Slacks and Scrubby Creeks Flood Study

Finalisation Project

Logan City Council

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1 Introduction

1.1 BACKGROUND

Logan City Council (LCC) engaged WRM Water and Environment Pty Ltd (WRM) to develop and calibrate hydrologic and hydraulic models of the Slacks and Scrubby creeks catchment. These models will be used by LCC as tools to estimate design discharges, flood levels, depths, velocities and flood hazard along Slacks and Scrubby creeks and their tributaries.

LCC engaged WRM to undertake the following:

- Set up and calibrate an XP-RAFTS hydrologic and TUFLOW hydraulic model against available data for the January 2013, May 2015 and March 2017 flood events;
- Set up and validate an XP-RAFTS hydrologic and TUFLOW hydraulic model against available data for the February 2022 flood event;
- Use the calibrated models to produce design discharge hydrographs, flood levels, depths, velocities and flood hazard maps for the 50% (1 in 1.44 ARI), 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI) and 0.05% (1 in 2,000 ARI) annual exceedance probability (AEP) design events as well as the Probable Maximum Precipitation Design Flood (PMPDF) event for the current climate (2020) rainfall and tidal estimates;
- Apply the Future Climate (2090) estimates of rainfall and tidal conditions to produce the design discharge hydrographs, flood levels, depths, velocities and flood hazard maps for the 20% (1 in 5), 10% (1 in 10), 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) annual exceedance probability (AEP) design events.

This report describes the configuration and calibration of the Slacks and Scrubby creeks hydrologic and hydraulic models, and the use of the calibrated models to produce estimates of design discharges as well as peak flood levels, depths, velocities and flood hazard.

1.2 SLACKS AND SCRUBBY CREEKS CATCHMENT DESCRIPTION

Figure 1.1 shows the location of Slacks and Scrubby creeks, the Logan River as well as the Slacks Creek catchment boundary upstream of the Logan Motorway. Figure 1.1 also shows the locations of rainfall and stream gauges within and in the vicinity of the Slacks Creek catchment.

Slacks Creek flows in a southeasterly direction adjacent to the Pacific Motorway, passing under the Logan Motorway near Murrays Road before draining into the Logan River approximately 500 m downstream of the Logan Motorway. Scrubby Creek flows in an easterly direction, passing under the Logan Motorway at Kingston Road before draining into Slacks Creek near Loganlea Road. The Karawatha Forest Park and the Berrinba Wetlands are located within the Scrubby Creek catchment.

The catchment area of Slacks Creek (including Scrubby Creek) is 105.8 km^2 upstream of Loganlea Road and 119.9 km^2 upstream of the Logan Motorway. The catchment area of Scrubby Creek upstream of the Slacks Creek confluence (near Loganlea Road) is 77.7 km^2. The Slacks Creek catchment upstream of the Logan Motorway is heavily urbanised. Land use within the catchment is a mix of open space, urban and rural residential uses, commercial centres and some industrial areas.

1.3 LIMITATIONS OF THIS STUDY

As with any catchment wide flood study, there are a number of limitations associated with the results and mapping presented in this report. A full discussion of limitations is provided in Section 13.

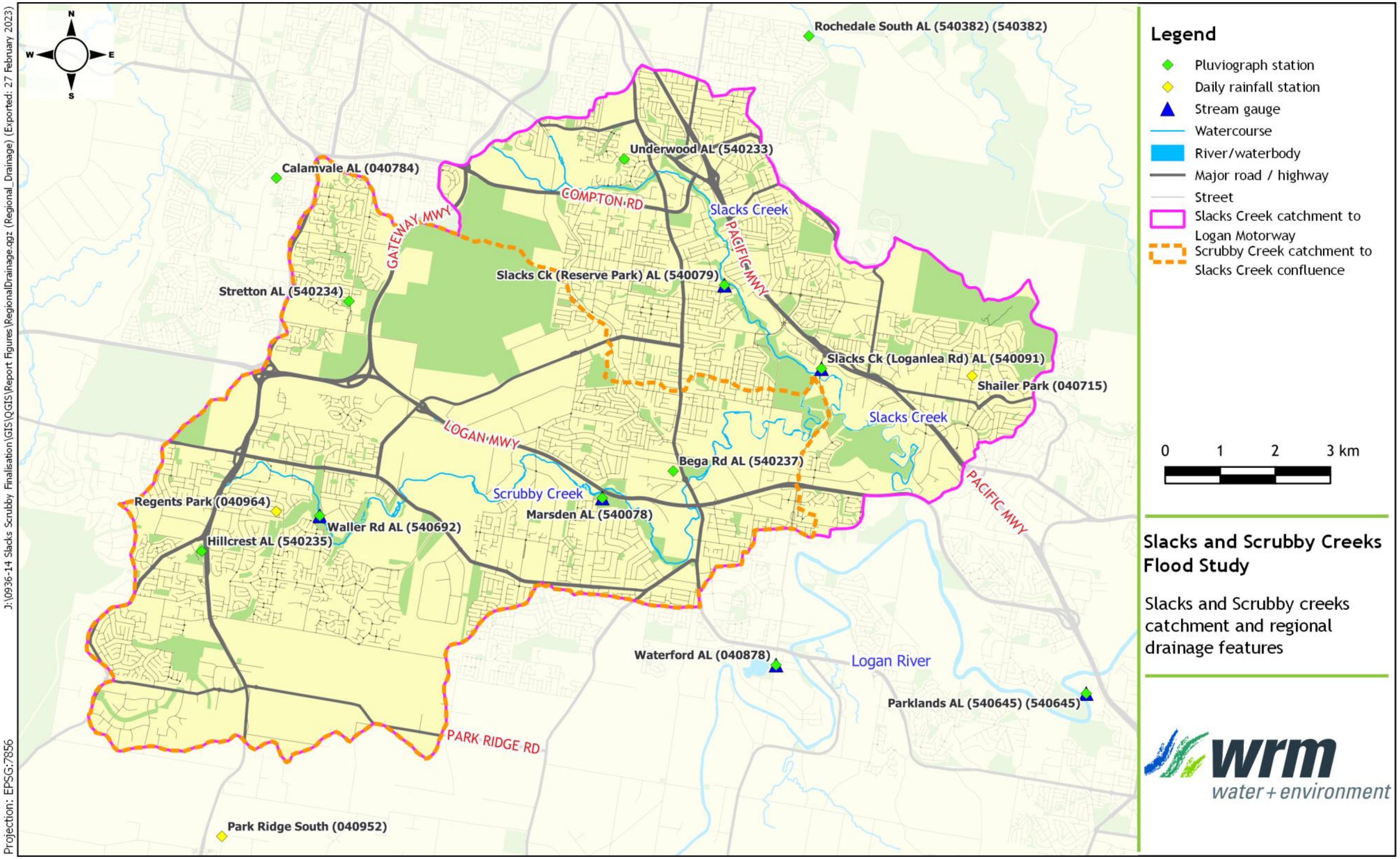

Figure 1.1 – Slacks and Scrubby creeks catchments and regional drainage features

2 Study methodology

2.1 HYDROLOGIC MODEL DEVELOPMENT

An XP-RAFTS runoff routing model (XP Software, 2016) was developed for the catchment of Slacks and Scrubby creeks upstream of the Logan Motorway. The XP-RAFTS hydrologic model was jointly calibrated with the TUFLOW hydraulic model against the January 2013, May 2015 and March 2017 flood events and validated against the February 2022 flood event. The aim of the calibration was to match predicted peak discharges with rated peak discharges at the Waller Road AL, Marsden AL, Reserve Park AL and Loganlea Road AL stream gauges (see Figure 1.1 for locations). The aim of the validation was to determine any substantial differences between the calibrated models against the rated peak discharges at the gauges for the February 2022 event. There is limited rating curve data available for these gauges to convert water level data to flow rates for a hydrologic model calibration. Therefore, results from the TUFLOW hydraulic model described in Section 6 was used to produce rating curves at the four available stream gauges, to enable calibration of the hydrologic model.

2.2 HYDRAULIC MODEL DEVELOPMENT

A TUFLOW two-dimensional (2D) hydrodynamic model (BMT WBM, 2016) was developed for Slacks and Scrubby creeks and their tributaries. The hydraulic model includes embedded one-dimensional (1D) elements such as culverts, trunk stormwater pipes, stormwater inlet pits and manholes. The hydraulic model covers almost the entire Slacks and Scrubby creeks catchment upstream of the Logan Motorway.

The TUFLOW hydraulic model was jointly calibrated with the XP-RAFTS hydrologic model to match recorded water levels at the Waller Road AL, Marsden AL, Reserve Park AL and Loganlea Road AL stream gauges for the January 2013, May 2015 and March 2017 flood events. The hydraulic model was also calibrated against peak flood levels at six maximum height gauges for all three flood events, and surveyed debris marks for the May 2015 and March 2017 events. The hydraulic model was also validated against peak flood levels and surveyed debris marks for the February 2022 flood event.

2.3 JOINT MODEL CALIBRATION

Predicted inflow hydrographs from the hydrologic model were used as input to the hydraulic model. The resulting water level hydrographs from the hydraulic model were compared with recorded water level hydrographs at three available stream gauges for the January 2013 event, and four available stream gauges for the May 2015 and March 2017 events. Rating curves for stream gauges were obtained from the hydraulic model to allow calibration of the hydrologic model.

For each of the three historical events, the resulting peak water levels from the hydraulic model were also compared against recorded peak flood levels at six maximum height gauges (MHGs) located in the northern tributaries of Scrubby Creek. For the May 2015 event, the hydraulic model predictions were also compared against surveyed peak flood levels across the Slacks and Scrubby creek floodplains.

The joint calibration approach allowed the suitability of the discharges estimated by the hydrologic model to be confirmed, as well as testing the performance of the hydraulic model. The joint calibration is presented in Section 7 of this report.

2.4 MODEL VALIDATION

The calibrated hydrologic and hydraulic models were used to validate against the February 2022 event to determine any substantial differences in the predicted and the recorded peak water level hydrographs at the available stream gauges.

The validation methodology was conducted for the purpose of determining how the calibrated model would perform against another historical dataset. The results of the validation assessment is presented in Section 7 of this report.

2.5 DESIGN DISCHARGE ESTIMATION

The calibrated hydrologic model was used to estimate design discharges in the Slacks Creek catchment for the 50% (1 in 1.44 ARI), 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI) and 0.05% (1 in 2,000 ARI) AEP and the PMPDF events for the current climate (2020). In addition, the Future Climate (2090) estimates were derived for the 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP events.

Design event hydrology was undertaken in accordance with the 2019 Australian Rainfall and Runoff (AR&R 2019) (Ball et al, 2019) for the ten specified design events ranging from 50% AEP to the PMPDF event.

2.6 ESTIMATION OF DESIGN FLOOD LEVELS, DEPTHS, VELOCITIES AND FLOOD HAZARD

The calibrated hydraulic model was used to estimate design flood levels, depths and velocities along Slacks and Scrubby creeks and their tributaries for the ten specified events ranging from the 50% AEP to the PMPDF event. The hydraulic model was configured to produce maximum water surface levels, depths, velocities, depth-velocity products and flood hazard for each design event simulation.

3 Available data

3.1 PREVIOUS STUDIES

3.1.1 Fern Street and Johnson Road Local Flood Study (2013)

In 2013, LCC engaged Engeny to undertake a local flood study for the Fern Street and Johnson Road catchment in Browns Plains, within the upper catchment of Scrubby Creek (Engeny, 2013). LCC supplied WRM with the XP-RAFTS hydrologic and TUFLOW hydraulic models developed as part of this Engeny study.

The Fern Street and Johnson Road TUFLOW model incorporated key hydraulic structures including culverts and trunk stormwater pipes located in the vicinity of Fern Street, Browns Plains Road, Johnson Road and Mount Lindesay Highway. The hydraulic structure information contained in this model was used to assist in the development of the Slacks and Scrubby creeks hydraulic model for the current study.

3.1.2 Logan-Albert River Flood Study Peer Review (2014)

The Logan-Albert River flood study was initially completed by Engeny in 2011 (on behalf of LCC). In 2014, WRM was engaged by Logan City Council (LCC) to implement peer review findings and reconfigure the hydrologic and hydraulic models of the Logan River catchment, referred to as the LCC (2014) models (WRM, 2014a). Hydrologic modelling was undertaken using XP-RAFTS while hydraulic modelling was undertaken using the TUFLOW (BMT WBM, 2016) software package.

The LCC (2014) TUFLOW model incorporated key hydraulic structures including culverts and bridges within the Logan River catchment, including those located within the Slacks Creek catchment. Some hydraulic structures included in the LCC (2014) TUFLOW model were incorporated to the Slacks and Scrubby creeks hydraulic model for the current study. In addition, some results from the LCC (2014) TUFLOW model were also used to configure the downstream tailwater conditions for the Slacks and Scrubby creeks TUFLOW model.

3.1.3 Wembley Road Interchange (Berrinba) Flood Study (2014)

WRM were commissioned by the Department of Transport and Main Roads (TMR) to undertake a flood study of Scrubby Creek at the Wembley Road interchange on the Logan Motorway (WRM, 2014b). WRM developed a fine-resolution XP-RAFTS (hydrologic) model of the Scrubby Creek catchment draining to the interchange area. The XP-RAFTS model was jointly calibrated with a TUFLOW (hydraulic) model against recorded water levels at the Marsden (First Avenue) flood warning gauge during the March 2009 and January 2013 flood events.

The WRM (2014b) TUFLOW model incorporated key existing hydraulic structures including culverts and weirs in the vicinity of the Wembley Road interchange. The existing hydraulic structures included in the WRM (2014b) TUFLOW model were incorporated to the Slacks and Scrubby creeks hydraulic model for the current study.

3.1.4 Slacks and Scrubby Creeks Flood Study Peer Review (2015)

In 2015, WRM was engaged by Logan City Council (LCC) to peer review and reconfigure hydrologic and hydraulic models of the Slacks Creek and Scrubby Creek catchments, referred to as the LCC (2015) models (WRM, 2015). Hydrologic modelling was undertaken using XP-RAFTS while hydraulic modelling was undertaken using the TUFLOW (BMT WBM, 2016) software package.

The LCC (2015) TUFLOW model incorporated key hydraulic structures including culverts, trunk stormwater pipes and bridges within the Slacks and Scrubby creeks catchment. Some hydraulic structures included in the LCC (2015) TUFLOW model were incorporated to the Slacks and Scrubby creeks hydraulic model for the current study.

3.1.5 M1 Motorway Upgrade Hydraulic Study (2016 to 2017)

From 2016 to 2017, TMR engaged WRM to undertake a flood and cross-drainage study of the M1 Motorway corridor between Springwood Road and the Logan Motorway (in three separate study package areas) (WRM, 2017). Separate TUFLOW models of the three TMR study areas were developed, based on the LCC (2015) TUFLOW model for Slacks and Scrubby creeks.

The TUFLOW models developed for this study incorporated key existing hydraulic structures including culverts, trunk stormwater pipes, bridges and detention basins upstream and downstream of the M1 Motorway. The existing hydraulic structures included in the M1 Motorway TUFLOW models were incorporated to the Slacks and Scrubby creeks hydraulic model for the current study.

3.1.6 Slacks and Scrubby Creeks Flood Study (2018)

In 2018, WRM was engaged by Logan City Council (LCC) to undertake a Flood Study for the Slacks and Scrubby Creeks catchment (WRM, 2018). The purpose of this study was to develop and calibrate the hydrologic and hydraulic models of the Slacks and Scrubby Creeks catchment. The WRM (2018) hydrologic and hydraulic models were calibrated against the 2013, 2015 and 2017 events.

The TUFLOW model developed for this study includes key hydraulic structures obtained by survey data, LCC's GIS hydraulic structures database, 2017 LCC and BCC LiDAR data, as-constructed drawings and PD online. The calibrated 2018 Slacks and Scrubby models were used as a basis for the current study.

3.1.7 Kingston Butter Factory Redevelopment (2019)

In 2019, WRM was engaged by Logan City Council (LCC) to undertake a Stormwater Management Plan and Hydraulic Assessment for the Kingston Butter Factory Redevelopment (WRM, 2019). The site is located near Jacaranda Avenue, Kingston and was redeveloped into an outdoor event venue, which includes an outdoor event space, new footpaths, a multi-use plaza, a new carpark and new access road to the site. The proposed works included bulk earthworks and the construction of a new bridge across the tributary of Scrubby Creek.

The TUFLOW model developed for this study incorporated the proposed bridge structure within Scrubby Creek, which was then incorporated to the Slacks and Scrubby creeks hydraulic model for the study.

3.1.8 M1 Motorway Upgrade (Stage 2) Hydraulic Study (2022)

In addition to the M1 2017 study, TMR engaged WRM to undertake additional works on the M1 Motorway upgrade which incorporates the section of the M1 Motorway corridor between Eight Mile Plains to Loganholme (Loganlea Road to Logan Motorway). In this study, several existing hydraulic structures included in the M1 Motorway TUFLOW models were incorporated to the Slacks and Scrubby creeks hydraulic model for the current study.

3.1.9 Logan Albert Rivers Flood Study Finalisation Project (2023)

In 2022-2023, WRM were commissioned by LCC to finalise the Logan Albert Rivers flood study based on Councils nominated climate change parameters, and by including new LiDAR data. The WRM (2023) Logan Albert Rivers hydrology and hydraulics models were used to derive tailwater conditions for the Slacks and Scrubby Creek hydraulic model.

3.2 TOPOGRAPHIC DATA

LCC provided two sets of LiDAR survey (undertaken in 2021 and 2017) which covers the portion of the Slacks and Scrubby creeks catchment located within the LCC local government area (LGA). This data is referred to in this report as the LCC 2021 LiDAR and LCC 2017 LiDAR respectively.

LCC also provided LiDAR survey which covers the portion of the Slacks and Scrubby creeks catchment located within the Brisbane City Council (BCC) LGA. This data is referred to in this report as the BCC 2017 LiDAR. It is unclear when the BCC 2017 LiDAR survey was captured. The BCC 2017 LiDAR survey appears consistent with the LCC 2017 LiDAR survey in areas where the two data overlap.

Both the LCC 2021, LCC 2017 and BCC 2017 LiDAR surveys were supplied as regularised elevation points in one metre horizontal intervals. This data was used to generate a digital elevation model (DEM) for modelling and mapping purposes.

3.3 AERIAL PHOTOGRAPHY

Aerial photography of the Scrubby and Slacks Creek catchments was provided by LCC for years 2013, 2016 and 2022.

3.4 COUNCIL'S GIS DATABASE OF HYDRAULIC STRUCTURES

LCC supplied WRM with a GIS database of hydraulic structures in ESRI shape file format. The data contains detailed mapping of hydraulic structures including culverts, trunk stormwater pipes, stormwater inlet pits and manholes located throughout the Slacks and Scrubby creeks catchment. The data also contains key details for these hydraulic structures including dimensions and invert levels.

Council's hydraulic structures database was used to delineate the Slacks and Scrubby creeks XP-RAFTS (hydrologic) model subcatchments for the current study, particularly in the highly urbanised areas of the catchment. This data was also used to configure the culverts, trunk stormwater pipes, inlet pits and manholes in the Slacks and Scrubby creeks TUFLOW model for the current study.

3.5 HYDRAULIC STRUCTURE SURVEY (2017)

In 2017, LCC surveyed a total of 134 culverts and 68 pits and manholes. The survey was undertaken to obtain dimensions, invert levels, road deck levels, guard rail configurations and photos of these structures. The results of this survey supplemented the information in Council's hydraulic structures database which were either missing or incomplete.

Council also surveyed and supplied photos of the Moss Street Bridge in Slacks Creek and the Waller Road Bridge in Scrubby Creek to confirm the road deck level, deck thickness, pier configuration and guard rail height at these bridges.

The survey results were supplied to WRM in a spreadsheet with accompanying photos. The data was used to configure the hydraulic structures in the Slacks and Scrubby creeks TUFLOW model for the current study.

3.6 AS-CONSTRUCTED DRAWINGS

LCC supplied WRM with as-constructed drawings for the following bridges:

- Gateway Motorway Bridge (Scrubby Creek);
- Waller Road Bridge (Scrubby Creek);
- Kingston Road Bridge (vehicle and pedestrian) (Scrubby Creek);
- Third Avenue Bridge (Scrubby Creek);
- Queens Road Bridge (Scrubby Creek);
- Loganlea Road Bridge (Scrubby Creek);
- Kingston Road Bridge (Slacks Creek).

LCC also supplied WRM with as-constructed drawings for the following developments:

- Bunnings Underwood re-development which was undertaken between 2017 and 2018;
- Cinderella Drive which was undertaken in 2000;
- Mount Lindsay Highway which was undertaken in 2013.

Several other as-constructed drawings from LCC development enquiry tool (LCC, 2022) were adopted for the following developments:

- Greenside Drive, Berrinba which was undertaken in 2009;
- Johnson Road, Hillcrest which was undertaken in 1993;
- Sanctuary Park, Daisy Hill which was undertaken in 2006.

These as-constructed drawings were used to configure bridges, the Bunnings Underwood site and stormwater networks of interest in the Slacks and Scrubby creeks TUFLOW model for the current study.

3.7 WRM SITE VISIT

WRM inspected a total of 21 culvert crossings located throughout the Scrubby Creek catchment to determine the culvert configurations (size and number of barrels) at these locations. The information obtained from the site visit was checked against other available data, and then used to configure the hydraulic structures in the Slacks and Scrubby creeks TUFLOW model for the current study.

3.8 RAINFALL DATA

Historical rainfall records from rainfall stations maintained by LCC within and in the vicinity of the Slacks Creek catchment were provided by LCC for the January 2013, May 2015, March 2017 and February 2022 events. Additional rainfall data was sourced for other BOM gauges in the vicinity of the catchment. Table 3.1 shows the available rainfall data for the 2013, 2015, 2017 and 2022 events. Figure 1.1 shows the locations of these rainfall stations. Table 3.2 shows the total rainfall depths recorded at each rainfall station during each event. Figure 3.1, Figure 3.2, Figure 3.3 and Figure 3.4 show the recorded cumulative rainfalls during the 2013, 2015, 2017 and 2022 events.

3.9 STREAMFLOW DATA

BoM operates flood warning gauges at Waller Road AL (gauge no. 540692), Marsden AL (gauge no. 540078), Reserve Park AL (gauge no. 540079) and Loganlea Road AL (gauge no. 540091) gauging stations. The locations of these gauges are the same for the respective pluviography stations and are shown on Figure 1.1. Recorded water levels at these key gauging stations are shown in the following figures:

- Figure 3.5 for the January 2013 event;
- Figure 3.6 and Figure 3.7 for the May 2015 event;
- Figure 3.8 and Figure 3.9 for the March 2017 event; and
- Figure 3.10 and Figure 3.11 for the February 2022 event.

Note that the Waller Road AL (gauge no. 540692) gauging station had not been installed during the January 2013 event. Hence there were no recorded water levels at this gauge for the 2013 event.

Table 3.1 - Rainfall data availability

Station no.	Station name	January 2013	May 2015	March 2017	February 2022
Pluviograph stations					
040784	Calamvale Alert	✓	✓	✓	✓
040878	Waterford Alert	✓	✓	✓	✓
540078	Marsden Alert	✓	✓	✓	✓
540079	Slacks Creek (Reserve Park) Alert	✓	✓	✓	✓
540091	Slacks Creek (Loganlea Rd) Alert	✓	✓	✓	✓
540233	Underwood Alert	✓	✓	✓	✓
540234	Stretton Alert	✓	✓	✓	✓
540235	Hillcrest (Wine Glass) Alert	✓	✓	✓	✓
540237	Bega Rd Alert	✓	✓	✓	✓
540692	Waller Road Alert	X	✓	✓	✓
Daily Rainfall Stations					
040715	Shailer park	✓	✓	✓	✓
040964	Regents Park	✓	✓	✓	✓

Table 3.2 - Recorded event rainfall totals

Station no.	Station name	Recorded event rainfall total (mm)			
		January 2013	May 2015	March 2017	February 2022
Pluviograph stations					
040784	Calamvale Alert	285	229	209	797
040878	Waterford Alert	315	236	197	710
540078	Marsden Alert	269	232	201	714
540079	Slacks Creek (Reserve Park) Alert	267	222	204	710
540091	Slacks Creek (Loganlea Rd) Alert	276	216	197	742
540233	Underwood Alert	241	201	176	678
540234	Stretton Alert	267	214	209	771
540235	Hillcrest (Wine Glass) Alert	257	208	271	723
540237	Bega Rd Alert	244	109	174	679
540692	Waller Road Alert	- [a]	223	233	740
Daily Rainfall Stations					
040715	Shailer park	332	232	232	803
040964	Regents Park	294	206	243	686

[a] - No available data

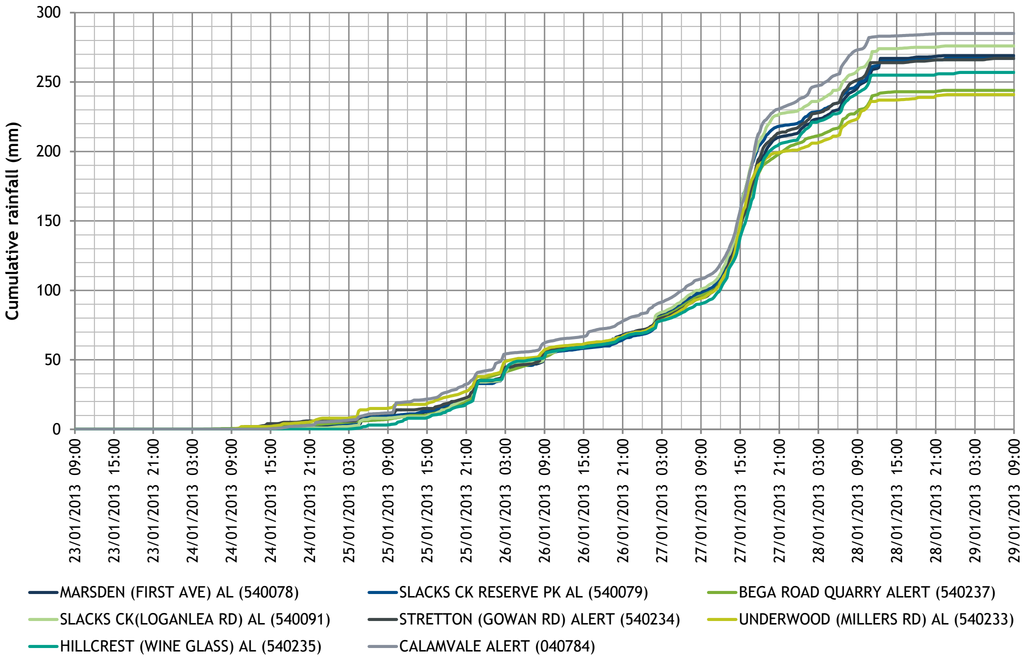

Figure 3.1 – Recorded cumulative rainfalls at available pluviography stations for the January 2013 event

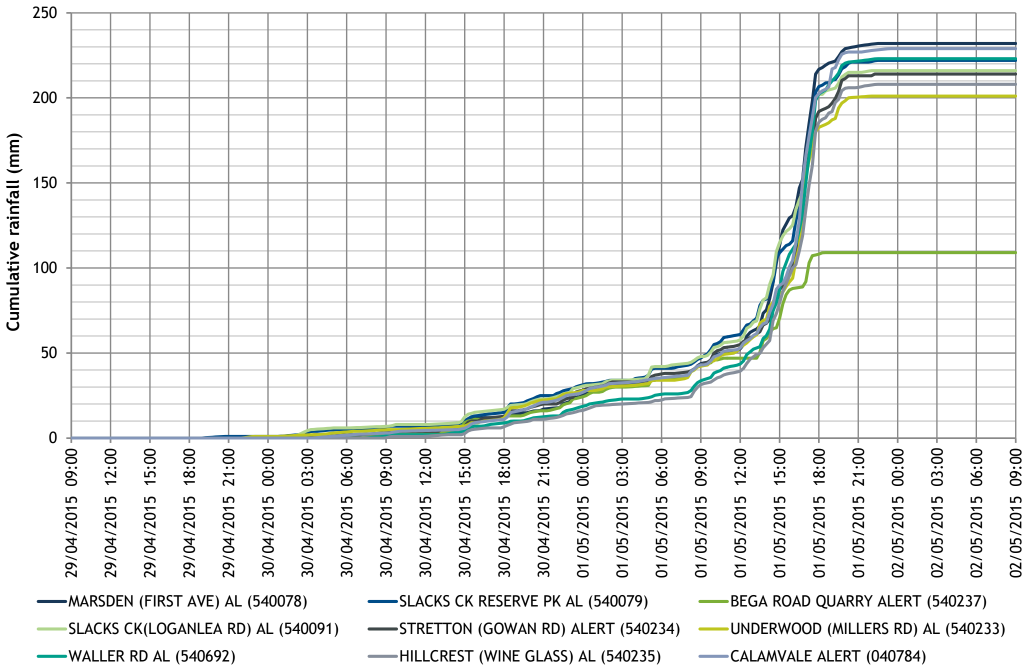

Figure 3.2 – Recorded cumulative rainfalls at available pluviography stations for the May 2015 event

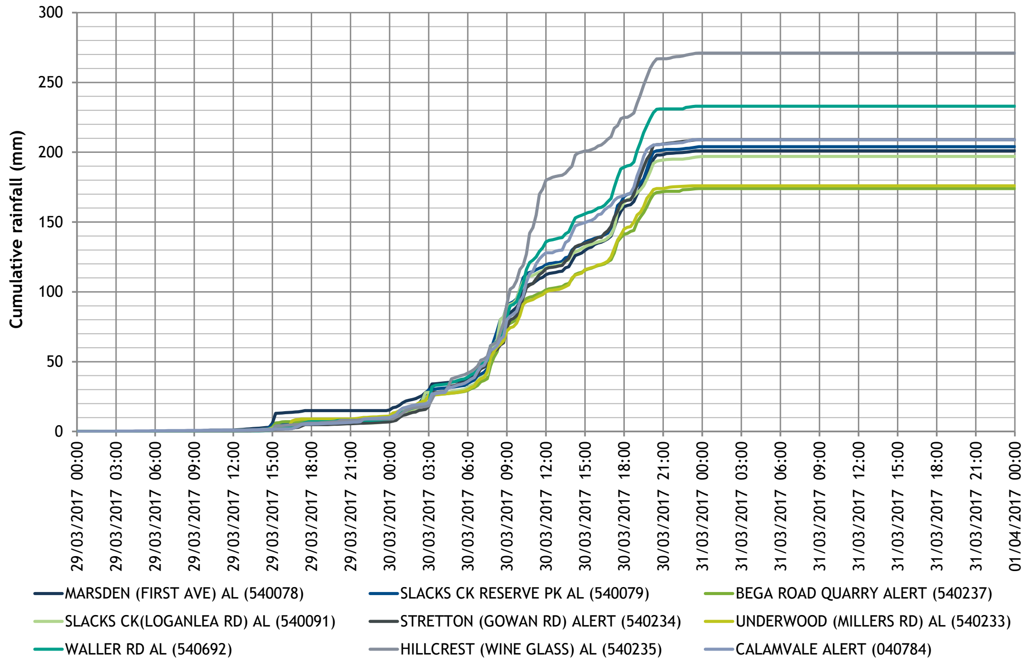

Figure 3.3 – Recorded cumulative rainfalls at available pluviography stations for the March 2017 event

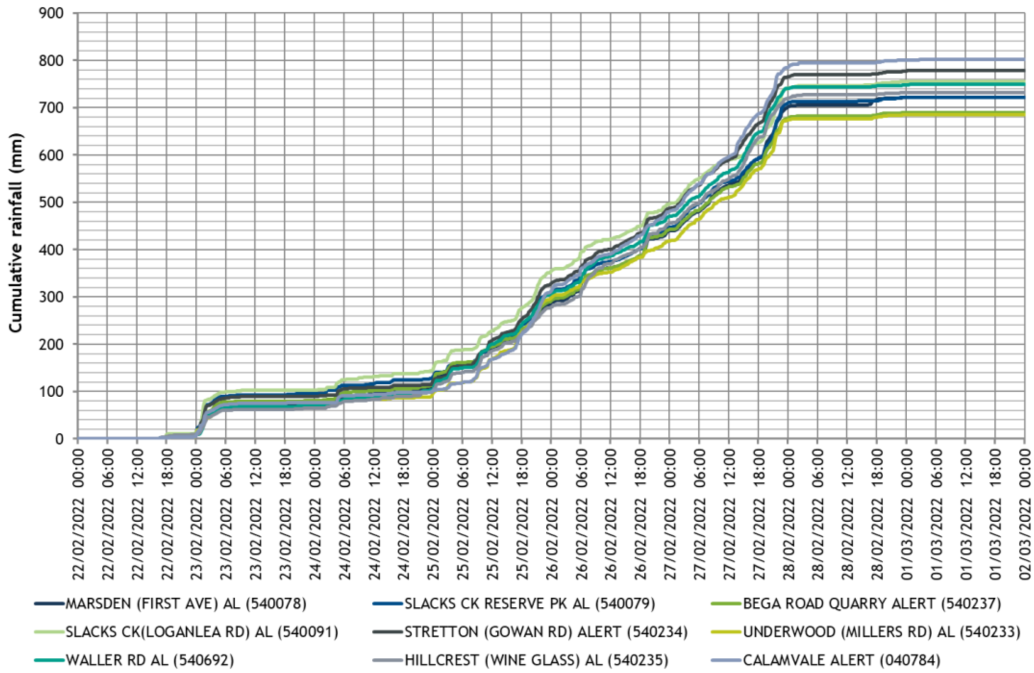

Figure 3.4 – Recorded cumulative rainfalls at available pluviography stations for the February 2022 event

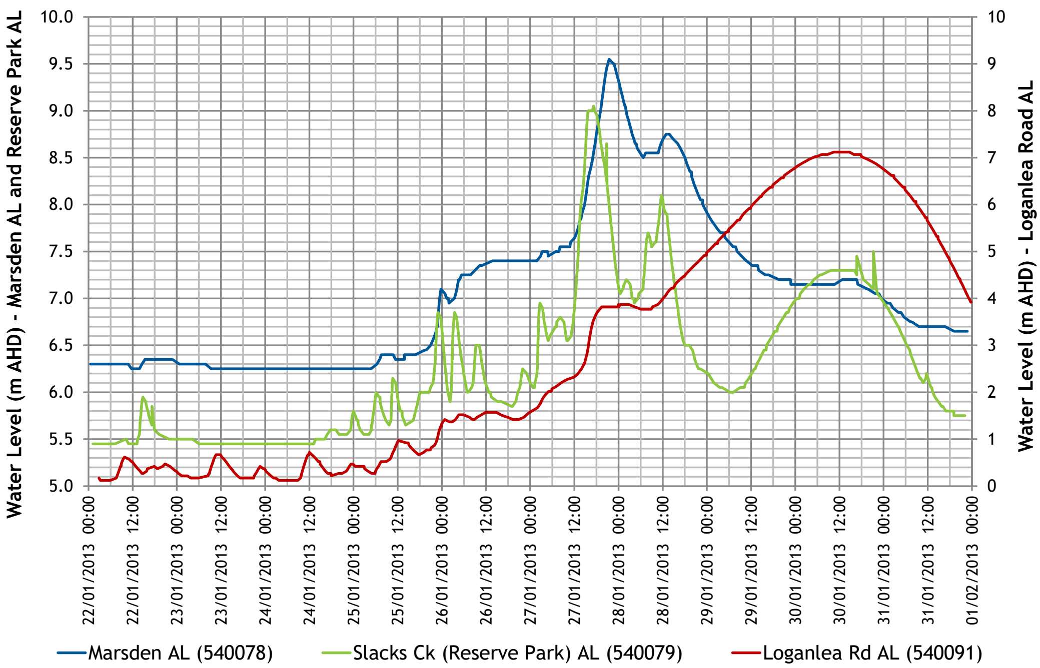

Figure 3.5 – Recorded water levels for the January 2013 flood event at Marsden AL, Reserve Park AL and Loganlea Road AL gauging stations

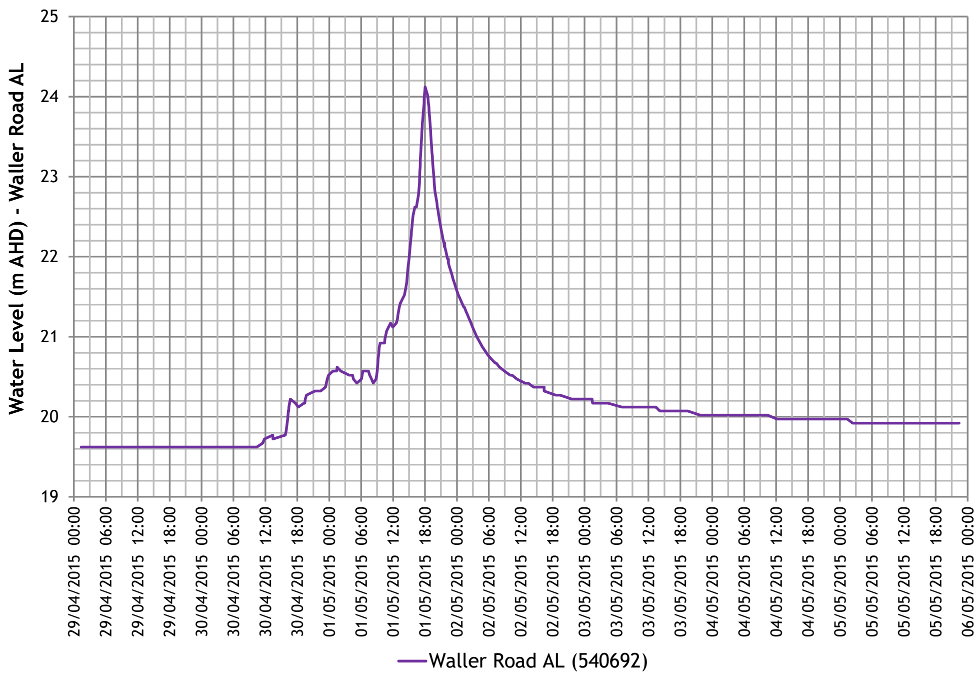

Figure 3.6 – Recorded water levels for the May 2015 flood event at Waller Road AL gauging station

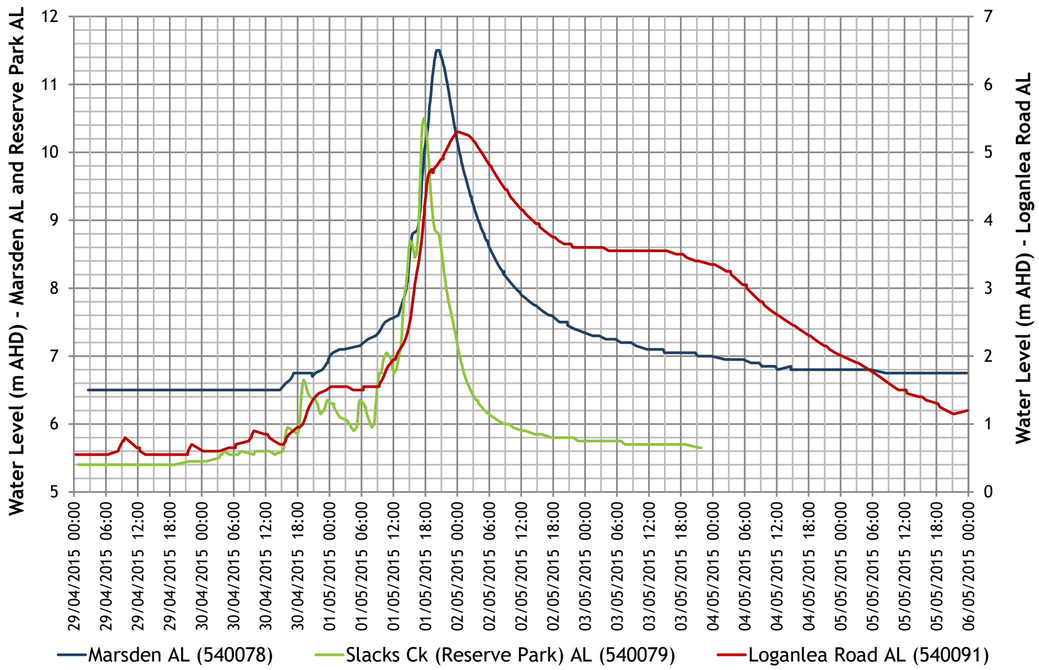

Figure 3.7 – Recorded water levels for the May 2015 flood event at Marsden AL, Reserve Park AL and Loganlea Road AL gauging stations

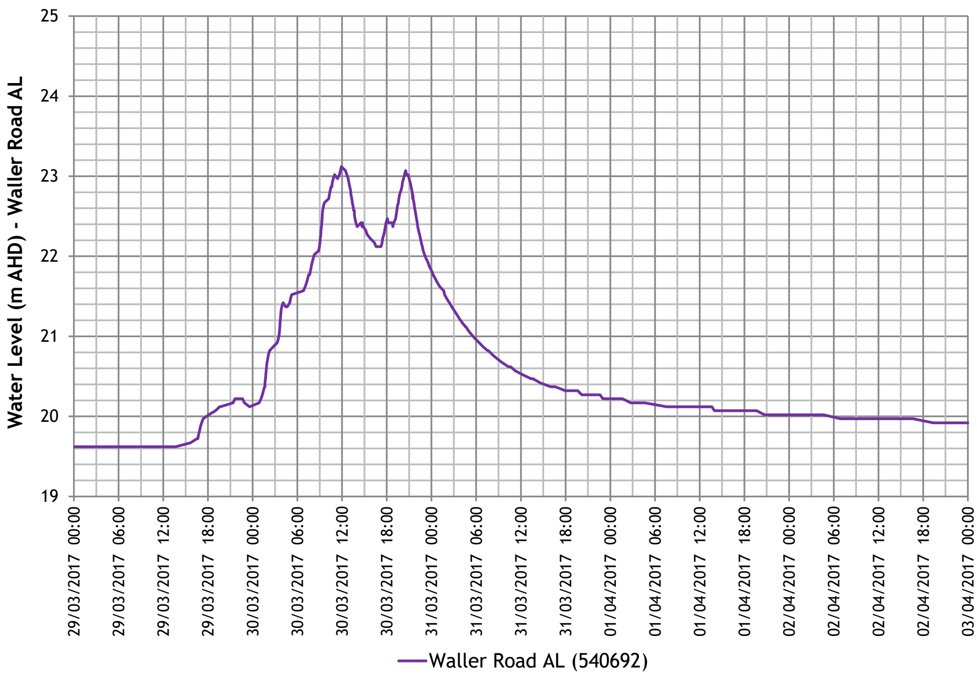

Figure 3.8 - Recorded water levels for the March 2017 flood event at Waller Road AL gauging station

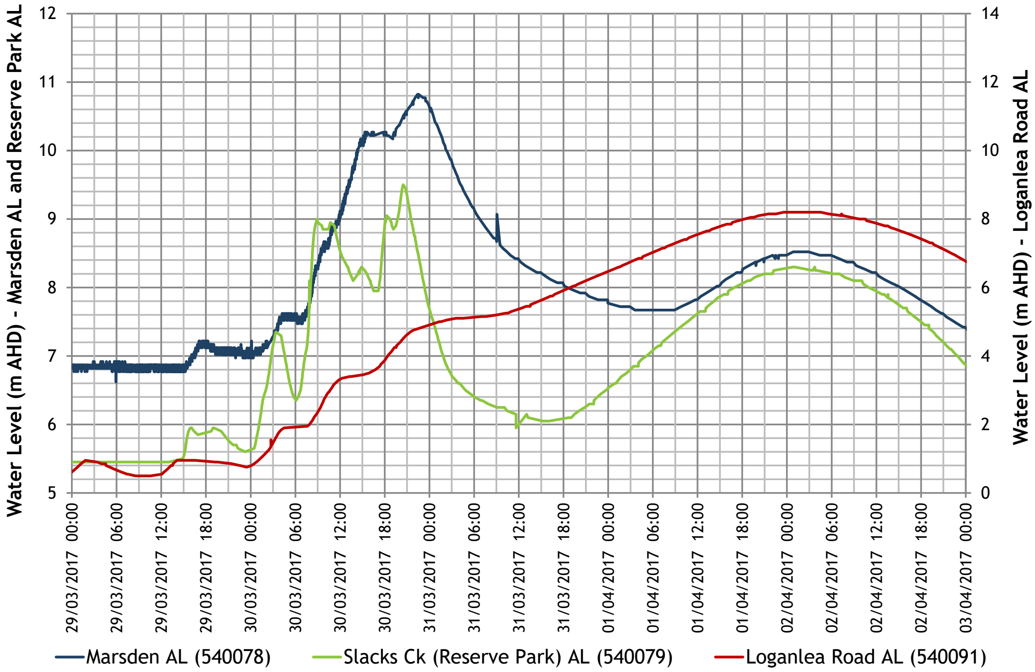

Figure 3.9 – Recorded water levels for the March 2017 flood event at Marsden AL, Reserve Park AL and Loganlea Road AL gauging stations

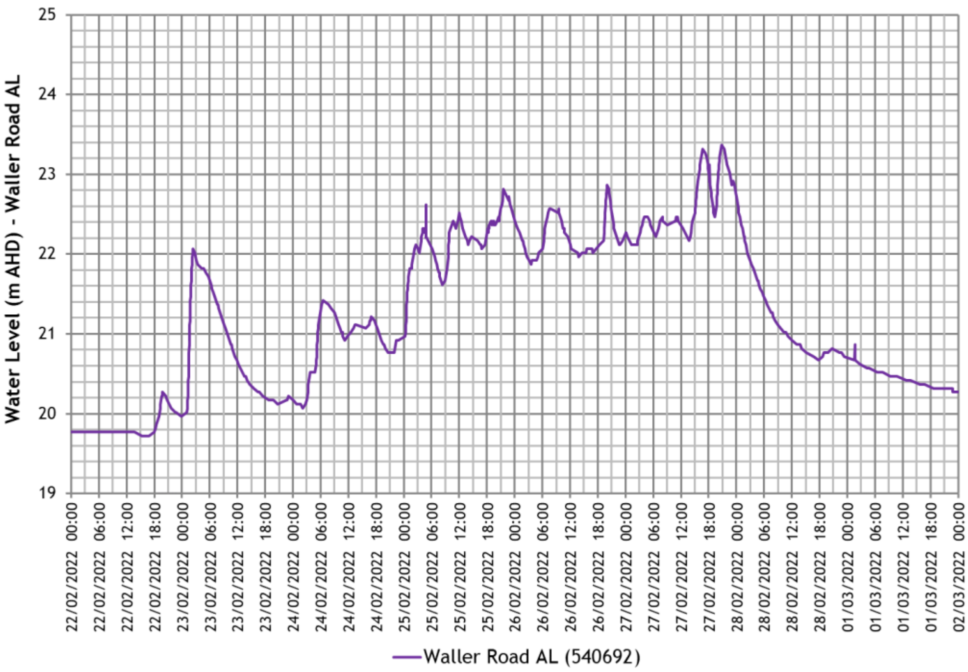

Figure 3.10 – Recorded water levels for the February 2022 flood event at Waller Road AL gauging station

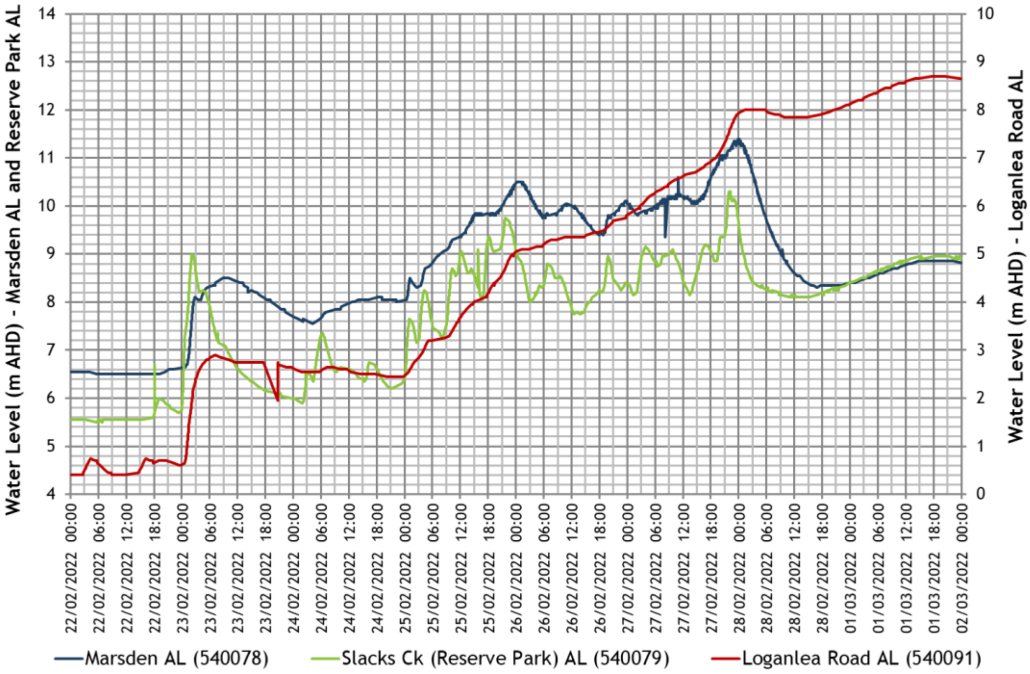

Figure 3.11 – Recorded water levels for the February 2022 flood event at Marsden AL, Reserve Park AL and Loganlea Road AL gauging stations

3.10 RATING CURVES

3.10.1 Waller Road AL stream gauge

The results from the TUFLOW model (described in Section 7) for the largest historical event (May 2015) were used to develop a rating curve for the Waller Road AL gauge. The rating curve was developed up to a maximum discharge of 260 m^3/s (corresponding to a water level of 24.18 mAHD). Figure 3.12 shows the adopted rating curve for the Waller Road gauge. Data points for the adopted WRM rating curve for Reserve Park are provided in Table A.1 in Appendix A.

3.10.2 Marsden AL stream gauge

A rating curve for the Marsden AL stream gauge has been developed by BoM. The BoM rating curve is not based on actual gauging and has not been validated with hydraulic analysis.

The results from the TUFLOW model (described in Section 7) for the largest historical event (May 2015) were used to develop a rating curve for the Marsden AL gauge. The rating curve was developed up to a maximum discharge of 500 m^3/s (corresponding to a water level of 11.71 mAHD).

Figure 3.13 shows a comparison between the BoM and WRM rating curves for the Marsden AL gauge. The WRM rating curve was adopted for this study. Data points for the adopted WRM rating curve for Marsden are provided in Table A.2 in Appendix A.

3.10.3 Reserve Park AL stream gauge

The results from the TUFLOW model (described in Section 7) for the largest historical event (May 2015) were used to develop a rating curve for the Reserve Park AL gauge. The rating curve was developed up to a maximum discharge of 273 m^3/s (corresponding to a water level of 10.54 mAHD). Figure 3.14 shows the adopted rating curve for the Waller Road gauge. Data points for the adopted WRM rating curve for Reserve Park are provided in Table A.3 in Appendix A.

3.10.4 Slacks Creek (Loganlea Road) AL stream gauge

The rating curve for Slacks Creek at the Loganlea Road AL gauge is heavily tailwater-affected by the Logan River, located about 4.5 km downstream of the gauge. The recorded water levels at this gauge cannot be accurately converted to corresponding discharges using a single rating curve and therefore are not suitable for hydrologic model calibration. Calibration to recorded water levels at the Loganlea Road AL gauge was achieved via the joint calibration of the hydrologic and hydraulic models.

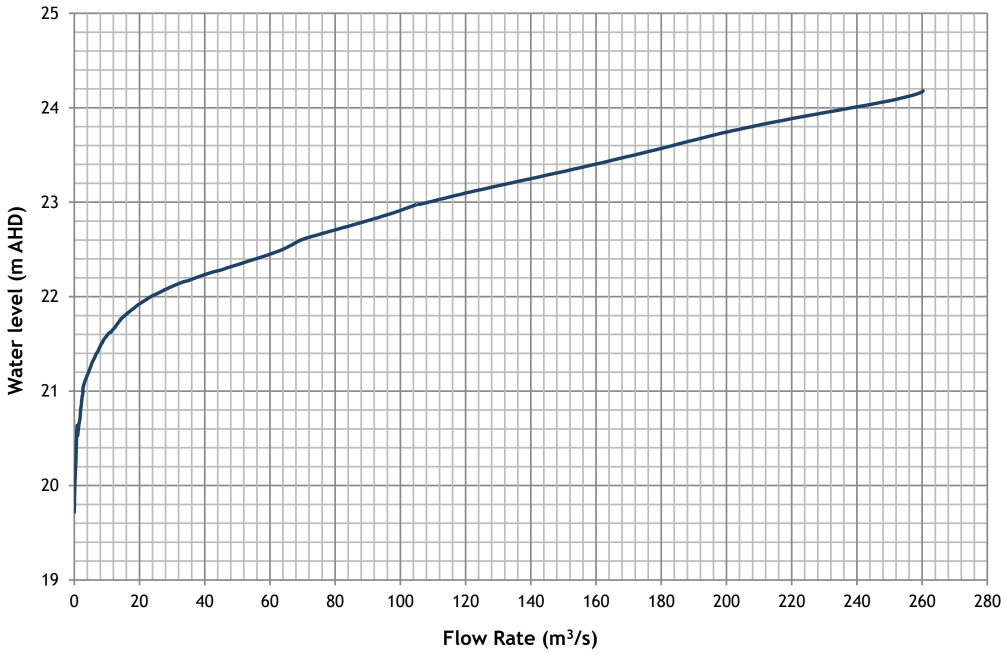

Figure 3.12 - Adopted WRM rating curve for the Waller Road AL stream gauge

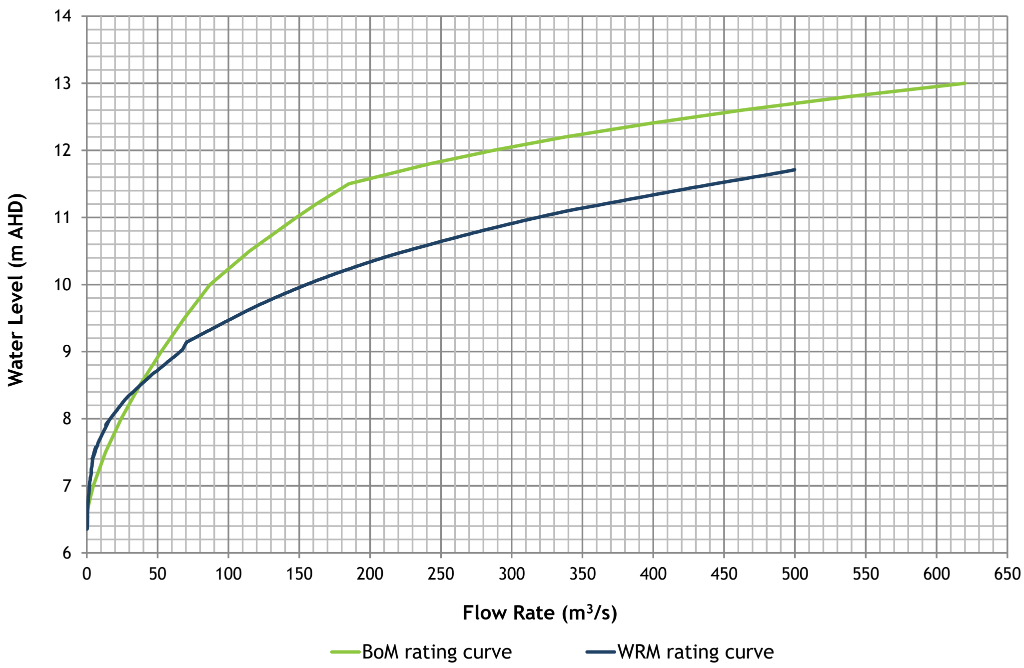

Figure 3.13 - Comparison of BoM and WRM rating curves for the Marsden AL stream gauge

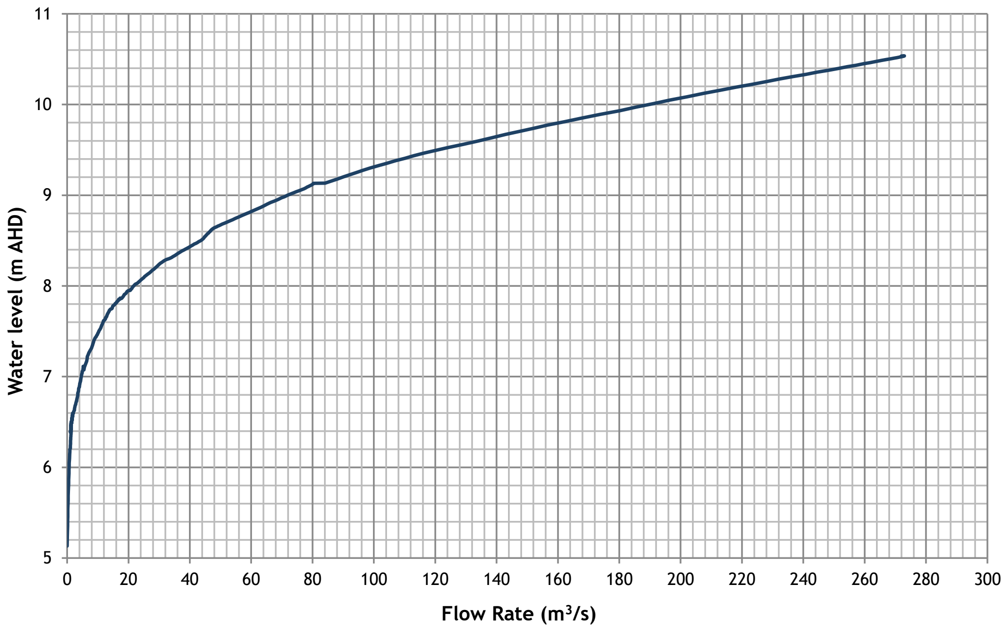

Figure 3.14 - Adopted WRM rating curve for the Reserve Park AL stream gauge

3.11 MAXIMUM HEIGHT GAUGES

A total of six MHGs are currently installed in the catchment. They are all located along the northern tributaries of Scrubby Creek. The locations of these gauges are shown in Figure 3.15. Data is available for the MHGs for the January 2013, May 2015 and March 2017 events. Table 3.3 shows the recorded peak flood levels at these locations during the 2013, 2015 and 2017 events. MHG levels were not procvided for the 2022 flood event.

