WESTERN DOWNS REGIONAL COUNCIL

Miles Flood Study

Volume I

Detailed Technical Report

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Executive Summary

Background

The Miles Flood Study is a Western Downs Regional Council (WDRC) initiative aimed at understanding the risks associated with flooding in Miles. Once the flood risks posed to the residents and businesses of Miles are understood, ways to manage these risks may be developed.

The Miles Flood Study is being undertaken as part of the full WDRC Planning Scheme review currently being undertaken to create one Planning Scheme for the Western Downs Region.

The Flood Study

A flood study is a comprehensive technical investigation of flooding behaviour that defines the extent, depth and velocity of floodwaters for floods of various magnitudes. This information is the principal technical information from which flood overlays for the Planning Scheme are formulated.

There are two principal components to a flood study:

- **Hydrologic analysis** or the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and hydrographs for a range of floods.
- **Hydraulic analysis** refers to the detailed description of flow down a watercourse or through a rural or urban floodplain or a combination of both to determine the extent, depths and velocities of flooding.

It is usual to undertake hydrologic and hydraulic analyses using computer modelling systems. Data about the catchments, floodplains, rivers, structures (e.g. bridges and culverts), land use (e.g. rural or urban) are all fed into the models. Once all the data is in the models, the models are "calibrated" to historic events to ensure that rainfall and floodplain processes can be accurately reproduced.

Following model calibration a series of theoretical "design" events are applied to the models with the aim of determining the flood hazard for flood events ranging from common (floods that could be expected to occur, on average every few years) to extreme (floods that could be expected to occur, on average once in a generation or even less frequently; e.g. the 1956 flood).

Flood Hazard

Flood hazard refers to the potential loss of life, injury and economic loss caused by future floods events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration and rate of rise of floodwaters), topography, population at risk and emergency management. Flood hazard is typically defined in the following terms:

- **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.
- **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.

- **High** – fit adults have difficulty in wading to safety; wading evacuation routes are long again; Motor vehicle evacuation is possible only by 4WD vehicles or trucks and only in the early stage of flooding. Boats or helicopters may be required.
- **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. Extreme hazard is produced when flood depths exceed 1.0m, velocities exceed 1.5m/s or the combination of depth and velocity exceeds $0.6m^2/s$.

Work undertaken for the Miles Flood Study

As this is the first substantial flood study for Miles, WDRC and the project team undertook a significant amount of research and data gathering. This was in the form of:

- Community consultation,
- Research by the Dalby Family Historical Society, the Chinchilla Museum and the Miles Museum,
- Research by Council officers, and
- Interviews with residents.

Data gathered included:

- Official records (e.g. Bureau of Meteorology).
- Previous flood study reports.
- Newspaper articles.
- Photos.
- Recorded flood height records by long-term town residents.
- Flood marks on buildings and other structures.
- Anecdotal evidence/family histories of flood heights on structures (e.g. for floods that occurred over 80 years ago where there is a family history of how high the flood occurred on the house; which is still standing).

WDRC also commissioned highly accurate, aerial survey over Miles, which has been a vital component of this study and will continue to be a valuable resource for the Miles community into the future.

Based on the historic flood information gathered by WDRC and the community, a significant amount of technical analysis was undertaken. This is discussed in detail in this document.

Study Update

The initial Miles Flood Study report was submitted in November 2012. Since then a significant amount of additional work has been undertaken including:

- Extensive community consultation and additional data gathering which resulted in a previously unavailable gauge record being identified (Dogwood Creek at the Warrego Highway). Previously, the earliest gauge record available was in 1949 whereas the gauge record now extends back to 1918,

- A revised Flood Frequency Analysis using the latest available techniques (as currently being developed through the revision of Australian Rainfall and Runoff) was undertaken on the newly available gauge record.

Through these additional investigations, an increased level of confidence in flood magnitude at Miles has been gained, and the design flood levels (including 1 in 100 AEP level) have been revised. The revised 1 in 100 AEP discharge estimate is approximately 20% lower than the Nov 2012 discharge estimate.

The decrease in the design flows has resulted in a corresponding decrease in design levels for Miles.

Miles Flood Study – Lessons Learned

The Miles Flood Study has provided an increased understanding of floods and flood hazard for Miles. Specific lessons learned include:

- There is substantial flood hazard in and around the lower parts of the town adjacent to Dogwood Creek (due to the depth of water). In most locations this flood hazard decreases relatively quickly with increasing terrain elevation.
- There has only been a small amount of development in and around Miles over recent decades. However, as this development has generally occurred outside of the floodplain, it has not had a substantial impact on (and is not significantly exposed to) flood risk.
- While the areas where there is ongoing development pressure in Miles are relatively low (Dogwood Creek) flood risk, WDRC need to ensure appropriate management (through the Planning Scheme) of stormwater flooding.

Outcomes of the Miles Flood Study

Outcomes of the Miles Flood Study that will have direct benefit to the Miles community include a series of maps detailing flood hazard for:

- Dogwood Creek floods, and
- Local stormwater floods.

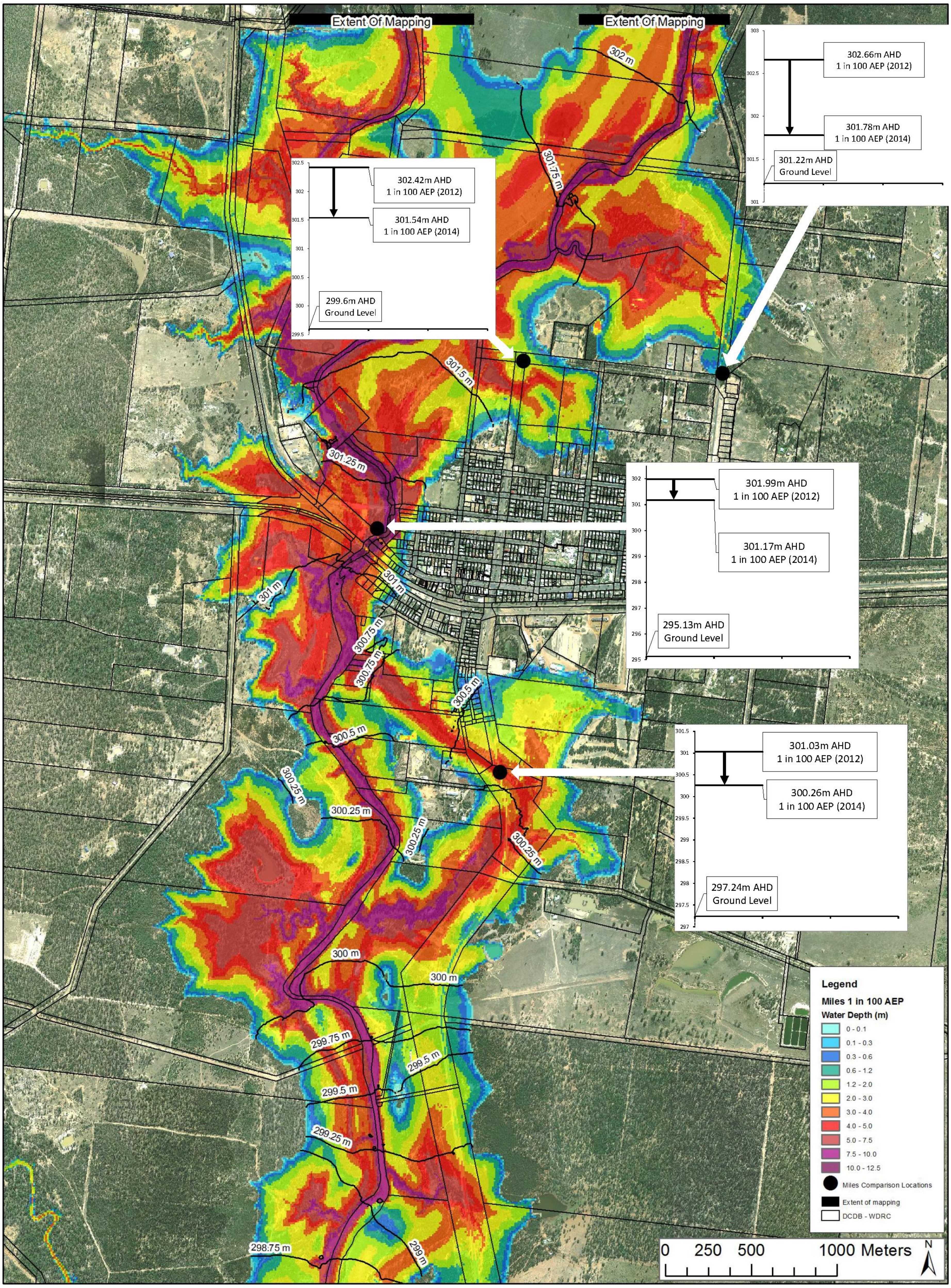
The maps will be an invaluable tool to ensure appropriate development that provides a suitable level of safety while not adversely impacting on existing properties or residents (e.g. by blocking of overland flowpaths and/or redirecting stormwater onto nearby properties).

Other outcomes of the study include a consolidated set of historic flood data that will be of ongoing value to the community and detailed survey information for the town.

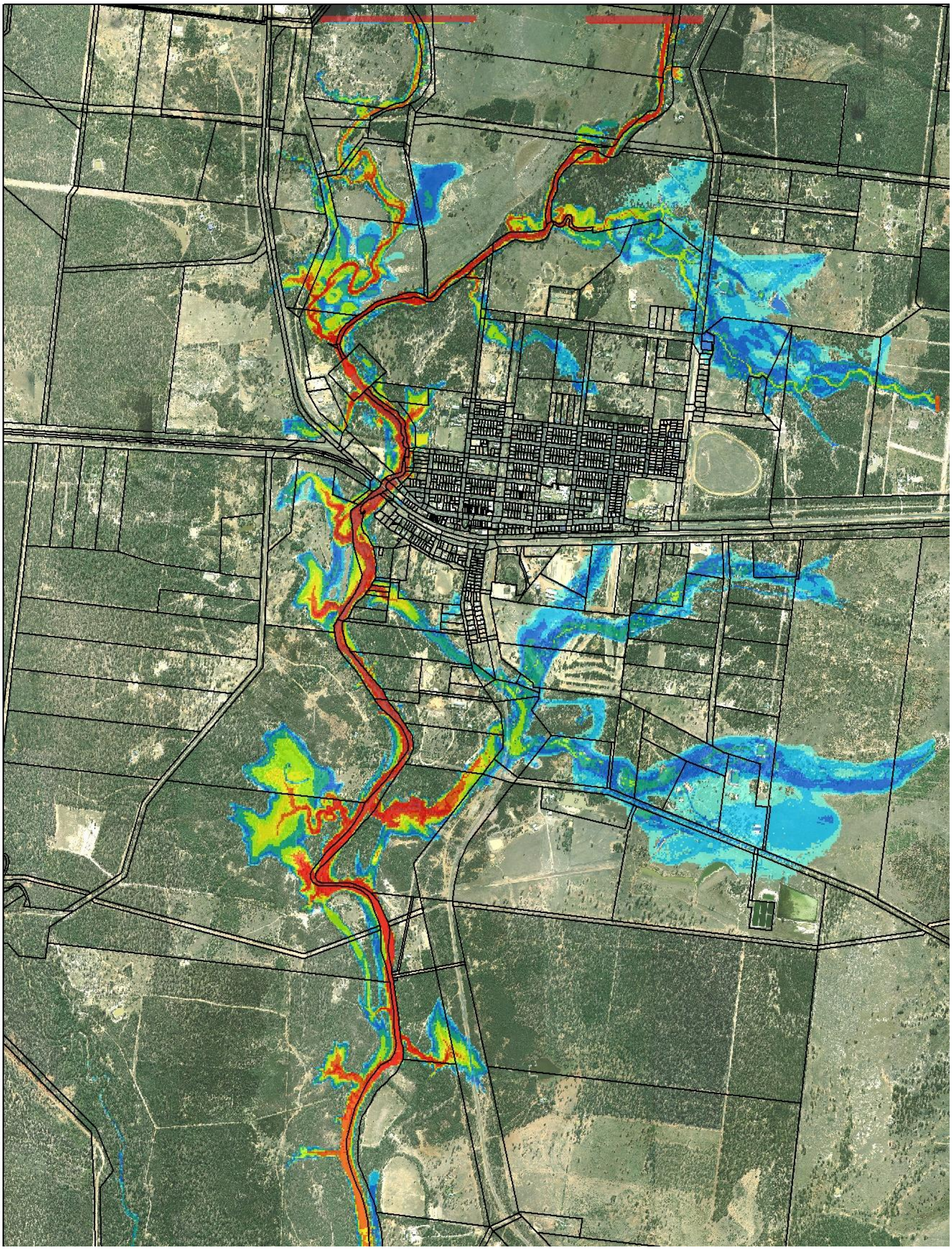
Report Format

For convenience, this report consists of two volumes:

- Volume I: Miles Flood Study Detailed Technical Report (this document).
- Volume II: Miles Flood Study Maps.



Miles 1 in 100 AEP Riverine Flood Depth



Miles 1 in 100 AEP Stormwater Flood Depth

Acknowledgements

This study would not have been possible without the support of the following people and organisations:

- The residents of Miles (past and present).
- The Dalby Family Historical Society.
- The Chinchilla Museum.
- The Miles Museum.
- WDRC Councillors.
- WDRC Officers.

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Abbreviations

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AR&R	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
DNRM	Department of Natural Resources and Mines
DFE	Defined Flood Event
DTM	Digital Terrain Model
DTMR	Department of Transport and Main Roads
EWS	Energy and Water Supply, Queensland Government
GIS	Geographic Information System
LIDAR	Light Detection and Ranging
NFRAG	National Flood Risk Advisory Group
NHMA	Natural Hazard Management Areas
NRW	Natural Resources and Water (Queensland Government)
QR	Queensland Rail
QRA	Queensland Reconstruction Authority
QFCI	Queensland Flood Commission of Inquiry
SPP 1/03	State Planning Policy 1/03

Glossary

Annual Exceedance Probability (AEP) means the chance of a flood of a given or large size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (1 in 20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Bureau of Meteorology (the Bureau) is Australia's national weather, climate and water agency.
Australian Height Datum (AHD) means a common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI) means the long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event (see AEP).
Catchment is the land area drained by a waterway and its tributaries.
Climate change a change in the state of the global climate induced by anthropogenic change to the atmospheric content of greenhouse gases and that persists for an extended period, typically decades or longer (Note 2)
Culvert is a short passageway under a road, railway or embankment designed to allow stormwater to allow from one side to the other without being dammed.
Defined flood event (DFE) is the flood event adopted by a local government for the management of development in a particular locality.
Defined flood level (DFL) is the level of a flood that would occur during a defined flood event (DFE).
Discharge is the rate of flow of water measured in terms of volume per unit of time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving.
Essential services encompass electrical power, the provision of drinking water, sewerage, stormwater drainage, telecommunications and roads and rail.
Flood relatively high water levels caused by excessive rainfall, storm surge, dam break or a tsunami that overtop the natural or artificial banks of a stream, creek, river, estuary, lake or dam (Note 4)
Flood damage the tangible (direct and indirect) and intangible costs (financial, opportunity cost, clean-up) of flooding. Tangible costs are qualified in monetary terms (e.g. damage to goods and possessions, loss of income or services in the flood aftermath). Intangible damages are difficult to quantify in monetary terms and include the increased levels of physical, emotional and psychological health problems suffered by flood-affected people and attributed to a flooding episode (Note 4)
Flood hazard potential loss of life, injury and economic loss caused by future floods events. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, duration and rate of rise of floodwaters), topography, population at risk and emergency management (Note 4)

Glossary cont.

Flood hazard area, for the purposes of Queensland Development Code, proposed new part 3.5: 'Construction of buildings in flood hazard areas', 21 November 2011 , means an area, whether or not mapped, designated by a local government as a natural hazard management area (flood) under section 13 of the *Building Regulation 2006.*
Flood map is a map which depicts the extent of a particular flood or floods, for example the 1% AEP flood or a historical flood.
Flood overlay map is a map used in land planning to depict the land constrained by planning controls imposed by a council because of the flood risk associated with the land.
Floodplain is an area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by floodwater.
Flood risk is a term that usually embodies both likelihood of flooding and the consequences of flood.
Flow velocity means the speed and direction of flow, measured in metres per second (m/s). (Note 6)
Hydrodynamic (hydraulic) model uses data about the flow in streams and the terrain of a particular area to estimate flood heights, velocities and flow over time. In order to do this the hydrodynamic model solves the equations for the conservation of mass and momentum/energy.
Hydrograph a graph that shows for a particular location, the variation with time of discharge (discharge hydrograph) or water level (stage hydrograph) during the course of a flood (Note 4)
Hydrologic model (runoff routing model) uses rainfall data and estimates of the proportion of the rainfall which turns into runoff and the time which the runoff from each part of the catchment rakes to flow into the stream to estimate flow in the stream over time.
Hydrology is the term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Major flooding is a term used by the Bureau of Meteorology to depict extensive flooding of rural areas and/or urban areas. Properties and towns are likely to be isolated and major traffic routes likely to be closed. Evacuation of people from flood affected areas may be required.
Major Overland Flow Path an overland flow path that drains water from more than one property, has no suitable flow bypass, and has a water depth in excess of 75mm during the major design storms, or is an overland flow path recognized as “significant” by the local government (Note 3).
Major Road a road whose primary function is to serve through traffic. These roads include Collector Roads, Sub-Arterial and Arterial Roads. Refer to Department of Main Roads or AustRoads for further definition (Note 3)
Minor flooding is a term used by the Bureau of Meteorology to depict flooding that occurs in low-lying areas next to watercourses where inundation may require the removal of stock and equipment. Minor roads may be closed and low-level bridges submerged.
Planning scheme is a local planning instrument for regulating development in Queensland. Planning schemes regulate what development must be assessed before it can be undertaken, the type of assessment required and the criteria used in an assessment in each council region. They also contain codes with which self-assessable development must comply.
Probable maximum flood is an estimate of the largest possible flood that could occur at a particular location, under the most severe meteorological and hydrological conditions.

Glossary cont.

