urban, grazing and agriculture. The topography varies from 12.0m AHD at the Don River to 1.0m AHD in the coastal tidal flats.

The study area can be divided into twelve principal catchment areas, as discussed in Section 2.1. Table 3 provides a summary of the areas attributed to each catchment.

Table 3 Summary of Catchment Areas

Catchment	Area (ha)
Don Street Catchment	61.4
Sinclair Street Catchment	106.4
Brisbane Street Catchment	50.2
Mullers Lagoon	121.9
Doughty Creek	700.9
Saltworks Catchment	273.1
Unnamed Drainage Catchment	348.2
Bells Gully Local Catchment	161.8
Queens Beach / Golf Course Catchment	242.9
Sandhills Creek Catchment	328.0
Magazine Creek Catchment	230.1
Rainbow Waterhole / Eastern Channel Catchment	586.1
TOTAL	**3,211.0**

4.2 Adopted Methodology

Hydrological analysis was undertaken to represent rainfall runoff within the hydraulic model used for this study. The general approach taken to define runoff within the study area was:

- The application of rainfall directly onto the two dimensional hydraulic model (rain-on-grid).
- Rainfall-runoff hydrologic modelling approach (XP-RAFTS) which was used only for the southern portion of the Doughty Creek catchment which was outside the hydraulic model domain. Design hydrographs calculated for this catchment were applied to the hydraulic model as an inflow boundary.

4.3 Design Rainfall

4.3.1 Intensity Frequency Duration Rainfall Data

Site specific Intensity Frequency Duration (IFD) data was determined using the design rainfall isopleths from Volume 2 of Australian Rainfall and Runoff (AR&R), 1987. The IFD input data set obtained for Bowen is shown in Table 4.

Table 4 Adopted IFD Input Parameters

Parameter	Value
1 hour, 2 year intensity (mm/hr)	53.40
12 hour, 2 year intensity (mm/hr)	10.15
72 hour, 2 year intensity (mm/hr)	3.44
1 hour, 50 year intensity (mm/hr)	98.90
12 hour, 50 year intensity (mm/hr)	22.48
72 hour, 50 year intensity (mm/hr)	8.37
Average Regional Skewness	0.10
Geographic Factor, F2	4.01
Geographic Factor, F50	17.58

Standard techniques from AR&R were used to determine rainfall intensities up to the 72 hour duration for the 1EY (exceedance per year), and 50%, 20%, 10%, 5%, 2%, 1% and 0.2% AEP events. The calculated IFD data is shown in Table 5.

Table 5 IFD Design Rainfall Intensities for Bowen (mm/hr)

Duration (hrs)	1EY	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.2% AEP
1	41.4	53.0	67.0	75.0	86.0	101.0	112.0	139.0
2	26.1	33.7	43.4	49.2	57.0	67.0	75.0	95.0
3	19.8	25.6	33.4	38.2	44.4	53.0	59.0	75.0
4.5	15.0	19.5	25.7	29.6	34.6	41.4	46.7	60.0
6	12.3	16.1	21.4	24.7	29.0	34.8	39.4	51.0
9	9.3	12.2	16.5	19.1	22.6	27.3	31.1	40.4
12	7.6	10.1	13.7	16.0	19.0	23.0	26.2	34.3
18	6.1	8.0	11.0	12.9	15.3	18.7	21.3	28.1
24	5.1	6.8	9.4	11.0	13.1	16.1	18.4	24.3
48	3.4	4.5	6.3	7.4	8.9	11.0	12.6	16.9
72	2.6	3.4	4.8	5.8	6.9	8.6	9.9	13.3

4.3.2 Temporal Pattern

Temporal patterns for Zone 3 were adopted for events up to the 0.2% AEP using the standard methodology outlined in AR&R (1987).

Temporal pattern for the Probable Maximum Precipitation (PMP) event were sourced from data provided with the Generalised Short Duration Method (GSDM) guidebook (refer Section 4.3.4).

4.3.3 Areal Reduction Factors

The IFD rainfall values derived in Section 4.3.1 are applicable strictly only to one point; however AR&R state that they may be taken to represent IFD values over a small area (up to 4 km^2). No reduction of the IFD rainfall was undertaken due to the relatively small catchment areas associated with this investigation.

4.3.4 Probable Maximum Precipitation Event

The PMP has been defined by the World Meteorological Organisation (2009) as 'the greatest depth of precipitation for a given duration, meteorologically possible for a given size storm area at a particular location at a particular time of year'.

The PMP event results in a Probable Maximum Flood (PMF) event. This is a theoretical event which is very unlikely to ever occur within any given catchment. The PMF event is typically used in design of hydraulic structures, such as dams.

Its most common use is in design of dam spillways to minimise the risk of overtopping of a dam and minimise the likelihood of dam failure. Other than this practical use, it is also used to provide an indication of the largest flood extents expected within any given catchment. This data can be used by emergency management agencies in their understanding of and planning for flood events.

The GSDM, as revised in 2003, was applied to derive estimates of PMP. The GSDM applies to catchments up to 1,000 km^2 in area and durations up to 6 hours, which makes the method applicable to the Bowen Local Drainage Study which has a catchment area of approximately 32 km^2 and a critical duration of 6 hours.

Using the methodology set out in the GSDM Guidebook, the following data for the PMP was determined:

- The coastal GSDM Method is applicable as the catchment lies on the Queensland coast.
- The Roughness (R), Elevation Adjustment Factor (EAF) and Moisture Adjustment Factor (MAF) were calculated as 1.0, 1.0 and 0.98 respectively.
- PMP parameters were calculated as shown in Table 6.

Table 6 Adopted PMP Parameters

Duration (hrs)	Rainfall Total (mm)	Rainfall Intensity (mm/hr)
1	400	400
3	720	240
6	950	158

The ARI of the PMP event was calculated as recommended in AR&R. Using a combined catchment area of 43 km^2, the PMP event is approximately a 1 in 10,000,000 ARI event.

4.4 Direct Rainfall Modelling

4.4.1 Overview

In traditional flood modelling, separate hydrological and hydraulic models are constructed. The hydrological model converts the rainfall within a sub-catchment into a peak flow hydrograph. This flow hydrograph is then applied to the hydraulic model, which estimates flood behaviour across the study area.

In the direct rainfall approach, the hydrological model is either partially or completely removed from the process. The hydrological routing is undertaken in the two dimensional hydraulic model domain, rather than in a lumped hydrological package.

The direct rainfall method involves the application of rainfall directly to the two dimensional model domain. The rainfall depth in a particular timestep is applied to each individual hydraulic model grid cell, and the two dimensional model calculates the runoff from this particular cell.

AR&R Revision Project 15 notes the following advantages of direct rainfall modelling:

- Use of the direct rainfall approach can negate the need to develop and calibrate a separate hydrological model, thus reducing overall model setup time.
- Assumptions on catchment outlet locations are not required. When a traditional hydrological model is utilised, an assumption is required on where the application of catchment outflows are made to the hydraulic model.

- Assumptions on catchment delineation are not required. Flow movement is determined by 2D model topography and hydraulic principles, rather than on the sub catchment discretisation, which is sometimes based on best judgement and can be difficult to define in flat terrains.
- Cross catchment flow is facilitated in the model. In flat catchments, flow can cross a catchment boundary during higher rainfall events. This can be difficult to represent in a traditional hydrological model.
- Overland flow is incorporated directly. Overland flow models in traditional hydrological packages require a significant number of small sub-catchments, to provide sufficient flow information to be applied to a hydraulic model.

There are also several disadvantages associated with the use of the direct rainfall approach:

- Direct rainfall is a new technique, with limited calibration or verification to gauged data.
- The rain-on-grid approach can potentially increase hydraulic model run times.
- Requires digital terrain information. Depending on the accuracy of the results required, there may be a need for extensive survey data, such as aerial survey data.
- Insufficient resolution of smaller flow paths may impact upon timing. Routing of the rainfall applied over the 2D model domain occurs according to the representation of the flow paths by the 2D model.
- The shallow flows generated in the direct rainfall approach may be outside the typical range where Manning's 'n' roughness parameters are utilised.

4.4.2 Approach

Two dimensional rainfall excess time series for each AEP event and duration were created to represent the local net precipitation for the study area. This rainfall excess was calculated by applying initial and continuing losses to the design rainfall to represent infiltration and storage of runoff in surface depressions.

Initial and continuous loss values of 28 mm / 2.5 mm/h and 1 mm / 0 mm/h were applied to pervious and impervious areas respectively. In the absence of gauged data which could be used for model calibration, these values were derived from comparisons to peak discharges calculated using the rational method at a number of key locations throughout the study area.

It is also noted that the loss values adopted are consistent with those documented within AR&R and those used in previous local catchment studies for Bowen - most notably the Bowen Local Catchment Study (Cardno, 2010) which adopted initial and continuous loss values of 15 mm / 2.5 mm/h for pervious areas.

A spatially varying imperviousness map for the base case scenario was created using WRC's property boundary dataset (refer to Figure 5). This dataset contains suitable descriptors that allow the separation between vacant land, vacant land intended for residential use, residential dwelling, parks, commercial and industrial lands, etc.

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 value was applied based on typical values for the type of land in the area identified from aerial imagery (2013). This process of creating the imperviousness map was performed using the ArcGIS software package.

4.5 Runoff-Routing Modelling

4.5.1 Overview

An XP-RAFTS runoff-routing hydrologic model has been developed for a southern portion of an unnamed drainage catchment to the west of Doughty Creek. The model quantifies the design discharge hydrographs from this catchment by modelling catchment flows using Laurenson's non-linear routing methods. XP-RAFTS has been widely used throughout Queensland and is an accepted model to quantify flood flows. The model predicts flows for urban and rural catchments and is well suited to modelling this catchment.

An XP-RAFTS model was necessary as the hydraulic model did not cover the entire unnamed drainage catchment and therefore the direct rainfall approach could not estimate runoff from the portion of the catchment that was outside the model extent.

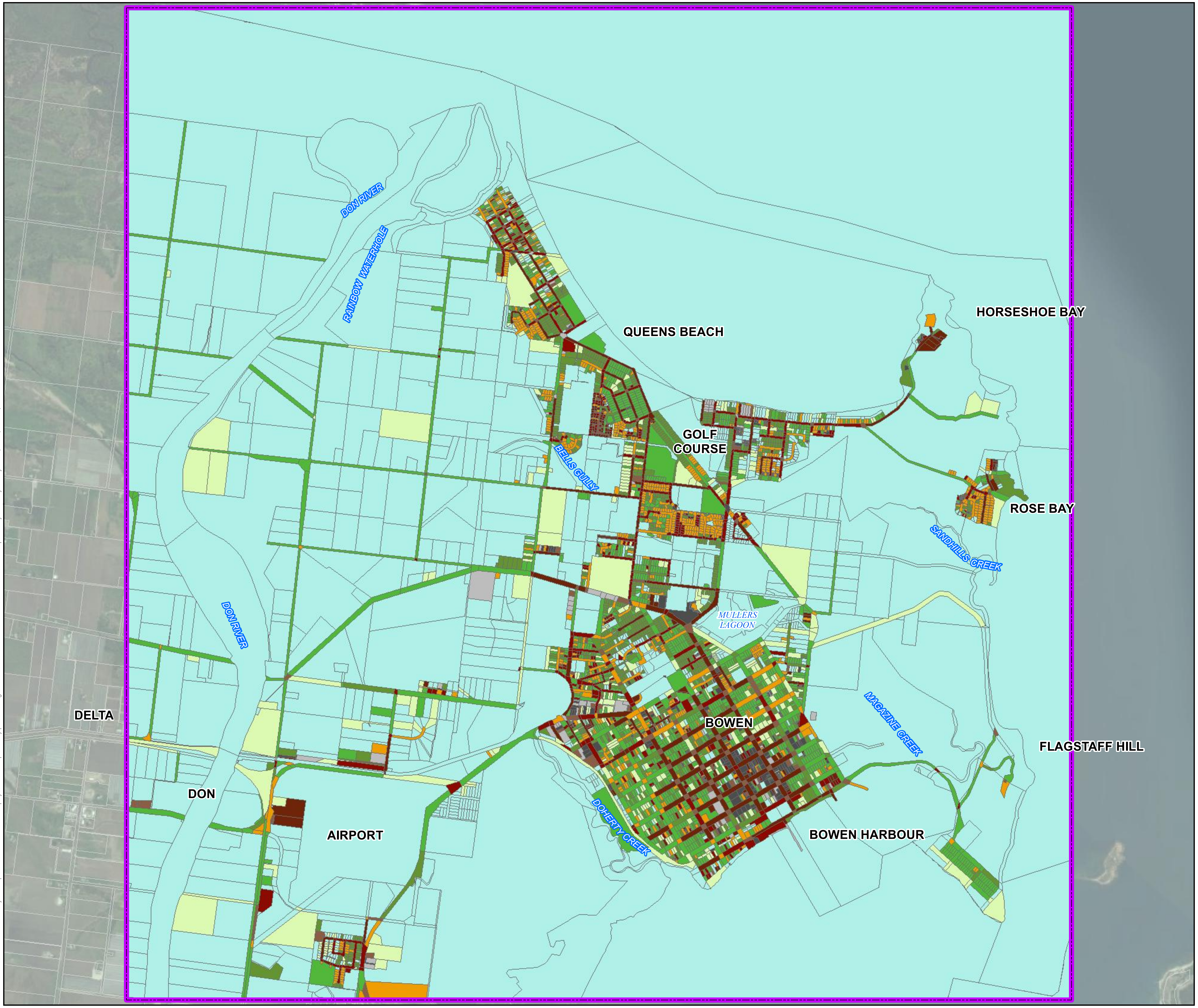
4.5.2 Model Configuration

The unnamed drainage catchment was delineated based on 2 metre topographic contours derived from the LiDAR data. The portion of the catchment that was external to the hydraulic model extents was subdivided into 12 sub-catchments according to tributary network, catchment topography, land use and location where the hydrograph would be applied as a boundary condition to the hydraulic model.

Each sub-catchment was described in the XP-RAFTS model by specifying:

- Sub-catchment areas (in hectares).
- Average equal area sub-catchment slope (in %).
- Sub-catchment roughness.
- Fraction Impervious.

The roughness and fraction impervious was determined using aerial imagery provided.



BOWEN LOCAL CATCHMENT FLOOD STUDY

Spatially Varying Imperviousness Map

Figure 5

LEGEND

- Property Boundary
- Hydraulic Model Area

Impervious Fraction (%)

- 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

0 250 500 1,000 1,500

Meters

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Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

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Table 7 summarises the parameters adopted for the unnamed drainage sub-catchments and Figure 6 shows the sub-catchment extents.

Table 7 XP-RAFTS Model Parameters

Catchment ID	Area (ha)	Catchment Slope (%)	Fraction Impervious (%)	Resistance (PERN)
1	134.8	0.55	1	0.05
2	37.9	1.29	1	0.06
3	23.1	1.15	1	0.05
4	17.9	1.69	1	0.07
5	21.5	0.63	1	0.05
6	51.8	1.10	1	0.05
7	75.9	18.28	1	0.07
8	118.8	0.52	1	0.06
9	36.6	0.45	1	0.05
10	38.9	0.76	1	0.05
11	20.8	0.98	1	0.05
12	22.9	1.15	1	0.06

4.5.3 Channel Routing

The Muskingum-Cunge routing method was used to route hydrographs between sub-catchments where natural channels existed. This method requires a defined reach length, slope, channel geometry, and roughness to determine appropriate hydrograph routing. Cross sections, link lengths and slopes were determined based on the available topographic data.

Time lag links were adopted where ‘man made’ drainage channels existed, particularly through agricultural properties. The adopted timing was based on estimates of velocity and link length using Manning’s Equation.

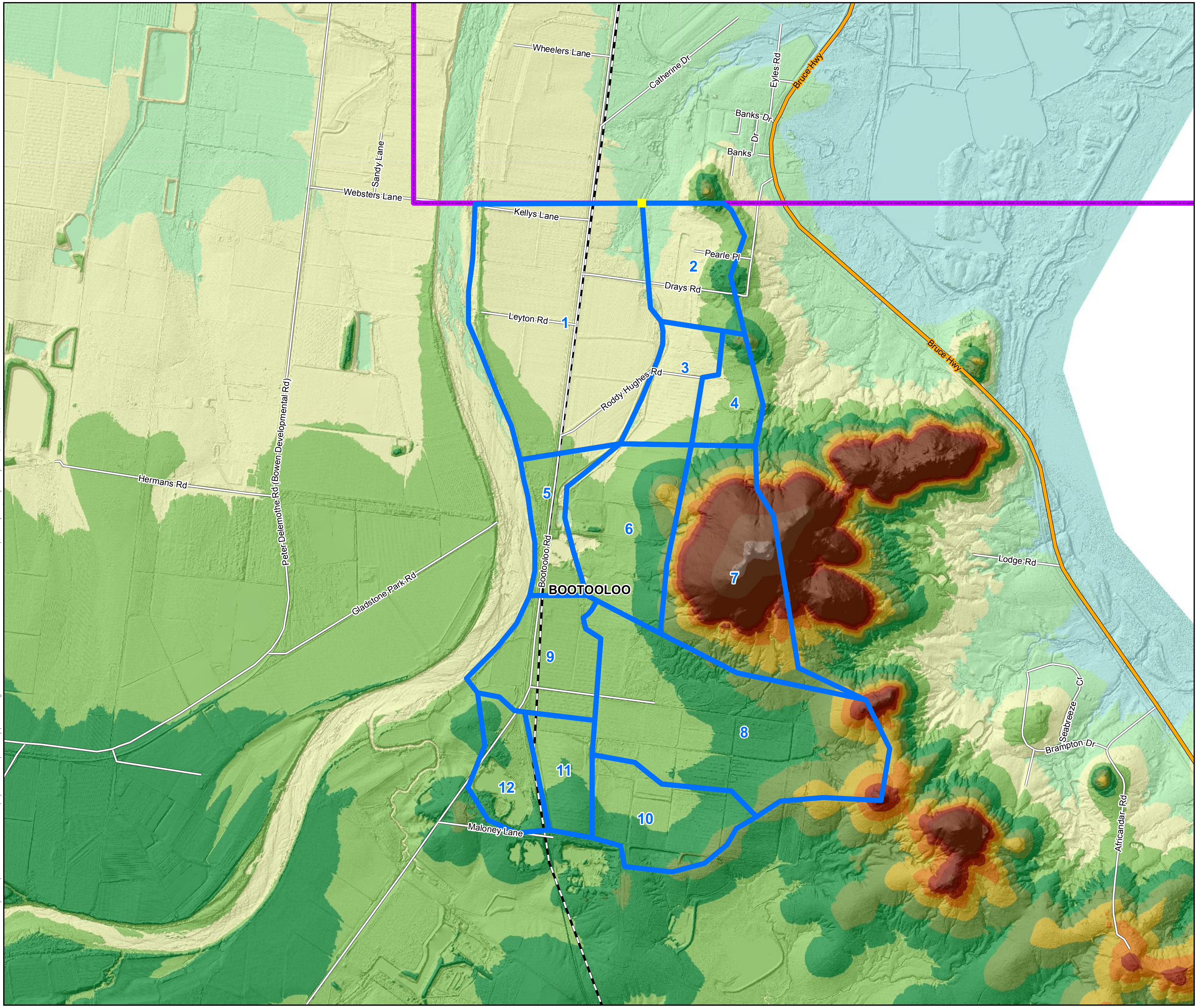
4.5.4 Selection of Rainfall Loss Values for Deign Rainfall Events

Rainfall loss values used in the direct rainfall approach (refer Section 4.4.2) were also adopted for the XP-RAFTS model to ensure consistency.

4.5.5 Model Verification Process

Calibration / validation of the XP-RAFTS model could not be undertaken due to the lack of an appropriate gauging station.

The rational method is generally used to estimate the peak design discharge for small rural and urban catchments. As outlined in AR&R, the rational method is applicable to simple rural catchments up to 25 km^2. For the purposes of the hydrologic assessment, several sub-catchments were selected and the rational method was applied to calculate the 1% AEP peak design discharge. Although not strictly a verification, the results of the rational method were compared to the XP-RAFTS peak discharge.



BOWEN LOCAL CATCHMENT FLOOD STUDY

XP-RAFTS Sub-Catchment Delineation

Figure 6

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Meters

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4.5.6 Adopted Design Discharges

The XP-RAFTS hydrologic model was run for the 50%, 20%, 10%, 2% and 1% AEP events for a range of standard duration storms (from 1 hour to 72 hours) to determine the critical duration storm event.

The critical duration for the unnamed drainage catchment was found to be 12 hours, however the critical duration adopted for the study area was 6 hours (as discussed in Section 7.2). Peak discharges from the XP-RAFTS model for both storm durations are summarised in in Table 8.

Table 8 Critical Duration Assessment

Duration	Peak Discharge (m^3/s)				
	50%	20%	10%	2%	1%
12 hours	18.5	32.4	41.1	62.9	75.6
6 hours (adopted)	18.2	29.5	36.1	56.3	66.3

The XP-RAFTS model was used to generate runoff hydrographs for the 50%, 20%, 10%, 2% and 1% AEP's and PMF event for the 6 hour storm duration to ensure consistency with the critical duration adopted for the study area. These hydrographs were converted to DFS0 files and applied to the MIKE FLOOD hydraulic model as a boundary inflow condition.

5.0 Hydraulic Model Development

5.1 Adopted Methodology

An integrated one-dimensional / two-dimensional numerical hydraulic model has been developed to simulate flood behaviour within the study area.

A MIKE FLOOD hydrodynamic model (DHI, 2014) has been developed which incorporates a MIKE21 fixed grid model (two-dimensional model), a MIKE11 (one dimensional model) to represent hydraulic structures and MIKE URBAN (one dimensional model) to represent the underground stormwater network. The 2014 software version has been used which utilises Graphical Processor Units (GPU) to decrease simulation times.

The MIKE FLOOD model represents hydraulic conditions on a 5 m square grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow.

An overview of the model setup and key parameters is provided in Table 9.

Table 9 Bowen Model Setup Overview

Parameter	Information
Completion Date	2015
AEP's Assessed	50%, 20%, 10%, 2%, 1%, PMF
Hydrologic Modelling Approach	XP-RAFTS, Direct Rainfall
IFD Input Parameters	Based on AR&R Volume 2, refer to Table 4
Hydraulic Modelling Approach	MIKE 21, MIKE 11, MIKE URBAN
Model Extent	Refer to Figure 7
Grid Size	5 m
DEM (year flown)	2013
Roughness	Spatially varying standard values compliant with AR&R guidelines (refer to Table 10 and Figure 8)
Eddy Viscosity	Constant, velocity based value of 2 m^2/s
Model Calibration	No calibration data available. Model used to simulate the 2008 event.
Model Inflows	Direct rainfall approach within the model extents, XP-RAFTS inflow from unnamed catchment applied to model boundary.
Downstream Model Boundary	Tidal boundary (constant MHWS)
Hydraulic Model Timestep	1.0 second
Hydraulic Model Flooding and Drying Depths	0.005 m and 0.002 m respectively
Sensitivity Analyses	Climate change with sea level rise and increased rainfall intensity, roughness, HAT tidal level

5.2 One Dimensional Model Development

5.2.1 MIKE 11 Model

The extent of the one-dimensional MIKE11 model components is shown in Figure 7. The one-dimensional model components were used to represent flow through hydraulic structures previously noted in Section 3.7.

Representing these structures in MIKE11 allows a more accurate representation of flow and associated head loss through these components where the structure width is less than the size of the two-dimensional grid upstream and downstream of the structure.

5.2.2 MIKE URBAN Model

MIKE URBAN is a software package used for one-dimensional simulation of sanitary or storm drain sewers as well as water distribution systems that couples with MIKE 11 and MIKE 21. This software package can be used to analyse a range of parameters including water quality, rainfall runoff and infiltration.

A MIKE URBAN model was developed to represent the underground drainage system within the study area and was based on data provided by WSG Whitsunday Surveys. The model is comprised of nodes representing manholes, inlet pits and outlets as well as links representing pipes. The model contained 782 nodes and 753 links to represent the drainage system.

GIS data for the network has been provided to WRC for future use.

5.3 Two Dimensional Model Development

5.3.1 Model Extents

Topographic data and historical reports were critically analysed to determine the extent of the two-dimensional hydraulic model for this study. The hydraulic model boundaries were dictated by the following:

- The northern boundary of the model is generally defined by the ocean and the Don River.
- The eastern boundary is also defined by ocean.
- The high bank of the Don River defines the western boundary of the hydraulic model.
- The southern boundary was selected by WRC to ensure the study area encompassed areas of interest. Of particular importance was ensuring that the airport area was included within the model extents.

Figure 7 shows the extent of the two dimensional hydraulic model, as well as the locations of the one-dimensional structures and boundaries. The MIKE URBAN network has also been shown.

There are three spatially varying model parameters that must be defined for the 2D component of the hydraulic model. These parameters are hydraulic roughness, eddy viscosity and topographic data which are associated with the governing equations of the hydraulic model.

5.3.2 Model Topography

A two-dimensional computational grid was prepared for the selected model extents. The compiled DTM (as discussed in Section 3.6.1) was applied to the 5m grid to develop the final two-dimensional model topography.

The DTM generally represents the average ground elevation over each 5 m grid cell area, however key hydraulic controls such as road crown levels and creek invert levels were manually refined in the MIKE 21 topographic grid to ensure that the overland flow regime was adequately represented.

5.3.3 Inflow and Outflow Boundaries

A single inflow boundary was specified and time varying discharge hydrographs were applied to represent the flows from Doughty Creek catchment upstream of the southern boundary of the hydraulic model. The discharge hydrographs were determined from the XP-RAFTS hydrological model.

5.3.4 Tidal Boundaries

A constant water surface level was applied as downstream boundary condition to represent the sea level for the design event runs. A static level of 1.1 m AHD representing the Mean High Water Springs (MHWS) tide level was adopted.

Sensitivity analysis was also undertaken to investigate the impacts of higher tidal conditions. This was undertaken by applying a static level of 1.97m AHD representing the Highest Astronomical Tide (HAT).

The impacts of future sea level rises have been assessed and details are included in Section 6.0 .

5.3.5 Eddy Viscosity

Eddy Viscosity is associated with the assumptions of sub-mesh scale turbulence. The eddy viscosity parameter describes the degree of turbulence that exists at scales smaller than mesh scale.

The eddy viscosity parameter is critical for describing the simulated transverse distribution of flow velocities in the rivers and creeks and is also important in describing the bifurcation of flows at junctions. The eddy viscosity parameter is generally adopted based on experience from previous modelling studies.

For this study, a constant velocity based eddy viscosity of 2.0 m^2/s was adopted. The viscosity value was based on the model time step and grid size.

5.3.6 Hydraulic Roughness

Hydraulic roughness is an important spatially varying factor that must be defined in the hydraulic model. Hydraulic roughness's associated with bed friction and is represented in MIKE FLOOD as Manning's M. This is the inverse of the most commonly used Manning's n.

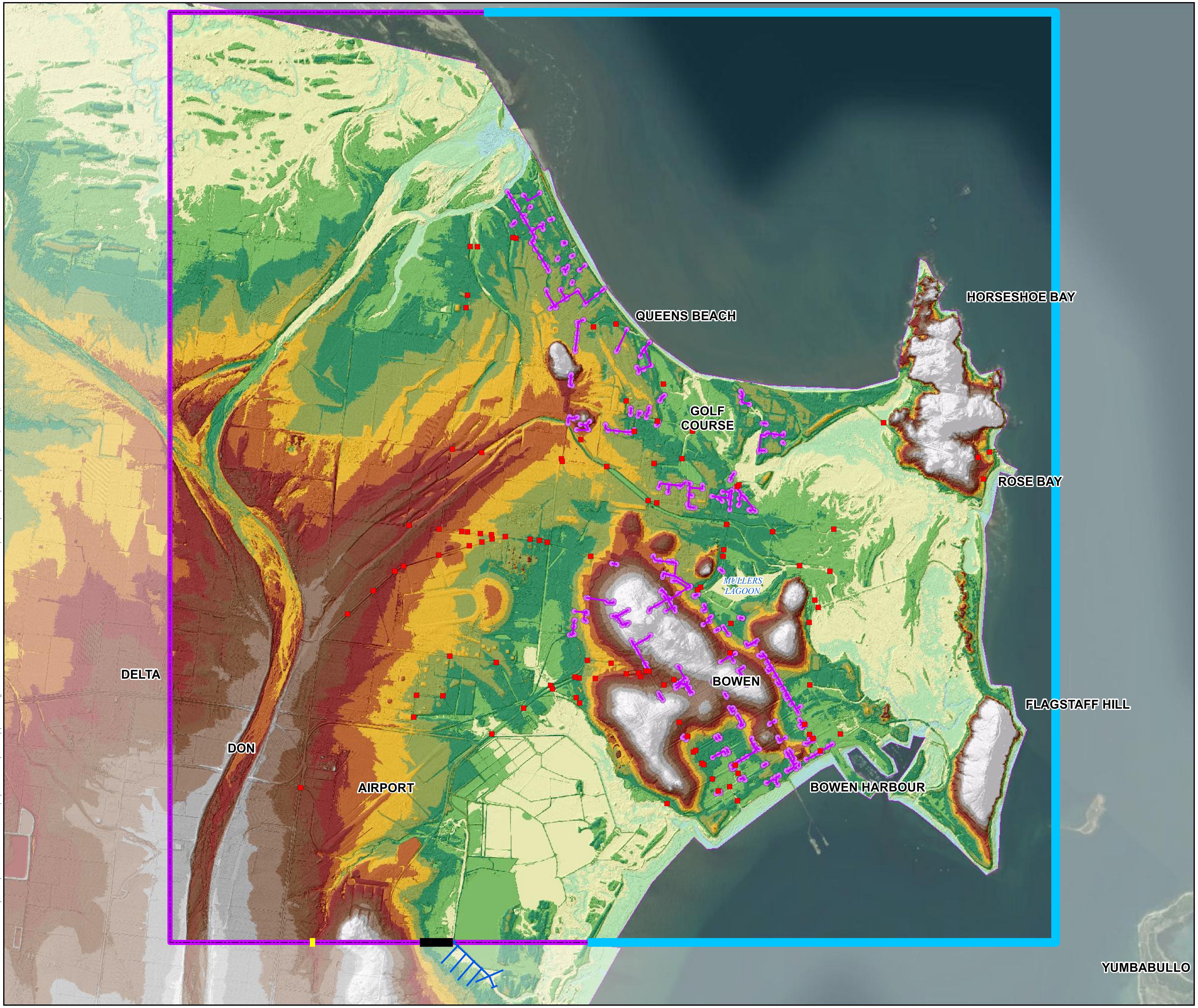
The hydraulic roughness generally reflects the types of development and vegetation that exists within the hydraulic model extent. Consequently it is appropriate to develop roughness maps that reflect the land use zoning within the model area.