Table 3.3 - Recorded peak flood levels at six maximum height gauges in the Scrubby Creek catchment

Gauge Name	Easting	Northing	Recorded peak flood level (mAHD)		
			27 January 2017	1 May 2015	30 March 2017
100	508,634	6,941,340	15.88	16.67	15.70
110	509,067	6,942,009	21.89	22.2	21.71
120	509,361	6,942,687	26.43	26.75	n/a
210	506,921	6,942,563	n/a	27.64	n/a
220	505,726	6,943,623	35.81	36.71	35.67
230	505,393	6,944,433	40.63	40.71	40.79

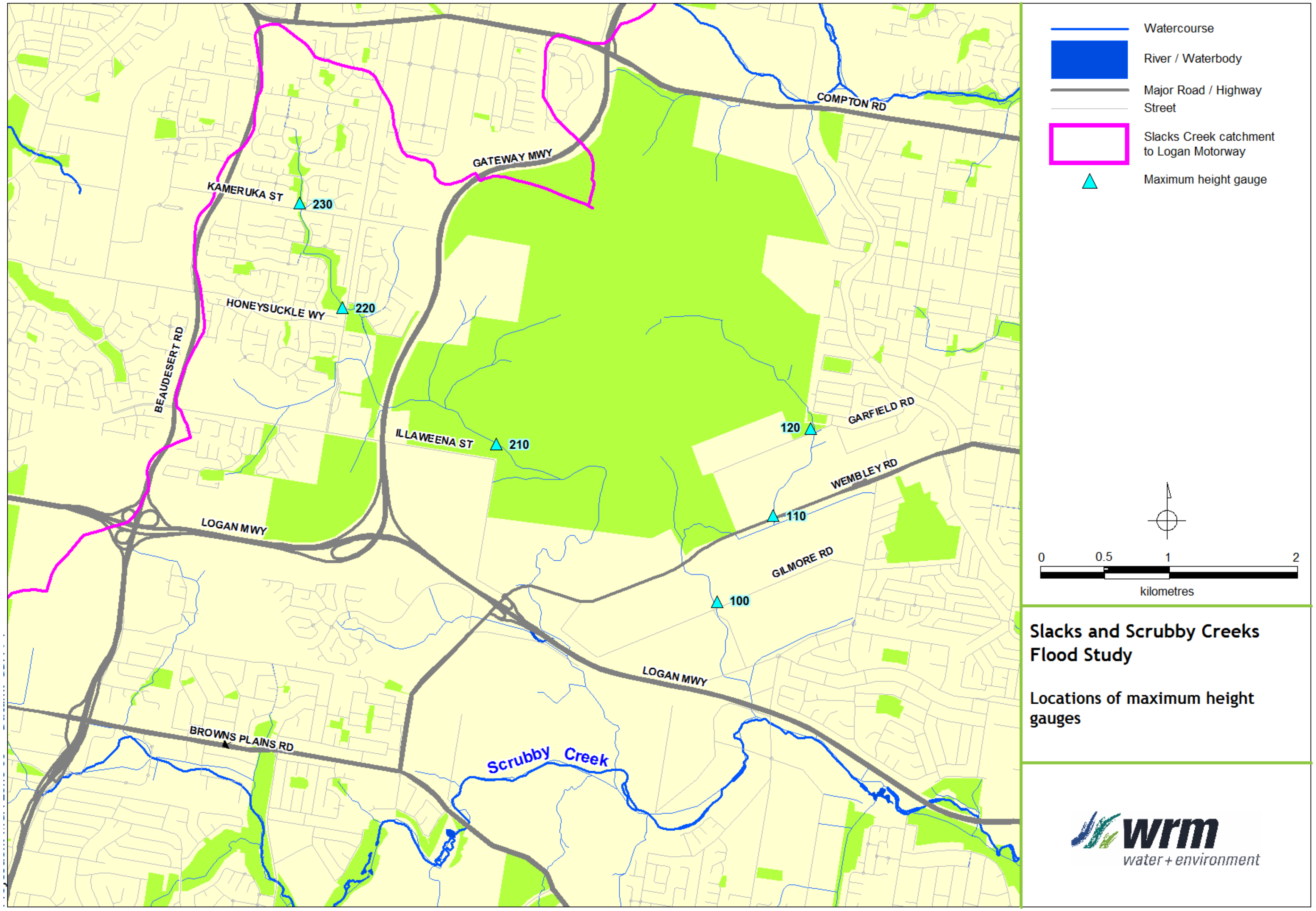

Figure 3.15 – Locations of maximum height gauges along the northern tributaries of Scrubby Creek

3.12 SURVEYED PEAK FLOOD LEVELS

3.12.1 May 2015 event

A total of 64 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the May 2015 flood event. The locations of these debris marks are shown in Figure 3.16. The surveyed flood levels at these locations are given in Table 3.4.

Table 3.4 – Surveyed flood levels (debris marks) throughout the Slacks and Scrubby creeks floodplain, May 2015 event

Debris Mark	Surveyed peak flood level (mAHD)	Debris Mark	Surveyed peak flood level (mAHD)	Debris Mark	Surveyed peak flood level (mAHD)
11	15.03	34	9.64	56	9.13
12	13.63	35	8.53	57	6.33
13	14.6	36	8.57	58	7.69
14	14.68	37	8.72	59	7.00
15	15.02	38	8.20	60	6.59
16	14.19	39	8.36	61	6.46
17	13.4	40	10.77	62	5.68
18	13.25	41	9.76	63	6.35
19	12.71	42	21.87	64	7.53
20	10.55	43	19.26	65	5.84
22	10.52	44	15.8	66	5.83
23	10.32	45	14.78	68	6.60
24	10.26	46	13.39	69	5.97
25	10.32	47	13.18	71	5.13
26	10.31	48	12.24	72	8.22
27	10.23	49	11.6	73	11.76
28	10.16	50	10.73	74	9.12
29	10.12	51	10.79	75	9.13
30	10.02	52	19.73	76	4.93
31	10.12	53	19.71	78	5.15
32	9.71	54	16.17	-	-
33	9.50	55	22.61	-	-

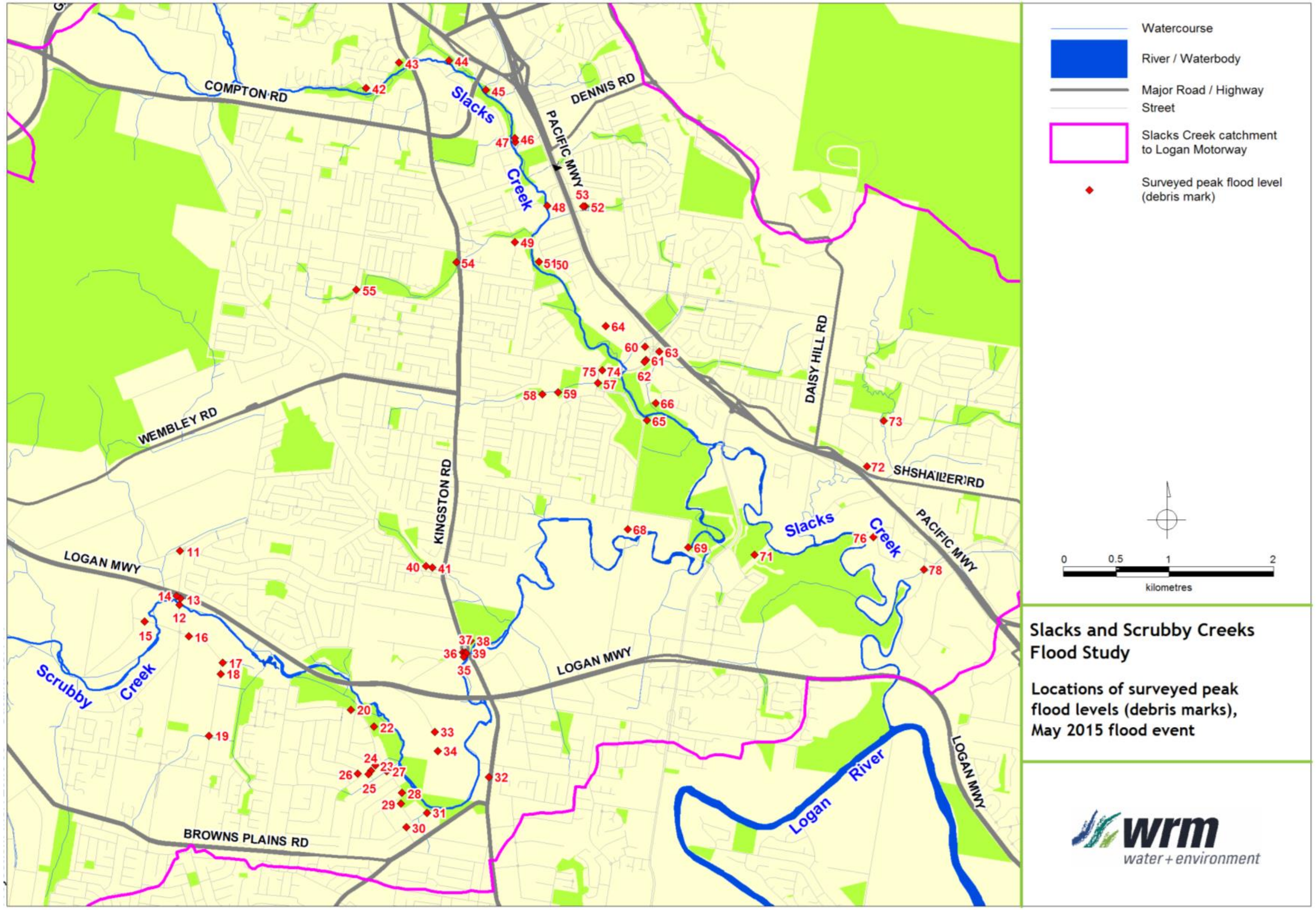

Figure 3.16 – Locations of surveyed peak flood levels throughout the Slacks and Scrubby creeks floodplain (debris marks), May 2015 event

3.12.2 March 2017 event

A total of 34 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the March 2017 flood event. The locations of these debris marks are shown in Figure 3.17. The surveyed flood levels at these locations are given in Table 3.5.

Table 3.5 - Surveyed flood levels (debris marks) throughout the Slacks and Scrubby creeks floodplain, March 2017 event

Debris Mark	Surveyed peak flood level (mAHD)	Debris Mark	Surveyed peak flood level (mAHD)
8	8.27	104	8.14
9	8.26	105	8.25
89	8.94	106	8.26
90	8.23	107	8.19
91	8.22	134	7.93
92	8.21	135	8.25
93	9.10	136	8.23
94	8.23	137	9.06
95	8.22	145	8.20
96	8.23	146	8.26
97	8.13	158	23.12
98	8.22	159	10.70
99	8.23	160	9.40
100	8.21	161	9.40
101	8.11	162	9.10
102	8.24	163	8.20
103	8.27	164	8.30

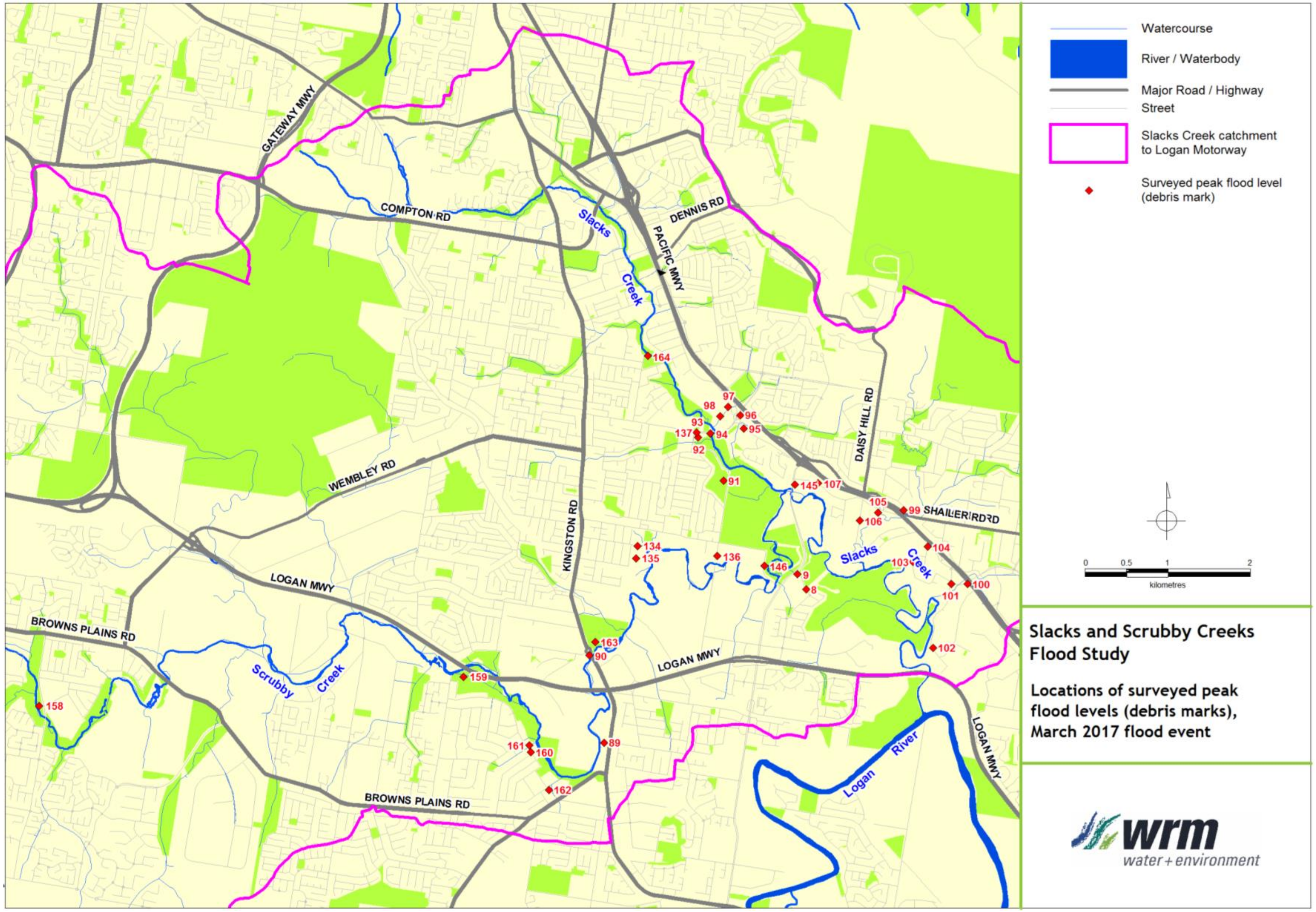

Figure 3.17 – Locations of surveyed peak flood levels throughout the Slacks and Scrubby creeks floodplain (debris marks), March 2017 event

3.12.3 February 2022 event

A total of 29 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the February 2022 flood event. The locations of these debris marks are shown in Figure 3.18. The surveyed flood levels at these locations are given in Table 3.6.

Table 3.6 - Surveyed flood levels (debris marks) throughout the Slacks and Scrubby creeks floodplain, February 2022 event

Debris Mark	Surveyed peak flood level (mAHD)	Debris Mark	Surveyed peak flood level (mAHD)
89	8.87	123	8.86
90	8.90	124	8.85
91	9.01	125	8.88
92	8.88	126	8.91
110	8.81	127	8.85
111	8.87	128	8.87
112	9.09	165	8.88
113	8.88	192	14.91
114	8.86	193	14.90
115	8.87	195	14.40
116	8.85	216	8.82
117	8.87	218	8.81
118	8.91		
119	8.91		
120	8.86		
121	8.89		
122	8.87		

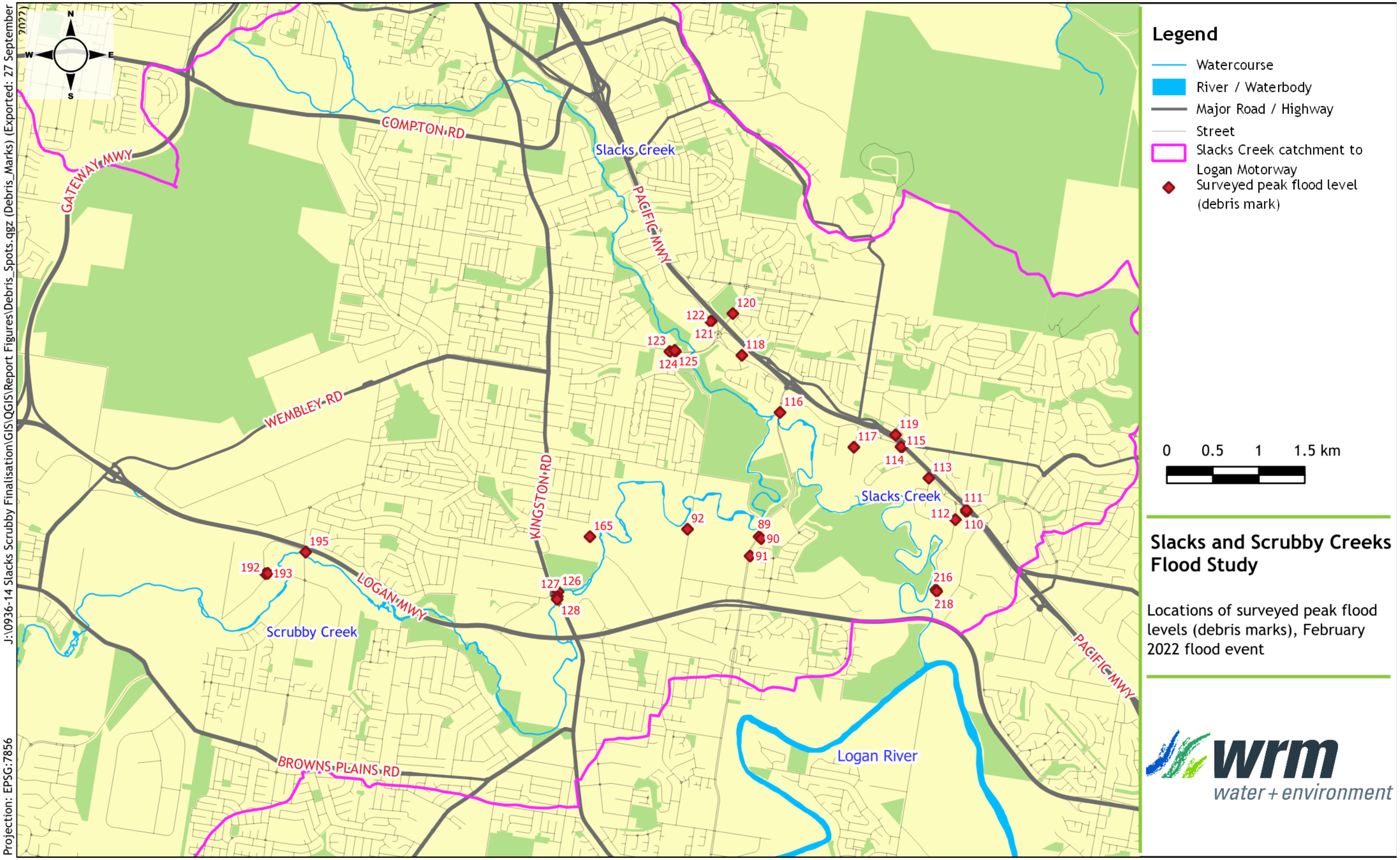

Figure 3.18 – Locations of surveyed peak flood levels throughout the Slacks and Scrubby creeks floodplain (debris marks), February 2022 event

4 Hydrologic model development

4.1 OVERVIEW

An XP-RAFTS runoff-routing model (XP Software, 2016) was developed for the catchment of Slacks and Scrubby creeks and their tributaries. XP-RAFTS models were developed for the following two scenarios:

- **Existing catchment conditions** – Model parameters were based on existing development within the catchment. This model was used for model calibration to historical events.
- **Ultimate catchment conditions** – Model parameters were based on ultimate development of the catchment in accordance with the current Council planning scheme. This model is used for design event modelling.

The XP-RAFTS model was calibrated to the January 2013, May 2015 and March 2017 flood events. The calibrated XP-RAFTS model was validated to the February 2022 flood event. Details of the XP-RAFTS model calibration methodology and results are described in Section 5 of this report. The use of the calibrated XP-RAFTS model to estimate design discharges is described in Section 7.5 of this report.

4.2 XP-RAFTS MODEL CONFIGURATION

4.2.1 Spatial configuration

Figure 4.1 shows the configuration of the Slacks and Scrubby creeks XP-RAFTS hydrologic model. The configuration of the XP-RAFTS model subcatchments and routing links are shown in more detail on Figure B.1 to Figure B.6 in Appendix B.

The hydrologic model covers an area of 119.9 km^2 and includes the entire catchment of Slacks and Scrubby creeks upstream of the Logan Motorway. The model consists of 498 subcatchments, including 305 subcatchments for the Scrubby Creek catchment upstream of the Slacks Creek confluence. The model subcatchment areas range from 2 ha to 58 ha, with an average subcatchment area of 24 ha.

4.2.2 Subcatchment parameters

The XP-RAFTS model uses a single subcatchment approach to determine runoff hydrographs, based on the overall subcatchment parameters (fraction impervious, roughness and slope). Subcatchment fraction impervious and roughness (Manning's 'n') were weighted based on the various land-use types in each subcatchment. The following is of note:

- For the existing catchment conditions XP-RAFTS model, land-use types were determined based on aerial photographs supplied by LCC.
- For the ultimate conditions catchment conditions XP-RAFTS model, land-use types were be determined based on the current Council planning scheme.

Subcatchment slopes were determined based on the available topographic data.

The adopted fraction impervious and roughness (Manning's 'n') for each land-use type are shown in Table B.1 in Appendix B. The adopted (weighted) subcatchment parameters (total area, fraction impervious, catchment slope and Manning's 'n') for each subcatchment are given in Table B.2 for existing catchment conditions and Table B.3 for ultimate catchment conditions in Appendix B.

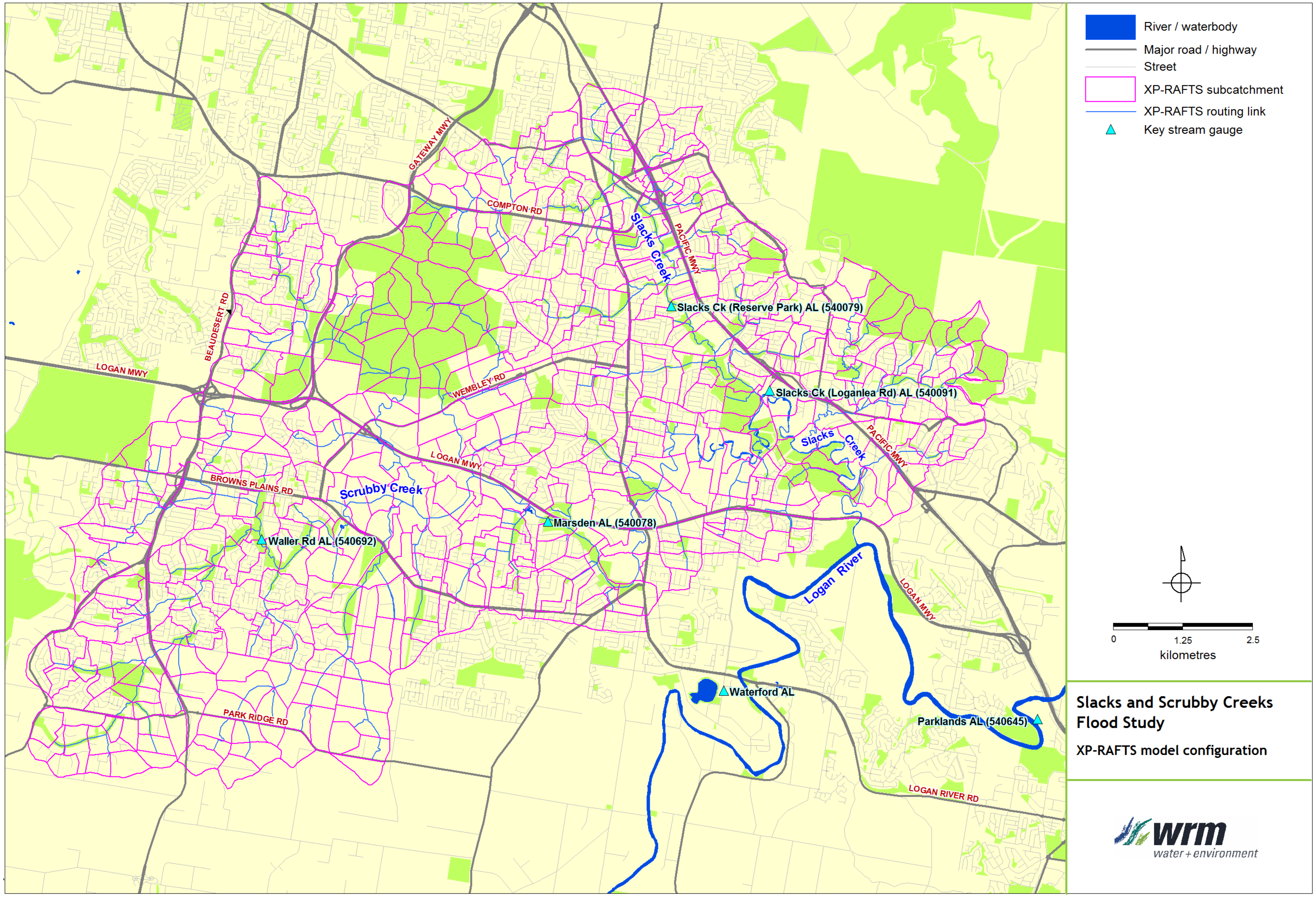

Figure 4.1 - XP-RAFTS model configuration

4.2.3 Losses

Initial and continuing losses were configured based on an adopted relationship with the percentage imperviousness of the model subcatchments. Subcatchment losses were determined based on the joint-calibration process (described in Section 7).

4.2.4 Channel routing parameters

Channel routing was configured by specifying a 'K' and 'X' value for each routing link. Routing link 'X' values of 0.25 and 0.5 were adopted for natural and urban (artificial) channels respectively. The 'K' values represent estimated flow travel times (in hours) and were calculated based on the flow path lengths and the following assumed flow velocities for the following four distinct channel types:

- natural channels = 0.6 m/s;
- artificial channels = 1.5 m/s;
- stormwater pipes = 2.0 m/s; and
- wetlands = 0.35 m/s.

The adopted routing link parameters are given in Table B.4 in Appendix B.

5 Hydrologic model calibration and validation

5.1 METHODOLOGY

The emphasis of the model calibration was to achieve the best possible fit between the predicted and rated discharge hydrographs (based on rating curves obtained from the hydraulic model) at three key gauging stations along Slacks and Scrubby creeks (Waller Road AL, Marsden AL and Reserve Park AL gauges). At these gauges, the calibration attempted to match the predicted and recorded flood peaks and volumes, and also the shapes of the flood hydrograph.

Discharges at the Loganlea Road AL gauging station are Logan River tailwater dependent and no rating curve is available. Therefore, a reliable calibration of the hydrologic model cannot be achieved at this location. The calibration at this gauge was undertaken as part of the joint calibration with the hydraulic model (see Section 7).

5.2 CALIBRATION AND VALIDATION EVENTS

The updated hydrologic model was calibrated against the January 2013, May 2015 and March 2017 events. The hydrologic model was also validated against the February 2022 event. The analysis period for each event was as follows:

- January 2013: 23/01/2013 9:00am to 29/01/2013 9:00am (6 days);
- May 2015: 29/04/2015 9:00am to 02/05/2015 9:00am (3 days);
- March 2017: 28/03/2017 12:00am to 03/04/2017 12:00am (6 days); and
- February 2022: 24/02/2022 8:00am to 02/03/2022 12:00am (6 days).

The selected events cover two relatively small flood events (January 2013 and March 2017) and two large flood event (May 2015 and February 2022) in Slacks and Scrubby creeks. Table 5.1 shows the rated peak discharges for each event at Marsden and Reserve Park. The peak discharges reported in Table 5.1 are based on the adopted rating curves discussed in Section 3.10.

Table 5.1 - Rated peak discharges during the calibration and validation events

Station No.	Station name	Watercourse	Rated peak discharge (m^3/s)			
			January 2013	May 2015	March 2017	February 2022
540692	Waller Road AL	Scrubby Creek	-	252.7	121.9	153.4
540078	Marsden AL	Scrubby Creek	107.5	442.8	282.3	403.3
540079	Reserve Park AL	Slacks Creek	74.9	266.6	119.6	235.3

5.3 ADOPTED MODEL PARAMETERS

The adopted subcatchment and routing link parameters are described in Section 4.2.4 and Appendix B. A subcatchment storage coefficient multiplication factor ‘Bx’ of 1.0 was adopted for all events.

5.4 ASSIGNMENT OF TOTAL RAINFALLS AND TEMPORAL PATTERNS

Total rainfalls and temporal patterns were initially assigned to the model subcatchments based on the proximity of each subcatchment to the nearest pluviography or daily rainfall station. Where recorded daily rainfall data was used, the temporal pattern from the nearest pluviography station was applied to the daily rainfall data.

Some adjustment of pluviography assignment was required to improve the calibration for all three events. Figure 5.1, Figure 5.2 and Figure 5.3 show the assignment of total rainfalls for the January 2013, May 2015, and March 2017 events. The following is of note with regards to the assignment of rainfalls and temporal patterns:

- For the January 2013 event:
  - Rainfall recorded at the Regents Park daily rainfall gauge station was approximately 30 mm to 40 mm higher than those recorded at the neighbouring stations. To achieve a good calibration at the Marsden gauge, recorded rainfall at the Regents Park gauge was ignored as it appeared to be inconsistent with surrounding data.
  - Rainfall recorded at the Shailer Park daily rainfall gauge was applied to 39 subcatchments at the eastern portion of the Slacks Creek catchment. The temporal pattern from the Loganlea Road gauge was applied to these areas.
- For the May 2015 event:
  - Recorded rainfall at the Bega Road gauge was more than 100 mm lower than all other nearby gauging stations. This suggests that the gauge may have malfunctioned during the event. For this reason, recorded rainfall at the Bega Road gauge was ignored.
  - Rainfall recorded at the Shailer Park daily rainfall gauge was applied to 40 subcatchments at the eastern portion of the Slacks Creek catchment. The temporal pattern from the Loganlea Road gauge was applied to these areas.
- For the March 2017 event:
  - Rainfall recorded at the Regents Park daily rainfall gauge station is within 10 mm of the recorded rainfall at the Waller Road gauge (located only 0.8 km to the east). This difference is not considered significant, therefore the sub-daily rainfall data recorded at the Waller Road gauge was applied to the subcatchments in this area.
  - The Hillcrest and Waller Road gauges are both located in the western part of the Scrubby Creek catchment and are located only 2.2 km from each other. However, to achieve a good calibration at the Marsden gauge, the recorded rainfall and temporal pattern at the Waller Road gauge was adopted for the majority of subcatchments in this area as it appeared to be more consistent with the recorded water level hydrograph shape at the Marsden gauge.
  - Rainfall recorded at the Shailer Park daily rainfall gauge was applied to 40 subcatchments at the eastern portion of the Slacks Creek catchment. The temporal pattern from the Loganlea Road gauge was applied to these areas.
- For the February 2022 event:
  - For the February 2022 validation event, the distribution of rainfall across the model subcatchments was tested using each of the above calibration models. The calibration model which achieved the closest characteristics to the February 2022 event was the March 2017 event, and was adopted for validating the predicted hydrographs against the recorded data.
  - Rainfall recorded at the Regents Park daily rainfall gauge station is within 10-30 mm of the recorded rainfall at the Waller Road gauge (located only 0.8 km

to the east). This difference is not considered significant, therefore the sub-daily rainfall data recorded at the Waller Road gauge was applied to the subcatchments in this area. However, it is of note that the recorded rainfall on the 27th is signiciantly lower than the surrounding gauges.

- The Hillcrest and Waller Road gauges are both located in the western part of the Scrubby Creek catchment and are located only 2.2 km from each other. However, to achieve a better calibration at the Marsden gauge, the recorded rainfall and temporal pattern at the Waller Road gauge was adopted for the majority of subcatchments in this area as it appeared to be more consistent with the recorded water level hydrograph shape at the Marsden gauge.
- Rainfall recorded at the Shailer Park daily rainfall gauge was applied to 40 subcatchments at the eastern portion of the Slacks Creek catchment. The temporal pattern from the Loganlea Road gauge was applied to these areas.
- It is of note that the varying the losses and rainfall distribution across the model subcatchments had little effect (in particular at the Marsden and Reserve Park gauges) on the predicted hydrograph peaks and shape in comparison to the recorded hydrographs.

5.5 INITIAL AND CONTINUING LOSSES

Initial (IL) and continuing (CL) losses were configured based on an adopted relationship with the percentage imperviousness of the model subcatchments, as shown on Table 5.2.

Table 5.2 – Initial (IL) and continuing (CL) losses for historical events

Percentage impervious (%)	January 2013 event		May 2015 event		March 2017 event		February 2022 event	
	IL (mm)	CL (mm/h)	IL (mm)	CL (mm/h)	IL (mm)	CL (mm/h)	IL (mm)	CL (mm/h)
0-30	200.0	1.1	70.0	0.9	50.0	1.1	10	1.1
30-40	155.0	0.8	50.0	0.7	32.0	0.8	6.4	0.8
40-50	120.0	0.7	40.0	0.5	28.0	0.7	5.6	0.7
50-60	110.0	0.6	35.0	0.5	23.0	0.6	4.6	0.6
60-75	70.0	0.5	25.0	0.3	17.0	0.5	3.4	0.5
75+	20.0	0.1	10.0	0.1	7.0	0.1	1.4	0.1

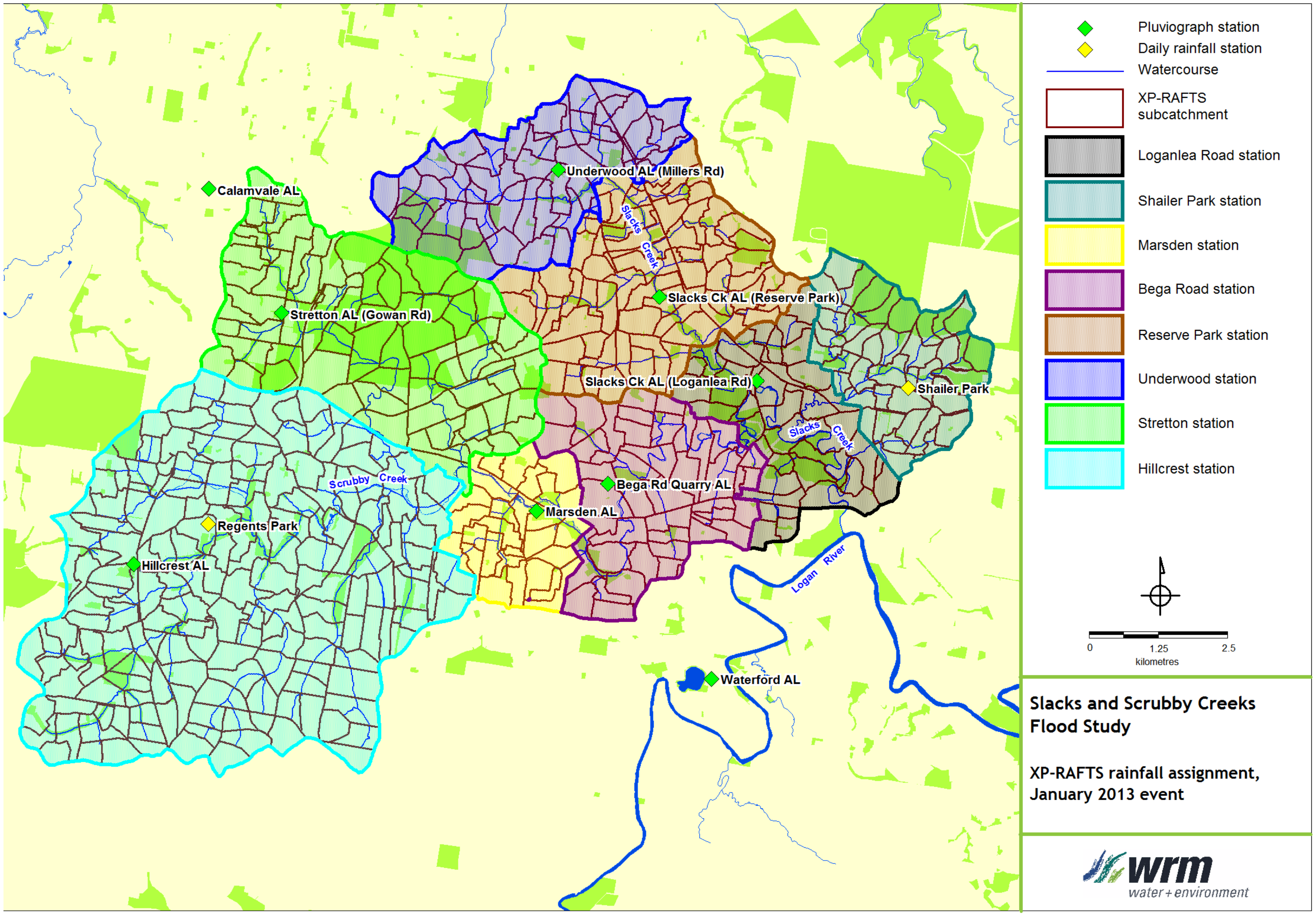

Figure 5.1 - Subcatchment rainfall assignment, January 2013 event

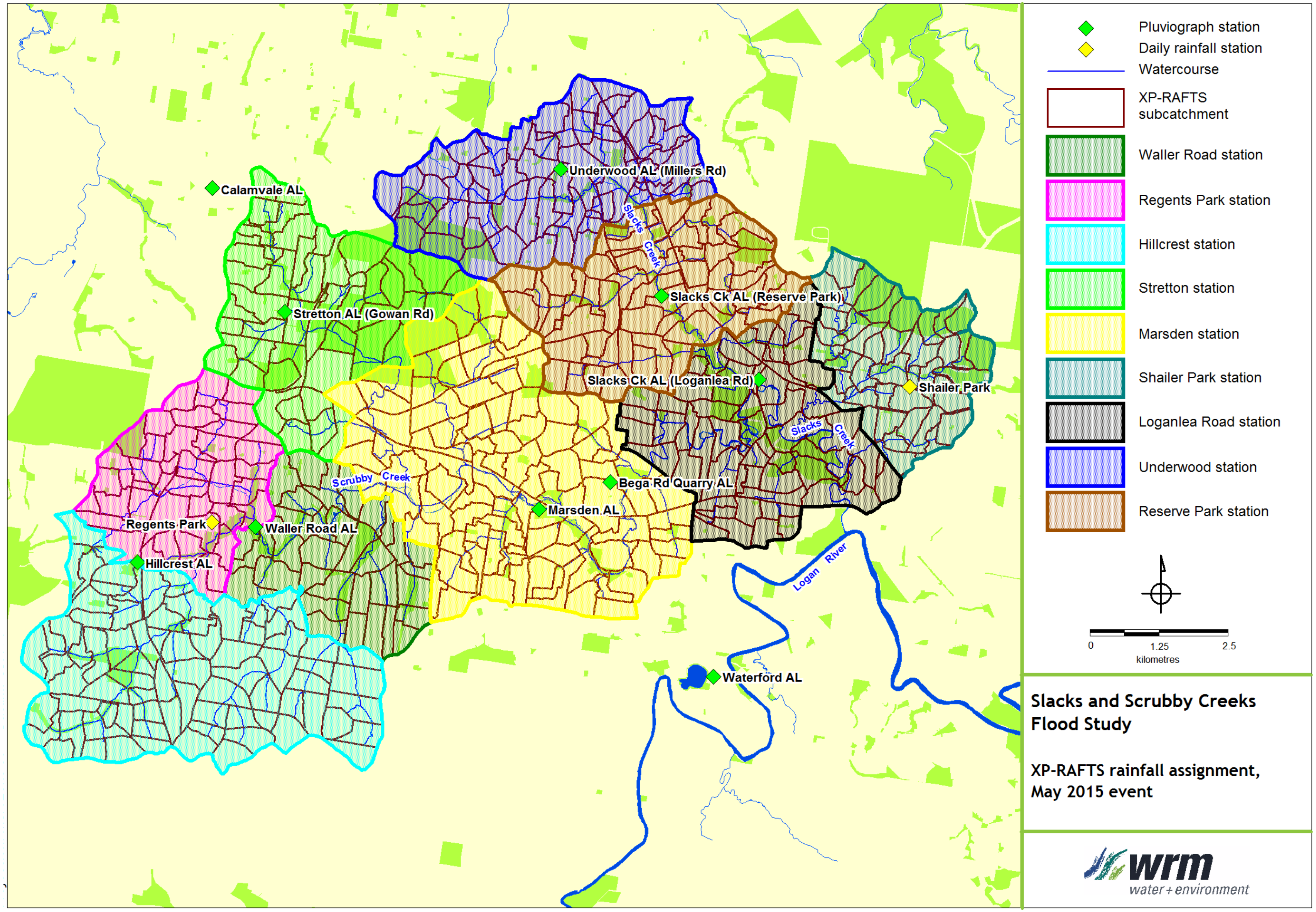

Figure 5.2 - Subcatchment rainfall assignment, May 2015 event

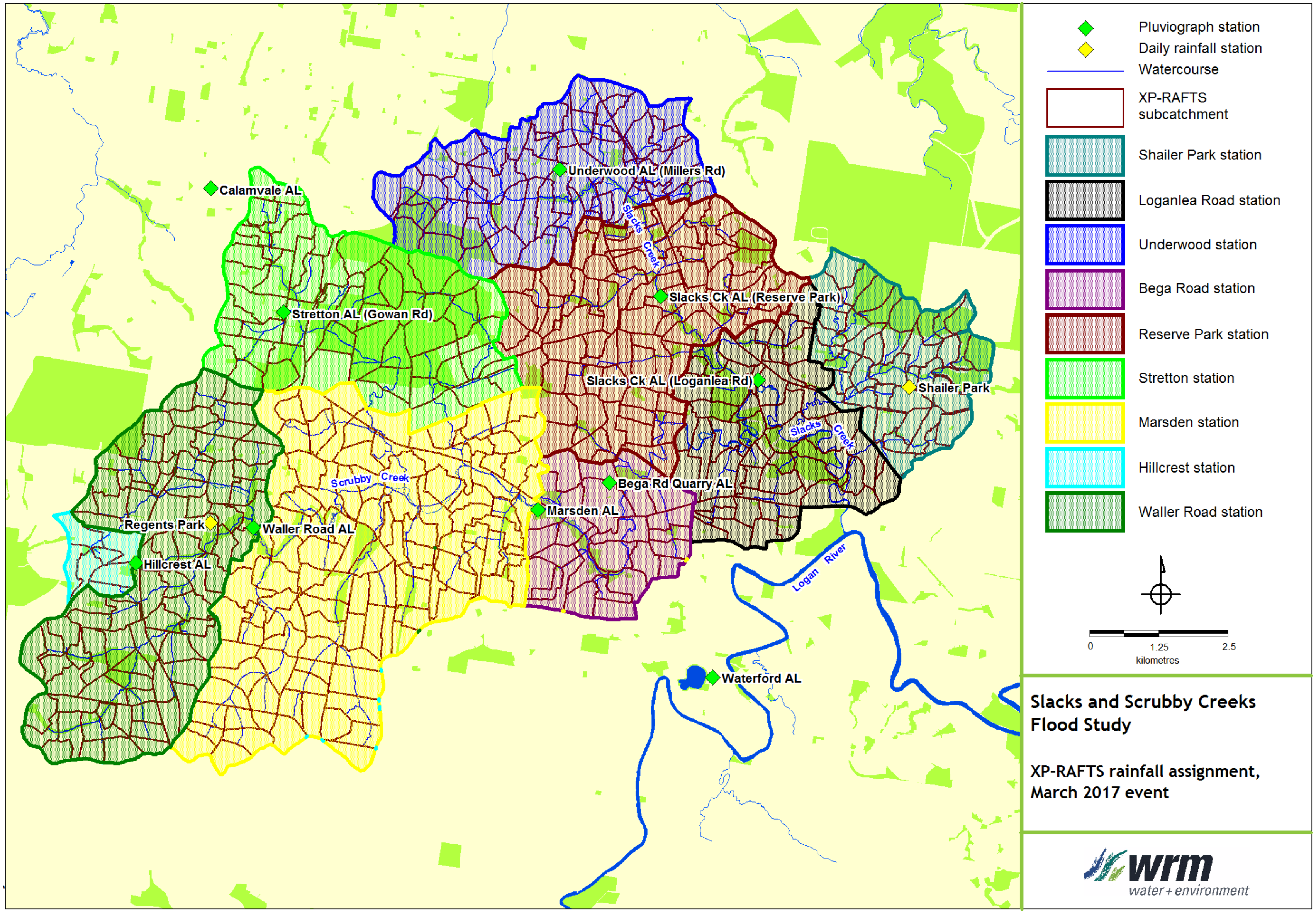

Figure 5.3 – Subcatchment rainfall assignment, March 2017 event

5.6 CALIBRATION AND VALIDATION RESULTS

5.6.1 January 2013 event

A comparison of predicted and rated peak discharges at Marsden and Reserve Park for the January 2013 event is shown in Table 5.3. Comparisons of predicted hydrographs at Marsden and Reserve Park with recorded data for the January 2013 event are shown in Figure 5.4 and Figure 5.5 respectively.

Table 5.3 – Predicted and rated peak discharges at Marsden and Reserve Park gauging stations, January 2013 flood event

Station No.	Station name	Watercourse	Peak discharge (m^3/s)		Difference (%)
			Rated	Predicted	
540692	Waller Road AL [a]	Scrubby Creek	-	77.4	-
540078	Marsden AL [b]	Scrubby Creek	107.5	132.8	23.5%
540079	Reserve Park AL [c]	Slacks Creek	74.9	82.7	10.5%

[a] – XP-RAFTS Subcatchment SC081

[b] – XP-RAFTS Subcatchment SC251

[c] – XP-RAFTS Subcatchment SL096

The following is of note with regards to the January 2013 calibration:

- The January 2013 flood is considered a relatively small event in the Slacks Creek and Scrubby Creek catchments. However, the January 2013 flood was a major flood event in the Logan River catchment.
- In Scrubby Creek:
  - The calibration is generally acceptable, with the predicted hydrograph at the Marsden gauge accurately reproducing the recorded hydrograph shape and flood timing, but significantly overestimating the peak discharge.
  - The difference in peak discharge at the Marsden gauge is likely due to the representation of rainfalls. The January 2013 event was a small event with rainfall severities of less than 20% (1 in 4.48 ARI) AEP for storm durations of less than 12 hours (which are likely to be critical in the Slacks Creek catchment). There were also significant differences between the total rainfalls recorded at the available rainfall stations (up to 90 mm) during this event. It is likely that the rainfall distribution across the catchment during relatively small events such as this was not represented adequately at the available rainfall stations. However, a satisfactory calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges.
- In Slacks Creek, the calibration is good, with the predicted hydrograph at the Reserve Park gauge accurately reproducing the recorded hydrograph shape, flood timing and flood volume, while only slightly overestimating the peak discharge.

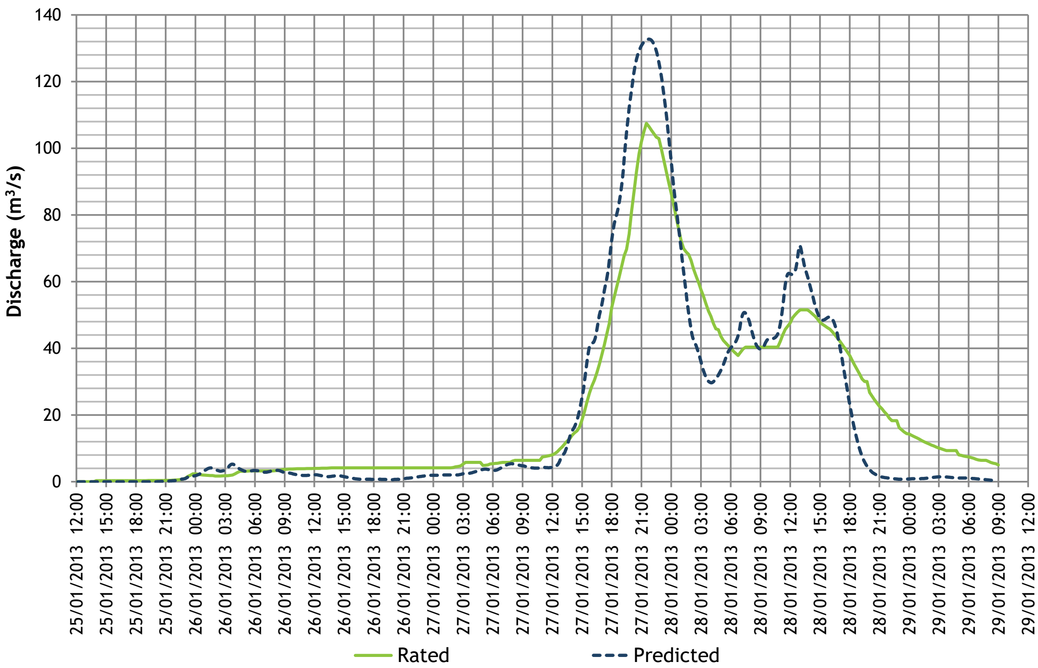

Figure 5.4 - Predicted and rated discharges in Scrubby Creek at Marsden (GS 540078), January 2013 flood event

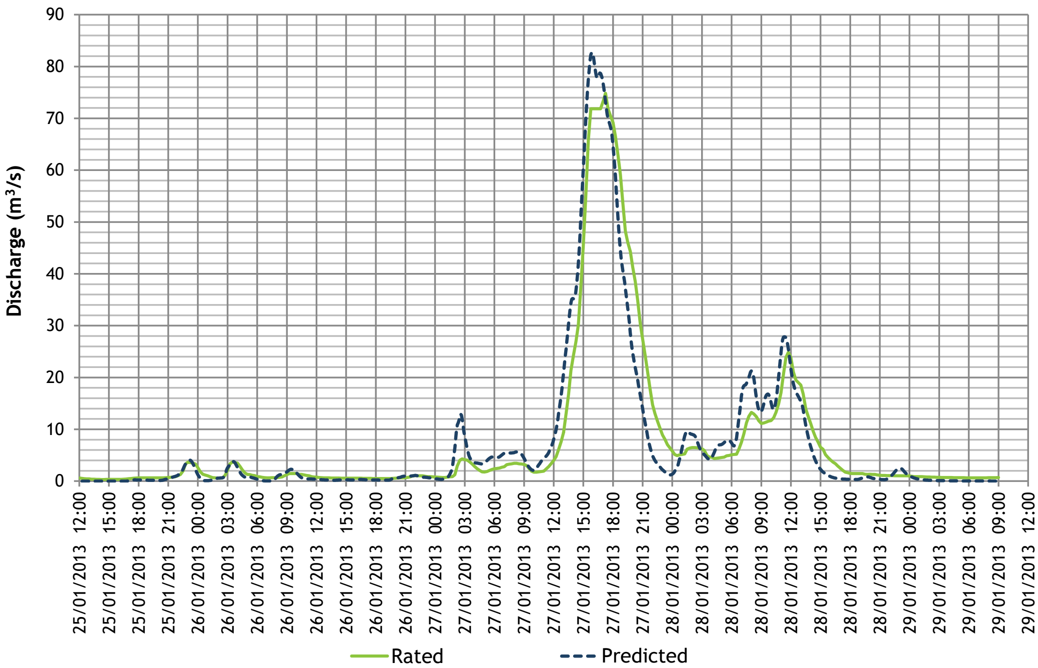

Figure 5.5 - Predicted and rated discharges in Slacks Creek at Reserve Park (GS 540079), January 2013 event

5.6.2 May 2015 event

A comparison of predicted and rated peak discharges at Waller Road, Marsden and Reserve Park for the May 2015 event is shown in Table 5.4. Comparison of predicted hydrographs at Waller Road, Marsden and Reserve Park with recorded data for the May 2015 event are shown in Figure 5.6, Figure 5.7 and Figure 5.8.

Table 5.4 - Predicted and rated peak discharges at Marsden and Reserve Park gauging stations, May 2015 flood event

Station No.	Station name	Watercourse	Peak discharge (m^3/s)		Difference (%)
			Rated	Predicted	
540692	Waller Road AL [a]	Scrubby Creek	252.7	218.7	-13.5%
540078	Marsden AL [b]	Scrubby Creek	442.8	421.1	-4.9%
540079	Reserve Park AL [c]	Slacks Creek	266.6	211.8	-20.5%

[a] - XP-RAFTS Subcatchment SC081

[b] - XP-RAFTS Subcatchment SC251

[c] - XP-RAFTS Subcatchment SL096

The following is of note with regards to the May 2015 calibration:

- The May 2015 flood is considered a major flood event in the Slacks Creek and Scrubby Creek catchments. However, the May 2015 flood was only a moderate flood event in the Logan River.
- In Scrubby Creek:
    - The calibration at the Waller Road gauge is generally acceptable, with the predicted hydrograph accurately reproducing the recorded hydrograph shape, flood timing, flood volume, but slightly underestimating the peak discharge. However, a good calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges. A discussion on predicted peak discharges is given in Section 5.6.2.1.
    - The predicted hydrograph at the Marsden gauge matches the recorded hydrograph shape and flood volume, while only slightly underestimating the peak discharge. However, the predicted flood peak occurs approximately 120 minutes later than the recorded flood peak.
    - The difference in flood timing at the Marsden gauge is due to the difference in flooding behaviour of the May 2015 event compared to the January 2013 and March 2017 events. Compared to the 2013 and 2017 events, the May 2015 event is a much larger flood which also occurred within a shorter duration. Therefore, flow velocities in Scrubby Creek were likely to have been faster than during the January 2013 and March 2017 events, resulting in an earlier flood peak. A good calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges. A discussion on predicted peak discharges is given in Section 5.6.2.1.
- In Slacks Creek, the calibration is generally acceptable, with the predicted hydrograph at the Reserve Park gauge accurately reproducing the recorded hydrograph shape and flood timing, but significantly underestimating the peak discharge. However, a good calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges. A discussion on predicted peak discharges is given in Section 5.6.2.1.

5.6.2.1 Discussion on peak discharges (May 2015 event)

The May 2015 event is a much larger event compared to the January 2013 and March 2017 events. Hydraulic modelling results (refer to Section 7) indicate that discharges for the January 2013 and March 2017 events are mainly confined within the main channels. However, hydraulic modelling for the May 2015 event indicates significant of out-of-bank flows occurred throughout the Slacks and Scrubby creeks floodplain.