Q100 is a probability-based design flood event discharge, aimed to reflect typical combinations of flood producing and flood modifying factors which act together to produce a flood event at a specific location of interest that has a I in 100 chance of being equalled or exceeded in any one year (1% annual exceedance probability - AEP): it is described as having an average recurrence interval (ARI) of 100 years. It is a theoretical flood model used to inform planning and policy (see AEP and ARI).

Stormwater is the rain water that has not yet entered a river system or soaked into the ground.

Stormwater flooding inundation by local runoff caused by heavier than usual rainfall. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow (Note 4).

Stream /river gauging station (gauge) a manual or automated gauge that measures the height of the water in a river at a particular location.

Watercourse as defined in the Sustainable Planning Regulation 2009 (Note 2):

(1) Generally, watercourse means a watercourse as defined under the *Water Act 2000,* schedule 4.
(2) Watercourse, for schedule 3, part 1, table 4, item 5(b)(iv), means a river, creek or stream in which water flows permanently or intermittently –
    (a) in a natural channel, whether artificially improved or not; or
    (b) in an artificial channel that has changed the course of the watercourse
(3) Watercourse, for schedule 24, part 1, section 1(2) –
    (a) Means a river, creek or stream in which water flows permanently or intermittently –
        i) in a natural channel, whether artificially improved or note; or
        ii) in an artificial channel that has changed the course of the watercourse; and
        iii) Includes the bed and banks and any other element of a river, creek or stream confining or containing water.

Waterway as defined under the *Environmental Protection Act 1994* means any of the following (Note 5):

- a creek, river, stream or watercourse
- an inlet of the sea into which a creek, river, stream or watercourse flows
- a dam or weir

Notes

(1) Unless otherwise noted, definitions have been taken from the QFCI Final Report.
(2) Definitions taken from SPP1/03.
(3) Definitions taken from the Queensland Urban Drainage Manual.
(4) Definitions taken from Floodplain Management in Australia, Best Practice Principles and Guidelines.
(5) Definitions taken from SPP4/10.

1 INTRODUCTION

Western Downs Regional Council (WDRC) was created in March 2008 after the amalgamations of local government areas throughout Queensland. WDRC contains six former local government areas and six different Planning Schemes. The former local government areas include Dalby Town Council, Wambo Shire Council, part of Taroom Shire Council, Chinchilla Shire Council, Murilla Shire Council and Tara Shire Council. A full Planning Scheme review is currently being undertaken to create one Planning Scheme for the Western Downs Region to resolve conflicts between the six different Planning Schemes within the Western Downs Regional Council.

WDRC proposed to undertake flood studies of six towns in the region in conjunction with the Planning Scheme review. There are two components to the flood studies; riverine flooding and stormwater flooding. The purpose of the riverine flood studies is to identify areas of risk of flood inundation, their impact upon current and future development and to identify flood hazard categories for the inundation areas for the defined flood event (DFE). The purpose of the stormwater flood analysis is to define and map stormwater corridors within current and future development areas. The six towns included in the study were Dalby, Chinchilla, Miles, Wandoan, Jandowae and Tara.

Figure 1.1 shows the WDRC area and the location of the six towns where flood studies have been undertaken as part of the current planning scheme review.

This report presents the technical analysis undertaken in support of the flood study for Miles. This report consists of two volumes:

- Volume I: Miles Flood Study Detailed Technical Report (this document).
- Volume II: Miles Flood Study Maps.

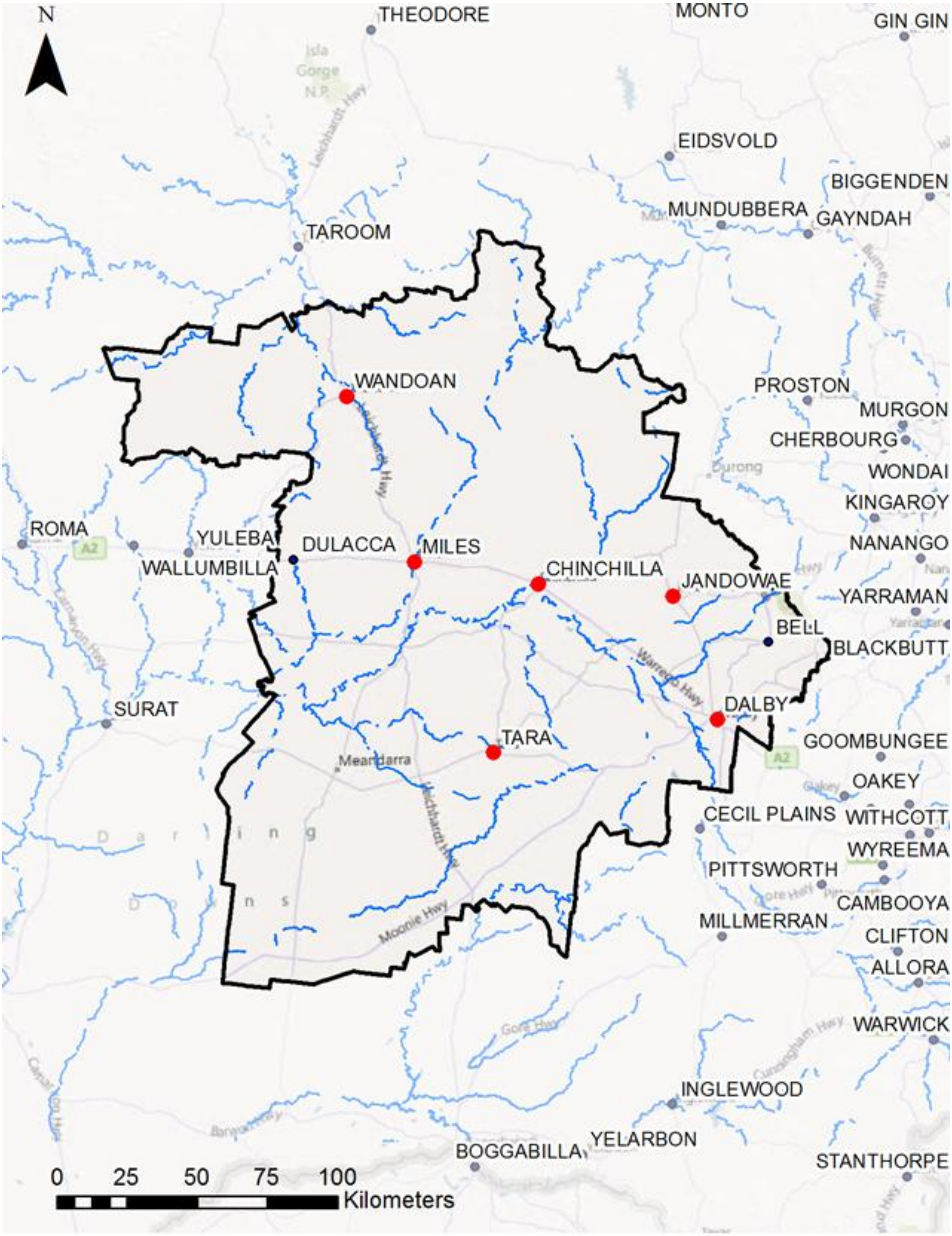

Figure 1.1 Western Downs Regional Council Area

(Red dots represent towns where a flood study has been undertaken as part of the planning scheme revision)

2 AVAILABLE DATA

2.1 Previous Investigations

No previous investigations (in the form of formal flood studies) were available for Miles.

2.2 Topographical Survey

The survey data adopted for this study are:

- A LIDAR survey of the six study towns undertaken by WDRC in 2010 was adopted for:
  - Hydraulic modelling of both riverine and stormwater flooding
  - Catchment delineation for stormwater modelling.
- Topographic data with a resolution of 3 arc seconds was used to estimate the catchments for the riverine flood studies.

2.3 Hydrometerological Data

2.3.1 Rainfall

Table 2.1 lists and Figure 2.1 shows the location of the available rainfall stations throughout the study area.

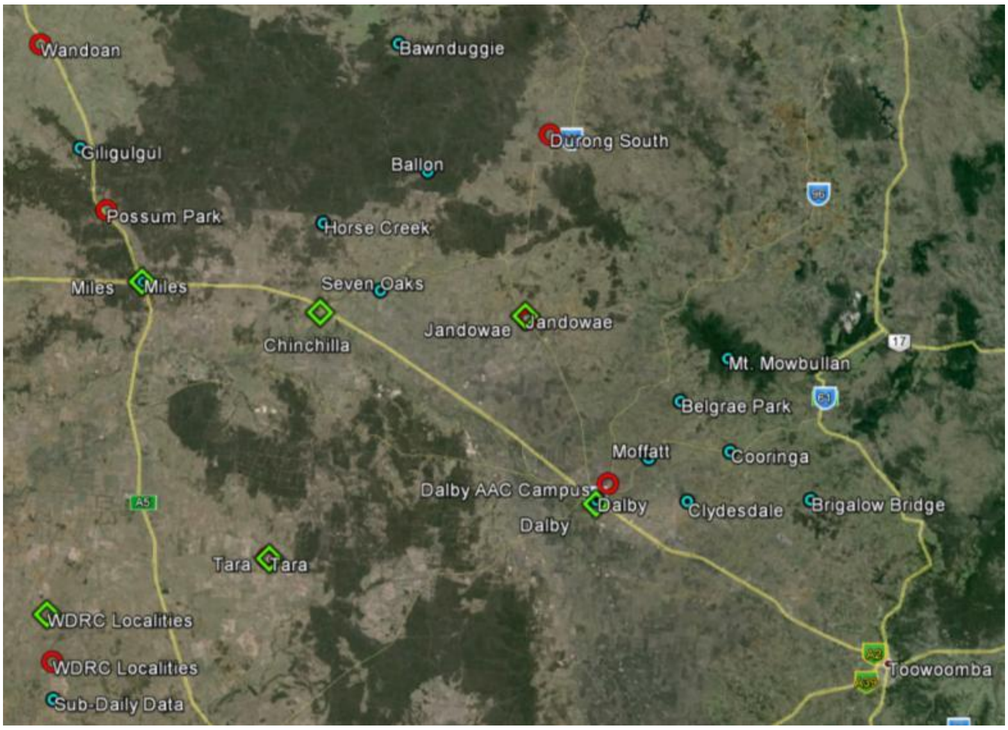

Figure 2.1 Available Rainfall Gauging Stations

(Red markers represent daily stations and blue markers represent sub-daily stations)

Table 2.1 Available Rainfall Stations

Station		
Name	**Number**	**Type [1]**
Miles	042112	AWS
Possum Park	042004	Daily
Seven Oaks	041020	TM
Ballon	041092	TM
Bawnduggie	042036	TM
Durong South	040071	Daily
Horse Creek	042025	TM
Giligulgul	035039	TM
Wandoan	035014	Daily
Jandowae	041050	Daily
Dalby	541041	Alert
Moffatt	541042	Alert
Clydesdale	541043	Alert
Tara	041009	Daily
Belgrae Park	041551	Alert
Cooringa	541044	Alert
Mt Mowbullan	541046	Alert
Brigalow Bridge	041490	TM
Dalby AAC Campus	041497	Daily

Note 1

Daily – Rainfall Stations report rainfall amount received in the 24 hours prior to 9am each day.

Alert – Rainfall and/or stream gauging stations that communicate every one millimetre of rainfall over radio network to Flood Warning Centre

AWS – Automatic Weather Station. Sub hourly data

TM – Rainfall station connected to the public phone network, polled regularly during periods of heavy rain

2.3.2 Stream Gauges

Table 2.2 presents the available stream gauge records for Charley's and Dogwood Creeks, while Figure 2.2 shows the location of the available stream gauging stations for Charley's and Dogwood Creeks.

Table 2.2 Available Stream Gauging Stations

Station		Period of Record	Comments
Name	Number		
Charleys Creek @ STP Telemetry Gauge	422343A (DERM)	19/9/2002 – present	Upstream of Weir near the Chinchilla Sewerage Treatment Plant (STP).
Charleys Creek @ Middle St	041411 (BoM) 422343A (DERM)	1/12/1969 – present	Manual Gauge
Charleys Creek @ Railway Bridge	041351 (BoM)	1943 – 1984	Manual Gauge
Charleys Creek @ Warrego Hwy	n/a	n/a	No gauge boards. Sometimes used as flood level reference.
Charleys Creek @ Seven Oaks	041020 (BoM)	18/5/1999 - present	Water level only – not rated
Dogwood Creek @ Gil Weir [1]	042107 (BoM) 422202B (DERM)	10/1/1949 – present	Upstream of Gil Weir
Dogwood Creek @ Warrego Highway	042049 (BoM)	9/2/1918 – present	- Dogwood Creek Bridge, Warrego Highway - Peak flood level only

Notes:

1) The correct place name is "Gil Weir". However, DERM have adopted the gauge name "Dogwood Creek @ Gilweir". For clarity and consistency, the name "Gil Weir" has been adopted in this report for both the place name and gauging station name.

Figure 2.2 Available Stream Gauging Stations –Charley's and Dogwood Creeks

2.3.3 Miles Gauging Stations.

There are two gauging stations on Dogwood Creek relevant to this study:

- Dogwood Creek at Gil Weir, some 6.5 km downstream of the town.
- Dogwood Creek at the Warrego Highway

Table 2.3 summarises the large floods in Miles between 1918 and 2014.

2.4 Hydraulic Structures

Details for all major hydraulic structures were provided by WDRC. Minor structures, for example culverts under private driveways, were not included in the hydraulic analysis.

2.5 Additional Flood Data Collection

Extensive research was undertaken as part of the study to identify and list historical floods for Dalby, Chinchilla and Miles. Full details are provided in the following sections.

2.6 Available Historical Flood Data Sets

Flood level data for selected large historical floods in Miles is provided in Table 2.3

The data was sourced from:

- WDRC.
- The Department of Environment and Resource Management (DERM).
- The Bureau of Meteorology (BoM).
- Historical research undertaken as part of this study.
- Modelling results from this study.

Table 2.3 Miles Historical Floods – Dogwood Creek at Warrego Highway

	Dogwood Creek at Warrego Highway		
Date [1]	Gauge Ht [2] (m)	Height (m AHD)	Source
5 Apr 1929	9.75	297.13	Dogwood Creek at Warrego Highway Manual Gauge
7 Dec 1931	9.80	297.19	
22 Mar 1941	9.75	297.13	
11 Feb 1942	11.89	299.28	
2 Jan 1943	9.75	297.13	
18 Feb 1950	10.67	298.06	
14 Jul 1954	12.09	299.48	
26 May 1955	9.58	296.97	
22 Jan 1956	13.41	300.80	
10 Feb 1956	11.43	298.82	
23 Dec 1956	9.25	296.64	
18 Feb 1959	10.59	297.98	
7 Feb 1971	10.90	298.29	
24 Feb 1971	9.30	296.69	
3 May 1983	12.70	300.15	
22 Jun 1983	9.40	296.85	
31 Feb 1984	9.90	297.35	
28 Jul 1984	9.20	296.65	
11 Jan 1996	11.40	298.85	
28 Aug 1998	10.80	298.25	
28 Dec 2011	12.52	299.97	Dogwood Creek at Gilweir TM Gauge (height = 296.36 mAHD)
29 Jan 2013	9.47	296.92	Dogwood Creek at Warrego Highway Manual Gauge

Notes:

1) Only Floods > 9.15m gauge ht (Warrego Hwy) are shown.
2) Gauge data:
   a. Gauge No 042049/422917 Miles at Warrego Highway 1918 – 01/01/1982 datum = 287.387m AHD
   b. Gauge No 042049/422917 Miles at Warrego Highway 01/01/1982 to present datum = 287.447m AHD
   c. Gauge No 422202B Dogwood Creek at Gilweir 01/10/1949 to present datum = 283.257m AHD

2.7 Historical Data

Extensive research was undertaken as part of the study to identify and list historical floods for Miles. This research included:

- Extensive research into historical floods based on community experiences.
- Research by the Dalby Family History Society, the Chinchilla Museum and the Miles Museum.
- Research by Council officers.
- Interviews with residents.
- Assessment of changes in land use back to 1920s.

The data collected generally consisted of:

- Official records (e.g. Bureau of Meteorology).
- Previous flood study reports.
- Newspaper articles.
- Photos.
- Recorded flood height records by long-term town residents.
- Flood marks on buildings and other structures.
- Anecdotal evidence/family histories of flood heights on structures (e.g. for floods that occurred over 80 years ago where there is a family history of how high the flood occurred on the house; which is still standing).

Of particular note, the community consultation provided historical levels for a number of extra historical floods back to 1918.

The data was collated and assessed for accuracy and usefulness to the study. That is, was it possible to identify a flood height taken at the flood peak on a structure that was still present? Topographical survey was undertaken of the identified historical flood marks to provide an estimate of the flood height.

2.8 Historical Hydraulic Roughness and Topography Maps

Miles, unlike Dalby and Chinchilla, has no major flow paths within developed areas which would have an impact on the historic rating for Dogwood Creek at the Warrego Highway. For this reason the 2010 roughness was used for all events. Sensitivity was done on the roughness which showed it to have a minimal impact on the rating at the Warrego Highway stream gauge.

2.9 Regional Flood Frequency Estimates

Software supporting the Australian Regional Flood Frequency (ARFF) estimates was released in November 2012 (Engineers Australia, 2012). This software was developed as part of the review of the Australian Rainfall and Runoff (ARR) guide to flood estimation. ARFF provides a regional estimate of discharge anywhere in Australia. The ARFF estimates were used as an additional piece of information in the determination of flood discharge magnitude for the six towns in the current study. The ARFF estimates for Chinchilla are presented and discussed further in Section 4.3.

3 FLOOD ANALYSIS APPROACH

3.1 Overview

The flood analysis of Dogwood Creek to Miles was undertaken using a combination of hydrologic and hydraulic modelling techniques.

3.2 Hydrologic (Rainfall/Runoff) Analysis

Hydrology is the term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

A **Hydrologic model (runoff routing model)** uses rainfall data and estimates of the proportion of the rainfall which turns into runoff and the time which the runoff from each part of the catchment takes to enter into the stream or watercourse over time. The 'RAFTS' runoff-routing model (XP Software, 2001) was used to model hydrologic processes for Dogwood Creek to Miles.