The roughness distribution adopted for this study was based on aerial topography and land use zoning information provided by WRC. The specific roughness values adopted for each zone are detailed in Table 10.

Table 10 Adopted Roughness Values

Category	Manning's n	Manning's M
Drains	0.025	40
Floodplain	0.05	20
Industry	0.06	16.67
Mangrove	0.1	10
Natural Water Channels (including Don River)	0.03	33.33
Ocean	0.03	33.33
Open Space	0.04	25
Roads	0.02	50
Rural Residential	0.04	25
Saltworks	0.03	33.33
Urban	0.06	16.67

The hydraulic roughness within the study area has been schematized as a hydraulic roughness grid, representing varied hydraulic roughness of typical land use elements. Figure 8 shows a representation of the roughness map.



BOWEN LOCAL CATCHMENT FLOOD STUDY

Hydraulic Model Configuration

Figure 7

LEGEND

- Mike 11 Model Network - Nodes
- Mike Urban Nodes
- Mike Urban Links
- Mike 11 Outflow Branch
- Inflow Boundary
- Outflow Boundary
- Tide Boundary
- Hydraulic Model

Elevation (m

- Below 0.00
- 0.01 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- 3.01 - 4.00
- 4.01 - 5.00
- 5.01 - 6.00
- 6.01 - 7.00
- 7.01 - 8.00
- 8.01 - 9.00
- 9.01 - 10.00
- 10.1 - 12.00
- 12.1 - 14.00
- 14.1 - 15.00
- Above 15.00

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Meters

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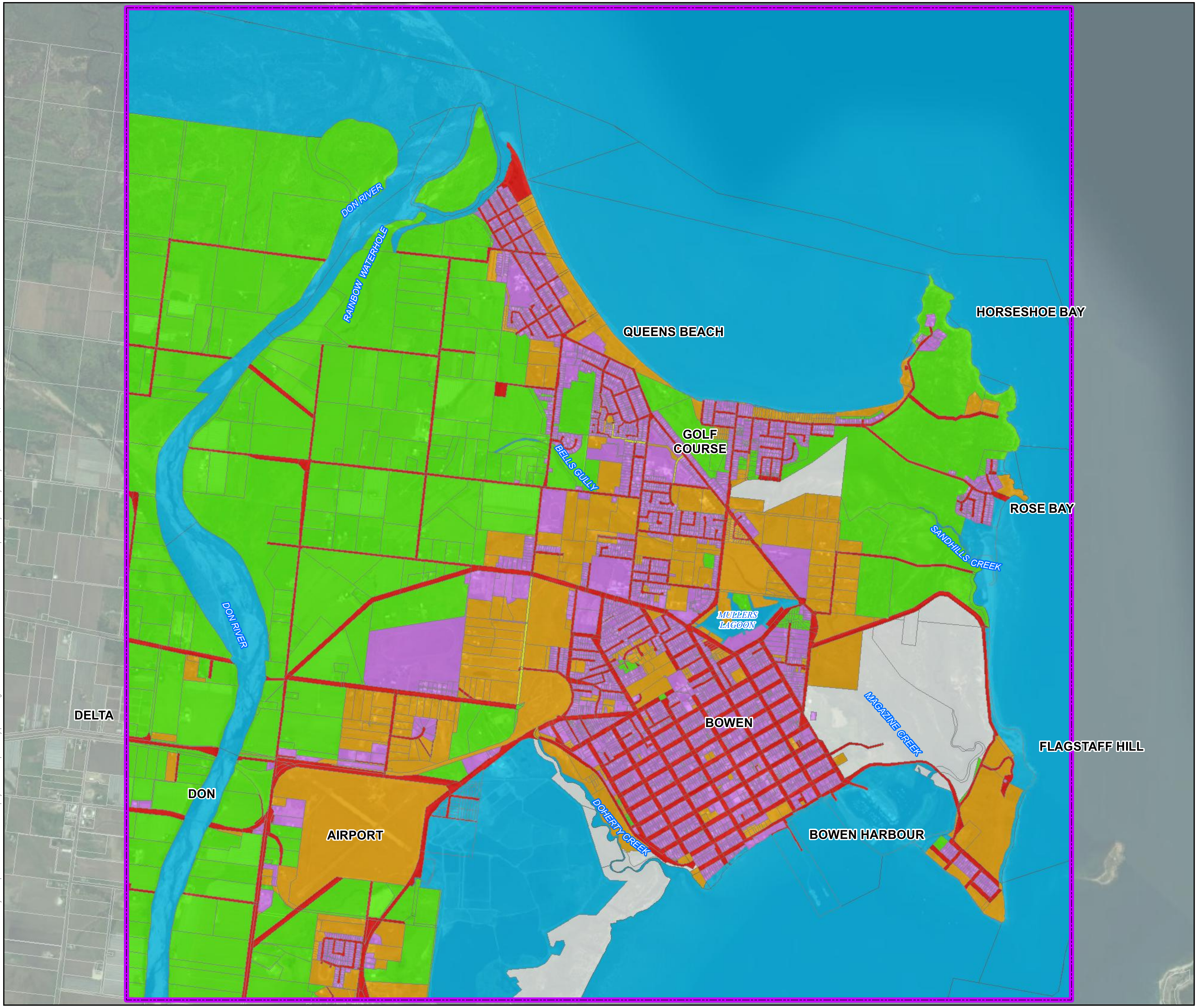
BOWEN LOCAL CATCHMENT FLOOD STUDY

Roughness Map

Figure 8



LEGEND

- Property Boundary
- Hydraulic Model Area

Manning's n

- 0.02
- 0.025
- 0.03
- 0.04
- 0.05
- 0.06
- 0.1

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

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Study Area, Catchments, Mannings m - AECOM 2015
Imagery - ESRI 2015

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5.3.7 Initial Conditions

Initial conditions were applied in the hydraulic model. This typically consisted of a set of adopted 'starting' flood levels in low-lying areas, waterways and storages. This included Mullers Lagoon which was assumed to be at full supply level at the commencement of the event. At the downstream boundary of the model, initial flood level conditions were set to equal the relevant tail water boundary condition.

5.3.8 Time Step

The model simulation time step is generally limited by the Courant conditions. The Courant condition is a function of the water depth and the flow velocities at any time step. The coupling with MIKE11 / MIKE URBAN components (i.e. explicit links) requires a Courant number less than 1.0.

A time step of 1.0 second was adopted to meet this requirement. The model simulation results were saved at 10 minute intervals.

5.3.9 Solution Scheme

The simulation time and accuracy of the model computations can be controlled by specifying the order of the numerical schemes which are used in the numerical calculations. For all simulations the higher order solution scheme within MIKE21 was used for both time integration and space discretisation. This is recommended for environments which are dominated by flow rather than diffusion, such as this flooding application.

5.3.10 Flooding and Drying Depths

MIKE21 allows the specification of flooding and drying depths, which control the depths at which elements are included or excluded from the computations. The model simulations were all carried out using:

- Drying depth of 0.002m.
- Flooding depth of 0.005m.

5.4 Model Checking and Verification

5.4.1 February 2008 Event

A number of peak flood height datasets were available however these were largely associated with the riverine flooding which occurred on the 11 February after the local catchment event.

The 2008 event discharge hydrographs from the XP-RAFTS model were applied to the MIKE FLOOD model along with direct rainfall grids which were applied to the hydraulic model. Direct rainfall grids were generated using historical rainfall gauge data from the stations noted in Section 3.3. A time varying tidal boundary was used based on tide records obtained.

The maximum water surface elevations were extracted from the hydraulic model and shown in Figure 9. Comparisons to peak flood heights were not possible as the recorded data was attributed to Don River flooding and not the local catchment event which occurred on the 10 February.

It is strongly suggested that Council record data for future local catchment events to aid in model calibration and verification.

5.4.2 Comparison to Alternative Methods

AR&R Revision Project 15 notes that direct rainfall models should be compared to alternative analysis methods given the relatively new technique with limited calibration or verification to gauged data.

This method of verification compares the results of the direct rainfall model with traditional hydrological methods – in this case the rational method has been used. Peak discharges have been calculated for a few sample sub-catchments within the study area, and compared with the flows in the direct rainfall MIKE FLOOD model.

The peak discharge comparisons indicated that the modelled peak discharges are reasonably similar to those calculated using the Rational Method. Further to the Rational Method checks, mapping for the 1% AEP design flood event was reviewed by Council. Reviews undertaken by Council suggested that the model is predicting flood behaviour as it is understood to occur in the study area.

5.4.3 Comparison to Previous Studies

Several previous studies have been undertaken as outlined in Section 3.2. Previous results have been compared to modelling outputs derived from this study. Comparisons have been made for the 1% AEP design flows for Bells Gully at Soldiers Road and the Golf Course Drain at the Ocean Outfall.

The comparison is provided below which would suggest that the current model predicts smaller peak discharges than the previous modelling. It is strongly recommended that calibration of the current model be undertaken to provide further confidence in the results.

Table 11 Comparison to Previous Studies

Location / Event	Cardno (2010)	Ullman & Nolan (1986)	AECOM (2015)
Bells Gully @ Soldiers Rd – 1% AEP Event	20.4	18.0	9.2
Golf Course Drain @ Outfall – 1% AEP Event	26.8	-	12.3

A comparison has also been made to baseline 1% AEP flood mapping produced by Cardno in 2010 for Case 10a (local catchment event only). The comparison shows general agreement between flood extents, peak velocities and depths in the common areas of interest. It was noted that the Bowen CBD and aerodrome area were not assessed by Cardno so no comparison could be made.

5.5 Discussion

Different hydrologic and hydraulic models have previously been used to estimate design event flood extents within the Bowen Township extents. Comparisons to the most recent studies undertaken by Cardno suggest a good agreement between model outputs. Additional comparisons to other traditional hydrologic methods provide additional reassurance that the model is performing adequately for the intended purpose.

AR&R Revision Project 15 outlines several fundamental themes which are also particularly relevant:

- All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately.
- Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data.
- Model accuracy and reliability will always be limited by the reliability / uncertainty of the inflow data.
- A poorly constructed model can usually be calibrated to the observed data but will perform poorly in events both larger and smaller than the calibration data set.
- No model is ‘correct’ therefore the results require interpretation.
- A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem.

BOWEN LOCAL CATCHMENT FLOOD STUDY

2008 Event Calibration Simulation Peak Water Surface Elevations

Figure 9

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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6.0 Effects of Climate Change

6.1 General

A suite of climate change literature is available, covering global, national and more localised state based climate change discussion and analysis. Whilst much of the literature states that, for Queensland, total annual rainfall is decreasing and rainfall intensity during rainfall events is increasing, there is comparatively little literature recommending actual values to adopt for these changes.

The Queensland Climate Change Strategy (QLD Government, 2007) indicated that cyclone intensity is expected to increase by 2050 with cyclone associated rainfall expected to increase by up to 20-30%. The other recently published document which provides guidance on the adoption of climate change values, and also provides guidance on the use of these scenarios in development planning is the Increasing Queensland's resilience to inland flooding in a changing climate: Final report on the Inland Flooding Study published by DERM, The Department of Infrastructure and Planning (DIP) and the Local Government Association of Queensland (LGAQ) in 2010.

The DERM, DIP and LGAQ Inland Flooding Study (2010) was specifically aimed at providing a benchmark for climate change impacts on inland flood risk. Whilst Bowen is not considered to be an inland area, this document does provide guidance on the adoption of climate change scenarios for development planning. The study recommends a 'climate change factor' be included into flood studies in the form of a 5% increase in rainfall intensity per degree of global warming. For the purposes of applying the climate change factor, the study outlines the following temperature increases and planning horizons:

- 2°Celsius by 2050;
- 3°Celsius by 2070; and
- 4°Celsius by 2100.

These increases in temperature equate to a 10% increase in rainfall intensity by 2050, and 15% increase in rainfall intensity by 2070 and a 20% increase in rainfall intensity by 2100.

In addition to impacts on rainfall, sea level rises are also commonly discussed in climate change literature. The most recent publication that relates to Queensland is the Queensland Coastal Plan (and more specifically the State Planning Policy Coastal Protection). The second document outlines sea level rises that should be considered when planning for development in coastal areas of Queensland. Table 22 details the projected sea level rise up to 2100.

Table 12 Projected Sea Level Rise (SPP 3/11, 2012)

Year of Planning Period	Projected Sea Level Rise (m)
2050	0.3
2060	0.4
2070	0.5
2080	0.6
2090	0.7
2100	0.8

In addition to the Coastal Plan, the Australian Government Department of Climate Change and Energy Efficiency report Climate Change Risks to Australia's Coast – A First Pass National Assessment for Australia (2009) identified that 1.1 m sea level rise by 2100 is a plausible value to adopt. Whilst this document is not a policy document, its recommendations should be considered.

6.2 Adopted Approach

Given the uncertainty in climate change and sea level rise projections, particularly with respect to changes in rainfall intensity, climate change sensitivity has been undertaken as part pf this study. The hydrologic and hydraulic models have been used to assess the impact of climate change that would be expected to occur in 2100 for the 1% AEP design event.

In addition to increased rainfall, climate change has the potential to increase sea levels. A sea level rise of 0.8m is expected by 2100. The MHWS level at the downstream boundary has been increased by 0.8m to 1.9m AHD for the design events.

6.3 Hydrologic Model Results

The XP-RAFTS model was run with increased rainfall intensities. The resulting peak discharges for the unnamed drainage catchment at the upstream boundary of the hydraulic model are presented in Table 13. Also included in the table is the existing case peak discharge for the 1% AEP event.

Table 13 Climate Change Event Peak Discharges for Doughty Creek (Year 2100 Scenario)

AEP (%)	Climate Change Scenario (+20% RI) Peak Discharge (m^3/s)	Existing Case Peak Discharge (m^3/s)
1	84.1	66.3

It is noted that the increased rainfall intensities were also included in the direct rainfall applied to the hydraulic model.

6.4 Hydraulic Model Results

Figure 10 presents the differences between the climate change scenario and the 1% AEP event results. This figure shows that, under a climate change scenario:

- Peak water surface levels are expected to increase by 50mm – 250mm throughout the majority of the study area as a result of increased rainfall intensity.
- Sea level rise is anticipated to impact on low lying areas - particularly the Magazine Creek, Sandhills Creek, Saltworks Catchment, Rainbow Waterhole / Eastern Channel Catchment and Doughty Creek Catchment.
- Increased tailwater conditions associated with sea level rise is also expected to increase water levels for key outfalls. These include Brisbane Street Catchment, Sinclair Street Catchment, Bells Gully and Queens Beach / Golf Course Catchment.

BOWEN LOCAL CATCHMENT FLOOD STUDY

Climate Change Scenario Difference Map (1% AEP)

Figure 10

LEGEND

- Property Boundary
- Hydraulic Model Area

Difference (m)

- Below -1
- -1.00 - -0.25
- -0.25 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- 0.20 - 0.25
- 0.25 - 0.50
- Above 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 250 500 1,000 1,500
Meters

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7.0 Design Flood Depths, Levels and Extents

7.1 Overview

The MIKE FLOOD model described in Section 5.0 was used to estimate the levels, extent and depth of flooding for the 50%, 20%, 10% AEP, 2% AEP, 1% AEP and PMF events. Design flood hydrographs predicted by the XP-RAFTS model were used as inflows into the MIKE FLOOD model. Downstream boundary condition was set to MHWS level, as noted in Section 5.3.4.

7.2 Design Flood Critical Duration Assessment

The critical duration for the 50%, 20%, 10%, 2% and 1% AEP events was assessed by simulating the 1, 3, 6, 9 and 12 hour durations for the 1% AEP events. Figure 11 shows the 1% AEP critical duration map.

The 3 and 9 hour durations were found to represent the critical durations across the majority of the study area. The 6 hour duration storm event was adopted as it represented a balanced output when comparing the 3 hour and 9 hour results. This critical duration was applied to the 50%, 20%, 10%, 2% and 1% AEP and PMF design event simulations.

7.3 Design Flood Depths and Extents

Figure 12 shows the 1% AEP design flood depths and extents for the study area.

Design flood depths and extents for the 50%, 20%, 10%, 2% and 1% AEP and PMF event are shown in Appendix C. The following is also of note:

Direct rainfall modelling uses a process whereby rainfall is applied to every model cell. Mapping of these results would show that the entire model area was flooded. For this reason, areas where the flow depth is less than 0.1m have been removed from the mapping. This process is aligned to guidance from AR&R Project 15.

7.4 Design Flood Elevations

Figure 13 shows the 1% AEP design flood elevations for the study area. Design flood elevations for the 50%, 20%, 10%, 2% and 1% AEP and PMF event are shown in Appendix D.

7.5 Design Flood Velocities

Figure 14 shows the 1% AEP design flood velocities for the study area.

Design flood velocities for the 50%, 20%, 10%, 2% and 1% AEP and PMF event are shown in Appendix E.

7.6 Peak Discharges

Modelled discharges at locations of strategic road links and areas of interest are summarised in Table 14.

Table 14 Modelled Peak Discharges

Location	Peak Discharge (m^3/s)			
	50% AEP	20% AEP	10% AEP	1% AEP
Bells Gully at Mt Nutt Road	1.1	2.4	3.2	7.2
Bells Gully at Jillets Road	0.5	2.5	3.5	8.0
Bells Gully at Argyle Park Road	0.6	2.3	3.4	8.4
Bells Gully at Soldiers Road	0.6	2.5	3.8	9.1
Bells Gully at Avoca Road	0.8	4.2	5.7	11.6
Golf Course Drain at Ocean Outfall	3.3	5.2	6.4	12.3
Golf Course Drain at Tollington Road	2.6	4.0	4.8	8.3

Location	Peak Discharge (m^3/s)			
	50% AEP	20% AEP	10% AEP	1% AEP
Downstream of Inveroona Road	1.9	4.0	5.4	12.3
Northern Golf Course Drain	1.1	1.8	2.1	3.5
Sinclair St Outfall	3.4	4.8	5.9	10.8
Brisbane St Outfall - US	1.1	1.8	1.8	3.1
Bruce Highway Culverts	23.4	38.0	47.2	87.7

7.7 Flood Hazard Mapping

Flood hazard categorisation provides a better understanding of the variation of flood behaviour and hazard across the floodplain and between different events. The degree of hazard varies across a floodplain in response to the following factors:

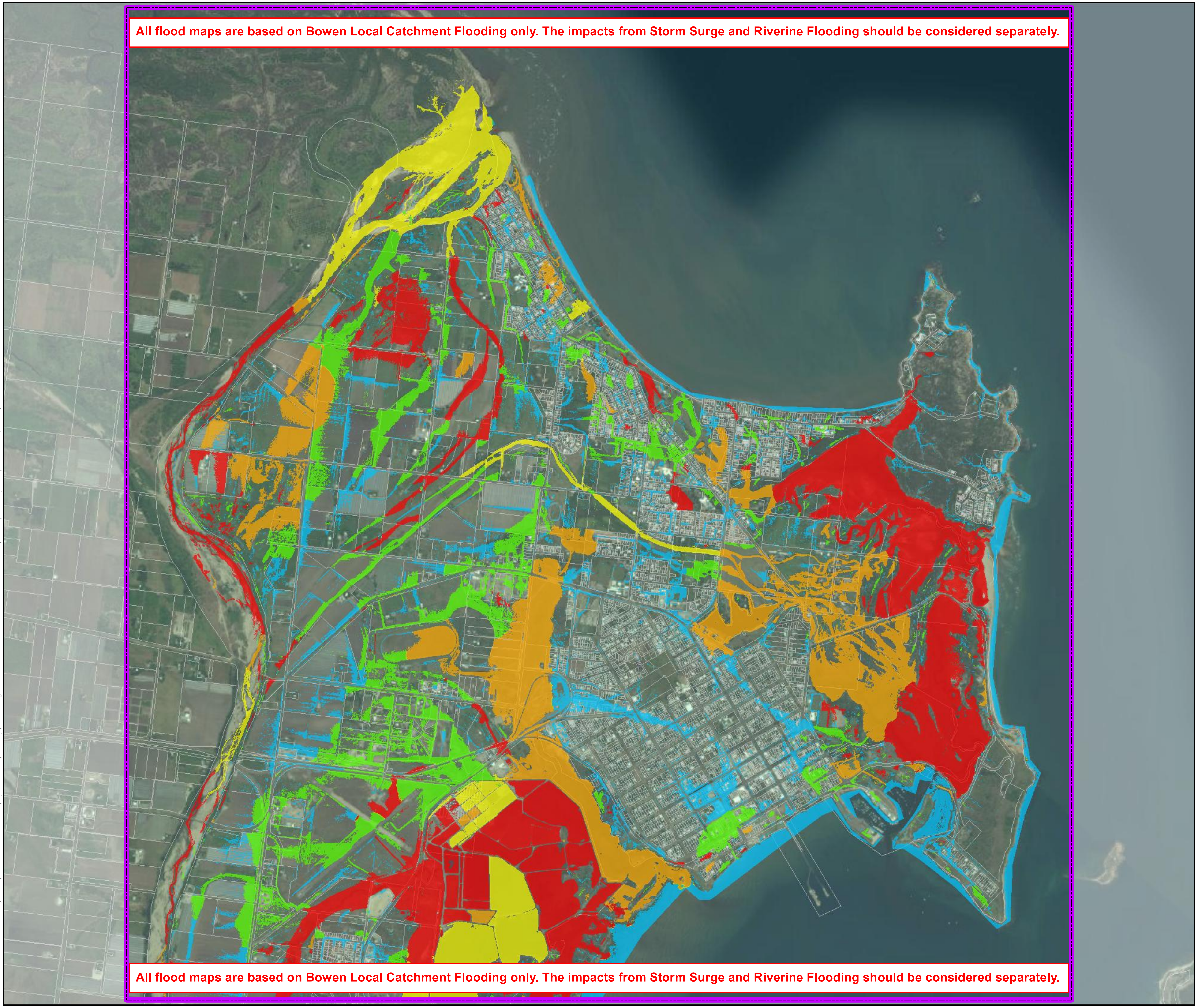
- Flow depth
- Flow velocity
- Rate of flood level rise (including warning times)
- Duration of inundation.

The State Planning Policy Guideline 1/03 (Sec A2.30) provides the following flood hazard definitions:

- Low – there are no significant evacuation problems. If necessary, children and elderly people could wade to safety with little difficulty; maximum flood depths and velocities along evacuation routes are low: evacuation distances are short. Evacuation is possible by a sedan-type motor vehicle, even a small vehicle. There is ample time for flood forecasting, flood warning, and evacuation routes remain trafficable for at least twice as long as the time required for evacuation.
- Medium – fit adults can wade to safety, but children and the elderly may have difficulty; evacuation routes are longer; maximum flood depths and velocities are greater. Evacuation by sedan-type vehicles is possible in the early stages of flooding, after which 4WD vehicles or trucks are required. Evacuation routes remain trafficable for at least 1.5 times as long as the necessary evacuation time.
- High – fit adults have difficulty in wading to safety; wading evacuation routes are longer again; maximum flood depths and velocities are greater (up to 1.0 m and 1.5 metres per second respectively). Motor vehicle evacuation is possible only by 4WD vehicles or trucks and only in the early stages of flooding. Boats or helicopters may be required. Evacuation routes remain trafficable only up to the maximum evacuation time.
- Extreme – boats or helicopters are required for evacuation; wading is not an option because of the rate of rise and depth and velocity of floodwaters. Maximum flood depths and velocities are over 1.0 m and over 1.5 m/s respectively.'

For the purposes of this study, flood hazard maps have been generated according to SCARM guidelines using both flood depth and flood velocity outputs to determine flood hazard. No assessment of evacuation times were incorporated in this assessment.

A flood hazard map has been prepared for the 1% AEP flood event and is shown in Figure 15. Additional mapping information has also been provided to WRC in GIS format to produce flood hazard maps for other AEP events as required.



BOWEN LOCAL CATCHMENT FLOOD STUDY

Critical Duration Assessment Map (1% AEP)

Figure 11

LEGEND

- Property Boundary
- Hydraulic Model Area

Critical Duration (hour)

- 1 hr
- 3 hr
- 6 hr
- 9 hr
- 12 hr

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

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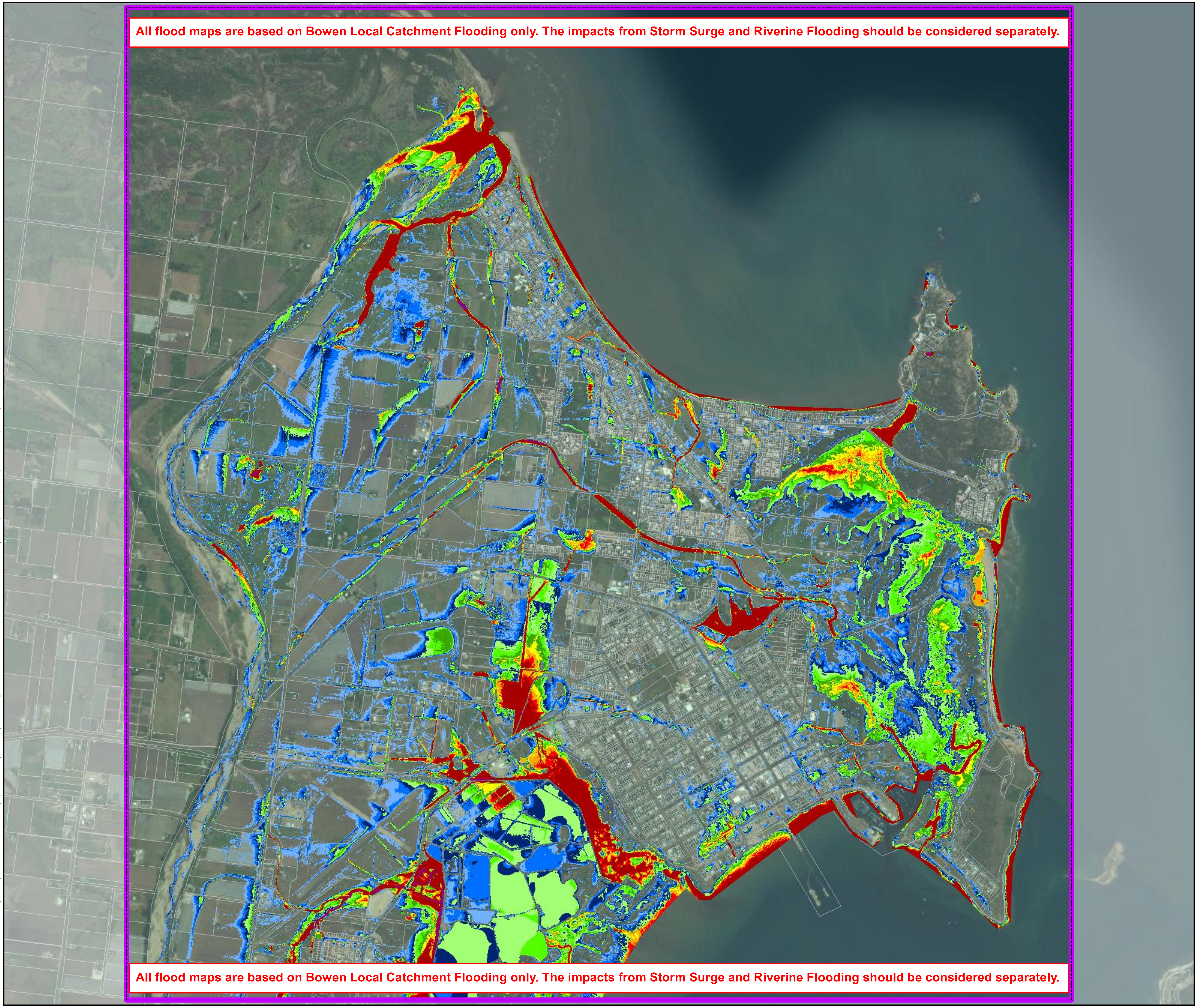

BOWEN LOCAL CATCHMENT FLOOD STUDY

1% AEP Design Flood Depths and Extents

Figure 12

LEGEND

Property Boundary

Hydraulic Model Area

Water Depths (m)

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0
1.0 - 2.0
> 2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

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BOWEN LOCAL CATCHMENT FLOOD STUDY

1% AEP Design Flood Elevations

Figure 13

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

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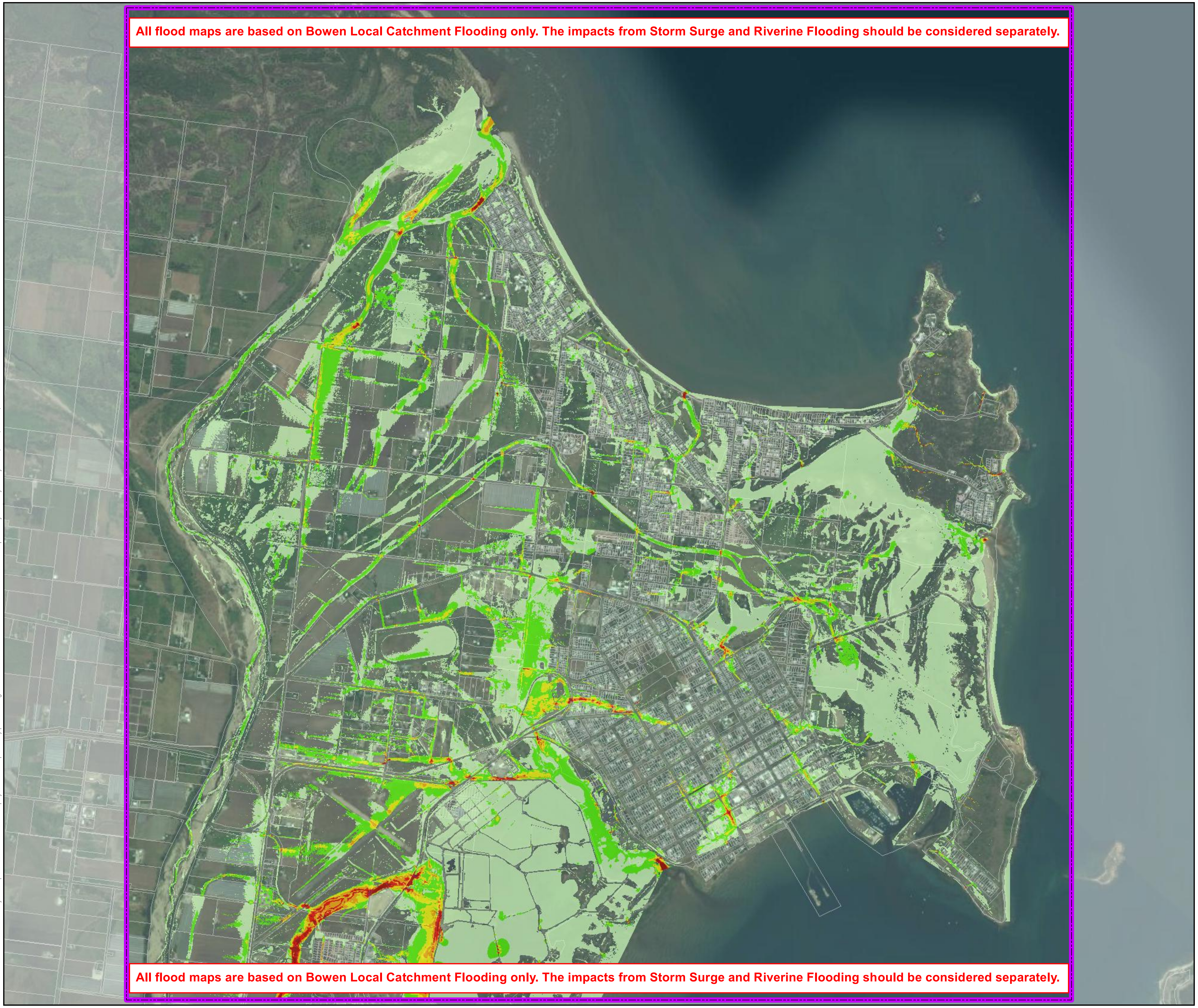
BOWEN LOCAL CATCHMENT FLOOD STUDY

1% AEP Design Flood Velocities

Figure 14



All flood maps are based on Bowen Local Catchment Flooding only. The impacts from Storm Surge and Riverine Flooding should be considered separately.