Due to these out-of-bank flows, the main flow paths in the hydraulic model are effectively much shorter than those adopted in the XP-RAFTS model for the May 2015 event. The XP-RAFTS model assumes that all discharges are confined within the channel. As a result, predicted peak discharges from the hydraulic model were higher (and occurs earlier) than the predicted XP-RAFTS peak discharges. The higher predicted discharges in the hydraulic model resulted in a good calibration against recorded water levels at the Waller Road, Marsden and Reserve Park gauges (and at the MHGs and surveyed debris marks), even though the XP-RAFTS model appears to significantly underestimate peak discharges.

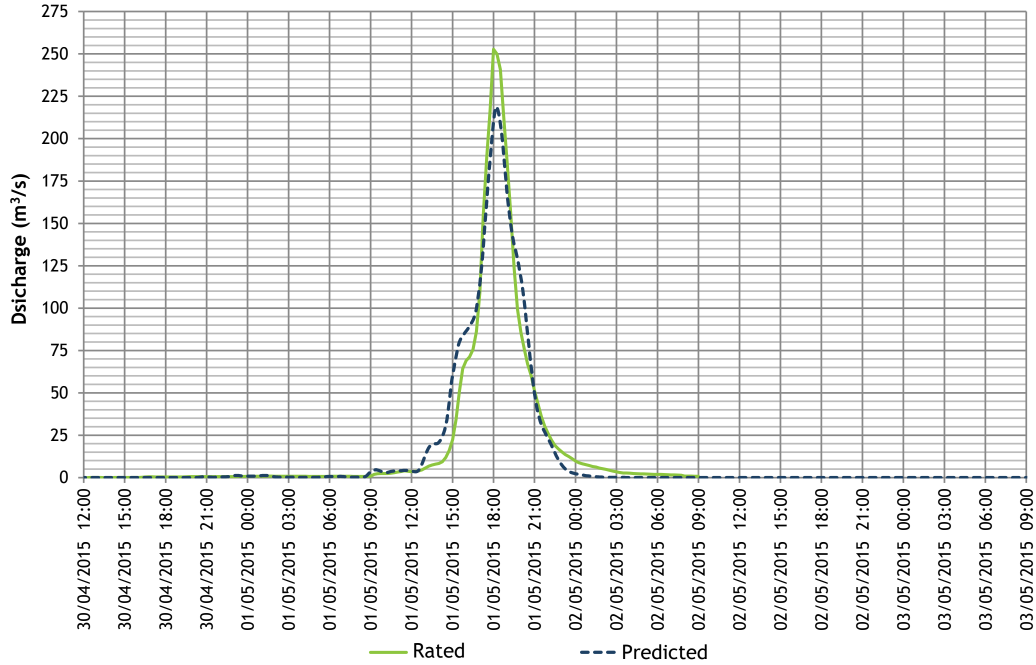

Figure 5.6 – Predicted and rated discharges in Scrubby Creek at Waller Road (GS 540692), May 2015 flood event

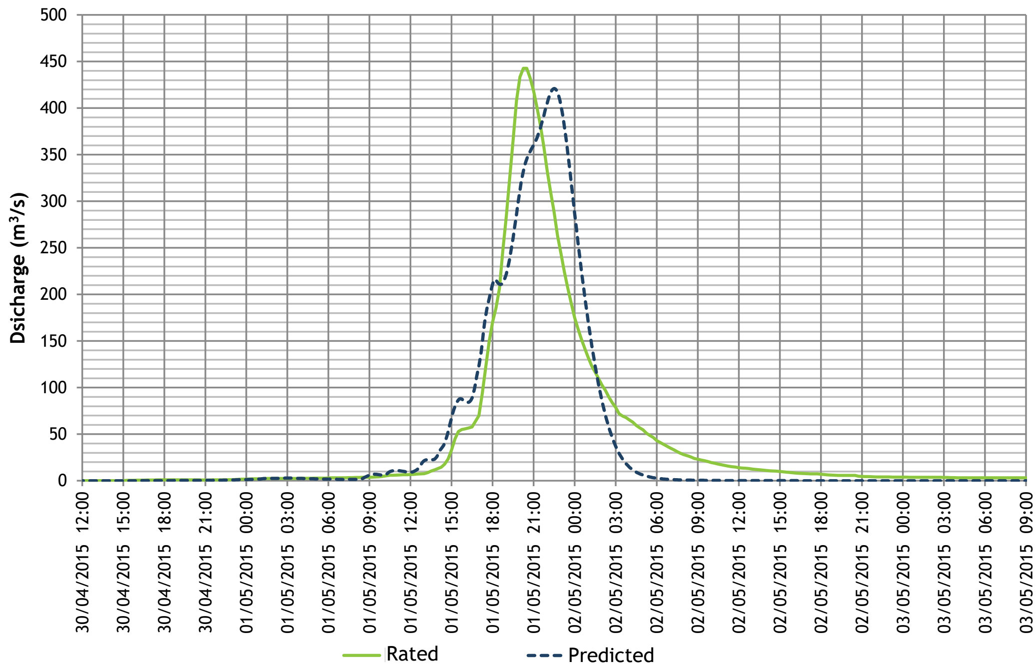

Figure 5.7 – Predicted and rated discharges in Scrubby Creek at Marsden (GS 540078), May 2015 flood event

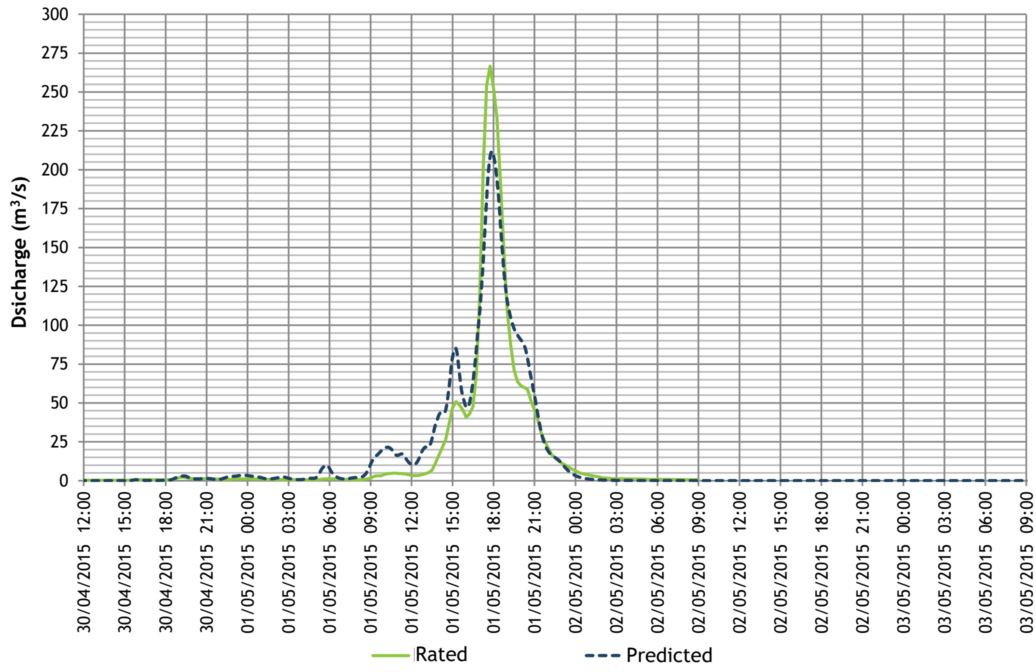

Figure 5.8 – Predicted and rated discharges in Slacks Creek at Reserve Park (GS 540079), May 2015 flood event

5.6.3 March 2017 event

A comparison of predicted and rated peak discharges at Waller Road, Marsden and Reserve Park for the March 2017 event is shown in Table 5.5. Comparisons of predicted hydrographs at Waller Road, Marsden and Reserve Park with recorded data for the March 2017 event are shown in Figure 5.9, Figure 5.10 and Figure 5.11.

Table 5.5 - Predicted and rated peak discharges at Marsden and Reserve Park gauging stations, March 2017 flood event

Station No.	Station name	Watercourse	Peak discharge (m^3/s)		Difference (%)
			Rated	Predicted	
540692	Waller Road AL [a]	Scrubby Creek	121.9	118.9	-2.4%
540078	Marsden AL [b]	Scrubby Creek	282.3	222.5	-21.2%
540079	Reserve Park AL [c]	Slacks Creek	119.6	86.4	-27.8%

[a] - XP-RAFTS Subcatchment SC081

[b] - XP-RAFTS Subcatchment SC251

[c] - XP-RAFTS Subcatchment SL096

The following is of note with regards to the March 2017 calibration:

- The March 2017 flood is considered a small to moderate event in Slacks and Scrubby creeks. However, the March 2017 flood was a major flood event in the Logan River catchment. The March 2017 event in Slacks and Scrubby creeks had two distinct flood peaks separated by a period of about 9 to 12 hours.
- In Scrubby Creek:
    - At the Waller Road gauge, the calibration is good. The predicted hydrograph at this gauge accurately reproduced the recorded hydrograph shape, flood timing and flood volume. The model also accurately matched the peak discharge of the first flood peak, but underestimated the peak discharge of the second flood peak. However, a good calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges.
    - At the Marsden gauge, the XP-RAFTS model cannot replicate the recorded hydrograph shape, timing and peak discharge. The model overestimates the peak discharge of the first flood peak, and significantly underestimates the peak discharge of the second flood peak at this gauge.
    - The differences in the hydrograph shape and peak discharges at the Marsden gauge is likely due to the representation of rainfalls. The March 2017 event was a small to moderate event in the Slacks Creek and Scrubby Creek catchments, with recorded rainfall severities of less than 10% (1 in 10 ARI) AEP for storm durations of less than 12 hours. There were also significant differences between the total rainfalls recorded at the available rainfall stations (up to 100 mm) during this event. It is likely that the variation in rainfall across the catchment during relatively small events such as this was not represented adequately at the available rainfall stations.
    - The difference in peak discharge for the second flood peak at the Marsden gauge is likely due to the influence of backwater flooding from the Logan River. A discussion on the influence of Logan River backwater flooding is given below in Section 5.6.3.1.
    - A satisfactory calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges.

- In Slacks Creek:
  - The calibration at the Reserve Park gauge is generally acceptable, with the predicted hydrograph accurately reproducing the recorded hydrograph shape, flood timing and flood volume, while only slightly overestimating the peak discharge of the first flood peak. However, the model significantly underestimates the peak discharge of the second flood peak.
  - The difference in peak discharge for the second flood peak at the Reserve Park gauge is likely due to the influence of backwater flooding from the Logan River. However, a good calibration at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges. A discussion on the influence of Logan River backwater flooding is given below in Section 5.6.3.1.

5.6.3.1 Discussion on the influence of Logan River backwater flooding

The March 2017 flood was a major event in the Logan River catchment. The time of peak local catchment flows in Slacks and Scrubby creeks during the second flood peak of the March 2017 event coincided with rising flood levels in the Logan River, which affected the stage-discharge behaviour at the Marsden and Reserve Park gauges. It is likely that the rating curves for the Marsden and Reserve Park gauges significantly overestimate discharges during periods when high Logan River tailwater levels affect these gauges.

A joint calibration with the hydraulic model was undertaken to validate the XP-RAFTS model predicted discharges (see Section 7). The change in hydraulic behaviour at the Marsden and Reserve Park gauges due to changing tailwater conditions was replicated well in the hydraulic model, which resulted in a good calibration for the second flood peak, even though the XP-RAFTS model appears to significantly underestimate the peak discharges.

Compared to the March 2017 event, the time of peak local catchment flows in Slacks and Scrubby creeks during the January 2013 and May 2015 events coincided with much lower flood levels in the Logan River. As a result, backwater flooding from the Logan River had little to no effect on the rating curves for the Marsden and Reserve Park gauges during the time of peak flows in the Slacks Creek catchment for the 2013 and 2015 events.

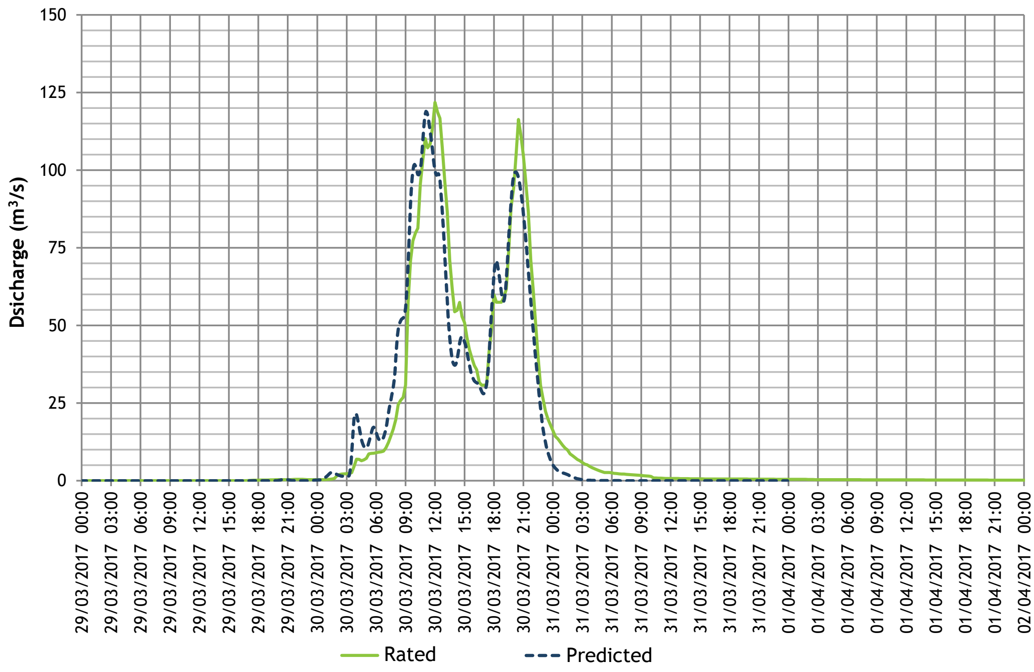

Figure 5.9 - Predicted and rated discharges in Scrubby Creek at Waller Road (GS 540692), March 2017 flood event

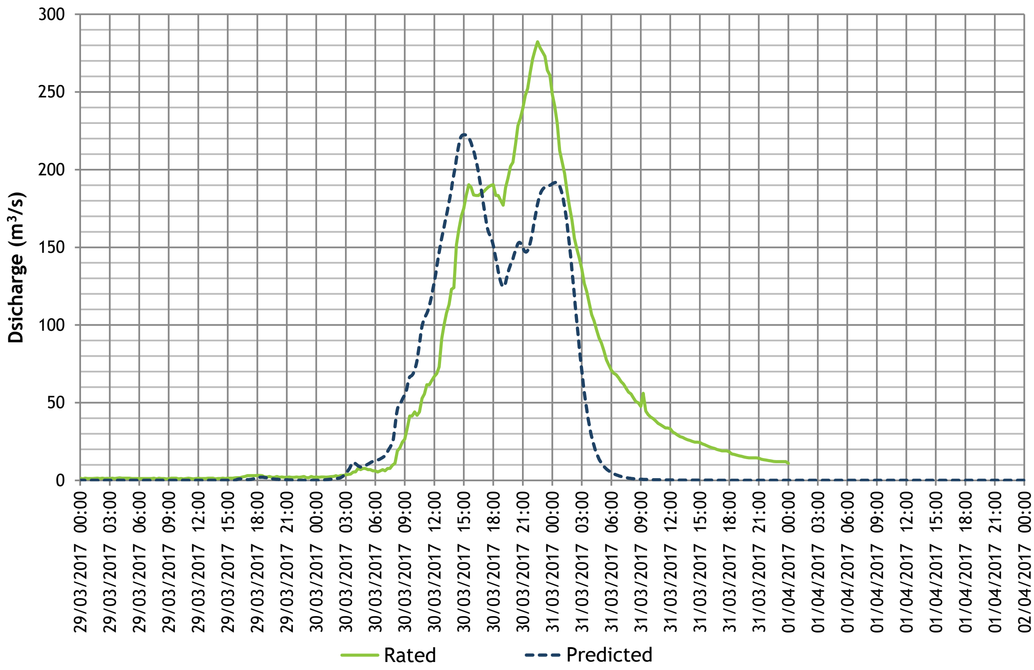

Figure 5.10 - Predicted and rated discharges in Scrubby Creek at Marsden (GS 540078), March 2017 flood event

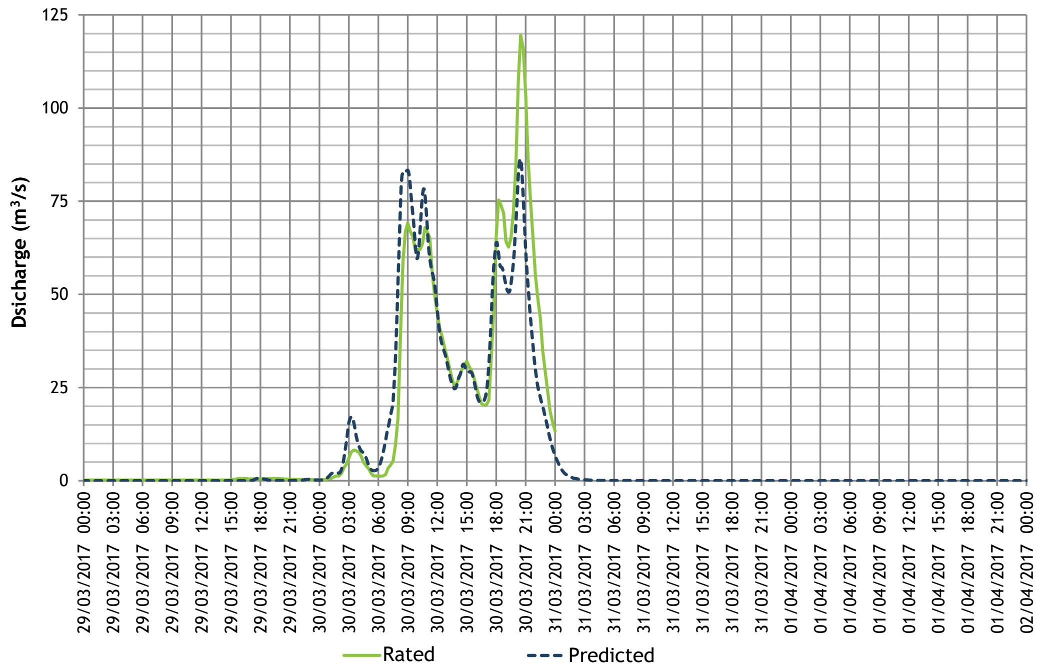

Figure 5.11 – Predicted and rated discharges in Slacks Creek at Reserve Park (GS 540079), March 2017 flood event

5.6.4 February 2022 event

A comparison of predicted and rated peak discharges at Waller Road, Marsden and Reserve Park for the February 2022 event is shown in Table 5.6. Comparisons of predicted hydrographs at Waller Road, Marsden and Reserve Park with recorded data for the February 2022 event are shown in Figure 5.12, Figure 5.13 and Figure 5.14.

Table 5.6 – Predicted and rated peak discharges at Marsden and Reserve Park gauging stations, February 2022 flood event

Station No.	Station name	Watercourse	Peak discharge (m³/s)		Difference (%)
			Rated	Predicted	
540692	Waller Road AL [a]	Scrubby Creek	153.4	112.2	-26.9%
540078	Marsden AL [b]	Scrubby Creek	403.3	301.6	-25.2%
540079	Reserve Park AL [c]	Slacks Creek	235.3	137.9	-41.4%

[a] – XP-RAFTS Subcatchment SC081

[b] – XP-RAFTS Subcatchment SC251

[c] – XP-RAFTS Subcatchment SL096

The following is of note with regards to the February 2022 validation:

- The February 2022 flood is considered a moderate to large event in Slacks and Scrubby creeks. There was generally consistent rainfall across a 3-day period with multiple peaks in rainfall throughout the event. Towards the end of the event, the backwater from the Logan Albert River has an effect on the downstream parts of Slacks and Scrubby creek (including the Loganlea Road gauge).
- In Scrubby Creek:

- At the Waller Road gauge, the validation is good. The predicted hydrograph at this gauge accurately reproduced the recorded hydrograph shape, flood timing and flood volume up to 27 February 12:00am. The predicted peak discharges generally match with the recorded data across the event with exceptions to the end, where model underestimates the peak discharges. In the joint calibration with the hydraulic model, there is a good match.
    - At the Marsden gauge, the XP-RAFTS model generally matches the recorded hydrograph shape, flood timing and flood volumes. The hydrologic model has a more defined shape in comparison to the recorded data. Similarly, the model underestimates the peak discharge in the latter half of the event. The difference in the peak discharge is likely due to the influence of backwater flooding from the Logan River.
    - A good validation at this gauge was achieved by joint calibration with the hydraulic model (described in Section 7) using these XP-RAFTS predicted discharges.
- In Slacks Creek:
    - The validation at the Reserve Park gauge is generally acceptable, with the predicted hydrograph accurately reproducing the recorded hydrograph shape, flood timing and flood volume. There are slight underestimations at the significant peaks however, the smaller spikes through the event are generally captured by the model.
    - The difference in peak discharges towards the latter half of the event is likely due to the influence of backwater flooding from the Logan River.
    - A good validation at this gauge was achieved by joint calibration with the hydraulic model using these XP-RAFTS predicted discharges.

5.6.4.1 Discussion on the influence of Logan River backwater flooding

The February 2022 flood was a major event in both the Slacks and Scrubby Creek and the Logan River catchments. The time of peak local catchment flows in the Slacks and Scrubby creeks during the second flood peak of the February 2022 event coincided with rising flood levels in the Logan River, which affected the stage-discharge behaviour at the Marsden and Reserve Park gauges. It is likely that the rating curves for the Marsden and Reserve Park gauges significantly overestimate discharges during periods when high Logan River tailwater levels affect these gauges.

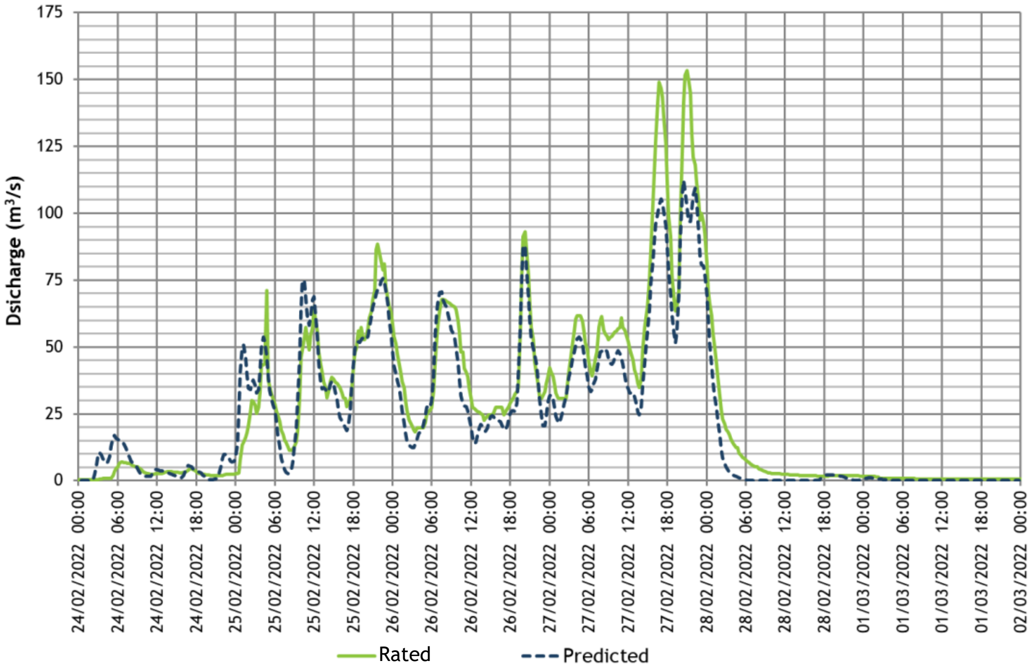

Figure 5.12 – Predicted and rated discharges in Scrubby Creek at Waller Road (GS 540692), February 2022 flood event

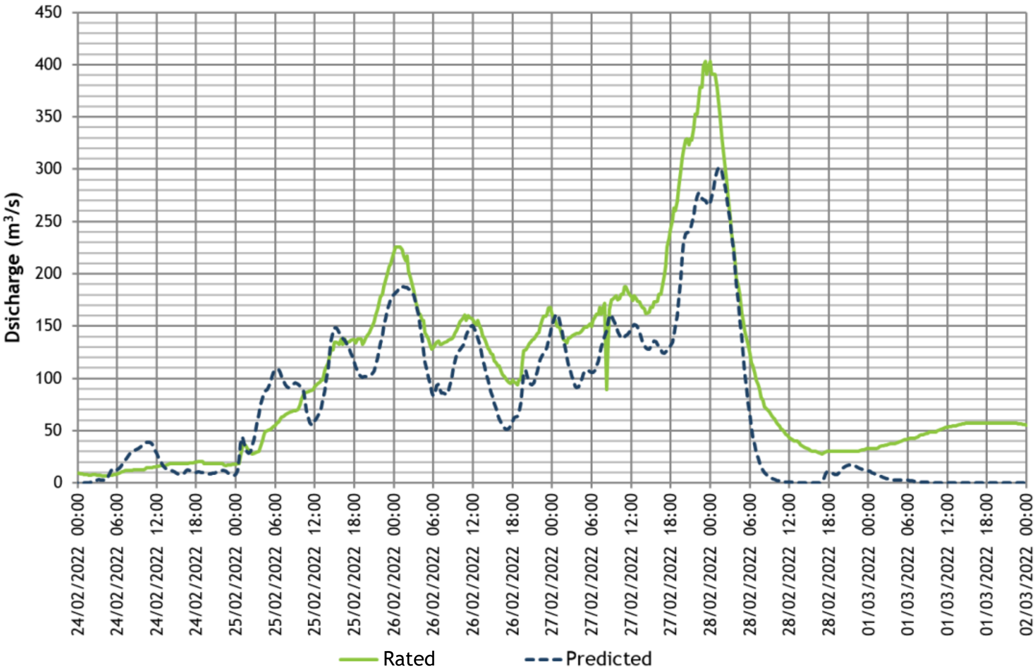

Figure 5.13 – Predicted and rated discharges in Scrubby Creek at Marsden (GS 540078), February 2022 flood event

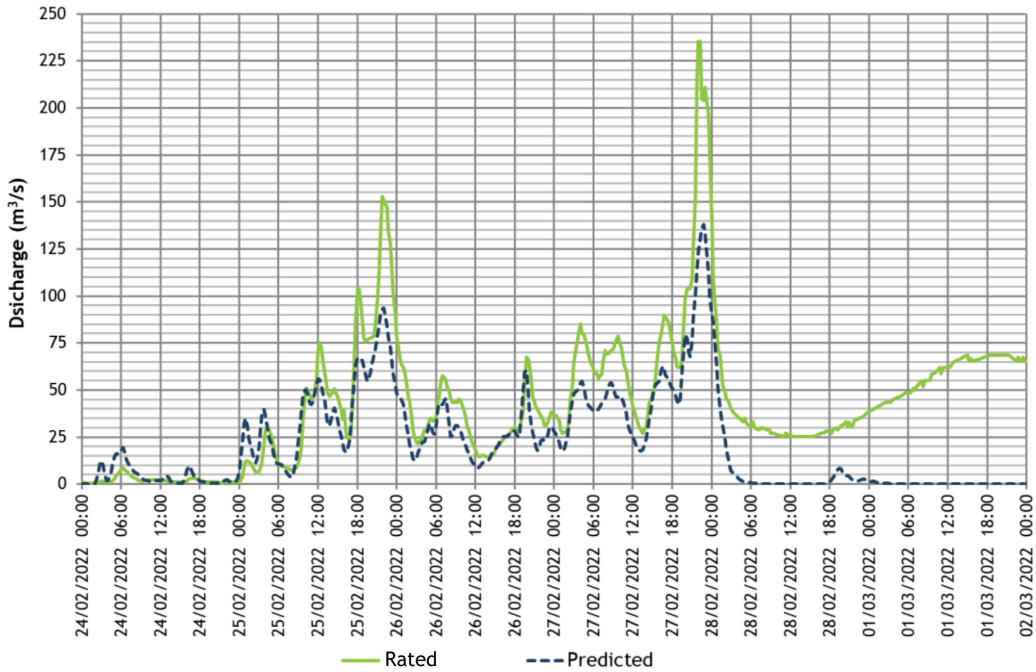

Figure 5.14 – Predicted and rated discharges in Slacks Creek at Reserve Park (GS 540079), February 2022 flood event

6 Hydraulic model development

6.1 OVERVIEW

A TUFLOW two-dimensional hydrodynamic model (BMT WBM, 2016) was used to estimate flood behaviour (depths, levels and velocities) throughout the LCC LGA located within the Slacks and Scrubby creeks catchment. The hydraulic model also includes part of the BCC LGA located within the Slacks and Scrubby creeks catchment.

TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically identifies breakout points and flow directions within the study area. All hydraulic modelling was undertaken using the TUFLOW Build 2018-03-AE HPC-GPU solver.

The TUFLOW modelling package is suited to simulation of dynamic hydraulic behaviour of complex overland flow in rural areas and was considered the most appropriate tool to determine the flood characteristics of Slacks and Scrubby creeks and their tributaries.

The discharges estimated using the XP-RAFTS hydrologic model were adopted as inflows to the TUFLOW hydraulic model. All XP-RAFTS hydrograph inputs are a combination of local and total subcatchment flows.

6.2 SPATIAL CONFIGURATION AND GRID CELL SIZE

Figure 6.1 shows the Slacks and Scrubby creeks TUFLOW model configuration. The model covers an area of 82 km^2 and includes almost the entire Slacks and Scrubby creeks catchment. The model extends downstream to the Logan Motorway Bridge across Slacks Creek.

The model was configured using a grid cell size of three meters. This provides a compromise between a coarse grid cell size sufficient for the main creek channels and floodplains of Slacks and Scrubby creeks, and a fine grid cell size required for the small drains and waterways in the upper catchment.

6.3 TOPOGRAPHY

6.3.1 Base model topography

The LCC 2021, LCC 2017 and BCC 2017 LiDAR data were used to develop a digital elevation model (DEM) with a grid size of 1 m. This 1 m resolution DEM was adopted as input into TUFLOW as an ascii grid file for the base topography.

For a 0.8 km^2 area adjacent to the M1 Motorway between Underwood Road and Springwood Road. TMR survey data supplied as part of the WRM (2017) study was used to represent the base model topography. This data appears to show a better representation of ground levels, drains and waterways in the vicinity of the M1 Motorway when compared to the LCC 2017 LiDAR data.

6.3.2 Representation of creek inverts

A series of ‘z-shape’ objects were used to improve the representation of invert levels along creeks, drains as well as culvert inlets and outlets in most areas within the TUFLOW model. Invert levels in some areas are also represented by using ‘z-tin’ and ‘z-poly’ objects. Some of these files were originally created as part of previous studies (refer to Section 3.1) and then modified to suit the current model grid size and orientation.

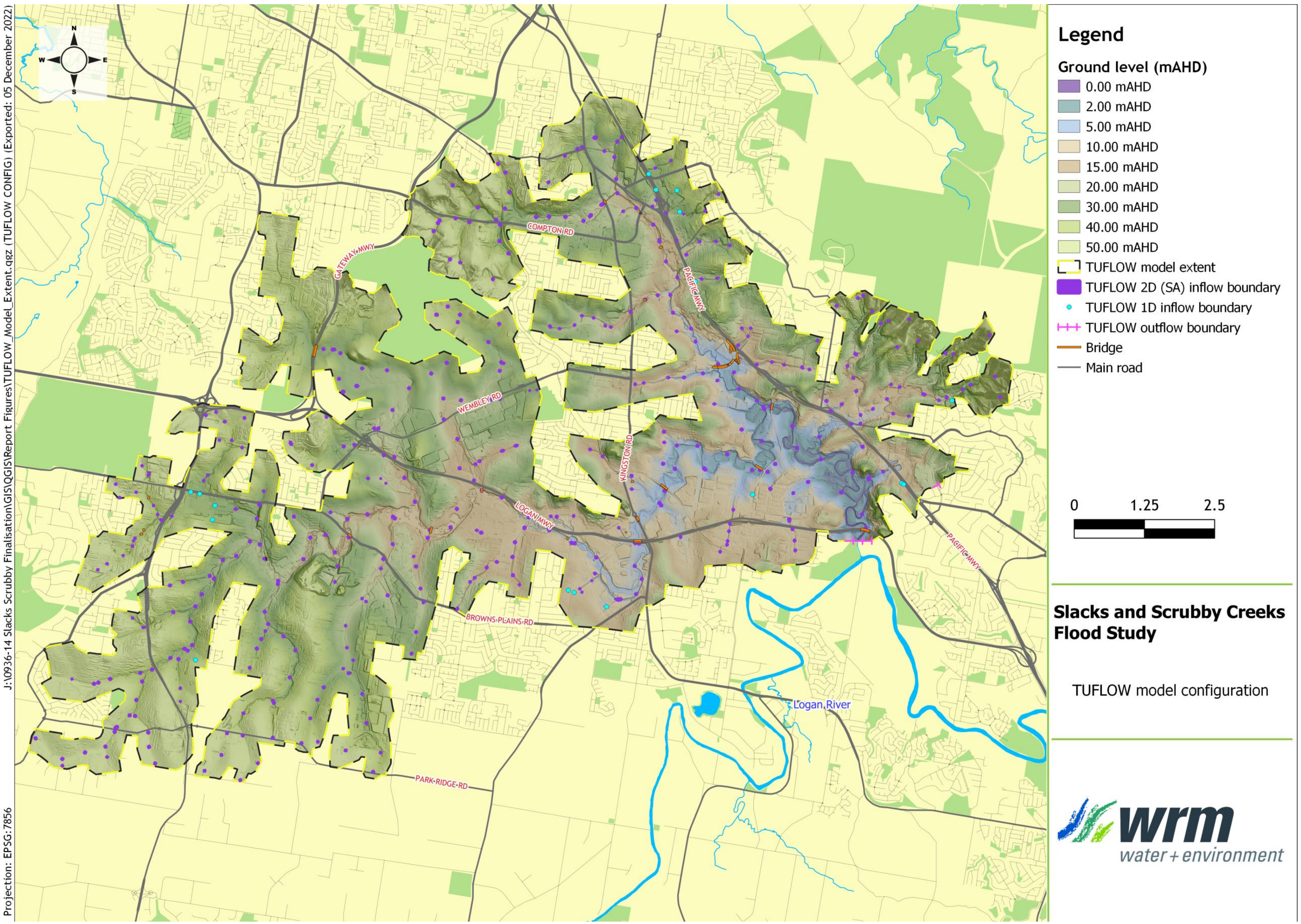

Figure 6.1 - TUFLOW model extent

The following is of note with regards to the representation of creek inverts in the model:

- A z-shape (2d_zsh_Creek_Inverts) was used to represent surveyed creek inverts along the main channel of Slacks Creek downstream of Zuleika Drive, and the main channel of Scrubby Creek downstream of Vansittart Road. The surveyed invert levels were obtained from the LCC (2015) model, and the surveyed inverts appear to be lower than all available LiDAR (2013, 2017 and 2021 LCC LiDAR captures).
- A z-shape (2d_zsh_Ck_Inverts_US) was used to reinforce the creek invert levels from the LCC 2021 and BCC 2017 LiDAR datasets. The elevations for the '2d_zsh_Ck_Inverts_US' file were obtained from the LCC 2021 LiDAR and BCC 2017 LiDAR data.
- For areas in the vicinity of the M1 Motorway (Pacific Highway), the representation of creek, drain and culvert inlet and outlet invert levels were improved using a series of TUFLOW z-shapes originally created as part of the M1 Motorway hydraulic study (WRM, 2017). These z-shapes were configured based on a collection of LiDAR, ground survey and as-constructed drawings supplied by TMR as part of the WRM (2017) study. Some of these z-shapes were modified slightly to suit the current model grid size and orientation.
- The two detention basins located adjacent to Mandew Street and the M1 Motorway were configured using a DEM created as part of the WRM (2017) study. This DEM was based on ground survey data supplied by TMR for the WRM (2017) study. This DEM shows significantly lower ground elevations at the base of the basins when compared to the LCC 2021 LiDAR data.
- For some areas in the upper catchment of Scrubby Creek in the vicinity of Fern Street and Johnson Road (Browns Plains), the representation of creek, drain and culvert inlet and outlet invert levels were improved using a series of TUFLOW z-shape and z-poly files originally created as part of the Engeny (2013) study. Some of these files were updated based the LCC 2021 LiDAR and latest LCC hydraulic structures data. These files were also modified to suit the current grid size and orientation.
- The series of detention basins and lakes located between Blackwell Street and Conifer Street (Hillcrest) were configured using a DEM created as part of the Engeny (2013) study. The DEM shows lower elevations along the base of the basins when compared to the LCC 2021 LiDAR due to the LiDAR capturing of standing water within the basins and lakes.

6.3.3 Representation of road embankments and building pads

A series of z-shape files were used to improve the representation of road crest levels, road embankments and building pads. A series of 'z-tin' and z-poly' files were also used in some areas. The following is of note:

- For areas in the vicinity of the M1 Motorway (Pacific Highway), the TUFLOW z-shapes for road crests and embankments were obtained from the M1 Motorway hydraulic model (WRM, 2017). Some of these files were modified to suit the current model grid cell size and orientation. TUFLOW z-shapes obtained from the WRM (2017) study were also used to improve the representation of ground levels across the IKEA (Logan) basement carpark.
- For some areas in the upper catchment of Scrubby Creek in the vicinity of Fern Street and Johnson Road (Browns Plains), z-shapes, z-poly and z-tin files obtained from the Engeny (2013) hydraulic model were used to improve the representation of building pads in this area including the large Grand Plaza complex (Browns Plains). TUFLOW z-shapes obtained from the Engeny (2013) hydraulic model were also used to represent the solid walls adjacent to the Scrubby Creek channel near Tradelink Road and Anzac Avenue.

6.3.4 Representation of road barriers and guard rails

Solid concrete road barriers as well as sound barriers represent a full blockage to incoming flows. Therefore, solid road barriers were incorporated at key locations throughout the TUFLOW model using z-shapes. TUFLOW z-shapes for concrete barriers and sound barriers located along the M1 Motorway were obtained from the M1 Motorway hydraulic models (WRM, 2017).

Guard rails represent partial blockages to incoming flows. Therefore, guard rails were incorporated at key locations throughout the model using "layered flow constrictions" (a TUFLOW feature commonly used to represent bridges). The mechanism of layered flow constrictions is described further in Section 6.6.5 (bridges). Guard rails located along Paradise Road were represented by layered flow constriction files obtained from the M1 Motorway hydraulic models (WRM, 2017). Guard rails at other culvert crossings were also incorporated where data is available from LCC hydraulic structures survey.

6.4 INFLOW AND OUTFLOW BOUNDARIES

6.4.1 Inflow boundaries

The majority of model inflow boundaries in the TUFLOW model was applied within the 2D model domain using 2D surface-area "SA" polygons. Using this approach, flows are initially applied to the lowest point within each SA polygon, and then gradually applied over a larger area within the SA polygon as the discharge increases.

For locations where drainage is mainly conveyed by subsurface stormwater pipe and trunk drainage networks, inflow boundaries were applied within the 1D model domain. Using this approach, flows are initially applied at the inlet of the stormwater pipe. Runoff in excess of the pipe capacity is allowed to surcharge via stormwater inlet pits to the 2D model domain.

Figure 6.1 shows the locations of 2D (SA) and 1D inflow boundaries in the hydraulic model. The model has a total of 25 total inflow boundaries and 418 local inflow boundaries (one for each XP-RAFTS model subcatchment), which include 426 inflows in the 2D model domain and 17 inflows within the 1D model domain. Local inflow hydrographs generated from the XP-RAFTS model for existing catchment conditions were adopted as inflows at the 2D and 1D inflow boundaries.

6.4.2 Outflow boundaries

The hydraulic model has one primary outflow boundary located in Slacks Creek approximately 220 m downstream of the Logan Motorway Bridge, and approximately 290 m upstream of the confluence with the Logan River. The model also has a secondary outflow boundary located across Mandew Street to the southeast of the Logan Hyperdome. Figure 6.1 shows the locations of the primary and secondary outflow boundaries.

For each of the calibration and validation events, a water level hydrograph was adopted at the primary outflow boundary. The derivation of tailwater hydrographs for the calibration and validation events is described in Section 6.7. For the design events, a constant tailwater approach was adopted at the primary outflow boundary. The derivation of tailwater levels for design events is described in Section 9.2.5.

The secondary outflow boundary at Mandew Street allows overland flows draining south from the intersection of Blackthorn Court and Mandew Street (during large and extreme flood events) to exit the model. A normal depth boundary was adopted for the secondary outflow boundary based on a slope of 1%, equal to the longitudinal slope of Mandew Street at the outflow boundary location.

6.5 HYDRAULIC ROUGHNESS

Hydraulic roughness in the TUFLOW model is represented by Manning's 'n' roughness coefficients. Manning's 'n' values for the various waterway channel types were selected based on typical published values (such as those in Chow (1959)). Landuses and waterway channel types within the model were identified using aerial photography supplied by LCC.

Based on the 2013 and 2016 aerial photographs supplied by LCC, there were no significant differences in landuses within the Slack and Scrubby creeks catchment between the three calibration events (2013, 2015 and 2017). Therefore, the mapping of landuses and waterway channel types are the same for all three calibration events.

The adopted hydraulic roughness (Manning's n) values for the variety of landuses and waterway channel types in the hydraulic model are given in Table 6.1. The distribution of hydraulic roughness (Manning's) in the TUFLOW model is shown in Figure 6.2.

Table 6.1 – Adopted hydraulic roughness coefficients

Landuse / waterway channel type	Manning's 'n' roughness coefficient
Open space, some sporadic trees	0.045
Rural areas	0.055
Low density residential	0.200
Medium density residential	0.250
High density residential	0.300
Dense bush	0.090
Medium density bush	0.060
Dense bushland in Scrubby Creek wetlands	0.120
Upper-catchment watercourse	0.065
Industrial	0.300
Lower river, open surface areas	0.025
Road, concrete channel	0.025
Very dense bushland in Scrubby Creek wetlands	0.150
Waterway in channel - lightly vegetated	0.035
Waterway in channel - moderately vegetated	0.050
Waterway in channel - heavily vegetated	0.070
Pipe crossings, small pedestrian bridges	0.200

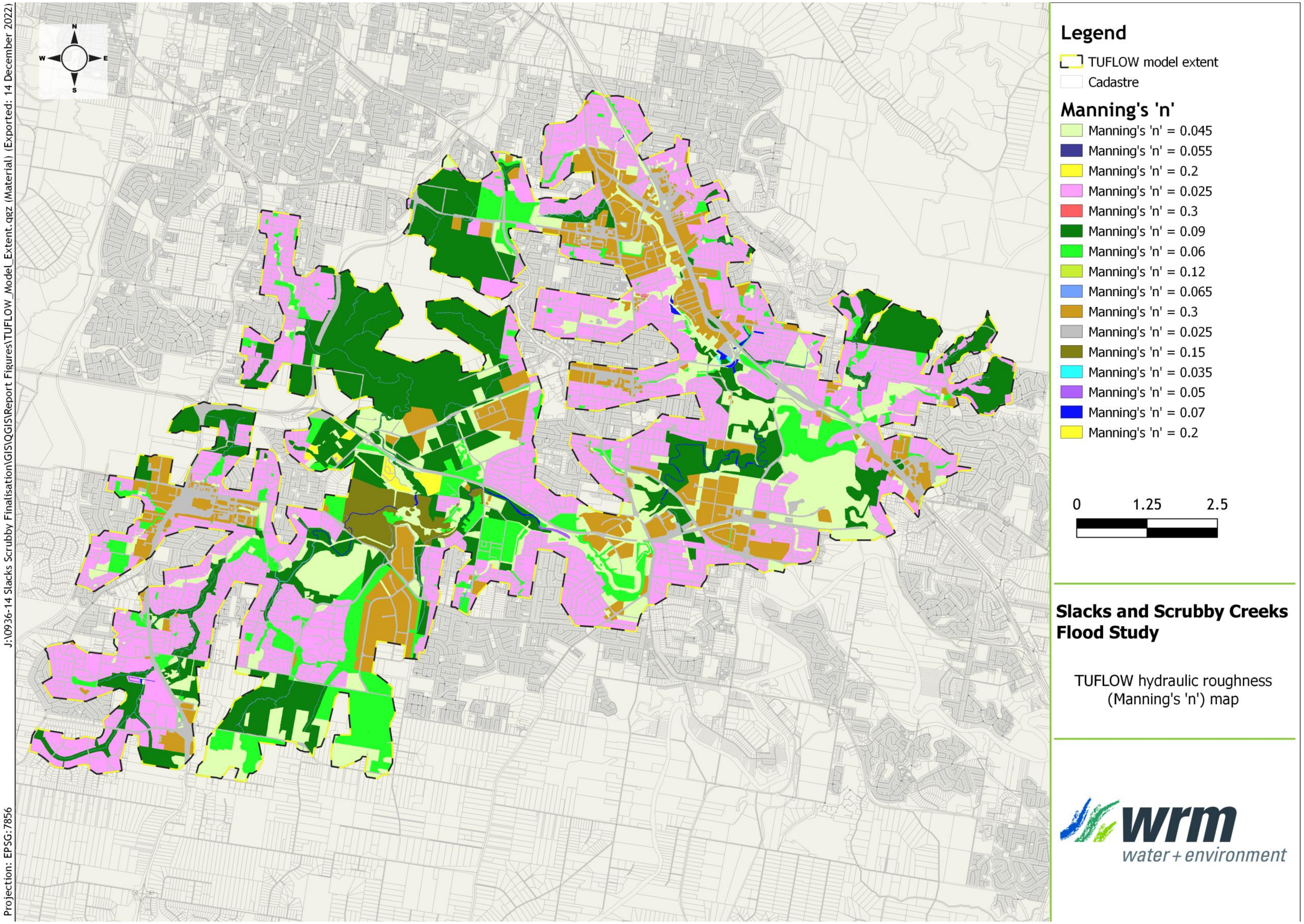

Figure 6.2 – TUFLOW hydraulic roughness (Manning's 'n') map

6.6 HYDRAULIC STRUCTURES

6.6.1 Overview

A summary of all hydraulic structures included in the hydraulic model is as follows:

- 778 stormwater culverts and trunk stormwater pipes, made up of:
  - 172 box culverts;
  - 144 pipe culverts; and
  - 462 trunk stormwater pipes.
- 545 stormwater inlet pits, made up of:
  - 509 side entry inlet pits; and
  - 36 grated field inlet pits.
- 34 manually created stormwater manholes.
- 28 bridge structures, including three major box culverts represented as bridges.

The locations of these structures are shown in Figure C.1 to Figure C.6 in Appendix C. Details of these hydraulic structures are shown in Table C.1 to Table C.5 in Appendix C.

6.6.2 Stormwater culverts and trunk stormwater pipes

Table C.1 and Table C.2 in Appendix C show details of all cross-drainage culvert structures and trunk stormwater drainage structures respectively included in the hydraulic model. Table C.1 and Table C.2 also show the information sources used to configure each structure. It is of note that some culverts were configured based on multiple sources of information.

Culverts in the TUFLOW model were modelled as 1D structures embedded within the 2D model domain. No culvert blockages were applied to the calibration and validation scenarios of the model, however design blockage was included for design event modelling (refer Section 9.2.2). The following is of note with regards to the configuration of stormwater culverts and trunk stormwater pipes:

- For areas in the vicinity of the M1 Motorway (Pacific Highway), details of stormwater culverts and trunk stormwater pipes were obtained from the M1 Motorway hydraulic model. The configuration of some of these structures were updated with information provided in the LCC hydraulic structures survey where available.
- For some areas in the upper catchment of Scrubby Creek in the vicinity of Fern Street and Johnson Road (Browns Plains), details of stormwater culverts and trunk stormwater pipes were initially obtained from the Engeny (2013) hydraulic model. The configuration of some of these structures were updated with information provided in the LCC hydraulic structures survey where available.
- For stormwater culverts and trunk stormwater pipes that were not included in the WRM (2017) and Engeny (2013) studies, these structures were configured as follows:
  - Stormwater pipe and box culvert details were generally obtained from the LCC hydraulic structures survey where data is available. Where survey data is not available, details of stormwater pipe and box culverts were obtained from the LCC hydraulic structures database.
  - Some stormwater pipe and box culvert invert levels were missing from the LCC hydraulic structures database. For these structures, invert levels were obtained from the LCC 2017 and BCC 2017 LiDAR data.
  - Data from the LCC hydraulic structures survey and the LCC hydraulic structures database were verified against measurements taken during the site visit by

WRM. Culvert dimensions obtained from the WRM site visit were adopted for some box culverts where link slabs were not accounted for in the supplied data.

  - Trunk stormwater pipes were generally configured based on information in the LCC hydraulic structures database. Where pipe invert levels are not available in the LCC hydraulic structures database, invert levels were interpolated based on the known invert levels of upstream and downstream connecting pipes.

6.6.3 Stormwater inlet pits

Table C.3 in Appendix C shows details of all stormwater inlet pits included in the hydraulic model. Table C.3 also shows the information sources used to configure each stormwater inlet pit.

Stormwater inlet pits were modelled as 1D structures embedded within the 2D model domain. The following is of note with regards to the configuration of stormwater inlet pits:

- Stormwater inlet pits included in the M1 Motorway (WRM, 2017) and the Engeny (2013) hydraulic models were incorporated to the Slacks and Scrubby creeks TUFLOW model.
- The majority of stormwater inlet pits in the model were configured as follows:
  - Stormwater inlet pits were generally configured based on information provided in the LCC hydraulic structures database, and supplemented with the LCC hydraulic structures survey data.
  - The model only includes stormwater inlet pits located adjacent to the modelled trunk stormwater drainage pipes. The model also does not include the majority of small pipes connecting the inlet pits to the main trunk drainage pipes. Instead, the “pit search distance” TUFLOW feature was adopted based on a search radius of 40 m. Using this approach, stormwater inlet pits located within a 40 m radius of a 1D stormwater pipe node are automatically connected to the stormwater pipe network. This allows water to flow between the 2D domain and the 1D stormwater pipes via the stormwater inlet pits.
  - Side entry inlet pits were classified as either “S” (small), “M” (medium) or “L” (large) lintel inlet pits. The stage-discharge relationships for these lintel inlet pits were obtained from standard BCC pit curves.
  - Grated field inlet pits were classified based on their grate dimensions, which ranges from 0.9 m x 0.6 m to 3.6 m x 1.2 m. The stage-discharge relationships for these inlet pits were derived using the weir and orifice flow equations.
  - To ensure that overland flows are captured in the inlet pits, the pit surface levels were obtained from the LCC 2017 and BCC 2017 LiDAR data (the base model topography). Pit invert levels were obtained from the LCC hydraulic structures database where data is available. Where pit invert levels are not available in the LCC hydraulic structures database, a pit depth of 1.2 m was assumed (i.e. the pit invert level is 1.2 m below the pit surface level).

6.6.4 Stormwater manholes

Due to the extensive trunk stormwater drainage network included in the model, the “automatic manholes” feature in TUFLOW was used. Using this approach, manholes are automatically generated at each pipe junction in the TUFLOW model.

For some major pipe junctions, such as the junctions of three or more pipes or box culverts, manholes were manually created within the 1D model domain using TUFLOW “1D_mh” objects. Details of manually created culverts were obtained from the LCC hydraulics structures database and the LCC hydraulic structures survey. Where details are not available from the supplied data, manhole dimensions were assumed based on the total widths of all connecting pipes.

Table C.4 in Appendix C shows details of all manually created stormwater manholes included in the hydraulic model. Table C.4 also shows the information sources used to configure each stormwater manhole. This report does not provide details of automatically generated manholes in the TUFLOW model.

6.6.5 Bridges

Table C.5 in Appendix C shows details of all bridges included in the hydraulic model. Table C.5 also shows the information sources used to configure each bridge.

Bridges in the TUFLOW model were modelled as "layered flow constrictions". Using this approach, bridges are modelled as partial blockages to incoming flows. Blockages were determined as percentages based on the configuration of bridge piers, deck and guard rails of each bridge.

The percentage blockage due to the bridge piers range between 0% and 5% depending on the bridge pier configuration. Bridge decks were considered as full blockages (100% blockage). Solid road barriers were also considered as full blockages (100% blockage), while guard rails were considered as partial blockages. The adopted percentage blockage for guard rails range from 20% to 50% depending on the guard rail configuration at each bridge.

Bridges in the TUFLOW model were configured based on as-constructed drawings and photos supplied by LCC. For bridges with no available as-constructed drawings, bridge details were obtained from hydraulic models developed from previous studies.

6.7 TAILWATER LEVELS

6.7.1 Overview

The primary outflow boundary of the hydraulic model is located in Slacks Creek approximately 220 m downstream of the Logan Motorway Bridge and approximately 290 m upstream of the confluence with the Logan River. There is no stream gauge at the TUFLOW model's downstream boundary location. Therefore, the adopted historical tailwater levels were derived based on the following methodology:

- For the May 2015 and March 2017 events:
  - A cut-down version of the Logan River hydraulic model (WRM, 2014a) was developed that extends between the Waterford AL (GS 040878) and Parklands AL (GS 540645) stream gauges (see Figure 1.1 for the stream gauge locations).
  - The cut-down model used recorded water levels at the Parklands AL and Waterford AL gauges as upstream and downstream boundary conditions respectively. The model was then used to derive tailwater hydrographs for use as the primary outflow boundary of the Slacks and Scrubby creeks TUFLOW model for the May 2015 and March 2017 events.
- For the January 2013 event, there is no recorded data at the Parklands AL gauge. However, the Logan River hydraulic model (WRM, 2014a) was calibrated to the January 2013 event. Therefore, the tailwater hydrograph for the January 2013 event was extracted from Logan River hydraulic model results (WRM, 2014a).
- For the February 2022 event, the Logan-Albert River hydraulic model (WRM, 2022) was used to extract the water level hydrograph at the Logan Motorway at Slacks Creek.

6.7.2 Development of the TUFLOW model for tailwater level estimation

Figure 6.3 shows the configuration of the cut-down TUFLOW model of the Logan River. The model covers an area of 45 km^2 and includes the lower floodplains of Slacks and Scrubby creeks. The model extends between the Parklands AL and Waterford AL gauges in the Logan River, up to Third Avenue in Scrubby Creek and up to Moss Street in Slacks Creek.

The model was configured with grid cell size of 10 m and was run using the TUFLOW Build 2017-09-AC HPC-GPU solver. The base model topography was based on LiDAR and bathymetric survey undertaken in 2013 and supplied by LCC as part of the WRM (2014b) study. Z-shapes used to improve the representation of creek inverts in the WRM (2014b) hydraulic model were incorporated to the cut-down model.

The upstream model boundary is located at the Waterford AL gauge, and the downstream model boundary is located at the Parklands AL gauge. Recorded water level hydrographs at the Waterford AL and Parklands AL gauges were adopted at the upstream and downstream boundaries respectively for the May 2015 and March 2017 events. The model has no other inflow and outflow boundaries, hence local catchment inflows from the Slacks Creek catchment were not modelled.

The Albert Street Bridge in the Logan River (just downstream of the Waterford AL gauge) was included in the model, however no other hydraulic structures were included. Culverts were simulated by using z-shapes to create gaps in the road embankments at some culvert crossing locations, allowing backwater to propagate into key flood storage areas.

Hydraulic roughness coefficients (Manning's 'n') and the mapping of landuse types in the cut-down model were obtained from the Logan River TUFLOW model (WRM, 2014a).

6.7.3 January 2013 event

Tailwater levels for the January 2013 event were extracted from the Logan River TUFLOW model results (WRM, 2014a). However, there were no results available from the Logan River model prior to 08:00am on 27 January 2013. In addition, there is some uncertainty in the Logan River model results between 08:00am and 04:00pm on 27 January 2013.

Based on expected water level behaviour in the downstream end of the Slacks Creek model, the recorded water levels at Waterford up to 04:00pm on 27 January 2013 were adopted as the model tailwater condition, combined with water levels extracted from the Logan River model results after 04:00pm on 27 January 2013 onwards. The timing of recorded water levels at Waterford was adjusted slightly based on the distance between the Waterford AL gauge and the Logan River confluence with Slacks Creek.