3.3 Hydraulic (Flow) Analysis

3.3.1 Overview

Hydraulics (in this context) refers to the detailed description of flow down a watercourse or through a rural or urban floodplain or a combination of both.

A hydraulic (or hydrodynamic) model uses data about the flow in streams and the terrain of a particular area to estimate flood heights, velocities and flow over time.

Hydraulic modelling of the Dogwood Creek floodplain through Miles has been undertaken utilising DHI Software's MIKE FLOOD modelling system.

MIKE FLOOD combines via dynamic coupling the one-dimensional MIKE 11 river model and MIKE 21 fully two-dimensional model systems. Through coupling of these two systems it is possible to accurately represent in and over-bank floodplain flood behaviour as well as sub-surface drainage flow behaviour through the application of a comprehensive range of hydraulic structures (including culverts, bridges, weirs, control gates etc.).

4 FLOOD HYDROLOGY

4.1 Overview

Uncertainty in flood magnitude estimation is a fundamental problem in flood hydrology. The geography of Dogwood Creek in and around Miles is hydrologically complex. The hydrological behaviour of the floodplain shows variation in space and time of infiltration characteristics, flowpaths, roughness and storage. Further, the extensive, flat floodplain introduces uncertainty into flow gauging and makes flood discharge estimation a complex task.

Given the uncertainty in discharge estimate, a number of techniques were employed in order to define the range of design events of Dogwood Creek at Miles. These techniques included the following methods for determining design event discharges and are discussed in following sections:

- Australian Rainfall Regional Flood Frequency Analysis (ARFF).
- A Flood Frequency Analysis (FFA) using the FLIKE analysis package.

4.2 Catchment Area

The adopted catchment area for all discharge estimation was 2,875 m^2. This is the Dogwood Creek catchment area to the Warrego Highway.

4.3 Regional Flood Frequency

4.3.1 Australian Regional Flood Frequency

The regional discharge-area technique provides a way to check flood magnitude estimates. It identifies poor data, non-representative catchments, compares results from different techniques (e.g. design rainfall, ARFF) and provides catchment understanding.

The Australian Regional Flood Frequency (ARFF) Model (Engineers Australia, 2012) was used to estimate Miles flood magnitudes. Note that Engineers Australia (2012) recommends that the ARFF is applicable for catchments with areas between 20 and 1000 km^2. The Dogwood Creek catchment at the Warrego Highway (area 2875 km^2) is outside this range. Notwithstanding this, the ARFF estimate is useful to provide an estimate to assist with flood magnitude selection. Table 4.1 shows the ARFF flood magnitude estimates for Dogwood Creek at Miles.

Table 4.1 ARFF Discharge Estimates for Dogwood Creek at Warrego Highway

AEP 1 in X	Discharge (m^3/s)
2	280
5	870
10	1450
20	2110
50	3120
100	3950

4.4 Design Rainfall Technique

The Design Rainfall Technique was not applied to the Dogwood Creek Catchment, as there was inadequate rainfall data available within the catchment for calibration of historic floods.

4.5 Flood Frequency Analysis

4.5.1 Overview

Dogwood Creek had an excellent discharge record from 1918 to 2013, which allowed a detailed flood frequency analysis to be undertaken. Considerable analysis was undertaken to check and correct the gauging data (using hydraulic models) and develop a peak annual discharge series for the Dogwood Creek at the Warrego Highway. The resultant data set has a high degree of confidence.

However, it was recognised that the Gil Weir rating curve did not adequately represent high flows where significant flow bypass was occurring which wasn't represented in the rating curve. A key component of the Flood Frequency Analysis was then the derivation of a more accurate rating curve for high flows.

4.5.2 Gil Weir Rating

The only gauging station with data suitable for a FFA for the study was Dogwood Creek at Gil Weir (422202B). The maximum recorded water level at the site was 14.02m (292.27m AHD), some 1.0 m above the top of bank, while the maximum stream gauging was undertaken at a water level of only 11.29 m, some 1.71 m below the top of bank. It appeared that the DERM rating curve was extrapolated from the maximum gauged discharge without allowing for the overbank flow; which potentially leads to substantial error in the rating curve. Therefore, a MIKE FLOOD hydraulic model of the Gil Weir area was developed to provide an accurate stream gauge – discharge relationship Figure 4.1 shows the different gauging data and rating curves for Gil Weir. The following is of note:

- The weir was raised in 1995 from a crest level of 288.4m AHD to 291.1m AHD.
- The current DERM rating curve and gauging data is shown. The "current DERM" rating curve appears to be based upon a combination of pre and post 1995 weir raising gaugings.
- The hydraulic model was unable to replicate the DERM curve; indicating a possible error in the rating. Discussions with Ken Klassen (Supervising Hydrographer, South West, DERM) revealed that there were potentially gauge errors in the highest stream gauging, upon which the rating curve relied heavily. Ken advised that the discharges for these gauging should be doubled (Ken Klasson, Pers. Commun. 31 Aug 2011).
- The two revised stage-discharge relationships derived through hydraulic modelling as part of this study for pre and post weir raising in 1995 are shown. Note how the pre 1995 curve fits the pre 1995 gauging and the post 1995 curve fits the post 1995 gauging.

Figure 4.1 suggests that there is substantial error in the current DERM rating curve. For example, for the maximum recorded water level of 14.02 m, the DERM and modelled discharges are 879 and 3071 m^3/s, respectively.

Based upon the results of the analysis of the Gil Weir rating, the rating curves derived from hydraulic modelling were adopted for this study. For clarity, Figure 4.2 shows the adopted Gil Weir rating curves without DERM data. Note that both curves shown in Figure 4.2 were used in the study to cater for pre and post 1995 stream gauging data.

Table 4.2 shows the estimated annual peak discharges at Gil Weir based upon the current DERM rating and the adopted rating curves derived through hydraulic modelling. The rain year starting 1 November was adopted.

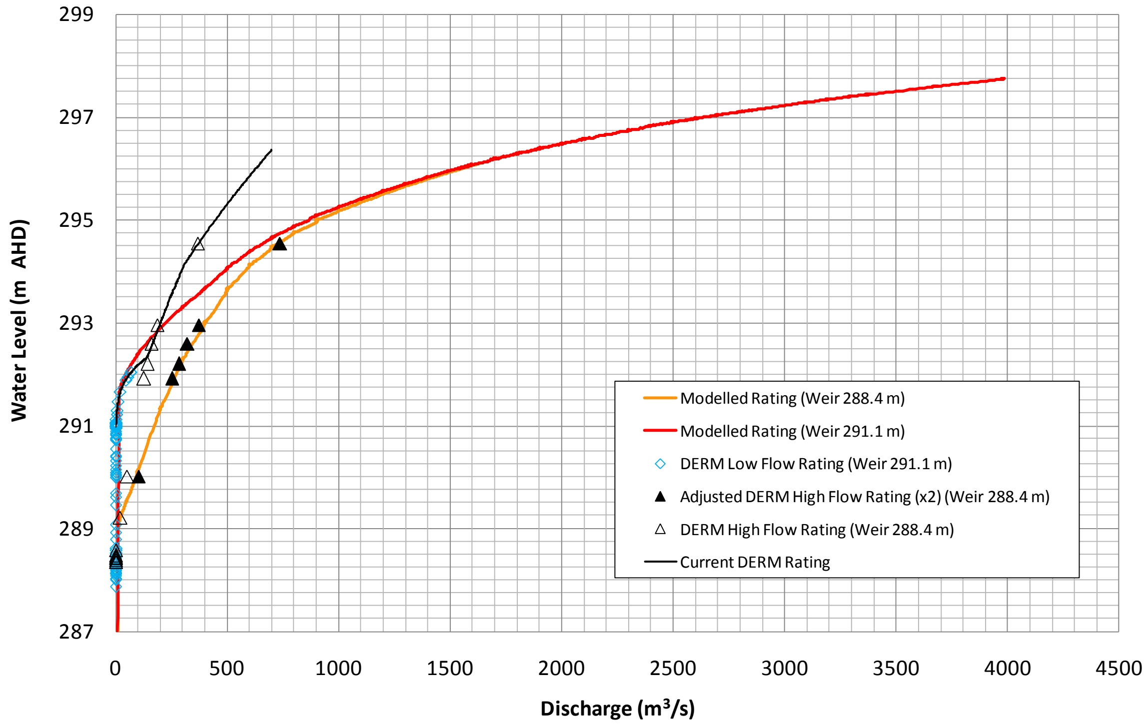

Figure 4.1 Rating Curves for Dogwood Creek at Gil Weir

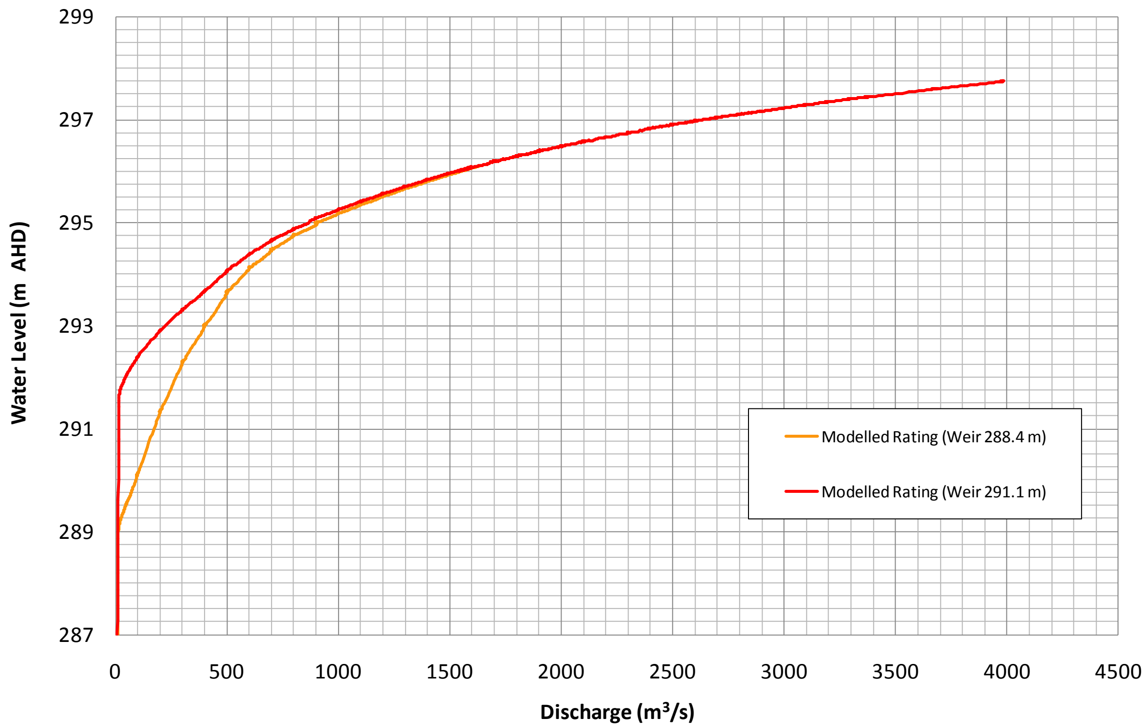

Figure 4.2 Adopted Rating Curves for Dogwood Creek at Gil Weir

4.5.3 Warrego Highway Rating

The Bureau of Meteorology (BoM) has a flood warning station on Dogwood Creek at the Warrego Highway (station number 042049). Peak water level data from 1918 to the present for this site has been provided by BoM.

4.5.4 Rating

The Dogwood Creek at Warrego Highway gauging station has the following limitations:

- It is a flood warning station and therefore does not have a rating curve. That is, only water levels are recorded, not discharges.
- Only peak water level for floods are recorded, not a continuous record.
- Many of the peak flood levels were recorded at the same time of day; most commonly 0900 hrs. It is assumed that many of the measurements are timed for convenience, not peak water level.

A series of peak annual discharges was developed for the Warrego Highway station as follows:

- The Miles hydraulic model was used to produce a rating curve for the site.
  - A sensitivity check of model roughness showed that the rating curve was quite insensitive to roughness changes.
- A relationship between the estimated discharges at the Warrego Highway and Gil Weir was developed; based upon the date/time of record at the Warrego Highway. Note that this was most likely not the time of the peak water level.
- Peak annual discharges at the Warrego highway were estimated by:
  - 1950-2013
    - The annual peak discharges at Gil Weir were used to estimate the same at the Warrego Highway using the discharge relationship between sites.
  - 1918-1949
    - The recorded height was adopted as the peak flood height and the discharge was calculated from the Warrego Highway rating curve.
    - Note that while not strictly correct, this method provided the best estimate given the limitations of the data.
- Table 4.3 shows the adopted peak annual series for Dogwood Creek at the Warrego Highway.
  - Note that the series has gaps between 1918 and 1950. These are gaps in the BoM record. The BoM only record floods above a defined threshold. Therefore, it is assumed that no flood of note occurred in these years.

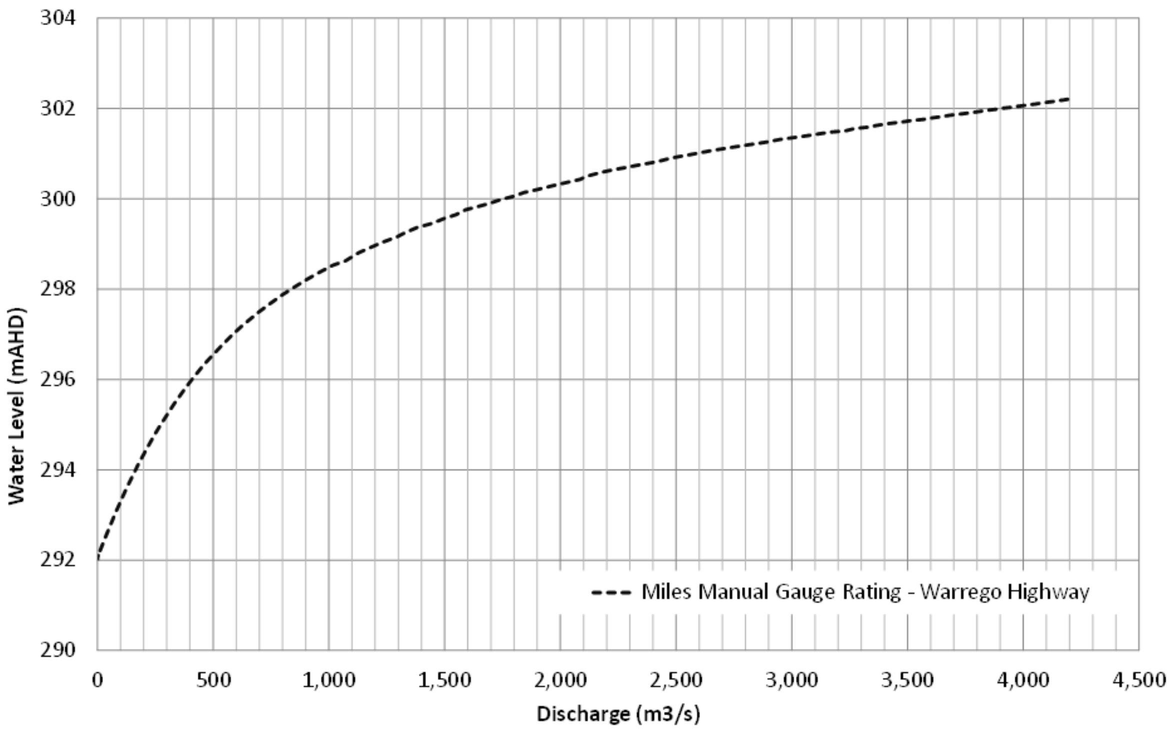

Figure 4.3 Adopted Rating Curve for Dogwood Creek at Warrego Highway

Table 4.2 Peak Annual Discharge for Dogwood Creek at Gil Weir

Year	Peak Discharge (m^3/s)			Year	Peak Discharge (m^3/s)	
	DERM Rating	Adopted			DERM Rating	Adopted
1950	453.3	958.9		1982	134.8	276.5
1951	57.9	105.7		1983	732.5	2142.5
1952	32.0	44.5		1984	412.9	842.6
1953	11.9	11.6		1985	37.9	60.9
1954	600.2	1515.7		1986	0.5	9.8
1955	299.9	580.3		1987	10.2	11.0
1956	879.3	3070.6		1988	95.7	184.3
1957	274.7	533.7		1989	90.5	171.6
1958	148.8	312.8		1990	126.1	253.7
1959	471.4	1020.5		1991	166.0	362.4
1960	69.6	128.0		1992	84.8	162.4
1961	68.6	128.0		1993	0.0	0.0
1962	101.7	198.5		1994	192.1	409.3
1963	17.3	17.1		1995	66.5	47.4
1964	27.1	34.6		1996	598.4	1410.9
1965	1.9	10.4		1997	93.8	65.3
1966	78.0	147.3		1998	531.4	1154.1
1967	37.4	58.8		1999	158.7	127.8
1968	37.5	58.8		2000	106.6	72.7
1969	0.2	9.8		2001	0.0	0.0
1970	14.5	13.9		2002	37.4	28.6
1971	498.2	1116.3		2003	147.3	101.0
1972	238.1	483.8		2004	32.4	24.8
1973	51.7	91.7		2005	25.3	18.7
1974	53.2	95.0		2006	173.0	157.3
1975	34.3	50.1		2007	4.8	14.5
1976	66.1	123.6		2008	1.7	13.9
1977	160.2	347.9		2009	4.1	14.5
1978	33.3	47.5		2010	271.8	428.7
1979	14.8	13.9		2011	699.0	1862.7
1980	8.8	11.0		2012	397.9	732.3
1981	258.7	506.6		2013	30.3	54.1

Table 4.3 Peak Annual Discharge for Dogwood Creek at the Warrego Highway – Adopted for Flood Frequency Analysis

Year	Peak Discharge (m^3/s) Adopted		Year	Peak Discharge (m^3/s) Adopted		Year	Peak Discharge (m^3/s) Adopted
1922	155.5		1953	10.9		1984	789.5
1923	No value recorded		1954	1420.2		1985	57.1
1924	204.6		1955	543.7		1986	9.2
1925	No value recorded		1956	2877.2		1987	10.3
1926	310.4		1957	500.1		1988	172.7
1927	71.6		1958	293.0		1989	160.8
1928	116.3		1959	956.2		1990	237.7
1929	624.4		1960	119.9		1991	339.6
1930	26.6		1961	119.9		1992	152.1
1931	310.4		1962	186.0		1993	0.0
1932	634.4		1963	16.1		1994	383.5
1933	186.3		1964	32.4		1995	44.4
1934	381.9		1965	9.8		1996	1322.0
1935	401.8		1966	138.0		1997	61.2
1936	26.6		1967	55.1		1998	1081.3
1937	325.9		1968	55.1		1999	119.8
1938	401.8		1969	9.2		2000	68.1
1939	135.9		1970	13.1		2001	11.4
1940	228.3		1971	1046.0		2002	26.8
1941	624.4		1972	453.3		2003	94.6
1942	1350.4		1973	85.9		2004	23.3
1943	624.4		1974	89.0		2005	17.5
1944	No value recorded		1975	47.0		2006	147.4
1945	No value recorded		1976	115.8		2007	13.6
1946	401.8		1977	326.0		2008	13.1
1947	No value recorded		1978	44.5		2009	13.6
1948	55.4		1979	13.1		2010	401.7
1949	No value recorded		1980	10.3		2011	1745.3
1950	898.4		1981	474.6		2012	23.4
1951	99.1		1982	259.1		2013	698.0
1952	41.7		1983	2007.5			

4.5.5 Flood Frequency Analysis

A flood frequency analysis of the adopted Dogwood Creek at Warrego Highway peak annual discharges was undertaken with the Flike software. FLIKE is a Flood Frequency Analysis tool that provides a comprehensive Bayesian analysis for a probability model fitted to gauged and censored historic data. Model outputs include probability plots showing data, quantiles and confidence limits, a text file summarising all the input data and results, and plots of the posterior density surface.