LEGEND

Property Boundary

Hydraulic Model Area

Velocity (m/s)

0.0 - 0.2

0.2 - 0.4

0.4 - 0.6

0.6 - 0.8

0.8 - 1.0

1.0 - 2.0

>2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

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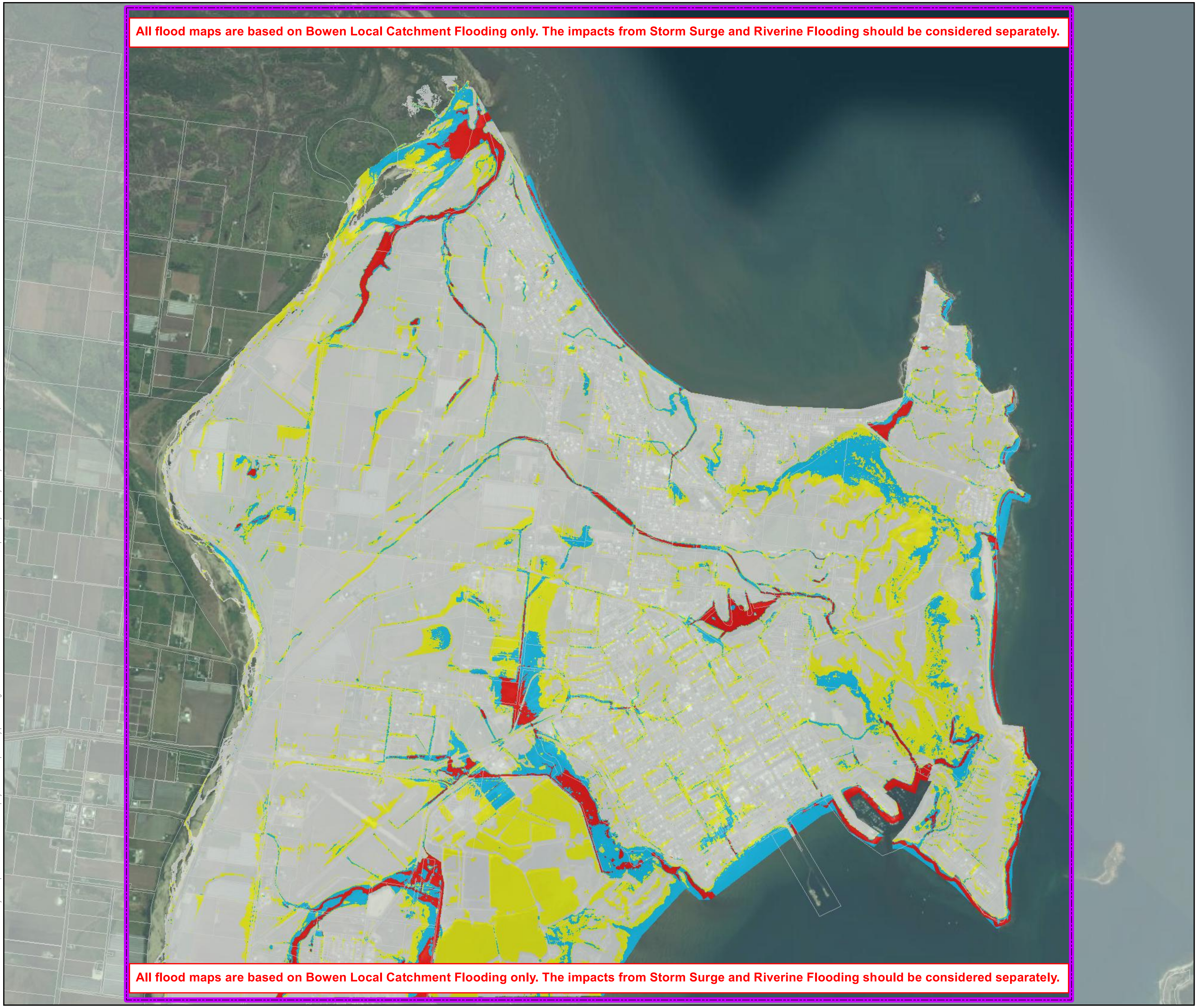
BOWEN LOCAL CATCHMENT FLOOD STUDY

1% AEP Flood Hazard Map

Figure 15



All flood maps are based on Bowen Local Catchment Flooding only. The impacts from Storm Surge and Riverine Flooding should be considered separately.

LEGEND

- Property Boundary
- Hydraulic Model Area

Hazard

- Low
- Medium
- High
- Extreme

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

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7.8 Sensitivity and Uncertainty in Design Flood Outputs

The following uncertainties required consideration in respect to sensitivity in the hydraulic model:

- Parameter uncertainty in the hydraulic model (roughness).
- Uncertainty in respect of downstream boundary conditions (HAT tidal level).
- Don River influence.

7.8.1 Hydraulic Roughness

In determining an appropriate freeboard allowance to account for possible errors in the model roughness and other parameters, sensitivity runs with roughness values altered by ±25%. This sensitivity testing was undertaken only for the 1% AEP event. The predicted difference in flood height due to a 25% increase and decrease in roughness is shown in Figure 16 and Figure 17.

Reference to Figure 16 shows that this scenario results in an increase in peak flood levels throughout the study area. Maximum increases were up to 0.1m but generally less than 0.05m.

Reference to Figure 17 shows that this scenario results in a decrease in peak flood levels throughout the study area. Maximum reductions were up to 0.25m but generally less than 0.1m.

The results of the sensitivity analyses suggest that the model is not highly sensitive to roughness changes and are within the proposed freeboard height.

7.8.2 Downstream Boundary Condition

Sensitivity to the downstream boundary condition was modelled by running the 1% AEP event with a higher boundary level equivalent to the HAT level of 1.97m AHD. The variation resulting from the increased boundary level is shown in Figure 18.

In a practical sense, the extent of inundation (or flood footprint) is more important than the difference in flood levels. If this difference is significant between various boundary conditions then careful consideration must be made. On the other hand, if the difference in flood footprint is only marginal, then there is no need to consider this in great detail as the outcome is not sensitive to boundary conditions assumptions.

In this case, the latter situation occurs throughout the majority of the study area. The only exceptions are within the Sandhills Creek and Magazine Creek catchments where there is minimal existing infrastructure.

Increased tailwater levels are predicted to reduce the outfall conveyance for the Golf Course Drain, Brisbane Street Drain and Doughty Creek. Flood levels are increased upstream of each outfall with increases of up to 0.1m.

7.8.3 Don River Influence

The Don River system is highly dynamic, evidenced by the number of minor and major breakouts which occur along the banks of the lower Don River in moderate and major flood events. River breakouts in some locations can directly threaten Queens Beach and Bowen township which are key areas of concern within this study area. Webster Brown, Bells Gully and Boottooloo are known break out points along the eastern bank of Don River which have potential to flood these areas.

Webster Brown, Bells Gully and the '1946 mouth' are still considered to be the highest risk breakout points in terms of future flood risk management for Bowen and Queens Beach. Any potential erosion of the bank adjacent to Webster Brown and significant deposition in the river channel adjacent to Bells Gully may potentially increase the conveyance through these flow paths and subsequently increase flood risk. Continual deposition and aggradation of the '1946 mouth' distributary could also have severe impacts as this results in a greater proportion of flows through Webster Brown.

AECOM has previously been commissioned by WRC to assess and quantify the potential flood risk posed by the Don River over a range of annual exceedance probability events and provide mitigation options to help improve future flood resilience of the Bowen community. The results of this investigation are reported separately in the Don River Flood Risk and Mitigation Study Stage 1 and Stage 2 Reports (AECOM, 2014).

This local catchment flood study does not assess impacts posed by Don River flood events, however it is recommended that WRC assess the potential impact of combination events in future stages of this study (i.e. riverine flood events occurring concurrently with local catchment events).

BOWEN LOCAL CATCHMENT FLOOD STUDY

Differences Due to Increased Roughness

Figure 16

LEGEND

- Property Boundary
- Hydraulic Model Area

Difference (m)

- Below -1
- -1.00 - -0.25
- -0.25 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- 0.20 - 0.25
- 0.25 - 0.50
- Above 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

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User: smithc5 | Date Saved: 13/02/2015 | FileName: Y:\TSV_GIS\Projects\60332898\02_MXDs\G60332898_030_IncreasedRoughness_20150121_v1_A3.mxd

BOWEN LOCAL CATCHMENT FLOOD STUDY

Differences Due to Decreased Roughness

Figure 17

LEGEND

- Property Boundary
- Hydraulic Model Area

Difference (m)

- Below -1
- -1.00 - -0.25
- -0.25 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- 0.20 - 0.25
- 0.25 - 0.50
- Above 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

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BOWEN LOCAL CATCHMENT FLOOD STUDY

Differences Due to Higher Downstream Boundary Level

Figure 18

LEGEND

- Property Boundary
- Hydraulic Model Area

Difference (m)

- Below -1
- -1.00 - -0.25
- -0.25 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- 0.20 - 0.25
- 0.25 - 0.50
- Above 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

Whitsunday Regional Council

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7.9 Further Model Revisions

In undertaking the final hydraulic modelling associated with this study, several limitations were noted which are outlined below:

- Aerodrome Site
  - Results suggest ponding on the upstream side of the runway; however aerial imagery suggests that three culvert structures drain the local catchment from west to east.
  - Two culverts drain to the Bruce Highway Culverts on the western side of the airport and the northern-most culvert drains to the culverts under the Bruce Highway / Don Street intersection.
  - Culverts details were not available from the survey provided. It is suggested that these culvert be surveyed and added to the model to accurately represent flow patterns within the airport site.
- Norris St Drain
  - There is an open channel on the western side of the Cokeworks Rail line in the vicinity of Norris Street between Livingstone Street and Kennedy Street.
  - This drain conveys flows from a catchment as far east as Mitchell Street through to Doherty Creek. Aerial imagery suggests that a cross drainage structure may exist in this location for which details were not available. It is recommended that this cross drainage structure be surveyed and added to the model.
- Seabreeze Estate
  - The estate is located west of the intersection between Golf Links Road and Tollington Road. The drainage in this area is characterised by open drains along the footpaths with culverts at driveways accesses. In addition, a detention basin collects runoff from this area and eventually releases it into a drain on the northern side of Queen Street which eventually drains through the Golf Course Drain.
  - The minor drainage infrastructure in the Seabreeze Estate was not included in the survey data provided. As a result, the modelled peak flood depths may be higher than actually expected in a flood event.

7.10 Freeboard Provision

Freeboard is added to flood levels to provide reasonable certainty of achieving the desired level of service from setting a general standard or Define Flood Event (DFE) for planning controls. The freeboard has been estimated in consideration of the following factors:

- Uncertainty in the estimate of flood levels.
  - Uncertainties due to the lack of available stream gauges within the study area and the lack of calibration data suggests a degree of uncertainty in the estimated flood levels.
- Local factors that can result in differences in water levels across the floodplain. These factors can often not be determined in flood modelling (i.e. blockage of stormwater infrastructure).
- The cumulative effect of subsequent infill development of existing zoned land.
- Where the future climate has the potential to significantly increase risk.

In effect, freeboard acts as a factor of safety. However, it should not be considered as giving additional protection beyond the DFE to which it is applied.

In consideration of the results of the sensitivity tests, and lack of data on which to base model calibration, it is recommended that Council consider a freeboard of 0.3m to be applied to the model results in using them for development control purposes.

8.0 Existing Drainage Deficiencies

8.1 Overview

The following sections outline stormwater drainage problems areas confirmed through hydraulic modelling undertaken during the study. The intent of this section is not determine and model the benefits of system augmentations and upgrades, rather it provides a starting point for WRC to undertake future investigations aimed at assessing the feasibility of such drainage improvements.

It is expected that these investigations would be coupled with stormwater asset condition assessments in order to prioritise drainage upgrades within future capital works budgets. Other key considerations include:

- Community and stakeholder consultation when determining major storm drainage paths in accordance with the Queensland Urban Drainage Manual (QUDM).
- Planning and design works including hydraulic investigations and sizing of drainage easements with consideration of environmental impacts, costs and funding options.
- Sea water intrusion into the coastal aquifer when assessing potential upgrades.
- Prevalence of acid sulfate soils that commonly occur in low lying coast environments.
- Assessment of the impacts to existing infrastructure immunity due to climate change impacts. Council should give consideration to increased tidal levels and rainfall intensities when implementing drainage upgrades and augmentations.

8.2 Current Design Criteria

Council's requirements in respect of stormwater drainage systems in residential and commercial areas are to satisfy the following criteria:

- 1% AEP flows are to be contained within reserves or easements with a positive outlet for flows.
- Drainage systems are to be a combination of above ground and underground drainage.
- Underground drainage shall be provided to meet the following design storms:
    - Residential Areas – 10% AEP.
    - Commercial areas – 10% AEP.

Future drainage upgrades / augmentations should meet these design criterions wherever possible.

8.3 Bells Gully

8.3.1 Characteristics

Bells Gully is a distributary in the lower Don River floodplain and serves as an overflow channel during large magnitude events in the Don River. It is also a drainage path for the local catchment between Bowen and Queens Beach and receives flows from Mullers Lagoon.

Bells Gully is characterised by a series of parallel channels with flat longitudinal grades.

8.3.2 Drainage Deficiencies

Runoff from the local catchment is contained within the confines of Bells Gully up to the 1% AEP event modelled for the study. Some flows are expected to overtop the banks of the channel and into the parallel channel, especially upstream of Argyle Park Road.

Mullers Lagoon has been shown to have limited capacity above the full supply level. In large magnitude events when Mullers Lagoon is at full supply level, inundation can occur near Reynolds Street and Herbert Street.

8.3.3 Potential Upgrades

Previous studies have assessed potential upgrades for Bells Gully in order to mitigate impacts associated with Don River overbank discharges. These upgrades are beyond the scope of this study and are discussed in more detail in the Don Flood Risk and Mitigation Study (AECOM, 2015).

In any case, it is clear that areas adjacent to Bells Gully are subject to future development. It is essential that Council resume drainage easements and / or reserves to maintain this key drainage path for future local catchment and Don River flood conveyance.

8.4 Sinclair Street Catchment

8.4.1 Characteristics

The Sinclair Catchment commences at Kennedy Street and runoff tends in a southerly direction before discharging into Port Denison south of Thomas Street. The catchment is bounded by Mitchell Street to the west and Herbert Street to the east.

Existing drainage infrastructure consists of lined open channels with shallow depths and cross drainage culverts at street crossings.

8.4.2 Drainage Deficiencies

The existing drainage system lacks capacity, with the majority of the open channels exhibiting less than 50% AEP capacity. Inundation of properties adjacent to the open channel drains are likely in a 50% AEP event. This matches the findings from historical studies.

8.4.3 Potential Upgrades

Very flat grades and development patterns make underground systems extremely difficult and costly to construct. For this reason, there are very limited opportunities for cost effective immunity improvements within the catchment.

Larger scale options that could be considered are:

- Widening of existing open channels resulting in some road reconstruction, cross drainage structure upgrades, service relocations and potential property resumptions.
- Diversion of some flows to Leichhardt Street which would necessitate a new drainage outfall into Port Denison.
- Investigate the opportunities for peak attenuation, albeit locations are likely to be limited to the downstream area of the network, adjacent to the existing outfall.

There are a number of practical issues that would need to be addressed before progressing any of these options.

8.5 Don Street Catchment

8.5.1 Characteristics

The Don Street Catchment extends from Gregory Street in the north and Kennedy Street in the south and discharges to Doughty Creek adjacent to the Old Bowen Railway Station. The catchment includes essential services including the Public Hospital and ambulance station.

Existing drainage infrastructure includes both pipes and open channels.

8.5.2 Drainage Deficiencies

The existing drainage system generally lacks capacity, with the majority of the open channels exhibiting less than 50% AEP capacity. Inundation of properties adjacent to the Livingstone Street / Sinclair Street intersection and Don Street / Leichhardt Street intersection is expected in a 50% AEP event. This matches the findings from historical studies.

8.5.3 Potential Upgrades

Minimal conveyance is available in the existing piped drainage system between Sinclair Street and Leichhardt Street. Additional capacity is required to raise the level of flood immunity for this portion of the system above the minor storm criteria (i.e. 10% AEP capacity).

Upgrades to the open channel downstream of Livingstone Street are deemed to be necessary in order to improve conveyance capacity.

8.6 Brisbane Street Catchment

8.6.1 Characteristics

The Brisbane Street Catchment commences at Kennedy Street and runoff tends in a southerly direction before discharging into Port Denison immediately south of Santa Barbara Parade. The catchment extends to Herbert Street in the west and Hay Street to the east.

Existing drainage infrastructure includes both pipes and open channels. Cross drainage structures have also been provided at street crossings. The outlet to Port Denison is via an open channel which is low lying and affected by tidal influence.

8.6.2 Drainage Deficiencies

Modelling indicates that the existing underground drainage system lacks capacity. There also appears to be insufficient inlet capture rates and poor longitudinal grading of Brisbane Street which prevents high flows from tending overland towards Port Denison.

Significant deficiencies are noted in the system between William Street and Dalrymple Street which results in the inundation of a number of surrounding properties.

8.6.3 Potential Upgrades

Upgrades to the open channel system along the southern portion of Brisbane Street are recommended. It is noted that these upgrades may not result in significant immunity benefits due to the low lying topography, flat longitudinal grades and tidal influence.

Other upgrades should be focussed on the underground network upstream of William Street which may also require upgrades to kerb inlets to ensure the system operates a maximum efficiency.

8.7 Queens Beach

8.7.1 Characteristics

Queens Beach has been developed on a dunal system immediately to the south of the Don River mouth. The area is characterised by numerous dunes which intervening swale areas. Low lying areas have no well-defined drainage outlets and development patterns have resulted in some dwellings being located in low lying areas. This has restricted options associated with filling and grading to maintain positive drainage outlets.

8.7.2 Drainage Deficiencies

There are several low lying areas within Queens Beach which result in overland flows becoming trapped in the absence of any underground drainage systems to reduce ponding.

Modelling indicates there are drainage deficiencies in the Bryant Avenue catchment which aligns with findings from other historical reports. Several existing properties traverse the natural low point and have partially blocked the overland flow path to the existing beach outlet.

8.7.3 Potential Upgrades

The topography of the area and maintenance issues associated with beach outlets are a significant constraint to potential drainage upgrades within Queens Beach. It is suggested that immunity to the major flood criteria (1% AEP) be achieved through localised filling and ensuring floor levels are above the peak flood level (with provision for freeboard).

Some upgrades / augmentation to the underground drainage systems may be feasible and could utilise the existing ocean outfalls. It is expected that some underground drainage systems may function primarily as anti-ponding devices to limit standing water after an event.

9.0 Emergency Management Planning

9.1 Overview

WRC's Local Disaster Management Group (LDMG) is responsible for coordinating local planning and response for flood events. A lack of available data can be a limiting factor for a LDMG's ability to plan for the event and to communicate the expected impacts to local residents / media.

It is for this reason that it is recommended that Council officers hold workshops with key members of the LDMG and emergency service personnel following the finalisation of this study to disseminate design event modelling outputs. This will enable the LDMG to review the outputs and request any additional information which would be of most use during a flood emergency.

It is noted that outputs from storm surge and Don River studies should also be combined with outputs from this study when developing emergency management plans.

The following sections provide information on several key items which should be developed to support emergency management planning.

9.2 Flood Emergency Plan

It is common for emergency management agencies to develop or amend their Flood Emergency Plan following the completion of a Flood Risk Study. This is a detailed document containing an agreed set of roles, responsibilities, functions, actions and management arrangements to deal with flood events of all sizes.

The primary aim of a flood emergency plan is to reduce hazard during an actual flood. Essential issues addressed in the plan are flood forecasting, flood warning, location of vulnerable people/communities and evacuation and initial recovery. A local flood emergency plan forms an essential component of a floodplain management plan and requires close liaison between emergency management staff.

Typically, a flood emergency plan has several trigger points that result in the activation and implementation of the plan as the actual flood event develops. The flood emergency plan should include activities to protect and reinstate essential infrastructure services required during clean-up and in the recovery phase.

9.3 Assessment of Critical Infrastructure

A list of critical infrastructure which may be inundated by local catchment flooding could be prepared. This could include infrastructure such as:

- Emergency services facilities (e.g. ambulance, police, fire, hospital).
- Significant facilities for evacuation (e.g. child care, education, retirement, nursing care).
- Key water and sewerage infrastructure.
- Roads / bridges.

9.4 Decision Support Tool

A decision support tool for emergency management procedures can assist the LDMG to identify the major decisions to be made during a flood event and during an evacuation.

This tool acts as a trigger for the LDMG to identify which decisions are required depending upon the expected magnitude of the flood event.

9.5 Flood Warnings

Pre-written flood warnings can be prepared. This allows for these warnings to be readily available for dissemination to the media during a flood event.

9.6 Evacuation Route Assessment

Using the inundation maps presented in this report, the persons likely to be affected by floods should be identified and their ability to manage their well-being during floods assessed. Evacuation routes should be assessed for susceptibility to flooding.

The assessment should include the development of evacuation messages containing the main evacuation routes, description of safe havens and a description on how to behave during an evacuation. This message should be differentiated according to the situation of the inhabitants regarding risk, evacuation routes and safe areas and shelter place. Vulnerable parts of the community should also be identified when assessing evacuation routes (i.e. hospitals, nursing homes, schools, etc) to ensure consideration is made for evacuation timings and special requirements.

Consideration should also be made for potential inundation of evacuation routes due to storm surge or local catchment flood events as there is a potential that these events can occur in combination with riverine flooding.

10.0 Community Awareness

10.1 Overview

It is critical that the communities of Bowen and Queens Beach be made aware – and remains aware – of their role in the overall floodplain management strategy for the region, including defence of their communities and the evacuation of themselves. Sustaining an appropriate level of flood awareness involves continuous effort by Council and the emergency services but can significantly increase the community's resilience to future flood events.

Irrespective of flood warnings, there can be widespread variation in flood awareness in a community which can result in a high degree of variation in flood damages. Within the Bowen area, the recent flood events have greatly raised the awareness of the community. However, as time passes, this awareness will reduce.

Council can enhance flood awareness through, for example, regular public education programs via newspaper, videos, pamphlets, meetings and other media outlets. Community awareness brochures have been widely adopted and many followed the successful implementation of NSW SES's 'Flood Safe' brochures. These brochures can include material specific to the local region and provide the following information:

- What floods are and the history on flooding in Bowen
- Flood behaviour in Bowen
- Flood warnings
- What to do before, during and after a flood
- Preparation of a household emergency plan

It is recommended that Council develop a communications plan to explain existing flood risk to the Bowen community following finalisation of this report.

11.0 Development Planning

11.1 Overview

Appropriate development and building controls can significantly reduce flood hazard and the amount of damage to flood prone properties when a flood greater than the DFE occurs. The level of protection provided by the Planning Scheme should be a consequence of an analysis of the risks and consequences of flooding and the opportunities provided by sustainable land uses.

An underlying factor of community vulnerability is the degree of exposure to flooding. Where people have chosen to live is their own decision however, they may not be aware of the flood risk and hazard to which they are exposed. Planning schemes are a key element to prevent increasing the number of people, business and assets exposed to flooding from events less than the design flood event. It is therefore fundamental that future development is guided so that people and their property have limited exposure to flood hazard.

Several broad recommendations have been provided below for further discussions with Council's Planning and Development officers:

- This study has assessed existing flood risk for local catchment events only. Storm surge and Don River catchment flood events should be considered in conjunction with the results of this study when undertaking development planning and assessments.
- Council needs to have regard to the cumulative impacts of developments, i.e. the consideration of the impacts of a development in combination with other developments.
- A key component of land use planning is the adoption of a DFE. This has traditionally been adopted as the 1% AEP flood however there is considerable evidence that rainfall intensity will increase during current planning horizons.
    - In application, a DFE being the 1% AEP flood with an allowance for the adverse impacts of climate change as represented by an increase in design rainfall intensities (of 20% being a 5% per degree Celsius rise in mean global temperature of 4°C to the year 2100) is recommended.
- In consideration of the results of the sensitivity tests, and lack of data on which to base model calibration, it is recommended that a freeboard of 0.3m be applied to the model results in using them for development control purposes (refer to Section 7.9).
- A comprehensive suite of measures against which to assess developments is recommended that not only includes the direct impact of development, but also the indirect impacts regarding flood warning and evacuation.
- Relevant Council staff should be appropriately trained in assessing flood study reports with respect to the development control measures selected.

12.0 Summary

12.1 Conclusion

This study is focussed on existing flood risk posed by local catchment flood events only. This flood risk assessment has been undertaken to assist WRC in land use planning, development assessment, community awareness and emergency management.

XP-RAFTS runoff-routing hydrologic model was developed for a portion of an Unnamed Drainage Catchment, with the remaining catchments located within the study area assessed using a direct rainfall approach. A MIKE FLOOD two dimensional hydraulic model was developed for the study area which included MIKE 21, MIKE 11 and MIKE URBAN components. The MIKE FLOOD model was calibrated against recorded flood heights for the 2008 event.

Design flood discharges, flood levels, flood extents and flood velocities were determined for a range of events from the 50% AEP to the PMF event. The study also included an assessment of the impact of climate change based on recommendations from the Queensland Government.

12.2 Recommendations

A number of recommendations have been identified throughout the course of this assessment. These additional studies / investigations would reduce uncertainties, provide additional information to Council and provide a better understanding of flooding in the Bowen region.

12.2.1 Calibration Data

To improve confidence in the results of the township model, calibration to several floods of varying magnitude is recommended. It is recommended that WRC staff investigate the need for peak flood height recorders, similar to those used in Proserpine to record flood heights.