Figure 6.4 compares recorded water levels at the Waterford AL and Loganlea Road AL gauges with the adopted tailwater levels for the Slacks Creek TUFLOW model.

6.7.4 May 2015

The cut-down model of the Logan River was used to derive tailwater levels in the downstream end of the Slacks Creek TUFLOW model for the May 2015 event. Figure 6.5 compares recorded water levels at the Waterford AL, Parklands AL and Loganlea Road AL gauges with the adopted tailwater levels for the Slacks Creek TUFLOW model.

6.7.5 March 2017

The cut-down model of the Logan River was used to derive tailwater levels in the downstream end of the Slacks Creek TUFLOW model for the March 2017 event. Figure 6.6 compares recorded water levels at the Waterford AL, Parklands AL and Loganlea Road AL gauges with the adopted tailwater levels for the Slacks Creek TUFLOW model.

6.7.6 February 2022

The Logan-Albert River model was used to derive tailwater levels in the downstream end of the Slacks Creek TUFLOW model for the February 2022 event. Figure 6.7 compares recorded water levels at the Waterford AL, Parklands AL and Loganlea Road AL gauges with the adopted tailwater levels for the Slacks Creek TUFLOW model.

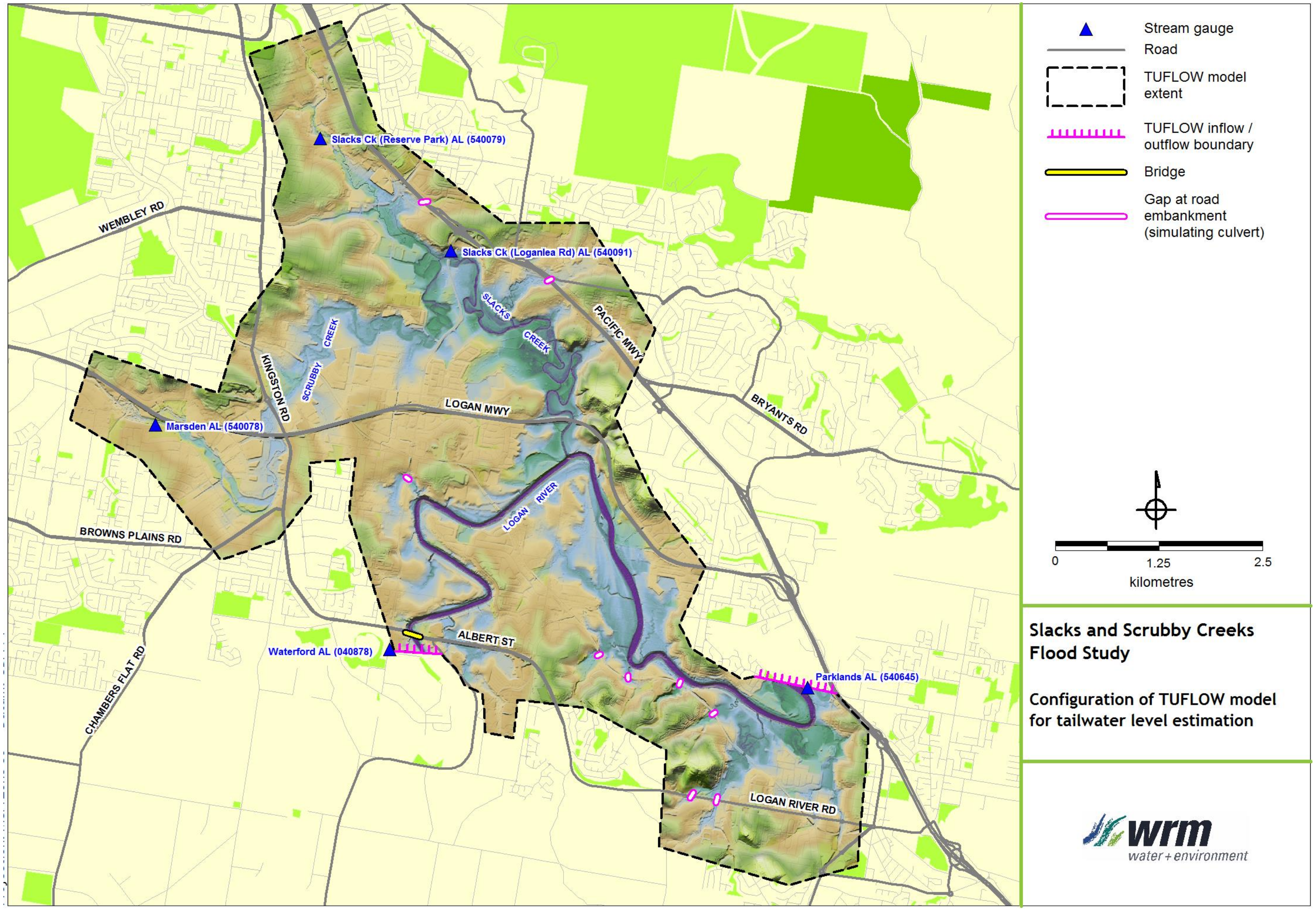

Figure 6.3 – Configuration of the cut-down TUFLOW model of the Logan River for tailwater level estimation

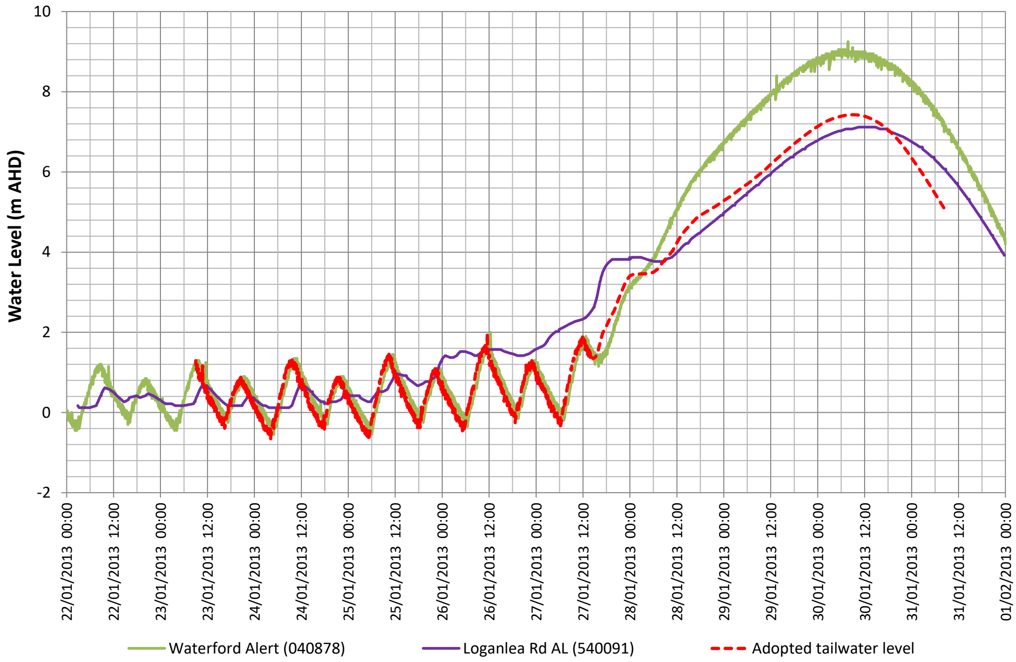

Figure 6.4 – Adopted tailwater level at the primary outflow boundary of the Slacks and Scrubby creeks TUFLOW model, January 2013 flood event

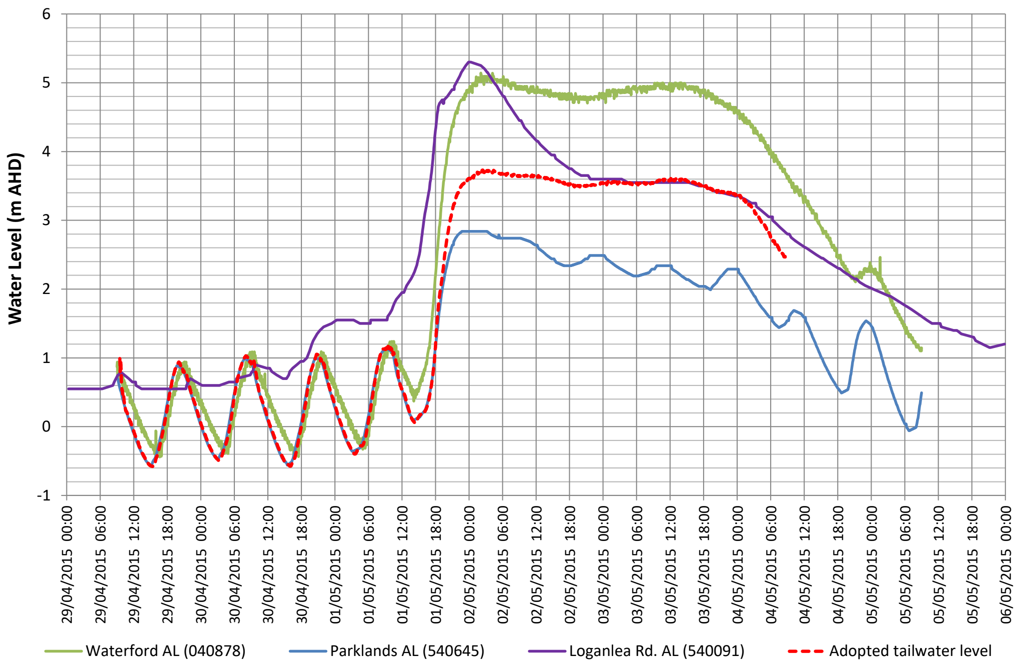

Figure 6.5 – Adopted tailwater level at the primary outflow boundary of the Slacks and Scrubby creeks TUFLOW model, May 2015 flood event

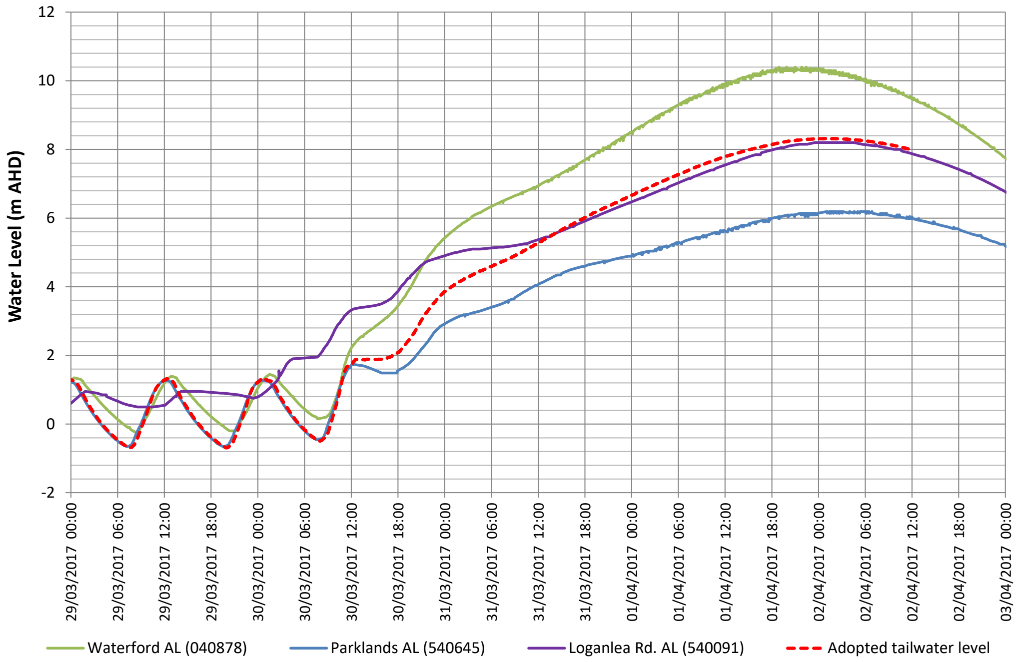

Figure 6.6 – Adopted tailwater level at the primary outflow boundary of the Slacks and Scrubby creeks TUFLOW model, March 2017 flood event

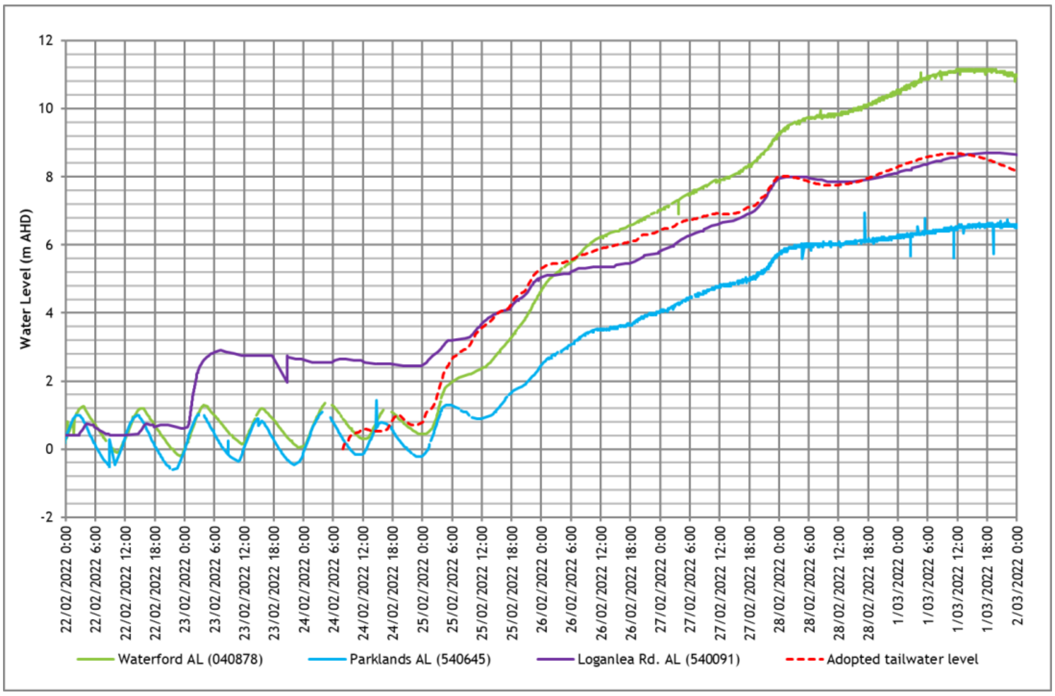

Figure 6.7 – Adopted tailwater level at the primary outflow boundary of the Slacks and Scrubby creeks TUFLOW model, February 2022 flood event

7 Joint calibration of hydrologic and hydraulic models

7.1 METHODOLOGY

Inflow hydrographs for the January 2013, May 2015, March 2017 and February 2022 events were generated from the XP-RAFTS hydrologic model, and used as input to the TUFLOW hydraulic model. The hydraulic model results were then compared with recorded water level hydrographs from the available stream gauges, as well as recorded peak flood levels from the available MHGs for all three events. The hydraulic model results for the May 2015, March 2017 and February 2022 events were also compared with surveyed debris marks throughout the Slacks Creek catchment. This approach allows the suitability of the discharges estimated by the hydrologic model to be confirmed, as well as testing the performance of the hydraulic model in the lower reaches of Slacks Creek.

7.2 JANUARY 2013 EVENT

7.2.1 Comparison of predicted and recorded water level hydrographs

The hydraulic model results for the January 2013 event were compared with recorded water level hydrographs at Marsden, Reserve Park and Loganlea Road.

Table 7.1 summarises the recorded peak water levels at the above locations, and compares them with peak water levels estimated by the hydraulic model. Figure 7.1, Figure 7.2 and Figure 7.3 show the recorded and predicted water level hydrographs at Marsden, Reserve Park and Loganlea Road.

The following is of note with regards to the comparison between the predicted and recorded water level hydrographs:

- At the Marsden gauge:
    - The hydraulic model accurately matches the recorded hydrograph shape and timing, but slightly overestimates the peak water level. This is likely due to the peak discharge being overestimated (as shown in in the XP-RAFTS hydrologic model results for this gauge in Section 5.6).
    - The January 2013 event is considered a small event, and the variation in rainfall across the catchment may not have been represented adequately at the available rainfall stations. Based on the available rainfall data, the XP-RAFTS hydrologic model could not produce a lower peak discharge at the Marsden gauge without adopting unreasonable model parameters in the XP-RAFTS hydrologic model.
    - Furthermore, the model slightly underestimates peak flood levels at some locations in the upper catchment of Scrubby Creek (see Section 7.2.2) based on comparisons with recorded water levels at MHGs, even though the model overestimates the peak flood level at the Marsden gauge. Therefore, the calibration at the Marsden gauge for the January 2013 event is considered acceptable when comparing all available data.
- At the Reserve Park gauge, the hydraulic model accurately matches the recorded hydrograph shape and timing, while only slightly overestimating peak the water level by 0.17 m.
- At the Loganlea Road gauge:
    - The hydraulic model matches the hydrograph shape and timing. The model also accurately matched recorded water levels from the start to the middle of the

simulation period, but slightly overestimates water levels at the end of the simulation period.

- Water levels at the Loganlea Road gauge are influenced by Logan River water levels, which were extracted from the Logan River model (WRM, 2014a) results. The difference in water levels between the middle and end of the simulation period is likely due to the Logan River model slightly overestimating water levels in the Logan River in the vicinity of the Slacks Creek confluence during this period.
- The peak water level at the Loganlea Road gauge during the January 2013 event was due to Logan River backwater, and had not been reached within the adopted model simulation period. Therefore, a comparison could not be made with the recorded peak water level at Loganlea Road. However, the model appears to predict water levels satisfactorily for the simulation period.

Table 7.1 - Predicted and recorded peak water levels at Marsden, Reserve Park and Loganlea Road gauging stations, January 2013 flood event

Station No.	Station name	Watercourse	Peak water level (mAHD)		Difference (m)
			Recorded	Predicted	
540078	Marsden AL	Scrubby Creek	9.55	9.83	0.28
540078	Reserve Park AL	Slacks Creek	9.05	9.24	0.17
540091	Loganlea Road	Slacks Creek	7.12	n/a [a]	n/a [a]

[a] - Peak water level at Loganlea Road due to Logan River backwater was not reached within the model simulation period.

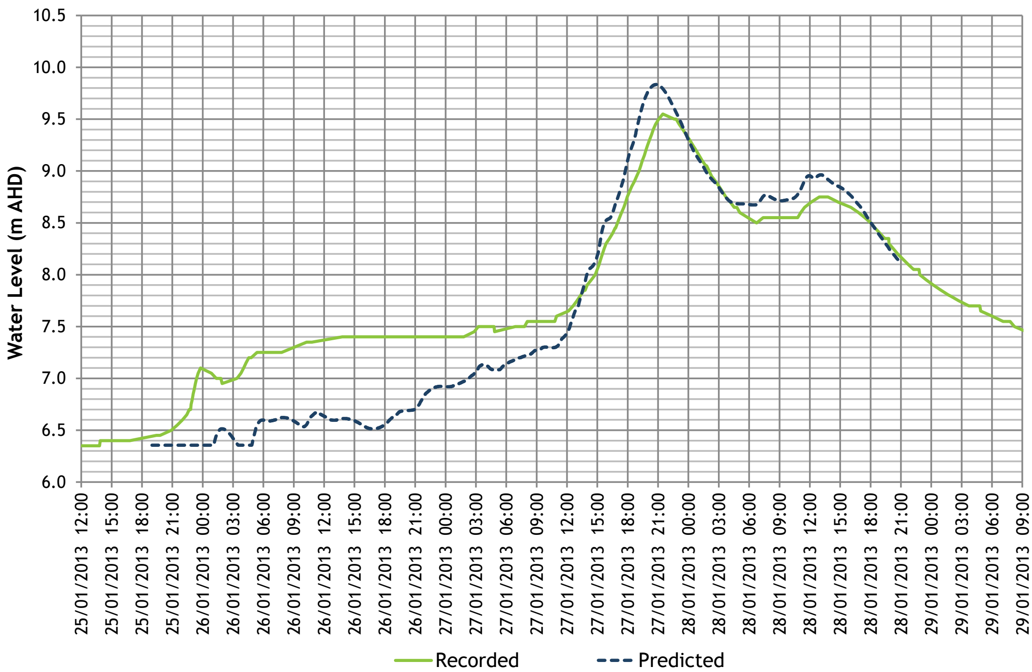

Figure 7.1 - Predicted and recorded water levels in Scrubby Creek at Marsden (GS 540078), January 2013 flood event

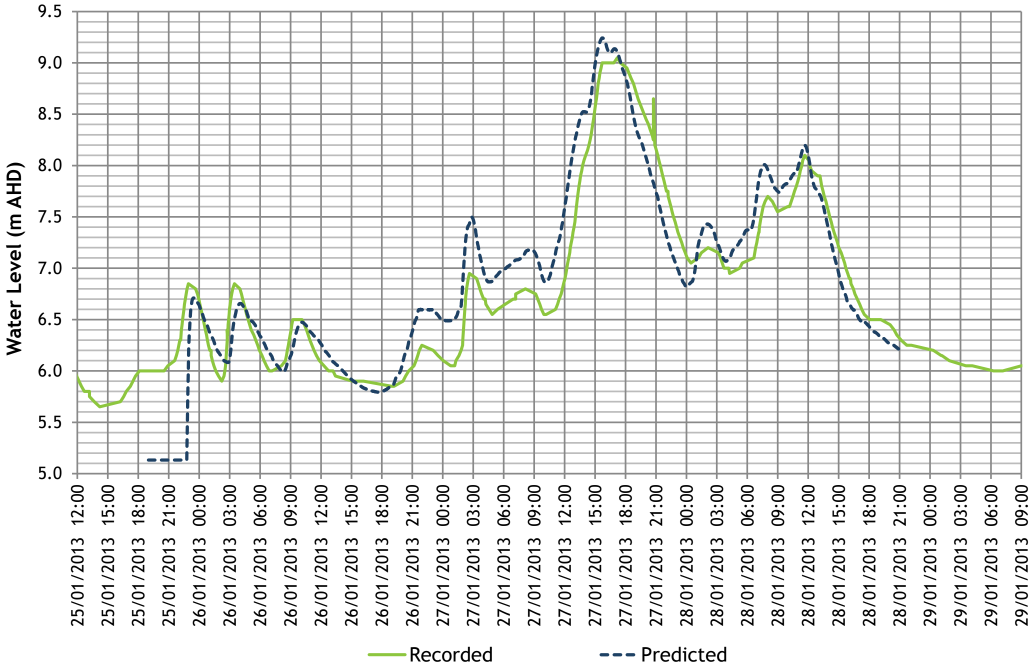

Figure 7.2 - Predicted and recorded water levels in Slacks Creek at Reserve Park (GS 540079), January 2013 flood event

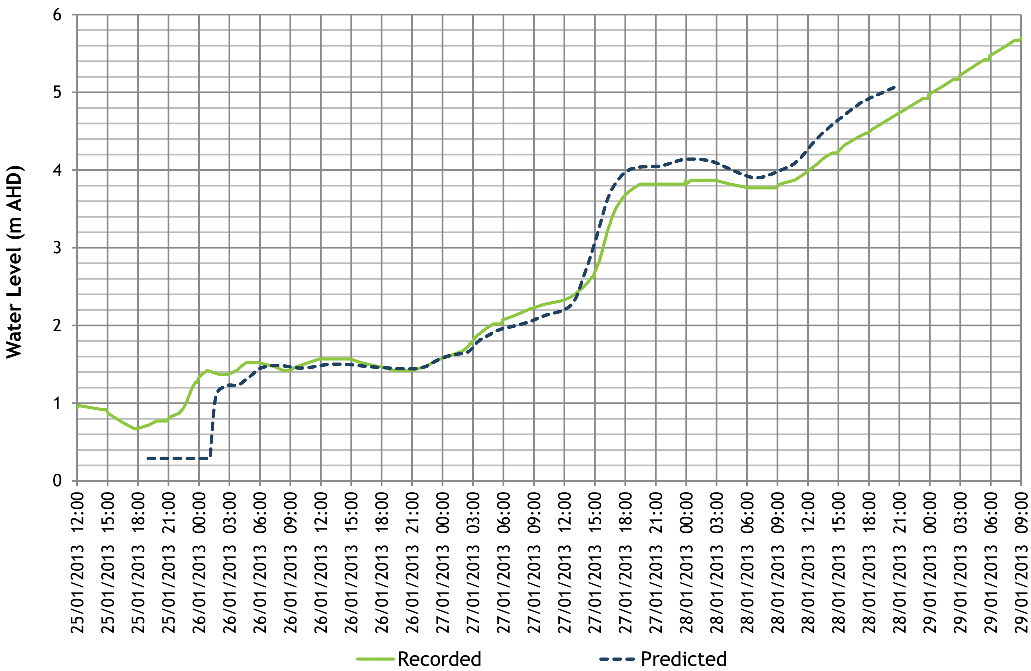

Figure 7.3 - Predicted and recorded water levels in Slacks Creek at Loganlea Road (GS 540091), January 2013 flood event

7.2.2 Comparison of predicted and recorded peak flood levels at maximum height gauges

The hydraulic model results were also compared with recorded peak flood levels at the MHGs in the northern tributaries of Scrubby Creek (see Figure 3.15 for locations). Table 7.2 summarises the recorded peak water levels at these MHGs for the January 2013 event, and compares them with peak water levels predicted by the hydraulic model.

The following is of note with regards to the comparison between the predicted and recorded peak flood levels at the MHGs:

- At the Scrubby Creek tributary upstream of Gowan Road (MHG #220 and #230), the calibration is good, with predicted peak flood levels within 0.13 m of recorded peak flood levels.
- At the Scrubby Creek tributary upstream of Gilmore Road (MHG #100) and Wembley Road (MHG #110), the calibration is considered acceptable, with predicted peak flood levels within 0.26 m of recorded peak flood levels.
- At the Scrubby Creek tributary upstream of Garfield Road (MHG #120), the predicted peak flood level is 0.4 m lower than the recorded peak flood level. This may be due to higher localised rainfalls not being represented in the hydrologic model. It may also be due to blockage in the downstream culvert during this event, which would cause elevated peak water levels at this gauge.

The results show that for the January 2013 event, the hydraulic model slightly underestimates peak water levels at some locations in the upper Scrubby Creek catchment (MHGs #100, #110 and #120). However, at the Marsden gauge (located downstream of all MHGs) (see Figure 7.2), the model slightly overestimates the peak water level. Therefore, the overall calibration result for the January 2013 event is considered acceptable based on a compromise between all available data.

Table 7.2 - Predicted and recorded peak water levels at maximum height gauges in the northern tributaries of Scrubby Creek, January 2013 flood event

Gauge Name	Easting	Northing	Peak flood level (mAHD)		Difference (m)
			Recorded	Predicted	
100	508,634	6,941,340	15.88	15.62	-0.26
110	509,067	6,942,009	21.89	21.71	-0.18
120	509,361	6,942,687	26.43	26.02	-0.41
210	506,921	6,942,563	- [a]	27.27	- [a]
220	505,726	6,943,623	35.81	35.94	0.13
230	505,393	6,944,433	40.63	40.72	0.09

[a] - No recorded data available.

7.3 MAY 2015 EVENT

7.3.1 Comparison of predicted and recorded water level hydrographs

Results from the hydraulic model for the May 2015 event were compared with recorded water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road. Table 7.3 summarises the recorded peak water levels at the above locations, and compares them with peak water levels predicted by the hydraulic model. Figure 7.4, Figure 7.5, Figure 7.6 and Figure 7.7 show the recorded and predicted water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road.

The following is of note with regards to the comparison between the predicted and recorded water level hydrographs:

- At the Waller Road gauge, the calibration is good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water level.
- At the Marsden gauge, the hydraulic model accurately matches the recorded hydrograph shape, but slightly overestimates the peak flood level. The predicted peak water level occurs slightly earlier than the recorded peak (by approximately 15 minutes), which is considered acceptable.
- At the Reserve Park gauge, the calibration is good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water level.
- At the Loganlea Road gauge, the calibration is good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water levels.

Table 7.3 - Predicted and recorded peak water levels at Waller Road, Marsden, Reserve Park and Loganlea Road gauging stations, May 2015 flood event

Station No.	Station name	Watercourse	Peak water level (mAHD)		Difference (m)
			Recorded	Predicted	
540692	Waller Road AL	Scrubby Creek	24.12	24.19	0.07
540078	Marsden AL	Scrubby Creek	11.50	11.72	0.22
540078	Reserve Park AL	Slacks Creek	10.50	10.54	0.04
540091	Loganlea Road	Slacks Creek	5.30	5.39	0.09

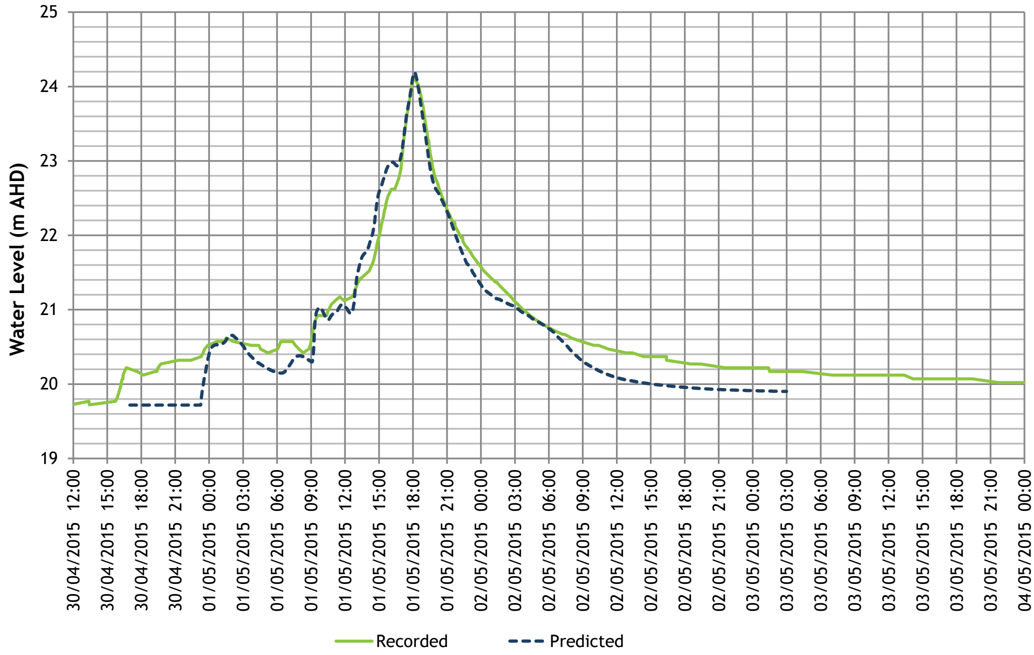

Figure 7.4 – Predicted and recorded water levels in Scrubby Creek at Waller Road (GS 540692), May 2015 flood event

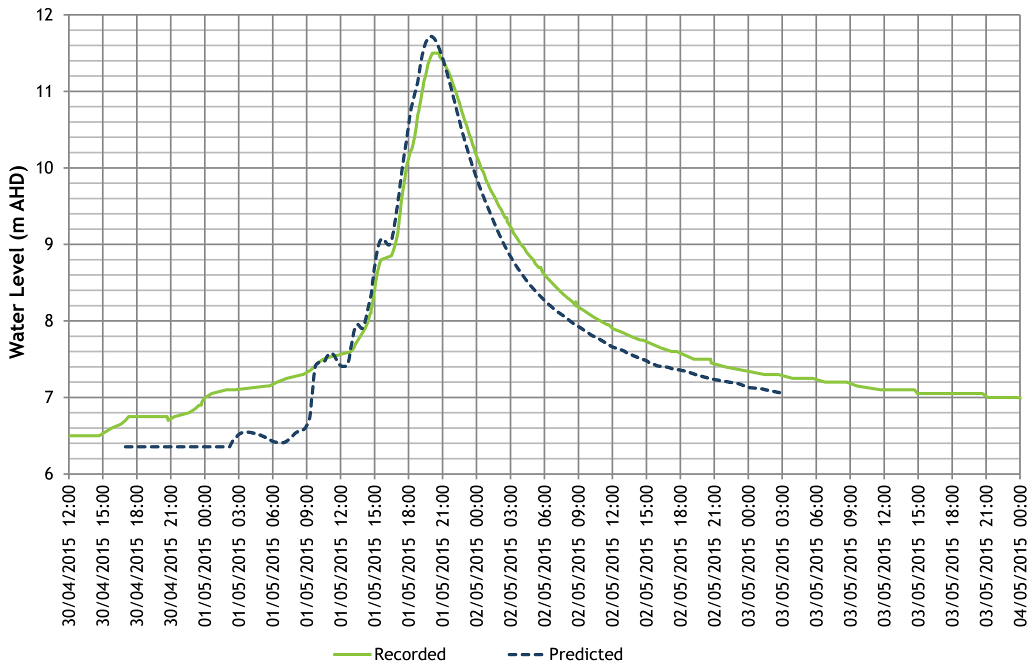

Figure 7.5 – Predicted and recorded water levels in Scrubby Creek at Marsden (GS 540078), May 2015 flood event

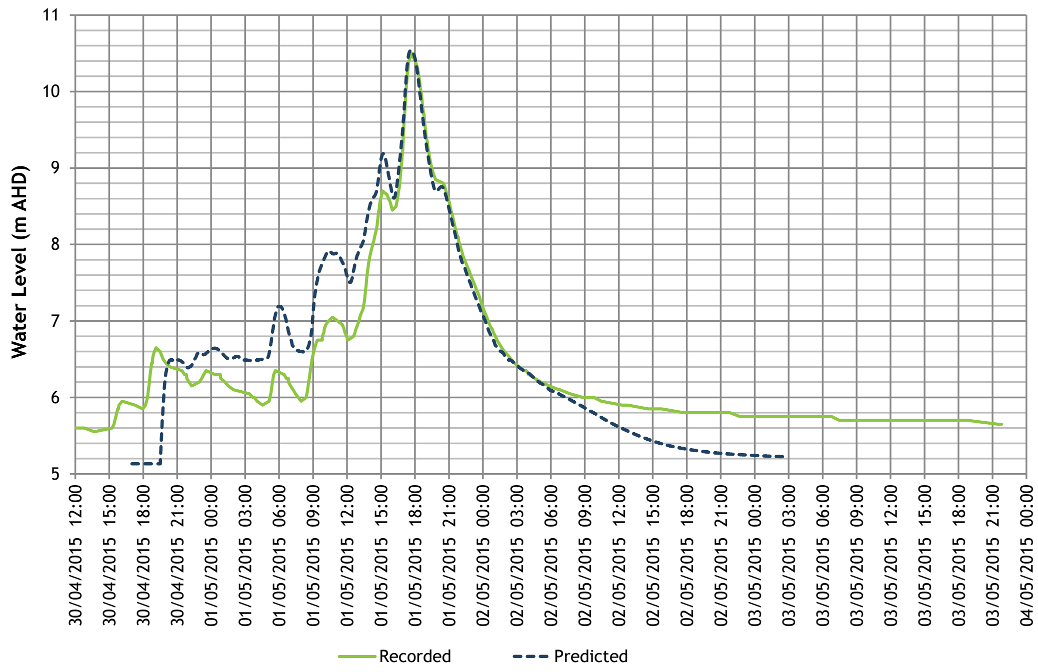

Figure 7.6 – Predicted and recorded water levels in Slacks Creek at Reserve Park (GS 540079), May 2015 flood event

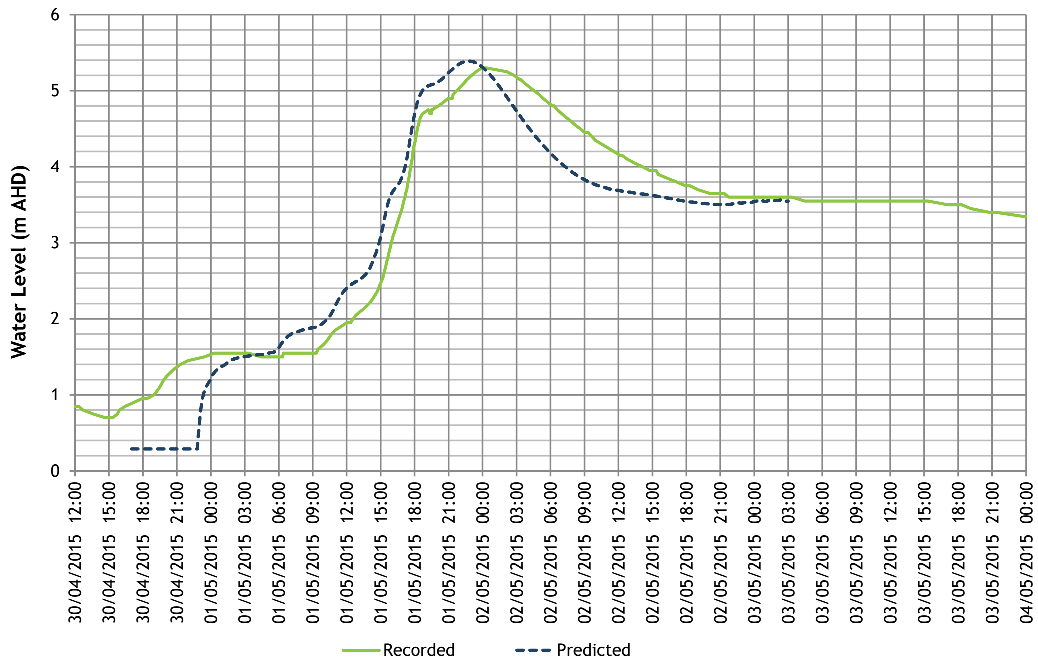

Figure 7.7 – Predicted and recorded water levels in Slacks Creek at Loganlea Road (GS 540091), May 2015 flood event

7.3.2 Comparison of predicted and recorded peak flood levels at maximum height gauges

The hydraulic model results were also compared with recorded peak flood levels at from the MHGs in the northern tributaries of Scrubby Creek (see Figure 3.15 for locations). Table 7.4 summarises the recorded peak water levels at these MHGs for the May 2015 event, and compares them with peak water levels predicted by the hydraulic model.

The following is of note with regards to the comparison between the predicted and recorded peak flood levels at the MHGs:

- At the Scrubby Creek tributary upstream of Gilmore Road (MHG #100), Wembley Road (MHG #110) and Garfield Road (MHG #120), the calibration is good, with predicted peak flood levels within 0.16 m of recorded peak flood levels.
- At the Scrubby Creek tributary near Illawena Street Road (MHG #210), upstream of Gowan Road (MHG #220), the calibration is good, with predicted peak flood levels within 0.12 m of recorded peak flood levels.
- At the Scrubby Creek tributary upstream of Kameruka Street (MHG #230), the predicted peak flood level is 0.85 m higher than the recorded peak flood level. The reason for the model overestimating the peak water level at MHG #230 is unknown. However, the model accurately matched the recorded peak water levels at the two MHGs immediately downstream (MHGs #220 and #210).

Table 7.4 - Predicted and recorded peak water levels at maximum height gauges in the northern tributaries of Scrubby Creek, May 2015 flood event

Gauge Name	Easting	Northing	Peak flood level (mAHD)		Difference (m)
			Recorded	Predicted	
100	508,634	6,941,340	16.67	16.82	0.16
110	509,067	6,942,009	22.20	22.22	0.02
120	509,361	6,942,687	26.75	26.68	-0.07
210	506,921	6,942,563	27.64	27.63	-0.01
220	505,726	6,943,623	36.71	36.83	0.12
230	505,393	6,944,433	40.71	41.56	0.85

7.3.3 Comparison of predicted peak flood levels with surveyed debris marks

A total of 64 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the May 2015 flood event. Of these, five were surveyed levels of permanent survey marks (PSM) and were not included for comparison with predicted flood levels.

Figure 7.8 shows the locations of the surveyed debris marks for the May 2015 event. Figure 7.8 also shows the predicted peak flood extent for the May 2015 event. Table 7.5 compares predicted peak flood levels for the May 2015 event with the surveyed debris marks. The accuracy of surveyed flood levels is not known. Based on previous experience, debris mark surveys are generally accurate to about ±0.3 m.

7.3.3.1 Scrubby Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Scrubby Creek floodplain (marks #11 to #69):

- In Scrubby Creek upstream of Third Avenue (marks #11 to #16), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.

- In the vicinity of the Marsden flood gauge (marks #17 to #22), the calibration is considered good, with predicted peak flood levels within 0.15 m of the surveyed flood levels.
- At the residential areas along Princess Street and Kurrajong Drive south of the Scrubby Creek channel (marks #23 to #31), the model accurately matched the surveyed flood levels (within 0.08 m).
- At the industrial areas west of Kingston Road and upstream of the Logan Motorway (marks #32 to #34), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.
- Between Kingston road and the railway (marks #35 to #38), the model overestimates peak flood levels by up to 0.34 m at #35, #36 and #38, but only by 0.15 m at #37. Mark #37 (debris on fence) was considered a more accurate representation of the peak flood level compared to marks #35, #36 and #38 (debris on ground). On this basis, the calibration at this location is considered acceptable.
- In the tributary west of the Kingston railway station (marks #40 and #41), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.
- In the vicinity of the Queens Road crossing (marks #68 and #69), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.

7.3.3.2 Slacks Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Slacks Creek floodplain (marks #42 to #78):

- In the tributary upstream of the Kingston Road and Parramatta Road intersection (marks #42 and #43), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.
- Between Parramatta Road and Moss Street (marks #44, #45, #46 and #47):
  - The model overestimates peak flood levels by up to 0.62 m. The Slacks Creek floodplain between Kingston Road and Moss Street is bounded by commercial buildings, some of which include solid vertical walls along the edge of the floodplain. The model results indicate that peak flood levels were higher than the ground levels adjacent to these walls. It is possible that debris #44, #45, #46 and #47 (debris on ground) may have settled at the base of the vertical walls after the flood had receded, resulting in the surveyed flood levels being much lower than the actual peak flood levels during the event.
  - In addition, the model accurately matched the surveyed peak flood levels immediately upstream at Kingston Road (#43), downstream at Park Road (#48) and at the Reserve Park gauge. On this basis, the model is considered to be predicting flood levels adequately in between Parramatta Road and Moss Street.
- In Slacks Creek at Park Road (mark #48), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.
- In the vicinity of the Reserve Park flood gauge (marks #50 and #51), the model accurately matched the surveyed flood levels (within 0.06 m). This is consistent with the results at the Reserve Park gauge shown in Figure 7.6.
- In the tributary north of and parallel to Shortland Street (marks #52 and #53), the model accurately matched the surveyed flood levels (within 0.06 m).
- In the tributary upstream of Rebecca Way (marks #49, #54 and #55), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.

- In the tributary upstream of Meakin Road (marks #57 to 59), the model accurately matched the surveyed flood levels (within 0.04 m).
- In Slacks Creek at Paradise Road (marks #60 to #63):
    - The calibration is considered good, with predicted peak flood levels within 0.3 m of the surveyed flood levels at marks #60, #61 and #63. The surveyed flood level at mark #62 was considered inaccurate as it is about 0.9 m higher than at the nearby marks #60 and 61.
    - The model results indicate that Paradise Road was not overtopped during the May 2015 event. This is consistent with the surveyed flood levels along the Paradise Road crossing.
- In Slacks Creek upstream of Paradise Road and IKEA (mark #64):
    - The model underestimated the peak flood level by 0.33 m. Debris #64 was located on a fence, therefore the difference in peak water levels may be due to the fence not being included in the model. Inclusion of the fence at this location is likely to add some flow blockage, resulting in higher water levels immediately upstream of the fence.
    - The model accurately matched the surveyed flood levels immediately upstream of mark #64 at the Reserve Park gauge (marks #50 and #51) and downstream at Paradise Road (marks #60 to #63). On this basis, the model is considered to be predicting flood levels adequately in the vicinity of mark #64.
- In Slacks Creek between Meakin Road and Valencia Way (marks #65 and #66), the calibration is considered good, with predicted peak flood levels within 0.2 m of the surveyed flood levels.
- Downstream of Loganlea Road (marks #71 to #78):
    - The calibration is considered acceptable, with predicted flood levels within 0.3 m of the surveyed flood levels, except at mark #72. The reason for the difference in peak water levels at mark #72 is unknown.
    - Flood levels downstream of Loganlea Road are controlled by Logan River backwater flooding. A good match was achieved between predicted and recorded flood levels at the Loganlea Road gauge (see Figure 7.7). On this basis, the model is considered to be predicting flood levels adequately at downstream of Loganlea Road.

Table 7.5 - Comparison of predicted peak water levels with surveyed debris marks in the Slacks and Scrubby creeks floodplains, May 2015 flood event

Debris mark	Easting	Northing	Surveyed flood level (mAHD)	Comments	Modelled peak flood level (mAHD)	Difference (m)
11	509,058	6,940,899	15.03	Debris on grass bank	14.95	-0.08
12	509,054	6,940,385	13.63	PSM [a]	-	-
13	509,062	6,940,443	14.60	Debris on ground	14.76	0.16
14	509,025	6,940,470	14.68	Debris on bridge wall	14.80	0.12
15	508,723	6,940,225	15.02	Debris on fence	15.14	0.13
16	509,141	6,940,086	14.19	Debris on fence	14.21	0.03
17	509,464	6,939,836	13.40	Debris on fence	13.25	-0.15
18	509,447	6,939,726	13.25	Debris on fence	13.20	-0.05
19	509,334	6,939,141	12.71	Debris on power pole	12.69	-0.03
20	510,679	6,939,387	10.55	Debris on ground	10.69	0.15
22	510,898	6,939,228	10.52	Debris on pole	10.39	-0.13
23	510,909	6,938,863	10.32	Debris on fence	10.24	-0.08
24	510,868	6,938,810	10.26	Debris on fence	10.24	-0.02
25	510,848	6,938,777	10.32	Debris on fence	10.24	-0.08
26	510,744	6,938,783	10.31	Debris on Fence	10.24	-0.07
27	511,018	6,938,806	10.23	Debris on fence post	10.24	0.01
28	511,161	6,938,601	10.16	Debris on fence	10.09	-0.07
29	511,154	6,938,497	10.12	Debris on scout sign	10.07	-0.05
30	511,205	6,938,275	10.02	Debris on post	10.07	0.05
31	511,399	6,938,411	10.12	Debris on wall	10.06	-0.05
32	511,988	6,938,750	9.71	Debris on ground	9.81	0.10
33	511,474	6,939,178	9.50	Debris on culvert wall	9.70	0.20
34	511,503	6,938,996	9.64	Debris on fence	9.76	0.12
35	511,748	6,939,893	8.53	Debris on ground	8.86	0.33
36	511,741	6,939,933	8.57	Debris on ground	8.87	0.30
37	511,764	6,939,933	8.72	Debris on fence	8.86	0.15
38	511,813	6,940,046	8.20	Debris on ground	8.54	0.34
39	511,775	6,939,922	8.36	PSM 9202[a]	-	-
40	511,393	6,940,753	10.77	Erosion line debris	10.61	-0.16
41	511,453	6,940,737	9.76	Debris line in waterway	9.93	0.17
42	510,825	6,945,289	21.87	Debris on ground	21.69	-0.18
43	511,135	6,945,533	19.26	Debris on ground	19.17	-0.10
44	511,612	6,945,550	15.80 [b]	Debris on ground	16.42	0.62
45	511,958	6,945,271	14.78 [b]	Debris on ground	15.13	0.36
46	512,235	6,944,814	13.39 [b]	Debris on ground	13.84	0.45
47	512,238	6,944,778	13.18 [b]	Debris on ground	13.67	0.49
48	512,542	6,944,171	12.24	Debris on ground	12.06	-0.17
49	512,232	6,943,825	11.60	Debris on post	11.48	-0.11

Debris mark	Easting	Northing	Surveyed flood level (mAHD)	Comments	Modelled peak flood level (mAHD)	Difference (m)
50	512,559	6,943,623	10.73	Debris on fence	10.68	-0.05
51	512,463	6,943,639	10.79	Debris on fence	10.73	-0.06
52	512,899	6,944,164	19.73	Debris on detention basin wall	19.60	-0.13
53	512,881	6,944,166	19.71	Top of detention basin wall	19.66	-0.05
54	511,681	6,943,634	16.17	Debris on ground	15.98	-0.19
55	510,731	6,943,376	22.61	Debris on fence	22.65	0.04
56	513,061	6,942,609	9.13	PSM [a]	-	-
57	513,021	6,942,490	6.33	Debris on road barrier	6.37	0.04
58	512,493	6,942,384	7.69	Debris on ground	7.68	-0.01
59	512,645	6,942,400	7.00	Debris on ground	6.98	-0.01
60	513,467	6,942,836	6.59	Debris on drainage channel	6.74	0.15
61	513,479	6,942,709	6.46	Debris on bank	6.75	0.29
62	513,465	6,942,691	5.68 [c]	Debris on bank	6.75	1.06
63	513,603	6,942,789	6.35	debris on drainage channel bank	6.51	0.16
64	513,094	6,943,032	7.53	Debris line on fence	7.20	-0.33
65	513,486	6,942,134	5.84	Debris line on tree	6.06	0.22
66	513,571	6,942,300	5.83	Debris on ground	6.03	0.20
68	513,306	6,941,102	6.60	Debris on ground	6.80	0.21
69	513,879	6,940,929	5.97	Debris on bank	6.11	0.14
71	514,507	6,940,861	5.13	Debris on ground	5.16	0.03
72	515,571	6,941,697	8.22	Debris on wall	8.61	0.39
73	515,730	6,942,133	11.76	Debris on ground - unclear	11.62	-0.13
74	513,061	6,942,609	9.12	PSM [a]	-	-
75	513,061	6,942,609	9.13	PSM [a]	-	-
76	515,635	6,941,027	4.93	Debris on ground	5.07	0.15
78	516,114	6,940,718	5.15	Debris on sign post	5.05	-0.10

[a] - Permanent survey mark (PSM) – not included for comparison.

[b] - Solid vertical walls exist along the edge of the floodplain at this location. Debris may have settled at the base of these walls after the flood had receded, resulting in the surveyed flood level being much lower than the actual peak flood level during the event.

[c] - Surveyed level is significantly different to other nearby debris marks. Therefore, the surveyed peak flood level at this location is likely to be inaccurate.

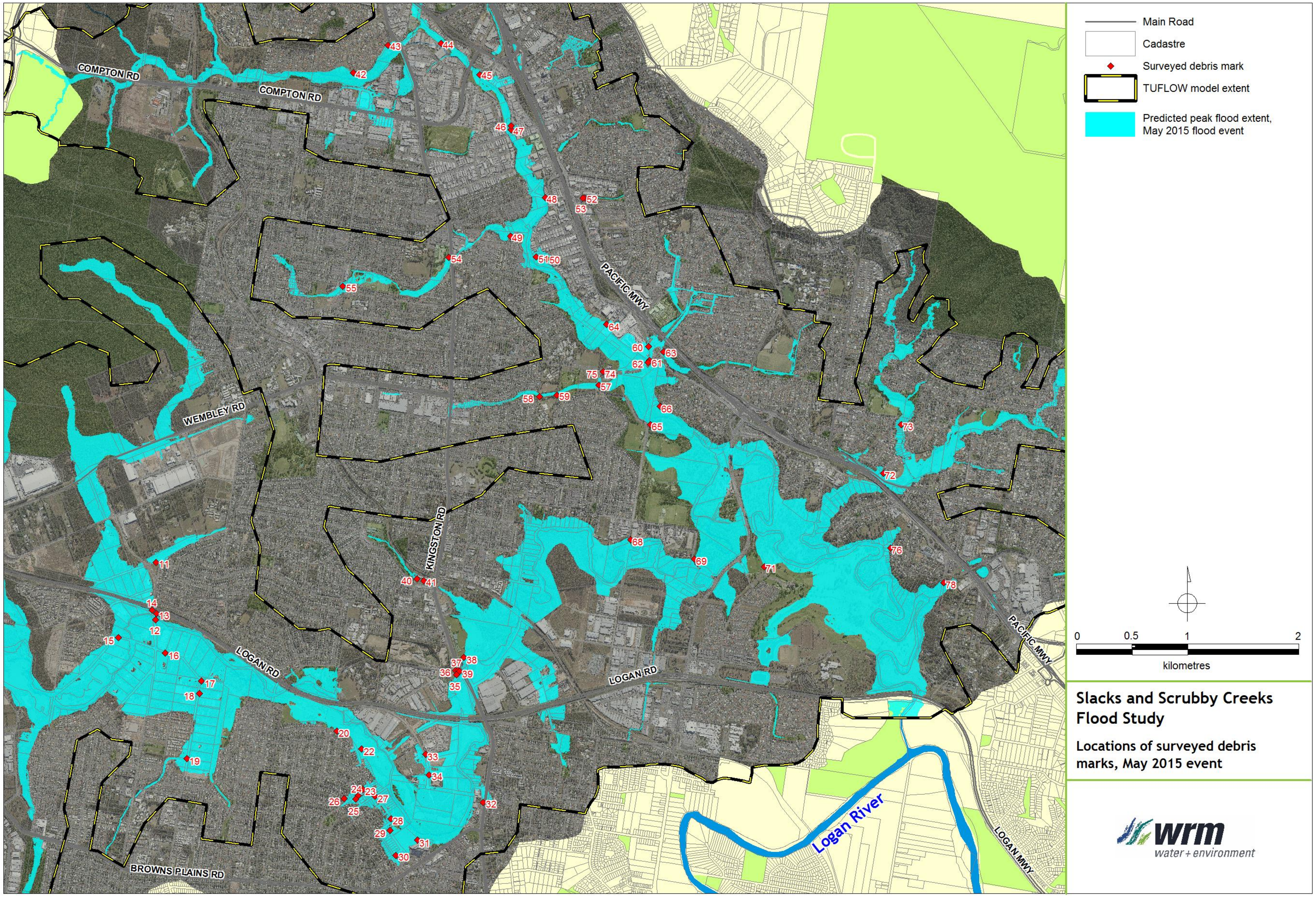

Figure 7.8 - Locations of surveyed peak flood levels (debris marks) throughout the Slacks and Scrubby creeks catchment, May 2015 event

7.4 MARCH 2017 EVENT

7.4.1 Comparison of predicted and recorded water level hydrographs

Results from the hydraulic model for the March 2017 event were compared with recorded water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road. Table 7.3 summarises the recorded peak water levels at the above locations, and compares them with peak water levels predicted by the hydraulic model. Figure 7.9, Figure 7.10, Figure 7.11 and Figure 7.12 show the recorded and predicted water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road.

The following Is of note with regards to the comparison between the predicted and recorded water level hydrographs:

- At the Waller Road gauge, the calibration is good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water level.
- At the Marsden gauge:
  - The model accurately matched the timing of the second flood peak, but could not match the timing of the first flood peak. The model also underestimated the peak flood level of the second (higher) flood peak.
  - The model accurately matched the recorded peak water levels at the Waller Road gauge (upstream of Marsden). Therefore, the difference between the predicted and recorded hydrograph shapes at the Marsden gauge is likely due to the timing of rainfalls within the Scrubby Creek catchment between the Waller Road and the Marsden gauges. The March 2017 event is considered a small event, and the rainfall distribution in this part of the Scrubby Creek catchment may not have been represented adequately at the available rainfall stations.
  - However, based on comparisons with surveyed flood (debris) levels for this event (see Section 7.4.3), the model accurately matched the surveyed flood levels immediately downstream of the Marsden gauge, even though the model could not accurately match the recorded hydrograph shape at Marsden. Therefore, the model is considered to predict peak flood levels adequately in the vicinity of the Marsden gauge even though the recorded hydrograph shape could not be replicated accurately for this event. On this basis, the calibration at the Marsden gauge is considered acceptable.
- At the Reserve Park gauge, the calibration is considered good, with the hydraulic model accurately matching the recorded hydrograph shape and timing. The model only slightly overestimated the peak flood level of the first flood peak, and only slightly underestimated the peak flood level of the second flood peak.
- At the Loganlea Road gauge:
  - The calibration is considered good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and water levels.
  - The peak water level at the Loganlea Road gauge during the March 2017 event is due to Logan River backwater (which were derived using the cut-down Logan River model described in Section 6.7). The peak water level at the Loganlea Road gauge due to Logan River backwater had not been reached within the adopted model simulation period. Therefore, a comparison could not be made with the recorded peak water level at Loganlea Road. However, the model appears to predict water levels satisfactorily for the simulation period.

Table 7.6 - Predicted and recorded peak water levels at Waller Road, Marsden, Reserve Park and Loganlea Road gauging stations, March 2017 flood event

Station No.	Station name	Watercourse	Peak water level (mAHD)		Difference (m)
			Recorded	Predicted	
540692	Waller Road AL	Scrubby Creek	23.12	23.14	0.02
540078	Marsden AL	Scrubby Creek	10.82	10.45	-0.37
540078	Reserve Park AL	Slacks Creek	9.50	9.28	-0.22
540091	Loganlea Road	Slacks Creek	8.20	n/a [a]	n/a [a]

[a]-- Peak water level at Loganlea Road due to Logan River backwater was not reached within the simulation period.