4.5.6 Low Flow Censoring

Table 4.4 shows the adopted flow censoring:

- 1950-2013
  - All flows < 26 m^3/s were censored to improve the LP3 fit.
- 1918-1949
  - There were a number of years with no flood depth recorded. It was assumed this was because no flood occurred in these years. While there is a discharge of 26 m^3/s recorded during this time it is unknown what the BoM threshold for recording was. Therefore a threshold value of 100 m^3/s was used for these years. A sensitivity analysis comparing a variation of threshold values found it to have only a minor influence of the FFA result.

4.5.7 Distribution

A number of distributions were fitted to the data to assess the best fit. The log Pearson III (LP3) distribution clearly provided the best fit. Figure 4.4 shows the plotted data and fitted LP3 distribution.

4.5.8 Results

Table 4.5 and Figure 4.4 show the adopted FFA results.

Table 4.4 FLIKE Censored Data

Threshold Value (m^3/s)	Ungauged Years > Threshold (years)	Ungauged Years <= Threshold (years)
100	0	6
26	0	17

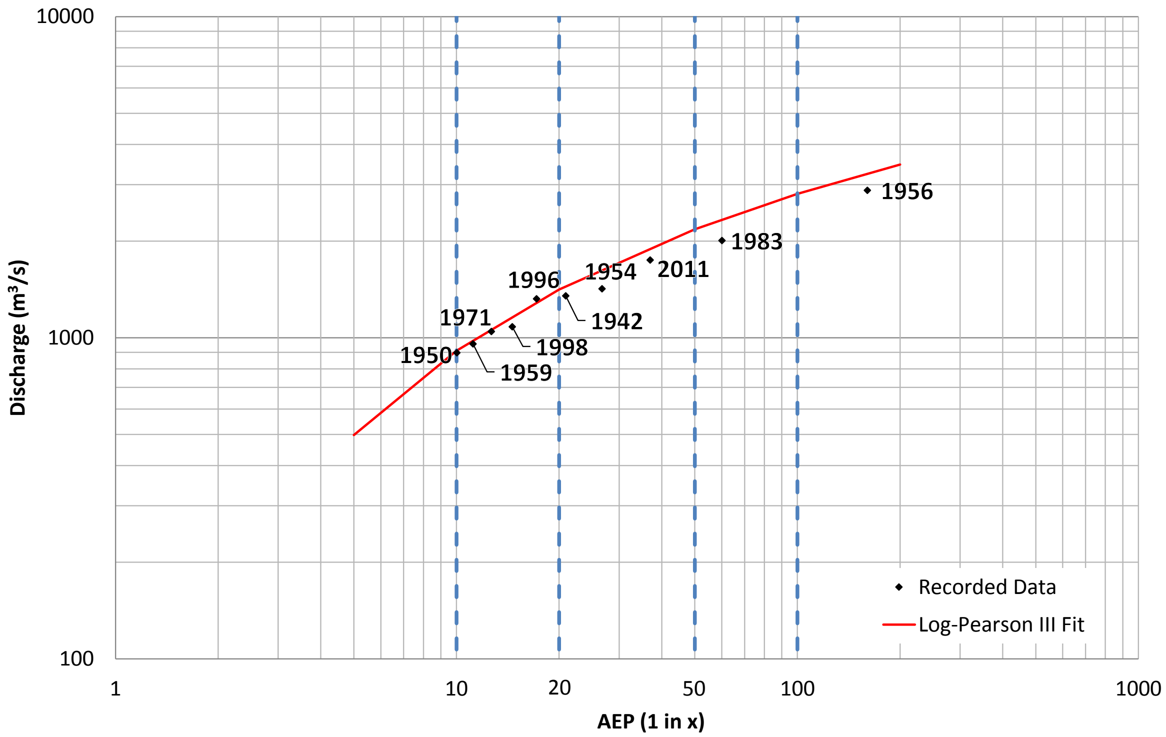

Figure 4.4 Adopted Flood Frequency Analysis

Table 4.5 Flood Frequency Results

AEP (1 in x)	Discharge (m^3/s)
2	120
5	500
10	910
20	1410
50	2180
100	2810

4.6 Design Discharge Selection

4.6.1 1 in 100 AEP

Estimates for the 1 in 100 AEP discharge for Dogwood Creek at the Warrego Highway are:

- Flood frequency analysis: 2810 m^3/s.
- Australian regional flood frequency estimate: 3950 m^3/s.

It was considered that the flood frequency analysis provided the most accurate estimation of the 1 in 100 AEP discharge for this study.

4.6.2 1 in 10 to 1 in 50 AEP

It was considered that the flood frequency analysis provided the most accurate estimation of the 1 in 10 to 1 in 50 AEP discharges.

4.7 Adopted Discharges

Table 4.6 shows the adopted 1 in 10 to 1 in 100 AEP discharges for Dogwood Creek at Warrego Highway, Miles.

Table 4.6 Adopted Discharge Estimates for Dogwood Creek at the Warrego Highway

AEP (1 in x)	Discharge (m^3/s)
10	910
20	1410
50	2180
100	2810

5 HYDROLOGIC MODELLING

5.1 RAFTS Model Configuration

RAFTS requires several key parameters to accurately model hydrologic processes. Many of these have been derived through a joint calibration process which will be described in detail in the following section. A summary of the general RAFTS modelling approach adopted for this study includes:

- Use of the "one-subcatchment" model for all catchments.
- A catchment Manning's n of 0.055 (based on calibration of the 2011 event through Chinchilla) was used for all catchments.
- A catchment percent imperviousness of 0% was adopted for all catchments at all locations. It was considered that the slight increase in imperviousness in the catchments that contained the towns would have an insignificant impact on discharges (due to the location in the catchment and the small area relative to the total catchment) and was therefore not included.
- The RAFTS Muskingum routing routine was used to model channel routing as follows:
  - The relationship between average stream velocity and stream slope was determined on a sample of representative streams in the study catchments. These relationships were then applied consistently across all catchments. Table 5.1shows the adopted channel slope – velocity relationships.
- A value of Muskingum x=0.2 was adopted for all streams.
- The RAFTS default storage coefficient 'Bx' = 1 was adopted.
- The initial loss (IL) and (CL) were used as calibration parameters.

Figure 5.1 shows the RAFTS model layout.

Table 5.1 Average Stream Velocities Adopted to Estimate Muskingum K for Miles

Channel Slope (m/m)	Velocity (m/s)
<= 0.0003	0.8
0.0007	1
>= 0.0012	1.5

5.2 RAFTS Results

A full suite of design events was analysed using the RAFTS model. Table 5.2 shows the adopted design rainfall loss parameters.

Table 5.2 Design Rainfall Results for the 1 in 10 to 1 in 100 AEP Discharge Estimates for Dogwood Creek at Miles

AEP (1 in x)	Initial Loss (mm)	Continuing Loss (mm/hr)	Discharge (m^3/s)
10	27	3.2	910
20	25	3.1	1410
50	18	2.8	2180
100	15	2.75	2810

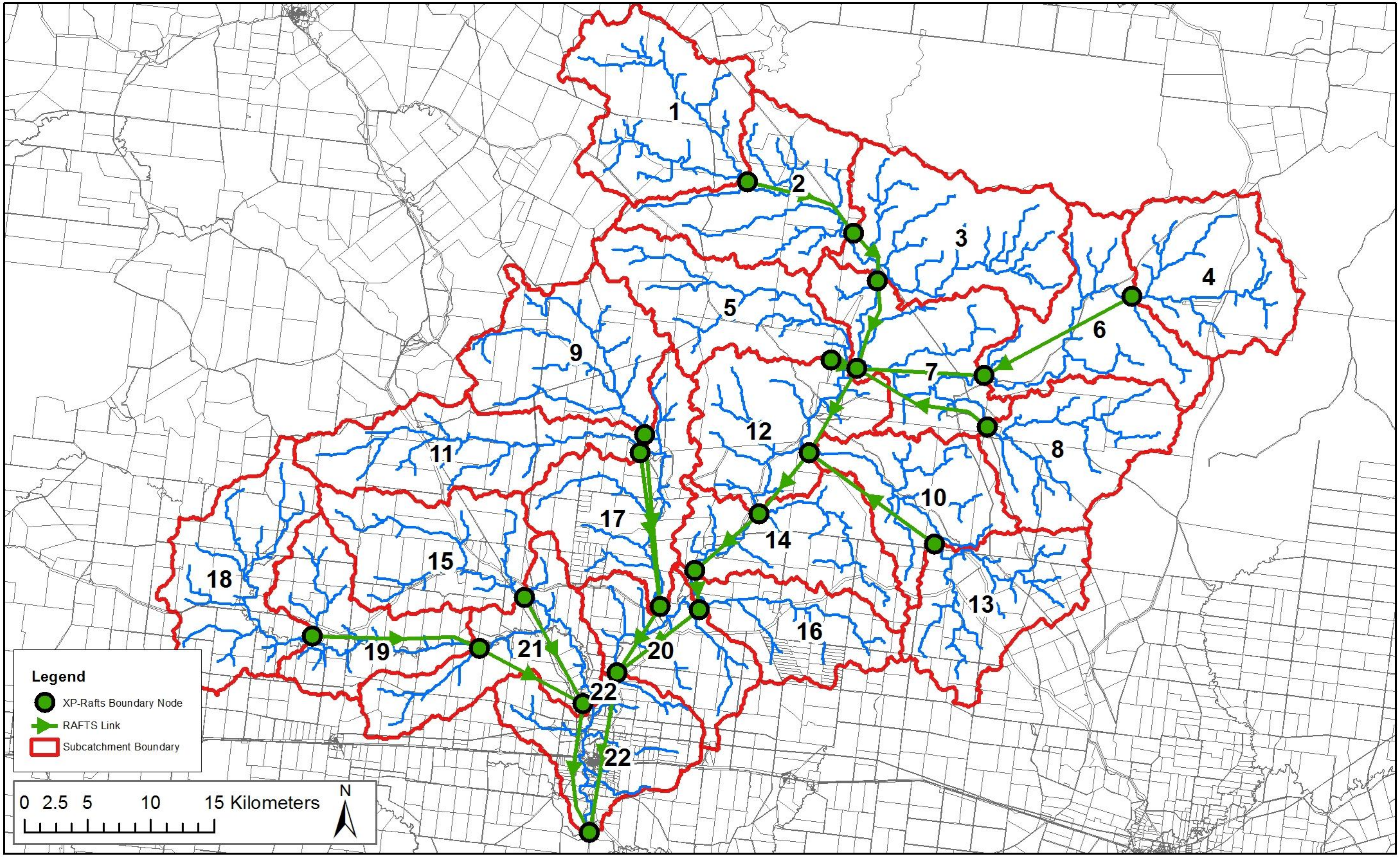

Figure 5.1 **Dogwood Creek RAFTS Model Layout**

6 RIVERINE FLOODING ANALYSIS

6.1 Overview

The MIKE FLOOD model was used to estimate flood levels for Miles. The 1% AEP flood was adopted as the defined flood event (DFE). The following sections describe the design event modelling process.

Model results are presented as maps of flood depth and flood hazard in Volume II of this report.

Figure 6.1 shows the topography and extent of the hydraulic model.

6.2 MIKE FLOOD Model Configuration

The model area and grid size were chosen to allow for practical model run times and to cover the area required. The Miles MIKE FLOOD model developed for this investigation has the following characteristics:

- Model terrain based on available LIDAR data sets.
- 10m grid size covering an area 8.81km x 5.90km.
- 0.5s timestep.
- Velocity based eddy viscosity of 0.1m^2/s.
- Inflow boundary conditions (from RAFTS).
- Fixed tailwater boundary condition.

A critical parameter within the hydraulic model is the hydraulic roughness. Hydraulic roughness is usually expressed in terms of the parameter Manning's n and varied according to land use type. For this investigation, adopted Manning's n values (corresponding to the various land use zonings within the revised planning scheme) are presented in Table 6.1.

Figure 6.2 shows the hydraulic roughness map used in the hydraulic model. The roughness is that for ultimate land use development in accordance with the planning scheme.

Appendix A presents the location of hydraulic structures in the model.