Flood gauge locations and recordings should be documented in a centralised spreadsheet along with the approximate date and time that the water level peaked. Maintenance of the recorders would be necessary and it is recommended that this is undertaken at least once per year.

12.2.2 Standards for Modelling Methodologies and Management

It is recommended that Council adopt a standard for modelling methodologies and model management, particularly given the number of models Council now possess.

Well defined standards can:

- Allow Council to be confident that their modelling and model results are consistent across the region and therefore easily comparable from catchment to catchment.
- Allow Council to better manage their files within their own systems.
- Ensure that original versions of models are protected.
- Can be more easily refined as more recent data becomes available rather than building a new model.

12.2.3 Development of a Communications Plan

It is recommended that Council develop a communications plan to explain existing flood risk to the Bowen community.

12.2.4 Review of Emergency Management Planning

It is recommended that Council officers hold workshops with key members of the LDMG and emergency service personnel to disseminate design event modelling outputs. Other key items related to the improvement of the emergency management planning should also be developed where possible.

13.0 References

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Appendix A

MIKE 11 Structures

Appendix A MIKE 11 Structures

Location	Configuration	Model Representation
Inveroona Road	2 / 600 x 300 RCBC	MIKE 11
Inveroona Road	1 / 600 x 300 RCBC	MIKE 11
Inveroona Road	1 / 600 RCP	MIKE 11
Inveroona Road	2 / 450 RCP	MIKE 11
Murray Avenue	1 / 600 x 300 RCBC	MIKE 11
Mt Nutt Road	2 / 600 x 200 RCBC	MIKE 11
Jilletts Road	1 / 1200 x 250 RCBC	MIKE 11
Inverdon Road	1 / 450 RCP	MIKE 11
Inverdon Road	1 / 600 RCP	MIKE 11
Woodlands Road	1 / 600 x 300 RCBC	MIKE 11
Woodlands Road	1 / 600 x 300 RCBC	MIKE 11
Woodlands Road	1 / 600 x 300 RCBC	MIKE 11
Woodlands Road	1 / 1500 x 450 RCBC	MIKE 11
Woodlands Road	4 / 1200 x 275 RCBC	MIKE 11
Woodlands Road	1 / 600 x 300 RCBC	MIKE 11
Woodlands Road	3 / 600 x 300 RCBC	MIKE 11
Richmond Road	1 / 1200 x 300 RCBC	MIKE 11
Richmond Road	1 / 600 x 300 RCBC	MIKE 11
Richmond Road	2 / 300 RCP	MIKE 11
Richmond Road	1 / 1200 x 300 RCBC	MIKE 11
Richmond Road	1 / 1750 x 300 RCBC	MIKE 11
Richmond Road	1 / 600 x 300 RCBC	MIKE 11
Richmond Road	1 / 600 x 300 RCBC	MIKE 11
Richmond Road	4 / 600 x 300 RCBC	MIKE 11
Richmond Road	3 / 600 x 300 RCBC	MIKE 11
Richmond Road	3 / 1200 x 300 RCBC	MIKE 11
Richmond Road	5 / 600 x 300 RCBC	MIKE 11
Don Street	2 / 600 RCP	MIKE 11
Don Street	1 / 600 RCP	MIKE 11
Betzels Lane	8 / 1200 x 600 RCBC	MIKE 11
Betzels Lane	1 / 1200 x 300 RCBC	MIKE 11
Ascot Crescent	1 / 1200 x 300 RCBC	MIKE 11
Flemington Road	1 / 1200 x 450 RCBC	MIKE 11
Flemington Road	3 / 1200 x 400 RCBC	MIKE 11

Location	Configuration	Model Representation
Santa Barbara Parade (Intersection with Brisbane St)	1 / 3600 x 1050 RCBC	MIKE 11
Dalrymple Street (Intersection with Brisbane St)	1 / 3600 x 1050 RCBC	MIKE 11
Soldiers Road	2 / 600 x 300 RCBC	MIKE 11
George Street (Intersection with Brisbane St)	1 / 3500 x 1100 RCBC	MIKE 11
Leichhardt Street (Intersection with Williams St)	2 / 1200 x 450 RCBC	MIKE 11
Duke Street	4 / 1200 x 450 RCBC	MIKE 11
Murray Avenue	1 / 1200 x 300 RCBC	MIKE 11
Gillies Street (Intersection with Don St)	2 / 600 x 300 RCBC	MIKE 11
George Street (Eastern side of Intersection with Sinclair St)	1 / 1700 x 300 RCBC	MIKE 11
Herbert Street (Northern side of Intersection with Livingstone St)	2 / 600 x 300 RCBC	MIKE 11
Reynolds Street	5 / 1200 x 300 RCBC	MIKE 11
Brisbane Street	2 / 450 RCP	MIKE 11
Soldiers Road	1 / 2000 x 600 RCBC	MIKE 11
West Street (Intersection with Richmond Rd)	2 / 1200 x 600 RCBC	MIKE 11
Soliders Road (Intersection with Hillview Rd)	2 / 600 x 300 RCBC	MIKE 11
Argyle Park Road (Intersection with Suthers St)	2 / 1200 x 300 RCBC	MIKE 11
Mullers Lane	1 / 450 RCP	MIKE 11
Blue Water Parade	2 / 600 x 300 RCBC	MIKE 11
Hay Street	2 / 1200 x 300 RCBC	MIKE 11
Queens Road	1 / 375 RCP	MIKE 11
Kings Beach Road	6 / 190 RCP	MIKE 11
Queens Road	2 / 525 RCP	MIKE 11
Hay Street	1 / 375 RCP	MIKE 11
Railway Street	2 / 1200 x 300 RCBC	MIKE 11
Station Street	2 / 1200 x 300 RCBC	MIKE 11
Don Street (Intersection with Belgravia Rd)	1 / 600 x 300 RCBC	MIKE 11
Reynolds Street (Intersection with Leichhardt Lane)	1 / 1200 x 550 RCBC	MIKE 11
Don Street (Intersection with Leichhardt Lane)	2 / 1200 x 300 RCBC	MIKE 11
Powell Street (Western side of Intersection with Leichhardt St)	2 / 1200 x 450 RCBC	MIKE 11
Leichhardt Street (Intersection with Dalrymple St)	1 / 1200 x 450 RCBC	MIKE 11
Soldiers Road (Intersection with Brisbane St)	2 / 900 RCP	MIKE 11
Johnston Street	1 / 1800 x 500 RCBC	MIKE 11
Johnston Street (Intersection with Arthur St)	1 / 1800 x 530 RCBC	MIKE 11
Parallel Don Street	2 / 3100 x 600 RCBC	MIKE 11

Location	Configuration	Model Representation
Pantall Street	2 / 3100 x 650 RCBC	MIKE 11
Kent Street	2 / 3100 x 600 RCBC	MIKE 11
Leichhardt Street (Intersection with Reynolds St)	1 / 3000 x 1230 RCBC	MIKE 11
Reynolds Street (Intersection with Leichhardt St)	2 / 1200 x 900 RCBC	MIKE 11
Gordon Street (Intersection with Leichhardt St)	1 / 600 x 400 RCBC	MIKE 11
Gordon Street (Intersection with Leichhardt St)	1 / 900 x 400 RCBC	MIKE 11
Powell Street (Eastern side of Intersection with Leichhardt St)	2 / 600 x 300 RCBC	MIKE 11
Williams Street (Intersection with Leichhardt St)	2 / 1550 x 650 RCBC	MIKE 11
George Street (Intersection with Leichhardt St)	2 / 1800 x 600 RCBC	MIKE 11
Thomas Street	4 / 2000 x 1550 RCBC	MIKE 11
Sinclair Street	3 / 1600 x 400 RCBC	MIKE 11
Blue Water Parade	1 / 525 RCP	MIKE 11
Banyan Drive	1 / 750 RCP	MIKE 11
Queens Road (Intersection with Conserdynes Rd)	1 / 1400 x 450 RCBC	MIKE 11
Parallel Conserdynes Road	1 / 1200 x 600 RCBC	MIKE 11
Golf Links Road	2 / 2000 x 1150 RCBC	MIKE 11
Wests Lane (Intersection with North Ct)	4 / 1800 x 700 RCBC	MIKE 11
Tollington Road	2 / 3100 x 900 RCBC	MIKE 11
Argyle Park Road (Intersection with Queens St)	2 / 3200 x 500 RCBC	MIKE 11
Seabreeze Estate	4 / 250 RCP	MIKE 11
Avoca Road	1 / 600 x 300 RCBC	MIKE 11
Avoca Road	3 / 375 RCP	MIKE 11
Queens Road (Intersection with Barton St)	2 / 375 RCP	MIKE 11
Queens Road	1 / 450 RCP	MIKE 11
Soldiers Road	1 / 600 RCP	MIKE 11
Argyle Park Road (Intersection with Mullers Ln)	1 / 1200 x 600 RCBC	MIKE 11
Jilletts Road	1 / 1200 x 600 RCBC	MIKE 11
Don Street	4 / 3600 x 1550 RCBC	MIKE 11
Dalrymple Street	3 / 1900 x 650 RCBC	MIKE 11
Rail Loop	4 / 1630 RCP	MIKE 11
Don Street	3 / 2730 x 1540 RCBC	MIKE 11
Rail near Norris Street	1 / 375 RCP	MIKE 11
Poole Street (Intersection with Leichhardt St)	1 / 375 RCP	MIKE 11
Poole Street (Intersection with Leichhardt St)	1 / 375 RCP	MIKE 11
Open Channel	1 / 450 RCP	MIKE 11
Golf Course	3 / 2400 x 600 RCBC	MIKE 11
Golf Course Access Raod	1 / 450 x 0 RCP	MIKE 11

Location	Configuration	Model Representation
Bootooloo Road	3 / 2100 x 900 RCBC	MIKE 11
Rose Bay Road	1 / 600 RCP	MIKE 11
Bruce Highway	3 / 2130 x 2130 RCBC	MIKE 11
Bruce Highway	3 / 2130 x 1200 RCBC	MIKE 11
Bruce Highway-Don Street	2 / 900 x 750 RCBC	MIKE 11

Appendix B

MIKE URBAN Model Data

Appendix B MIKE URBAN Model Data

MIKE URBAN Nodes

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
Out_1	Headwall	2.57	3.181			
Out_3	Headwall	2.75	3.09			
Out_4	Headwall	3.08	3.898			
Out_10	Headwall	2.21	3.132			
Out_11	Headwall	3.24	3.77			
Out_15	Headwall	1.75	2.432			
Out_17	Headwall	1.28	3.29			
Out_23	Headwall	3.28	3.537			
Out_25	Headwall	6.91	7.173			
Out_26	Headwall	1.72	2.714			
Out_35	Headwall	2.16	2.402			
Out_36	Headwall	2.99	3.016			
Out_39	Headwall	2.91	3.421			
Out_55	Headwall	4.77	5.844			
Out_57	Headwall	4.49	5.152			
Out_74	Headwall	2.5	3.363			
Out_80	Headwall	1.81	3.662			
Out_82	Headwall	1.81	3.684			
Out_89	Headwall	1.25	2.427			
Out_92	Headwall	1.79	2.169			
Out_96	Headwall	2.04	2.34			
Out_101	Headwall	2.45	2.612			
Out_114	Headwall	2.58	2.81			
Out_117	Headwall	0	1.078			
Out_156	Headwall	2.24	2.438			
Out_271	Headwall	8.2	8.584			
Out_273	Headwall	8.28	8.7			
Out_283	Headwall	8.32	9.04			
Out_288	Headwall	2.22	3.279			
Out_314	Headwall	1.17	1.918			
Out_422	Headwall	12.94	13.079			
Out_430	Headwall	2.42	2.559			

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
Out_435	Headwall	2.09	2.546			
Out_438	Headwall	2.43	2.52			
Out_161	Headwall	1.64	1.708			
Out_163	Headwall	1.99	2.471			
Out_166	Headwall	3.18	3.468			
Out_167	Headwall	2.07	2.6			
Out_176	Headwall	6.35	6.488			
Out_179	Headwall	2.98	3.024			
Out_194	Headwall	1.6	2.105			
Out_196	Headwall	1.39	2.126			
Out_212	Headwall	1.69	1.903			
Out_229	Headwall	1.11	1.894			
Out_231	Headwall	1.26	2.52			
Out_235	Headwall	1.5	1.66			
Out_236	Headwall	1.97	2.184			
Out_256	Headwall	1.15	1.515			
Out_343	Headwall	2.48	3.049			
Out_344	Headwall	2.48	3.319			
Out_360	Headwall	8.48	8.613			
Out_366	Headwall	2.42	2.474			
Out_388	Headwall	2.75	3.07			
Out_404	Headwall	5.75	6.426			
Out_411	Headwall	3.72	4.002			
Out_445	Headwall	0.89	0.991			
Out_447	Headwall	0.75	0.9			
Out_454	Headwall	0.83	1.441			
Out_456	Headwall	1	1.119			
Out_475	Headwall	1.76	1.964			
Out_483	Headwall	2.93	3.231			
Out_498	Headwall	2.06	2.705			
Out_512	Headwall	6.08	6.305			
Out_518	Headwall	12.73	13.009			
Out_524	Headwall	9.12	9.379			
Out_531	Headwall	3.8	4.212			
Out_537	Headwall	3.8	4.011			
Out_542	Headwall	2.41	3.25			
Out_547	Headwall	4.67	5.226			
Out_554	Headwall	10.03	10.268			
Out_667	Headwall	1.64	2.128			

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
Out_670	Headwall	0.38	1.221			
Out_678	Headwall	1.71	2.118			
Out_682	Headwall	2.85	3.177			
Out_691	Headwall	2.67	2.971			
Out_694	Headwall	2.87	3.464			
Out_719	Headwall	1.05	1.754			
Out_561	Headwall	13.78	13.974			
Out_564	Headwall	3.67	3.701			
Out_568	Headwall	2.89	3.941			
Out_574	Headwall	5.85	5.936			
Out_576	Headwall	3.06	3.346			
Out_581	Headwall	3.9	4.888			
Out_589	Headwall	1.56	1.823			
Out_595	Headwall	4.68	5.157			
Out_612	Headwall	6.74	8.165			
Out_628	Headwall	7.38	7.448			
Out_635	Headwall	11.58	11.653			
Out_641	Headwall	2.36	2.471			
Out_643	Headwall	2.36	3.014			
Out_650	Headwall	0.57	1.808			
Out_651	Headwall	0.75	1.834			
HW_9	Headwall	3.5	3.917			
HW_8	Headwall	3.64	4.073			
HW_7	Headwall	3.54	4.123			
HW_6	Headwall	2.3	2.62			
HW_52	Headwall	2.17	2.329			
HW_51	Headwall	1.15	2.138			
HW_50	Headwall	3.15	3.6			
HW_5	Headwall	7.16	7.339			
HW_49	Headwall	3.28	3.6			
HW_48	Headwall	1.83	2.026			
HW_47	Headwall	1.91	2.465			
HW_46	Headwall	1.9	2.116			
HW_45	Headwall	2.45	2.663			
HW_44	Headwall	11.98	12.253			
HW_43	Headwall	12.72	13.1			
HW_42	Headwall	14.03	14.429			
HW_41	Headwall	1.65	1.823			
HW_40	Headwall	1.72	2.083			
HW_4	Headwall	2.31	2.593			
HW_39	Headwall	5.41	5.75			
HW_38	Headwall	4.58	4.876			
HW_37	Headwall	4.56	4.864			

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
HW_36	Headwall	4.68	4.947			
HW_35	Headwall	4.14	4.384			
HW_34	Headwall	10.1	10.512			
HW_33	Headwall	9.97	10.441			
HW_32	Headwall	9.72	9.926			
HW_31	Headwall	13.9	14.254			
HW_30	Headwall	13.62	13.83			
HW_3	Headwall	3.64	3.827			
HW_29	Headwall	12.99	13.259			
HW_28	Headwall	6.56	6.966			
HW_27	Headwall	6.83	7.095			
HW_26	Headwall	6.27	6.617			
HW_25	Headwall	6.18	6.572			
HW_24	Headwall	6.62	6.768			
HW_23	Headwall	6.5	7.044			
HW_22	Headwall	3.41	3.759			
HW_21	Headwall	1.85	2.176			
HW_20	Headwall	2	2.36			
HW_2	Headwall	3.58	3.684			
HW_19	Headwall	1.86	2.357			
HW_18	Headwall	2.16	2.428			
HW_17	Headwall	2.54	2.548			
HW_16	Headwall	2.49	2.83			
HW_15	Headwall	2.7	2.778			
HW_14	Headwall	27.29	27.65			
HW_13	Headwall	14.02	14.174			
HW_12	Headwall	5.28	5.922			
HW_11	Headwall	20.97	21.15			
HW_10	Headwall	6.37	6.96			
HW_1	Headwall	3.6	3.82			
HW_0	Headwall	3.1	3.38			
Out_564c	Headwall	3.7	3.701			
Out_564b	Headwall	3.7	3.701			
Out_39b	Headwall	2.91	3.421			
Out_388a	Headwall	2.75	3.07			
Out_288a	Headwall	2.22	3.279			
Out_283a	Headwall	8.32	9.04			
Out_26a	Headwall	1.72	2.714			
Out_25a	Headwall	6.91	7.173			
Out_179a	Headwall	2.98	3.024			
Out_166a	Headwall	3.18	3.468			
HW_5a	Headwall	7.16	7.339			
HW_50a	Headwall	3.15	3.6			

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
HW_48a	Headwall	1.83	2.026			
HW_41a	Headwall	1.65	1.823			
HW_39a	Headwall	5.41	5.75			
HW_27a	Headwall	6.83	7.095			
HW_23a	Headwall	6.5	7.044			
HW_17a	Headwall	2.54	2.548			
Out_92a	Headwall	1.79	2.169			
Out_682a	Headwall	2.85	3.177			
Out_678a	Headwall	1.71	2.118			
Out_635a	Headwall	11.58	11.653			
Out_612a	Headwall	6.74	8.165			
Out_595a	Headwall	4.68	5.157			
Out_589a	Headwall	1.56	1.823			
Out_581a	Headwall	3.9	4.888			
Out_564a	Headwall	3.7	3.701			
Out_554a	Headwall	10.03	10.268			
Out_542a	Headwall	2.41	3.25			
Out_512a	Headwall	6.08	6.305			
Out_498a	Headwall	2.06	2.705			
Out_483a	Headwall	2.93	3.231			
Out_438a	Headwall	2.43	2.52			
Out_430a	Headwall	2.42	2.559			
Out_422a	Headwall	12.94	13.079			
Out_39a	Headwall	2.91	3.421			
In_9a	Manhole	2.02	3.821	1.2	0.21	0.063
In_99a	Manhole	2.47	3.447	0.6	0.4	0.12
In_98a	Manhole	2.55	3.538	0.6	0.3913	0.1174
In_97a	Manhole	2.3	3.404	1.65	0.2413	0.0724
In_96a	Manhole	2.26	3.266	1.95	0.8944	0.2684
Pit_21	Manhole	3.55	3.812	0.6		
Pit_22	Manhole	3.31	3.766	0.6		
Pit_30	Manhole	2.16	3.027	1.65		
Pit_34	Manhole	2.16	3.178	0.6		
In_95a	Manhole	2.26	3.246	0.6	0.9034	0.2711
In_94a	Manhole	2.09	3.184	1.95	0.3975	0.1193
Pit_44	Manhole	4.94	6.549	0.6		
Pit_46	Manhole	5.67	7.373	0.6		
Pit_54	Manhole	4.99	6.949	0.9		
In_93a	Manhole	2.07	3.177	1.95	0.4	0.12
In_92a	Manhole	3.16	4.186	0.6	0.7628	0.2289
In_91a	Manhole	2.02	3.257	2.75	1.69	0.507
In_90a	Manhole	1.92	3.406	1.2	1.125	0.3375
In_8a	Manhole	3.26	3.807	1.05	0.396	0.2376

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_89a	Manhole	1.29	3.479	1.2	0.225	0.0675
Pit_69	Manhole	4.08	5.472	1.2		
Pit_70	Manhole	4.03	5.224	1.2		
Pit_75	Manhole	4.04	4.283	1.65		
Pit_78	Manhole	2.12	3.914	1.5		
In_88a	Manhole	2.81	3.33	0.9	0.175	0.07
In_87a	Manhole	2.93	3.242	0.9	0.39	0.117
In_86a	Manhole	0.43	2.884	1.95	0.25	0.075
In_85a	Manhole	2.12	2.764	0.9	0.175	0.0875
In_84a	Manhole	2.33	3.741	0.6	0.7099	0.213
In_83a	Manhole	3.02	3.631	0.6	0.12	0.036
Pit_81	Manhole	2.42	3.514	1.5		
Pit_83	Manhole	3.26	5.163	1.65		
Pit_84	Manhole	2.99	4.811	1.35		
In_82a	Manhole	2.91	3.433	0.6	0.12	0.036
In_81a	Manhole	0.37	2.962	1.95	0.25	0.075
In_80a	Manhole	0.59	3.085	1.95	0.25	0.075
In_7a	Manhole	3.26	3.758	1.05	0.256	0.0768
In_79a	Manhole	0.15	3.052	1.95	0.395	0.1185
In_78a	Manhole	0.69	3.24	1.95	0.25	0.075
In_77a	Manhole	2.78	3.679	0.6	0.23	0.069
In_76a	Manhole	2.88	3.684	0.6	0.226	0.0678
In_75a	Manhole	2.3	3.443	1.05	0.223	0.0669
In_74a	Manhole	2.37	3.482	0.6	0.224	0.0672
In_73a	Manhole	2.03	3.405	1.05	0.229	0.0687
Pit_120	Manhole	0.34	3.063	1.95		
Pit_121	Manhole	0.28	3.222	1.95		
Pit_122	Manhole	0.25	3.293	1.95		
Pit_123	Manhole	0.21	3.191	1.95		
Pit_133	Manhole	1.88	3.941	1.2		
Pit_134	Manhole	1.73	3.876	1.2		
Pit_135	Manhole	1.63	3.786	1.2		
Pit_136	Manhole	1.39	3.628	1.2		
Pit_137	Manhole	1.1	3.531	1.2		
Pit_138	Manhole	0.86	3.526	1.95		
Pit_139	Manhole	0.79	3.728	1.95		
In_72a	Manhole	1.97	3.456	0.9	0.231	0.0693
Pit_143	Manhole	2.12	3.25	1.95		
Pit_148	Manhole	2.29	3.556	1.65		
Pit_152	Manhole	2.44	3.135	0.9		
Pit_159	Manhole	3.07	4.132	0.6		
In_71a	Manhole	2.26	3.575	0.6	0.23	0.069
In_70a	Manhole	1.75	3.644	0.9	0.229	0.0687

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_6a	Manhole	2.17	3.215	1.05	0.24	0.192
In_69a	Manhole	1.49	3.261	1.05	0.226	0.0678
In_68a	Manhole	2.24	3.265	0.6	0.218	0.0654
In_67a	Manhole	1.4	3.118	1.05	0.233	0.0699
Pit_276	Manhole	9.25	10.402	1.2		
In_66a	Manhole	1.49	2.771	1.2	0.405	0.405
In_65a	Manhole	2.42	3.45	0.6	0.336	0.1008
In_64a	Manhole	3.2	4.42	0.6	0.095	0.038
In_63a	Manhole	3.22	4.44	0.6	0.097	0.0291
In_62a	Manhole	2.28	2.95	1.2	0.25	0.075
In_61a	Manhole	2.16	2.988	0.9	0.25	0.075
In_60a	Manhole	1.75	3.13	1.5	0.14	0.042
In_5a	Manhole	2.17	3.305	1.05	0.225	0.135
Pit_281	Manhole	8.5	9.606	3.5		
Pit_282	Manhole	8.33	9.19	3.5		
Pit_284	Manhole	9.03	10.084	1.65		
Pit_285	Manhole	8.89	10.039	1.65		
Pit_291	Manhole	2.23	4.08	0.9		
Pit_292	Manhole	2.48	4.498	0.9		
Pit_295	Manhole	2.29	4.167	1.8		
In_59a	Manhole	1.7	3.132	1.5	0.14	0.042
In_58a	Manhole	2.02	2.906	0.6	0.14	0.042
In_57a	Manhole	2.06	2.871	0.6	0.14	0.042
Pit_303	Manhole	3.43	4.228	0.6		
Pit_304	Manhole	3.36	4.378	0.6		
In_56a	Manhole	2.39	2.973	1.2	0.25	0.075
In_55a	Manhole	2.55	3.19	1.2	0.25	0.075
In_54a	Manhole	2.49	3.124	1.2	0.25	0.075
In_53a	Manhole	3.17	3.689	0.6	0.12	0.036
In_52a	Manhole	2.71	3.558	1.5	0.444	0.1332
In_51a	Manhole	2.3	3.784	0.9	0.45	0.135
In_514a	Manhole	1.22	2.431	1.5	0.35	0.105
Pit_420	Manhole	11.69	12.615	0.9		
Pit_421	Manhole	13.61	14.98	3.1		
Pit_426	Manhole	2.07	2.925	2.1		
Pit_431	Manhole	2.45	3.043	1.8		
Pit_432	Manhole	2.4	2.952	1.8		
Pit_434	Manhole	2.13	2.615	2.1		
In_513a	Manhole	1.72	2.663	0.6	0.7729	0.2319
In_511a	Manhole	1.58	2.813	0.9	0.7673	0.2302
Pit_162	Manhole	1.96	3.478	2.75		
Pit_169	Manhole	7.94	9.679	0.6		
Pit_172	Manhole	6.65	7.948	0.6		

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
Pit_174	Manhole	7.9	9.495	0.6		
In_510a	Manhole	1.62	2.834	0.9	0.7639	0.2292
In_50a	Manhole	2.46	3.502	0.9	0.423	0.1269
Pit_181	Manhole	3.15	4.411	4.7		
Pit_188	Manhole	2.83	4.311	0.6		
Pit_192	Manhole	3.64	4.696	0.6		
Pit_195	Manhole	1.78	3.412	0.9		
Pit_197	Manhole	1.74	3.316	1.65		
Pit_198	Manhole	3.42	4.307	0.6		
In_509a	Manhole	1.75	2.903	1.65	0.5	0.15
In_508a	Manhole	1.85	2.907	1.65	0.5	0.15
In_507a	Manhole	1.99	3.03	1.65	0.2488	0.0747
In_506a	Manhole	2.12	3.383	1.05	0.7661	0.2299
Pit_200	Manhole	2.12	3.597	1.65		
Pit_204	Manhole	2.78	4.08	0.6		
Pit_211	Manhole	1.72	3.336	0.6		
Pit_217	Manhole	2	2.968	0.6		
Pit_218	Manhole	1.44	3.158	1.95		
Pit_219	Manhole	1.67	3.537	1.2		
In_505a	Manhole	2.13	3.312	0.6	0.765	0.2295
In_504a	Manhole	2.42	3.897	0.6	0.7639	0.2292
In_503a	Manhole	2.61	3.855	0.6	0.7639	0.2292
In_502a	Manhole	3.21	5.04	0.6	0.7628	0.2289
Pit_223	Manhole	1.73	3.691	0.6		
Pit_228	Manhole	1.28	2.845	1.8		
Pit_238	Manhole	1.96	2.597	0.9		
In_501a	Manhole	3.65	5.057	0.6	0.7661	0.2299
In_500a	Manhole	3.96	5.117	0.9	0.25	0.075
In_4a	Manhole	2.74	3.736	1.05	0.434	0.1302
In_49a	Manhole	4.46	6.217	1.05	0.7673	0.2302
Pit_254	Manhole	1.23	2.631	1.95		
In_499a	Manhole	3.96	5.243	0.6	0.765	0.2295
In_498a	Manhole	4.01	5.199	0.6	0.7639	0.2292
In_497a	Manhole	4.33	5.473	0.9	0.2475	0.0743
In_496a	Manhole	4.14	5.956	0.6	0.7414	0.2225
In_495a	Manhole	4.36	5.922	0.6	0.7661	0.2299
In_494a	Manhole	4.29	5.413	0.6	0.2525	0.0758
In_493a	Manhole	4.37	5.404	0.9	0.5	0.2
In_492a	Manhole	4.29	5.414	0.6	0.4	0.12
In_491a	Manhole	4.71	5.857	0.6	0.7695	0.2309
Pit_323	Manhole	4.42	5.349	1.2		
In_490a	Manhole	4.95	5.915	0.6	0.765	0.2295
In_48a	Manhole	5.06	7.493	1.65	0.3	0.09