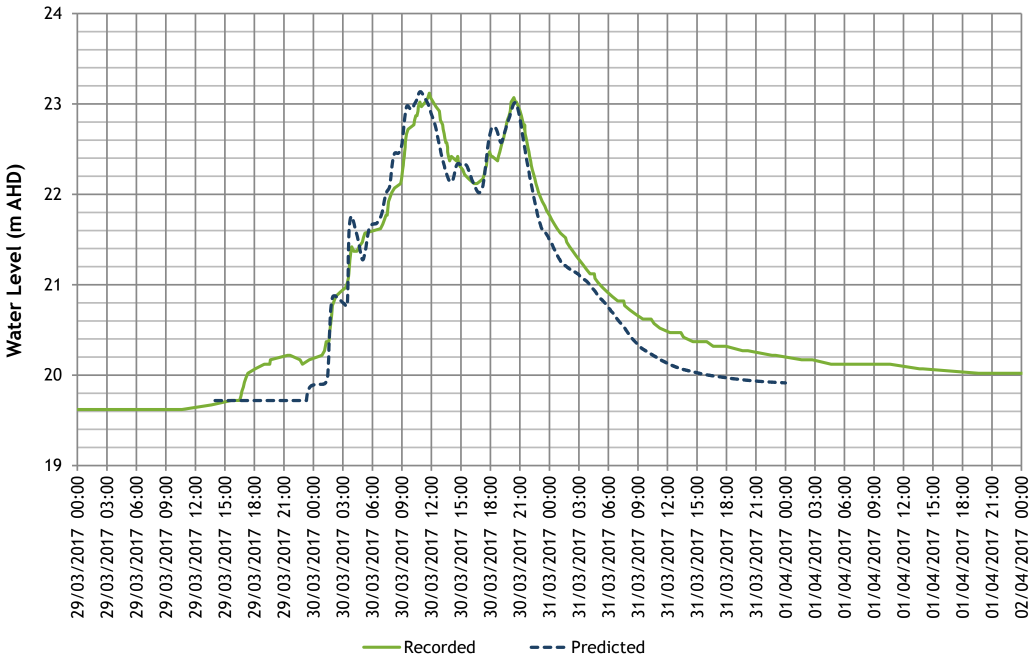

Figure 7.9 - Predicted and recorded water levels in Scrubby Creek at Waller Road (GS 540692), March 2017 flood event

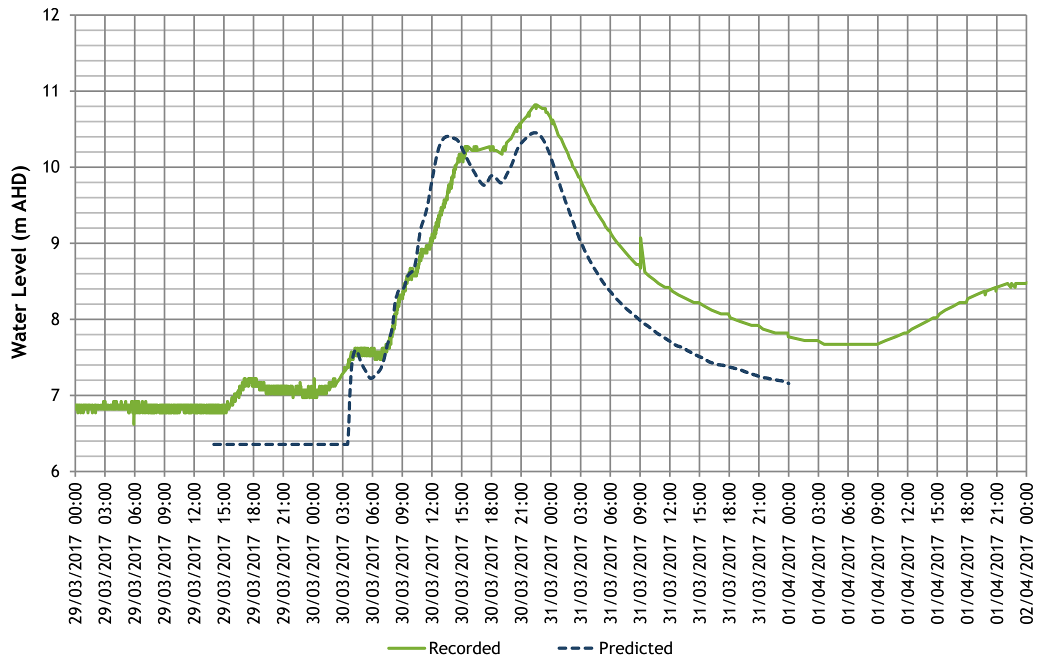

Figure 7.10 - Predicted and recorded water levels in Scrubby Creek at Marsden (GS 540078), March 2017 flood event

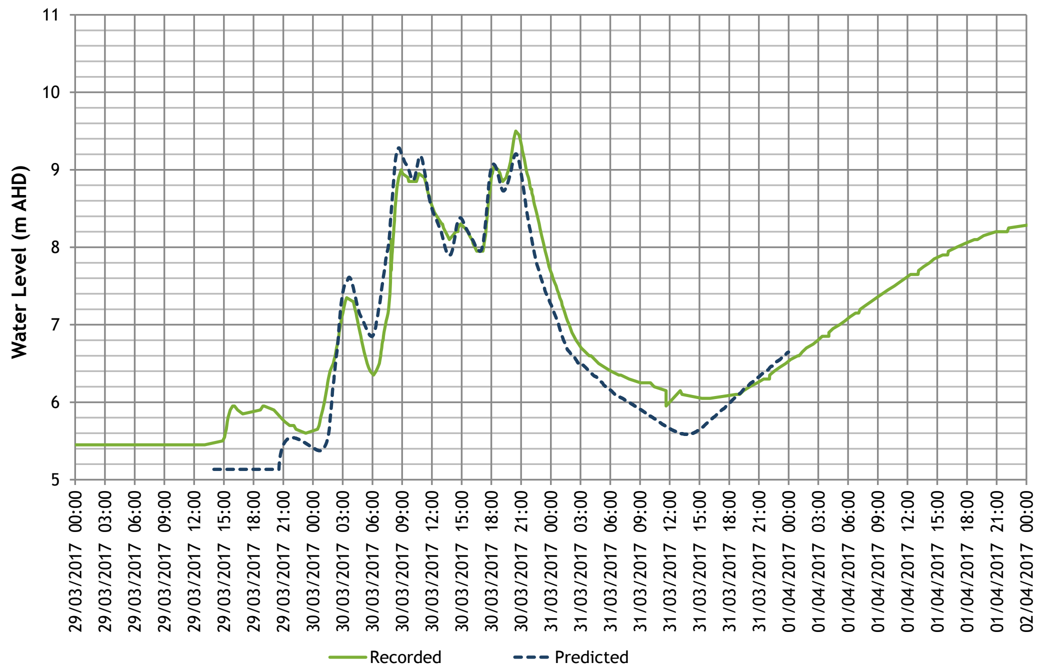

Figure 7.11 - Predicted and recorded water levels in Slacks Creek at Reserve Park (GS 540079), March 2017 flood event

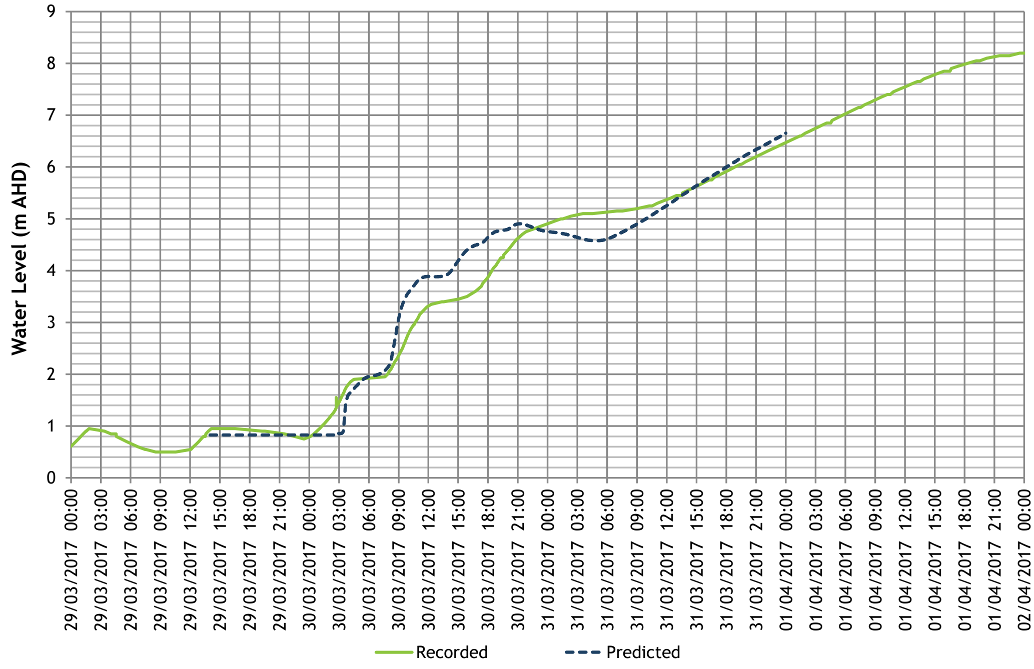

Figure 7.12 - Predicted and recorded water levels in Slacks Creek at Loganlea Road (GS 540091), May 2015 flood event

7.4.2 Comparison of predicted and recorded peak flood levels at maximum height gauges

The hydraulic model results were also compared with recorded peak flood levels at the MHGs in the northern tributaries of Scrubby Creek (see Figure 3.15 for locations). Table 7.7 summarises the recorded peak water levels at these MHGs for the March 2017 event, and compares them with peak water levels predicted by the hydraulic model.

The following is of note with regards to the comparison between the predicted and recorded peak flood levels at the MHGs:

- At the Scrubby Creek tributary upstream of Gilmore Road (MHG #100) and Wembley Road (MHG #110), the predicted peak flood levels are up to 0.37 m higher than the recorded peak flood levels. This may be due to some blockage in the culverts downstream of these MHGs. It may also be due to peak discharges being slightly overestimated in these tributaries.
- At the Scrubby Creek tributary upstream of Gowan Road (MHG #220), the predicted peak flood is 0.39 m higher than the recorded peak flood levels. In the same tributary upstream of Kameruka Street (MHG #230), the calibration is considered good, with the predicted peak flood level only 0.16 m higher than the recorded peak flood level.
- The calibration at the MHGs generally indicate that the model slightly overestimates peak flood levels in the upper catchments of Scrubby Creek for this event, even though the model appears to underestimate the peak flood level at the Marsden gauge (located downstream of these MHGs). However, the model accurately matches the recorded water level hydrograph at Waller Road. The model also accurately matches the surveyed peak flood levels (debris marks) immediately downstream of the Marsden gauge (see Section 7.4.3). On this basis, calibration at the MHGs for the March 2017 event is considered acceptable when comparing all available data.

Table 7.7 – Predicted and recorded peak water levels at maximum height gauges in the northern tributaries of Scrubby Creek, March 2017 flood event

Gauge Name	Easting	Northing	Peak flood level (mAHD)		Difference (m)
			Recorded	Predicted	
100	508,634	6,941,340	15.70	16.07	0.37
110	509,067	6,942,009	21.71	21.98	0.27
120	509,361	6,942,687	- [a]	26.40	- [a]
210	506,921	6,942,563	- [a]	27.39	- [a]
220	505,726	6,943,623	35.67	36.06	0.39
230	505,393	6,944,433	40.79	40.98	0.19

[a] – No recorded data available.

7.4.3 Comparison of predicted peak flood levels with surveyed debris marks

A total of 34 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the March 2017 flood event. Of these, two were surveyed levels of permanent survey marks (PSM) and were not included for comparison with predicted flood levels. In addition, five of these surveyed levels were obtained at existing stream gauges within the catchment.

Figure 7.8 shows the locations of the debris marks for the March 2017 event. Table 7.5 compares predicted peak flood levels for the March 2017 event with the surveyed debris mark. The accuracy of surveyed flood levels is not known. Based on previous experience, debris mark surveys are generally accurate to about ±0.3 m.

7.4.3.1 Scrubby Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Scrubby Creek floodplain (marks #89 to #90, #134 to #136, #146 and #158 to #163):

- At the Waller Road gauge (mark #158), the model accurately matches the surveyed flood level (within 0.04 m).
- At the Marsden gauge (mark #159), the calibration is considered acceptable, with the predicted peak flood level within 0.25 m of the surveyed peak flood level. Note that the surveyed flood level at mark #159 (10.70 mAHD) is 0.12 m lower than the recorded peak water level at the Marsden gauge (10.82 mAHD).
- At the residential areas along Princess Street and Kurrajong Drive, south of the Scrubby Creek channel (marks #160 and #161), the model accurately matches the surveyed flood levels (within 0.04 m).
- At the residential areas along Tamarind Street, south of the Scrubby Creek channel (mark #162), the calibration is considered good, with the predicted peak flood level within 0.2 m of the surveyed flood level.
- At the industrial areas west of Kingston Road and upstream of the Logan Motorway (mark #89), the calibration is considered good, with the predicted peak flood level within 0.15 m of the surveyed flood level.
- Downstream of the Logan Motorway (marks #90, #134 to #136, #146 and #163):
    - The surveyed peak flood levels in Scrubby Creek downstream of the Logan Motorway (Kingston) are consistent with the recorded peak water level due to backwater flooding from the Logan River (8.20 mAHD at 11:33pm on 1 April 2017 recorded at the Loganlea Road AL gauge). The peak water level due to Logan River flooding occurred approximately two days after the peak water level due to local catchment flows in Scrubby Creek.

- The peak water level (resulting from backwater flooding from the Logan River) had not been reached within the adopted model simulation period (02:00pm on 29 March 2017 to 12:00am on 1 April 2017). Therefore, the modelled peak water levels downstream of the Logan Motorway (Kingston) were not included for comparison.

7.4.3.2 Slacks Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Slacks Creek floodplain (marks #91 to #107, #137, #145 and #164):

- At the Reserve Park AL gauge (mark #164):
  - The predicted peak water level is 0.95 m higher than the surveyed flood level. However, the surveyed flood level at mark #164 (8.3 mAHD) is not consistent with the recorded peak water level at the Reserve Park gauge as shown in Figure 7.10 (9.5 mAHD at 08:28pm on 30 March 2017).
  - Based on the recorded peak water level at the Reserve Park gauge (9.5 mAHD), the predicted peak water level at mark #164 (9.24 mAHD) is 0.26 m lower than the recorded peak water level. On this basis, the calibration at mark #164 is considered acceptable.
- Downstream of the Paradise Road (marks #91 to #107, #137 and #145):
  - The surveyed peak flood levels downstream of paradise Road are consistent with the recorded peak water level due to backwater flooding from the Logan River (8.20 mAHD at 11:33pm on 1 April 2017 recorded at the Loganlea Road AL gauge). The peak water level due to Logan River flooding occurred approximately two days after the peak water level due to local catchment flows in Slacks Creek.
  - The peak water level (resulting from backwater flooding from the Logan River) had not been reached within the adopted model simulation period (02:00pm on 29 March 2017 to 12:00am on 1 April 2017). Therefore, the modelled peak water levels downstream of Paradise Road were not included for comparison.

Table 7.8 - Comparison of predicted peak water levels with surveyed debris marks in the Slacks and Scrubby creeks floodplains, March 2017 flood event

Debris mark	Easting	Northing	Surveyed flood level (mAHD)	Comments	Modelled peak flood level (mAHD)	Difference (m)
8	508,780	6,936,303	8.27 [a]	Debris on ground	- [c]	-
9	508,813	6,936,476	8.26 [a]	Debris on pole	- [c]	-
89	508,814	6,936,513	8.94	Debris on wall	8.79	-0.15
90	508,655	6,936,269	8.23 [a]	Debris on ground	- [c]	-
91	497,550	6,934,106	8.22 [a]	Debris on wall	- [c]	-
92	495,637	6,933,032	8.21 [a]	Debris on fence	- [c]	-
93	494,755	6,932,336	9.10	PSM [b]	-	-
94	494,713	6,932,411	8.23 [a]	Debris on pole	- [c]	-
95	509,918	6,928,027	8.22 [a]	Debris on pole	- [c]	-
96	509,058	6,940,899	8.23 [a]	Debris on fence	- [c]	-
97	509,054	6,940,385	8.13 [a]	Debris on ground	- [c]	-
98	509,062	6,940,443	8.22 [a]	Debris on pole	- [c]	-
99	509,025	6,940,470	8.23 [a]	Debris on pole	- [c]	-
100	508,723	6,940,225	8.21 [a]	Debris on pole	- [c]	-
101	509,141	6,940,086	8.11 [a]	Debris on ground	- [c]	-
102	509,464	6,939,836	8.24 [a]	Debris on ground	- [c]	-
103	509,447	6,939,726	8.27 [a]	Debris on pole	- [c]	-
104	509,334	6,939,141	8.14 [a]	Debris on ground	- [c]	-
105	510,679	6,939,387	8.25 [a]	Debris on fence	- [c]	-
106	510,898	6,939,228	8.26 [a]	Debris on ground	- [c]	-
107	510,909	6,938,863	8.19 [a]	Debris on ground	- [c]	-
134	510,868	6,938,810	7.93 [a]	Debris on ground	- [c]	-
135	510,848	6,938,777	8.25 [a]	Debris on fence	- [c]	-
136	510,744	6,938,783	8.23 [a]	Debris on wall	- [c]	-
137	511,018	6,938,806	9.06	PSM [b]	-	-
145	511,161	6,938,601	8.20	Loganlea Road AL gauge	- [c]	-
146	511,154	6,938,497	8.26	Debris on ground	- [c]	-
158	511,205	6,938,275	23.12	Waller Road AL gauge	23.08	-0.04
159	511,399	6,938,411	10.70	Marsden AL gauge	10.45	-0.25
160	511,988	6,938,750	9.40	Debris on ground	9.36	-0.04
161	511,474	6,939,178	9.40	Kurrajong AL gauge	9.36	-0.04
162	511,503	6,938,996	9.10	Debris	9.26	0.16
163	511,748	6,939,893	8.20	Debris on ground	- [c]	-
164	511,741	6,939,933	8.30 [d]	Reserve Park AL gauge	9.25	0.95 [e]

[a] - Surveyed level at this location is consistent with the recorded peak water level due to backwater flooding from the Logan River (8.20 mAHD at 11:33pm on 1 April 2017 recorded at the Loganlea Road AL gauge).

[b] - Permanent survey mark (PSM) - not included for comparison.

[c] – The peak water level (resulting from backwater flooding from the Logan River) had not been reached within the adopted model simulation period (02:00pm on 29 March 2017 to 12:00am on 1 April 2017). Therefore, the modelled peak water level at this location was not included for comparison.

[d] – Surveyed level is inconsistent with the recorded peak water level at the Reserve Park AL gauge shown in Figure 7.11 (9.5 mAHD at 08:28pm on 30 March 2017).

[e] – Based on the recorded peak water level at the Reserve Park AL gauge (see Figure 7.11), the predicted peak water level (9.24 mAHD) is 0.26 m lower than the recorded peak water level (9.50 mAHD at 08:28pm on 30 March 2017).

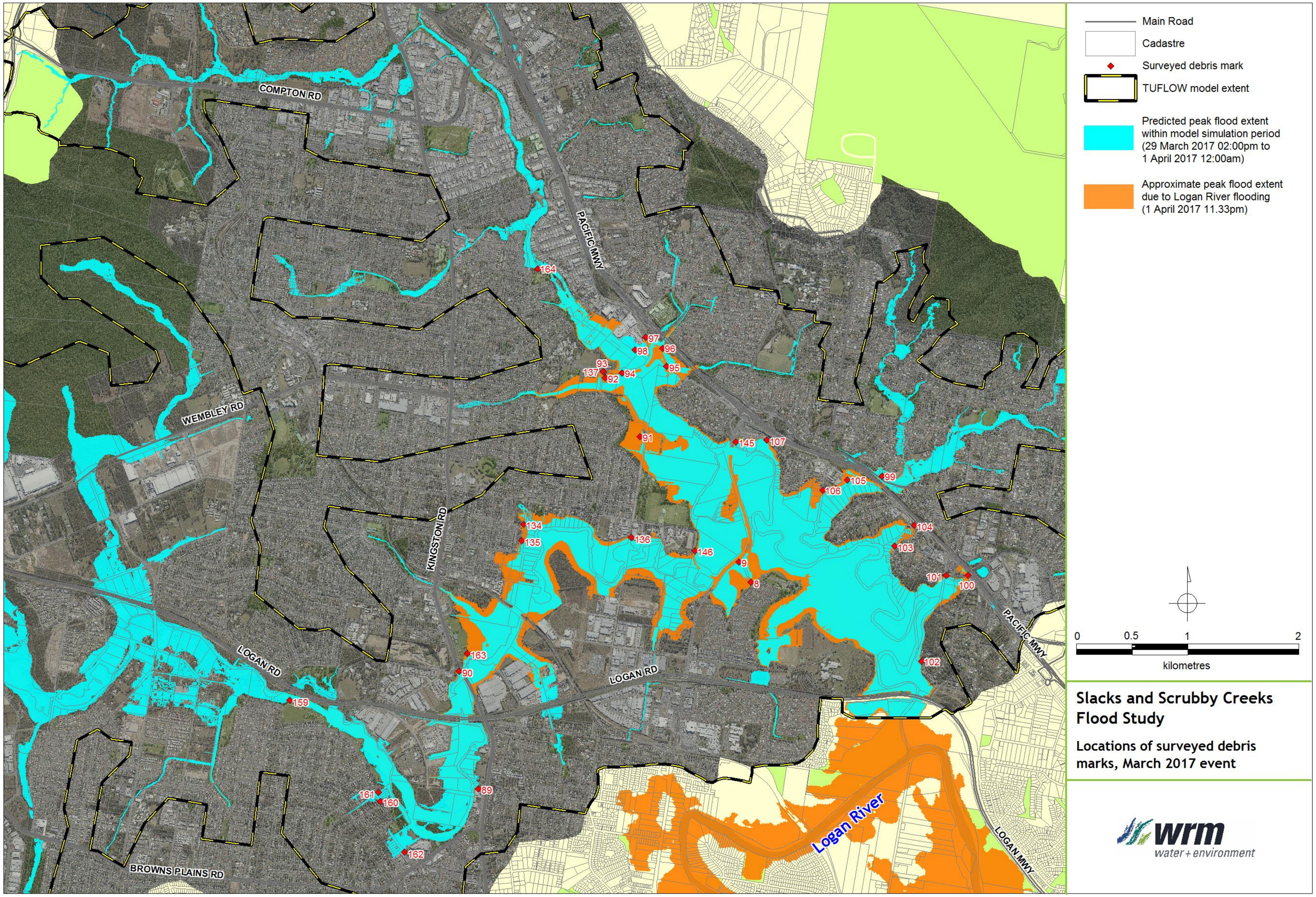

Figure 7.13 – Locations of surveyed peak flood levels (debris marks) throughout the Slacks and Scrubby creeks catchment, March 2017 event

7.5 FEBRUARY 2022 EVENT

7.5.1 Comparison of predicted and recorded water level hydrographs

Results from the hydraulic model for the February 2022 event were compared with recorded water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road. Table 7.9 summarises the recorded peak water levels at the above locations, and compares them with peak water levels predicted by the hydraulic model. Figure 7.9, Figure 7.10, Figure 7.11 and Figure 7.12 show the recorded and predicted water level hydrographs at Waller Road, Marsden, Reserve Park and Loganlea Road.

The following is of note with regards to the comparison between the predicted and recorded water level hydrographs:

- At the Waller Road gauge, the validation is good, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water level.
- At the Marsden gauge, the hydraulic model accurately matches the recorded hydrograph shape and timing, but slightly underestimates the peak flood level towards the latter half of the event.
- At the Reserve Park gauge, the hydraulic model accurately matches the recorded hydrograph shape, timing and peak water level throughout the event. The peak level towards the latter half of the event is slightly underestimated.
- At the Loganlea Road gauge, the validation is okay, with the hydraulic model accurately matching the recorded hydrograph shape, timing and peak water levels.

Table 7.9 – Predicted and recorded peak water levels at Waller Road, Marsden, Reserve Park and Loganlea Road gauging stations, February 2022 flood event

Station No.	Station name	Watercourse	Peak water level (mAHD)		Difference (m)
			Recorded	Predicted	
540692	Waller Road AL	Scrubby Creek	23.35	23.37	0.02
540078	Marsden AL	Scrubby Creek	11.35	11.17	-0.18
540078	Reserve Park AL	Slacks Creek	10.30	10.00	-0.30
540091	Loganlea Road	Slacks Creek	8.70	8.68	-0.02

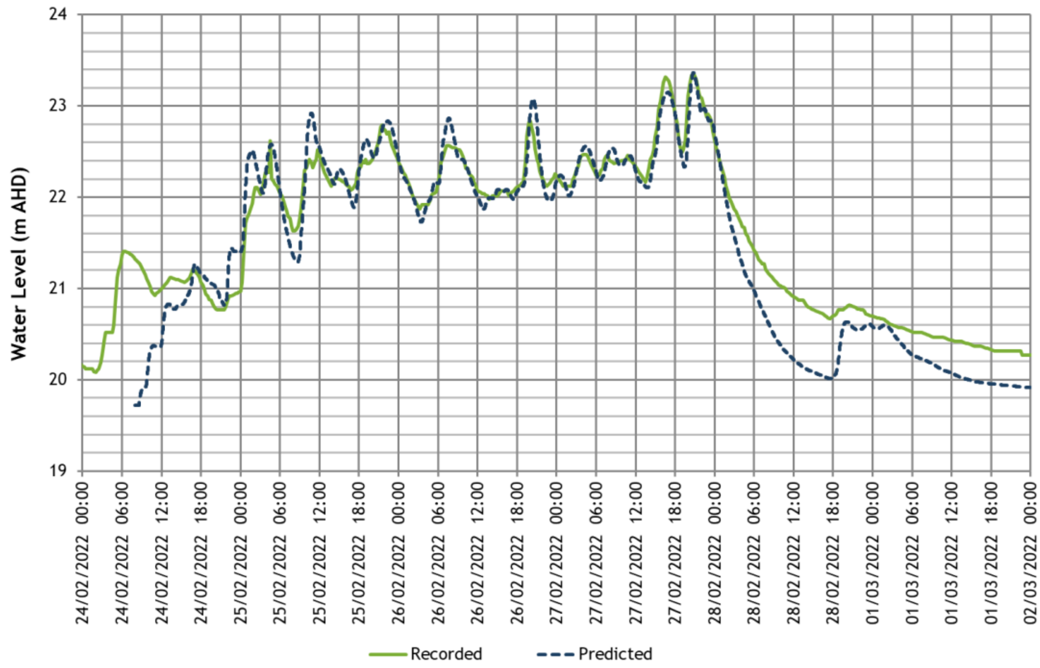

Figure 7.14 – Predicted and recorded water levels in Scrubby Creek at Waller Road (GS 540692), February 2022 flood event

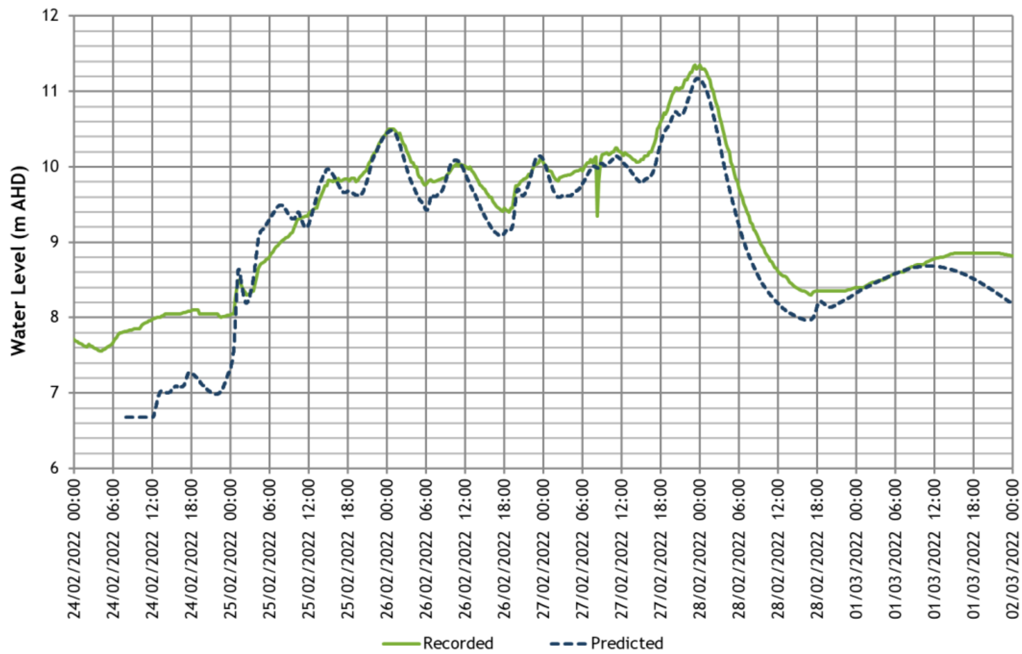

Figure 7.15 – Predicted and recorded water levels in Scrubby Creek at Marsden (GS 540078), February 2022 flood event

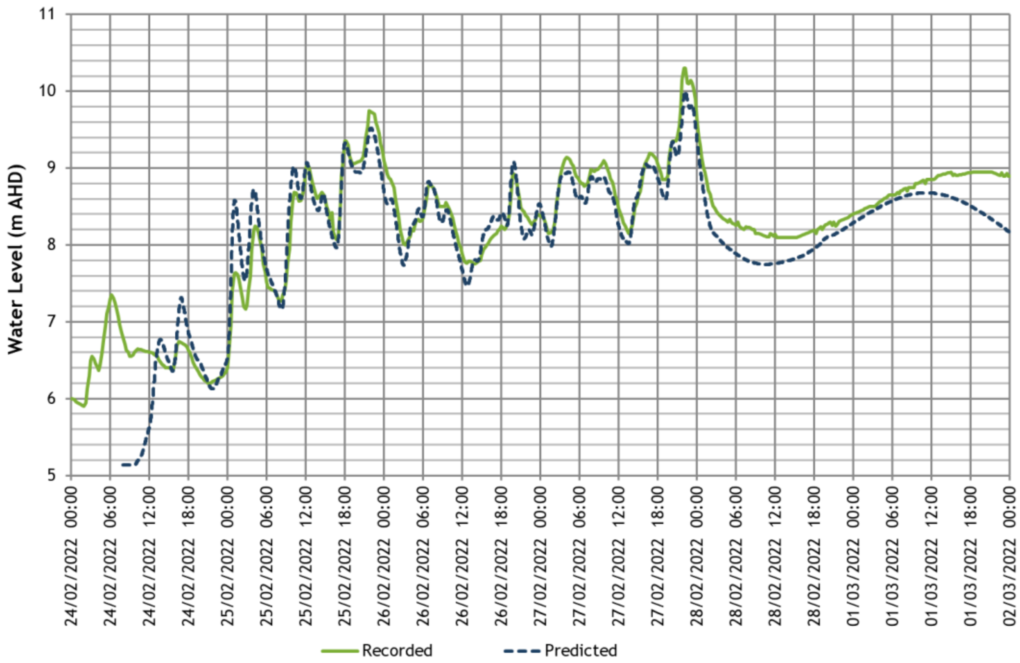

Figure 7.16 – Predicted and recorded water levels in Slacks Creek at Reserve Park (GS 540079), February 2022 flood event

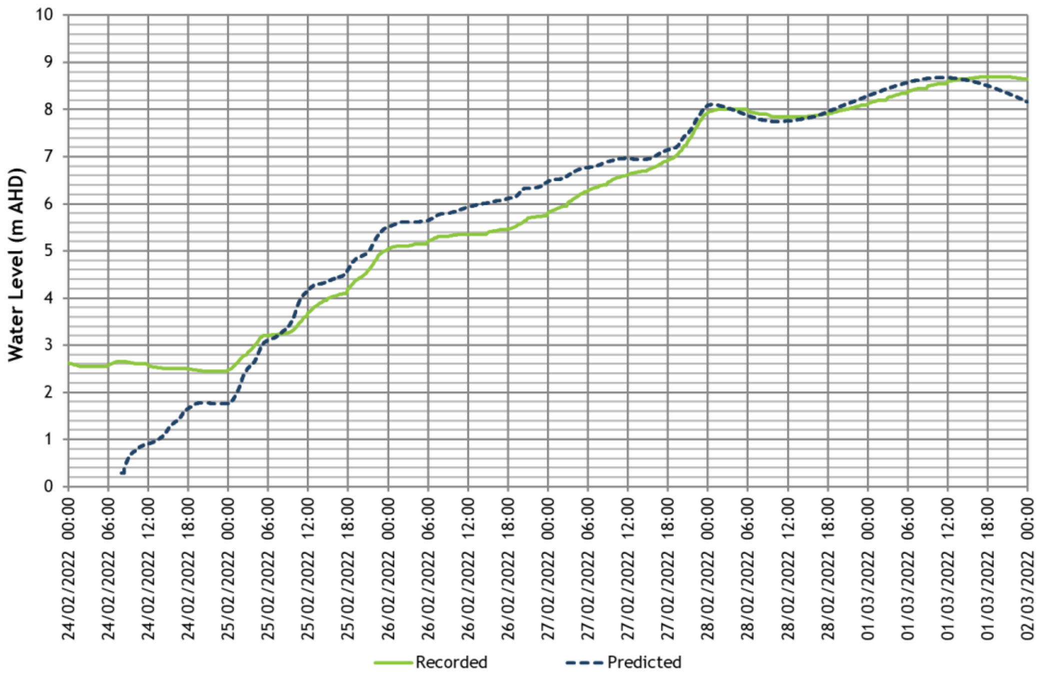

Figure 7.17 – Predicted and recorded water levels in Slacks Creek at Loganlea Road (GS 540091), February 2022 flood event

7.5.2 Comparison of predicted peak flood levels with surveyed debris marks

A total of 29 surveyed flood debris marks were available throughout the Slacks and Scrubby creeks floodplain for the February 2022 flood event.

Figure 7.18 shows the locations of the debris marks for the February 2022 event. Table 7.10 compares predicted peak flood levels for the February 2022 event with the surveyed debris mark. The accuracy of surveyed flood levels is not known. Based on previous experience, debris mark surveys are generally accurate to about ±0.3 m.

7.5.2.1 Scrubby Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Scrubby Creek floodplain:

- At the residential areas along Demeio Road and Second Avenue, upstream the Marsden gauge (marks #192 and #193), the model accurately matches the surveyed flood level (within 0.07 m).
- Downstream of the Logan Motorway (marks #89 to #92, #126 to #128 and #165):
  - The surveyed peak flood levels are generally within ±0.3m than the recorded peak water levels due to backwater flooding from the Logan River (8.70 mAHD at 5:30pm on 1 March 2022 recorded at the Loganlea Road AL gauge).
  - The surveyed marks along the downstream section of Scrubby Creek are likely to coincide with the levels from the Logan Albert River due to backwater flooding.
  - There is little to no variation in the predicted peak water levels in the downstream catchments of Scrubby and Slacks Creek due to the influence of backwater from the Logan River.

7.5.2.2 Slacks Creek floodplain

The following is of note with regards to the comparison between the surveyed flood levels and the predicted flood levels in the Slacks Creek floodplain:

- Downstream the Reserve Park AL gauge:
  - The surveyed peak flood levels are generally within ±0.3m than the recorded peak water levels due to backwater flooding from the Logan River (8.70 mAHD at 5:30pm on 1 March 2022 recorded at the Loganlea Road AL gauge).
  - The surveyed marks along the downstream section of Scrubby Creek are likely to coincide with the levels from the Logan Albert River due to backwater flooding.
  - There is little to no variation in the predicted peak water levels in the downstream catchments of Scrubby and Slacks Creek due to the influence of backwater from the Logan River.

Table 7.10 - Comparison of predicted peak water levels with surveyed debris marks in the Slacks and Scrubby creeks floodplains, February 2022 flood event

Debris mark	Easting	Northing	Surveyed flood level (mAHD)	Comments	Modelled peak flood level (mAHD)	Difference (m)
89	513,992	6,940,602	8.87	on ground	8.68	-0.2
90	514,015	6,940,580	8.90	on ground	8.68	-0.22
91	513,894	6,940,391	9.01	on ground	8.68	-0.33
92	513,214	6,940,683	8.88	on ground	8.68	-0.2
110	516,246	6,940,872	8.81	on fence	8.68	-0.13
111	516,244	6,940,891	8.87	on ground	8.68	-0.19
112	516,125	6,940,787	9.09	on pole	8.68	-0.41
113	515,837	6,941,239	8.88	on fence	8.68	-0.2

114	515,541	6,941,572	8.86	on rail	8.68	-0.18
115	515,534	6,941,580	8.87	on rail	8.68	-0.19
116	514,219	6,941,952	8.85	on ground	8.68	-0.17
117	515,022	6,941,575	8.87	on wall	8.68	-0.19
118	513,805	6,942,573	8.91	on pole	8.68	-0.23
119	515,475	6,941,709	8.91	on post	8.68	-0.23
120	513,706	6,943,027	8.86	on post	8.68	-0.19
121	513,472	6,942,944	8.89	on ground	8.68	-0.21
122	513,463	6,942,942	8.87	on ground	8.68	-0.19
123	513,022	6,942,615	8.86	on ground	8.68	-0.18
124	513,081	6,942,614	8.85	on ground	8.68	-0.17
125	513,075	6,942,628	8.88	on ground	8.68	-0.2
126	511,807	6,940,003	8.91	on post	8.68	-0.22
127	511,799	6,939,952	8.85	on ground	8.70	-0.15
128	511,796	6,939,920	8.87	on wall	8.77	-0.1
165	512,153	6,940,601	8.88	on fence	8.68	-0.2
192	508,625	6,940,199	14.91	on fence	14.84[a]	-0.07
193	508,652	6,940,203	14.90	on shed	14.83[a]	-0.06
195	509,063	6,940,434	14.40	on ground	14.36[a]	-0.04
216	515,914	6,940,025	8.82	on pole	8.68	-0.14
218	515,922	6,940,006	8.81	on ground	8.68	-0.13

[a] - Surveyed level at this location is consistent with the recorded peak water level. It is unlikely that the upstream sections of Scrubby Creek are affected by the backflow from the Logan River.

J:\0936-14 Slacks Scrubby Finalisation\GIS\QGIS\Report Figures\Calibration_2022.qgz (Debris_Marks) (Exported: 27 February 2023)

Projection: EPSG:7856

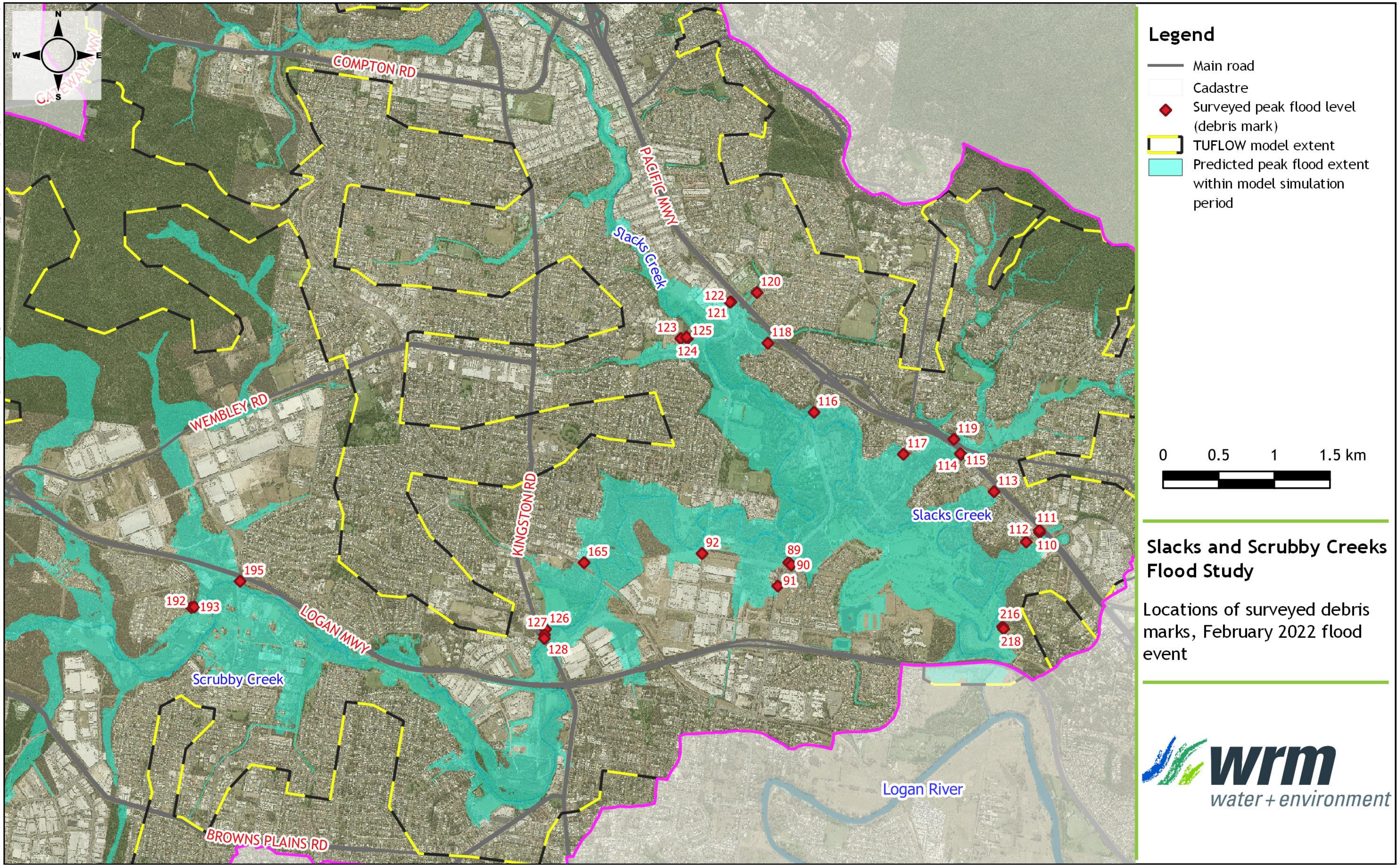

Figure 7.18 – Locations of surveyed peak flood levels (debris marks) throughout the Slacks and Scrubby creeks catchment, February 2022 event

8 Estimation of design flood discharges

8.1 METHODOLOGY

This section describes the methodology adopted to estimate design discharges throughout the Slacks and Scrubby creeks catchment.

The calibrated XP-RAFTS model was used to estimate design flood discharges throughout the Slacks Creek and Scrubby Creek catchments based on design rainfall intensity-frequency-duration (IFD) data from a number of sources (Refer to Section 8.2). Design flood hydrographs were estimated for the 50% (1 in 1.44 ARI), 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI) and 0.05% (1 in 2,000 ARI) AEP and the PMPDF events for the current climate (2020). In addition, the Future Climate (2090) estimates were derived for the 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI) and 0.2% (1 in 500 ARI) AEP events.

A summary of the adopted design hydrology methodology for this study is given in Table 8.1.

Table 8.1 – Summary of methodology for design event analysis

Design flood parameter	AEP (1 in X ARI)	Source/method	Comment
Rainfall depth	≤ 100	AR&R 2019	Industry standard.
	> 100 to 2,000	AR&R 2019	Industry standard.
	PMPDF	BoM GSDM	Industry standard approach for durations ≤ 6 hours. Adopted in this study for durations up to and including 12 hours.
		BoM GTSMR	Industry standard approach for durations ≥ 24 hours. Adopted in this study for durations longer than 12 hours.
Areal Reduction Factor (ARF)	≤ 2,000	AR&R 2019	Adopted an ARF based on the Scrubby Creek confluence with Slacks Creek (77.7 km^2)
	PMFDF	BoM GTSMR	Industry standard.
Temporal pattern	≤ 100	AR&R 2019	A point location at the centroid of the Slacks Creek catchment upstream of the Logan Motorway was selected to produce 'point' temporal patterns for these events. 'Areal' temporal patterns were not be used as critical storm durations in most parts of the catchment are generally less than 12 hours.
	> 100 to PMPDF	BoM GSDM	Industry standard approach for durations ≤ 6 hours. Adopted in this study for durations up to and including 12 hours.
		BoM GTSMR	Industry standard approach for durations ≥ 24 hours. Adopted in this study for durations longer than 12 hours.
Spatial distribution	≤ 2,000	Single distribution	Intensity-Frequency-Duration (IFD) data was produced at 13 locations throughout the Slacks Creek catchment upstream of the Logan Motorway. The centroid IFD between all 13 locations was selected as the representative IFD for the entire Slacks Creek catchment upstream of the Logan Motorway.
	PMPDF	BoM GTSMR	Adopt PMP spatial distribution as recommended by AR&R 2019.
Rainfall losses	≤ 100	AR&R 2019	Adopted initial loss and median pre-burst rainfalls was based on estimates given in AR&R 2019 . Adopted continuing loss was based on the calibration event continuing losses.
	> 100 to PMPDF	Adopt minimum losses	Adopt 0.0 mm initial loss and calibration event continuing losses for this range of event magnitudes.

8.2 DESIGN RAINFALL DEPTH ESTIMATION

8.2.1 50% (1 in 1.44 ARI) to 0.05% (1 in 2,000 ARI) AEP design events

Design rainfalls for different storm durations for all AEPs up to and including the 1% (1 in 100 ARI) AEP event were estimated using the 2016 IFDs from BoM (BoM, 2016) as per the procedure outlined in AR&R 2019 (Ball et al, 2019).

8.2.2 PMPDF event

PMP rainfall depths for durations up to and including 6 hours were estimated using the methodology given in The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method-- GSDM (BoM, 2003).

PMP rainfall depths for durations of 24 hours and longer were estimated using the standard methodology given in the Generalised Tropical Storm Method – Revised Edition-- GTSMR (BoM, 2005), based on the catchment area of Slacks Creek upstream of the Logan Motorway.

PMP rainfall depths for durations of between 6 and 24 hours were interpolated between the GSDM (for durations up to and including 6 hours) and GTSMR (for durations of 24 hours and longer) estimates.

8.3 AREAL REDUCTION FACTOR

An ARF based on the catchment of Scrubby Creek upstream the confluence with Slacks Creek (77.7 km^2) was adopted. It is believed to be appropriate as Scrubby Creek is the larger of the two creek systems, and contains more flood affected properties. LCC had also completed overland flow mapping which would adequately represent flooding in the upper tributaries of the creeks.

8.4 TEMPORAL PATTERNS

8.4.1 50% (1 in 1.44 ARI) to 1% (1 in 100 ARI) AEP design events

Temporal patterns were obtained from the AR&R data hub based on a point location at the centroid of the Slacks Creek catchment to the Logan Motorway. The AR&R 2019 temporal pattern methodology involves the use of an 'ensemble' of 10 temporal patterns, which produces 10 design storms for each duration for each AEP. The temporal pattern which results in a peak flood discharge slightly above the average of the 10 design storms for each storm duration was selected as the representative temporal pattern for that storm duration.

As the critical duration varies significantly across the catchment, the ensemble method was used to determine the representative temporal pattern that gives slightly above average peak discharges at the majority of key reporting locations for each critical duration. This representative temporal pattern for each storm duration was adopted for hydraulic modelling. XP-RAFTS post-processing tools were be used to identify the critical duration and representative temporal pattern at every node in the hydrologic model, ensuring that the temporal pattern that is representative at most locations in adopted for hydraulic modelling.

In some cases, additional temporal patterns were run through the hydraulic model depending on whether flood levels are determined by conveyance or floodplain storage, or if there is no clearly dominant representative temporal pattern for a certain duration.

To illustrate the range of peak discharges produced by the ensemble method of AR&R 2019, Appendix D provides box and whisker plots (box plots) to summarise the statistics of the XP-RAFTS model peak discharge results for the 50% AEP to 1% AEP design events in Scrubby Creek at Marsden, and in Slacks Creek at Reserve Park. The box plots present the maximum, minimum, median, average, 25th and 75th percentile predicted peak discharges based on the model results for the 10 design storms for each storm duration. The box plots shown in Appendix D indicate that:

- In Scrubby Creek at Marsden, the difference in peak discharges produced by the 10 design storms for each duration is not significant for storm durations of up to two to three hours. However, for longer storm durations, the 10 design storms for each duration produced significantly different results at this location.
- In Slacks Creek at Reserve Park, the difference in peak discharges produced by the 10 design storms for each duration is not significant for storm durations of up to 45 minutes. However, for storm durations longer than 45 minutes, the 10 design storms for each duration produced significantly different results at this location.

AR&R 2019 recommends using areal temporal patterns for when the catchment area exceeds 75 km^2. Although the Slacks Creek catchment area upstream of the Logan Motorway (119.9 km^2) satisfies this criteria, the main focus of this study are the waterways the upper catchments of Slacks and Scrubby creeks where catchments areas are less than 75 km^2. In addition, the critical storm durations in the upper catchments of Slacks and Scrubby creeks are not expected to exceed 12 hours. Therefore, areal temporal patterns were not used for this study.

8.4.2 0.5% (1 in 200 ARI) to 0.05% (1 in 2,000 ARI) AEP design events

The temporal patterns for durations up to and including 12 hours were obtained from the Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM) (BoM, 2003).

Temporal patterns for durations longer than 12 hours were obtained for Coastal AVM storms from the Generalised Tropical Storm method – Revised Edition (GTSMR) (BoM, 2005).

8.4.3 PMPDF event

The temporal patterns for durations up to and including 6 hours were obtained from the Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM) (BoM, 2003).

Temporal patterns for durations of 18 hours and longer were obtained for Coastal AVM storms from the Generalised Tropical Storm method – Revised Edition (GTSMR) (BoM, 2005). Note that the 24-hour duration temporal pattern was adopted for the 18-hour duration storm.

For the 9-hour and 12-hour duration storms, design discharges were initially estimated using temporal patterns obtained from both the GSDM (BoM, 2003) and GTSMR (BoM, 2005). The results indicate that the GSDM temporal patterns produced larger peak discharges compared to the GTSMR temporal patterns for these durations. Therefore, the GSDM temporal pattern was adopted for the 9-hour and 12-hour duration storms.

8.5 SPATIAL DISTRIBUTION

8.5.1 50% (1 in 1.44 ARI) to 0.05% (1 in 2,000 ARI) AEP design events

Rainfall IFDs generated at 13 locations across the Slacks Creek catchment were compared to investigate the variability of design rainfall intensities across the catchment. Figure 8.1 shows the 13 IFD locations, including one point location at the centroid of the Slacks Creek catchment upstream of the Logan Motorway.

The investigation indicated that design rainfall intensities across the catchment generally increase from west to east (closer to the coast). However, when comparing the IFDs generated at each location against the average from all 13 locations, and against the IFDs generated at the centroid of the catchment, the variation in rainfall intensities within the catchment was not significant.

Figure 8.2 and Figure 8.3 compare the design rainfall intensities generated at the 13 IFD locations against the average for the 10% (1 in 10 ARI) and 1% (1 in 100 ARI) AEP events respectively, and for storm durations between 1 minute and 18 hours (1,080 minutes). Figure 8.2 and Figure 8.3 also shows the 5% upper and lower bands of design rainfall intensities generated at the catchment centroid, that is, the design rainfall intensities generated at the centroid of the Slacks Creek catchment ±5%. The following is of note:

For storm durations of up to 3 hours (180 minutes), the design rainfall intensities generated at all 13 locations are within 5% of those generated at the centroid of the Slacks Creek catchment.

- For storm durations between 4.5 hours (270 minutes) and 18 hours (1,080 minutes), the design rainfall intensities generated at all locations are generally within 5% of those generated at the centroid of the Slacks Creek catchment, except at the easternmost and westernmost locations where the difference is slightly larger.
- The average of rainfall intensities generated at all 13 locations is generally equal to or slightly larger than the rainfall intensities generated at the centroid of the Slacks Creek catchment.

Based on preliminary hydrologic modelling results for design storm events, the critical storm durations at the minor tributaries of Slacks and Scrubby creeks are generally less than or equal to 3 hours, while the critical storm durations in the main channels of Slacks and Scrubby creeks are generally less than or equal to 12 hours. On this basis, the average of rainfall IFDs generated at all 13 locations is considered representative of the entire Slacks Creek catchment to the Logan Motorway. Therefore, the average rainfall IFD was adopted for the entire Slacks Creek catchment for all events up to and including the 0.05% (1 in 2,000 ARI) AEP event.

8.5.2 PMPDF event

Spatial distribution of rainfall for storm durations between 1 hour and 6 hours is accounted for in the Generalised Tropical Storm method – Revised Edition (BoM, 2005) rainfall depth estimation methodology.

Spatial distribution of rainfall for storm durations longer than 6 hours is accounted for in the Generalised Tropical Storm method – Revised Edition (BoM, 2005) rainfall depth estimation methodology.

8.6 RAINFALL LOSSES

8.6.1 50% (1 in 1.44 ARI) to 1% (1 in 100 ARI) AEP design events

The initial (IL)/ continuing loss (CL) method of accounting for rainfall losses was adopted for this study. AR&R 2019 (Ball et al, 2019) recommends an IL of 21 mm and a CL of 1.5 mm/h.

Design ILs were derived based on the following methodology:

- Subcatchments with less than 30% fraction imperviousness were initially assigned the recommended design IL obtained from AR&R 2019;
- Subcatchments that more than 75% impervious were assigned zero ILs; and
- ILs for other subcatchments (with fraction imperviousness of between 30% and 75%) were interpolated based on the subcatchment fraction imperviousness.