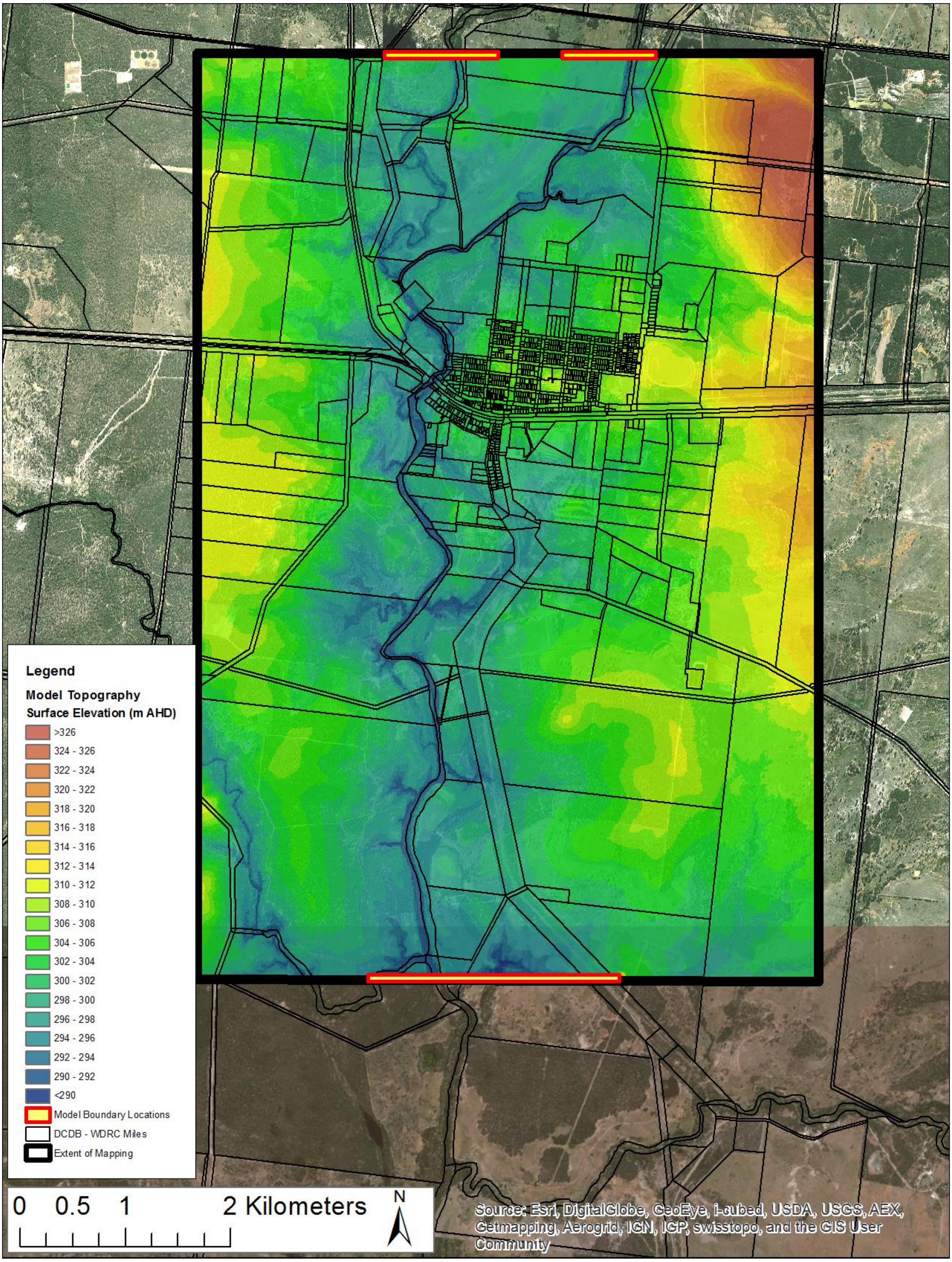

Figure 6.1 Hydraulic Model Extent and Topography

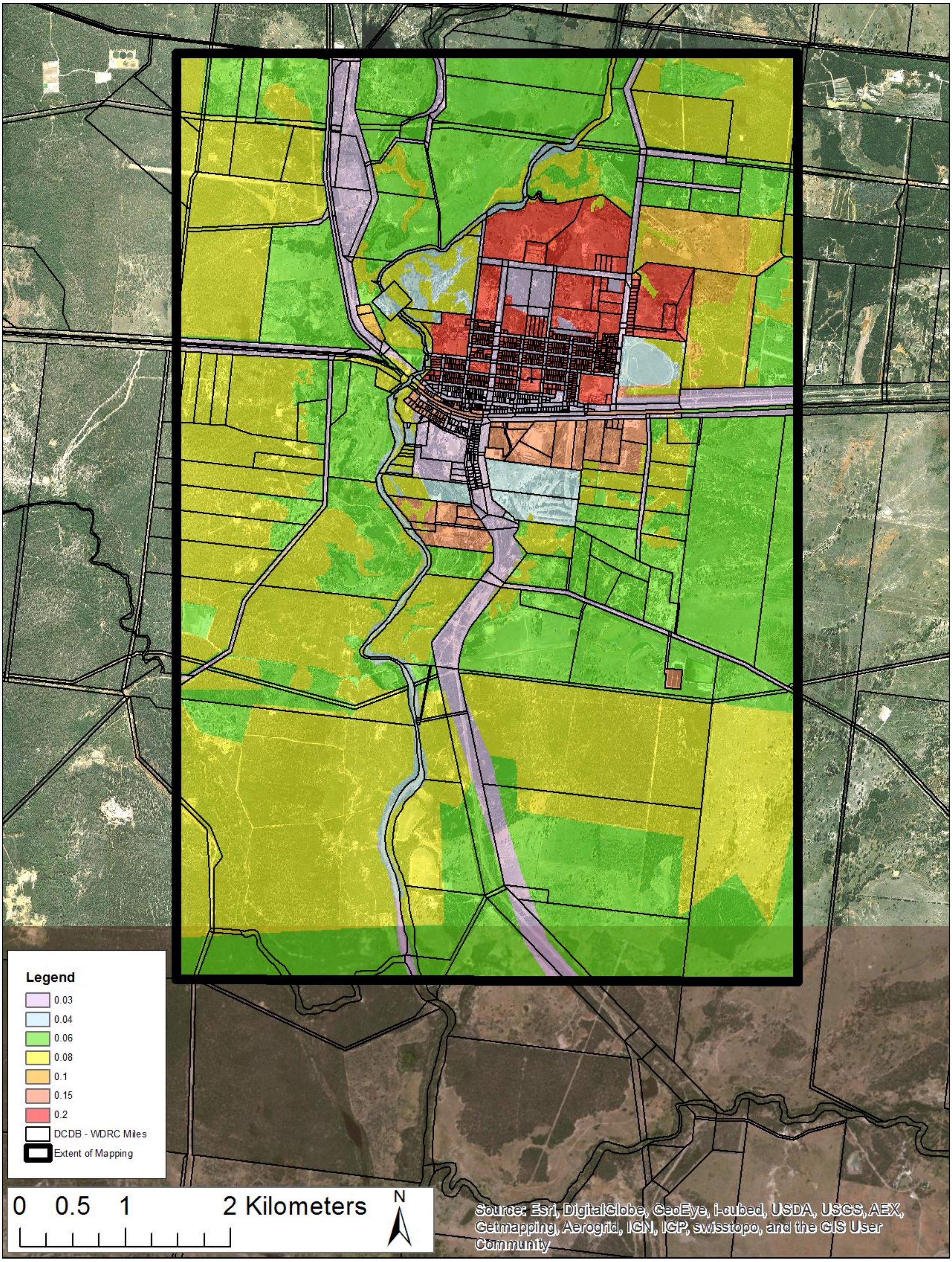

Figure 6.2 Hydraulic Roughness Map – Ultimate Development Conditions

Table 6.1 Adopted MIKE FLOOD Manning's n Values

Land Use	Manning's n
Roads	0.03
Open Space	0.04
Vegetation	0.06
Dense Vegetation	0.08
Rural Residential	0.1
Industrial/Commercial	0.15
Dense Residential	0.2

6.3 Downstream Boundary Sensitivity Analysis

A downstream boundary sensitivity analysis was undertaken for the Dogwood Creek MIKE FLOOD model. The results showed that the adopted boundary levels have a minimal affect within the study area. Appendix B contains full details of the assessment.

6.4 Mapping Conventions

6.4.1 Freeboard

A 300mm freeboard was added to the modelled defined flood level to create the Planning Scheme Overlay. The adopted freeboard is in accordance with the Queensland Urban Drainage Manual (NRW, 2007).

6.4.2 Hazard Mapping

Flood hazard categories were adopted from "*Floodplain Management in Australia: Best Practice Principles and Guidelines*" (CSIRO, 2000). Table 6.2 shows the adopted categories.

Table 6.2 Adopted Hazard Categories (CSIRO, 2000)

Criteria	Low	Medium	High	Extreme
Wading Ability	All including children and elderly (v*d <0.25)	Fit Adults (v*d <0.4)	Fit Adults have difficulty (v*d <0.6)	Wading not an option (v*d >= 0.6)
Max. Flood Velocity (m/s)	< 0.4	< 0.8	< 1.5	>1.5
Max. Flood Depths (m)	< 0.3	< 0.6	< 1.2	> 1.2
Typical Means of Egress	Sedan	Sedan early, but 4WD or trucks later	4WD or Trucks only in early stages, boats or helicopters	Large trucks, boats or helicopters

6.5 Hydraulic Results

Table 6.3 shows the seven different types of flood maps produced. Aerial photograph and cadastre are used as the background for all maps. These maps are presented in Volume II of this report.

Table 6.3 Riverine Flood Maps Produced

AEP (1 in x)	Flood Map Type	Description - Map Name
10	Extent + Depth	10% AEP riverine flood extent and depth
20	Extent + Depth	5% AEP riverine flood extent and depth
50	Extent + Depth	2% AEP riverine flood extent and depth
100	Extent + Depth	1% AEP riverine flood extent and depth
100	Extent + Hazard	Defined Flood Event (DFE): 1% AEP riverine flood hazard

7 UPDATE TO THE NOVEMBER 2012 REPORT

The initial Miles Flood Study report was submitted in November 2012. Since then a significant amount of additional work has been undertaking. More specifically:

- additional flood level information was gathered through the efforts of WDRC officers and the community,
- In particular, through the community consultation process, a gauge record (Dogwood Creek at the Warrego Highway) was provided. Prior to this, records were available back to 1949 whereas the Warrego Highway record provided data back to 1918,
- A new Flood Frequency Analysis using the latest available techniques (as currently being developed through the revision of Australian Rainfall and Runoff) was undertaken on the Warrego Highway record.

This additional data and new Flood Frequency analysis has resulted in a decrease in the design flows and corresponding levels for Dogwood Creek at Miles for the 1 in 100 AEP event. Smaller changes are observed for the 1 in 10, 20 and 50 AEP events.

Table 7-1 and Table 7-2 below present comparisons of the design flows and associated levels for Dogwood Creek as presented in the Nov 2012 report and this current report for Miles.

Table 7-1 Comparison between the previously adopted flows (Nov 2012 report) and current flows at Dogwood Creek, Warrego Highway (Miles)

AEP (1 in x)	Previous Discharge – Nov 2012 Report (m^3/s)	Revised Discharge - (m^3/s)
10	920	910
20	1480	1410
50	2510	2180
100	3620	2810

Table 7-2 Comparison between adopted levels in 2012 and 2014 Report at Miles

AEP (1 in x)	Previous Levels – Nov 2012 (m AHD)	Revised Levels (m AHD)
10	299.00	298.85
20	299.95	299.76
50	301.12	300.65
100	302.03	301.20

For Myall Creek in Dalby, the reduction in design levels between the November 2012 report and this current report associated with the reduction in design inflows for Myall Creek were not uniformly distributed across the floodplain. However, the reduction in design flows for Dogwood Creek at Miles has produced a corresponding reduction in design level.

Another difference between the levels presented in the November 2012 report and this current report is that in the previous report, the Defined Flood Event (DFE) was defined as the 1 in 100 AEP event + an allowance for 1oC climate change (5% increase in rainfall intensity). For the purposes of this current report, the climate change allowance has not been included and the DFE has been defined as the 1 in 100 AEP event.

An appropriate freeboard allowance (300mm has previously been adopted) should be added to the 1 in 100 AEP event levels for planning levels.

Figure 7.1 and Figure 7.2 present:

- a comparison of flood levels from the November 2012 report and the current report,
- the 1 in 100 AEP flood depths, and
- indicators of the relative levels of historic events and the 1 in 100 AEP flood depths at indicative locations through the town.

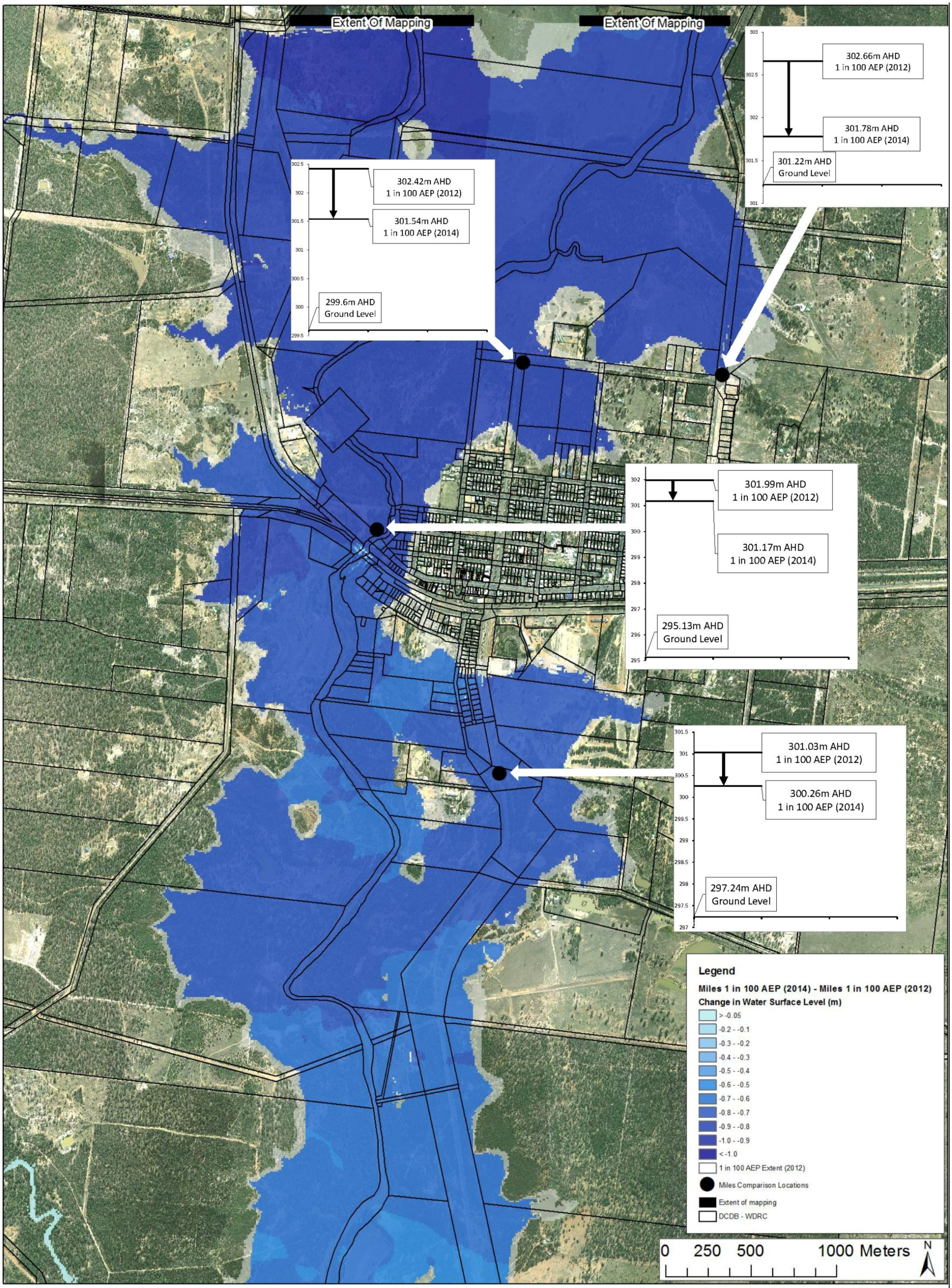

Figure 7.1 1 in 100 AEP flood level comparison – Revised flood levels compared to Nov 2012 flood levels

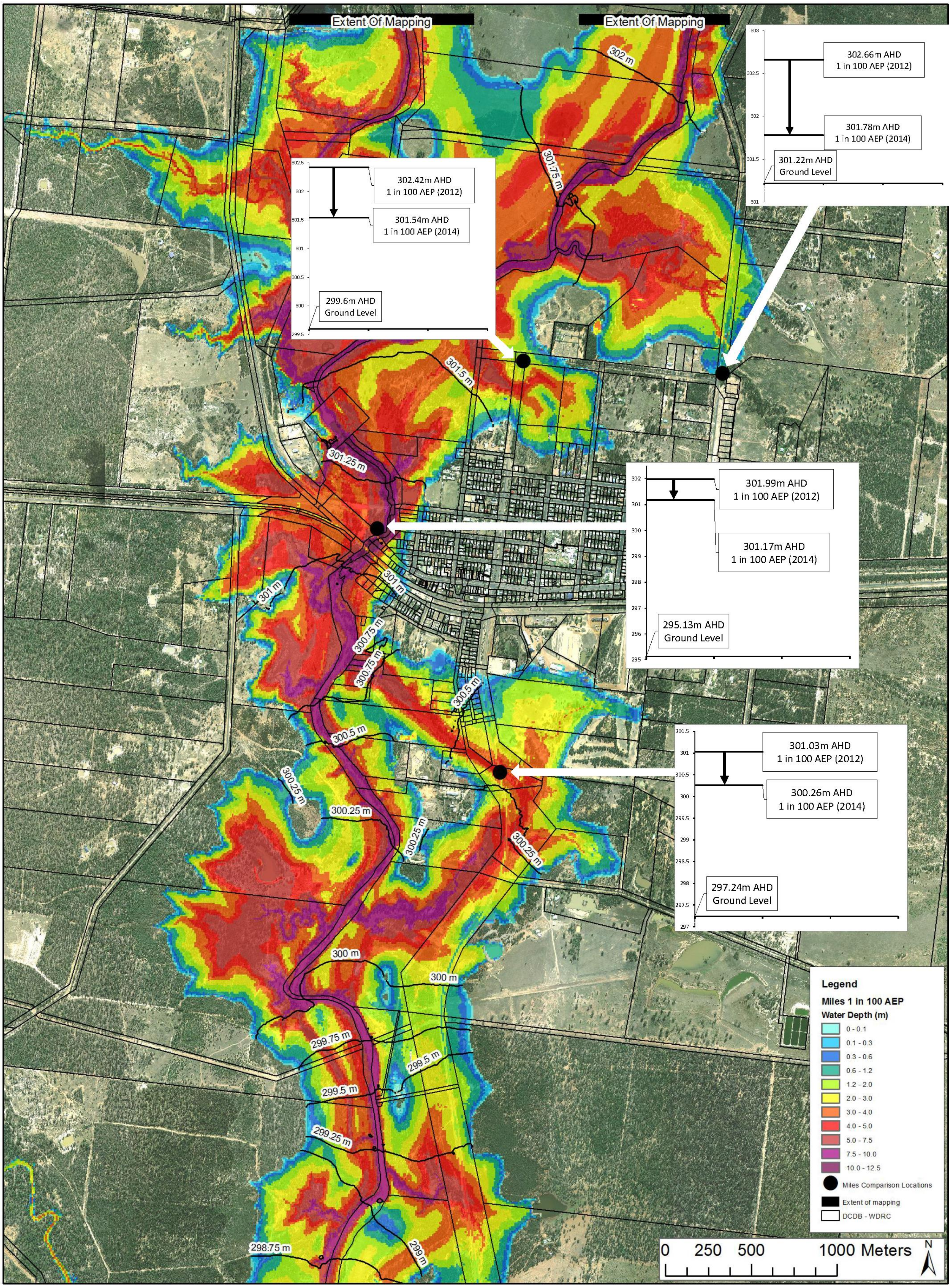

Figure 7.2 1 in 100 AEP depths with indicators of historic and design levels at key locations

8 STORMWATER FLOODING

8.1 Overview

Stormwater floods are local floods through the numerous overland flowpaths through the towns. These floods are short duration (an hour or so) and are usually the result of localised, short duration rainfall. These floods contrast with riverine floods, which are large regional floods from the creeks running through each town. Riverine floods may last several days and are usually the result of widespread, long duration rainfall.

For the purposes of modelling stormwater, Miles was divided into a number of stormwater catchments. The 1 in 10, 1 in 50 and 1 in 100 AEP floods were modelled.

8.2 Catchments

Miles was divided into a number of catchments based upon the following:

- Location of flow paths.
- Desired location of discharge estimation points.
- Key infrastructure.

Appendix D of this report shows the adopted stormwater catchments for each town.

8.3 Method

The Rational Method was used to determine discharges in accordance with the procedure defined in the Queensland Urban Drainage Manual (NRW, 2007). Note that NRW (2007) recommends that the maximum catchment area upon which the Rational Method may be applied is either 5 km^2 (urban catchments) or 25 km^2 (rural catchments). In a number of instances the catchment areas in this study are greater than these values. Notwithstanding the recommendations of NRW (2007), it is considered that the adoption of the Rational Method for this study is acceptable for the following reasons:

- The primary reason for the catchment area limit is because the Rational Method does not allow for channel routing.
- It is considered that the estimation error due to this is small, for small catchments, but increases with larger catchments. The 5 and 25 km^2 areas have been selected as the approximate catchment area where the error becomes significant.
- In larger catchments, the Rational Method will tend to overestimate discharges. Therefore, for the proposed application of the results of this study (to define planning levels), the use of the Rational Method provides a conservatively high discharge.
- There are no other suitable methods for discharge estimation for catchments of this size.