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_489a	Manhole	5.42	6.972	0.6	0.7673	0.2302
In_488a	Manhole	5.1	6.533	0.75	0.2488	0.0747
In_487a	Manhole	5.98	7.106	0.6	0.25	0.075
In_486a	Manhole	5.18	6.531	0.75	0.2463	0.0739
In_484a	Manhole	1.37	3.792	1.5	0.7616	0.2285
In_483a	Manhole	1.23	3.448	1.5	0.5	0.35
In_482a	Manhole	2.61	3.957	0.6	0.15	0.045
Pit_341	Manhole	7.49	8.834	0.75		
Pit_352	Manhole	2.82	4.126	1.65		
Pit_354	Manhole	8.66	9.759	0.75		
Pit_356	Manhole	8.36	9.636	0.75		
In_481a	Manhole	2.68	4.028	0.6	0.2538	0.0762
In_480a	Manhole	3.07	3.906	0.6	0.2475	0.0743
In_47a	Manhole	6.81	7.391	1.65	0.7684	0.2306
In_479a	Manhole	3.1	3.993	0.6	0.2563	0.0769
In_478a	Manhole	3.12	3.85	0.6	0.75	0.225
Pit_372	Manhole	2.48	3.786	1.65		
In_477a	Manhole	2.59	3.954	0.6	0.7616	0.2285
In_476a	Manhole	3.41	4.013	0.6	0.7695	0.2309
In_475a	Manhole	3	3.584	0.6	0.765	0.2295
In_474a	Manhole	2.71	3.782	0.6	0.2538	0.0762
In_473a	Manhole	2.71	3.843	0.6	0.2388	0.0717
In_472a	Manhole	3.46	4.163	0.6	0.354	0.1416
In_471a	Manhole	2.75	3.922	0.6	0.2525	0.0758
Pit_387	Manhole	2.74	3.526	1.2		
Pit_391	Manhole	18.18	19.778	0.6		
Pit_392	Manhole	15.03	16.931	0.6		
In_470a	Manhole	2.87	4.082	0.9	0.2563	0.0769
In_46a	Manhole	4.28	4.973	0.6	0.097	0.0485
In_469a	Manhole	2.98	4.112	0.6	0.7144	0.2144
In_468a	Manhole	2.98	4.084	0.75	0.7121	0.2137
In_467a	Manhole	3.06	4.12	0.6	0.2513	0.0754
In_466a	Manhole	2.72	4.315	0.9	0.7211	0.2164
In_465a	Manhole	2.82	4.292	0.9	0.7155	0.2147
Pit_405	Manhole	5.86	6.632	1.65		
Pit_406	Manhole	11.04	11.971	1.65		
Pit_410	Manhole	3.89	5.994	2.45		
Pit_414	Manhole	21.98	23.039	0.6		
Pit_418	Manhole	13.29	14.336	0.9		
In_464a	Manhole	2.87	4.389	0.9	0.7166	0.215
In_463a	Manhole	2.95	4.429	0.6	0.72	0.216
In_462a	Manhole	3.04	4.54	0.75	0.7166	0.215
In_461a	Manhole	3.1	4.597	0.75	0.7166	0.215

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_460a	Manhole	3.1	3.676	2.85	0.12	0.036
Pit_458	Manhole	1.04	2.283	0.6		
In_45a	Manhole	4.15	5.351	0.9	0.101	0.0303
In_457a	Manhole	3.2	3.826	0.6	0.272	0.0816
In_453a	Manhole	1.62	3.243	1.95	0.2588	0.0777
In_452a	Manhole	1.67	3.336	0.6	0.3	0.09
In_451a	Manhole	1.76	2.954	0.6	0.7639	0.2292
In_450a	Manhole	2.13	3.049	0.6	0.7808	0.2343
Pit_473	Manhole	1.84	2.488	2.2		
Pit_474	Manhole	1.83	2.51	2.2		
Pit_476	Manhole	1.87	2.577	1.65		
Pit_477	Manhole	1.78	2.427	2.2		
In_44a	Manhole	3.83	5.138	1.05	0.3	0.09
In_449a	Manhole	2.15	3.127	0.6	0.7819	0.2346
In_448a	Manhole	1.99	3.364	0.6	0.3	0.09
In_447a	Manhole	1.78	3.247	1.65	0.27	0.081
Pit_481	Manhole	3.34	3.899	1.65		
Pit_482	Manhole	2.98	3.612	1.65		
Pit_492	Manhole	4.09	5.203	0.75		
Pit_495	Manhole	3.68	4.785	3.1		
Pit_496	Manhole	3.4	4.068	1.65		
Pit_497	Manhole	2.83	3.21	1.95		
In_446a	Manhole	1.98	3.389	0.6	0.7763	0.2329
In_445a	Manhole	2.16	3.36	0.6	0.3	0.09
In_444a	Manhole	1.78	2.961	0.6	0.7988	0.2397
Pit_508	Manhole	6.3	6.818	1.65		
Pit_510	Manhole	6.45	7.157	1.65		
Pit_511	Manhole	6.07	6.572	1.65		
Pit_516	Manhole	13.42	14.053	0.9		
Pit_517	Manhole	12.75	13.171	0.9		
In_443a	Manhole	1.62	2.826	0.75	0.3	0.09
In_442a	Manhole	1.73	2.808	0.75	0.3	0.09
In_441a	Manhole	0.98	2.624	1.05	0.3	0.09
In_440a	Manhole	1.2	2.525	1.05	0.3	0.09
Pit_522	Manhole	9.83	10.356	0.9		
Pit_523	Manhole	9.29	9.917	0.9		
Pit_530	Manhole	4.07	4.967	1.95		
Pit_533	Manhole	4.47	5.118	2.35		
Pit_535	Manhole	5.06	5.503	2.35		
Pit_536	Manhole	3.83	4.461	1.95		
In_439a	Manhole	0.96	2.367	1.5	0.2525	0.0758
In_438a	Manhole	1.08	2.38	1.05	0.255	0.0765
Pit_540	Manhole	4.63	5.388	0.9		

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
Pit_545	Manhole	4.61	5.415	0.9		
Pit_549	Manhole	6.49	7.723	0.9		
Pit_551	Manhole	6.19	7.421	0.9		
Pit_553	Manhole	10.04	11.617	3.1		
Pit_557	Manhole	10.3	12.443	1.05		
In_437a	Manhole	0.61	2.469	0.6	0.7706	0.2312
In_436a	Manhole	1.11	2.522	0.6	0.7774	0.2333
In_435a	Manhole	0.91	2.558	0.6	0.7886	0.2366
Pit_666	Manhole	1.68	3.11	0.6		
Pit_669	Manhole	0.89	3.316	1.95		
Pit_672	Manhole	1.29	3.592	1.95		
Pit_676	Manhole	1.74	2.718	1.65		
Pit_677	Manhole	1.7	2.428	1.65		
In_434a	Manhole	1.06	2.403	0.6	0.3	0.09
In_433a	Manhole	1.11	2.142	0.6	0.2625	0.0788
In_432a	Manhole	1.27	2.175	0.6	0.2563	0.0769
Pit_681	Manhole	2.91	3.48	5.2		
Pit_698	Manhole	2.7	4.007	0.6		
In_431a	Manhole	2.37	3.151	0.9	0.24	0.072
In_42a	Manhole	4.19	5.139	0.6	0.24	0.072
In_427a	Manhole	12.96	13.418	0.9	0.2	0.06
In_425a	Manhole	7.97	9.317	1.65	0.2	0.06
In_424a	Manhole	9.07	10.303	0.6	0.765	0.2295
In_423a	Manhole	8.05	9.432	0.6	0.484	0.1452
Pit_706	Manhole	3.43	4.244	0.6		
Pit_707	Manhole	3.41	4.268	0.6		
Pit_710	Manhole	3.05	4.051	0.6		
Pit_713	Manhole	2.31	4.125	0.9		
Pit_714	Manhole	2.56	4.007	0.6		
Pit_715	Manhole	2.34	4.092	0.6		
Pit_716	Manhole	2.26	4.18	1.5		
Pit_717	Manhole	1.77	4.06	1.5		
Pit_718	Manhole	1.75	3.938	1.5		
In_422a	Manhole	8.69	9.684	0.6	0.32	0.096
In_421a	Manhole	9.23	11.073	0.6	0.495	0.1485
Pit_721	Manhole	1.07	4.169	1.5		
Pit_722	Manhole	1.37	4.023	1.5		
Pit_731	Manhole	5.4	7.389	0.9		
Pit_732	Manhole	4.59	6.144	0.9		
In_420a	Manhole	4.63	5.865	0.6	0.7751	0.2326
In_41a	Manhole	4.46	5.654	0.9	0.254	0.0762
In_419a	Manhole	5.69	7.264	0.6	0.7628	0.2289
In_418a	Manhole	5	6.821	0.6	0.2475	0.0743

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_417a	Manhole	3.85	4.763	3.1	0.2575	0.0773
In_416a	Manhole	4.11	5.09	3.1	0.2575	0.1288
In_415a	Manhole	4.13	5.235	1.2	0.7774	0.3887
Pit_560	Manhole	14.16	15.348	1.65		
Pit_570	Manhole	4.29	5.014	0.9		
Pit_573	Manhole	7.18	8.039	1.65		
In_414a	Manhole	5.06	6.816	0.6	0.765	0.2295
In_413a	Manhole	12.35	14.061	0.9	0.7763	0.2329
In_412a	Manhole	14.13	15.853	0.6	0.7808	0.2343
Pit_586	Manhole	4.96	6.844	0.6		
Pit_592	Manhole	1.61	2.339	3.1		
Pit_594	Manhole	4.82	6.113	3.1		
Pit_597	Manhole	4.92	6.008	3.1		
Pit_599	Manhole	21.18	22.573	0.6		
In_411a	Manhole	6.91	8.318	1.5	0.3388	0.1017
In_410a	Manhole	7.66	9.117	1.05	0.8539	0.2562
In_40a	Manhole	4.92	6.129	0.6	0.233	0.0699
In_409a	Manhole	7.75	9.175	0.6	0.278	0.0834
Pit_607	Manhole	9.41	11.209	1.05		
Pit_608	Manhole	9.15	10.464	1.5		
Pit_611	Manhole	6.71	8.212	2.75		
In_408a	Manhole	16.14	17.736	0.75	0.774	0.2322
In_407a	Manhole	18.23	19.713	0.75	0.7796	0.2339
In_406a	Manhole	12.06	13.919	0.75	0.7819	0.2346
In_405a	Manhole	10.98	12.438	1.05	0.7785	0.2336
In_404a	Manhole	7.13	8.699	1.05	0.15	0.045
In_403a	Manhole	5.04	5.981	3.1	1.5	0.45
Pit_625	Manhole	8.04	9.497	0.6		
Pit_627	Manhole	7.38	8.025	1.65		
Pit_630	Manhole	7.87	9.316	1.65		
Pit_634	Manhole	11.58	11.653	2.75		
Pit_637	Manhole	11.78	12.44	0.9		
In_402a	Manhole	5.02	5.946	0.6	0.219	0.0657
In_400a	Manhole	1.66	2.148	1.2	0.085	0.0595
In_3a	Manhole	3.07	3.773	0.9	0.13	0.039
Pit_640	Manhole	2.38	3.237	0.9		
Pit_642	Manhole	2.33	3.207	0.9		
In_39a	Manhole	5.06	6.174	0.6	0.234	0.0702
In_391a	Manhole	4	4.61	0.9	0.175	0.0525
In_390a	Manhole	4.08	4.474	0.9	0.175	0.0525
In_38a	Manhole	4.62	5.885	0.75	0.232	0.0696
In_389a	Manhole	3.23	3.737	1.2	0.175	0.0525
Pit_743	Manhole	3.49	4.909	0.9		

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Pit_744	Manhole	3.05	4.534	0.9		
Pit_748	Manhole	2.83	4.44	0.9		
Pit_751	Manhole	2.42	3.682	0.9		
Pit_752	Manhole	2.02	3.218	1.05		
Pit_757	Manhole	1.75	2.768	1.65		
Pit_759	Manhole	1.52	2.994	1.5		
In_388a	Manhole	7.27	7.974	0.9	0.7661	0.2299
In_387a	Manhole	7.35	8.122	0.9	0.7695	0.2309
In_386a	Manhole	4.49	5.038	0.9	0.3	0.09
Pit_763	Manhole	1.22	2.712	1.5		
In_385a	Manhole	2.89	3.945	1.65	0.21	0.063
In_384a	Manhole	4.45	4.932	0.9	0.3	0.09
In_383a	Manhole	4.31	4.936	0.6	0.15	0.045
In_382a	Manhole	3.69	4.488	3.1	0.465	0.1395
In_381a	Manhole	4.82	5.776	3.1	0.892	0.2676
In_380a	Manhole	14.93	16.267	0.9	0.496	0.1488
In_37a	Manhole	4.55	5.705	0.6	0.236	0.0708
In_379a	Manhole	14.55	16.175	0.9	0.503	0.1509
In_378a	Manhole	10.48	12.431	1.05	0.498	0.1494
In_262a	Manhole	3.49	4.191	0.6	0.765	0.306
In_261a	Manhole	3.24	4.016	1.2	0.765	0.2295
In_260a	Manhole	3.04	3.599	1.2	0.2488	0.0747
In_25a	Manhole	3.12	3.929	1.8	0.7133	0.214
In_259a	Manhole	2.74	3.682	0.6	0.185	0.074
In_258a	Manhole	2.75	4.023	1.65	0.183	0.0549
In_257a	Manhole	2.9	4.26	0.6	0.19	0.057
In_256a	Manhole	2.87	4.082	0.75	0.103	0.0309
In_255a	Manhole	2.6	3.848	1.65	0.203	0.0609
In_254a	Manhole	2.86	3.773	0.6	0.208	0.0624
In_253a	Manhole	3.15	4.455	0.6	0.281	0.0843
In_252a	Manhole	2.96	4.037	0.6	0.101	0.0303
In_251a	Manhole	2.93	4.168	0.75	0.292	0.0876
In_250a	Manhole	3.14	4.216	0.6	0.194	0.0582
In_24a	Manhole	3.16	3.934	0.6	0.7144	0.2144
In_249a	Manhole	8.94	10.14	0.9	0.36	0.108
In_248a	Manhole	9.04	10.181	0.9	0.36	0.108
In_247a	Manhole	9.14	10.318	0.6	0.36	0.108
In_246a	Manhole	8.43	9.497	0.75	0.311	0.0933
In_245a	Manhole	8.6	9.538	0.9	0.05	0.015
In_244a	Manhole	4.29	5.872	1.8	0.637	0.1911
In_243a	Manhole	6.32	7.589	1.8	0.57	0.171
In_242a	Manhole	6.84	8.075	1.65	0.9686	0.2906
In_241a	Manhole	7.11	8.275	1.8	0.9878	0.2964

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In_240a	Manhole	3.99	4.808	0.75	0.7684	0.2306
In_23a	Manhole	3.08	3.829	1.8	0.5125	0.1538
In_239a	Manhole	8.56	9.608	0.6	0.7684	0.2306
In_238a	Manhole	4.89	5.905	0.6	0.227	0.0681
In_237a	Manhole	2.83	4.085	1.65	0.7684	0.2306
In_236a	Manhole	6.85	8.203	1.65	0.9664	0.29
In_235a	Manhole	8.15	9.533	1.05	0.356	0.1068
In_234a	Manhole	4.53	5.503	0.75	0.7706	0.2312
In_233a	Manhole	16.44	19.286	0.6	0.3	0.09
In_232a	Manhole	30.73	32.819	0.6	0.7841	0.2353
In_231a	Manhole	15.7	18.052	0.6	0.7639	0.2292
In_230a	Manhole	12.75	14.416	0.6	0.7661	0.2299
In_22a	Manhole	3.44	4.211	1.2	0.7628	0.2289
In_229a	Manhole	9.14	10.248	0.9	0.36	0.108
In_228a	Manhole	9.91	10.819	0.6	0.362	0.1086
In_227a	Manhole	7.59	8.657	0.6	0.364	0.1092
In_377a	Manhole	11.78	13.51	1.05	0.497	0.1491
In_376a	Manhole	11.17	12.923	0.6	0.48	0.144
In_375a	Manhole	6.98	7.517	0.9	0.765	0.2295
In_374a	Manhole	7.04	7.795	0.9	0.7605	0.2282
In_373a	Manhole	6.85	7.833	0.9	0.7673	0.2302
In_372a	Manhole	4.88	5.7	0.6	0.238	0.0714
In_371a	Manhole	4.88	5.313	0.9	0.222	0.0666
In_370a	Manhole	2.88	4.203	0.9	0.5563	0.1669
In_36a	Manhole	3.86	4.831	0.75	0.3	0.09
In_369a	Manhole	4.83	5.832	0.9	0.3	0.09
In_368a	Manhole	6.51	7.962	0.6	0.227	0.0681
In_365a	Manhole	4.6	5.268	2.35	2.64	0.792
In_361a	Manhole	5.09	5.505	1.2	0.7695	0.2309
In_35a	Manhole	4.75	6.213	1.05	0.5	0.15
In_34a	Manhole	5.18	6.543	0.9	0.2525	0.0758
In_348a	Manhole	2.46	2.981	1.95	0.073	0.0219
In_347a	Manhole	2.66	3.137	1.95	0.215	0.0645
In_346a	Manhole	2.09	2.81	3.9	0.223	0.0669
In_345a	Manhole	2.21	2.856	1.95	0.224	0.0672
In_344a	Manhole	4	4.659	1.2	1.6504	0.4952
In_343a	Manhole	3.48	4.04	0.6	1.6414	0.4925
In_342a	Manhole	4.73	5.587	0.6	1.1059	0.3318
In_341a	Manhole	4.31	4.931	0.6	0.7718	0.2316
In_340a	Manhole	4.51	5.053	0.6	0.7661	0.2299
In_33a	Manhole	5.69	7.533	0.6	0.2513	0.0754
In_339a	Manhole	4.17	4.788	0.6	0.6446	0.1934
In_338a	Manhole	4.25	4.772	0.6	0.6334	0.1901

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In_337a	Manhole	4.12	4.68	0.6	0.6368	0.1911
In_336a	Manhole	4.34	4.946	0.6	0.7898	0.237
In_335a	Manhole	4.58	5.11	0.6	0.774	0.2322
In_333a	Manhole	3.39	3.874	1.65	0.9	0.27
In_332a	Manhole	3.01	3.48	1.65	0.27	0.081
In_32a	Manhole	6.45	8.163	0.6	0.765	0.2295
In_329a	Manhole	2.03	2.548	1.65	0.428	0.214
In_327a	Manhole	2.13	2.596	1.65	0.449	0.1796
In_326a	Manhole	1.07	2.215	1.2	0.7684	0.2306
In_325a	Manhole	1.15	2.191	1.2	0.2563	0.0769
In_324a	Manhole	1.3	2.599	0.6	0.7796	0.2339
In_323a	Manhole	1.6	2.498	0.6	0.7695	0.2309
In_322a	Manhole	4.09	4.981	0.6	0.125	0.0375
In_321a	Manhole	4.11	4.959	0.6	0.27	0.081
In_320a	Manhole	4.51	5.693	0.6	0.125	0.0375
In_31a	Manhole	6.37	7.531	0.6	0.2525	0.0758
In_319a	Manhole	1.01	2.225	0.6	0.7684	0.2306
In_318a	Manhole	1.08	2.115	1.2	0.2563	0.1538
In_317a	Manhole	0.98	2.1	1.65	0.2525	0.1263
In_316a	Manhole	0.98	2.091	1.65	0.2513	0.1508
In_315a	Manhole	1.1	2.075	1.65	0.2513	0.1257
In_314a	Manhole	1.18	2.145	0.9	0.3013	0.1808
In_313a	Manhole	1.23	2.112	0.9	0.3113	0.0934
In_312a	Manhole	1.21	2.269	0.6	0.7684	0.2306
In_30a	Manhole	6.75	7.929	0.6	0.765	0.2295
In_304a	Manhole	2.56	3.135	2.35	0.945	0.4725
In_303a	Manhole	2.76	3.773	0.75	0.079	0.0237
In_2a	Manhole	3.09	3.806	0.9	0.106	0.0318
In_29a	Manhole	7.13	8.066	0.6	0.7594	0.2279
In_298a	Manhole	2.27	2.864	0.6	0.269	0.0807
In_297a	Manhole	2.24	2.981	0.75	0.353	0.1765
In_296a	Manhole	2.17	2.862	0.75	0.078	0.0312
In_295a	Manhole	11.94	12.421	0.6	0.245	0.0735
In_294a	Manhole	11.59	12.326	1.65	0.49	0.147
In_293a	Manhole	14.36	15.407	0.9	0.7594	0.2279
In_292a	Manhole	13.68	14.682	0.9	0.307	0.0921
In_28a	Manhole	7.22	8.131	0.6	0.7639	0.2292
In_288a	Manhole	13.75	14.668	0.9	0.2175	0.0653
In_287a	Manhole	13.93	14.732	0.9	0.17	0.051
In_286a	Manhole	4.96	5.972	0.6	0.438	0.1314
In_285a	Manhole	5.32	6.205	0.6	0.217	0.0651
In_284a	Manhole	4.59	5.569	0.6	0.354	0.1062
In_283a	Manhole	4.91	5.649	0.6	0.359	0.1077

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In_282a	Manhole	4.44	5.502	0.6	0.215	0.0645
In_281a	Manhole	16.56	17.785	0.6	0.7774	0.2333
In_280a	Manhole	20.9	21.996	0.6	0.7943	0.2383
In_27a	Manhole	5.44	6.39	0.6	0.2463	0.0739
In_279a	Manhole	26.43	27.872	0.6	0.783	0.2349
In_278a	Manhole	13.64	14.802	0.9	0.4	0.12
In_277a	Manhole	14.07	15.145	0.9	0.8111	0.2434
In_276a	Manhole	15.18	16.14	0.6	0.18	0.054
In_273a	Manhole	2.77	3.564	1.2	0.216	0.0648
In_272a	Manhole	2.88	3.345	0.9	0.73	0.219
In_271a	Manhole	3.21	3.626	0.6	0.783	0.2349
In_270a	Manhole	2.96	3.826	0.9	0.192	0.0576
In_26a	Manhole	3.61	4.192	1.05	0.2525	0.1263
In_269a	Manhole	3.3	4.197	1.2	0.204	0.0612
In_268a	Manhole	3.37	3.964	0.9	0.6728	0.2019
In_267a	Manhole	3.45	4.104	0.6	0.6784	0.2036
In_266a	Manhole	3.1	3.806	0.9	0.6705	0.2012
In_265a	Manhole	3.16	3.809	0.6	0.6784	0.2036
In_264a	Manhole	3.66	4.182	0.6	0.2475	0.1485
In_263a	Manhole	4.02	4.659	1.05	0.3	0.09
In_226a	Manhole	35.42	37.125	0.6	0.7808	0.2343
In_225a	Manhole	8.48	8.72	0.9	0.23	0.069
In_224a	Manhole	8.73	9.324	0.9	0.14	0.042
In_223a	Manhole	12.31	13.499	0.75	0.2475	0.0743
In_222a	Manhole	9.18	10.452	0.6	0.245	0.0735
In_221a	Manhole	9.04	9.94	0.9	0.226	0.0678
In_220a	Manhole	7.5	8.689	0.75	0.1	0.03
In_21a	Manhole	3.02	3.603	1.2	0.2475	0.0743
In_219a	Manhole	4.66	5.341	1.2	0.7661	0.2299
In_218a	Manhole	4.49	5.231	0.9	0.2525	0.0758
In_217a	Manhole	1.58	3.165	0.6	0.7796	0.2339
In_216a	Manhole	1.98	3.196	0.6	0.7796	0.2339
In_215a	Manhole	1.52	3.013	0.6	0.3	0.09
In_214a	Manhole	1.57	3.019	0.6	0.3	0.09
In_213a	Manhole	1.18	2.782	1.2	0.2513	0.0754
In_212a	Manhole	1.25	2.697	1.05	0.2588	0.1035
In_211a	Manhole	1.44	2.725	1.05	0.2563	0.1025
In_210a	Manhole	1.53	3.271	0.75	0.7808	0.2343
In_20a	Manhole	2.24	2.791	0.6	0.196	0.0588
In_209a	Manhole	1.92	3.624	0.75	0.7661	0.2299
In_208a	Manhole	3.21	4.949	1.2	0.7673	0.2302
In_207a	Manhole	2.58	4.7	1.2	0.774	0.2322
In_206a	Manhole	4.09	5.169	0.6	0.7751	0.2326

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_205a	Manhole	3.74	4.844	0.6	0.2525	0.0758
In_204a	Manhole	4.56	5.373	1.2	0.2563	0.0769
In_203a	Manhole	1.72	2.781	0.9	0.2575	0.0773
In_201a	Manhole	3.25	4.046	0.9	0.225	0.0675
In_200a	Manhole	3.08	4.252	0.9	0.2525	0.0758
In_19a	Manhole	2.08	2.852	1.65	0.129	0.0387
In_199a	Manhole	3.25	4.258	0.6	0.2488	0.0747
In_198a	Manhole	2.53	4.218	0.9	0.7571	0.2272
In_197a	Manhole	2.98	3.833	0.75	0.255	0.0765
In_196a	Manhole	2.66	4.21	1.65	0.7639	0.2292
In_195a	Manhole	2.91	4.094	0.9	0.2475	0.0743
In_194a	Manhole	3.02	4.012	0.9	0.25	0.075
In_193a	Manhole	2.55	3.694	0.75	0.25	0.075
In_192a	Manhole	2.51	4.202	0.6	0.7605	0.2282
In_189a	Manhole	8.34	9.325	0.9	0.63	0.189
In_188a	Manhole	8.43	9.356	1.2	0.405	0.162
In_187a	Manhole	8.68	9.492	1.65	0.81	0.243
In_186a	Manhole	8.89	9.588	0.9	0.229	0.0687
In_185a	Manhole	9.32	10.072	1.2	0.224	0.0672
In_184a	Manhole	9.02	9.756	1.65	0.096	0.0288
In_183a	Manhole	8.89	9.617	1.65	0.219	0.0657
In_182a	Manhole	8.25	9.217	0.9	0.2525	0.0758
In_181a	Manhole	8.59	9.498	0.6	0.2463	0.1232
In_180a	Manhole	8.7	9.463	0.9	0.405	0.162
In_17a	Manhole	1.98	2.787	1.65	0.064	0.0192
In_179a	Manhole	9.37	10.141	0.9	0.23	0.069
In_178a	Manhole	8.94	9.77	1.2	0.357	0.1071
In_177a	Manhole	9.24	10.102	1.2	0.358	0.1074
In_176a	Manhole	8.73	10.186	1.65	0.433	0.1299
In_175a	Manhole	8.89	10.432	1.65	0.353	0.1059
In_174a	Manhole	8.44	9.449	0.6	0.7616	0.2285
In_173a	Manhole	8.95	10.12	0.6	0.7594	0.2279
In_172a	Manhole	13.15	14.531	0.9	0.357	0.1071
In_171a	Manhole	13.76	15.096	0.6	0.357	0.1071
In_170a	Manhole	12.92	14.448	0.9	0.352	0.1056
In_16a	Manhole	1.76	2.708	1.65	0.245	0.245
In_169a	Manhole	8.61	9.305	1.65	0.7684	0.2306
In_168a	Manhole	1.19	2.256	1.95	0.6773	0.2032
In_167a	Manhole	1.62	2.992	0.6	0.7706	0.2312
In_166a	Manhole	1.78	2.959	0.6	0.7718	0.2316
In_165a	Manhole	1.24	2.413	1.95	0.2525	0.0758
In_164a	Manhole	1.36	2.701	0.6	0.7706	0.2312
In_163a	Manhole	1.47	2.928	0.6	0.7673	0.2302

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_162a	Manhole	1.6	2.885	0.6	0.7706	0.2312
In_161a	Manhole	1.38	2.69	0.6	0.7706	0.2312
In_160a	Manhole	1.24	2.386	1.95	0.255	0.0765
In_15a	Manhole	2.28	2.869	0.6	0.273	0.0819
In_159a	Manhole	1.36	2.52	1.2	0.7673	0.2302
In_158a	Manhole	1.36	2.576	1.2	0.774	0.2322
In_157a	Manhole	1.43	2.846	1.2	0.7706	0.2312
In_156a	Manhole	1.44	2.728	1.2	0.24	0.072
In_155a	Manhole	1.82	2.857	0.9	0.7706	0.2312
In_154a	Manhole	1.82	2.998	0.6	0.774	0.2322
In_153a	Manhole	1.45	2.786	1.2	0.2575	0.0773
In_152a	Manhole	2.02	2.583	0.9	0.18	0.09
In_151a	Manhole	1.58	2.305	1.2	0.19	0.057
In_150a	Manhole	1.67	2.308	0.9	0.206	0.0618
In_14a	Manhole	7.2	8.177	1.65	0.255	0.0765
In_149a	Manhole	1.77	2.203	0.9	0.18	0.072
In_148a	Manhole	1.42	2.504	0.75	0.2525	0.0758
In_147a	Manhole	1.53	2.588	0.6	0.4939	0.1482
In_146a	Manhole	1.7	2.756	0.6	0.6716	0.2015
In_145a	Manhole	1.82	2.73	0.6	0.4961	0.1489
In_144a	Manhole	1.94	2.725	0.6	0.4883	0.1465
In_143a	Manhole	1.85	3.134	0.6	0.2463	0.0739
In_142a	Manhole	2.28	3.11	1.2	0.2413	0.0724
In_141a	Manhole	2.3	3.165	0.9	0.2438	0.0732
In_140a	Manhole	2.01	2.756	0.6	0.5828	0.1749
In_139a	Manhole	1.63	2.818	0.75	0.7706	0.2312
In_138a	Manhole	1.86	2.801	0.6	0.7695	0.2309
In_137a	Manhole	2.15	3.152	0.6	0.7684	0.2306
In_136a	Manhole	1.8	2.628	1.65	0.1525	0.0458
In_135a	Manhole	2.15	2.495	1.65	0.215	0.0645
In_134a	Manhole	2.06	2.976	0.6	0.186	0.0558
In_133a	Manhole	2.18	2.62	0.6	0.3	0.12
In_132a	Manhole	3.59	5.073	3.1	0.7684	0.2306
In_131a	Manhole	3.72	5.067	1.2	0.5	0.15
In_130a	Manhole	3.48	4.329	0.6	0.5985	0.1796
In_129a	Manhole	3.14	4.057	0.6	0.25	0.075
In_128a	Manhole	2.3	3.073	1.65	0.2688	0.0807
In_127a	Manhole	3.41	4.383	0.6	0.229	0.0687
In_125a	Manhole	3.45	4.234	0.6	0.233	0.0699
In_124a	Manhole	2.38	2.852	0.9	0.2488	0.0747
In_123a	Manhole	3.31	4.065	0.6	0.2688	0.0807
In_122a	Manhole	3.12	4.217	0.6	0.18	0.054
In_121a	Manhole	3.21	4.162	0.6	0.362	0.1086