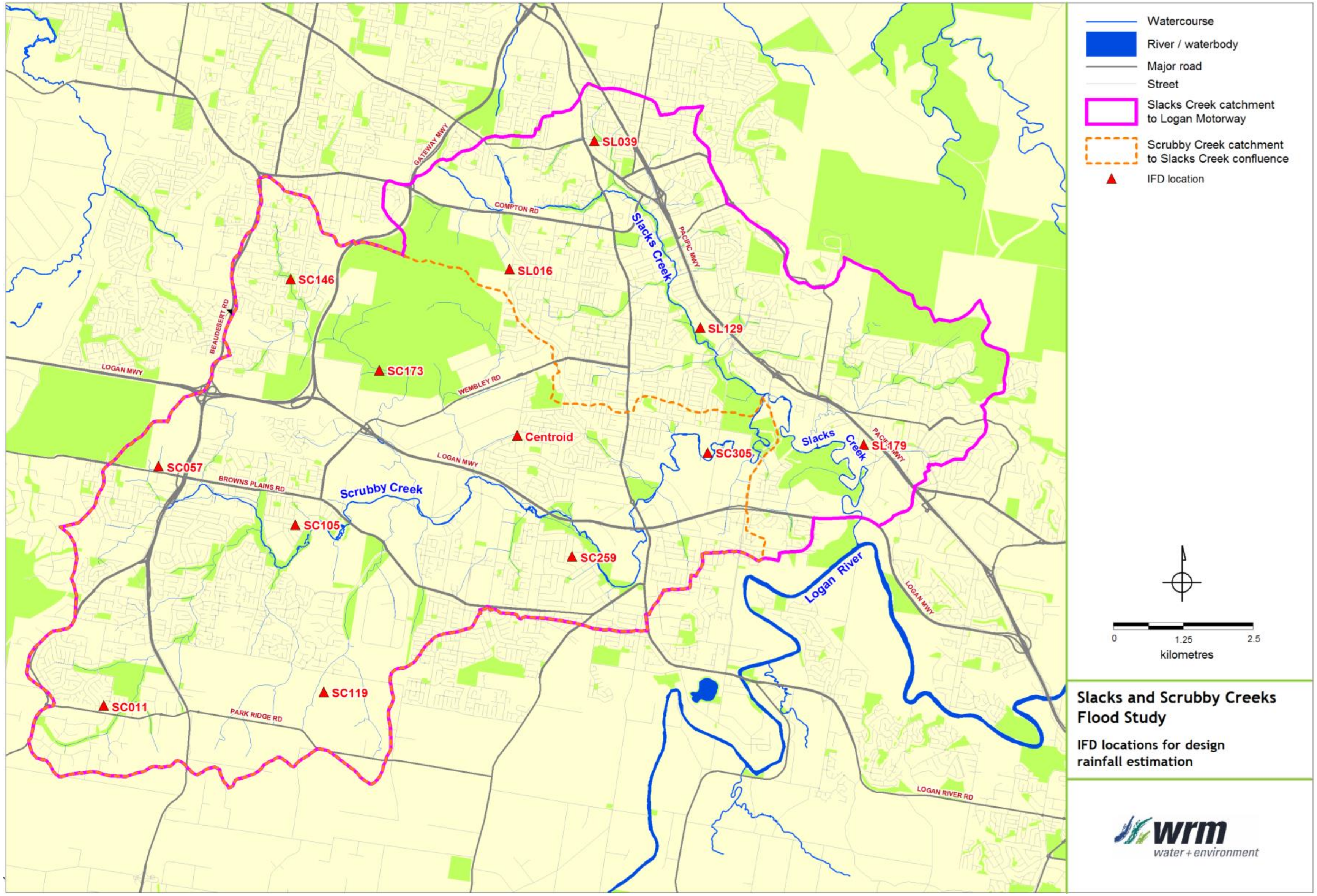

Figure 8.1 – Adopted IFD point locations for estimation of design rainfalls in the Slacks Creek catchment

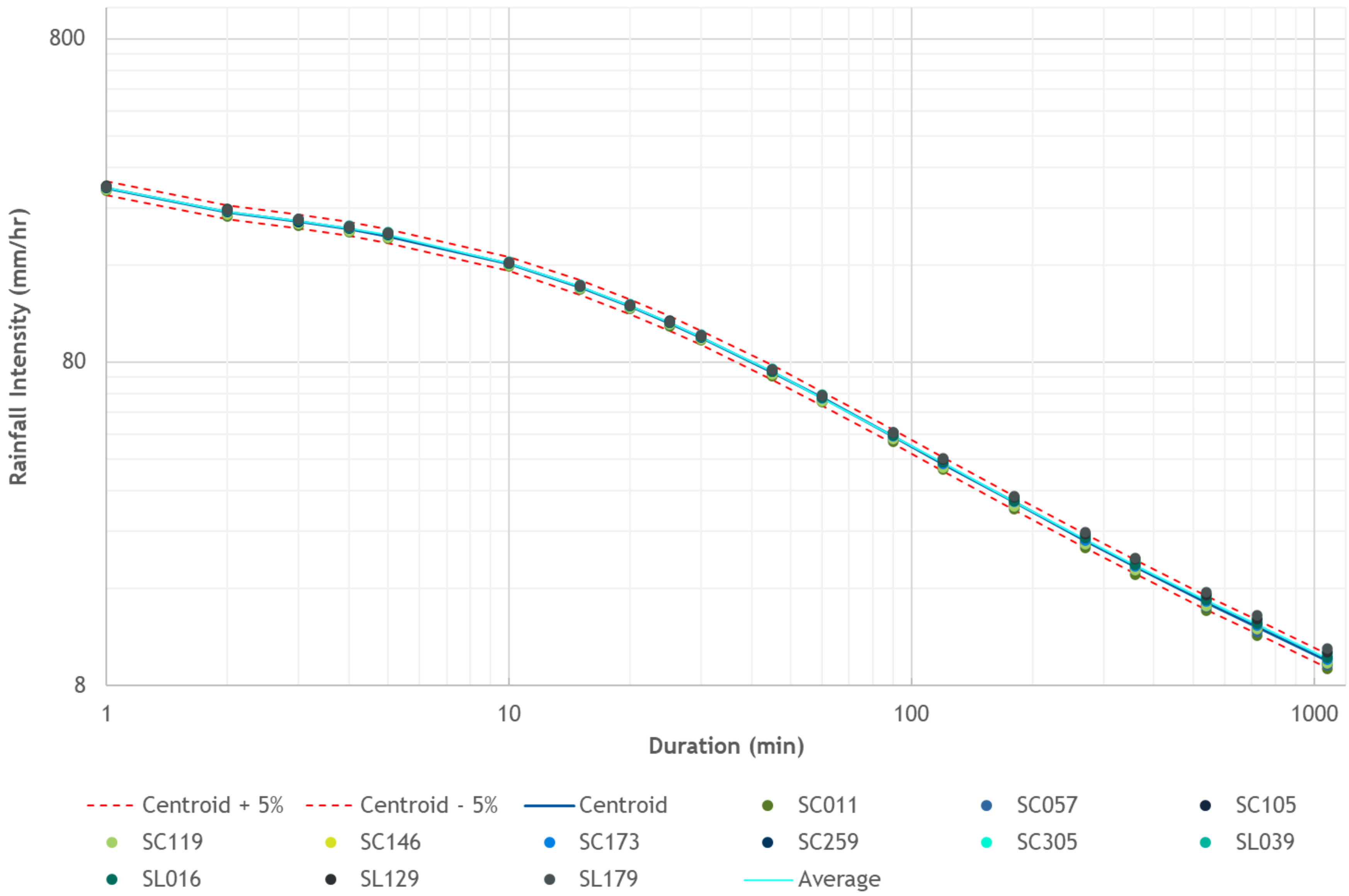

Figure 8.2 - Comparison between IFDs generated at 13 locations in the Slacks Creek catchment, 10% (1 in 10 ARI) AEP design event

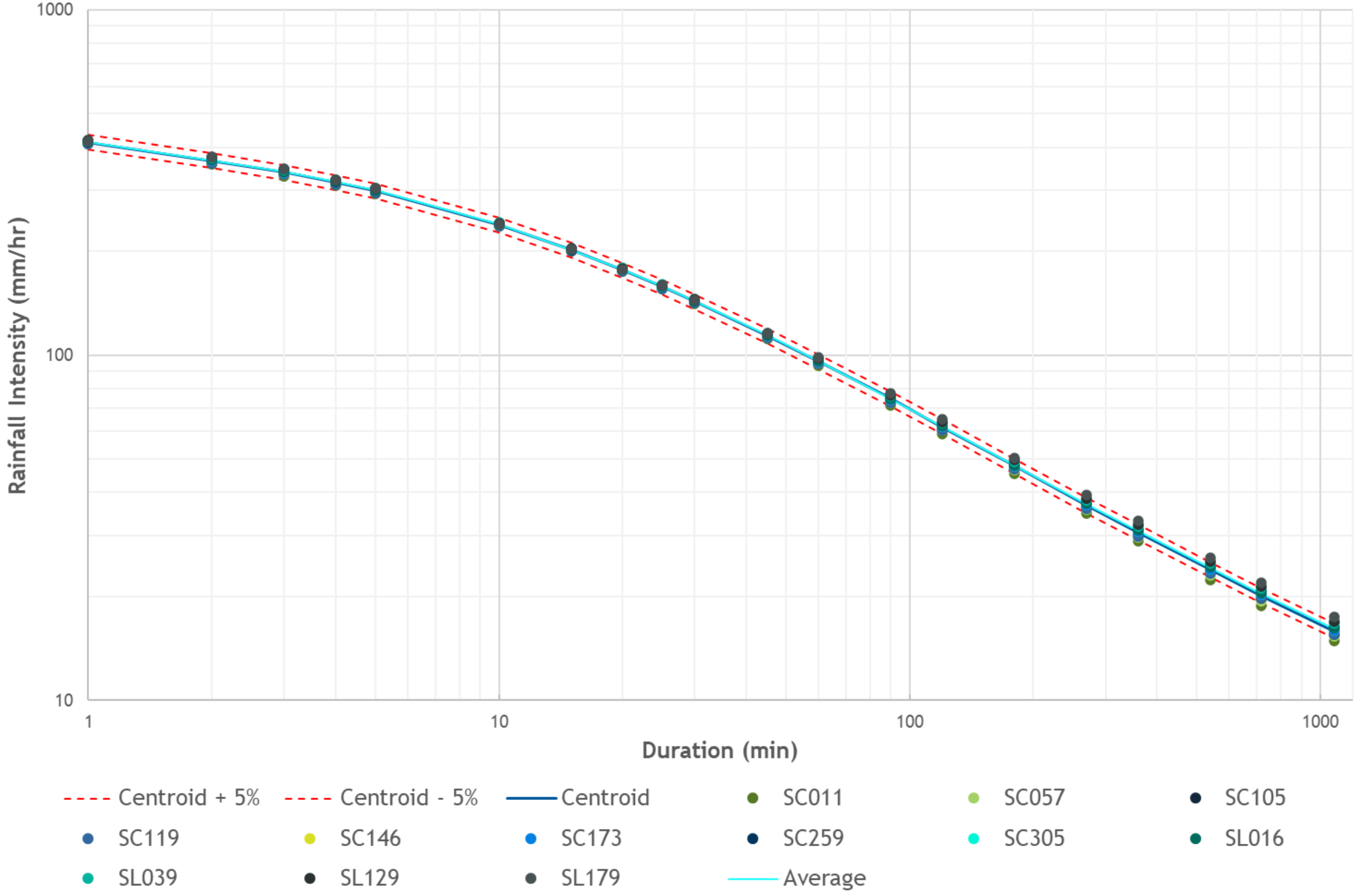

Figure 8.3 - Comparison between IFDs generated at 13 locations in the Slacks Creek catchment, 1% (1 in 100 ARI) AEP design event

Design CLs were derived based on the following methodology:

- The adopted CLs for this study were based on the calibration event CLs given in Section 5.5;
- Subcatchments with less than 30% imperviousness were assigned a CL of 1.1 mm/h;
- Subcatchments with more than 75% imperviousness were assigned a CL of 0.1 mm/h;
- CLs for other subcatchments were interpolated based on the subcatchment fraction imperviousness (as per the calibration event modelling); and
- Although AR&R 2019 recommends a CL of 1.5 mm/h, the calibration event CLs were adopted for the following two reasons:
    - Adopting the calibration event CLs resulted in a good match between modelling results and recorded data. Therefore, the calibration event CLs are considered more representative of local catchment characteristics when compared to the CL recommended by AR&R 2019.
    - The calibration event CLs produces more conservative estimates of design discharges when compared to the CL recommended by AR&R 2019.

Table 8.2 shows the median design event pre-burst rainfalls obtained from the AR&R 2019 data hub. Table 8.3 shows the adopted design CLs.

Table 8.2 - Adopted median design event pre-burst rainfall depths

Storm duration (hours)	AR&R 2019 median pre-burst rainfall depths (mm)					
	50% AEP event	20% AEP event	10% AEP event	5% AEP event	2% AEP event	1% AEP event
1.0	7.9	7.4	7.0	6.6	9.2	11.0
1.5	1.3	9.4	14.8	19.9	15.4	12.0
2.0	2.7	10.9	16.3	21.5	21.7	21.8
3.0	2.7	10.8	16.2	21.3	27.0	31.3
6.0	10.2	15.9	19.7	23.3	44.5	60.3
12.0	4.6	15.2	22.3	29.0	46.7	60.0
18.0	4.4	13.4	19.4	25.1	41.8	54.3

Table 8.3 - Adopted design continuing loss values

Subcatchment percentage impervious (%)	Adopted CL (mm/h)
0-30	1.1
30-40	0.8
40-50	0.7
50-60	0.6
60-75	0.5
75+	0.1

8.6.2 0.5% (1 in 200 ARI) to 0.05% (1 in 2,000 ARI) AEP design events

A 0.0 mm initial loss was adopted for the 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI) and 0.05% (1 in 2,000 ARI) AEP design events. The CLs for these events were adopted as per the CLs for the smaller events as shown in Table 8.3.

8.6.3 PMPDF event

A 0.0 mm initial loss was adopted for the PMPDF event. The CLs for this event were adopted as per the CLs for the smaller events as shown in Table 8.3.

8.7 FUTURE CLIMATE SCENARIO (2090)

To obtain climate change scenario design flow hydrographs, design rainfall in the XP-RAFTS hydrologic model was increased by a factor of 1.095 (9.5% increase) in accordance with guidelines in Book 1 Chapter 6 of the 2019 ARR (Ball et al, 2019). The adopted multiplication factor is based on the RCP4.5 climate change projection, a planning horizon of year 2090 and a projected warming of 1.862 degrees Celsius. Design rainfall losses and all other hydrologic model parameters are the same for both the current climate and future climate scenarios.

8.8 DESIGN PEAK DISCHARGES

The XP-RAFT model was used to generate design discharge hydrographs at each subcatchment only. These XP-RAFTS local subcatchment design discharge hydrographs were then applied as inflows to the TUFLOW hydraulic model. The TUFLOW model is considered to represent channel routing within the Slacks and Scrubby creeks catchment more accurately when compared to the XP-RAFTS model. Therefore, design discharges at various locations throughout the Slacks and Scrubby creeks catchment were extracted from the TUFLOW model results.

A summary of design peak discharges and critical storm durations at key locations in the Slacks and Scrubby creeks catchment is given in Section 10.3 of this report.

9 Design event hydraulic model development

9.1 OVERVIEW

The calibrated TUFLOW model was used to estimate flood levels, depths, velocities and flood hazard in Slacks and Scrubby creeks for the 50% (1 in 1.44 ARI), 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI), 0.05% (1 in 2,000 ARI) AEP events and the PMPDF event, for a range of storm durations from 10 minutes to 18 hours.

The calibrated TUFLOW model described in Section 6 was modified for design event and validation modelling to reflect the following changes:

- The re-development of Bunnings Warehouse, Underwood at the corner of Compton and Ewing Roads (Bunnings Underwood);
- A new pedestrian bridge parallel to the Kingston Road Bridge in Scrubby Creek;
- New developments and structures captured by the LCC 2021 LiDAR; and
- Updated inflow and outflow boundary conditions.

Sensitivity testing was also undertaken for the 1% (1 in 100 ARI) AEP event to assess the impact of increased rainfalls due to climate change, increased hydraulic roughness, and increased blockage of hydraulic structures as well as removal of blockage of hydraulic structures on the model results.

This section presents the methodology adopted to produce the desired outputs from the hydraulic model throughout the Slacks and Scrubby creeks catchment.

9.2 HYDRAULIC MODEL CHANGES

9.2.1 Topography

9.2.1.1 Bunnings Underwood

Based on historical aerial photos, the re-development of Bunnings Underwood began in 2017 and was completed in 2018 (after the three calibration events assessed in this study). Building pads and parking lots were re-graded and a new trunk stormwater pipe network installed as part of this re-development. The revised finished floor levels at Bunnings Underwood was incorporated into the TUFLOW model, and was configured based on as-constructed drawings supplied by LCC. It is of note that the open channel located along the eastern lot boundary of the Bunnings Underwood site has been filled as part of the re-development, and replaced with a run of stormwater pipes.

9.2.1.2 LCC 2021 LiDAR

Based on the LCC 2021 LiDAR, there are several areas which have been newly developed or under development in comparison to the calibration models. To reflect the changes in topography in 2021, the LCC 2021 LiDAR was incorporated into the TUFLOW model.

9.2.2 Hydraulic structures

The TUFLOW model for design events includes two new runs of trunk stormwater pipes, two new field inlet pits and three new manholes which were installed as part of the Bunnings Underwood re-development. This new network of stormwater pipes, pits and manholes were configured based on as-constructed drawings supplied by LCC. It is of note that this new trunk stormwater network replaces the open channel that was previously located along the eastern lot boundary of the Bunnings Underwood site. All other culverts, trunk stormwater pipes, inlet pits and manholes included in the calibration event TUFLOW model (described in Section 4) were also included in the TUFLOW model for design events.

The TUFLOW model for design events also includes:

- An additional pedestrian bridge parallel to the Kingston Road Bridge in Scrubby Creek, which was recently constructed. This bridge did not exist during the three model calibration periods (January 2013, May 2015 and March 2017), hence it was not included in the calibration event TUFLOW model. The additional pedestrian bridge was configured using a layered flow constriction based on design drawings supplied by LCC. All other bridges included in the calibration event TUFLOW model (described in Section 4) were also included in the TUFLOW model for design events.
- An additional bridge constructed near Jacaranda Avenue, Kingston. This bridge did not exist for model calibration periods, hence it was not included in the calibration event model. The additional bridge was configured using a layered flow constriction, and was incorporated in the TUFLOW model for the validation and design events.

Blockage factors for inlet pits, culverts and bridges were determined based on the guidelines in Book 6 - Chapter 6 of ARR 2019 (Ball et al., 2019). Table 9.1 shows the adopted blockage factors for culverts. The following is of note with regards to the adopted design blockage factors:

- The adopted blockage factors for culverts and bridges were determined individually depending on the size and configuration of each structure.
- The debris potential classification for structures within the model extent was determined as “Medium”, based on the assessment of the following:
  - An L_{10} value of 1.2 m was adopted. This was estimated as the average length of the longest 10% of the debris that could potentially contribute to streams within the study area.
  - The ‘debris availability” classification was determined as “Medium” based on the modelled streams having moderate to flat slopes with stable bed and banks.
  - The “debris mobility” classification was determined as “High”, based on steep upstream source areas with fast catchment response times and high annual rainfall, the modelled streams considered to frequently overtop their banks, and the main debris areas being close to the streams.
  - The “debris transportability” was determined as “Medium”, based on the study area containing a mixture of streams with flat and steep bed slopes, deep and wide streams relative to the potential debris dimension, and streams that generally meander through the floodplain.
- Design blockage factors were applied to all cross-drainage culverts and pipes as shown in Table 9.1. However, zero blockage was applied to all trunk stormwater pipes.
- For inlet pits, QUDM recommends blockage factors of 20% and 50% for kerb and grated inlet pits respectively. For this study, a blockage factor of 50% was adopted for all kerb and grated inlet pits.
- For bridges, blockage factors due to piers were determined by doubling the pier width (to simulate debris accumulation). A full (100%) blockage was adopted for road barriers and guard rails.

Table 9.1 – Adopted blockage factors for hydraulic structures

Storm event (AEP)	Design blockage (%)		
	W[a] < L_{10}	L_{10}< W < 3* L_{10}	W > 3*L_{10}
50% to 10%	25%	0%	0%
5% to 0.5%	50%	10%	0%
0.2% to PMPDF	100%	20%	10%

[a] –W is the width of a single barrel across the drainage structure.

9.2.3 Hydraulic roughness

The hydraulic roughness mapping for the Bunnings Underwood site was revised slightly due to the de-development of the site. For all other areas in the model, the hydraulic roughness mapping adopted for the calibration events was also adopted for the design events without changes.

Based on the Council planning scheme, some undeveloped areas within the Slacks and Scrubby creeks catchment are zoned for future development. Although these areas may undergo significant urbanisation, it is assumed that the waterway channels in these areas will be maintained close to existing conditions.

9.2.4 Inflow boundaries

Due to the re-development of Bunnings Underwood, two 2D (SA) inflow boundaries in the calibration model (inflow locations SL066 and SL067) were replaced with 1D inflow boundaries. In comparison with the calibration events, several 2D (SA) inflow boundaries were moved to match the predicted waterway extent provided by LCC. Where applicable, local inflow boundaries were converted into total inflow boundaries at the upstream section of the water way extent. Local and total inflow hydrographs generated from the XP-RAFTS model for ultimate catchment conditions were adopted as inflows at the 2D and 1D inflow boundaries.

The hydraulic model was run for one design storm for each storm duration. In some cases, additional design storms were run through the hydraulic model depending on whether flood levels are determined by conveyance or floodplain storage, or if there are no clearly dominant representative temporal pattern for a certain duration. A discussion on the selection of representative temporal patterns (design storms) for each storm duration is provided in Section 10.2.2 of this report.

9.2.5 Outflow boundaries

9.2.5.1 Methodology for Logan River tailwater level estimation

Tailwater levels in the Logan River are likely to influence peak flood levels near the downstream boundary of the TUFLOW model. Therefore, at the primary outflow boundary located in Slacks Creek, a constant tailwater level equal to an adopted coincident Logan River flood level for each event was used for all modelled events. The secondary 'normal depth' outflow boundary located at Mandew Street was unchanged from the calibration event TUFLOW model.

The Logan River tailwater levels at the primary outflow boundary was estimated using the 'Hydrograph procedure for non-tidal creeks and rivers' procedure given in the background notes of the Queensland Urban Drainage Manual (QUDM) (IPWEA, 2016).

It is of note that Chapter 8.3.4 in QUDM only explicitly outlines the 'Simplified Rational Method time of concertation' method for estimating coincident flooding. However, QUDM also provides alternative procedures for estimating coincident flooding in the QUDM background notes.

The method that is considered most appropriate for use in this study is the 'Hydrograph procedure for non-tidal creeks and rivers'. Based on this method, the Logan River hydraulic model (WRM, 2022) was used to estimate Logan River tailwater levels at the confluence with Slacks Creek at the time that corresponds to the Slacks Creek peak discharge at the catchment outlet.

The Logan River tailwater levels were determined by comparing discharge hydrographs at the outlet of Slacks Creek with the predicted water level hydrograph in the Logan River for the critical storm duration in the Slacks Creek catchment at the outlet (12 hours based on the hydrologic modelling results). The water level in the Logan River at the time of the peak discharge at the outlet of Slacks Creek was then adopted as the tailwater condition for that design event.

The Logan River tailwater level derived for the 12-hour storm duration was then adopted for all other storm durations for each event (i.e. the tailwater for the 12-hour storm was also adopted for the 1-hour storm). This results in conservatively high tailwater levels being adopted for shorter duration storm events.

It is of note that both the Logan Albert River hydraulic model (WRM, 2022) and the Slacks Creek model uses the AR&R 2019 hydrology (Ball et al, 2019), and hence the outputs o the two studies are compatible for the QUDM Hydrograph Procedure.

9.2.5.2 Adopted Logan River tailwater levels

Table 9.2 shows the adopted Logan River tailwater levels for all modelled events, which were obtained from the Logan Albert model (WRM, 2022) using the QUDM hydrograph procedure.

Table 9.2 – Adopted Logan River tailwater levels

AEP (%) in Slacks Creek	Adopted Logan River tailwater level (mAHD)	Adopted future climate (2090) Logan River tailwater level (mAHD)
50	3.43	-[a]
20	3.76	4.51
10	4.46	5.04
5	4.97	5.42
2	5.74	6.06
1	6.27	6.55
0.50	6.38	6.69
0.20	6.71	7.06
0.05	7.16	-[a]
PMPDF	9.48	-[a]

[a] – No climate change modelling was undertaken for event

10 Design event hydraulic modelling results

10.1 OVERVIEW

This section presents the outputs (results) from the hydraulic model throughout the Slacks and Scrubby creeks catchment. The hydraulic model results include design flood levels, depths, velocities and flood hazard.

10.2 INTERPRETATION OF RESULTS

10.2.1 'Max-Max' water surface profiles

A 'max-max' water surface profile was developed for each design event by interrogating the results for all representative temporal patterns for each storm duration to obtain the design flood level, depth, velocity, critical storm duration, depth-velocity product and flood hazard classification for every location impacted by flooding from Slacks and Scrubby creeks.

10.2.2 Discussion on selection of representative temporal patterns (current climate)

Table 10.1 shows the representative temporal patterns that were selected to produce the 'max-max' water surface profiles for each event. Initially, additional temporal patterns were selected in addition to those shown in Table 10.1 based on the XP-RAFTS hydrologic model results. However, based on the TUFLOW hydraulic model results, only the representative temporal patterns shown in Table 10.1 were eventually adopted for mapping.

Note that for some storm durations in each event, the TUFLOW model results indicate that more than one (and up to three) temporal patterns were equally dominant (refer to Table 10.1). Therefore, for these storm durations, up to three representative temporal patterns were adopted for mapping.

The reasons for selecting the temporal patterns shown in Table 10.1 as the representative temporal patterns are described below:

- For the 50% AEP (1 in 1.44 ARI) event:
    - For storm durations between 15 minutes and 270 minutes (4.5 hours), between one and three temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.
    - For the 720-minute (12-hour) storm duration, temporal pattern #8 was initially selected in addition to temporal pattern #2 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #8 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper tributaries of the catchment where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #2 was adopted for mapping.
- For the 20% AEP (1 in 4.48 ARI) event:
    - For storm durations between 15 minutes and 120 minutes (2 hours), between one and two temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the

  - XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.
  - For the 540-minute (9-hour) storm duration, temporal pattern #1 was initially selected in addition to temporal pattern #6 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #1 produced discharge hydrographs that did not appear consistent with discharge hydrographs for shorter storm durations. In addition, temporal pattern #1 produced critical peak discharges and water levels in the upper parts of the Scrubby Creek catchment where a nine-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #6 was adopted for mapping.
  - For the 720-minute (12-hour) storm duration, temporal pattern #2 were initially selected in addition to temporal pattern #1 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal patterns #2 contained concentrated storm bursts which produced critical peak discharges and water levels in the upper parts of the Scrubby Creek catchment where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #1 was adopted for mapping.
- For the 10% AEP (1 in 10 ARI) event:
  - For storm durations between 15 minutes and 360 minutes (6 hours), between one and two temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.
  - For the 720-minute (12-hour) storm duration, temporal pattern #9 was initially selected in addition to temporal pattern #4 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal patterns #9 contained concentrated storm bursts which produced critical peak discharges and water levels in the upper parts of the Scrubby Creek catchment where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #4 was adopted for mapping.
- For the 5% AEP (1 in 20 ARI) event:
  - For storm durations between 15 minutes and 540 minutes (9 hours), between one and two temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.
  - For the 720-minute (12-hour) storm duration, temporal patterns #9 was initially selected in addition to temporal pattern #10 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #9 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper parts of the Scrubby Creek catchment where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #10 was adopted for mapping.
- For the 2% AEP (1 in 50 ARI) event:
  - For storm durations between 10 minutes and 270 minutes (4.5 hours), between one and three temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.

- For the 360-minute (6-hour) storm duration, temporal pattern #7 was initially selected in addition to temporal pattern #3 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #7 produced a discharge hydrograph shape that did not appear consistent with the discharge hydrograph shapes for shorter storm durations. In addition, temporal pattern #7 produced significantly higher peak discharges along Scrubby Creek when compared to temporal pattern #3, resulting in inconsistent peak discharges when compared against smaller events. On this basis, only temporal pattern #3 was adopted for mapping.
- For the 540-minute (9-hour) storm duration, temporal patterns #6 was initially selected in addition to temporal pattern #1 and #2 based on the XP-RAFTS model results. The TUFLOW model results indicate that temporal pattern #6 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper tributaries of Slacks Creek where a 9-hour critical storm duration is considered unlikely. On this basis, temporal patterns #1 and #2 was adopted for mapping.
- For the 720-minute (12-hour) storm duration, temporal patterns #10 was initially selected in addition to temporal pattern #6 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #10 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper tributaries of Scrubby Creek where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #6 was adopted for mapping.

* For the 1% AEP (1 in 100 ARI) event:
    - For storm durations between 10 minutes and 270 minutes (4.5 hours), between one and three temporal patterns were run in addition to those shown in Table 10.1. These additional temporal patterns were initially selected based on the XP-RAFTS model results. The hydraulic model results were then used to identify the dominant representative temporal patterns (shown in Table 10.1). These representative temporal patterns were adopted for mapping.
    - For the 360-minute (6-hour) storm duration, temporal patterns #7 was initially selected in addition to temporal pattern #3 based on the XP-RAFTS model results. Similar to the 50% AEP event results, temporal pattern #7 appeared inconsistent and produced significantly higher peak discharges along Scrubby Creek when compared to temporal pattern #3. For the 1% AEP event, temporal pattern #7 produced peak discharges near Marsden that were close to the 0.5% AEP peak discharges. On this basis, only temporal pattern #3 was adopted for mapping.
    - For the 540-minute (9-hour) storm duration, temporal patterns #6 was initially selected in addition to temporal pattern #2 based on the XP-RAFTS model results. The TUFLOW model results indicate that temporal pattern #6 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper tributaries of Slacks Creek where a 9-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #2 was adopted for mapping.
    - For the 720-minute (12-hour) storm duration, temporal patterns #10 was initially selected in addition to temporal pattern #6 based on the XP-RAFTS model results. However, the TUFLOW model results indicate that temporal pattern #10 contained a concentrated storm burst which produced critical peak discharges and water levels in the upper tributaries of Scrubby Creek where a 12-hour critical storm duration is considered unlikely. On this basis, only temporal pattern #6 was adopted for mapping.
* For the 0.5% AEP (1 in 200 ARI) to PMPDF events:

- The GSDM temporal pattern was adopted for all storm durations up to and including 720 minutes (12 hours), while the GTSMR temporal pattern was adopted for the 1,080-minute (18-hour) storm duration.
- The GSDM temporal pattern used for the 0.5% AEP event vary significantly from the AR&R ensemble temporal patterns used for the 1% AEP event. For a given rainfall depth, the AR&R temporal patterns may produce a larger design discharge when compared to the GSDM temporal patterns for short duration storm events. This could also produce inconsistent 0.5% AEP design discharges when compared with 1% AEP design discharges for short duration storm events if the differences in design rainfall depths between 1% AEP and 0.5% AEP events are small. This is most likely to occur at the headwater subcatchments in the Slacks and Scrubby creeks catchment where the critical storm durations are short (e.g. less than 2 hours).

Table 10.1 - Design event representative temporal patterns

Storm duration	Design event representative temporal pattern									
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	0.05% AEP	PMPDF
10 minutes	5	5	6	6	2	1,2	GSDM	GSDM	GSDM	GSDM
15 minutes	6	6	5	5,8	5	5	GSDM	GSDM	GSDM	GSDM
20 minutes	7	7	4	4	8,9	9	GSDM	GSDM	GSDM	GSDM
25 minutes	8	8	10	10	5	8	GSDM	GSDM	GSDM	GSDM
30 minutes	9	9	8	8	2	2	GSDM	GSDM	GSDM	GSDM
45 minutes	7	1	4	5	5	2	GSDM	GSDM	GSDM	GSDM
60 minutes	5	5	7	7	3	3	GSDM	GSDM	GSDM	GSDM
90 minutes	10	10	6	6	6	6	GSDM	GSDM	GSDM	GSDM
120 minutes	5	3	8,9	8,9	9	2,3	GSDM	GSDM	GSDM	GSDM
180 minutes	10	1,9	8	2,4	2,6	6	GSDM	GSDM	GSDM	GSDM
270 minutes	10	10	4,9	4,10	1,8	9	GSDM	GSDM	GSDM	GSDM
360 minutes	5,6	6	2,9	9	3	3	GSDM	GSDM	GSDM	GSDM
540 minutes	1	6	4	4	1,2	2	GSDM	GSDM	GSDM	GSDM
720 minutes	2	1	4	10	6	6	GSDM	GSDM	GSDM	GSDM
1,080 minutes	7	7	5	5	1	3	GTSMR	GTSMR	GTSMR	GTSMR

10.2.3 Flood hazard classification

Figure 10.1 shows the adopted flood hazard vulnerability curves (AIDR, 2017), based on the flood depth, depth-velocity product and the flood velocity, that have been used to define the flood hazard vulnerability cross the floodplain. Descriptions of the hazard vulnerability classifications based on the vulnerability thresholds are given in Table 10.2.

Table 10.2 – Hazard vulnerability classifications

Hazard vulnerability	Description
H1	Generally safe for vehicles, people and buildings.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure.
H6	Unsafe for vehicles and people. All building types vulnerable to failure.

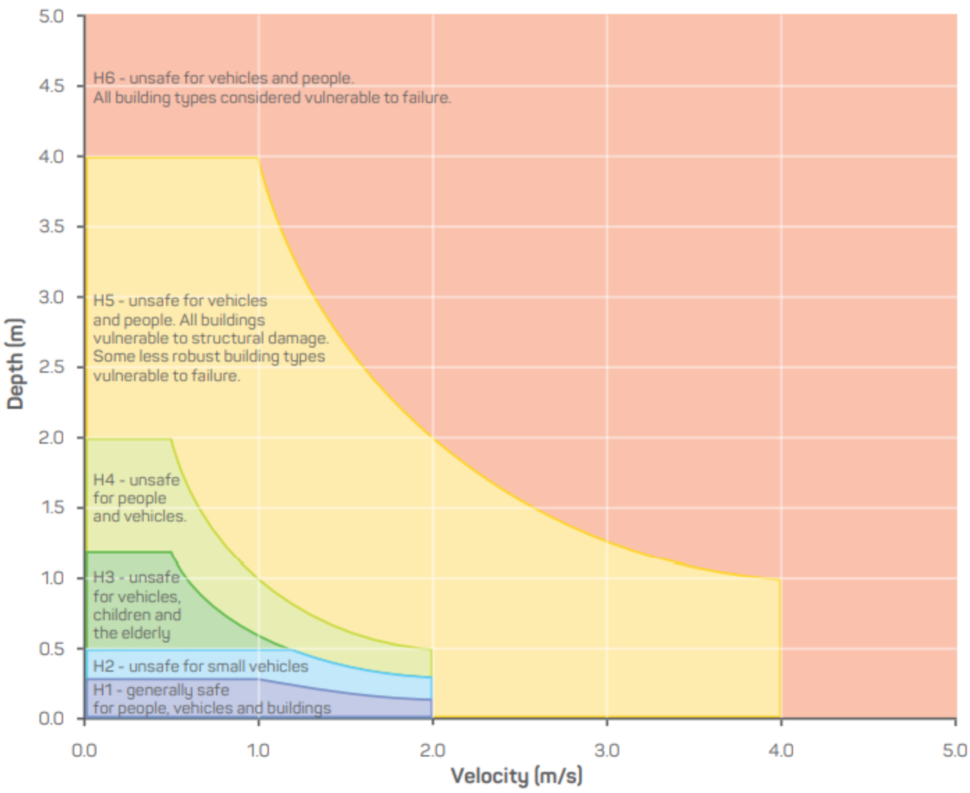

Figure 10.1 – Adopted flood hazard classification (AIDR, 2017)

10.3 SUMMARY OF DESIGN PEAK DISCHARGES

Table 10.3 shows the TUFLOW model predicted design peak discharges for the 10 modelled design events (50% AEP to the PMPDF event) at key locations in the Slacks and Scrubby creeks catchment. Table 10.5 shows the predicted critical storm durations.

10.4 SUMMARY OF DESIGN PEAK FLOOD LEVELS

Table 10.4 shows the TUFLOW model predicted design peak flood levels for the 10 modelled design events (50% AEP to the PMPDF event) at key locations in the Slacks and Scrubby creeks catchment. Table 10.5 shows the predicted critical storm durations.

10.5 FLOOD MAPPING

High-resolution flood maps (in A3 size and pdf format) are provided in Appendix E of this report. These maps include:

- Design peak flood levels for current and future climate scenarios;
- Design peak flood depths for current and future climate scenarios;
- Design peak flood velocities for current and future climate scenarios;
- Depth x velocity products for current and future climate scenarios;
- Flood hazard classifications (AEMI) for current and future climate scenarios);
- Critical storm duration maps for current and future climate scenarios; and
- Sensitivity analyses results (described in Section 10.7), including:
    - Flood level impact maps for the 1% AEP event, for the 'increased hydraulic roughness' and 'increased hydraulic structures blockage' scenarios (2 maps);
    - Flood level impact map comparing design peak flood levels between the 'no blockage' and 'design blockage' scenarios for the 1% AEP event without climate change (1 map);
    - Flood level impact maps for the 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP event for the 'climate change' scenarios (5 maps);
    - Flood level impact maps for the 20% and 1% AEP events for the waterway restoration scenario.

Flood maps for the 1% AEP (1 in 100 ARI) event (design blockage scenario) are also shown in Figure 10.2 for design peak flood levels, Figure 10.3 for design peak flood depths, Figure 10.4 for design flood velocities, Figure 10.5 for peak depth-velocity products, Figure 10.6 for flood hazard classifications and Figure 10.7 for critical storm durations.

10.6 LONGITUDINAL PROFILES OF DESIGN PEAK WATER LEVELS

Figure 10.8 and Figure 10.9 show longitudinal profiles of predicted peak water levels along Scrubby Creek and Slacks Creek respectively for all 10 design events. The chainage locations are shown in Figure 10.2. Note that:

- the longitudinal profiles along Scrubby Creek shown in Figure 10.8 start at Hilton Road (chainage SC-0 on Figure 10.2) and end at the Slacks Creek confluence just upstream of Loganlea Road (chainage SC-26600 on Figure 10.2); and
- the longitudinal profiles along Slacks Creek shown in Figure 10.9 start at the Gateway Motorway (chainage SL-0 on Figure 10.2) and end at the Slacks Creek outlet just downstream of the Logan Motorway (chainage SL-18000 on Figure 10.2).

Table 10.3 – TUFLOW model predicted design peak discharges at key locations in Slacks and Scrubby creeks, 50% AEP to PMPDF events

Location	TUFLOW model design peak discharge (m^3/s)									
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	0.05% AEP	PMPDF
Scrubby Creek										
Waller Road	97.4	151	181	218	262	285	349	399	514	1067
Marsden (First Avenue)	158	229	311	381	463	505	654	776	994	2107
Slacks Creek										
Reserve Park	95.6	153	167	206	251	280	382	444	556	1086
Loganlea Road	128	239	321	411	499	595	656	799	1012	2443
Logan Motorway	127	234	334	435	562	676	683	845	1097	2615

Table 10.4 – TUFLOW model predicted design peak flood levels in Slacks and Scrubby creeks, 50% AEP to PMPDF events

Location	TUFLOW model design peak flood level (mAHD)									
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	0.05% AEP	PMPDF
Scrubby Creek										
Waller Road	23.0	23.48	23.70	23.97	24.27	24.43	24.81	25.05	25.47	26.68
Marsden (First Avenue)	10.12	10.62	11.05	11.35	11.64	11.77	12.13	12.38	12.78	14.29
Slacks Creek										
Reserve Park	9.42	9.92	10.02	10.27	10.51	10.66	11.09	11.32	11.70	13.03
Loganlea Road	4.10	4.69	5.21	5.68	6.33	6.84	6.94	7.36	7.95	10.94
Logan Motorway	3.56	4.00	4.61	5.08	5.86	6.39	6.49	6.84	7.26	9.90

Table 10.5 – TUFLOW model predicted critical storm durations, 50% AEP to PMPDF events

Location	TUFLOW model critical storm duration (hours)									
	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	0.05% AEP	PMPDF
Scrubby Creek										
Waller Road	4.5	3.0	4.5	1.5	1.5	1.5	1.0	1.0	1.0	0.75
Marsden (First Avenue)	9.0	9.0	6.0	6.0	4.5	6.0	3.0	3.0	3.0	3.0
Slacks Creek										
Reserve Park	3.0	1.5	1.5	4.5	1.5	1.5	0.75	0.75	0.75	0.75
Loganlea Road	12.0	9.0	18.0	18.0	9.0	9.0	6.0	6.0	6.0	6.0
Logan Motorway	12.0	9.0	18.0	18.0	9.0	9.0	6.0	6.0	6.0	6.0

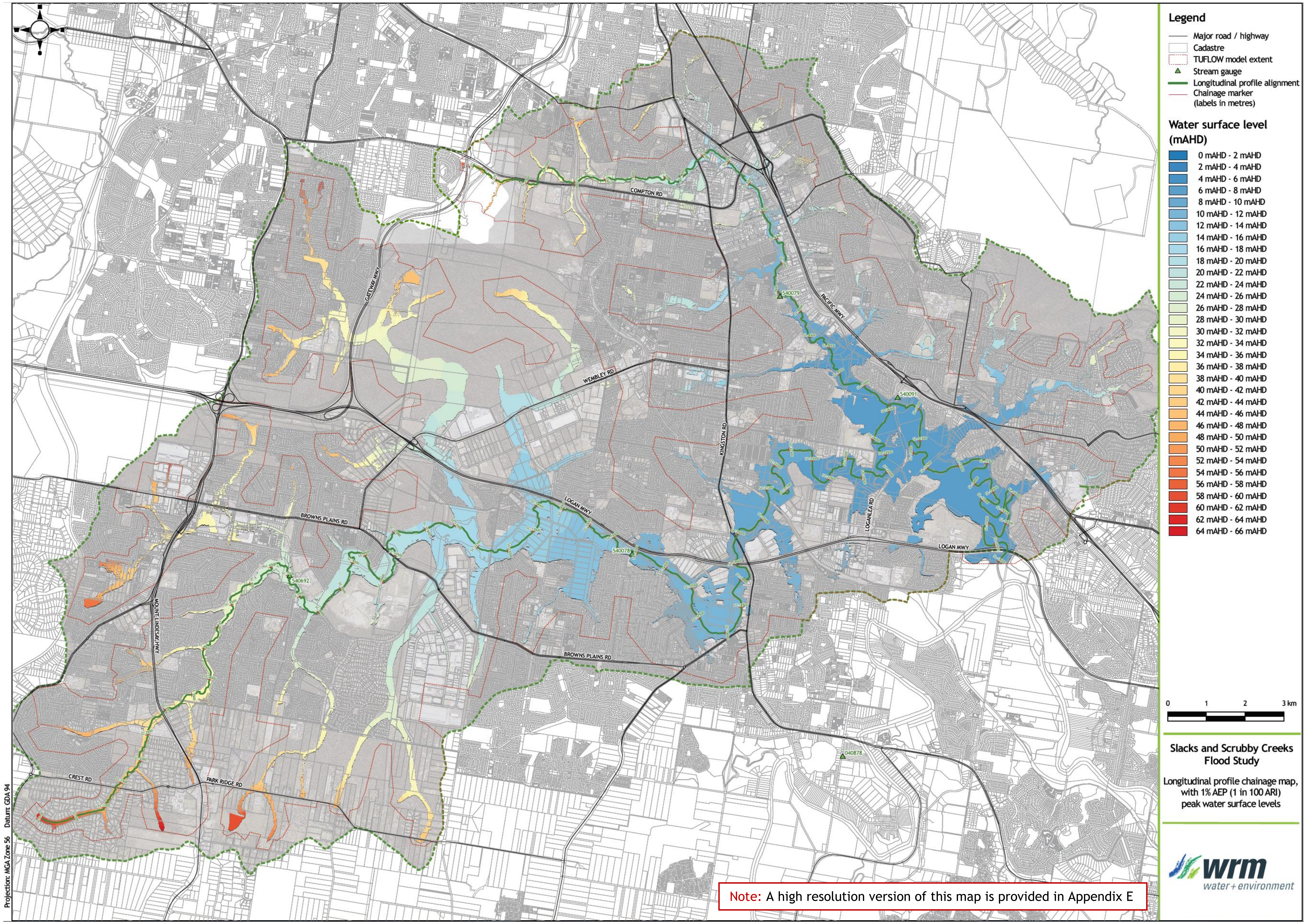

Figure 10.2 – Predicted design peak flood levels, 1% AEP (1 in 100 ARI) event

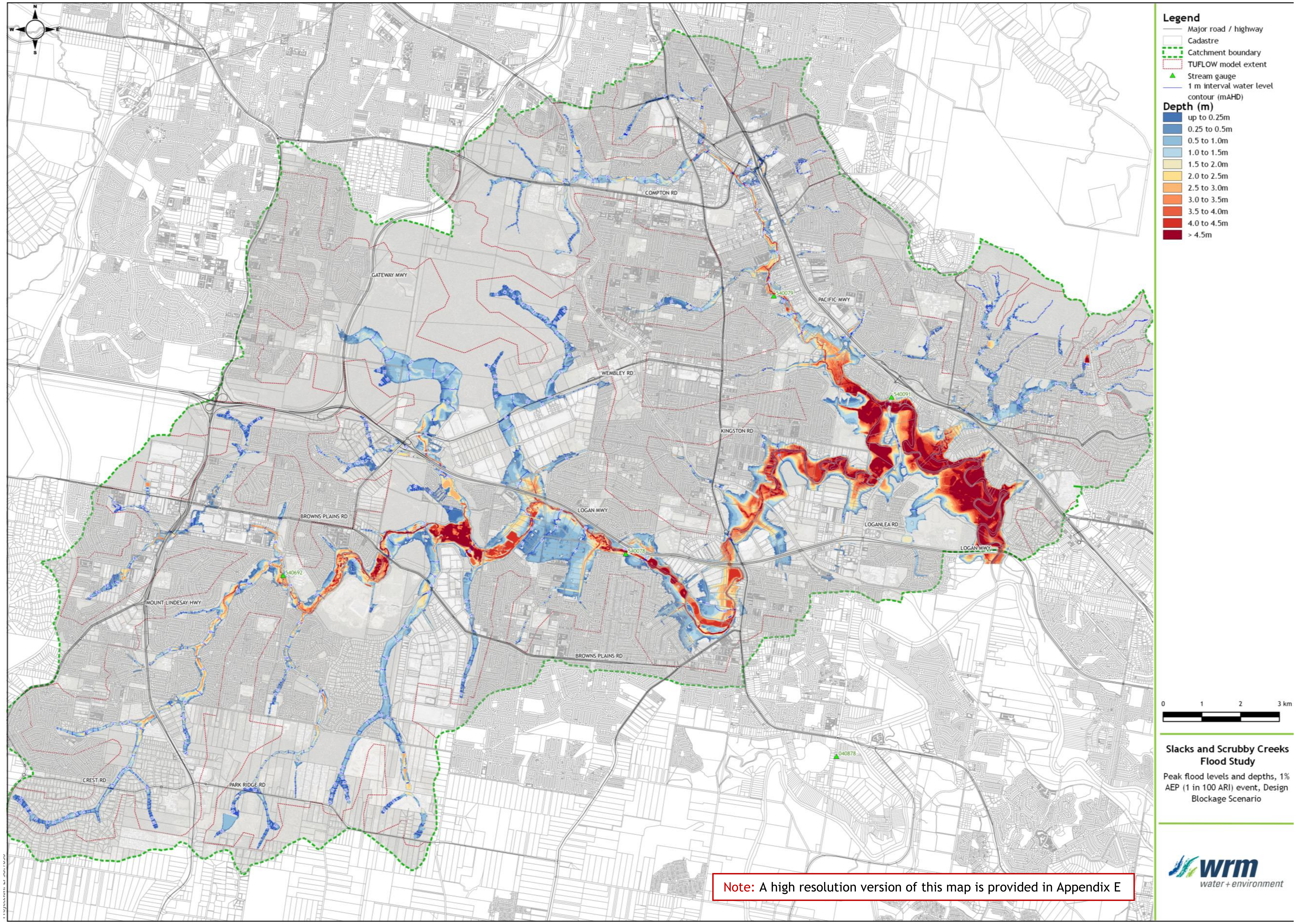

Figure 10.3 – Predicted design peak flood depths, 1% AEP (1 in 100 ARI) event

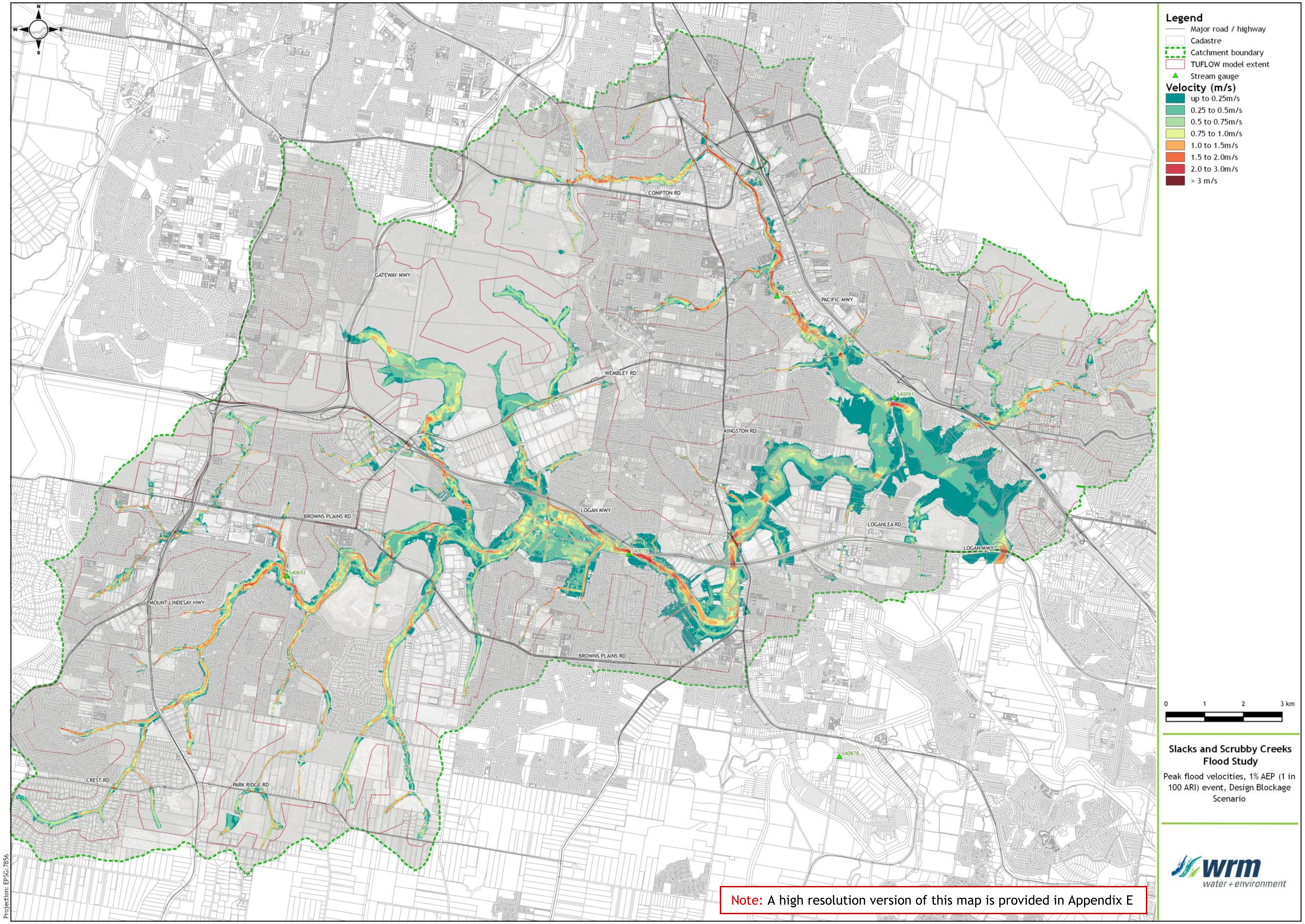

Figure 10.4 – Predicted design peak velocities, 1% AEP (1 in 100 ARI) event

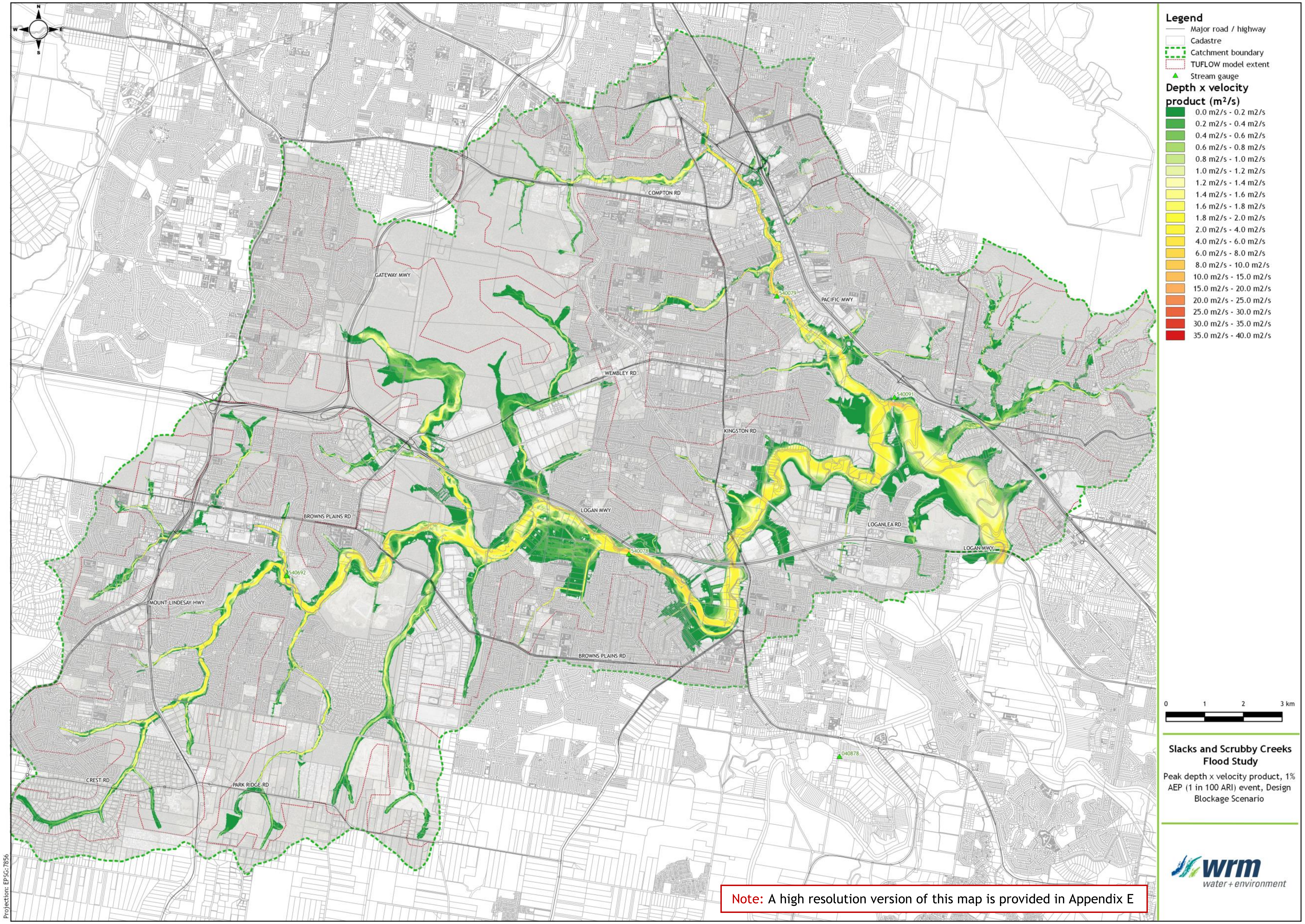

Figure 10.5 - Predicted peak depth x velocity product (dV), 1% AEP (1 in 100 ARI) event