8.4 Hydrologic Analysis

8.4.1 Time of Concentration

The MIKE FLOOD hydraulic model was used to estimate the stream velocity. Table 8.1 shows the adopted velocities. It was found that a number of different velocities were required for the Miles catchment, based upon stream slope. For all other towns it was found that the application of one average velocity for all streams was appropriate.

8.4.2 Runoff Coefficients

An impervious percentage was assigned to each land use category in the revised planning scheme based upon recommendations in NRW (2007) and discussions with WDRC. Each impervious percentage was converted to a C10 runoff coefficient for use with the Rational Method. The same impervious percentage – land use category relationships were adopted for all towns within the WDRC area. Table 8.2 shows the adopted impervious percentages and runoff coefficients for each land use category for Miles.

Table 8.1 Adopted Average Stream Velocity for Rational Method Calculations

Town	Slope (%)	Velocity (m/s)
Miles	0.5	0.30
	0.6	0.40
	0.7	0.49
	0.8	0.59
Chinchilla	All	0.6
Wandoan	All	0.5
Jandowae	All	0.5
Tara	All	0.5

8.4.3 Partial Area Effect

It was found that the catchment characteristics (long, elongated main streams with a number of short adjoining streams) created the partial area effect in a number of locations. This was evidenced in the results by having higher discharges in an upstream node. Where this occurred, the maximum discharge was adopted. Note that this adjustment for partial area effect results in identical discharges at a number of adjacent nodes in a reach.

8.4.4 Results

Rational Method parameters and results for each town are provided in Appendix C.

Table 8.2 Adopted Impervious Percentage and C10 Runoff Coefficients

Land Use	Impervious Percentage (%)	C10 Runoff Coefficient	Manning's 'n'	Comments
Rural Zone	0	0.39	0.05	Negligible
Township Zone	60	0.7	0.2	Residential – Lot size >750m2
Recreation Zone	0	0.39	0.04/0.08	Open Space (eg Parks)
Community Purpose Zone	Varies according to proposal	Mixed	0.2	Open Space/Township
Rural Residential Zone	15	0.47	0.1	Rural – 2-5 dwelling per ha
Residential Living Zone	60	0.7	0.2	Residential – Lot size >750m2
Local Centre Zone	90	0.85	0.2	Commercial or Industrial
Emerging Communities Zone	60	0.7	0.2	Residential – Lot size >750m2
Major Centre Zone	100	0.85	0.2	Commercial or Industrial
Residential Choice Zone	60	0.7	0.2	Residential – Lot size >750m2
Medium Impact Industry Zone	90	0.85	0.15	Commercial or Industrial
Low Impact Industry Zone	90	0.85	0.15	Commercial or Industrial
Specialist Centre Zone	90	0.85	0.2	Commercial or Industrial
District Centre Zone	100	0.90	0.2	Central Business

8.5 Stormwater Flood Hydraulic Modelling

8.5.1 Overview

The MIKE FLOOD hydraulic model was used to estimate stormwater flooding for the five study towns.

8.5.2 Model Configuration

8.5.2.1 Model Description

Hydraulic modelling of the study area has been undertaken utilising DHI Software's MIKE FLOOD modelling system. The following is of note:

- Adopted model Grid configurations are identical to the riverine model which is detailed in Section 6 of this report.

- The stormwater model was run in steady state mode.

8.5.2.2 Modelled Events

The following events were modelled:

- 1 in 10 AEP.
- 1 in 50 AEP.
- 1 in 100 AEP.

8.5.2.3 Manning's n

Manning's n values were based upon the following:

- The majority of the modelled area adopted land use zonings from the revised planning scheme. Table 8.2 shows the adopted values for each land use.
- A Manning's n of 0.08 was adopted for major flow paths that were considered to be unlikely to be developed.
- Different roughness files were adopted for the riverine and stormwater hydraulic models for each town.

8.5.2.4 Structures

Structure locations are provided in Appendix A. Note that only structures that were considered to have a substantial effect on stormwater were included. For example, there are numerous small culverts under roads in Miles. These were considered to have negligible impact on flooding and were ignored.

8.5.2.5 Model Run Sequence

To avoid a significant overstatement of flows in the downstream reaches (as stream branches converge) each model for each town was split into a number of "component runs". Each component run modelled separate creek branches, with each successive run (generally) modelling a larger proportion of the catchment. Appendix D contains the model run sequence for Miles.

8.5.3 Adopted Discharges

The calculated Rational Method discharges were adopted. The convention commonly adopted for steady state hydraulic models of inputting the estimated discharge for each node at the adjacent upstream node was adopted.

8.5.4 Results

The MIKE FLOOD model was run multiple times for each catchment to account for the partial area effect. The adopted flood extent for each AEP was developed from a mosaic of the maximum modelled flood extent from all model runs for each town. Maps of stormwater flood extent and depth were created for the 1 in 10, 1 in 50 and 1 in 100 AEP floods for Miles. The background for all maps is an aerial photograph and cadastre. All maps are provided in Volume II of this report.

9 CONCLUSIONS

Western Downs Regional Council (WDRC) was created in March 2008 after the amalgamations of local government areas throughout Queensland. A full Planning Scheme review is currently being undertaken to create one Planning Scheme for the Western Downs Region. WDRC proposed to undertake flood studies of six towns in the region in conjunction with the Planning Scheme review of which Miles, the subject of this report was one. There were two components to the flood studies; riverine flooding and stormwater flooding. The purpose of the riverine flood studies was to identify areas of risk of flood inundation, their impact upon current and future development and to identify flood hazard categories for the inundation areas for the defined flood event (DFE). The purpose of the stormwater flood analysis was to define and map stormwater corridors within current and future development areas. The six towns included in the study were Dalby, Chinchilla, Miles, Wandoan, Jandowae and Tara.

Extensive research was undertaken as part of the study to identify and list historical floods for Miles. This included:

- Community consultation.
- Research by the Dalby Family History Society, the Chinchilla Museum and the Miles Museum.
- Research by Council officers.
- Interviews with residents.

Two different types of floods were assessed; riverine and stormwater floods. Riverine floods are large regional floods from the creeks running through each town. These floods may last several days and are usually the result of widespread, long duration rainfall. Stormwater floods are local floods through the numerous overland flowpaths through the towns. These floods are short duration (an hour or so) and are usually the result of localised, short duration rainfall.

For the riverine flood, different flood magnitude estimation techniques were adopted for each town. This is a reflection of differences in the available data. The 1% AEP flood was modelled. Results were presented as maps of flood depths and flood hazard. The 1 in 100 AEP flood was adopted as the defined flood event (DFE).

Stormwater flooding was also assessed in detail.

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APPENDIX A MILES HYDRAULIC MODEL CONFIGURATION

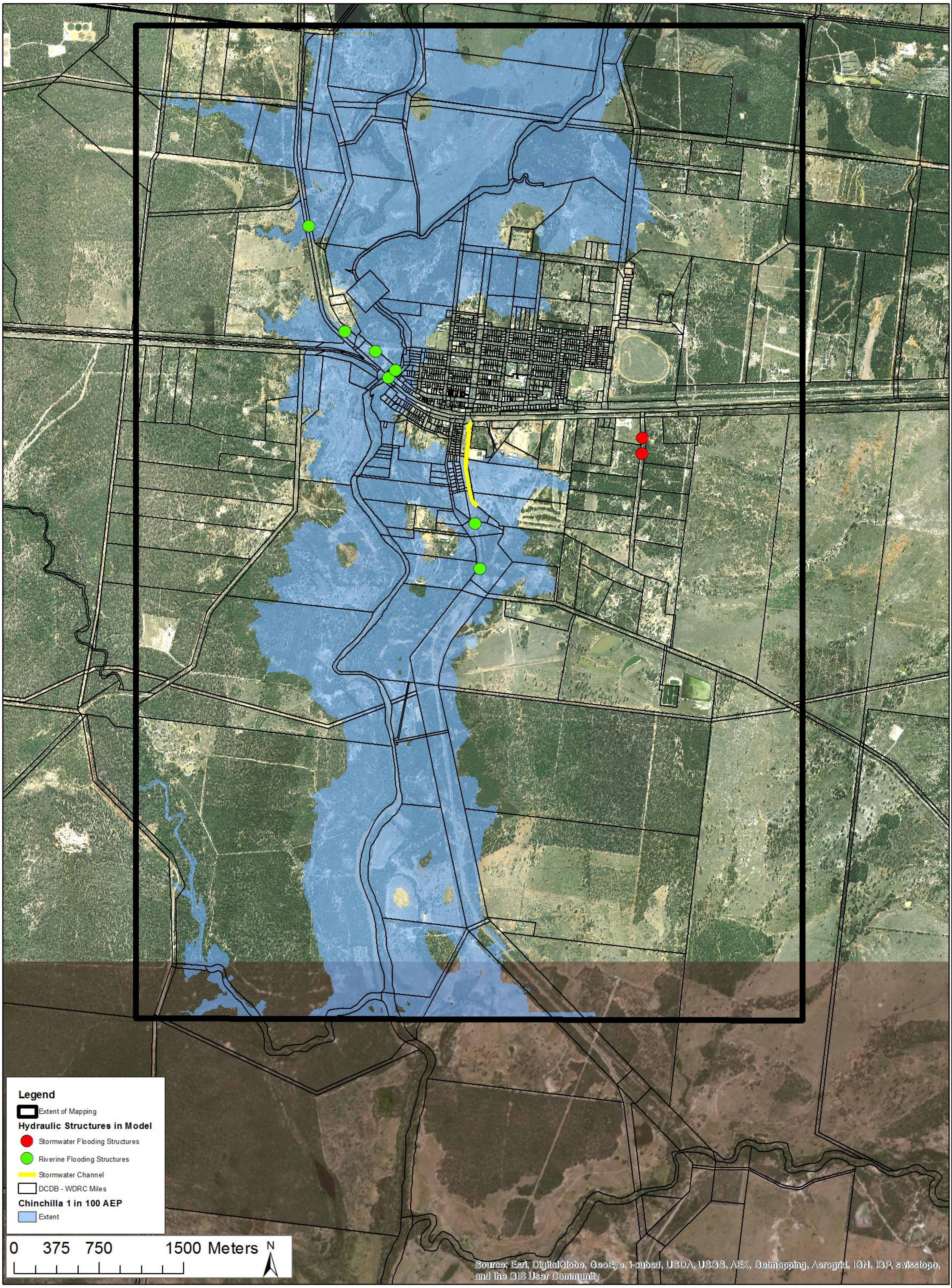

Figure A.1 Miles Hydraulic Structures

APPENDIX B HYDRAULIC MODEL DOWNSTREAM BOUNDARY SENSITIVITY TESTING

A downstream boundary sensitivity analysis was undertaken for the Dogwood Creek MIKE FLOOD model. A normal depth was approximated from the preliminary water surface profile which was then refined by modelling to get a closer estimate. Water surface level (WSL) differences were then compared at a point 1000m upstream of the boundary as well as at a point that was deemed within the town area. Table B.1 shows the results of the sensitivity analysis.

Table B.1 shows that changes in the WSL 1000m upstream of the boundary were within 0.1m. When measured at a point within the town area changes in WSL were within 0.02m. The results indicate the adopted approximate normal depth boundary levels are acceptable with boundary level variations having a minimal affect within the study area. Figure B.1 shows the water surface profiles upstream of the boundary for Dogwood Creek.

Table B.1 Downstream Sensitivity Analysis Results

Town	Run	Boundary Level	Δ WSL 1000m Upstream	Distance to Town	Δ WSL at town
		(m AHD)	(m)	(m)	(m)
Miles	Adopted	295.5	-	2000	-
	Increase	297	0.09		0.00
	Decrease	292	0.00		0.00

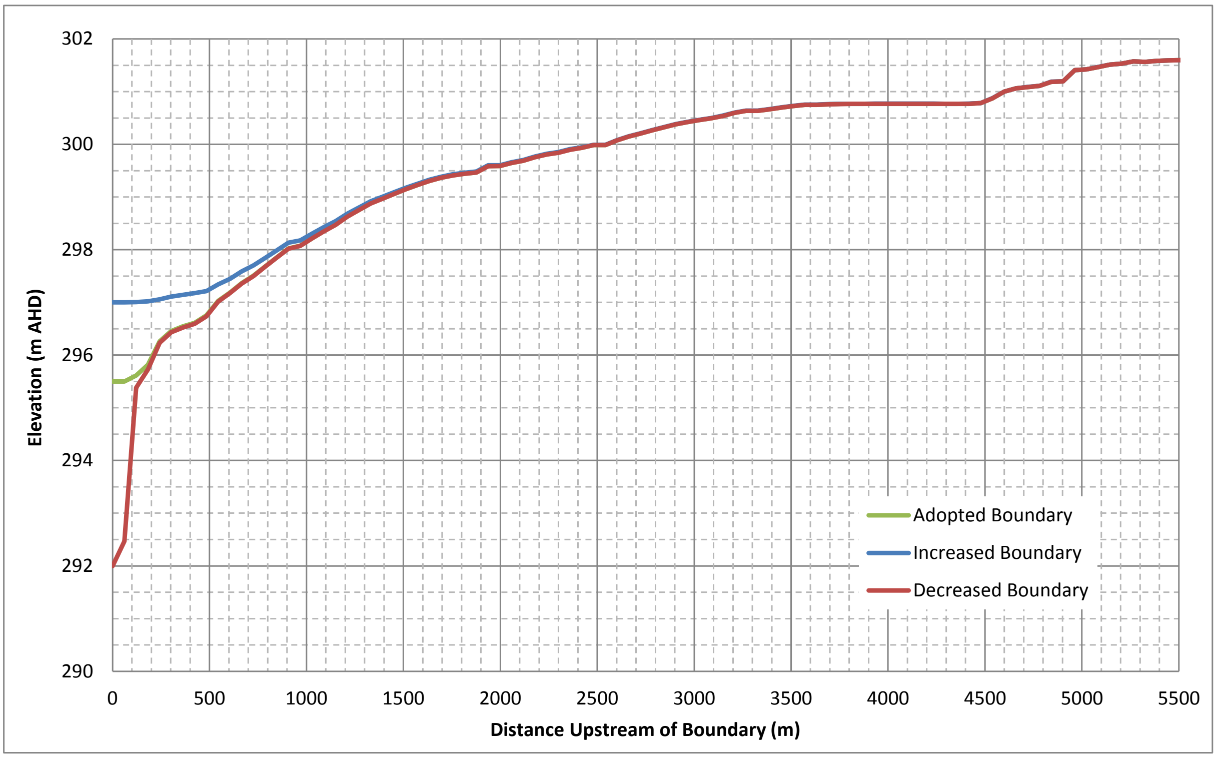

Figure B.1 Miles downstream water surface profile

APPENDIX C MILES STORMWATER MODELLING – RATIONAL METHOD PARAMETERS AND RESULTS

Table C.1 1 in 100 AEP Miles Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Mannings n	Length (m)	Slope (m/m)	Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
A1	23.6	513	0.004	23.6	0.39	0.39	513	1	0.47	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	94.5	2.9	2.9	**2.9**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.47							0.60	49.7	90.0	55.9	8.7	5.8	**8.7**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.47							0.60	22.7	112.6	47.9	9.8	1.1	**9.8**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.47	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	95.4	2.3	2.3	**2.3**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.47							0.60	9.5	49.2	83.6	3.1	0.8	**3.1**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.47	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	97.4	1.6	1.6	**1.6**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.47							0.60	11.6	49.9	82.8	2.1	0.5	**2.1**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.90	Std. Inlet	15					0.60	21.4	36.4	100.4	3.3	3.3	**3.3**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.90							0.60	8.7	45.1	88.2	4.3	1.0	**4.3**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.89							0.60	13.8	58.9	74.5	10.8	6.5	**10.8**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.99	Std. Inlet	15					0.60	15.1	30.1	112.0	4.4	4.4	**4.4**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.87	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	95.8	1.3	1.3	**1.3**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.84	Std. Inlet	15					0.60	8.4	23.4	128.4	11.9	11.9	**11.9**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.83							0.60	19.5	43.0	90.9	15.2	3.3	**15.2**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.51	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	88.3	6.7	6.7	**6.7**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.80	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	98.7	1.5	1.5	**1.5**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.82							0.60	11.0	48.4	84.5	3.7	2.2	**3.7**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.72	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	128.3	1.0	1.0	**1.0**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.82							0.60	14.1	37.6	98.4	4.4	3.4	**4.4**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.84	Std. Inlet	15					0.60	13.3	28.3	115.8	2.9	2.9	**2.9**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.83							0.60	6.8	35.1	102.5	4.7	1.7	**4.7**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.84	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	100.9	1.9	1.9	**1.9**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.84							0.60	16.0	52.0	80.7	4.8	2.9	**4.8**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.47	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	52.1	16.4	16.4	**16.4**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.47							0.60	29.3	129.3	43.3	26.5	10.1	**26.5**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.47							0.60	23.7	153.0	38.2	29.1	2.6	**29.1**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.47							0.60	24.4	177.4	34.3	30.2	1.1	**30.2**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.53							0.60	9.8	187.3	33.0	51.3	21.1	**51.3**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.54							0.60	19.3	206.6	30.6	52.5	1.2	**52.5**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.55							0.60	12.1	218.6	29.4	52.4	-0.1	**52.5**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.56							0.60	11.4	230.0	28.3	56.2	3.8	**56.2**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.57							0.60	16.3	246.3	26.9	61.3	5.1	**61.3**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.52	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	84.6	13.2	13.2	**13.2**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.58							0.60	31.2	79.4	61.2	24.2	11.0	**24.2**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.56							0.60	18.1	97.5	53.0	24.7	0.4	**24.7**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.62							0.60	10.0	107.5	49.4	31.9	7.3	**31.9**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.89	Std. Inlet	15					0.60	8.5	23.5	128.4	1.8	1.8	**1.8**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.85							0.60	9.2	32.6	107.0	5.5	3.7	**5.5**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.86							0.60	11.1	43.7	90.0	6.1	0.6	**6.1**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.85	Std. Inlet	15					0.60	13.1	28.1	116.4	6.7	6.7	**6.7**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.84							0.60	17.1	45.2	88.1	14.8	8.1	**14.8**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.86							0.60	12.9	58.1	75.1	16.1	1.2	**16.1**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.84							0.60	12.0	70.1	66.7	27.1	11.1	**27.1**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.57	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	73.2	9.3	9.3	**9.3**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.53							0.60	28.4	88.8	56.5	12.9	3.6	**12.9**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.52							0.60	19.3	108.1	49.2	26.2	13.3	**26.2**