ID	Node Type	Invert Level (m AHD)	Ground Level (m AHD)	Chamber Diameter (m)	Max Inflow (m^3/s)	Inlet Area (m^2)
In_120a	Manhole	3.55	4.926	1.65	0.7673	0.2302
In_119a	Manhole	3.45	4.692	1.65	0.765	0.2295
In_118a	Manhole	3.43	4.501	1.65	0.2563	0.0769
In_117a	Manhole	3.34	4.56	1.65	0.2588	0.0777
In_116a	Manhole	3.19	4.308	3.1	0.2525	0.0758
In_115a	Manhole	3.12	4.417	3.1	0.7785	0.2336
In_114a	Manhole	3.14	4.298	0.6	0.103	0.0309
In_113a	Manhole	6.32	7.363	1.05	0.7639	0.2292
In_112a	Manhole	8.63	9.291	0.6	0.765	0.2295
In_111a	Manhole	8.5	10.07	0.6	0.7639	0.2292
In_110a	Manhole	8.85	10.322	0.6	0.7605	0.2282
In_10a	Manhole	1.93	3.894	1.5	0.3	0.09
In_109a	Manhole	10.38	11.276	0.6	0.7673	0.2302
In_108a	Manhole	7.02	7.984	0.6	0.765	0.2295
In_106a	Manhole	2.01	3.096	0.6	0.2475	0.0743
In_105a	Manhole	2.2	3.237	0.6	0.7594	0.2279
In_104a	Manhole	2.25	3.228	0.6	0.7616	0.2285
In_103a	Manhole	2.29	2.814	1.2	0.3938	0.1182
In_102a	Manhole	2.34	3.013	1.65	0.2363	0.0709
In_101a	Manhole	2.44	3.078	1.05	0.2513	0.0754
In_100a	Manhole	2.46	3.167	0.9	0.7628	0.2289

MIKE URBAN Links

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
ArgSold_180	RCBC	1.79	1.7	3.3		0.6	0.3
ArgSold_182	Pipe	2.18	1.88	58.9	0.375		
ArgSold_183	Pipe	1.88	1.65	55.7	0.375		
ArgSold_184	Pipe	1.65	1.45	54.1	0.525		
ArgSold_185	Pipe	2.03	1.47	7.2	0.375		
ArgSold_186	Pipe	2.03	2.03	3.1	0.375		
ArgSold_187	RCBC	1.47	1.37	57.4		1.5	0.35
ArgSold_188	Pipe	1.75	1.73	5.8	0.375		
ArgSold_189	Pipe	1.7	1.48	89.8	0.825		
ArgSold_190	Pipe	2.3	1.73	51.4	0.825		
ArgSold_191	RCBC	2.32	2.3	7.3		0.6	0.3
ArgSold_192	Pipe	1.88	1.76	45.6	0.375		
ArgSold_193	Pipe	1.97	1.88	7.5	0.375		
ArgSold_194	Pipe	1.85	1.67	56	0.45		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
ArgSold_195	Pipe	1.55	1.37	6	0.45		
ArgSold_196	Pipe	1.73	1.67	7.5	0.375		
ArgSold_197	RCBC	1.7	1.61	30.4		0.6	0.3
ArgSold_198	RCBC	1.61	1.5	39.1		0.9	0.3
ArgSold_202	RCBC	1.31	1.11	28.3		1.4	0.45
ArgSold_203	Pipe	1.45	1.26	7.5	0.525		
ArgSold_207	RCBC	1.48	1.47	8.2		0.9	0.45
ArgSold_208	Pipe	1.5	1.5	15.9	0.375		
ArgSold_209	Pipe	1.85	1.85	14.5	0.375		
ArgSold_210	Pipe	1.85	1.48	22.2	0.6		
ArgSold_211	RCBC	1.47	1.46	14.6		0.9	0.45
ArgSold_212	RCBC	1.46	1.38	101.7		0.9	0.45
ArgSold_213	RCBC	1.39	1.38	34		0.9	0.6
ArgSold_214	RCBC	1.26	1.26	10.7		1.5	0.75
ArgSold_215	RCBC	1.26	1.26	9.3		1.5	0.75
ArgSold_216	RCBC	1.38	1.28	13.7		0.9	0.6
ArgSold_217	Pipe	1.4	1.38	11.7	0.375		
ArgSold_218	Pipe	1.63	1.5	8.6	0.375		
ArgSold_219	Pipe	1.38	1.28	28.3	0.45		
ArgSold_220	Pipe	1.64	1.4	60.2	0.375		
ArgSold_221	Pipe	1.8	1.66	11	0.375		
ArgSold_222	RCBC	1.26	1.22	41.5		1.5	0.75
ArgSold_223	RCBC	1.22	1.18	29.4		1.5	0.75
ArgSold_250	Pipe	3.56	3.51	1.0915	0.15		
ArgSold_251	Pipe	3.67	3.59	1.412677	0.15		
ArgSold_252	Pipe	2.32	2.27	38.8	0.675		
ArgSold_253	Pipe	2.26	2.25	11.7	0.675		
ArgSold_254	Pipe	2.53	2.53	10.6	0.45		
ArgSold_255	Pipe	2.57	2.43	15.1	0.525		
ArgSold_256	Pipe	2.51	2.35	63.8	0.6		
ArgSold_257	Pipe	3.15	2.53	85.8	0.6		
ArgSold_258	Pipe	2.94	2.53	27.9	0.6		
ArgSold_259	Pipe	3.04	3	6.5	0.6		
ArgSold_260	Pipe	2.55	2.34	109.5	0.6		
ArgSold_261	Pipe	2.69	2.58	7.1	0.6		
ArgSold_262	Pipe	3	2.56	34.4	0.525		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
ArgSold_263	Pipe	3.28	3.14	24.7	0.675		
ArgSold_264	Pipe	3.27	3.1	6.7	0.375		
ArgSold_265	Pipe	3.39	3.27	26.15	0.375		
ArgSold_266	Pipe	3.52	3.46	14.55	0.375		
ArgSold_267	Pipe	3.46	3.39	18.74	0.375		
ArgSold_320	Pipe	3.17	2.96	7.6	0.375		
ArgSold_321	Pipe	2.98	2.89	48.9	0.525		
ArgSold_322	Pipe	2.99	2.91	7.6	0.375		
ArgSold_323	Pipe	3.18	2.93	44.5	0.375		
ArgSold_324	Pipe	2.62	2.51	26.9	0.6		
ArgSold_325	Pipe	2.89	2.85	18.9	0.375		
ArgSold_326	Pipe	2.51	2.42	45.9	0.6		
ArgSold_327	Pipe	2.78	2.62	78.4	0.6		
ArgSold_328	Pipe	2.9	2.78	0	0.525		
ArgSold_329	Pipe	2.94	2.78	80.4	0.45		
ArgSold_330	RCBC	2.77	2.5	1		0.3	0.3
ArgSold_676	Pipe	2.32	2.27	38.8	0.675		
ArgSold_677	Pipe	2.26	2.25	11.7	0.675		
ArgSold_678	Pipe	2.51	2.35	63.8	0.6		
ArgSold_679	Pipe	3.15	2.53	85.8	0.6		
ArgSold_680	Pipe	2.55	2.34	109.5	0.6		
ArgSold_681	Pipe	2.69	2.58	7.1	0.6		
ArgSold_683	Pipe	2.62	2.51	26.9	0.6		
ArgSold_684	Pipe	2.78	2.62	78.4	0.6		
CBD_268	Pipe	1.75	1.52	31	0.675		
CBD_269	RCBC	4.58	2.6	43.4		0.9	0.35
CBD_270	RCBC	4.45	3.24	30.8		0.9	0.35
CBD_271	Pipe	3.76	3.24	12.1	0.45		
CBD_272	Pipe	4.12	3.08	14.1	0.3		
CBD_273	Pipe	2.6	1.95	49.1	0.375		
CBD_274	Pipe	3.24	1.6	72.5	0.45		
CBD_275	Pipe	1.55	1.52	29	0.525		
CBD_276	Pipe	1.95	1.6	34.2	0.525		
CBD_277	Pipe	1.47	1.27	14	0.75		
CBD_278	Pipe	1.2	1.26	0	0.9		
CBD_279	Pipe	1.34	1.3	8	0.75		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_280	Pipe	1.54	1.27	37.3	0.375		
CBD_281	Pipe	1.6	1.55	8	0.3		
CBD_282	Pipe	1.61	1.54	32.9	0.3		
CBD_283	Pipe	2	1.66	8.1	0.3		
CBD_284	RCBC	4.52	4.45	0		0.6	0.2
CBD_285	RCBC	4.68	4.45	5.91		0.9	0.35
CBD_375	RCBC	2.16	2.1	29.7		1.6	0.4
CBD_376	RCBC	3.23	3.18	1.1		0.25	0.3
CBD_377	RCBC	7.37	7.21	6.4		0.6	0.3
CBD_378	Pipe	11.19	10.88	6.3	0.375		
CBD_379	Pipe	8.08	8.07	1	0.375		
CBD_385	Pipe	10.33	10.1	31.7	0.6		
CBD_386	Pipe	5.04	4.95	17.4	0.45		
CBD_388	Pipe	9.25	8.08	46.6	0.375		
CBD_389	Pipe	4.6	4.37	6.2	0.375		
CBD_390	Pipe	4.37	4.02	11.1	0.375		
CBD_391	Pipe	4.14	4.02	9.5	0.375		
CBD_392	Pipe	4.2	4.14	7.4	0.375		
CBD_393	Pipe	4.27	4.2	6.8	0.375		
CBD_394	Pipe	4.12	3.71	45.5	0.525		
CBD_395	Pipe	4.33	4.18	13.1	0.45		
CBD_396	Pipe	4.54	4.33	9.8	0.375		
CBD_397	Pipe	4.75	4.18	0	0.45		
CBD_398	RCBC	13.45	12.78	27.2		0.6	0.3
CBD_408	RCBC	2.2	2.16	57.8		0.55	0.4
CBD_409	RCBC	2.26	2.16	118		0.55	0.4
CBD_410	RCBC	9.86	9.32	40.3		0.6	0.3
CBD_411	RCBC	5.09	4.64	38.4		0.9	0.3
CBD_412	Pipe	2.78	2.59	4.3	0.525		
CBD_413	RCBC	6.88	6.52	5.4		0.6	0.4
CBD_414	RCBC	6.22	4.7	58.8		0.6	0.3
CBD_415	RCBC	7.29	7.21	9		0.6	0.3
CBD_416	RCBC	7.21	5.85	51.8		1.2	0.15
CBD_417	RCBC	10.07	10.03	25		1.2	0.3
CBD_418	Pipe	8.72	8.41	6	0.3		
CBD_435	Pipe	1.24	1.03	30	0.45		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_436	RCBC	1.21	1.13	4.7		0.6	0.45
CBD_437	RCBC	1.25	1.23	6		0.6	0.45
CBD_438	RCBC	1.13	1	1.47		1.2	0.3
CBD_439	RCBC	1	1	4.8		1.2	0.3
CBD_440	RCBC	1.03	0.86	29.3		1.2	0.3
CBD_441	RCBC	1.1	0.78	20.1		0.9	0.6
CBD_442	Pipe	1.33	1.1	14.6	0.375		
CBD_443	Pipe	4.54	4.14	15.7	0.375		
CBD_444	RCBC	1.17	0.92	20.3		0.9	0.6
CBD_445	Pipe	1.63	1.2	13	0.375		
CBD_446	Pipe	4.12	1.38	53.2	0.375		
CBD_447	Pipe	4.14	4.12	7.7	0.375		
CBD_449	Pipe	1.29	1.16	7.5	0.375		
CBD_450	Pipe	1.13	0.94	45	0.375		
CBD_451	Pipe	1.09	0.98	8.4	0.375		
CBD_452	Pipe	0.94	0.75	65.2	0.375		
CBD_453	Pipe	1.13	0.68	8	0.375		
CBD_454	Pipe	0.63	0.57	13.2	0.375		
CBD_455	Pipe	1	0.75	34.1	1.05		
CBD_456	Pipe	1.11	1.04	7.9	0.75		
CBD_457	Pipe	1	0.99	47.9	0.75		
CBD_458	Pipe	1.23	1.02	8	0.75		
CBD_459	Pipe	1.64	1.02	66.9	0.525		
CBD_460	Pipe	1.75	1.65	8.1	0.525		
CBD_461	Pipe	1.8	1.78	7.9	0.375		
CBD_462	Pipe	2	1.64	32.1	0.375		
CBD_463	Pipe	2.19	2.03	8	0.375		
CBD_464	Pipe	1.8	1.78	8	0.6		
CBD_465	Pipe	2.01	1.73	8	0.375		
CBD_466	Pipe	2.16	1.73	66.9	0.375		
CBD_467	Pipe	2.18	2.16	8	0.375		
CBD_468	RCBC	1.72	1.64	7		0.6	0.3
CBD_472	Pipe	3.5	3.43	4	0.375		
CBD_473	Pipe	4.02	3.84	12.5	0.45		
CBD_474	RCBC	3.12	2.94	15.7		1.1	0.4
CBD_475	RCBC	1.64	1.56	13.8		1.2	0.45

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_476	RCBC	6.33	6.1	27.41		0.6	0.3
CBD_477	RCBC	3.37	3	28.6		0.6	0.3
CBD_478	RCBC	1.77	1.73	15.7		0.6	0.3
CBD_479	RCBC	2.58	2.43	25.6		0.9	0.45
CBD_481	RCBC	7.06	6.52	3.8		0.6	0.4
CBD_482	RCBC	5.12	5.09	0		0.9	0.15
CBD_483	Pipe	4.95	4.86	11.9	0.75		
CBD_484	Pipe	8.07	7.99	7.5	0.375		
CBD_485	Pipe	1.11	1.07	14	0.45		
CBD_486	Pipe	1.07	1.03	17.7	0.45		
CBD_488	RCBC	3.73	2.69	104.3		1.2	0.35
CBD_489	Pipe	1.32	0.92	19.2	0.75		
CBD_490	RCBC	12.99	12.78	8.5		0.6	0.15
CBD_491	RCBC	13.62	13.45	8.5		0.6	0.3
CBD_492	Pipe	6.52	6.22	31.2	0.6		
CBD_493	Pipe	2.29	2.1	6	0.375		
CBD_494	RCBC	2.7	2.6	5		0.6	0.15
CBD_495	RCBC	2.49	2.48	5		0.6	0.15
CBD_496	RCBC	2.16	1.86	10		1.2	0.35
CBD_497	RCBC	1.88	1.87	10		1.2	0.35
CBD_498	RCBC	2.05	1.9	3		1.2	0.3
CBD_499	RCBC	2.02	1.9	20		1.2	0.45
CBD_500	RCBC	3.43	2.86	89		1.2	0.35
CBD_501	RCBC	2.86	2.12	208		1.5	0.3
CBD_502	RCBC	9.72	9.32	7.3		0.6	0.2
CBD_503	RCBC	9.97	9.86	6		0.6	0.3
CBD_504	RCBC	6.5	6.48	4.5		0.6	0.3
CBD_505	RCBC	6.52	6.33	26.1		0.6	0.3
CBD_506	RCBC	6.62	6.54	4		0.6	0.3
CBD_507	RCBC	6.18	6.1	4		0.6	0.3
CBD_508	RCBC	6.27	6.1	26		1.2	0.3
CBD_509	RCBC	4.16	4.1	0		0.8	0.25
CBD_510	RCBC	4.68	4.1	0		0.6	0.3
CBD_511	RCBC	4.56	4.1	0		0.75	0.3
CBD_512	RCBC	4.62	4.5	0		0.9	0.3
CBD_513	RCBC	4.1	3.86	26.1		1.5	0.5

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_514	RCBC	4.5	3.8	0		1.5	0.5
CBD_515	RCBC	3.28	2.94	0		2.2	0.3
CBD_516	RCBC	14.57	14.19	0		0.6	0.4
CBD_517	RCBC	14.95	14.19	0		0.6	0.4
CBD_518	RCBC	14.19	13.78	0		1.2	0.3
CBD_519	Pipe	11.81	10.5	0	0.375		
CBD_520	Pipe	10.5	10.33	0	0.375		
CBD_521	RCBC	7.9	7.41	48.7		1.2	0.3
CBD_522	Pipe	9.1	8.15	0	0.375		
CBD_523	RCBC	7.43	7.38	0		1.2	0.3
CBD_530	Pipe	1.03	1.07	16	0.45		
CBD_531	Pipe	1.78	1.71	0	0.375		
CBD_532	Pipe	1.71	1.64	0	0.375		
CBD_533	Pipe	1.7	1.32	0	0.375		
CBD_534	Pipe	0.92	0.38	0	1.02		
CBD_535	RCBC	1.9	1.73	4.5		0.6	0.3
CBD_536	RCBC	1.91	1.77	32		0.6	0.3
CBD_537	RCBC	4.85	4.68	21.5		1.2	0.4
CBD_538	RCBC	1.68	1.64	37.6		0.9	0.3
CBD_539	RCBC	2.49	2.24	49.8		1.5	0.3
CBD_540	RCBC	3.03	3	4		0.6	0.3
CBD_541	RCBC	3.42	3.37	2.3		0.6	0.3
CBD_542	RCBC	4.58	4.5	0		0.9	0.3
CBD_543	RCBC	3.73	3.43	14.6		1.2	0.35
CBD_544	RCBC	6.83	6.54	19.7		0.6	0.3
CBD_545	RCBC	6.56	6.48	5.4		0.6	0.3
CBD_546	RCBC	6.1	6.08	4.18		0.6	0.3
CBD_547	RCBC	13.9	13.45	6.8		0.6	0.3
CBD_548	RCBC	12.78	12.73	6.8		0.6	0.3
CBD_549	RCBC	10.1	9.86	9.9		0.6	0.3
CBD_550	RCBC	9.32	9.12	8.4		0.6	0.3
CBD_551	RCBC	2.54	2.48	6.7		1.4	0.3
CBD_552	RCBC	2.43	2.42	6.1		1.4	0.3
CBD_553	RCBC	2.48	2.43	27.65		1.4	0.3
CBD_554	RCBC	1.86	1.81	29.2		1.7	0.35
CBD_555	RCBC	1.88	1.87	5.1		1.7	0.35

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_556	RCBC	1.87	1.86	4		1.7	0.35
CBD_557	RCBC	1.81	1.79	6		1.7	0.35
CBD_558	RCBC	1.9	1.81	20		1.2	0.45
CBD_559	RCBC	3.44	3.37	5.6		0.6	0.3
CBD_560	RCBC	3	2.96	6.3		0.6	0.3
CBD_561	RCBC	2.12	2.09	5		1.5	0.3
CBD_562	RCBC	2.24	2.12	28.7		1.5	0.3
CBD_563	RCBC	2.69	2.49	40.2		1.5	0.3
CBD_564	RCBC	5.41	5.09	27.4		0.9	0.3
CBD_565	RCBC	3.86	3.8	6.1		1.5	0.5
CBD_566	RCBC	7	6.52	6.7		0.6	0.3
CBD_569	RCBC	1.65	1.64	3.2		1.2	0.45
CBD_570	Pipe	5.06	4.95	5.9	0.75		
CBD_571	RCBC	7.99	7.9	9.3		1.2	0.3
CBD_574	Pipe	1.68	1.32	18.6	0.75		
CBD_575	RCBC	2.16	2.16	1		1.6	0.4
CBD_576	RCBC	2.1	2.09	6.2		1.6	0.4
CBD_577	RCBC	1.83	1.77	17.4		0.6	0.3
CBD_578	RCBC	1.73	1.71	7.6		0.6	0.3
CBD_579	RCBC	2.94	2.85	7.1		2	0.3
CBD_580	RCBC	3.15	3.12	2		1.1	0.4
CBD_617	Pipe	1.25	1.17	19.1	1.05		
CBD_618	Pipe	5.2	5.18	23.4	0.525		
CBD_619	Pipe	6	5.52	26.3	0.45		
CBD_620	Pipe	5.12	5.43	35	0.525		
CBD_621	Pipe	5.45	5.41	7.2	0.45		
CBD_622	Pipe	4.97	4.79	10	0.45		
CBD_623	Pipe	4.74	4.62	5.8	0.45		
CBD_624	Pipe	5.43	4.62	59.3	0.6		
CBD_625	Pipe	4.62	4.39	44.8	0.6		
CBD_626	Pipe	4.31	4.31	3.6	0.45		
CBD_627	Pipe	4.39	4.35	6.8	0.6		
CBD_628	Pipe	4.52	4.35	23	0.45		
CBD_629	Pipe	4.39	4.24	21.3	0.45		
CBD_630	Pipe	4.16	3.99	41.5	0.45		
CBD_631	Pipe	4.35	3.99	28.6	0.6		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_632	Pipe	4.04	4.06	12.1	0.45		
CBD_633	Pipe	3.99	3.52	5.5	0.45		
CBD_634	Pipe	3.99	3.52	60.7	0.6		
CBD_635	Pipe	3.68	3.27	29.8	0.45		
CBD_636	Pipe	3.52	3.08	56.9	0.6		
CBD_637	Pipe	3.08	2.86	28.7	0.6		
CBD_638	Pipe	3.24	2.86	25.7	0.45		
CBD_639	Pipe	2.64	2.7	12.5	0.45		
CBD_640	Pipe	2.65	2.45	0	0.45		
CBD_641	Pipe	2.86	2.45	54.7	0.6		
CBD_642	Pipe	2.16	2.26	12.3	0.45		
CBD_643	Pipe	2.15	2.06	5.2	0.75		
CBD_644	Pipe	2.45	2.06	49.6	0.6		
CBD_645	Pipe	2.05	1.9	14	0.75		
CBD_646	RCBC	2.01	1.89	25.7		1.2	0.4
CBD_647	Pipe	1.88	1.78	27.9	1.05		
CBD_648	RCBC	1.81	1.78	0		1.2	0.4
CBD_649	Pipe	1.64	1.61	12.2	0.6		
CBD_650	Pipe	1.78	1.55	61.4	1.05		
CBD_651	Pipe	1.55	1.34	58.4	1.05		
CBD_652	Pipe	1.61	1.55	5.8	0.6		
CBD_653	Pipe	2.2	1.34	0	0.375		
CBD_654	Pipe	1.75	1.34	0	0.375		
CBD_655	Pipe	1.34	1.25	26.2	1.05		
CBD_682	Pipe	1.55	1.52	29	0.525		
CBD_688	RCBC	5.09	4.64	38.4		0.9	0.3
CBD_689	RCBC	10.07	10.03	25		1.2	0.3
CBD_695	Pipe	1.8	1.78	8	0.6		
CBD_696	Pipe	4.02	3.84	12.5	0.45		
CBD_697	RCBC	3.12	2.94	15.7		1.1	0.4
CBD_698	RCBC	1.64	1.56	13.8		1.2	0.45
CBD_699	RCBC	6.33	6.1	27.41		0.6	0.3
CBD_700	RCBC	3.37	3	28.6		0.6	0.3
CBD_701	RCBC	1.77	1.73	15.7		0.6	0.3
CBD_702	RCBC	2.58	2.43	25.6		0.9	0.45
CBD_703	Pipe	4.95	4.86	11.9	0.75		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
CBD_704	Pipe	1.32	0.92	19.2	0.75		
CBD_705	RCBC	6.5	6.48	4.5		0.6	0.3
CBD_706	RCBC	6.52	6.33	26.1		0.6	0.3
CBD_707	RCBC	4.62	4.5	0		0.9	0.3
CBD_708	Pipe	10.5	10.33	0	0.375		
CBD_709	RCBC	4.85	4.68	21.5		1.2	0.4
CBD_710	RCBC	3.42	3.37	2.3		0.6	0.3
CBD_711	RCBC	6.83	6.54	19.7		0.6	0.3
CBD_712	RCBC	6.1	6.08	4.18		0.6	0.3
CBD_713	RCBC	2.54	2.48	6.7		1.4	0.3
CBD_714	RCBC	2.43	2.42	6.1		1.4	0.3
CBD_715	RCBC	2.48	2.43	27.65		1.4	0.3
CBD_716	RCBC	3	2.96	6.3		0.6	0.3
CBD_717	RCBC	2.12	2.09	5		1.5	0.3
CBD_718	RCBC	5.41	5.09	27.4		0.9	0.3
CBD_720	RCBC	1.65	1.64	3.2		1.2	0.45
CBD_721	Pipe	5.06	4.95	5.9	0.75		
CBD_723	Pipe	1.68	1.32	18.6	0.75		
CBD_724	RCBC	1.83	1.77	17.4		0.6	0.3
CBD_725	RCBC	1.73	1.71	7.6		0.6	0.3
CBD_726	RCBC	2.94	2.85	7.1		2	0.3
CBD_727	RCBC	3.15	3.12	2		1.1	0.4
DonSt_0	Pipe	7.22	6.91	45.7	0.6		
DonSt_224	RCBC	8.75	8.64	42		1.2	0.6
DonSt_225	Pipe	12.94	9.15	0	0.45		
DonSt_226	RCBC	13.18	12.94	8		0.6	0.3
DonSt_227	Pipe	13.78	13.18	17.4	0.375		
DonSt_228	Pipe	8.98	8.61	40.8	0.375		
DonSt_229	Pipe	8.47	8.28	28.8	0.375		
DonSt_230	RCBC	8.91	8.9	14		1.2	0.45
DonSt_231	RCBC	8.97	8.91	45.6		0.9	0.45
DonSt_232	RCBC	9.27	8.97	0		0.9	0.25
DonSt_233	RCBC	9.39	8.91	0		0.6	0.3
DonSt_234	Pipe	8.73	8.7	12.4	0.6		
DonSt_235	Pipe	8.61	8.58	11.7	0.45		
DonSt_236	RCBC	8.91	8.53	13.8		1.2	0.6