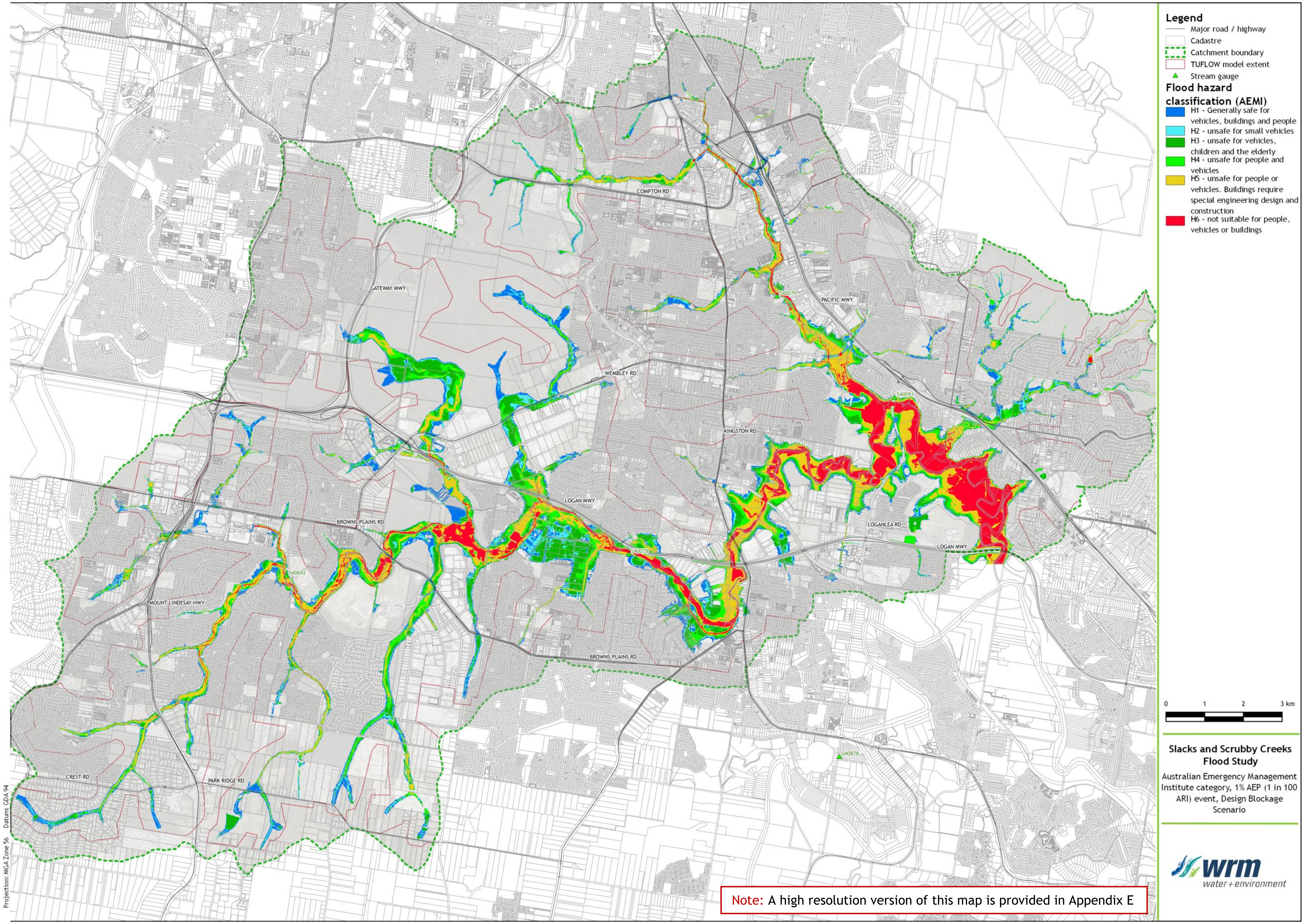

Figure 10.6 - Predicted flood hazard classification, 1% AEP (1 in 100 ARI) event

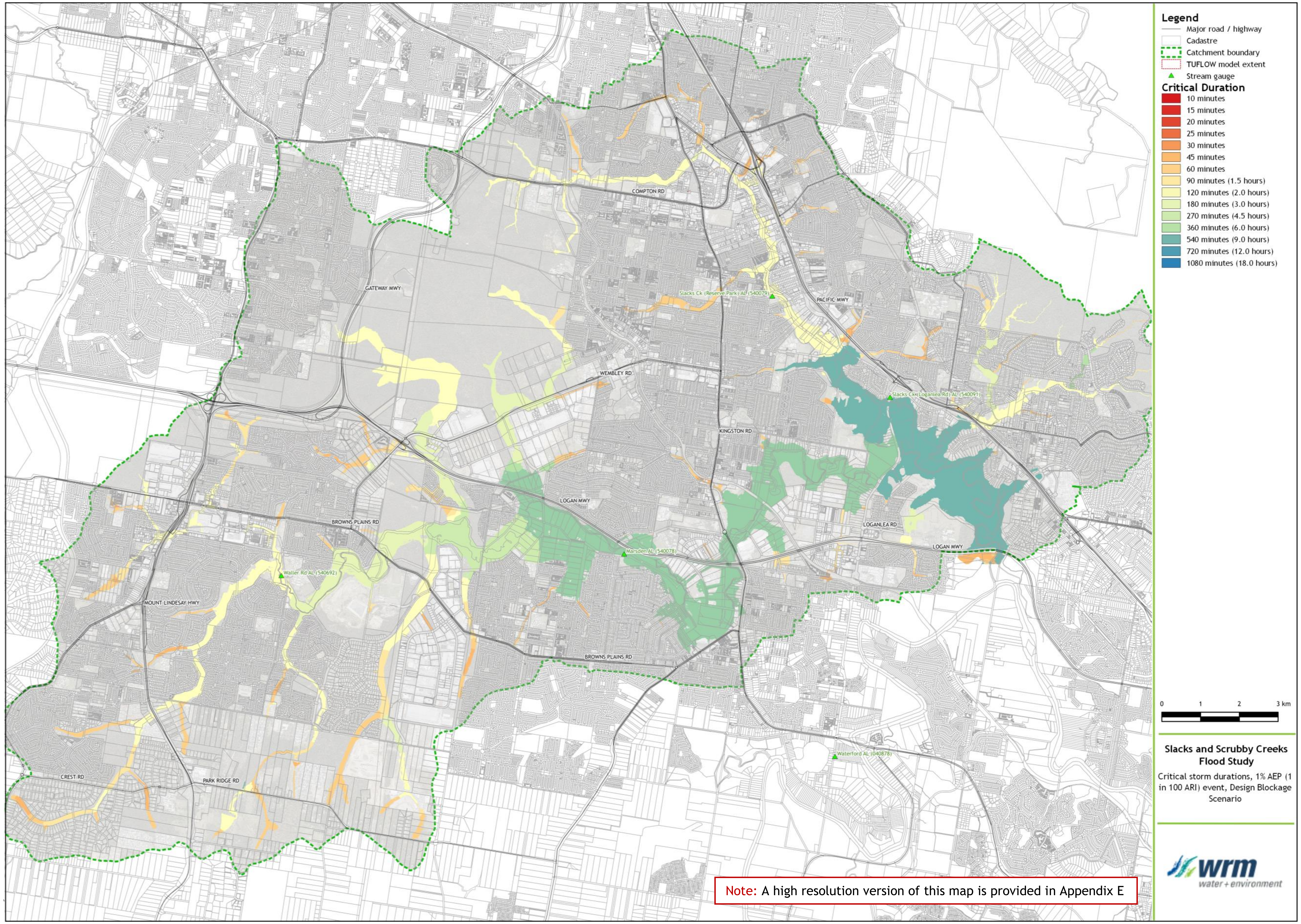

Figure 10.7 – Predicted critical storm durations, 1% AEP (1 in 100 ARI) event

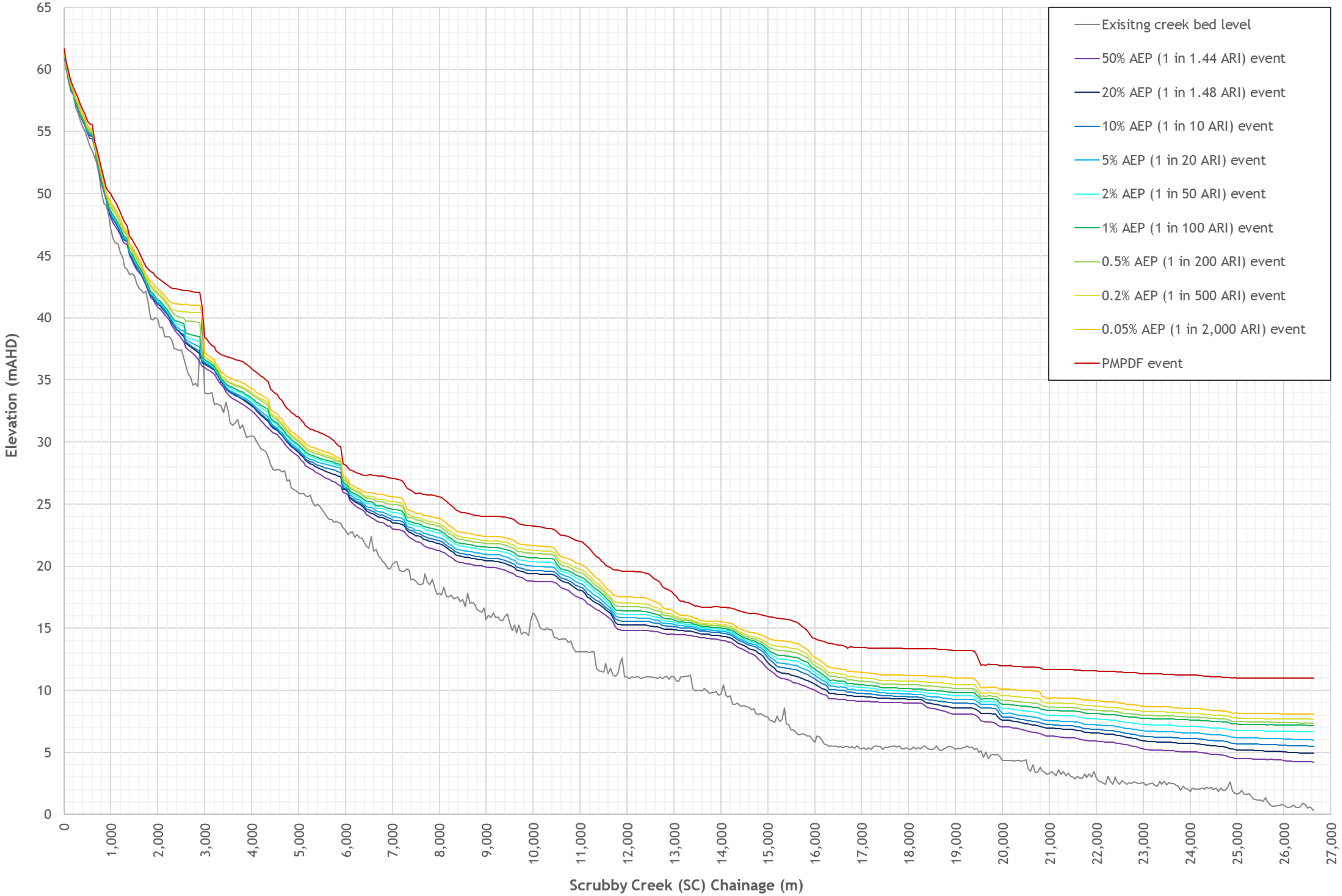

Figure 10.8 - Longitudinal profile of design peak water levels along Scrubby Creek (refer to Figure 10.2 for chainage locations)

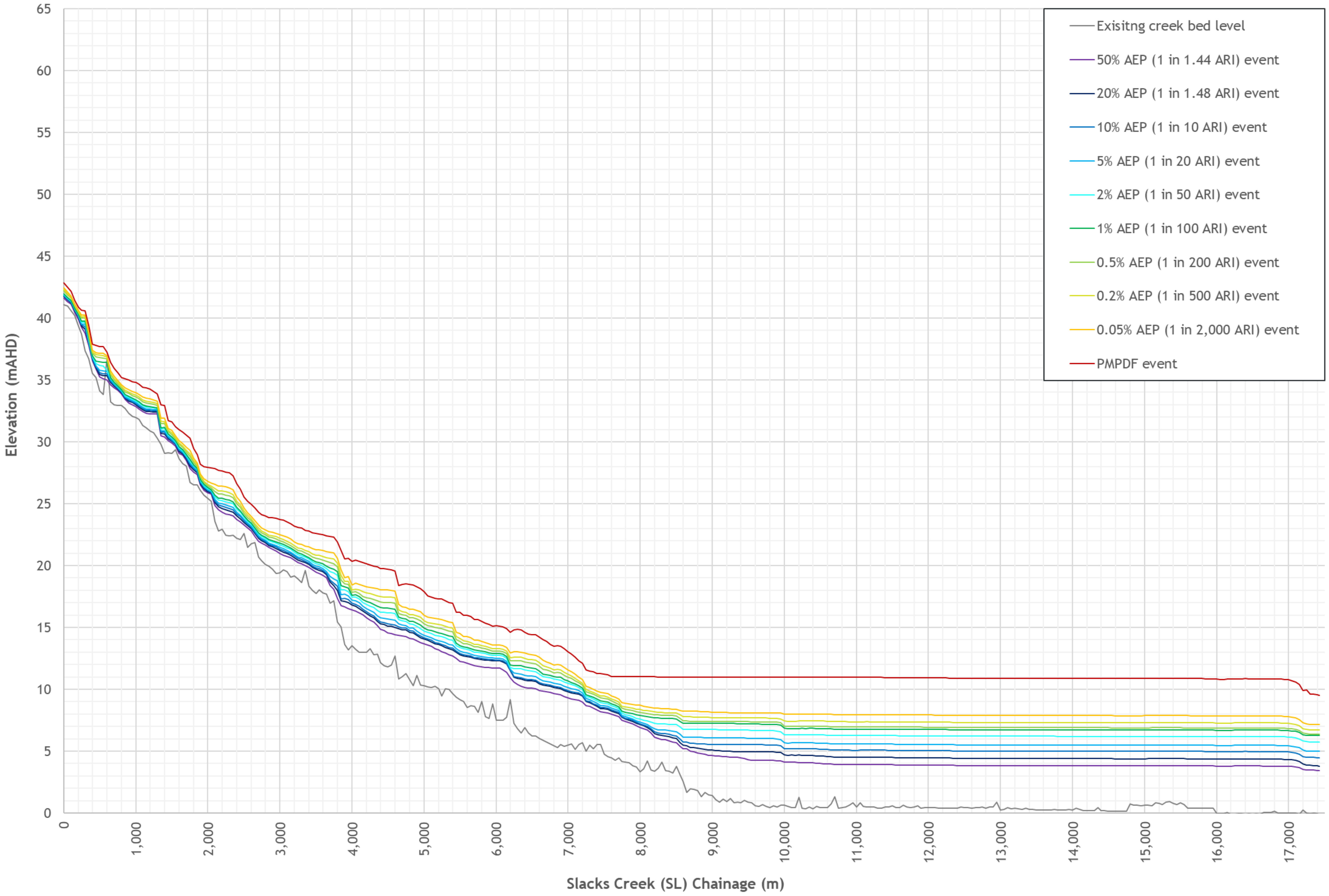

Figure 10.9 - Longitudinal profile of design peak water levels along Slacks Creek (refer to Figure 10.2 for chainage locations)

10.7 FUTURE CLIMATE SCENARIO (2090)

Figure 10.12 to Figure 10.16 shows the predicted impact of increased rainfall and higher Logan River tailwater levels due to climate change on 20% AEP (1 in 4.48 ARI), 10% AEP (1 in 10 ARI), 5% AEP (1 in 20 ARI), 2% AEP (1 in 50 ARI), 1% AEP (1 in 100 ARI), 0.5% AEP (1 in 200 ARI) and 0.2% AEP (1 in 500 ARI) peak flood levels. The model results indicate that the increased in rainfall intensities combined with increases in Logan River tailwater levels resulted in increases in peak flood levels throughout the Slacks and Scrubby creeks catchment. The predicted increases in peak flood levels for this scenario are summarised as follows:

- In the upper tributaries of Slacks and Scrubby creeks, the predicted increases in peak flood levels were not considered significant (generally between 0.01 m to 0.1 m) and did not result in major changes to the predicted flood extent.
- In the main channel of Scrubby Creek upstream of Kingston Road and the main channel of Slacks Creek upstream of Paradise Road, the predicted increases in peak flood levels were more significant (generally between 0.1 m and 0.3 m). Peak flood levels in these areas are impacted more by the increase in rainfall intensities compared to the increase in Logan River tailwater levels.
- In Scrubby Creek downstream of Kingston Road and in Slacks Creek downstream of Paradise Road, the predicted increases in peak flood levels are significant (between 0.3 m to 1 m). This is mainly due to the increase in Logan River tailwater levels.

Table 10.6 shows the selection of design temporal patterns for the future climate scenario. Table 10.7 and Table 10.8 shows the TUFLOW model predicted design peak discharges and peak flood levels for the 10 modelled design events (5% AEP to the 0.2% AEP) at key locations in the Slacks and Scrubby creeks catchment. Table 10.9 shows the predicted critical storm durations.

Table 10.6 – Design event representative temporal patterns for future climate

Storm duration	Design event representative temporal pattern for future climate						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
10 minutes	5	6	6	2	2	GSDM	GSDM
15 minutes	6	5	5	5	5	GSDM	GSDM
20 minutes	4	4	4	8,9	9	GSDM	GSDM
25 minutes	6,8	10	10	5	8	GSDM	GSDM
30 minutes	7,9	8	6,8	2,10	2,7	GSDM	GSDM
45 minutes	2,5,7	4,5	5	3,5	2	GSDM	GSDM
60 minutes	1,3,5	1,6	1,3	1,2,3,4	1,3	GSDM	GSDM
90 minutes	4,8,10	5,6	6	6	6	GSDM	GSDM
120 minutes	3,5	3,9	8,9	9	2,3	GSDM	GSDM
180 minutes	10	8	2,4	2,6	6	GSDM	GSDM
270 minutes	10	4,9,10	4,10	1,8,9	9	GSDM	GSDM
360 minutes	6,7	2,9	9	3	3	GSDM	GSDM
540 minutes	6	4	4	1,2	2	GSDM	GSDM
720 minutes	1	4	9	6	6	GSDM	GSDM
1,080 minutes	7	5	5	1	3	GTSMR	GTSMR

Table 10.7 – TUFLOW model predicted design peak discharges at key locations in Slacks and Scrubby creeks, 20% AEP to 0.2% AEP future climate change events

Location	TUFLOW model design peak discharge (m^3/s)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scrubby Creek							
Waller Road	169	199	244	287	312	410	471
Marsden (First Avenue)	260	352	428	522	560	731	874
Slacks Creek							
Reserve Park	172	193	228	278	311	434	505
Loganlea Road	287	373	441	555	693	747	934
Logan Motorway	288	395	489	628	763	790	1018

Table 10.8 – TUFLOW model predicted design peak flood levels in Slacks and Scrubby creeks, 20% AEP to 0.2% AEP future climate change events

Location	TUFLOW model design peak flood level (mAHD)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scrubby Creek							
Waller Road	23.62	23.84	24.15	24.44	24.60	25.11	25.34
Marsden (First Avenue)	10.80	11.23	11.52	11.81	11.92	12.29	12.58
Slacks Creek							
Reserve Park	10.05	10.19	10.39	10.65	10.80	11.29	11.54
Loganlea Road	5.10	5.62	6.01	6.63	7.15	7.28	7.79
Logan Motorway	4.70	5.25	5.62	6.23	6.70	6.85	7.33

Table 10.9 – TUFLOW model predicted critical storm durations, 20% AEP to 0.2% AEP future climate change events

Location	TUFLOW model design critical duration (h)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
Scrubby Creek							
Waller Road	2.0	4.5	1.5	1.5	1.5	1.5	1.5
Marsden (First Avenue)	9.0	6.0	6.0	4.5	6.0	3.0	4.5
Slacks Creek							
Reserve Park	1.5	4.5	4.5	1.5	1.5	1.0	1.0
Loganlea Road	9.0	18.0	12.0	9.0	6.0	6.0	9.0
Logan Motorway	9.0	18.0	12.0	9.0	9.0	6.0	9.0

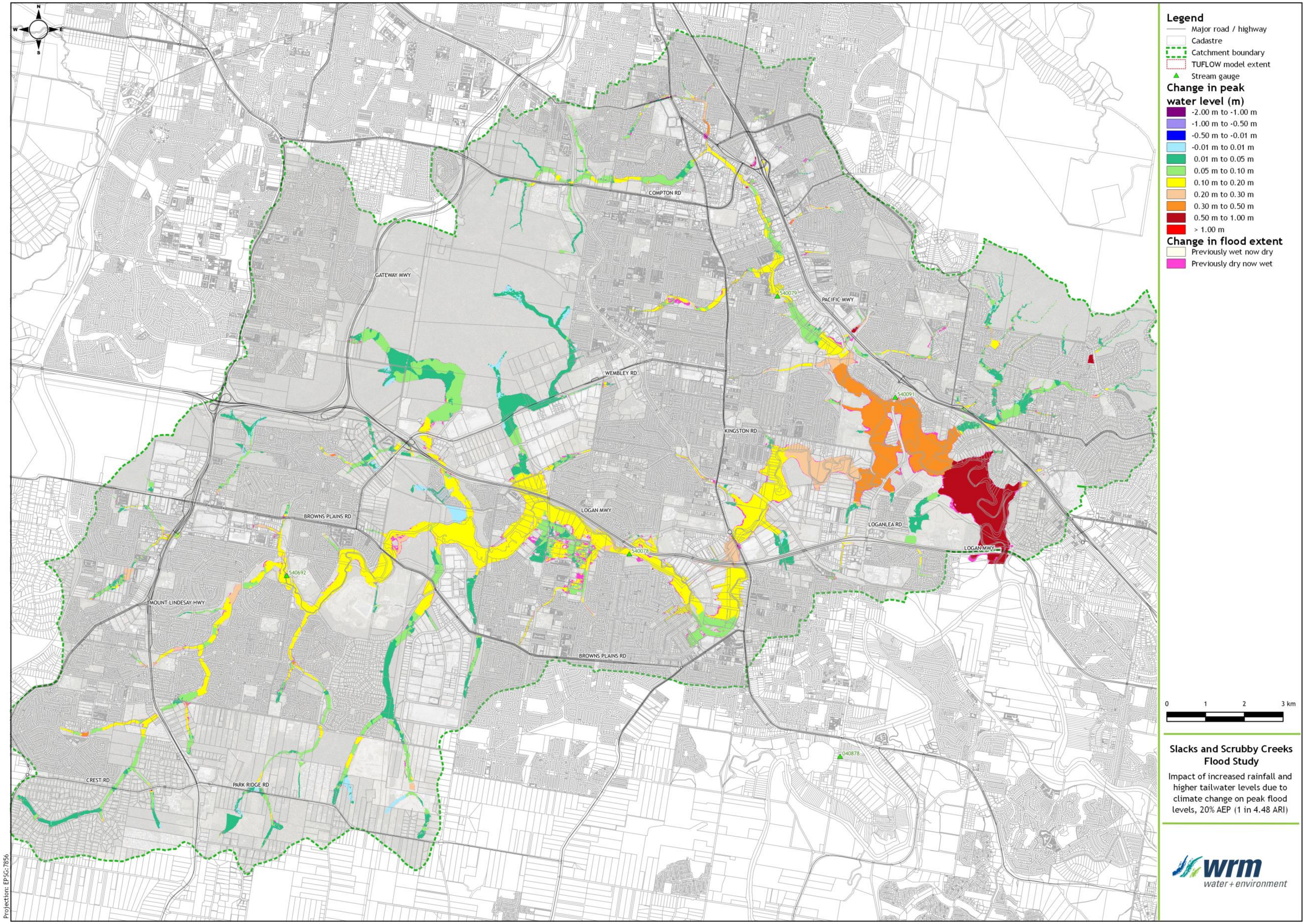

Figure 10.10 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 20% AEP (1 in 4.48 ARI) peak flood levels

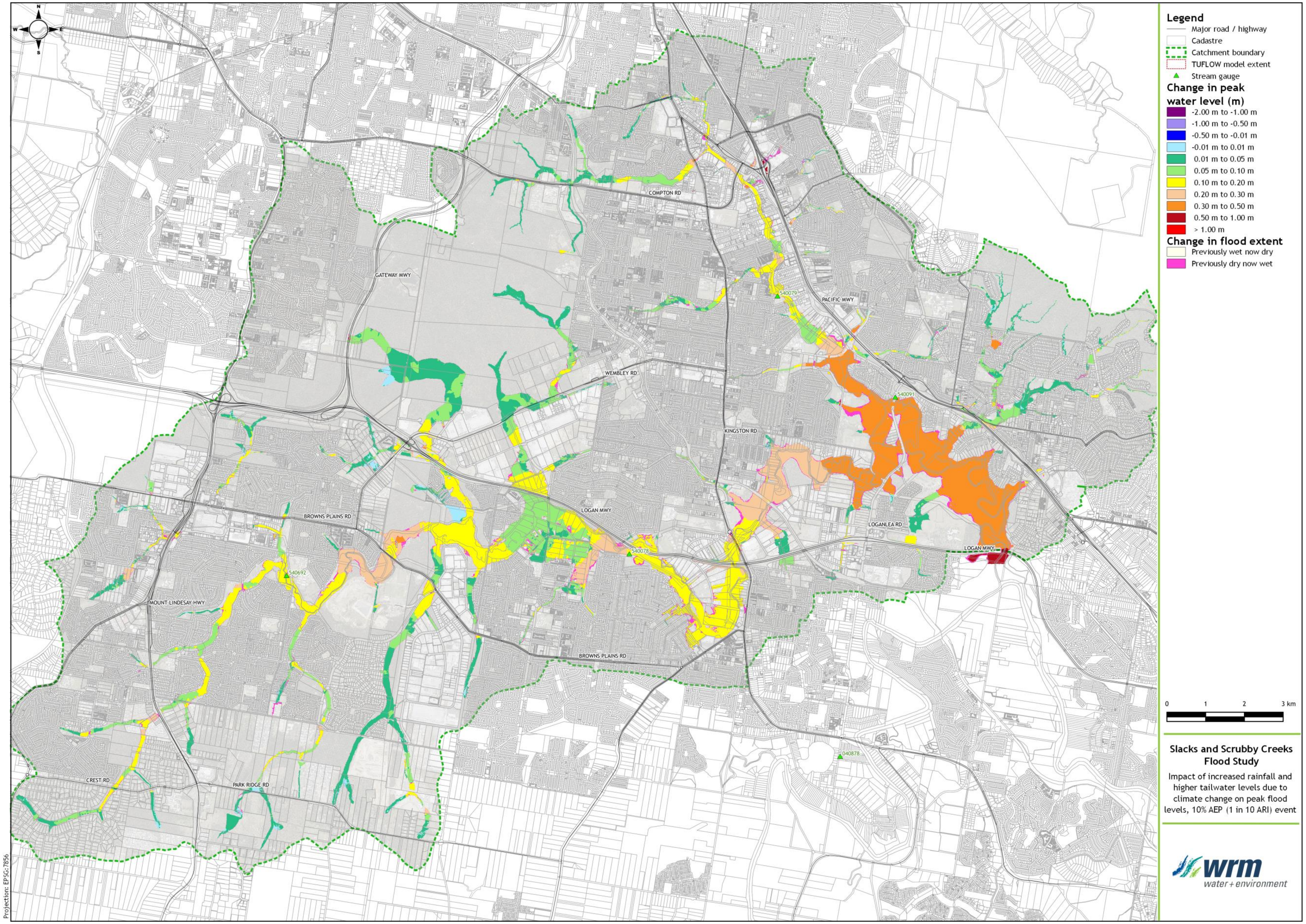

Figure 10.11 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 10% AEP (1 in 10 ARI) peak flood levels

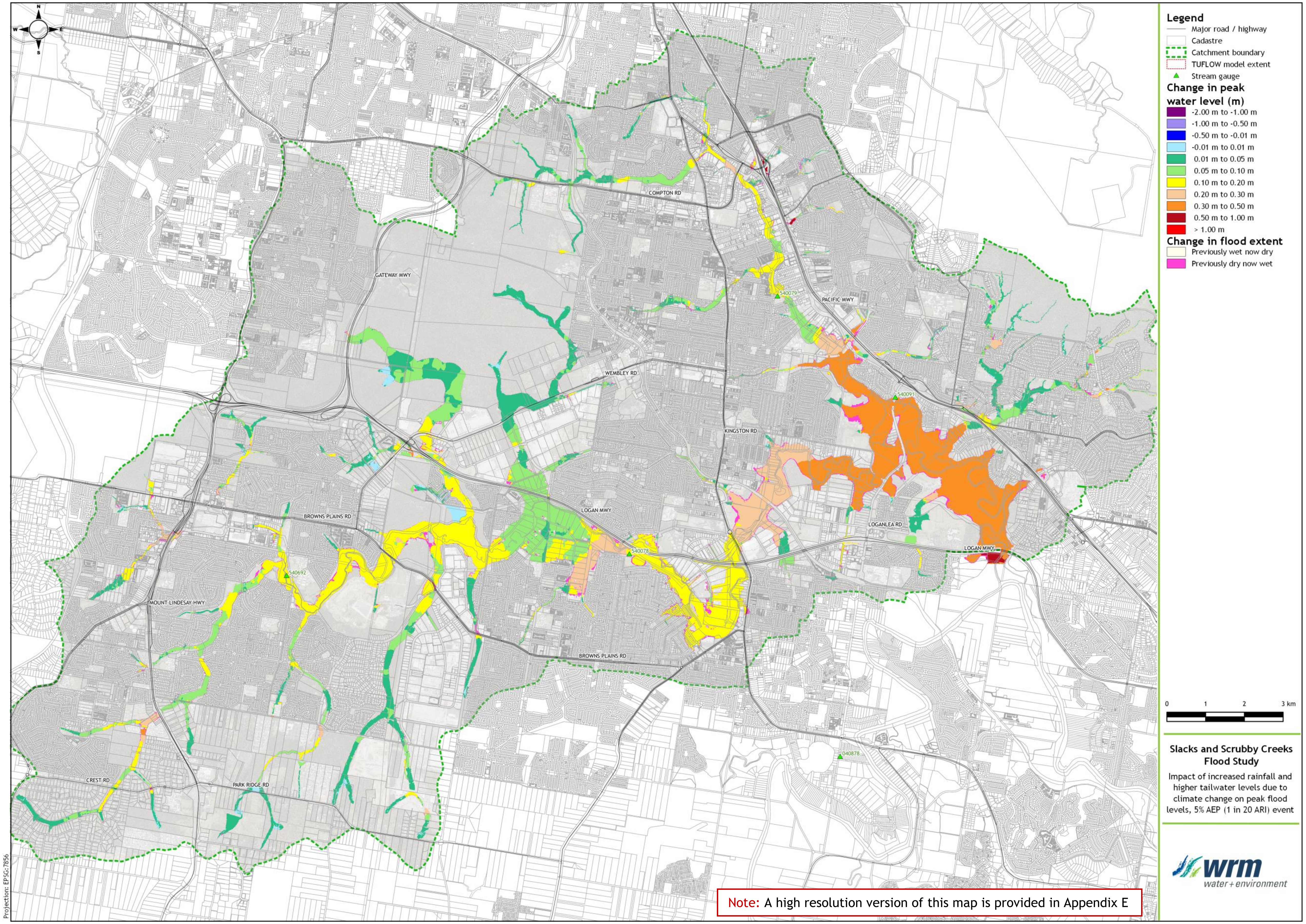

Figure 10.12 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 5% AEP (1 in 20 ARI) peak flood levels

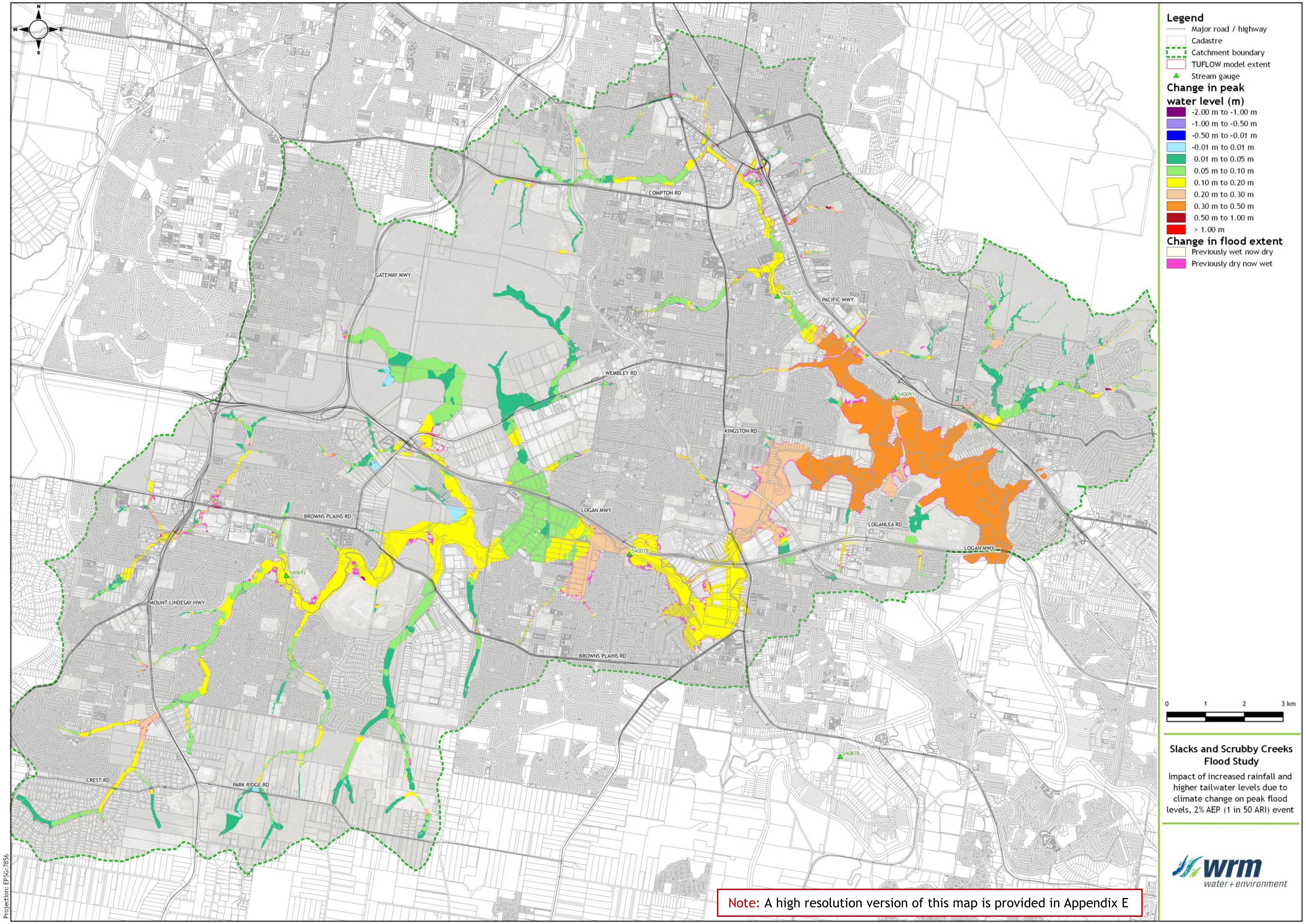

Figure 10.13 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 2% AEP (1 in 50 ARI) peak flood levels

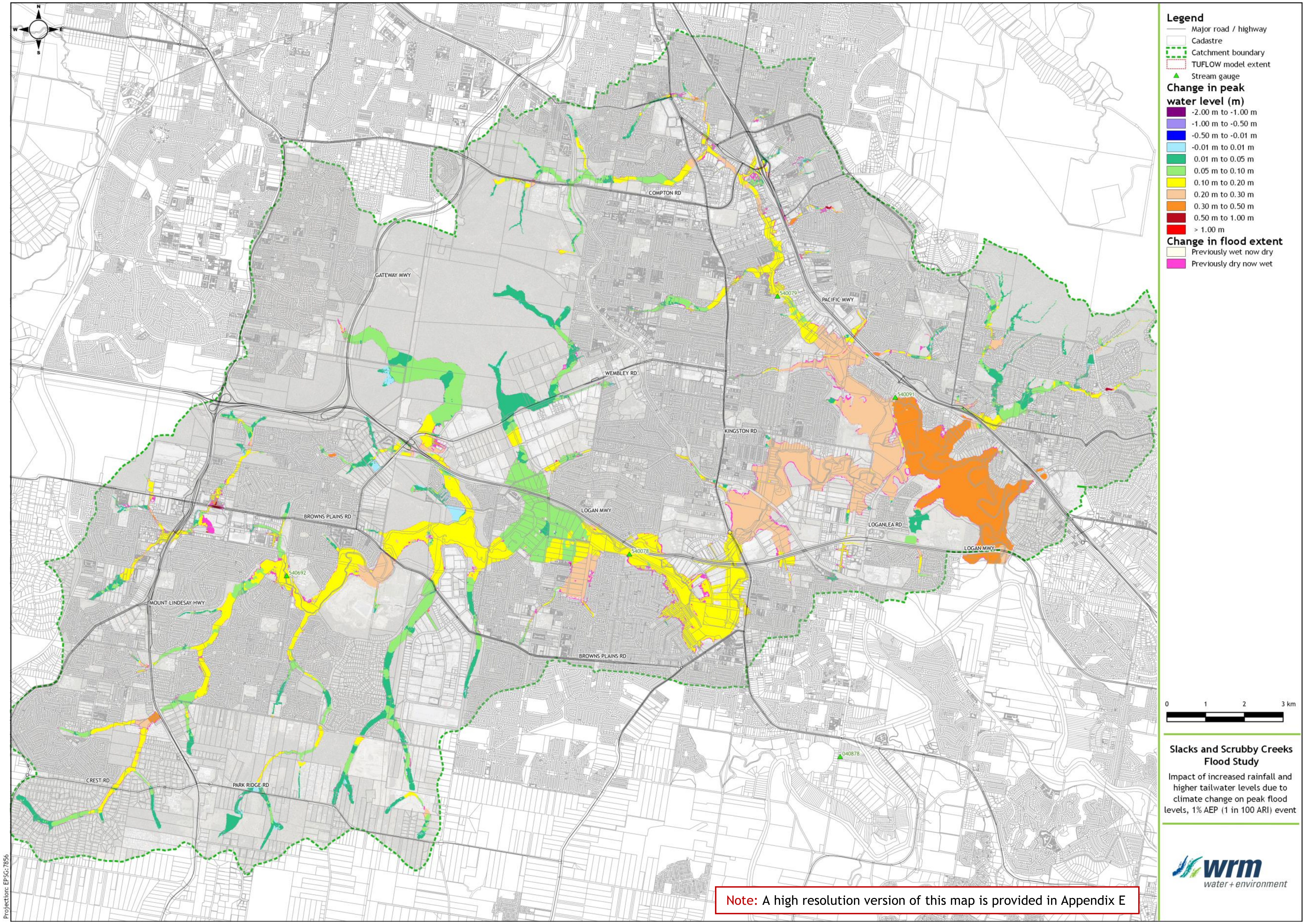

Figure 10.14 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 1% AEP (1 in 100 ARI) peak flood levels

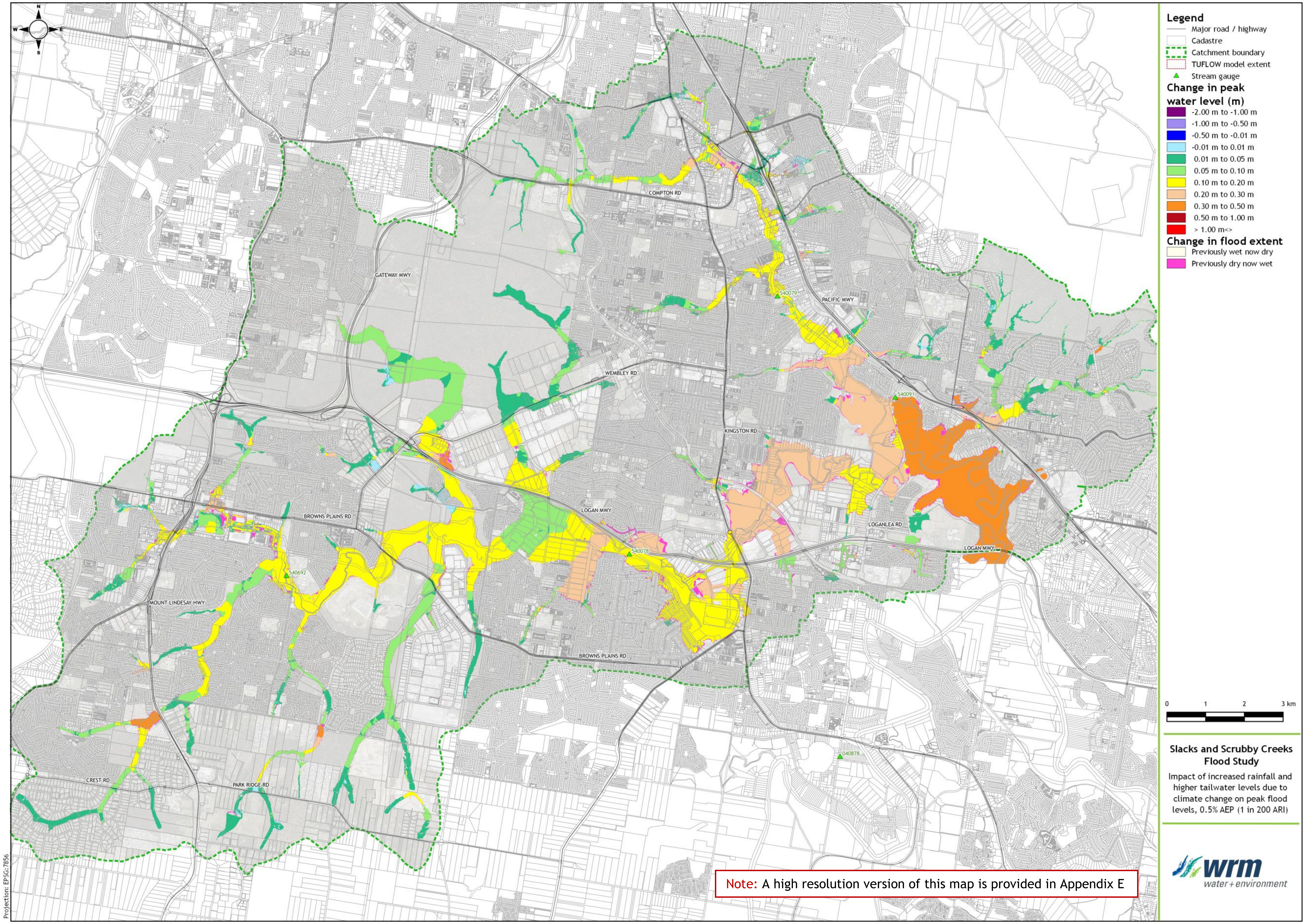

Figure 10.15 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 0.5% AEP (1 in 200 ARI) peak flood levels

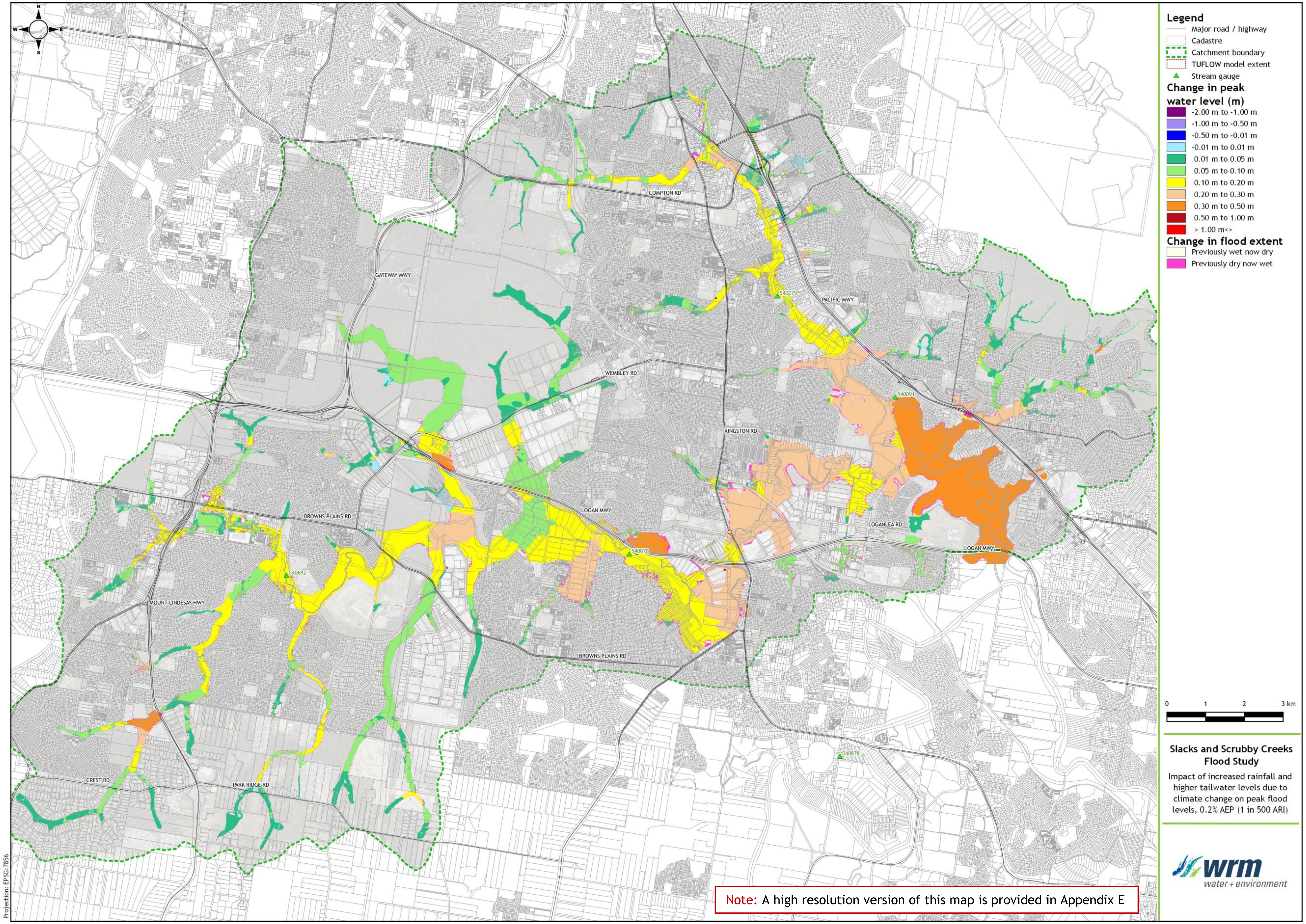

Figure 10.16 – Predicted impact of increased rainfall and higher tailwater levels due to climate change on 0.2% AEP (1 in 500 ARI) peak flood levels

11 Sensitivity analyses

11.1 OVERVIEW

Sensitivity analyses were undertaken for the 1% AEP (1 in 100 ARI) event to assess the impact of the following three scenarios:

- Increased hydraulic roughness;
- Increased blockage of culverts and bridges;
- Zero blockage of culverts and bridges; and
- Waterway restoration (increased hydraulic roughness in waterway corridor), assessed for 1% and 20% AEP events.

11.2 METHODOLOGY

11.2.1 Increased hydraulic roughness

For this scenario, the hydraulic roughness (Manning's n) values for all landuses (shown in Table 6.1) were increased by 20% (e.g. the Manning's n value for 'open space' was increased from 0.045 to 0.054). Table 11.1 compares the hydraulic roughness (Manning's n) values adopted for the 'base case' and the 'increased roughness' case. The TUFLOW hydraulic model was then re-run for the 1% AEP event using the higher hydraulic roughness (Manning's n) values.

11.2.2 Increased blockage of culverts and bridges

For this scenario, blockage factors for culverts and some bridges were increased to simulate a 'severe blockage' case. The TUFLOW hydraulic model was then re-run for the 1% AEP event using the higher blockage factors for the culverts and bridges. The following is of note with regards to the adopted blockage factors for the 'severe blockage' case:

- The blockage factors for culverts were increased from the design blockage factors to 100%.
- For bridges with clear opening heights of less than three metres, the blockage factor for the underside of these structures were increased to 100%.
- For bridges with clear opening heights of greater than three metres, blockage factors for the underside of these structures remain unchanged compared to the base case. It is considered unlikely that full (100%) blockage would occur at the underside of these large structures.

Table 11.1 – Comparison between adopted hydraulic roughness (Manning's n) values for the base case and for the sensitivity analyses

Landuse / waterway channel type	Mannin''s'''' roughness coefficient	
	Design value (base case)	Sensitivity analyses (Increased roughness case)
Open space, some sporadic trees	0.045	0.054
Rural areas	0.055	0.066
Low density residential	0.200	0.240
Medium density residential	0.250	0.300
High density residential	0.300	0.360
Dense bush	0.090	0.108
Medium density bush	0.060	0.072
Dense bushland in Scrubby Creek wetland	0.120	0.144
Upper-catchment watercourse	0.065	0.078
Industrial	0.300	0.360
Lower river, open surface areas	0.025	0.030
Road, concrete channel	0.025	0.030
Very dense bushland in Scrubby Creek wetlands	0.150	0.180
Waterway in channel-- lightly vegetated	0.035	0.042
Waterway in channel-- moderately vegetated	0.050	0.060
Waterway in channel-- heavily vegetated	0.070	0.084
Pipe crossings, small pedestrian bridges	0.200	0.240

11.2.3 Zero blockage of culverts and bridges

For this scenario, zero blockage was applied to culverts and trunk stormwater pipes, while blockage due to bridge piers and guard rails were configured based on the configurations of each bridge without the addition of debris blockage. However, the adopted percentage blockage of the inlet pits (50%) were unchanged compared to the base case.

The TUFLOW hydraulic model was then re-run for the 1% AEP event with the blockages removed from culverts and bridges. The impact of blockage removal was assessed for the 1% AEP event for the following 'no blockage' scenario:

- **'No blockage'** – This scenario compares the 'no blockage' case peak flood levels against the 'base case' (design blockage) peak flood levels, based on catchment discharges and tailwater levels for the 1% AEP event without climate change.

11.2.4 Waterway restoration

For this scenario, the hydraulic roughness (Manning's n) value for the waterway corridor was increased to 0.15. The waterway corridor polygon extent provided by LCC was incorporated into the hydraulic model for this scenario. The TUFLOW hydraulic model was then re-run for the 1% AEP and 20% AEP events using the higher hydraulic roughness (Manning's n) value for the waterway corridor.

11.3 RESULTS

11.3.1 Increased hydraulic roughness

Figure 11.1 shows the predicted impact of increased hydraulic roughness (Manning's n) values on 1% AEP (1 in 100 ARI) peak flood levels. The model results indicate that a 20% increase of hydraulic roughness (Manning's n) values results in increases in peak flood levels throughout most the Slacks and Scrubby creeks catchment, with reductions in peak flood levels predicted in some areas. The predicted increases in peak flood levels for this scenario are summarised as follows:

- In the upper tributaries of Slacks and Scrubby creeks, the predicted increases in peak flood levels were not considered significant. These increases are generally between 0.01 m to 0.1 m, with localised increases of up to 0.2 m in some areas. In addition, there were no significant changes to the predicted flood extent along these tributaries.
- In the main channel of Scrubby Creek upstream of Kingston Road, the predicted increases in peak flood levels are generally between 0.1 m and 0.2 m, with localised increases of up to 0.3 m in some areas. In the main channel of Slacks Creek, the predicted increases in peak flood levels are less significant (between 0.01 m to 0.1 m, with localised increases of up to 0.2 m in some areas).
- In the downstream reaches of Slacks and Scrubby creeks (downstream of Kingston Road and Paradise Road), the predicted increases in peak flood levels are not considered significant (generally between 0.01 m and 0.1 m). There are no noticeable changes in flood extent in this area.
- There are reductions in peak flood levels predicted in some areas, particularly in areas immediately upstream of major culvert or bridge crossings. Peak flood levels in these areas are predominantly controlled by the hydraulic capacity of the adjacent structure (culvert or bridge), with the hydraulic roughness having little to no influence. However, the higher hydraulic roughness values has the effect of attenuating flows in the channels upstream of these culvert/bridge crossings, resulting in lower peak flood levels at these crossings.

11.3.2 Increased blockage of culverts and bridges

Figure 11.2 shows the predicted impact of increased blockage of culverts and bridges on 1% AEP (1 in 100 ARI) peak flood levels. The model results indicate that a full blockage of major culverts results in significant increases in peak flood levels in areas immediately upstream of major culvert crossings, while reductions in peak flood levels are predicted downstream of these crossings. However, the predicted increases in peak flood levels at bridges crossings are less significant. The predicted increases in peak flood levels for this scenario are summarised as follows:

- There are significant increases in peak flood levels of between 0.5 m and 2 m in the immediate vicinity of major culvert crossings, these include (but are not limited to) areas adjacent to and immediately upstream of the Logan Motorway, the M1 Motorway and Mount Lindesay Highway. A full (100%) culvert blockage at these locations results in flood waters ponding behind the road embankment until the road is overtopped. This also results in significant increases in the predicted flood extent at some of these major crossings.
- At smaller culvert crossings (along the tributaries upstream of the Logan Motorway, the M1 Motorway and Mount Lindesay Highway), the effect of full (100%) culvert blockage is less significant. There are no predicted increases in peak flood levels in most areas along these tributaries, while any predicted increases are generally within 0.3 m.
- There are reductions in peak flood levels predicted along the main channels of Slacks and Scrubby creeks. This is due to the retention of flows upstream of major culvert crossings where full (100%) culvert blockages were applied. The reduction in

peak flood levels extends downstream to the Slacks Creek outlet (at the Logan Motorway).

- At low bridge crossings (where the clear opening heights are less than three metres), the predicted increases on peak flood levels are not considered significant (generally within 0.2 m).
- The impact of increased blockage at major bridge crossings (where clear opening heights are larger than three metres) was not assessed. However, severe blockage at the undercroft of these large structures (although unlikely) may result in significant impacts similar in magnitude to those predicted at major culvert crossings.

11.3.3 Zero blockage of culverts and bridges

Figure 11.3 shows the predicted impact of removing the design blockage from (i.e. applying zero blockage to) culverts and bridges on peak flood levels, based on catchment discharges and tailwater levels for the 1% AEP (1 in 100 ARI) event without climate change.

The model results indicate that the removal of blockages from major culverts results in reductions in peak flood levels in area immediately upstream of major culvert and bridge crossings, while increases in peak flood levels are predicted downstream of these crossings. The predicted impacts on peak flood levels for this scenario are summarised as follows:

- There are reductions in peak flood levels of between 0.1 m and 0.3 m upstream of major culvert crossings, these include (but are not limited to) areas adjacent to and immediately upstream of the Logan Motorway, the M1 Motorway and Mount Lindesay Highway. Reductions in peak flood levels upstream of bridges are less significant and are generally within 0.1 m.
- Downstream of culverts and bridge crossings, there are generally minor increases in peak flood levels. The predicted flood level increases are generally not significant (within 0.08 m), and they generally occur along the main channel of Scrubby Creek upstream of the Logan Motorway, and along the main channel of Slacks Creek upstream of Paradise Road. The predicted flood level increases are noticeably more significant (up to 0.2 m) at one location downstream of the Grand Plaza complex (Browns Plains).
- There are no predicted increases in peak flood levels in Scrubby Creek downstream of the Logan Motorway, and in Slacks Creek downstream of Paradise Road due to the removal of bridge and culvert blockages. This may be due to flood levels in this area being driven by backwater flooding from the Logan River, hence the removal of partial blockages from culverts and bridges has no noticeable impact on peak flood levels in this area.

11.3.4 Waterway restoration

Figure 11.4 and Figure 11.5 shows the predicted impact of increasing the hydraulic roughness of the waterway corridor for 20% AEP (1 in 4.48 ARI) and the 1% AEP (1 in 100 ARI) events without climate change. The model results indicate that increasing the hydraulic roughness (Manning's n) values within the waterway corridor results in increases in peak flood levels throughout most the Slacks and Scrubby creeks catchment, with reductions in peak flood levels predicted in some areas. The predicted increases in peak flood levels for this scenario are summarised as follows:

- In the upper tributaries of Slacks and Scrubby creeks, there are significant increases in peak flood levels up to 0.3 m, with localised impacts of up to 0.5 m towards the downstream side.
- In the main channel of Scrubby Creek upstream of Kingston Road, the predicted increases in peak flood levels are generally between 0.3 m and 0.5 m. In the main channel of Slacks Creek, there are significant increases in flood levels up to and

greater than 1.0 m along the Logan Motorway. The higher levels have lead to an increase flood extent for both the 20% AEP and the 1% AEP events.

- In the downstream reaches of Slacks and Scrubby creeks (downstream of Kingston Road and Paradise Road), the predicted increases in peak flood levels range from 0.2 m to 0.5 m. Although the levels have increased, there is only a minor increase in flood extent in this area.
- There are reductions in peak flood levels predicted in some areas, particularly in areas immediately upstream of major culvert or bridge crossings. Peak flood levels in these areas are predominantly controlled by the hydraulic capacity of the adjacent structure (culvert or bridge), with the hydraulic roughness having little to no influence. However, the higher hydraulic roughness values has the effect of attenuating flows in the channels upstream of these culvert/bridge crossings, resulting in lower peak flood levels at these crossings.

11.4 CONCLUSION

In summary, the sensitivity analyses results indicate that:

- In the upper tributaries of Slacks and Scrubby creeks, peak flood levels are moderately sensitive to variations in hydraulic roughness. Peak flood levels along these tributaries are less sensitive to variations in culvert blockages except at major culvert crossings. Peak flood levels along these tributaries are relatively unaffected by variations in Logan River tailwater levels.
- Peak flood levels adjacent to major culvert crossings are very sensitive to variations in culvert blockages. Severe culvert blockage in these areas may result in significant increases in peak flood levels and extents upstream of these culvert crossings and reductions in peak flood levels downstream. Conversely, removal of blockages from these culverts may reduce peak flood levels and extents upstream, while increasing peak flood levels downstream.
- Peak flood levels adjacent to low bridge crossings (where the clear opening heights are less than three metres) are affected by severe blockage to these structures, but not significantly. The impact of increased blockage at major bridge crossings (where the clear opening heights are larger than three metres) was not assessed. However, severe blockage at the undercroft of these large structures (although unlikely) may result in significant impacts similar to those predicted near major culvert crossings.
- Peak flood levels immediately upstream of major culvert and bridge crossings are predominantly controlled by the hydraulic capacity of the adjacent structure (culvert or bridge), hence peak flood levels in these areas are not sensitive to variations in hydraulic roughness, and only moderately sensitive to variations in rainfall intensities.
- In the main channels of Scrubby Creek upstream of Kingston Road, and the main channel of Slacks Creek upstream of Paradise Road, peak flood levels are more sensitive to variations in hydraulic roughness compared to the upper tributaries. Peak flood levels in these areas are also considered sensitive to culvert blockages in the upstream tributaries. That is, severe culvert blockages along the upstream tributaries would result in extensive reductions in flood levels along main channels of Slacks and Scrubby creeks. Conversely, removal of culvert blockages along the upstream tributaries may result in extensive increases in peak flood levels along main channels of Slacks and Scrubby creeks.
- In the low-lying areas of Slacks and Scrubby creeks (downstream of Kingston Road and Paradise Road), peak flood levels are sensitive to Logan River tailwater levels, particularly during large flood events. Peak flood levels in these areas are less sensitive to variations in hydraulic roughness as well as blockages of culverts and bridges in the upstream catchment.