Table C.1 1 in 100 AEP Miles Stormwater Modelling - Model Parameters and Results

Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Overland Flow: Mannings n	Overland Flow: Length (m)	Overland Flow: Slope (m/m)	Overland Flow: Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.51							0.60	22.3	130.5	43.0	27.5	1.3	**27.5**
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.84	Std. Inlet	15					0.60	12.3	27.3	118.3	1.3	1.3	**1.3**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.84							0.60	10.9	38.1	97.6	1.9	0.6	**1.9**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.84							0.60	11.4	49.6	83.1	10.9	9.0	**10.9**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.84	Std. Inlet	15					0.60	12.3	27.3	118.3	1.5	1.5	**1.5**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.84							0.60	10.9	38.1	97.6	2.1	0.7	**2.1**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.49	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	61.5	17.9	17.9	**17.9**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.48							0.60	30.3	109.0	48.9	20.9	3.0	**20.9**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.58	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	101.0	3.9	3.9	**3.9**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.52							0.60	19.7	55.7	77.2	6.9	3.0	**6.9**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.52							0.60	19.6	75.3	63.2	7.4	0.5	**7.4**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.51							0.60	9.5	84.7	58.5	7.9	0.5	**7.9**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.56	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	97.1	3.2	3.2	**3.2**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.60							0.60	9.4	47.9	85.0	6.9	3.7	**6.9**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.67							0.60	21.0	68.9	67.5	8.5	1.6	**8.5**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.66	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	99.5	2.6	2.6	**2.6**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.70							0.60	12.5	49.4	83.3	3.7	1.1	**3.7**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.79							0.60	15.2	64.6	70.4	12.0	8.3	**12.0**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.84	Std. Inlet	15					0.60	17.0	32.0	108.2	7.1	7.1	**7.1**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.56	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	104.4	2.7	2.7	**2.7**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.53							0.60	16.3	50.4	82.3	7.0	4.3	**7.0**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.84	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	106.9	1.2	1.2	**1.2**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.84							0.60	13.1	45.8	87.4	5.7	4.5	**5.7**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.84							0.60	11.0	56.7	76.3	8.9	3.2	**8.9**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.84							0.60	11.9	68.6	67.7	11.5	2.6	**11.5**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.78							0.60	8.9	77.5	62.1	25.8	14.3	**25.8**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.59							0.60	16.2	93.7	54.5	60.9	35.1	**60.9**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.58							0.60	24.7	118.4	46.1	61.3	0.4	**61.3**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.84	Std. Inlet	15					0.60	12.0	27.0	119.0	1.7	1.7	**1.7**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.84							0.60	11.0	38.0	97.9	2.3	0.6	**2.3**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.47	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	78.3	14.9	14.9	**14.9**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.47	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	110.8	1.1	1.1	**1.1**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.47							0.60	9.9	40.6	94.0	2.5	1.4	**2.5**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.47	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	119.7	0.7	0.7	**0.7**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.81	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	109.5	2.9	2.9	**2.9**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.93	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	94.3	5.3	5.3	**5.3**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.47	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	112.9	2.4	2.4	**2.4**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.53							0.60	7.1	36.8	99.7	4.2	1.8	**4.2**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.81	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	90.2	3.6	3.6	**3.6**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.82							0.60	12.3	55.8	77.1	4.8	1.1	**4.8**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.92							0.60	18.9	74.7	63.6	9.2	4.4	**9.2**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.90							0.60	9.4	84.1	58.9	9.9	0.7	**9.9**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.76	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	115.9	4.3	4.3	**4.3**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.94	Std. Inlet	15					0.60	7.9	22.9	130.0	2.1	2.1	**2.1**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.95							0.60	8.4	31.3	109.6	4.1	2.0	**4.1**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.98							0.60	14.1	45.4	87.9	13.3	9.2	**13.3**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.92							0.60	9.8	55.2	77.6	12.9	-0.4	**13.3**

Table C.1 1 in 100 AEP Miles Stormwater Modelling - Model Parameters and Results

Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Overland Flow: Mannings n	Overland Flow: Length	Overland Flow: Slope	Overland Flow: Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.90	Std. Inlet	15					0.60	5.4	20.4	138.2	1.6	1.6	**1.6**
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.47	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	104.2	3.3	3.3	**3.3**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.52							0.60	16.4	50.5	82.1	3.6	0.3	**3.6**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	1.01	Std. Inlet	15					0.60	9.5	24.5	125.4	3.9	3.9	**3.9**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	1.01							0.60	10.8	35.3	102.1	5.0	1.0	**5.0**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	1.02	Std. Inlet	15					0.60	8.0	23.0	129.8	1.4	1.4	**1.4**

Table C.2 1 in 50 AEP Miles Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Mannings n	Length	Slope	Overland flow travel time	Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
A1	23.6	513	0.004	23.6	0.39	0.39	513	1	0.45	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	85.0	2.5	2.5	**2.5**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.45							0.60	49.7	90.0	50.3	7.5	5.0	**7.5**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.45							0.60	22.7	112.6	43.0	8.5	0.9	**8.5**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.45	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	85.8	2.0	2.0	**2.0**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.45							0.60	9.5	49.2	75.3	2.6	0.7	**2.6**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.45	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	87.7	1.4	1.4	**1.4**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.45							0.60	11.6	49.9	74.5	1.8	0.4	**1.8**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.86	Std. Inlet	15					0.60	21.4	36.4	90.3	2.9	2.9	**2.9**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.86							0.60	8.7	45.1	79.4	3.7	0.9	**3.7**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.85							0.60	13.8	58.9	67.1	9.3	5.6	**9.3**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.95	Std. Inlet	15					0.60	15.1	30.1	100.7	3.8	3.8	**3.8**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.83	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	86.2	1.1	1.1	**1.1**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.80	Std. Inlet	15					0.60	8.4	23.4	115.3	10.3	10.3	**10.3**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.80							0.60	19.5	43.0	81.8	13.1	2.9	**13.1**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.49	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	79.5	5.8	5.8	**5.8**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.76	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	88.8	1.3	1.3	**1.3**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.79							0.60	11.0	48.4	76.0	3.2	1.9	**3.2**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.69	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	115.2	0.9	0.9	**0.9**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.78							0.60	14.1	37.6	88.5	3.8	3.0	**3.8**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.80	Std. Inlet	15					0.60	13.3	28.3	104.1	2.5	2.5	**2.5**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.80							0.60	6.8	35.1	92.2	4.0	1.5	**4.0**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.81	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	90.8	1.6	1.6	**1.6**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.81							0.60	16.0	52.0	72.6	4.1	2.5	**4.1**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.45	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	46.8	14.1	14.1	**14.1**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.45							0.60	29.3	129.3	38.9	22.8	8.7	**22.8**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.45							0.60	23.7	153.0	34.3	25.0	2.2	**25.0**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.45							0.60	24.4	177.4	30.7	25.9	0.9	**25.9**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.51							0.60	9.8	187.3	29.5	44.1	18.1	**44.1**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.52							0.60	19.3	206.6	27.4	45.1	1.0	**45.1**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.52							0.60	12.1	218.6	26.3	45.0	-0.1	**45.1**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.54							0.60	11.4	230.0	25.3	48.2	3.2	**48.2**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.55							0.60	16.3	246.3	24.1	52.6	4.4	**52.6**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.50	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	76.2	11.4	11.4	**11.4**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.55							0.60	31.2	79.4	55.0	20.9	9.5	**20.9**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.54							0.60	18.1	97.5	47.7	21.3	0.4	**21.3**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.60							0.60	10.0	107.5	44.4	27.5	6.3	**27.5**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.85	Std. Inlet	15					0.60	8.5	23.5	115.3	1.6	1.6	**1.6**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.82							0.60	9.2	32.6	96.2	4.8	3.2	**4.8**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.83							0.60	11.1	43.7	81.0	5.3	0.5	**5.3**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.81	Std. Inlet	15					0.60	13.1	28.1	104.6	5.8	5.8	**5.8**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.81							0.60	17.1	45.2	79.3	12.8	7.0	**12.8**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.82							0.60	12.9	58.1	67.6	13.9	1.1	**13.9**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.81							0.60	12.0	70.1	60.0	23.4	9.6	**23.4**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.55	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	65.9	8.0	8.0	**8.0**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.51							0.60	28.4	88.8	50.8	11.1	3.1	**11.1**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.50							0.60	19.3	108.1	44.2	22.5	11.4	**22.5**
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.49							0.60	22.3	130.5	38.6	23.7	1.1	**23.7**

Table C.2 1 in 50 AEP Miles Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Mannings n	Length (m)	Slope (m/m)	Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.81	Std. Inlet	15					0.60	12.3	27.3	106.3	1.1	1.1	**1.1**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.81							0.60	10.9	38.1	87.8	1.7	0.5	**1.7**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.80							0.60	11.4	49.6	74.8	9.4	7.7	**9.4**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.81	Std. Inlet	15					0.60	12.3	27.3	106.3	1.3	1.3	**1.3**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.81							0.60	10.9	38.1	87.8	1.8	0.6	**1.8**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.47	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	55.4	15.4	15.4	**15.4**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.46							0.60	30.3	109.0	44.0	18.0	2.6	**18.0**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.56	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	90.8	3.4	3.4	**3.4**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.50							0.60	19.7	55.7	69.5	6.0	2.6	**6.0**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.50							0.60	19.6	75.3	56.9	6.4	0.4	**6.4**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.49							0.60	9.5	84.7	52.7	6.8	0.4	**6.8**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.53	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	87.4	2.8	2.8	**2.8**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.58							0.60	9.4	47.9	76.5	6.0	3.2	**6.0**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.64							0.60	21.0	68.9	60.8	7.4	1.4	**7.4**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.63	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	89.5	2.3	2.3	**2.3**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.67							0.60	12.5	49.4	75.0	3.2	0.9	**3.2**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.76							0.60	15.2	64.6	63.4	10.3	7.2	**10.3**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.81	Std. Inlet	15					0.60	17.0	32.0	97.3	6.1	6.1	**6.1**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.54	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	93.9	2.3	2.3	**2.3**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.51							0.60	16.3	50.4	74.1	6.0	3.7	**6.0**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.81	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	96.2	1.0	1.0	**1.0**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.81							0.60	13.1	45.8	78.7	4.9	3.9	**4.9**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.81							0.60	11.0	56.7	68.7	7.7	2.8	**7.7**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.80							0.60	11.9	68.6	60.9	9.9	2.2	**9.9**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.75							0.60	8.9	77.5	55.9	22.3	12.3	**22.3**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.57							0.60	16.2	93.7	49.0	52.5	30.2	**52.5**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.56							0.60	24.7	118.4	41.4	52.8	0.3	**52.8**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.81	Std. Inlet	15					0.60	12.0	27.0	106.9	1.5	1.5	**1.5**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.81							0.60	11.0	38.0	88.0	2.0	0.5	**2.0**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.45	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	70.5	12.8	12.8	**12.8**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.45	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	99.6	0.9	0.9	**0.9**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.45							0.60	9.9	40.6	84.6	2.1	1.2	**2.1**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.45	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	107.6	0.6	0.6	**0.6**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.77	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	98.4	2.5	2.5	**2.5**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.89	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	84.8	4.6	4.6	**4.6**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.45	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	101.5	2.0	2.0	**2.0**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.51							0.60	7.1	36.8	89.7	3.6	1.6	**3.6**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.78	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	81.2	3.1	3.1	**3.1**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.79							0.60	12.3	55.8	69.4	4.1	1.0	**4.1**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.89							0.60	18.9	74.7	57.2	7.9	3.8	**7.9**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.86							0.60	9.4	84.1	53.0	8.5	0.6	**8.5**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.73	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	104.1	3.7	3.7	**3.7**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.90	Std. Inlet	15					0.60	7.9	22.9	116.7	1.8	1.8	**1.8**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.91							0.60	8.4	31.3	98.5	3.5	1.7	**3.5**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.94							0.60	14.1	45.4	79.1	11.5	8.0	**11.5**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.88							0.60	9.8	55.2	69.9	11.1	-0.4	**11.5**
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.86	Std. Inlet	15					0.60	5.4	20.4	124.0	1.4	1.4	**1.4**

Table C.2 1 in 50 AEP Miles Stormwater Modelling - Model Parameters and Results

Catchment ID	Area	Stream Length	Slope	Total Upstream Area	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time	Overland Flow				Channel Velocity	Tc Channel	Total Tc	Rainfall Intensity	Discharge	Difference	Corrected Discharge (for partial area effect)
												Mannings n	Length	Slope	Overland flow travel time							
	(ha)	(m)	(m/m)	(ha)			(m)				(mins)		(m)	(m/m)	(mins)	(m/s)	(mins)	(min)	(mm/hr)	(m^3/s)	(m^3/s)	(m^3/s)
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.45	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	93.7	2.9	2.9	**2.9**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.50							0.60	16.4	50.5	73.9	3.1	0.2	**3.1**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	0.97	Std. Inlet	15					0.60	9.5	24.5	112.6	3.4	3.4	**3.4**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	0.97							0.60	10.8	35.3	91.9	4.3	0.9	**4.3**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	0.98	Std. Inlet	15					0.60	8.0	23.0	116.6	1.2	1.2	**1.2**

Table C.3 1 in 10 AEP Miles Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Mannings n	Length (m)	Slope (m/m)	Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
A1	23.6	513	0.004	23.6	0.39	0.39	513	1	0.39	overland		0.045	95.7	0.004	26.0	0.60	14.3	40.3	63.8	1.6	1.6	**1.6**
A2	96.2	1788	0.002	119.8	0.39	0.39	2301	1	0.39							0.60	49.7	90.0	37.7	4.9	3.3	**4.9**
A3	37.8	816	0.002	157.6	0.39	0.39	3117	1	0.39							0.60	22.7	112.6	32.2	5.5	0.6	**5.5**
AA1	18.6	539	0.006	18.6	0.39	0.39	539	1	0.39	overland		0.045	94.5	0.006	24.7	0.60	15.0	39.7	64.4	1.3	1.3	**1.3**
AA2	9.6	342	0.002	28.1	0.39	0.39	881	1	0.39							0.60	9.5	49.2	56.5	1.7	0.4	**1.7**
AB1	12.6	492	0.006	12.6	0.39	0.39	492	1	0.39	overland		0.045	94.4	0.006	24.6	0.60	13.7	38.2	65.8	0.9	0.9	**0.9**
AB2	6.4	418	0.002	19.0	0.39	0.39	910	1	0.39							0.60	11.6	49.9	56.0	1.2	0.3	**1.2**
AC1	13.3	770	0.002	13.3	0.75	0.75	770	1	0.75	Std. Inlet	15					0.60	21.4	36.4	67.8	1.9	1.9	**1.9**
AC2	6.3	313	0.002	19.6	0.75	0.75	1083	1	0.75							0.60	8.7	45.1	59.6	2.4	0.6	**2.4**
AC3	10.5	496	0.002	58.6	0.78	0.74	1579	1	0.74							0.60	13.8	58.9	50.4	6.1	3.6	**6.1**
AD1	14.1	544	0.007	14.1	0.83	0.83	544	1	0.83	Std. Inlet	15					0.60	15.1	30.1	75.4	2.4	2.4	**2.4**
AE1	5.4	316	0.002	5.4	0.72	0.72	316	1	0.72	overland		0.045	98	0.002	30.6	0.60	8.8	39.4	64.7	0.7	0.7	**0.7**
AF1	39.8	304	0.011	39.8	0.70	0.70	304	1	0.70	Std. Inlet	15					0.60	8.4	23.4	86.2	6.7	6.7	**6.7**
AF2	32.5	703	0.002	72.3	0.69	0.70	1007	1	0.70							0.60	19.5	43.0	61.5	8.6	1.9	**8.6**
AG1	53.2	915	0.015	53.2	0.43	0.43	915	1	0.43	overland		0.045	85.2	0.015	19.6	0.60	25.4	45.0	59.7	3.8	3.8	**3.8**
AI1	6.9	179	0.002	6.9	0.66	0.66	179	1	0.66	overland		0.045	98.5	0.002	32.4	0.60	5.0	37.4	66.7	0.8	0.8	**0.8**
AI2	12.3	395	0.002	19.1	0.70	0.69	574	1	0.69							0.60	11.0	48.4	57.1	2.1	1.2	**2.1**
AJ1	3.9	167	0.017	3.9	0.60	0.60	167	1	0.60	overland		0.045	83	0.017	18.9	0.60	4.6	23.5	86.1	0.6	0.6	**0.6**
AJ2	16.0	509	0.002	19.9	0.70	0.68	676	1	0.68							0.60	14.1	37.6	66.4	2.5	1.9	**2.5**
AK1	10.9	480	0.004	10.9	0.70	0.70	480	1	0.70	Std. Inlet	15					0.60	13.3	28.3	78.0	1.6	1.6	**1.6**
AK2	8.7	244	0.002	19.6	0.69	0.69	724	1	0.69							0.60	6.8	35.1	69.2	2.6	1.0	**2.6**
AL1	7.9	226	0.002	7.9	0.70	0.70	226	1	0.70	overland		0.045	97.72	0.002	29.8	0.60	6.3	36.0	68.1	1.0	1.0	**1.0**
AL2	17.6	576	0.002	25.5	0.70	0.70	802	1	0.70							0.60	16.0	52.0	54.6	2.7	1.7	**2.7**
B1	242.2	2500	0.002	242.2	0.39	0.39	2500	1	0.39	overland		0.045	98	0.002	30.6	0.60	69.4	100.0	35.1	9.2	9.2	**9.2**
B2	226.3	1054	0.002	468.5	0.39	0.39	3554	1	0.39							0.60	29.3	129.3	29.0	14.8	5.6	**14.8**
B3	114.2	854	0.002	582.7	0.39	0.39	4408	1	0.39							0.60	23.7	153.0	25.6	16.2	1.4	**16.2**
B4	41.6	879	0.002	671.4	0.43	0.39	5287	1	0.39							0.60	24.4	177.4	22.9	16.8	0.6	**16.8**
B5	16.2	354	0.002	1062.4	0.56	0.44	5641	1	0.44							0.60	9.8	187.3	21.9	28.5	11.7	**28.5**
B6	37.4	694	0.002	1148.4	0.61	0.45	6335	1	0.45							0.60	19.3	206.6	20.4	29.1	0.6	**29.1**
B7	29.7	435	0.002	1178.1	0.70	0.45	6770	1	0.45							0.60	12.1	218.6	19.5	29.0	-0.1	**29.1**
B8	18.3	410	0.002	1273.9	0.54	0.47	7180	1	0.47							0.60	11.4	230.0	18.7	31.0	2.1	**31.0**
B9	10.2	586	0.002	1437.1	0.39	0.48	7766	1	0.48							0.60	16.3	246.3	17.8	33.8	2.8	**33.8**
C1	108.2	775	0.004	108.2	0.43	0.43	775	1	0.43	overland		0.045	96.2	0.004	26.7	0.60	21.5	48.3	57.2	7.4	7.4	**7.4**
C2	138.5	1122	0.002	246.7	0.52	0.48	1897	1	0.48							0.60	31.2	79.4	41.3	13.6	6.2	**13.6**
C3	52.1	650	0.002	298.8	0.40	0.47	2547	1	0.47							0.60	18.1	97.5	35.7	13.9	0.2	**13.9**
C4	8.4	360	0.002	374.7	0.47	0.52	2907	1	0.52							0.60	10.0	107.5	33.2	17.9	4.1	**17.9**
D1	5.8	305	0.007	5.8	0.74	0.74	305	1	0.74	Std. Inlet	15					0.60	8.5	23.5	86.1	1.0	1.0	**1.0**
D2	16.0	330	0.002	21.7	0.70	0.71	635	1	0.71							0.60	9.2	32.6	72.1	3.1	2.1	**3.1**
D3	6.7	399	0.002	28.4	0.75	0.72	1034	1	0.72							0.60	11.1	43.7	60.8	3.5	0.4	**3.5**
E1	24.5	471	0.011	24.5	0.71	0.71	471	1	0.71	Std. Inlet	15					0.60	13.1	28.1	78.3	3.8	3.8	**3.8**
E2	47.5	615	0.002	71.9	0.70	0.70	1086	1	0.70							0.60	17.1	45.2	59.6	8.4	4.6	**8.4**
E3	17.8	466	0.002	89.7	0.77	0.71	1552	1	0.71							0.60	12.9	58.1	50.8	9.0	0.7	**9.0**
E4	11.7	431	0.002	173.7	0.66	0.70	1983	1	0.70							0.60	12.0	70.1	45.1	15.3	6.2	**15.3**
F1	80.1	1132	0.003	80.1	0.48	0.48	1132	1	0.48	overland		0.045	97.42	0.003	29.0	0.60	31.4	60.5	49.5	5.2	5.2	**5.2**
F2	74.6	1021	0.002	154.7	0.41	0.44	2153	1	0.44							0.60	28.4	88.8	38.1	7.3	2.0	**7.3**
F3	57.0	695	0.002	366.4	0.39	0.44	2848	1	0.44							0.60	19.3	108.1	33.1	14.7	7.4	**14.7**
F4	81.6	804	0.002	448.0	0.40	0.43	3652	1	0.43							0.60	22.3	130.5	28.8	15.4	0.7	**15.4**