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
DonSt_237	Pipe	8.28	8.23	4.1	0.6		
DonSt_238	RCBC	8.92	8.91	0		1.2	0.45
DonSt_239	RCBC	9.28	9.06	54.3		0.9	0.25
Muller_387	RCBC	4.64	2.91	53.2		0.6	0.3
Muller_399	RCBC	4.66	2.91	0		0.6	0.3
Muller_419	RCBC	4.47	2.92	0		0.6	0.3
Muller_420	RCBC	2.91	2.41	8.4		0.6	0.3
Muller_421	RCBC	4.85	3.72	30.6		0.6	0.3
Muller_422	RCBC	3.72	3.7	2.7		0.6	0.3
Muller_423	RCBC	4	3.25	61.6		0.6	0.3
Muller_424	RCBC	3.25	3.06	24.7		0.9	0.3
Muller_425	RCBC	4.1	4.02	6.7		0.6	0.3
Muller_426	RCBC	2.45	2.41	2.6		0.6	0.3
Muller_427	RCBC	2.4	2.36	2.7		0.6	0.3
Muller_428	RCBC	2.41	2.36	31		0.6	0.3
Muller_429	RCBC	2.36	2.36	31		0.6	0.3
Muller_430	Pipe	5.09	5.02	17.6	0.45		
Muller_431	Pipe	4.66	4.16	34.1	0.45		
Muller_432	Pipe	4.16	4.14	13.3	0.45		
Muller_433	RCBC	3.91	3.9	0		1.2	0.3
Muller_434	RCBC	4.14	3.98	26		1.2	0.3
Muller_48	Pipe	3.89	3.65	4.8	0.525		
Muller_480	RCBC	4.91	4.64	5.8		0.6	0.3
Muller_487	Pipe	4.91	4.64	0	0.375		
Muller_49	Pipe	4.56	4.5	12.2	0.3		
Muller_50	Pipe	4.64	4.5	46.5	0.525		
Muller_51	Pipe	4.95	4.68	44.3	0.375		
Muller_52	Pipe	5.08	4.99	10.3	0.3		
Muller_524	RCBC	4	2.92	50.4		0.6	0.3
Muller_525	RCBC	2.92	2.89	5.2		0.6	0.3
Muller_526	RCBC	4.52	4.32	0		0.6	0.3
Muller_527	Pipe	5.02	4.99	0	0.45		
Muller_528	Pipe	5.72	4.99	19	0.45		
Muller_529	Pipe	4.99	4.66	29	0.45		
Muller_53	Pipe	4.49	4.19	75.7	0.6		
Muller_54	Pipe	4.22	4.18	10.2	0.3		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
Muller_55	Pipe	4.08	4.07	2.3	0.9		
Muller_56	RCBC	7.16	6.83	11.9		0.6	0.3
Muller_567	RCBC	4.32	4	13.8		0.6	0.3
Muller_57	Pipe	4.49	3.89	41.4	0.75		
Muller_58	Pipe	3.85	3.29	0	0.75		
Muller_60	Pipe	4.18	4.11	0	0.6		
Muller_61	Pipe	4.31	4.11	0	0.3		
Muller_62	Pipe	4.11	4.06	26.8	0.9		
Muller_63	RCBC	6.83	5.79	0		1.2	0.3
Muller_64	Pipe	5.08	4.52	0	0.75		
Muller_65	RCBC	3.02	2.5	113.3		1	0.85
Muller_66	RCBC	4.07	3.29	0		1.2	0.3
Muller_662	RCBC	7.16	6.83	11.9		0.6	0.3
Muller_67	RCBC	2.49	2.45	0		0.6	0.3
Muller_68	RCBC	2.33	2.15	0		0.6	0.4
Muller_69	Pipe	2.15	1.81	33	1.05		
Muller_690	RCBC	2.91	2.41	8.4		0.6	0.3
Muller_691	Pipe	4.66	4.16	34.1	0.45		
Muller_692	Pipe	4.16	4.14	13.3	0.45		
Muller_693	RCBC	3.91	3.9	0		1.2	0.3
Muller_694	RCBC	4.14	3.98	26		1.2	0.3
Muller_70	Pipe	2.45	1.81	0	1.05		
Muller_71	RCBC	3.29	3.02	57.7		1	0.85
Muller_72	Pipe	2.74	2.15	12.3	1.05		
Muller_729	RCBC	4.85	3.72	30.6		0.6	0.3
Muller_730	RCBC	3.72	3.7	2.7		0.6	0.3
Muller_732	RCBC	4.85	3.72	30.6		0.6	0.3
Muller_733	RCBC	3.72	3.7	2.7		0.6	0.3
Muller_734	RCBC	4.85	3.72	30.6		0.6	0.3
Muller_735	RCBC	3.72	3.7	2.7		0.6	0.3
NthJill_1	Pipe	1.78	1.72	1.35	0.6		
NthJill_10	RCBC	3.06	3.04	6.7		0.9	0.4
NthJill_11	RCBC	3.26	3.05	35.2		0.9	0.4
NthJill_12	RCBC	3.47	3.28	90.2		0.9	0.375
NthJill_13	Pipe	3.51	3.47	6.7	0.375		
NthJill_14	RCBC	3.64	3.48	77.8		0.75	0.375
NthJill_144	Pipe	2.3	1.82	53.6	0.6		
NthJill_145	Pipe	7.04	6.89	1.5	0.375		
NthJill_147	Pipe	2.94	2.07	189.7	0.45		
NthJill_148	Pipe	6.68	6.35	32	0.45		
NthJill_149	Pipe	10.4	8.07	26.9	0.375		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
NthJill_15	Pipe	3.1	2.91	35.9	0.45		
NthJill_150	Pipe	7.97	7.95	3.9	0.375		
NthJill_151	Pipe	8.53	8.07	9.4	0.375		
NthJill_152	Pipe	8.87	8.56	6.8	0.375		
NthJill_153	Pipe	7.93	7.2	29.7	0.375		
NthJill_154	Pipe	8.66	8.49	1.5	0.375		
NthJill_155	RCBC	6.37	6.35	15.3		0.75	0.4
NthJill_157	RCBC	3.23	3.18	31		1.2	0.6
NthJill_158	RCBC	3.36	3.15	66.5		1.2	0.6
NthJill_159	RCBC	3.18	3	46		1.8	0.6
NthJill_16	Pipe	3.15	3.15	19.7	0.45		
NthJill_160	RCBC	3.22	3.18	11.3		1.2	0.6
NthJill_161	RCBC	3.46	3.36	39.9		1.2	0.6
NthJill_162	RCBC	3.48	3.46	32.6		1.2	0.6
NthJill_163	RCBC	3.57	3.48	59.3		1.2	0.45
NthJill_164	RCBC	3.61	3.61	14.5		1.2	0.45
NthJill_165	Pipe	3.24	2.92	30.4	0.45		
NthJill_166	Pipe	3.15	2.86	0	0.45		
NthJill_167	Pipe	3.33	3.19	7.4	0.45		
NthJill_168	RCBC	2.41	2.4	7.6		0.6	0.3
NthJill_17	Pipe	3.19	3.17	6.5	0.45		
NthJill_171	RCBC	1.77	1.6	0		1.2	0.6
NthJill_172	Pipe	1.81	1.39	0	0.6		
NthJill_173	RCBC	2.15	1.77	0		1.2	0.6
NthJill_175	RCBC	2.32	2.15	0		1.2	0.3
NthJill_176	Pipe	2.81	2.33	0	0.45		
NthJill_177	Pipe	3.17	2.81	32.8	0.45		
NthJill_178	Pipe	3.51	2.81	0	0.375		
NthJill_179	Pipe	3.75	3.61	19	0.45		
NthJill_18	RCBC	4.05	3.65	0		0.75	0.375
NthJill_19	Pipe	3.67	3.64	6.7	0.375		
NthJill_2	Pipe	2.3	2.26	14.2	0.375		
NthJill_3	Pipe	2	1.79	13.6	0.6		
NthJill_36	Pipe	4.97	4.79	5.122	0.45		
NthJill_37	Pipe	5.7	5.29	35.7	0.45		
NthJill_38	Pipe	5.47	5.29	10.3	0.375		
NthJill_39	Pipe	7.16	5.81	31.9	0.375		
NthJill_4	Pipe	2.23	2	25.1	0.6		
NthJill_40	Pipe	7.24	7.2	7.7	0.375		
NthJill_41	Pipe	5.72	4.97	41.5	0.45		
NthJill_42	Pipe	6.77	5.74	54.2	0.375		
NthJill_43	Pipe	6.39	5.74	7.2	0.375		
NthJill_44	Pipe	6.47	5.72	46.7	0.375		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
NthJill_45	Pipe	5.2	5.02	10.1	0.6		
NthJill_46	Pipe	5.02	4.77	42.1	0.6		
NthJill_47	Pipe	4.77	4.49	105.9	0.75		
NthJill_5	Pipe	2.12	2.19	27.3	0.6		
NthJill_581	Pipe	3.12	3.1	8.2	0.525		
NthJill_582	Pipe	3.06	2.91	39.8	0.525		
NthJill_583	Pipe	2.98	2.93	6.6	0.375		
NthJill_584	Pipe	2.9	2.84	9.9	0.6		
NthJill_585	Pipe	2.87	2.79	7.6	0.6		
NthJill_586	Pipe	2.75	2.67	34.9	0.6		
NthJill_587	Pipe	3	2.91	17.8	0.525		
NthJill_588	Pipe	3.08	3.03	6.6	0.45		
NthJill_589	Pipe	2.9	2.87	20.5	0.6		
NthJill_590	Pipe	3	2.96	16	0.45		
NthJill_6	RCBC	2.31	2.1	11.1		0.6	0.3
NthJill_657	Pipe	1.78	1.72	1.35	0.6		
NthJill_658	Pipe	2	1.79	13.6	0.6		
NthJill_659	Pipe	2.23	2	25.1	0.6		
NthJill_660	Pipe	2.12	2.19	27.3	0.6		
NthJill_661	Pipe	3.15	3.15	19.7	0.45		
NthJill_666	RCBC	3.23	3.18	31		1.2	0.6
NthJill_667	RCBC	3.36	3.15	66.5		1.2	0.6
NthJill_668	RCBC	3.18	3	46		1.8	0.6
NthJill_669	RCBC	3.22	3.18	11.3		1.2	0.6
NthJill_670	Pipe	3.75	3.61	19	0.45		
NthJill_7	Pipe	2.26	2.19	23.2	0.375		
NthJill_728	Pipe	3.1	2.91	35.9	0.45		
NthJill_731	Pipe	3.1	2.91	35.9	0.45		
NthJill_8	Pipe	2.21	2.16	7.2	0.375		
NthJill_9	RCBC	3.04	2.99	35		0.9	0.4
QueenB_100	Pipe	2.8	2.58	27.1	0.375		
QueenB_101	Pipe	0.82	0.71	32.8	1.5		
QueenB_102	Pipe	0.19	0	45.4	1.5		
QueenB_103	Pipe	0.46	0.4	31.3	1.5		
QueenB_104	Pipe	0.62	0.47	109.4	1.5		
QueenB_105	Pipe	0.4	0.37	26.6	1.5		
QueenB_106	Pipe	0.37	0.31	76.7	1.5		
QueenB_107	Pipe	0.31	0.28	28.7	1.5		
QueenB_108	Pipe	0.28	0.24	48.5	1.5		
QueenB_109	Pipe	2.94	2.74	0	0.375		
QueenB_110	Pipe	3.05	2.85	0	0.375		
QueenB_111	Pipe	2.36	1.76	0	0.3		
QueenB_112	RCBC	2.15	1.43	9.8		0.6	0.3

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
QueenB_113	RCBC	2.96	2.55	4		0.6	0.3
QueenB_114	RCBC	2.83	2.44	8		0.6	0.3
QueenB_115	Pipe	1.31	1.01	6	0.825		
QueenB_116	Pipe	1.95	1.91	0	0.825		
QueenB_117	Pipe	1.42	1.13	86.5	0.825		
QueenB_118	Pipe	1.91	1.76	42.9	0.825		
QueenB_119	Pipe	1.76	1.66	28.8	0.825		
QueenB_120	Pipe	1.66	1.42	70.3	0.825		
QueenB_121	Pipe	1.13	0.89	70.4	0.825		
QueenB_122	Pipe	0.89	0.82	23.8	1.5		
QueenB_146	Pipe	3.25	3.18	48	0.45		
QueenB_156	Pipe	3.44	3.25	95	0.45		
QueenB_169	Pipe	3.48	3.45	0	0.45		
QueenB_170	Pipe	3.67	3.17	0	0.45		
QueenB_174	Pipe	3.45	3.44	0	0.45		
QueenB_20	RCBC	2.8	2.57	21.8		0.6	0.15
QueenB_21	RCBC	3.1	2.75	22.4		0.6	0.3
QueenB_22	Pipe	3.09	3.08	3	0.45		
QueenB_23	RCBC	3.11	3.09	16.9		0.6	0.4
QueenB_24	RCBC	2.76	2.2	46.4		0.7	0.45
QueenB_25	RCBC	3.58	3.34	13.5		0.45	0.15
QueenB_26	RCBC	2.21	2.2	20.9		0.7	0.45
QueenB_27	RCBC	2.21	2.21	4.6		0.7	0.45
QueenB_28	RCBC	3.28	3.24	3.5		0.7	0.3
QueenB_29	RCBC	3.29	3.28	16.4		0.8	0.3
QueenB_30	Pipe	2.04	1.75	20	0.9		
QueenB_31	Pipe	1.96	1.28	66.2	1.05		
QueenB_32	RCBC	3.6	3.58	2.5		0.45	0.15
QueenB_33	RCBC	3.58	3.34	2.5		0.45	0.15
QueenB_34	RCBC	3.64	3.58	3		0.45	0.15
QueenB_35	RCBC	3.34	3.28	3.3		0.45	0.15
QueenB_591	Pipe	2.78	2.73	2.22	0.45		
QueenB_592	Pipe	2.73	2.58	6.3	0.45		
QueenB_593	Pipe	3.15	2.99	19.5	0.375		
QueenB_594	Pipe	3.49	3.46	13.8	0.375		
QueenB_595	Pipe	2.74	2.59	2	0.375		
QueenB_596	Pipe	2.74	2.65	10.5	0.375		
QueenB_597	Pipe	3.02	2.58	6.3	0.45		
QueenB_598	Pipe	1.4	1.25	122.5	1.05		
QueenB_599	Pipe	3.44	2.47	10.3	0.375		
QueenB_600	Pipe	1.8	1.78	0	1.05		
QueenB_601	Pipe	2.61	2.5	0	0.45		
QueenB_602	Pipe	3.08	3.05	0	0.375		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
QueenB_603	Pipe	2.37	2.34	0	0.375		
QueenB_604	Pipe	2.34	2.29	0	0.6		
QueenB_605	Pipe	3.44	3.27	0	0.375		
QueenB_606	Pipe	3.46	3.44	0	0.375		
QueenB_607	Pipe	3.12	3.1	0	0.375		
QueenB_608	Pipe	3.09	3.08	0	0.375		
QueenB_609	Pipe	2.71	2.62	0	0.375		
QueenB_610	Pipe	2.64	2.59	0	0.375		
QueenB_611	Pipe	2.61	2.37	0	0.375		
QueenB_612	Pipe	2.29	1.8	0	1.05		
QueenB_613	Pipe	1.78	1.4	0	1.05		
QueenB_614	Pipe	1.1	1.05	0	1.05		
QueenB_615	Pipe	1.27	1.1	0	1.05		
QueenB_616	Pipe	1.4	1.4	2.5	1.05		
QueenB_663	Pipe	1.86	1.79	7	0.525		
QueenB_664	Pipe	1.73	1.76	6.8	0.525		
QueenB_665	Pipe	3.25	3.18	48	0.45		
QueenB_73	Pipe	3.2	3	0	0.375		
QueenB_74	RCBC	2.31	2.3	1.1056		0.9	0.3
QueenB_75	RCBC	2.52	2.45	1.5		0.9	0.45
QueenB_76	RCBC	2.57	2.49	1.72		0.9	0.45
QueenB_77	RCBC	2.42	2.32	1.92		0.9	0.45
QueenB_78	Pipe	2.04	1.25	189	0.45		
QueenB_79	Pipe	2.08	2.04	10.7	0.375		
QueenB_80	Pipe	1.86	1.79	7	0.525		
QueenB_81	Pipe	1.73	1.76	6.8	0.525		
QueenB_82	RCBC	2.19	2.04	16.5		0.6	0.3
DonSt_240	Pipe	8.64	8.31	26.6	0.375		
DonSt_241	RCBC	9.65	9.06	0		1.2	0.25
DonSt_242	RCBC	9.35	9.28	16.5		0.9	0.25
DonSt_243	RCBC	8.92	8.92	0		0.6	0.3
DonSt_244	Pipe	8.7	8.53	0	0.6		
DonSt_245	RCBC	8.45	8.36	23.8		0.9	0.45
DonSt_246	Pipe	8.36	8.36	10.4	0.6		
DonSt_247	RCBC	8.53	8.36	40.8		1.35	0.6
DonSt_248	RCBC	8.36	8.35	50		1.35	0.6
DonSt_249	RCBC	9.06	8.92	36.5		0.9	0.25
DonSt_331	Pipe	3.19	3.12	3.8	0.375		
DonSt_332	RCBC	3.12	2.99	16.4		0.6	0.3
DonSt_333	RCBC	3.4	3.34	7.2		0.6	0.3
DonSt_334	Pipe	3.48	3.4	3.8	0.375		
DonSt_335	Pipe	3.32	2.99	53	0.45		
DonSt_336	Pipe	2.99	2.79	57.5	0.45		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
DonSt_337	RCBC	2.94	2.89	7		0.6	0.3
DonSt_338	Pipe	3.24	2.91	12	0.375		
DonSt_339	Pipe	2.79	2.77	0	0.45		
DonSt_340	Pipe	2.77	2.75	0	0.45		
DonSt_341	Pipe	6.37	5.99	2.72	0.525		
DonSt_342	Pipe	18.21	15.11	22	0.45		
DonSt_343	Pipe	20.97	18.4	18.5	0.375		
DonSt_344	Pipe	22	18.24	24	0.3		
DonSt_345	Pipe	15.06	14.23	42.8	0.45		
DonSt_346	Pipe	15.2	14.85	5.9	0.3		
DonSt_347	Pipe	14.1	13.66	34.2	0.6		
DonSt_348	Pipe	13.66	13.65	15.5	0.6		
DonSt_349	Pipe	26.46	21.05	38.8	0.3		
DonSt_350	Pipe	20.93	16.66	31.6	0.3		
DonSt_351	Pipe	16.58	14.43	29.1	0.375		
DonSt_352	Pipe	4.47	3.93	0	0.45		
DonSt_353	Pipe	4.62	4.47	13.3	0.45		
DonSt_354	Pipe	4.93	4.62	13	0.375		
DonSt_355	Pipe	5.35	4.99	12.4	0.375		
DonSt_356	Pipe	4.99	4.87	17.5	0.45		
DonSt_357	RCBC	5.89	5.75	18		1.2	0.45
DonSt_358	RCBC	11.07	5.91	157.9		1.2	0.45
DonSt_359	RCBC	11.61	11.07	18.8		1.2	0.45
DonSt_360	RCBC	13.78	13.69	21.4		0.6	0.3
DonSt_361	RCBC	13.95	13.81	14.4		0.6	0.3
DonSt_362	RCBC	5.31	3.93	27.3		1.2	0.5
DonSt_363	RCBC	3.92	3.72	92		1.9	0.45
DonSt_364	RCBC	14.02	13.65	15.5		0.6	0.3
DonSt_365	Pipe	27.29	22.11	12.6	0.3		
DonSt_366	RCBC	13.7	13.65	0		0.6	0.3
DonSt_367	RCBC	14.39	13.65	0		0.6	0.3
DonSt_368	Pipe	11.72	11.61	0	0.6		
DonSt_369	Pipe	13.32	11.72	0	0.6		
DonSt_370	Pipe	11.97	11.82	0	0.375		
DonSt_371	RCBC	13.64	12.94	0		1.2	0.3
DonSt_380	RCBC	12.99	11.61	48.7		0.6	0.3
DonSt_381	Pipe	7.16	6.97	22	0.75		
DonSt_382	Pipe	7.68	7.18	28	0.75		
DonSt_383	Pipe	9.18	6.74	187.5	1.05		
DonSt_384	Pipe	21.21	18.63	44.5	0.375		
DonSt_400	Pipe	12.37	11.07	30	0.6		
DonSt_401	Pipe	11	9.48	38.3	0.75		
DonSt_402	Pipe	12.08	11.11	15.3	0.525		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
DonSt_403	Pipe	16.16	12.12	53.3	0.525		
DonSt_404	Pipe	18.25	16.23	63.5	0.525		
DonSt_405	Pipe	7.77	7.77	15	0.45		
DonSt_406	Pipe	6.93	6.74	19.5	1.05		
DonSt_407	Pipe	9.44	9.19	18.8	0.75		
DonSt_448	Pipe	14.15	12.43	33.33	0.45		
DonSt_469	RCBC	14.03	12.98	48.7		0.6	0.3
DonSt_470	RCBC	12.72	11.81	34.4		0.6	0.3
DonSt_471	RCBC	11.81	11.61	15.9		0.6	0.3
DonSt_568	Pipe	6.74	6.74	0.5	1.05		
DonSt_572	RCBC	11.61	11.58	0.5		0.6	0.3
DonSt_573	RCBC	12	11.81	7.5		0.6	0.3
DonSt_656	Pipe	7.22	6.91	45.7	0.6		
DonSt_672	RCBC	8.91	8.53	13.8		1.2	0.6
DonSt_673	Pipe	8.7	8.53	0	0.6		
DonSt_674	RCBC	8.53	8.36	40.8		1.35	0.6
DonSt_675	RCBC	8.36	8.35	50		1.35	0.6
DonSt_685	Pipe	2.79	2.77	0	0.45		
DonSt_686	Pipe	2.77	2.75	0	0.45		
DonSt_687	RCBC	13.64	12.94	0		1.2	0.3
DonSt_719	Pipe	6.74	6.74	0.5	1.05		
DonSt_722	RCBC	11.61	11.58	0.5		0.6	0.3
Horse_123	RCBC	2.09	2.04	5.8		1.5	0.6
Horse_124	RCBC	2.28	2.16	10.7		1.5	0.6
Horse_125	RCBC	2.04	1.99	169.4		2.1	0.65
Horse_126	Pipe	3.19	3.1	18.5	0.45		
Horse_127	RCBC	2.11	2.09	7		1.5	0.6
Horse_128	RCBC	2.15	2.11	12.6		1.5	0.6
Horse_129	RCBC	2.32	2.3	61.7		1.2	0.5
Horse_130	Pipe	2.28	2.28	7.2	0.45		
Horse_131	RCBC	2.39	2.32	54.8		1.2	0.5
Horse_132	RCBC	2.32	2.32	18.2		1.2	0.5
Horse_133	Pipe	2.5	2.34	12.5	0.45		
Horse_134	Pipe	2.57	2.5	7.3	0.45		
Horse_135	RCBC	2.49	2.47	18		0.6	0.4
Horse_136	RCBC	2.49	2.36	6.9		0.6	0.4
Horse_137	RCBC	2.47	2.41	7.8		0.75	0.4
Horse_138	RCBC	2.31	2.24	12.7		0.9	0.3
Horse_139	Pipe	2.23	2.12	25.3	0.45		
Horse_140	Pipe	2.27	2.25	7.6	0.375		
Horse_141	Pipe	3.1	1.99	0	0.45		
Horse_142	Pipe	2.03	1.64	13.1	0.45		
Horse_143	RCBC	1.99	1.99	15		2.1	0.65

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
Horse_181	Pipe	1.83	1.79	59.2	0.375		
Horse_199	Pipe	2.21	2.08	0	0.3		
Horse_200	Pipe	2.08	1.85	16.9	0.375		
Horse_201	RCBC	2.18	1.84	14.6		0.6	0.3
Horse_206	Pipe	1.75	1.69	60	0.375		
Horse_671	RCBC	2.18	1.84	14.6		0.6	0.3
Muller_204	Pipe	1.99	1.97	0	0.525		
Muller_205	RCBC	2.04	1.99	0		0.6	0.3
Muller_286	Pipe	7.53	7.52	1.8	0.525		
Muller_287	RCBC	6.87	6.87	0		1.2	0.52
Muller_288	RCBC	9.07	8.69	0		0.5	0.4
Muller_289	Pipe	9.2	8.6	43.3	0.45		
Muller_290	Pipe	12.33	8.39	72.3	0.525		
Muller_291	RCBC	8.62	8.51	17		0.6	0.3
Muller_292	RCBC	8.75	8.5	12.9		0.6	0.2
Muller_293	Pipe	35.44	31.18	24	0.375		
Muller_294	Pipe	7.62	6.99	13.2	0.45		
Muller_295	Pipe	8.97	8.18	39.2	0.6		
Muller_296	Pipe	9.94	9.4	15.3	0.375		
Muller_297	Pipe	12.78	8.61	63.9	0.45		
Muller_298	Pipe	15.73	12.83	30.9	0.45		
Muller_299	Pipe	16.46	15.86	7	0.45		
Muller_300	Pipe	30.75	16.62	63.5	0.375		
Muller_301	Pipe	4.56	4.02	35.9	0.525		
Muller_302	Pipe	8.18	6.87	56.5	0.75		
Muller_303	Pipe	8.39	7.52	38.86	0.525		
Muller_304	RCBC	2.85	2.5	0		1.2	0.6
Muller_305	RCBC	2.85	2.5	0		1.2	0.6
Muller_306	Pipe	4.91	4.52	0	0.45		
Muller_307	RCBC	8.69	8.39	0		0.5	0.4
Muller_308	Pipe	8.58	6.87	0	0.45		
Muller_309	Pipe	4.02	2.85	0	0.525		
Muller_310	RCBC	7.14	6.35	0		1.3	0.45
Muller_311	RCBC	6.87	6.35	0		1.2	0.52
Muller_312	RCBC	6.35	4.32	0		1.4	0.8
Muller_313	Pipe	4.32	2.85	0	1.05		
Muller_314	Pipe	8.45	8.39	2.8	0.525		
Muller_315	Pipe	7.52	7.14	34.56	0.525		
Muller_316	Pipe	9.25	9.16	3.73	0.375		
Muller_317	Pipe	9.16	9.07	3.55	0.6		
Muller_318	Pipe	9.07	8.97	3.73	0.6		
Muller_319	RCBC	8.51	8.51	0.2		0.6	0.3
Muller_372	Pipe	6.54	4.91	58.5	0.375		

ID	Type	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Length (m)	Diameter (m)	Width (m)	Height (m)
Muller_373	Pipe	4.33	4	4	0.375		
Muller_374	RCBC	4.85	4.66	7.6		0.6	0.3
QueenB_83	RCBC	2.3	2.22	7		0.6	0.3
QueenB_84	Pipe	0.24	0.18	57.8	1.5		
QueenB_85	Pipe	3.25	3.23	7.5	0.375		
QueenB_86	Pipe	3.23	2.45	20	0.375		
QueenB_87	Pipe	2.47	2.45	18.8	0.375		
QueenB_88	Pipe	0.73	0.62	54.3	1.5		
QueenB_89	Pipe	1.51	1.31	11.2	0.825		
QueenB_90	Pipe	1.42	1.31	10.6	0.75		
QueenB_91	Pipe	1.51	1.5	9.7	0.75		
QueenB_92	Pipe	1.77	1.63	73.1	0.6		
QueenB_93	Pipe	2.26	1.62	7.7	0.375		
QueenB_94	Pipe	2.05	1.77	9.22	0.6		
QueenB_95	Pipe	2.28	2.14	28	0.375		
QueenB_96	Pipe	2.05	2	14.1	0.6		
QueenB_97	Pipe	2.32	2.08	11.1	0.8		
QueenB_98	Pipe	2.4	2.36	7.4	0.375		
QueenB_99	Pipe	2.91	2.8	7.4	0.375		

Appendix C

Design Flood Depths Maps

BOWEN LOCAL CATCHMENT FLOOD STUDY

50% AEP Design Flood Depths and Extents

Appendix C

LEGEND

Property Boundary
Hydraulic Model Area

Water Depths (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0 - 2.0
- > 2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

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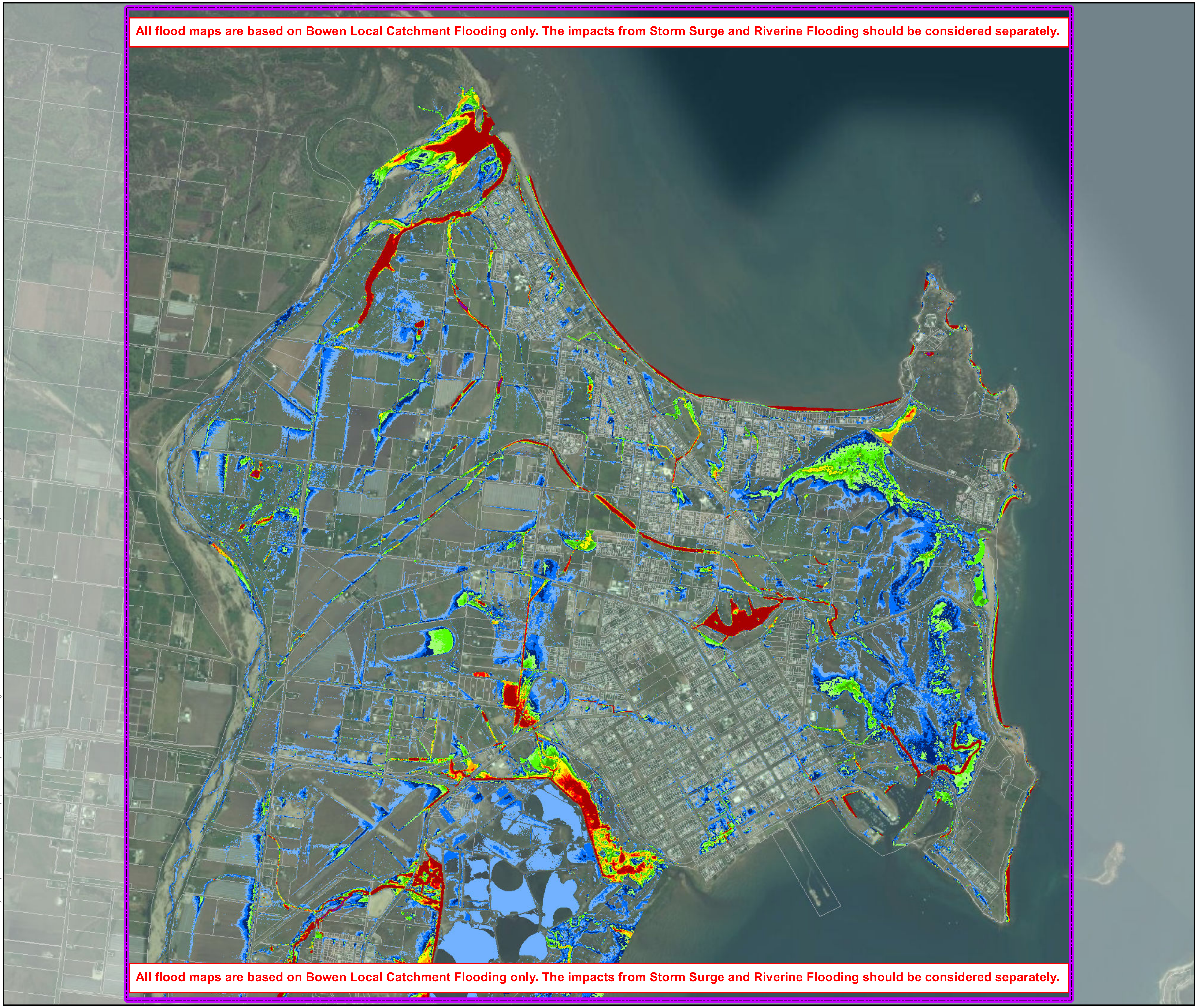

BOWEN LOCAL CATCHMENT FLOOD STUDY

20% AEP Design Flood Depths and Extents

Appendix C

LEGEND

Property Boundary
Hydraulic Model Area

Water Depths (m)