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Table C.3 1 in 10 AEP Miles Stormwater Modelling - Model Parameters and Results

												Overland Flow										
Catchment ID	**Area (ha)**	**Stream Length (m)**	**Slope (m/m)**	**Total Upstream Area (ha)**	**Catchment C10**	**Tot. u/s area Av. C10**	**Sum Stream Length (m)**	**Fy**	**Cy**	**Overland Flow/Std Inlet Time**	**Std Inlet Time (mins)**	**Mannings n**	**Length (m)**	**Slope (m/m)**	**Overland flow travel time (mins)**	**Channel Velocity (m/s)**	**Tc Channel (mins)**	**Total Tc (min)**	**Rainfall Intensity (mm/hr)**	**Discharge (m^3/s)**	**Difference (m^3/s)**	**Corrected Discharge (for partial area effect) (m^3/s)**
G1	4.8	442	0.005	4.8	0.70	0.70	442	1	0.70	Std. Inlet	15					0.60	12.3	27.3	79.6	0.7	0.7	**0.7**
G2	3.7	391	0.002	8.5	0.70	0.70	833	1	0.70							0.60	10.9	38.1	65.9	1.1	0.4	**1.1**
G3	9.4	412	0.002	56.3	0.70	0.70	1245	1	0.70							0.60	11.4	49.6	56.2	6.1	5.1	**6.1**
GN1	5.3	442	0.002	5.3	0.70	0.70	442	1	0.70	Std. Inlet	15					0.60	12.3	27.3	79.6	0.8	0.8	**0.8**
GN2	4.1	391	0.002	9.4	0.70	0.70	833	1	0.70							0.60	10.9	38.1	65.9	1.2	0.4	**1.2**
H1	215.0	1807	0.003	215.0	0.41	0.41	1807	1	0.41	overland		0.045	97.2	0.003	28.5	0.60	50.2	78.7	41.5	10.1	10.1	**10.1**
H2	105.2	1091	0.002	320.2	0.39	0.40	2898	1	0.40							0.60	30.3	109.0	32.9	11.7	1.7	**11.7**
I1	24.0	425	0.006	24.0	0.49	0.49	425	1	0.49	overland		0.045	94	0.006	24.2	0.60	11.8	36.0	68.2	2.2	2.2	**2.2**
I2	38.1	709	0.002	62.0	0.40	0.43	1134	1	0.43							0.60	19.7	55.7	52.2	3.9	1.7	**3.9**
I3	19.3	704	0.002	81.3	0.43	0.43	1838	1	0.43							0.60	19.6	75.3	42.7	4.2	0.3	**4.2**
I4	13.1	341	0.002	94.5	0.40	0.43	2179	1	0.43							0.60	9.5	84.7	39.5	4.4	0.3	**4.4**
J1	21.5	485	0.005	21.5	0.46	0.46	485	1	0.46	overland		0.045	94.8	0.005	25.0	0.60	13.5	38.5	65.6	1.8	1.8	**1.8**
J2	27.2	340	0.002	48.7	0.53	0.50	825	1	0.50							0.60	9.4	47.9	57.5	3.9	2.1	**3.9**
J3	19.6	755	0.002	68.3	0.69	0.56	1580	1	0.56							0.60	21.0	68.9	45.6	4.8	0.9	**4.8**
K1	14.4	269	0.002	14.4	0.55	0.55	269	1	0.55	overland		0.045	97.6	0.002	29.4	0.60	7.5	36.9	67.2	1.5	1.5	**1.5**
K2	8.1	450	0.002	22.5	0.66	0.59	719	1	0.59							0.60	12.5	49.4	56.3	2.1	0.6	**2.1**
K3	15.9	547	0.002	77.5	0.70	0.66	1266	1	0.66							0.60	15.2	64.6	47.6	6.7	4.7	**6.7**
L1	28.0	611	0.002	28.0	0.70	0.70	611	1	0.70	Std. Inlet	15					0.60	17.0	32.0	72.9	4.0	4.0	**4.0**
M1	16.5	442	0.010	16.5	0.47	0.47	442	1	0.47	overland		0.045	90.4	0.010	21.8	0.60	12.3	34.0	70.4	1.5	1.5	**1.5**
M2	40.8	588	0.002	57.3	0.43	0.44	1030	1	0.44							0.60	16.3	50.4	55.7	3.9	2.4	**3.9**
N1	4.8	280	0.005	4.8	0.70	0.70	280	1	0.70	overland		0.045	94.7	0.005	24.9	0.60	7.8	32.7	72.1	0.7	0.7	**0.7**
N2	23.0	472	0.002	27.8	0.70	0.70	752	1	0.70							0.60	13.1	45.8	59.1	3.2	2.5	**3.2**
N3	22.3	395	0.002	50.1	0.70	0.70	1147	1	0.70							0.60	11.0	56.7	51.6	5.0	1.8	**5.0**
N4	22.7	427	0.002	72.9	0.70	0.70	1574	1	0.70							0.60	11.9	68.6	45.8	6.5	1.5	**6.5**
N6	43.0	320	0.002	191.7	0.48	0.65	1894	1	0.65							0.60	8.9	77.5	42.0	14.5	8.0	**14.5**
N7	39.0	583	0.002	678.8	0.48	0.49	2477	1	0.49							0.60	16.2	93.7	36.7	34.2	19.7	**34.2**
N8	92.2	888	0.002	824.1	0.45	0.48	3365	1	0.48							0.60	24.7	118.4	31.0	34.3	0.1	**34.3**
NG1	6.3	432	0.002	6.3	0.70	0.70	432	1	0.70	Std. Inlet	15					0.60	12.0	27.0	80.0	1.0	1.0	**1.0**
NG2	4.0	395	0.002	10.3	0.70	0.70	827	1	0.70							0.60	11.0	38.0	66.1	1.3	0.3	**1.3**
O1	146.2	1170	0.009	146.2	0.39	0.39	1170	1	0.39	overland		0.045	90.8	0.009	22.0	0.60	32.5	54.5	53.0	8.4	8.4	**8.4**
P1	7.4	268	0.007	7.4	0.39	0.39	268	1	0.39	overland		0.045	92.8	0.007	23.2	0.60	7.4	30.7	74.7	0.6	0.6	**0.6**
P2	12.8	358	0.004	20.2	0.39	0.39	626	1	0.39							0.60	9.9	40.6	63.5	1.4	0.8	**1.4**
Q1	4.7	219	0.012	4.7	0.39	0.39	219	1	0.39	overland		0.045	88	0.012	20.6	0.60	6.1	26.7	80.5	0.4	0.4	**0.4**
R1	11.8	414	0.014	11.8	0.67	0.67	414	1	0.67	overland		0.045	86	0.014	19.8	0.60	11.5	31.3	73.8	1.6	1.6	**1.6**
S1	21.8	355	0.002	21.8	0.77	0.77	355	1	0.77	overland		0.045	98	0.002	30.6	0.60	9.9	40.4	63.7	3.0	3.0	**3.0**
T1	16.2	393	0.017	16.2	0.39	0.39	393	1	0.39	overland		0.045	82.6	0.017	18.7	0.60	10.9	29.7	76.1	1.3	1.3	**1.3**
T2	12.4	257	0.002	28.6	0.51	0.44	650	1	0.44							0.60	7.1	36.8	67.3	2.4	1.0	**2.4**
U1	17.9	466	0.002	17.9	0.68	0.68	466	1	0.68	overland		0.045	98	0.002	30.6	0.60	12.9	43.5	61.0	2.0	2.0	**2.0**
U2	9.3	442	0.003	27.2	0.70	0.68	908	1	0.68							0.60	12.3	55.8	52.1	2.7	0.6	**2.7**
U3	29.1	681	0.002	56.3	0.85	0.77	1589	1	0.77							0.60	18.9	74.7	42.9	5.2	2.5	**5.2**
U4	11.2	337	0.002	67.5	0.64	0.75	1926	1	0.75							0.60	9.4	84.1	39.7	5.6	0.4	**5.6**
V1	17.5	412	0.025	17.5	0.63	0.63	412	1	0.63	overland		0.045	75	0.025	16.9	0.60	11.4	28.3	78.0	2.4	2.4	**2.4**
W1	6.2	285	0.002	6.2	0.78	0.78	285	1	0.78	Std. Inlet	15					0.60	7.9	22.9	87.2	1.2	1.2	**1.2**
W2	7.9	301	0.002	14.0	0.80	0.79	586	1	0.79							0.60	8.4	31.3	73.9	2.3	1.1	**2.3**
W3	15.9	507	0.002	55.6	0.82	0.82	1093	1	0.82							0.60	14.1	45.4	59.4	7.5	5.2	**7.5**
W4	9.2	354	0.002	64.8	0.47	0.77	1447	1	0.77							0.60	9.8	55.2	52.5	7.3	-0.2	**7.5**
WE1	4.6	194	0.002	4.6	0.75	0.75	194	1	0.75	Std. Inlet	15					0.60	5.4	20.4	92.4	0.9	0.9	**0.9**

Table C.3 1 in 10 AEP Miles Stormwater Modelling - Model Parameters and Results

Catchment ID	Area (ha)	Stream Length (m)	Slope (m/m)	Total Upstream Area (ha)	Catchment C10	Tot. u/s area Av. C10	Sum Stream Length (m)	Fy	Cy	Overland Flow/Std Inlet Time	Std Inlet Time (mins)	Overland Flow: Mannings n	Overland Flow: Length (m)	Overland Flow: Slope (m/m)	Overland Flow: Overland flow travel time (mins)	Channel Velocity (m/s)	Tc Channel (mins)	Total Tc (min)	Rainfall Intensity (mm/hr)	Discharge (m^3/s)	Difference (m^3/s)	Corrected Discharge (for partial area effect) (m^3/s)
X1	24.5	556	0.018	24.5	0.39	0.39	556	1	0.39	overland		0.045	82.4	0.018	18.7	0.60	15.4	34.1	70.3	1.9	1.9	**1.9**
X2	5.7	591	0.002	30.2	0.62	0.43	1147	1	0.43							0.60	16.4	50.5	55.5	2.0	0.2	**2.0**
Z1	11.1	343	0.002	11.1	0.84	0.84	343	1	0.84	Std. Inlet	15					0.60	9.5	24.5	84.2	2.2	2.2	**2.2**
Z2	6.1	389	0.002	17.2	0.85	0.85	732	1	0.85							0.60	10.8	35.3	68.9	2.8	0.6	**2.8**
ZW1	3.8	287	0.000	3.8	0.85	0.85	287	1	0.85	Std. Inlet	15					0.60	8.0	23.0	87.1	0.8	0.8	**0.8**

APPENDIX D STORMWATER HYDRAULIC MODEL CATCHMENTS AND RUN SEQUENCE DETAILS

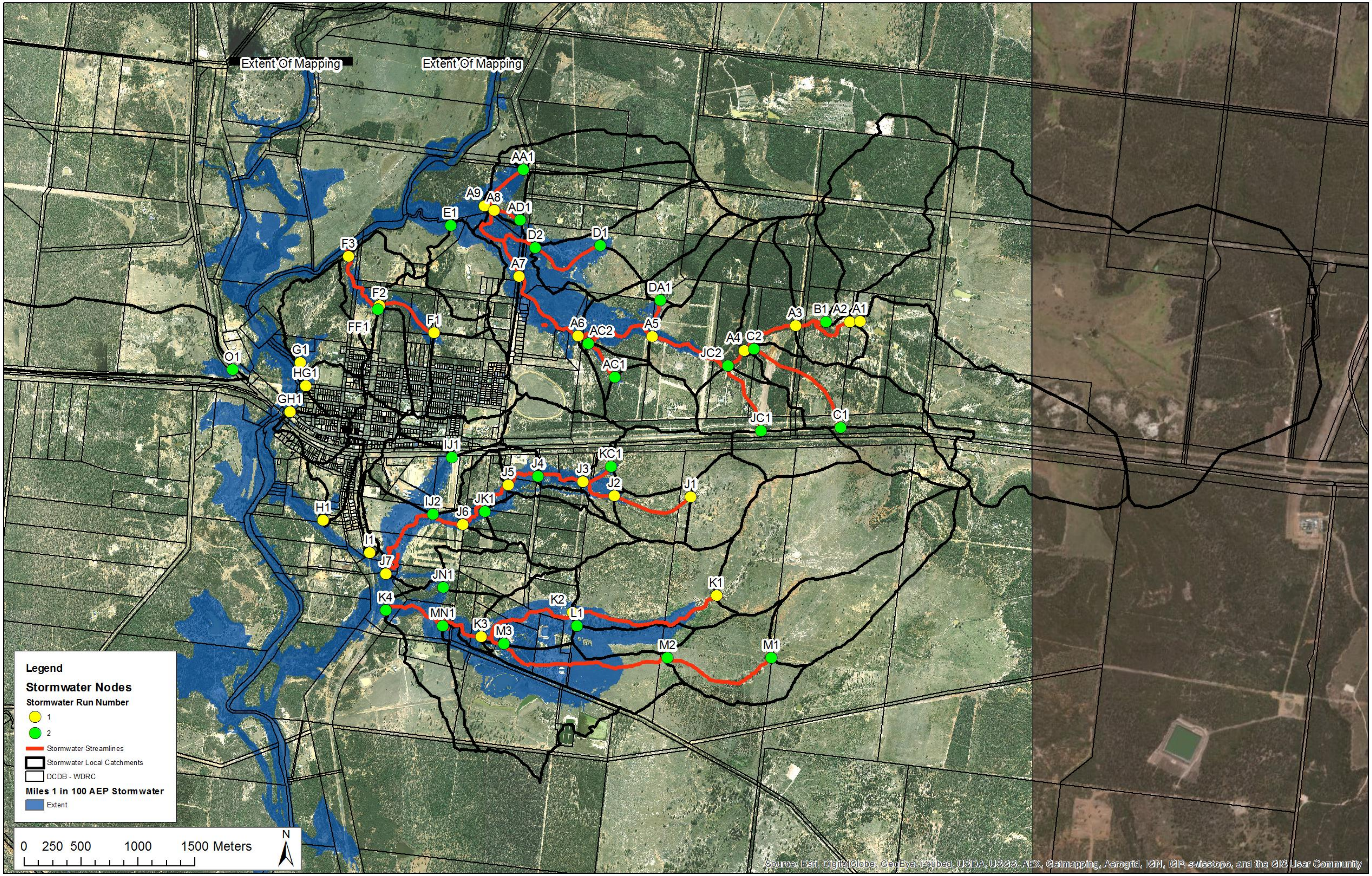

Figure D.1 Chinchilla 1 in 100 AEP Stormwater Flood Extent – Stormwater Catchments and Nodes