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0
1.0 - 2.0
> 2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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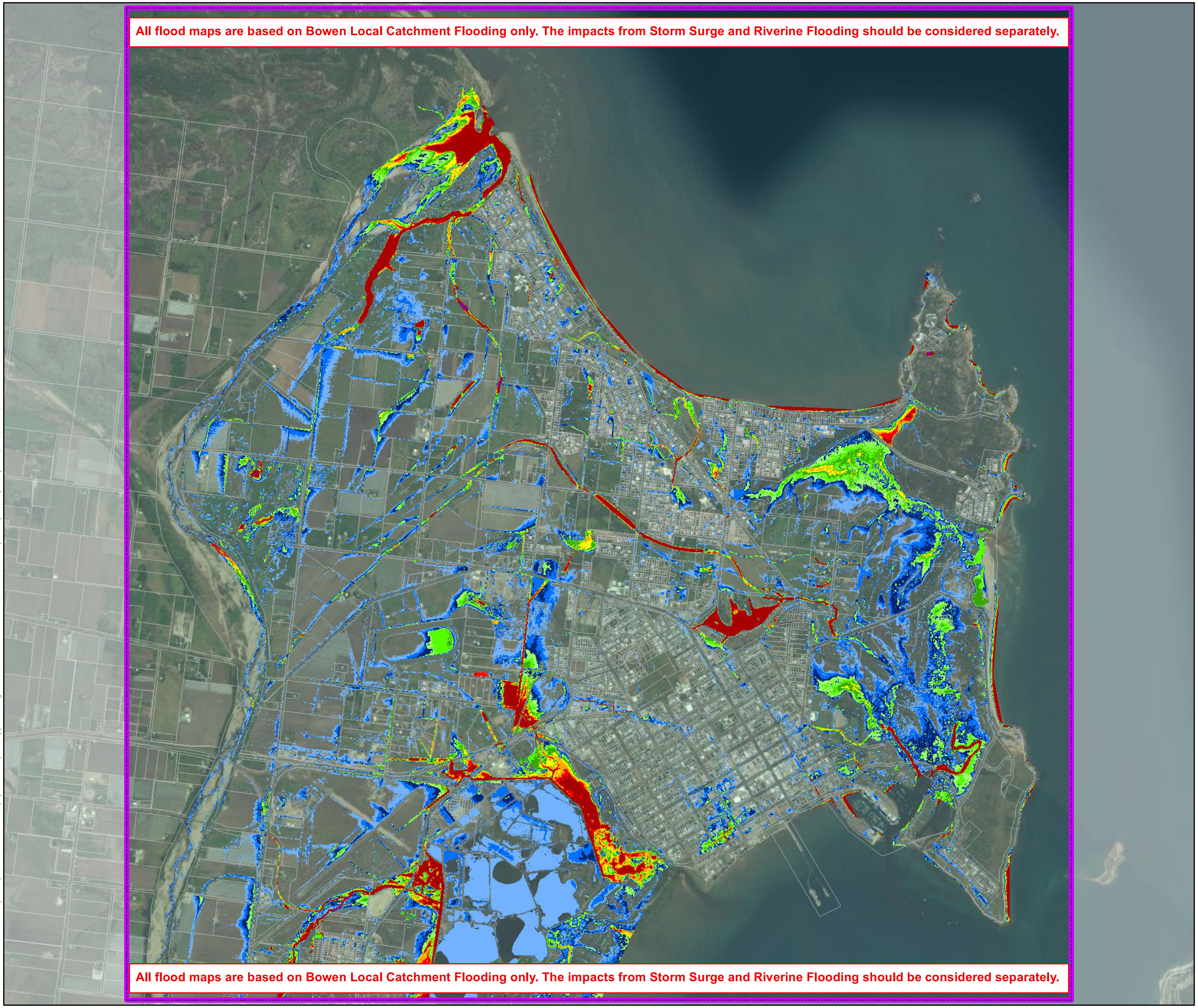
BOWEN LOCAL CATCHMENT FLOOD STUDY

10% AEP Design Flood Depths and Extents

Appendix C



LEGEND

Property Boundary

Hydraulic Model Area

Water Depths (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0 - 2.0
- > 2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

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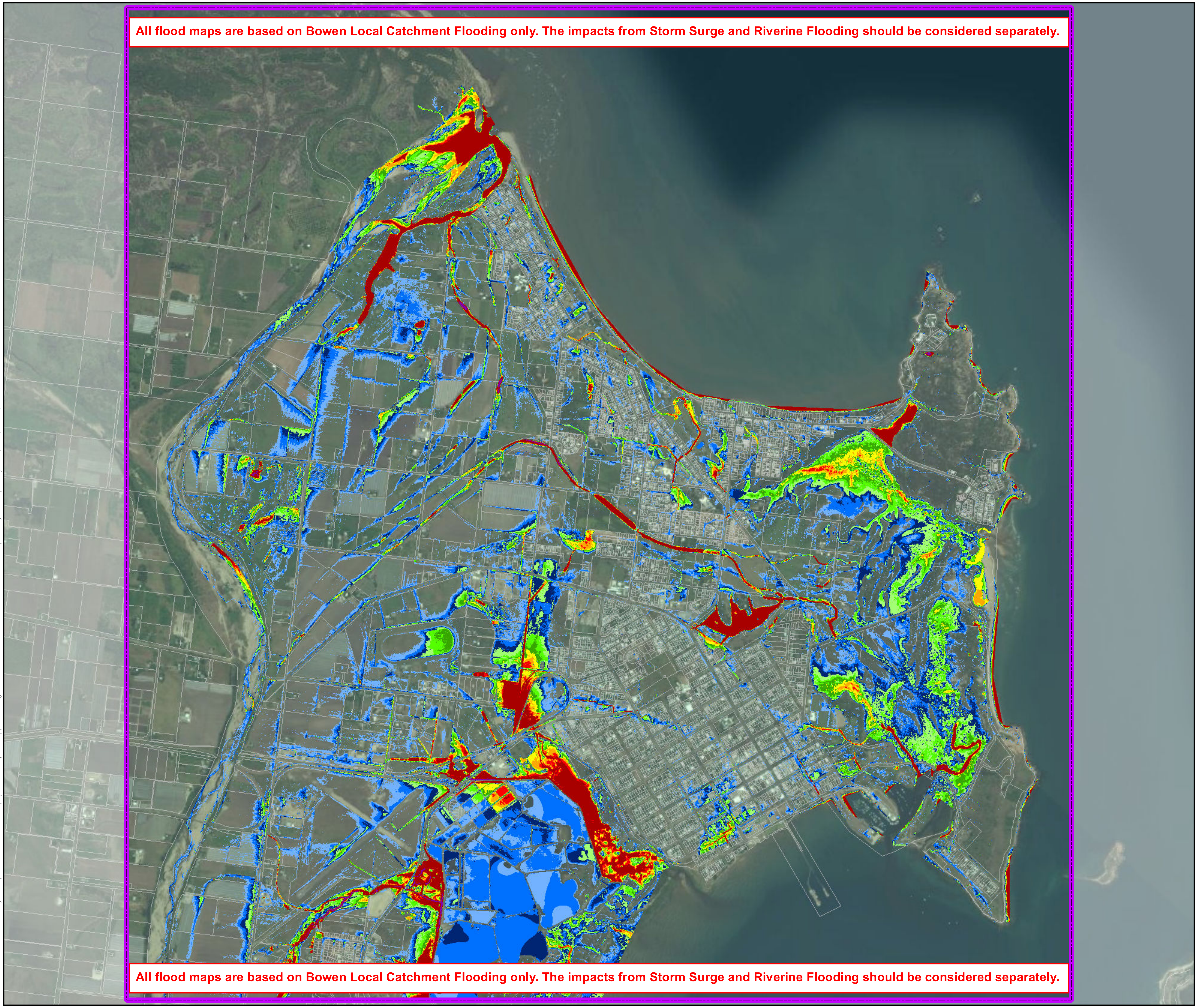

BOWEN LOCAL CATCHMENT FLOOD STUDY

2% AEP Design Flood Depths and Extents

Appendix C

LEGEND

Property Boundary
Hydraulic Model Area

Water Depths (m)

0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
0.8 - 0.9
0.9 - 1.0
1.0 - 2.0
> 2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
Imagery - ESRI 2015

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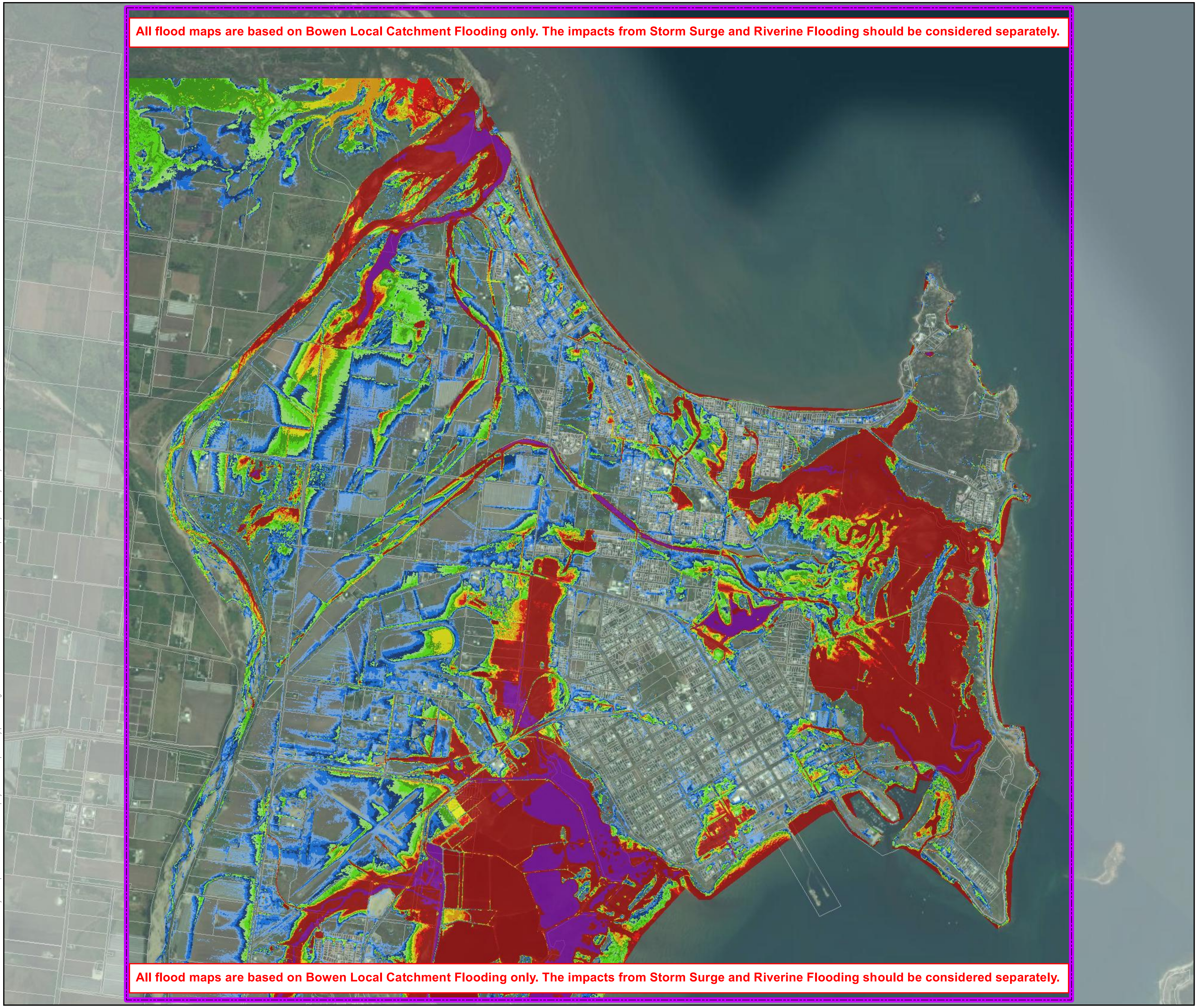

BOWEN LOCAL CATCHMENT FLOOD STUDY

PMF Design Flood Depths and Extents

Appendix C

LEGEND

- Property Boundary
- Hydraulic Model Area

Water Depths (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- 1.0 - 2.0
- > 2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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Appendix D

Design Flood Elevation Maps

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BOWEN LOCAL CATCHMENT FLOOD STUDY

50% AEP Design Flood Elevations

Appendix D

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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Imagery - ESRI 2015

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BOWEN LOCAL CATCHMENT FLOOD STUDY

20% AEP Design Flood Elevations

Appendix D

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
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BOWEN LOCAL CATCHMENT FLOOD STUDY

10% AEP Design Flood Elevations

Appendix D

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
Highway, Roads - StreetPro 2014
Study Area, Catchments - AECOM 2015
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BOWEN LOCAL CATCHMENT FLOOD STUDY

2% AEP Design Flood Elevations

Appendix D

LEGEND

Property Boundary
Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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BOWEN LOCAL CATCHMENT FLOOD STUDY

PMF Design Flood Elevations

Appendix D

LEGEND

- Property Boundary
- Hydraulic Model Area

Levels (m AHD)

- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- 3.00 - 3.50
- 3.50 - 4.00
- 4.00 - 4.50
- 4.50 - 5.00
- 5.00 - 5.50
- 5.50 - 6.00
- 6.00 - 6.50
- 6.50 - 7.00
- 7.00 - 7.50
- 7.50 - 8.00
- 8.00 - 8.50
- 8.50 - 9.00
- 9.00 - 9.50
- 9.50 - 10.00
- > 10.00

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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Appendix E

Design Flood Velocity Maps

BOWEN LOCAL CATCHMENT FLOOD STUDY

50% AEP Design Flood Velocities

Appendix E

LEGEND

- Property Boundary
- Hydraulic Model Area

Velocity (m/s)

- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 2.0
- >2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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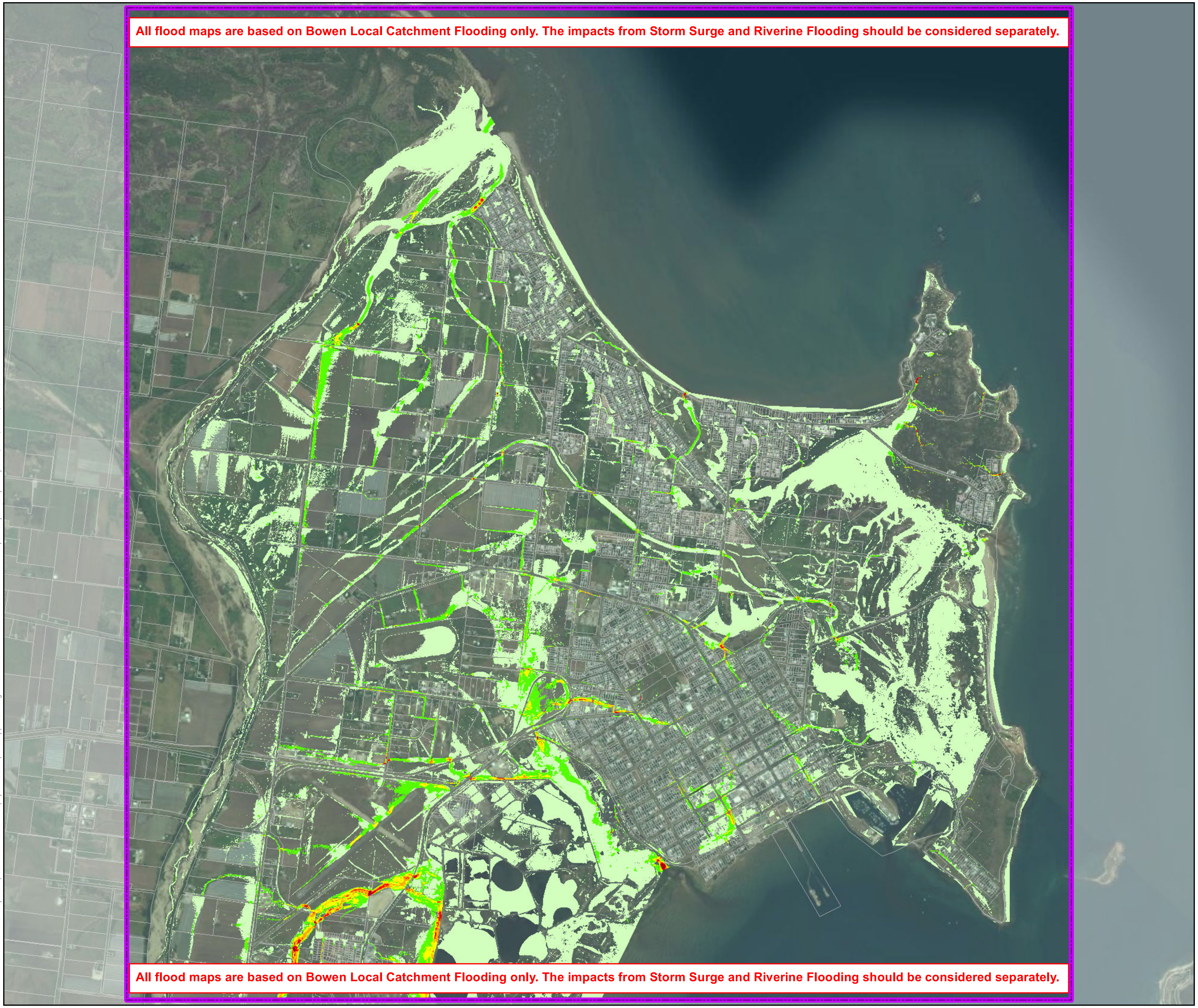
User: smithc5 | Date Saved: 11/02/2015 | FileName: Y:\TSV_GIS\Projects\60332898\02_MXDs\G60332898_021_50percentVel_20150121_v1_A3.mxd

BOWEN LOCAL CATCHMENT FLOOD STUDY

20% AEP Design Flood Velocities

Appendix E



LEGEND

Property Boundary

Hydraulic Model Area

Velocity (m/s)

- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 2.0
- >2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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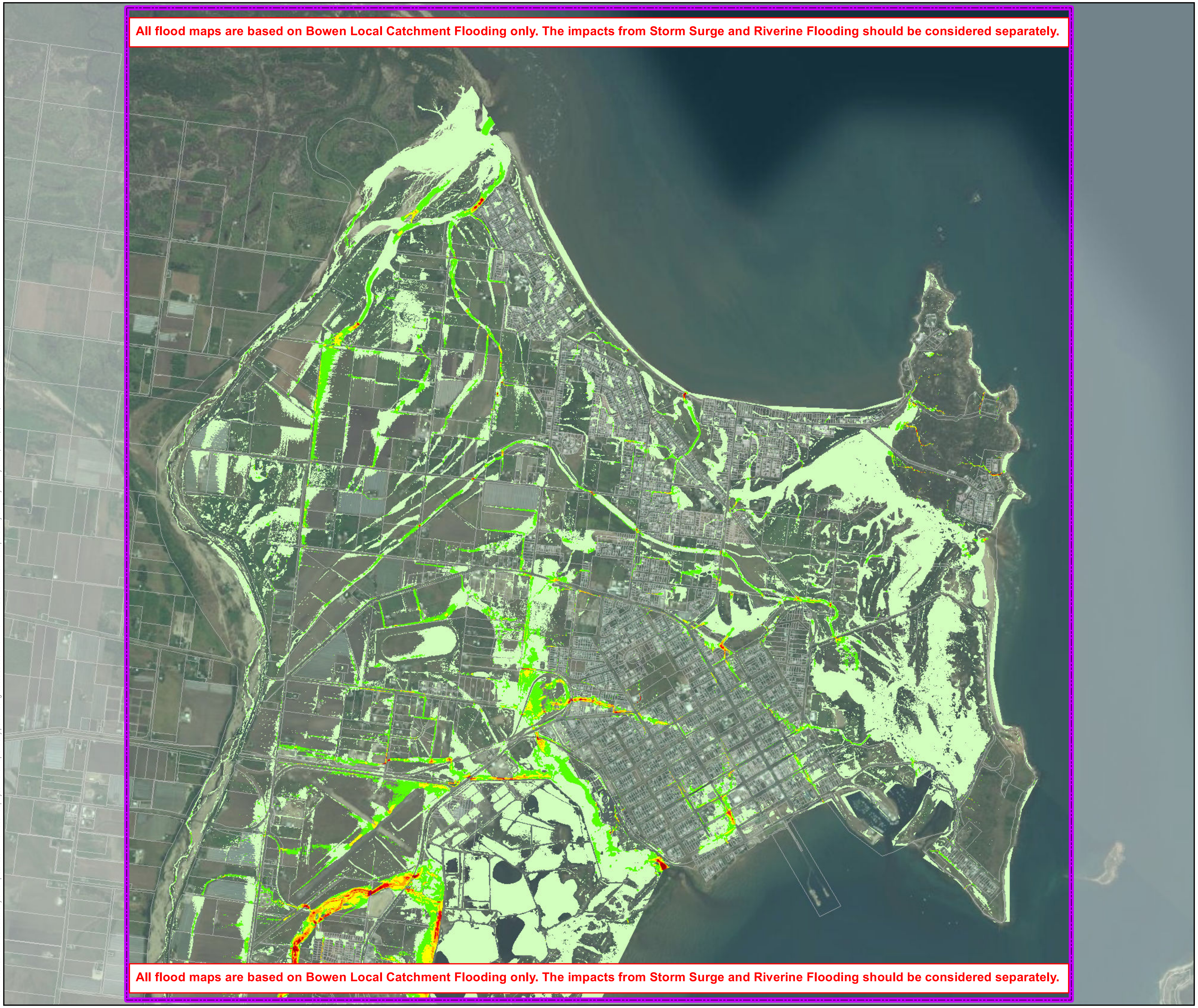
BOWEN LOCAL CATCHMENT FLOOD STUDY

10% AEP Design Flood Velocities

Appendix E



LEGEND

Property Boundary

Hydraulic Model Area

Velocity (m/s)

- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 2.0
- >2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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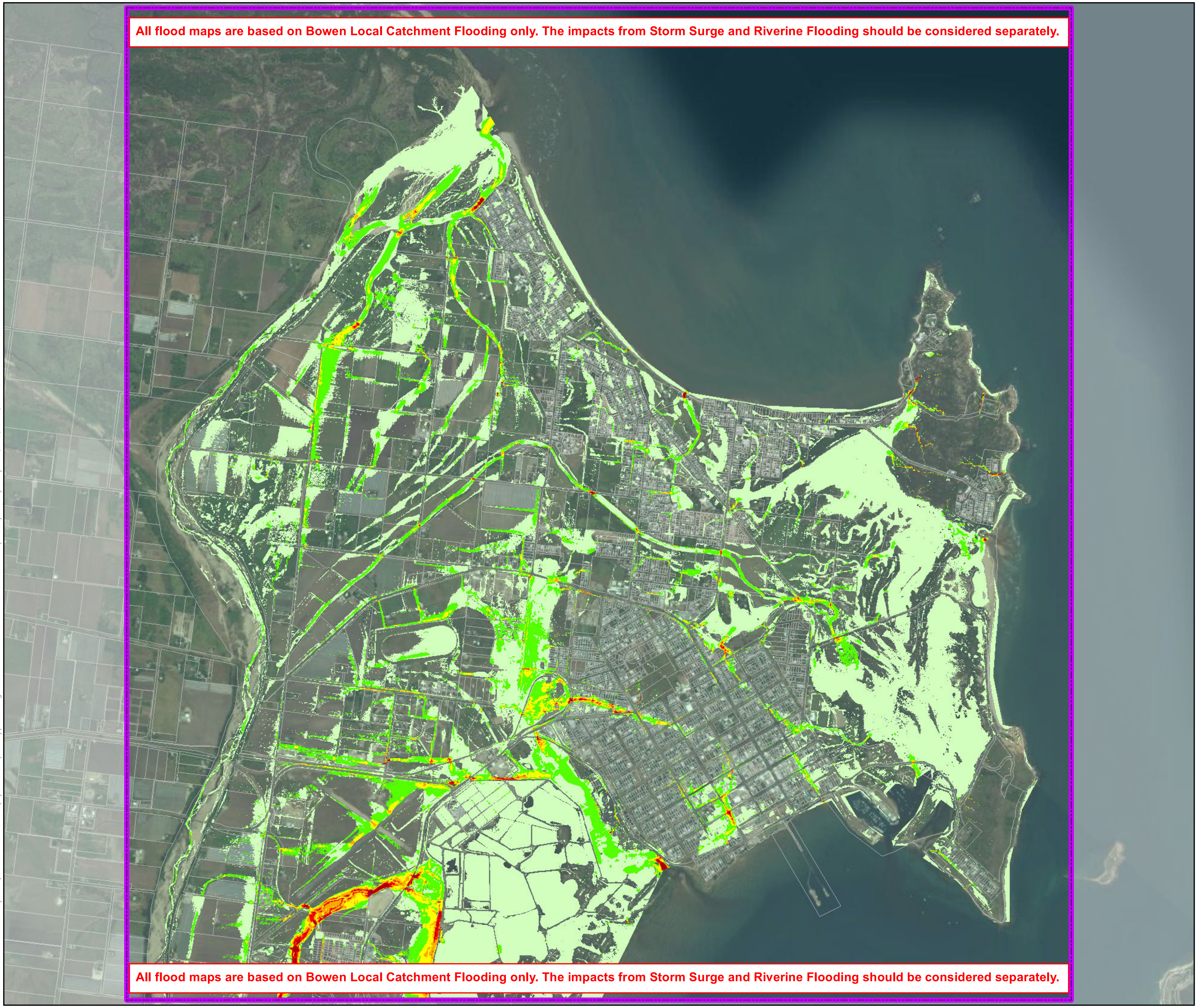

All flood maps are based on Bowen Local Catchment Flooding only. The impacts from Storm Surge and Riverine Flooding should be considered separately.

BOWEN LOCAL CATCHMENT FLOOD STUDY

2% AEP Design Flood Velocities

Appendix E

LEGEND

Property Boundary
Hydraulic Model Area

Velocity (m/s)

0.0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 2.0
>2.0

0 250 500 1,000 1,500
Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

Data sources:
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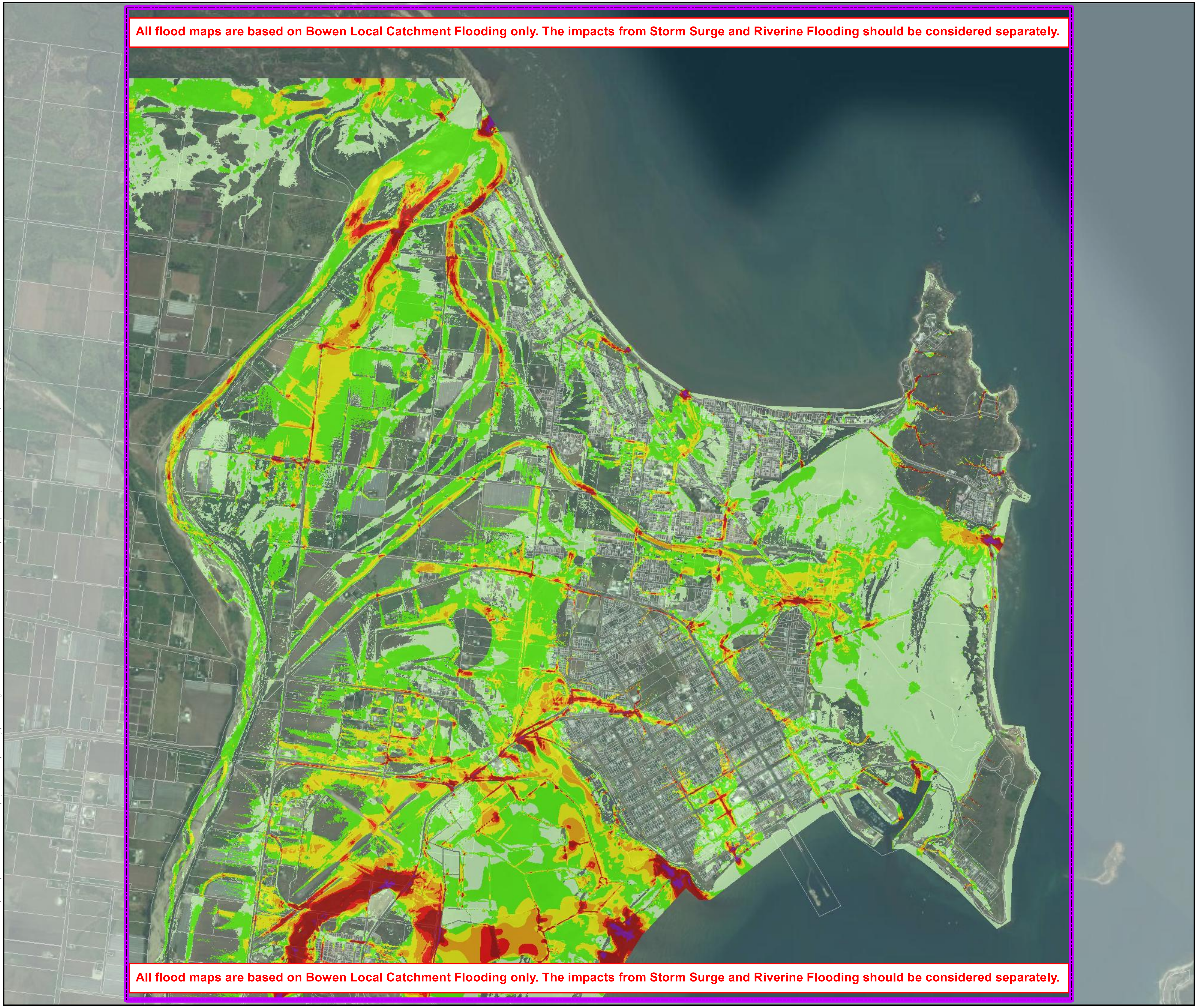
BOWEN LOCAL CATCHMENT FLOOD STUDY

PMF Design Flood Velocities

Appendix E



LEGEND

- Property Boundary
- Hydraulic Model Area

Velocity (m/s)

- 0.0 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 2.0
- >2.0

0 250 500 1,000 1,500

Meters

1:30,000 (when printed at A3)

N

Coordinate System: GDA 1994 MGA Zone 55

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Study Area, Catchments - AECOM 2015
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