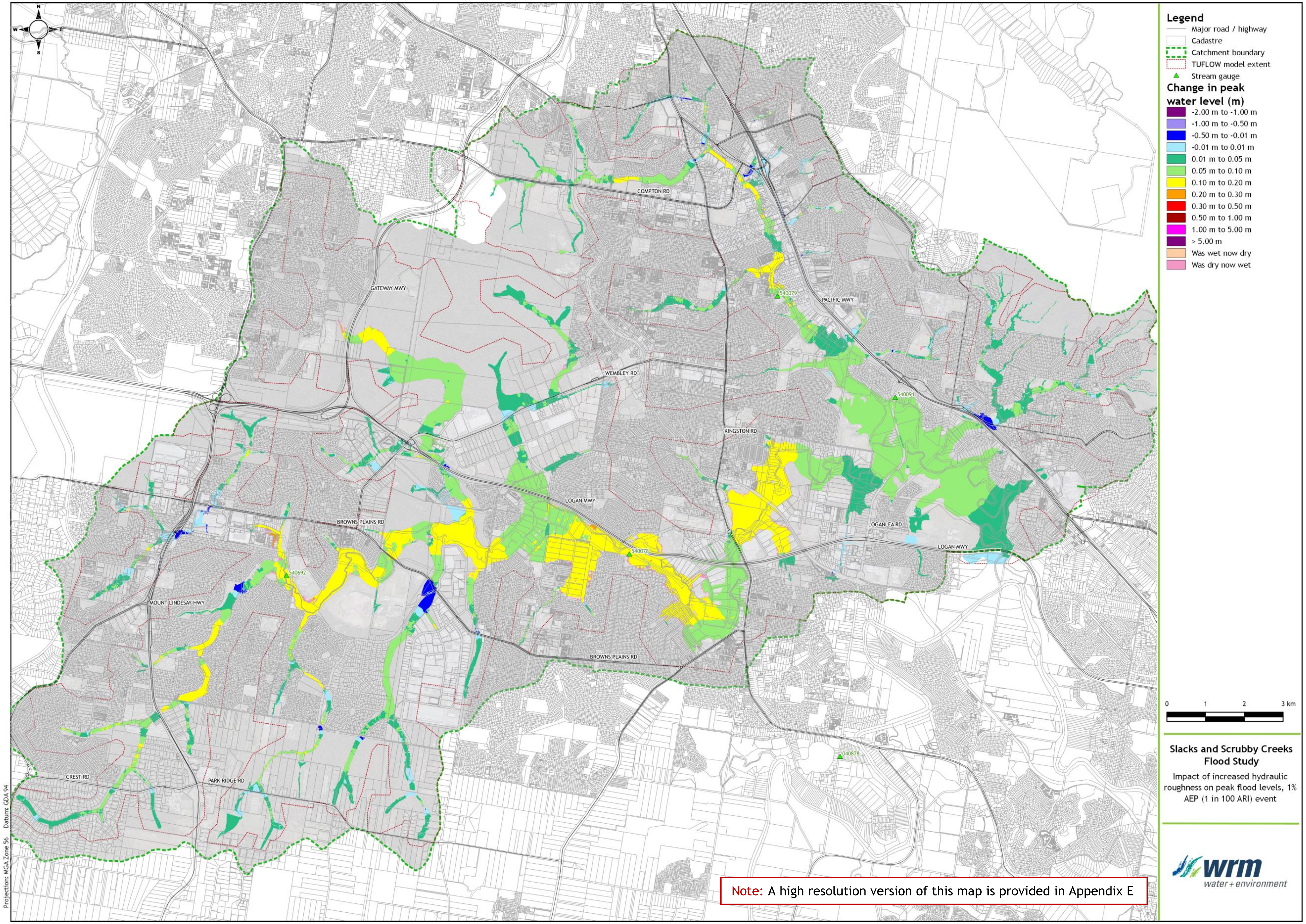

Figure 11.1 – Predicted impact of increased hydraulic roughness (Manning's n) values on 1% AEP (1 in 100 ARI) peak flood levels

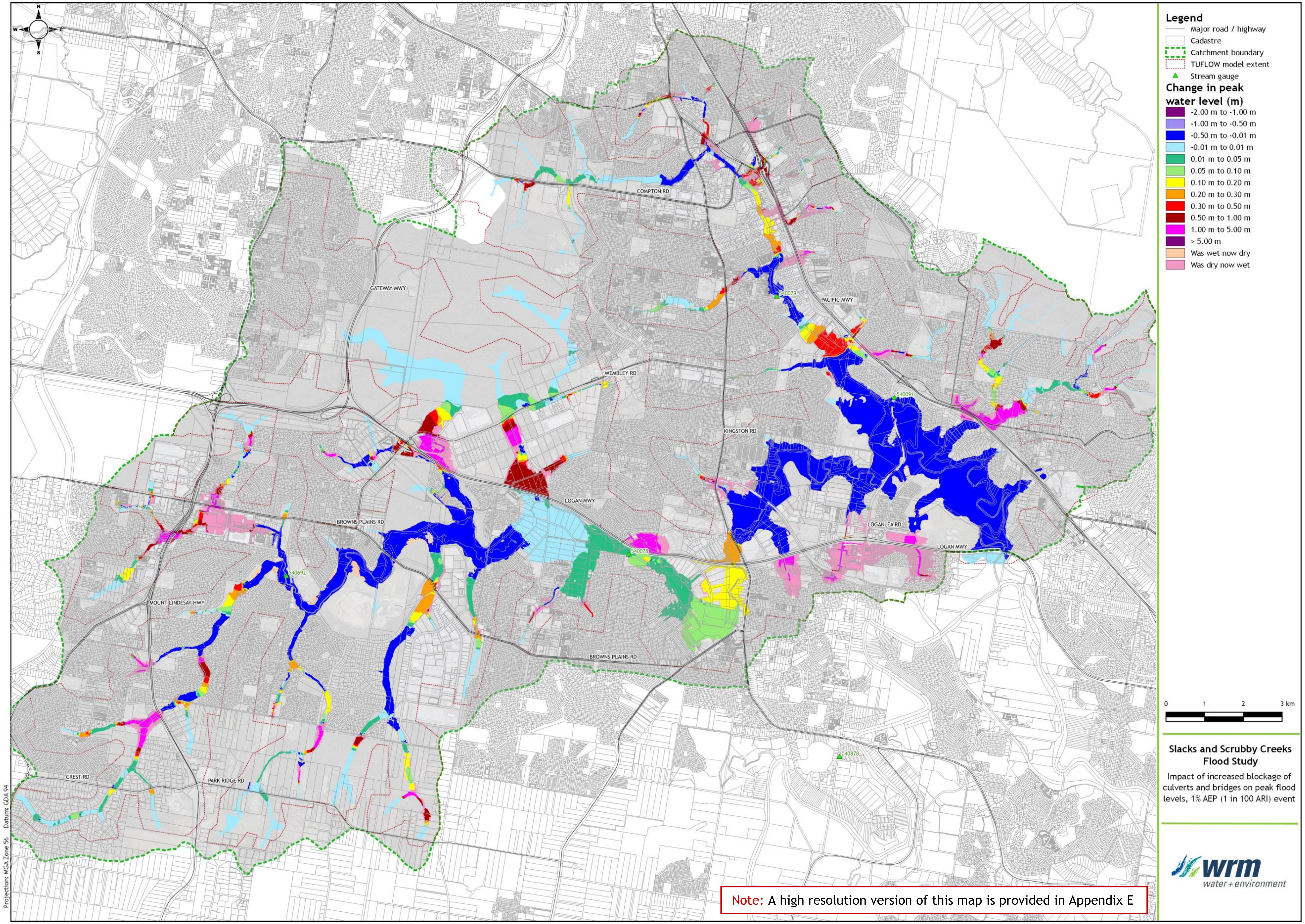

Figure 11.2 – Predicted impact of increased blockage of culverts and bridges on 1% AEP (1 in 100 ARI) peak flood levels (without climate change)

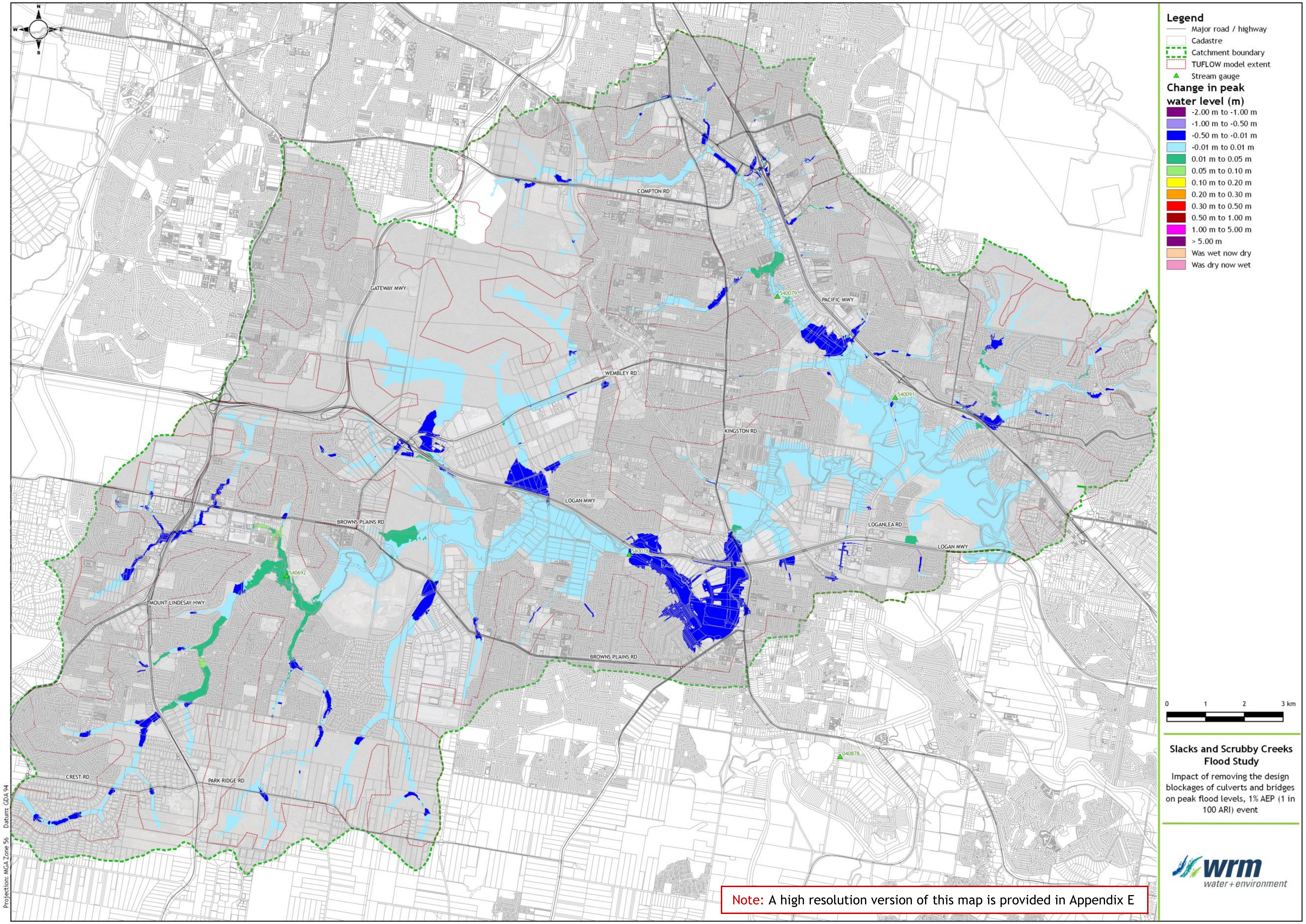

Figure 11.3 – Predicted impact of removing the design blockage of culverts and bridges on peak flood levels, 1% AEP (1 in 100 ARI) event without climate change

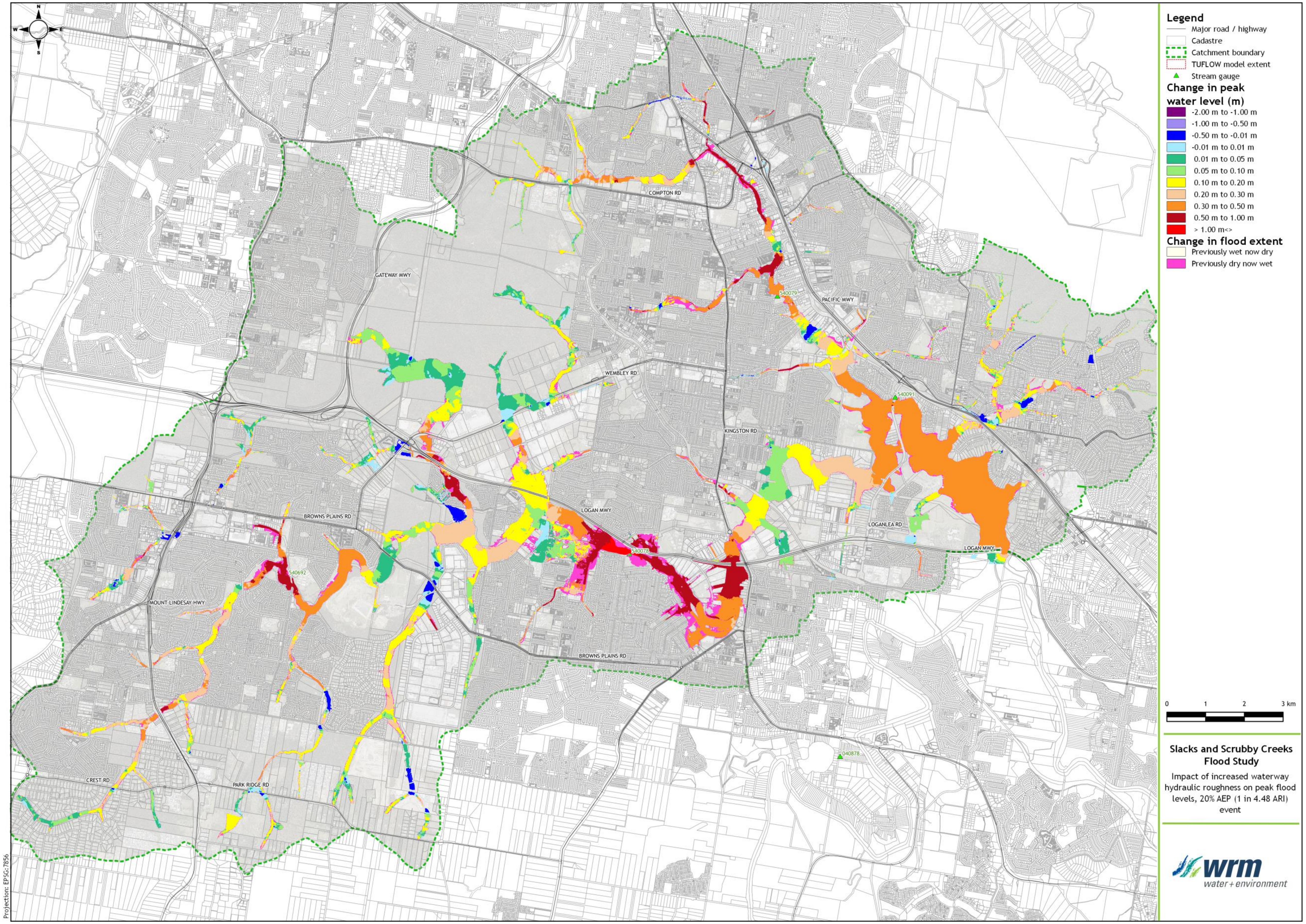

Figure 11.4 – Predicted impact of waterway restoration on peak flood levels, 20% AEP (1 in 4.48 ARI) event without climate change

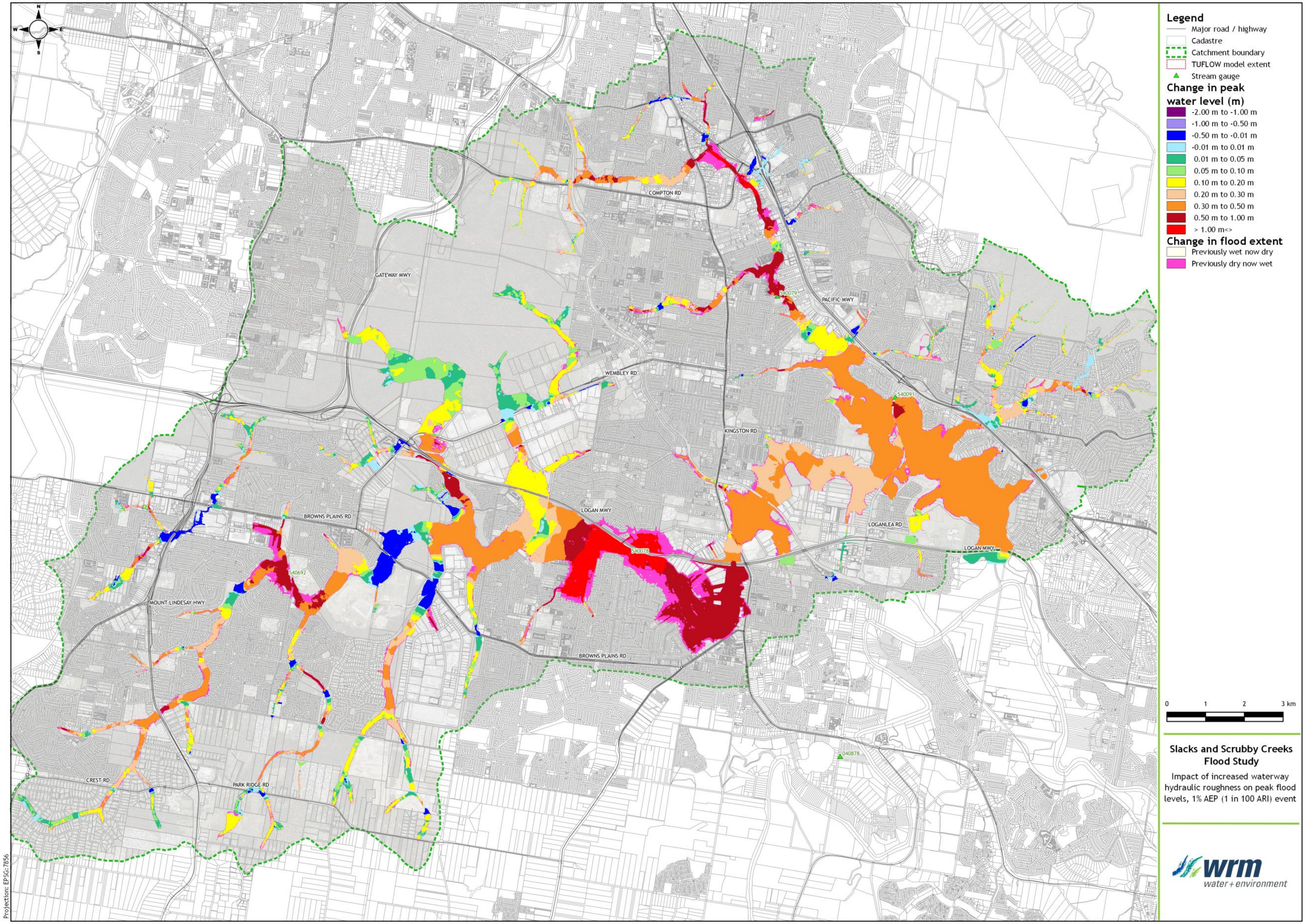

Figure 11.5 – Predicted impact of waterway restoration on peak flood levels, 1% AEP (1 in 100 ARI) event without climate change

12 Summary and conclusions

12.1 OVERVIEW

An XP-RAFTS hydrologic and TUFLOW hydraulic models were developed for the Slacks and Scrubby creeks catchment. The models were calibrated against the January 2013, May 2015 and March 2017 events. The models were also validated against the February 2022 event.

The calibrated XP-RAFTS and TUFLOW models was used to estimate design discharges, flood levels, depths, velocities and flood hazard in the Slacks and Scrubby creeks catchment for the 50% (1 in 1.44 ARI), 20% (1 in 4.48 ARI), 10% (1 in 10 ARI), 5% (1 in 20 ARI), 2% (1 in 50 ARI), 1% (1 in 100 ARI), 0.5% (1 in 200 ARI), 0.2% (1 in 500 ARI) and 0.05% (1 in 2,000 ARI) AEP design events as well as the PMPDF event for the current climate (2020). In addition, the Future Climate (2090) estimates were derived for the 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP events.

12.2 HYDROLOGIC MODEL DEVELOPMENT

XP-RAFTS models were developed for ‘existing catchment conditions’ (for model calibration purposes) and ‘ultimate catchment conditions’ (for design event modelling).

The model uses a single subcatchment approach to determine runoff hydrographs, based on the overall weighted subcatchment parameters (fraction impervious, roughness and slope). The model consists of 498 subcatchments ranging in size from 2 ha to 58 ha, with an average subcatchment area of 24 ha.

Channel routing in the XP-RAFTS model was configured based on specifying a ‘K’ and ‘X’ value for each routing link. The ‘K’ values represent estimated flow travel times (in hours) and were calculated based on the routing lengths and assumed flow velocities for four distinct channel types (natural, artificial, pipes and wetlands).

12.3 HYDRAULIC MODEL DEVELOPMENT

The Slacks and Scrubby creeks TUFLOW model covers an area of 86 km^2 and includes almost the entire Slacks and Scrubby creeks catchment. The model was configured using a grid cell size of three meters. All hydraulic modelling was undertaken using the TUFLOW Build 2018-03-AE HPC-GPU solver.

The LCC (2021), LCC (2017) and BCC (2017) LiDAR data were used to generate a DEM with a grid size of 1m for use as the base topography for the hydraulic model. A series of TUFLOW z-shapes, z-lines, z-tin and z-poly objects were used to improve the representation of creek inverts, road embankments, solid road barriers and building pads throughout the hydraulic model.

Hydraulic roughness coefficients were initially configured based on the supplied aerial photography for year 2016, and then adjusted to improve calibration.

The model inflow boundaries were configured using 2D (SA) polygons within the 2D model domains, and 1D inflow boundaries within the trunk stormwater drainage networks. The model has a total of 25 total inflow boundaries and 418 local inflow boundaries (one for each XP-RAFTS model subcatchment), which include 426 inflows in the 2D model domain and 17 inflows within the 1D model domain. Inflow hydrographs generated from the XP-RAFTS model were adopted as inflows at the 2D and 1D inflow boundaries.

The hydraulic model has one primary outflow boundary located in Slacks Creek near the Logan River confluence, and one secondary outflow boundary located across Mandew

Street to the southeast of the Logan Hyperdome. These outflow boundaries were configured as follows:

- For each of the calibration events, a water level hydrograph was adopted at the primary outflow boundary. Tailwater levels for the January 2013 event were extracted from the Logan River TUFLOW model results (WRM, 2014a). Tailwater levels for the May 2015 and March 2017 events were derived using a cut-down version of the Logan River hydraulic model (WRM, 2014a) developed for this study.
- For the validation event, a water level hydrograph was adopted at the primary outflow boundary. Tailwater levels for the Feburyary 2022 event were extracted from the Logan Albert River TUFLOW model results (WRM, 2022).
- For the design flood events, a constant tailwater level approach was adopted based on the 'Hydrograph procedure for non-tidal creeks and rivers' procedure given in the QUDM background notes (QUDM) (IPWEA, 2016).
- For the secondary outflow boundary, a normal depth approach was adopted for both the calibration and design events based on a slope of 1%, equal to the longitudinal slope of Mandew Street at the secondary outflow boundary location.

The model includes a significant number of hydraulic structures, including:

- 778 stormwater culverts and trunk stormwater pipes, 545 stormwater inlet pits, 34 manually created manholes (excluding automatically generated manholes) and 28 bridge structures.

The majority these hydraulic structures were configured based on information obtained from the 2017 LCC hydraulic structures survey and the LCC GIS hydraulic structures database. Some details were also obtained from other sources of information including hydraulic models developed from previous studies, as-constructed drawings and a site visit.

12.4 MODEL CALIBRATION AND VALIDATION

The hydrologic and hydraulic models were satisfactorily calibrated to the January 2013, May 2015 and March 2017 events and validated against the February 2022 event. For each event, the model results were compared against recorded water level hydrographs at four stream gauges, recorded peak water levels at six maximum height gauges, as well as surveyed debris marks (for the 2015 and 2017 events). Based on comparisons between model results and all of the available data, the hydrologic model produces discharges that reproduce recorded peak flood levels well in the hydraulic model along both Slacks and Scrubby creeks and their tributaries for all four events.

The May 2015 event is a significantly larger flood event when compared to the January 2013 and March 2017 events. Based on the severity of rainfall intensities within the Slacks and Scrubby creeks catchment, the May 2015 event had an AEP of between 2% (1 in 50 ARI) and 1% (1 in 100 ARI), while the January 2013 and March 2017 events had AEPs of less than 20% (1 in 4.48 ARI) and 10% (1 in 10 ARI) respectively.

12.5 DESIGN FLOOD DISCHARGES

The calibrated hydrologic model was used to estimate design flood discharges throughout the Slacks and Scrubby creeks catchments using design intensity-frequency-duration (IFD) data from a number of sources, in accordance with procedures in AR&R 2019 (Ball et al, 2019).

The XP-RAFT model for 'ultimate catchment conditions' was then used to generate design discharge hydrographs at each subcatchment only, for a range of storm durations up to 18 hours for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.05% AEP and PMPDF events for the current climate (2020). In addition, the Future Climate (2090) estimates were derived for the 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP events.

. These XP-RAFTS local subcatchment design discharge hydrographs were then applied as inflows to the TUFLOW hydraulic model.

The TUFLOW model is considered to represent channel routing within the Slacks and Scrubby creeks catchment more accurately when compared to the XP-RAFTS model. Therefore, design discharges at various locations throughout the Slacks and Scrubby creeks catchment were extracted from the TUFLOW hydraulic model results.

12.6 DESIGN FLOOD LEVELS, DEPTHS, VELOCITIES, FLOOD HAZARD AND CRITICAL STORM DURATIONS

The calibrated TUFLOW model was used to estimate the Slacks and Scrubby creeks design flood levels for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.05% AEP and PMPDF events for the current climate (2020) and for the 5% (1 in 20), 2% (1 in 50), 1% (1 in 100), 0.5% (1 in 200) and 0.2% (1 in 500) AEP event for the future climate (2090), for a range of storm durations up to 18 hours. The hydraulic model was run for one design storm for each storm duration when appropriate. In many cases, additional design storms were run through the hydraulic model depending on whether flood levels are determined by conveyance or floodplain storage, or if there is no clearly dominant representative temporal pattern for a certain duration.

A 'max-max' water surface profile was developed for each design event by interrogating the results for all representative temporal patterns for each storm duration to obtain the design flood level, depth, velocity, critical storm duration, depth-velocity product and flood hazard classification for every location impacted by flooding from Slacks and Scrubby creeks.

A total of 78 high-resolution flood maps (in A3 size and pdf format) are provided in Appendix E of this report. Longitudinal profiles of design peak water levels along Slacks and Scrubby creeks are also provided in this report.

12.7 SENSITIVITY ANALYSIS

Several different analyses were undertaken for the 1% AEP (1 in 100 ARI) event to assess the impact of increase hydraulic roughness, increase blockage of culverts and bridges as well as removal of blockage from culverts and bridges on the predicted design peak flood levels for this event. In summary, the sensitivity analyses results indicate that:

- In the upper tributaries of Slacks and Scrubby creeks, peak flood levels are moderately sensitive to variations in hydraulic roughness. Peak flood levels along these tributaries are less sensitive to variations in culvert blockages except at major culvert crossings.
- Peak flood levels adjacent to major culvert crossings are very sensitive to variations in culvert blockages. Severe culvert blockage in these areas may result in significant increases in peak flood levels and extents upstream of these culvert crossings and reductions in peak flood levels downstream. Conversely, removal of blockages from these culverts may reduce peak flood levels and extents upstream, while increasing peak flood levels downstream.
- Peak flood levels adjacent to low bridge crossings (where the clear opening heights are less than three metres) are affected by severe blockage to these structures, but not significantly. The impact of increased blockage at major bridge crossings (where the clear opening heights are larger than three metres) was not assessed. However, severe blockage at the undercroft of these large structures (although unlikely) may result in significant impacts similar to those predicted near major culvert crossings.
- Peak flood levels immediately upstream of major culvert and bridge crossings are predominantly controlled by the hydraulic capacity of the adjacent structure (culvert or bridge), hence peak flood levels in these areas are not sensitive to variations in hydraulic roughness, and only moderately sensitive to variations in rainfall intensities.

- In the main channels of Scrubby Creek upstream of Kingston Road, and the main channel of Slacks Creek upstream of Paradise Road, peak flood levels are more sensitive to variations in hydraulic roughness and rainfall intensities compared to the upper tributaries. Peak flood levels in these areas are also considered sensitive to culvert blockages in the upstream tributaries. That is, severe culvert blockages along the upstream tributaries would result in extensive reductions in flood levels along main channels of Slacks and Scrubby creeks. Conversely, removal of culvert blockages along the upstream tributaries may result in extensive increases in peak flood levels along main channels of Slacks and Scrubby creeks.
- In the low-lying areas of Slacks and Scrubby creeks (downstream of Kingston Road and Paradise Road), peak flood levels are sensitive to Logan River tailwater levels, particularly during large flood events. Peak flood levels in these areas are less sensitive to variations in hydraulic roughness, rainfall intensities as well as blockages of culverts and bridges in the upstream catchment.

13 Limitations of this study

The Slacks and Scrubby Creek Flood Study described in this report is a catchment wide investigation of flooding throughout the Slacks and Scrubby Creek catchment. Although every effort has been taken to ensure that the model accurately represents flooding throughout the study area, it should be noted that there are limitations to the accuracy of the modelling, including the flood mapping especially at the edges of the flood extent. In particular, the results of the study should not be relied upon at an individual allotment scale in areas where flooding is due to exceedances of the trunk stormwater pipe network (i.e. outside of the extent of creek flooding).

This is due to the fact that not all stormwater network infrastructure has been included in the model. Stormwater pipes, tanks and pits not owned and maintained by LCC are generally not represented in the model. In addition, most minor LCC stormwater pipes and pits also have been excluded. It is also possible that there is trunk stormwater infrastructure represented inaccurately (e.g. assumed invert levels), due to lack of available survey or as-constructed data, or missing records in the LCC GIS database. Further, the extent of overland flow shown through private allotments should not be relied upon due to approximations with regards to model topography and roughness mapping at an allotment scale.

14 References

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Appendix A – Stream gauge rating curves

A1 Waller Road AL stream gauge rating curve

Table A.1 - WRM rating curve for Waller Road AL stream gauge

Water level (mAHD)	Flow rate (m^3/s)
19.72	0.00
19.85	0.07
19.98	0.17
20.11	0.31
20.24	0.47
20.37	0.59
20.51	0.72
20.64	1.41
20.77	1.89
20.90	2.27
21.03	2.67
21.16	3.90
21.29	5.38
21.42	7.29
21.56	9.23
21.69	12.69
21.82	16.08
21.95	21.13
22.08	28.18
22.21	38.17
22.34	50.44
22.47	61.99
22.60	69.85
22.74	82.96
22.87	95.97
23.00	108.43
23.13	124.17
23.26	141.51
23.39	158.35
23.52	174.56
23.65	189.54
23.79	205.71
23.92	224.89
24.18	260.29

A2 Marsden AL stream gauge rating curve

Table A.2 – WRM rating curve for Marsden AL stream gauge

Water level (mAHD)	Flow rate (m^3/s)
6.36	0.00
6.51	0.41
6.67	0.71
6.83	1.18
6.99	1.79
7.15	2.80
7.30	3.75
7.46	4.94
7.62	7.70
7.78	11.10
7.94	14.55
8.09	20.06
8.25	25.80
8.41	33.29
8.57	41.33
8.73	50.27
8.88	59.35
9.04	67.91
9.20	75.75
9.36	90.09
9.52	104.47
9.67	119.41
9.83	136.07
9.99	154.00
10.15	173.76
10.31	195.56
10.46	219.60
10.62	246.46
10.78	274.87
10.94	305.57
11.10	339.05
11.25	379.03
11.41	419.30
11.71	499.78

A3 Reserve Park AL stream gauge rating curve

Table A.3 - WRM rating curve for Reserve Park AL stream gauge

Water level (mAHD)	Flow rate (m^3/s)
5.13	0.00
5.29	0.09
5.45	0.18
5.61	0.29
5.77	0.41
5.93	0.60
6.09	0.77
6.25	1.05
6.40	1.29
6.56	1.76
6.72	2.96
6.88	3.90
7.04	4.86
7.20	6.50
7.36	8.37
7.52	10.61
7.68	12.99
7.83	16.54
7.99	21.48
8.15	27.11
8.31	33.89
8.47	41.95
8.63	47.40
8.79	57.77
8.95	68.26
9.11	79.20
9.26	95.51
9.42	111.63
9.58	131.77
9.74	152.29
9.90	174.97
10.06	197.96
10.22	222.34
10.54	272.90

Appendix B – XP-RAFTS model configuration

B1 XP-RAFTS subcatchment mapping

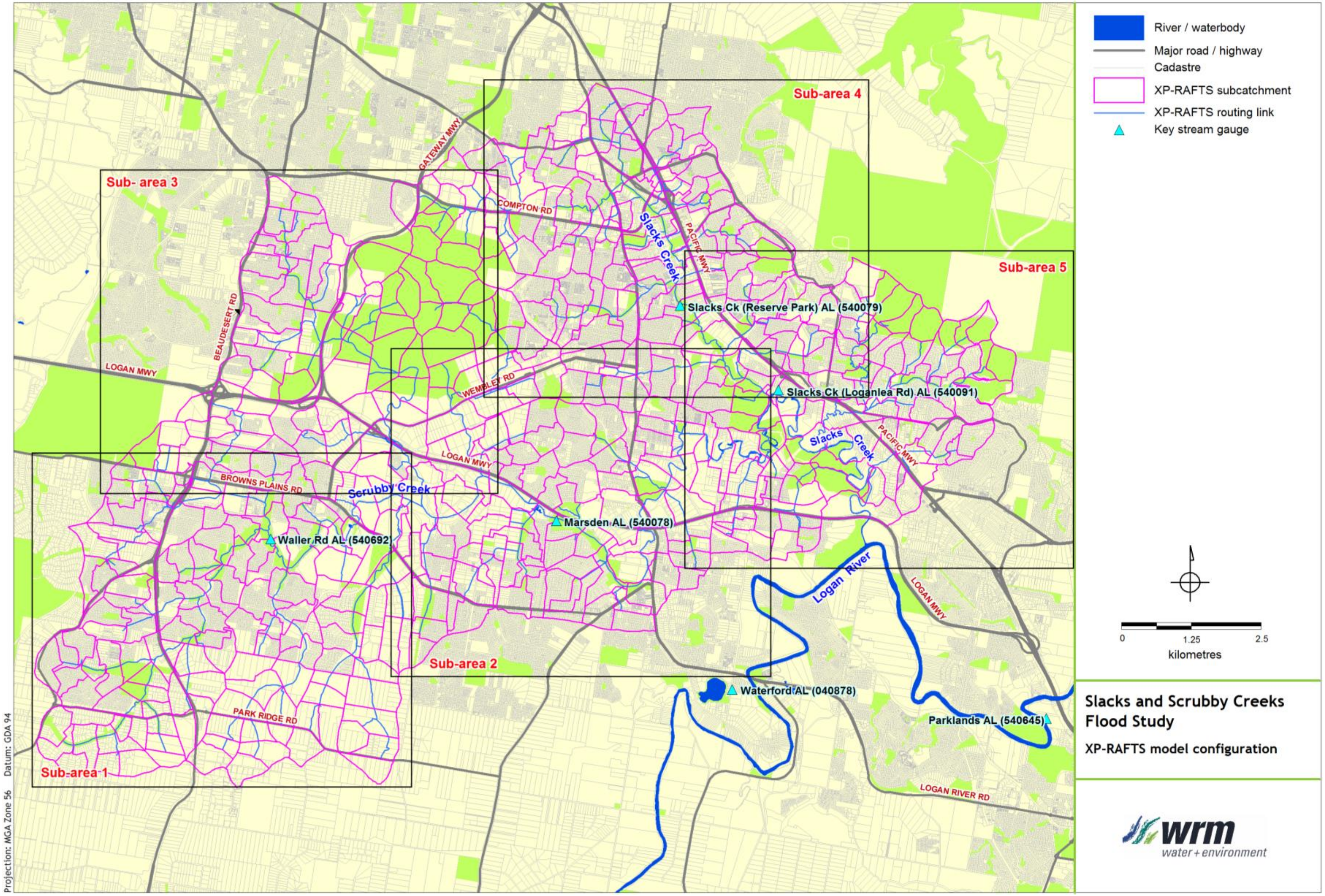


Figure B.1 – XP-RAFTS model configuration – Sub-area tile index

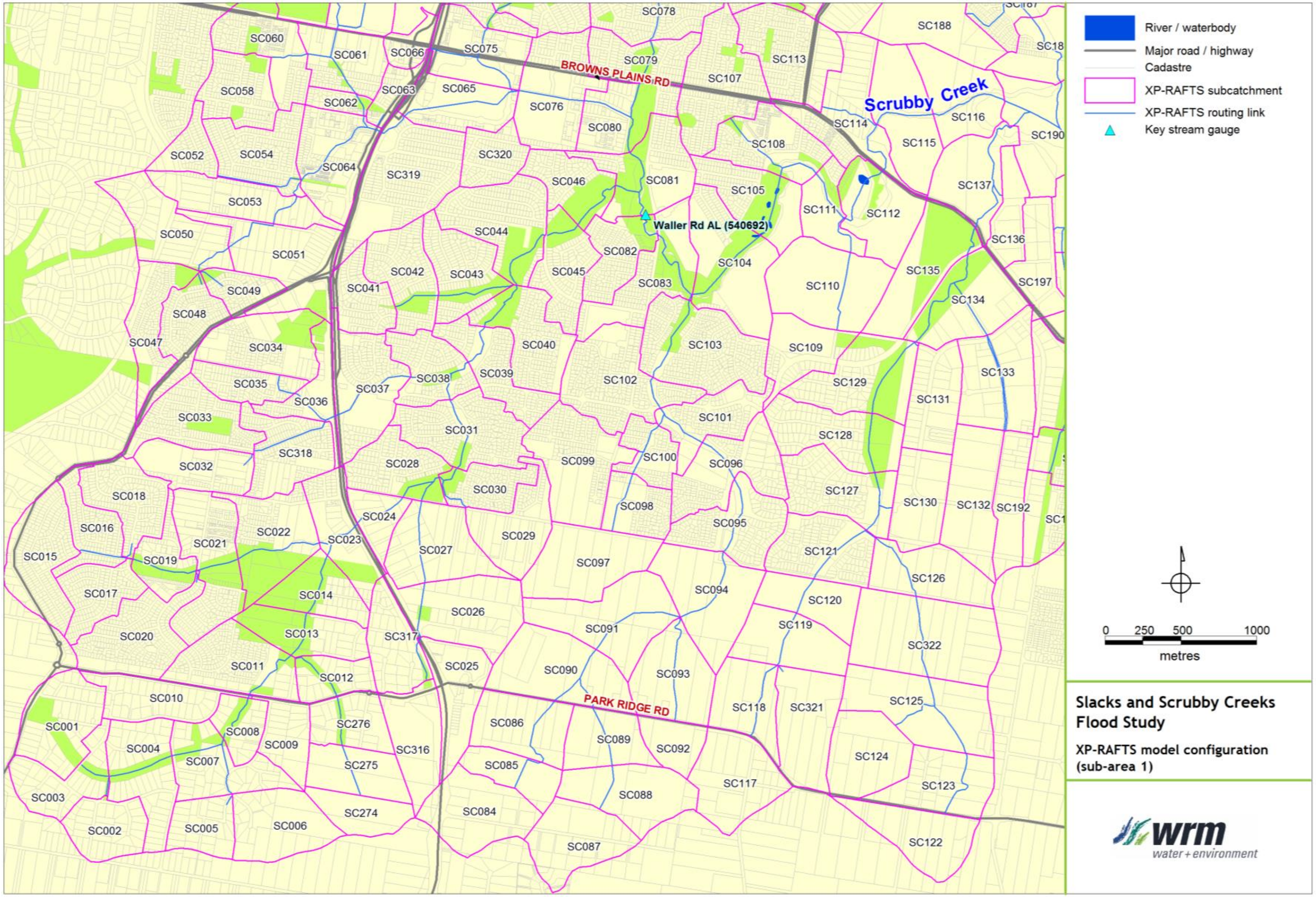


Figure B.2 – XP-RAFTS model configuration – Sub-area 1

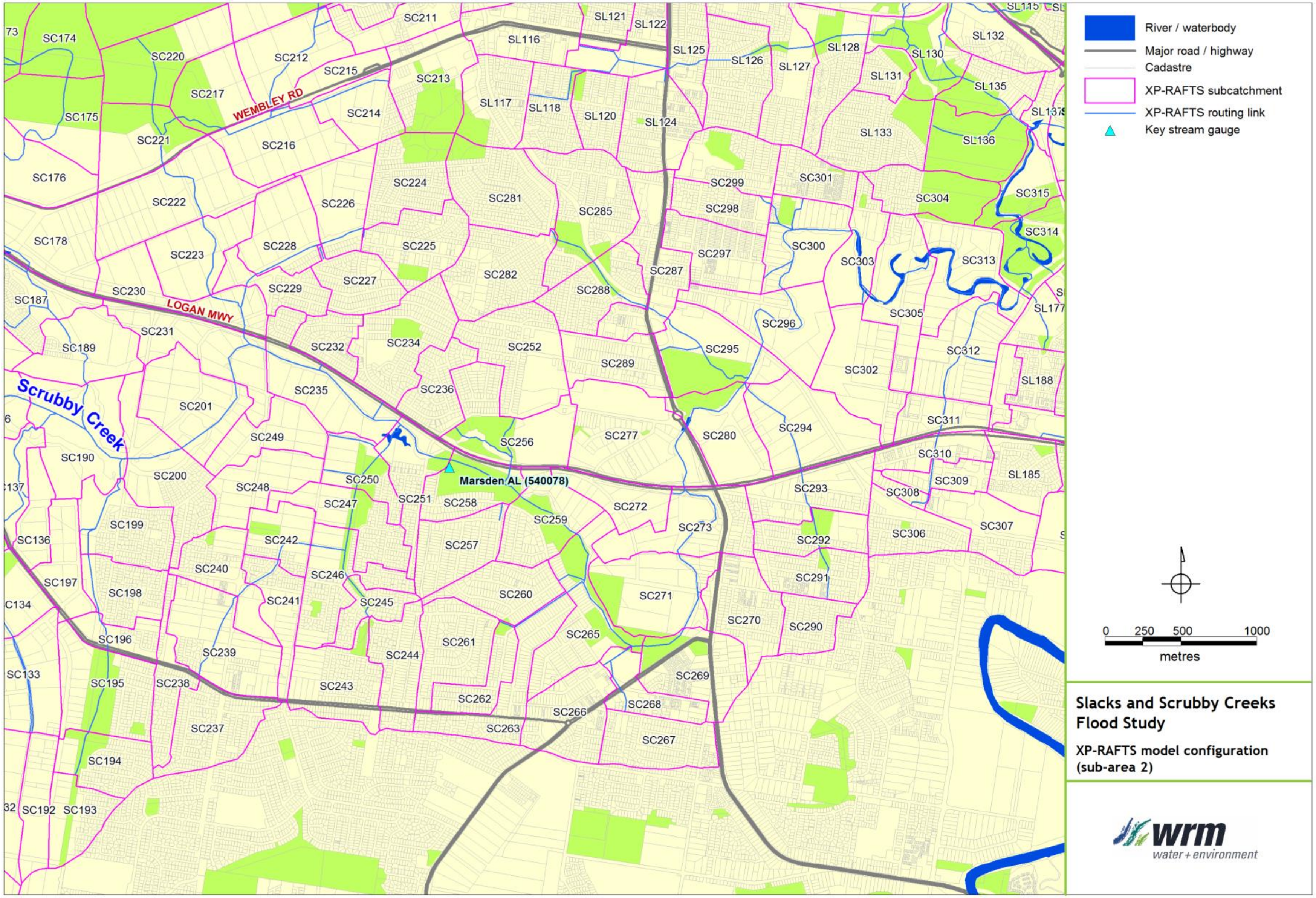


Figure B.3 – XP-RAFTS model configuration – Sub-area 2

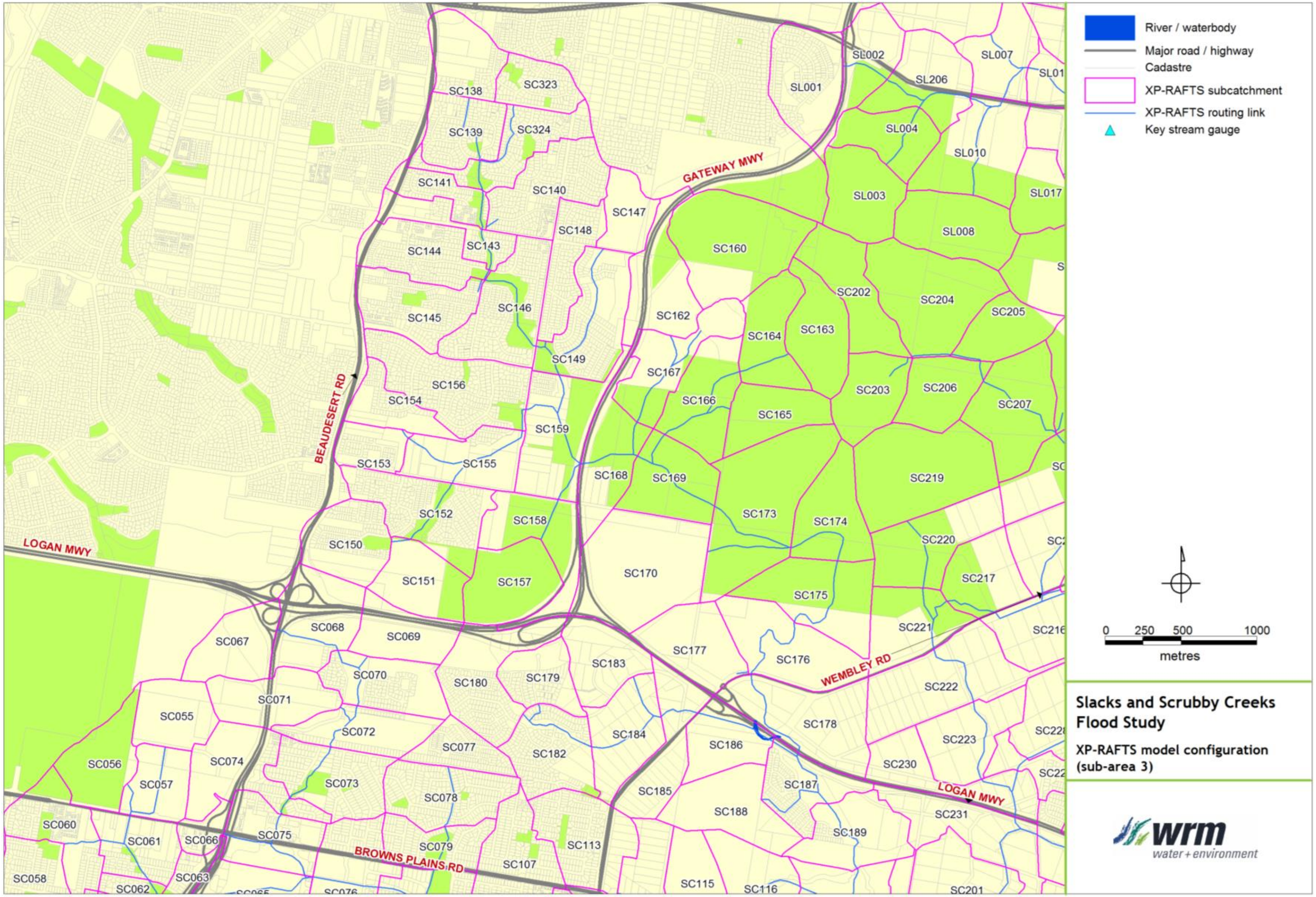


Figure B.4 – XP-RAFTS model configuration – Sub-area 3

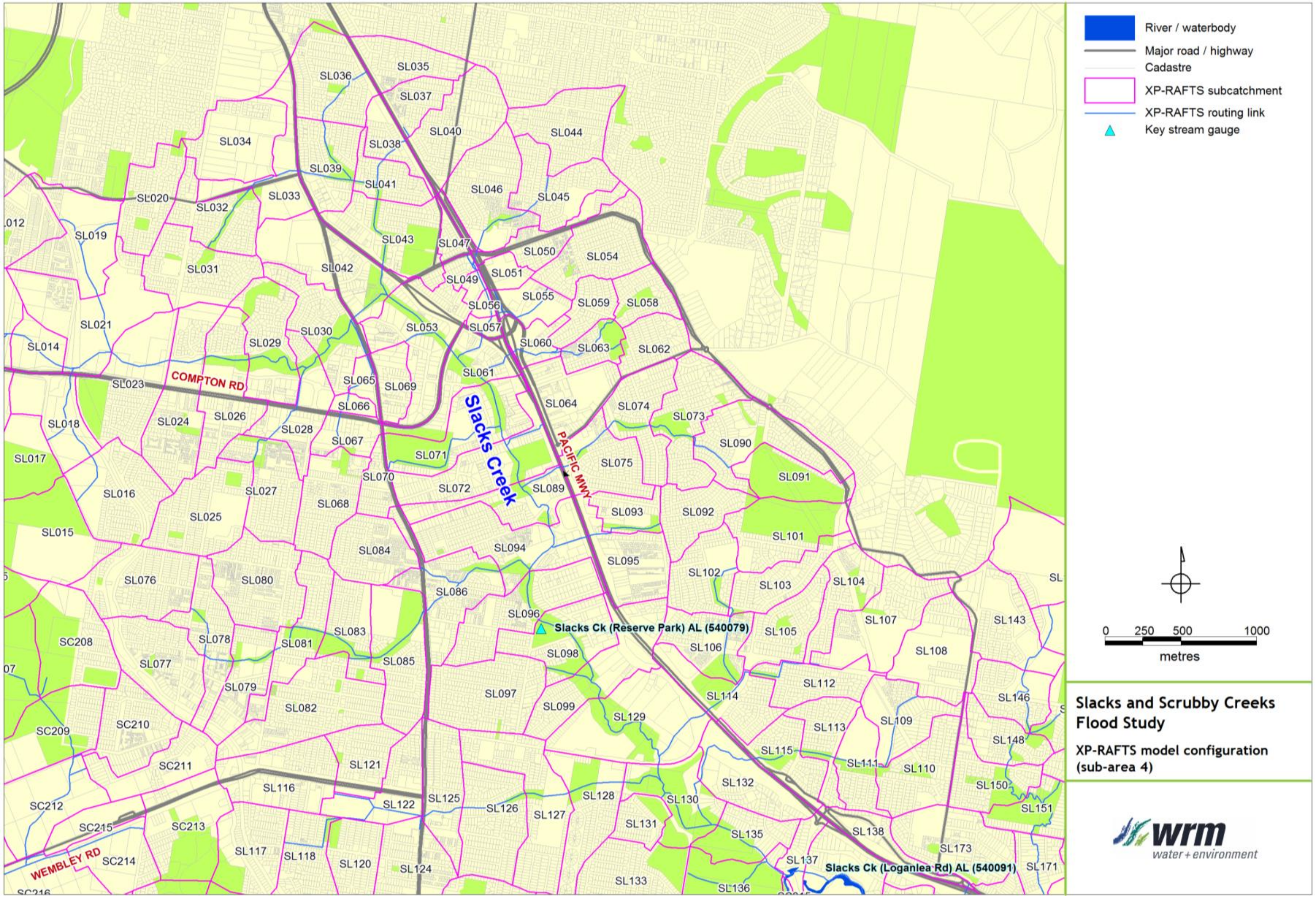


Figure B.5 – XP-RAFTS model configuration – Sub-area 4

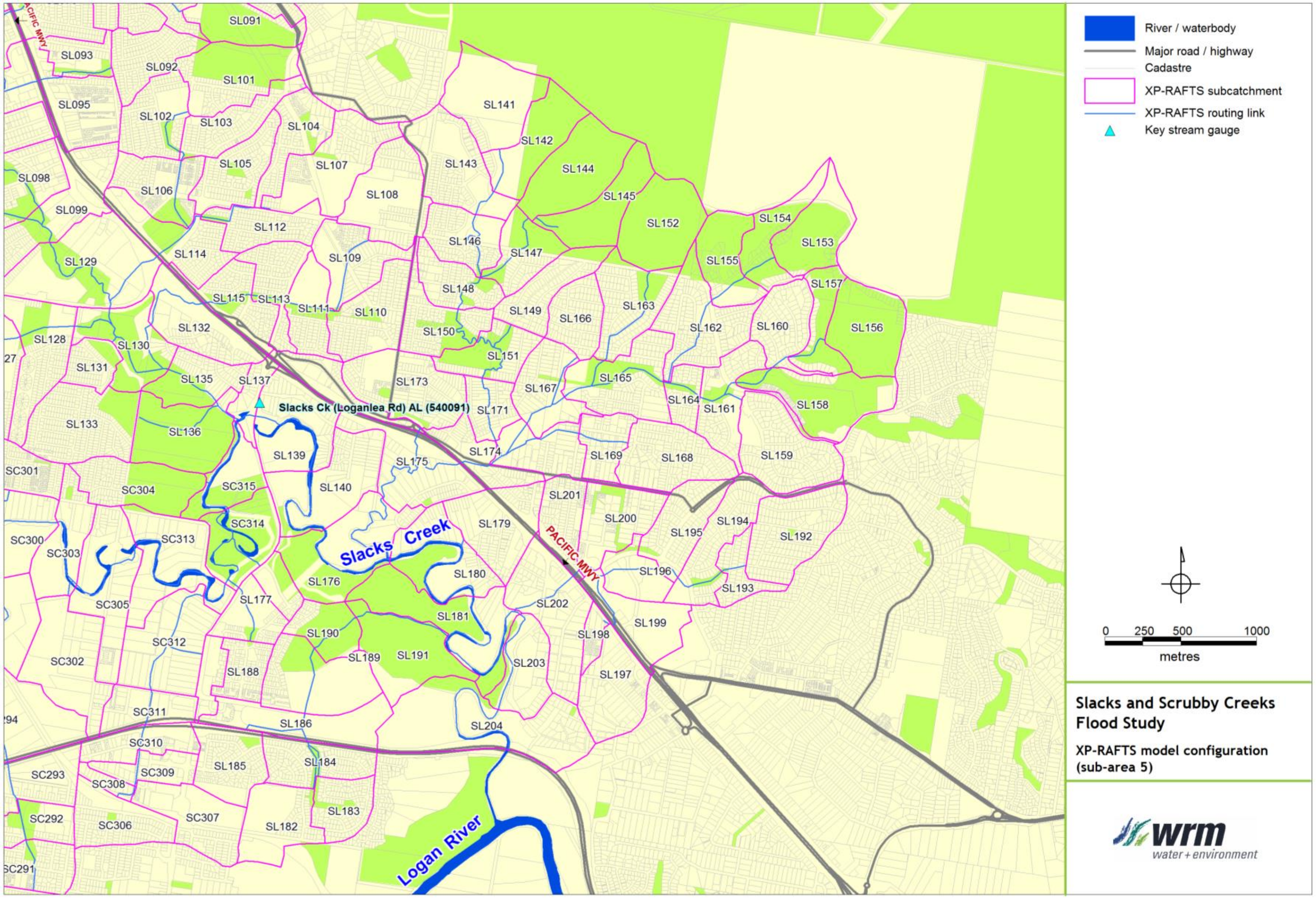


Figure B.6 – XP-RAFTS model configuration – Sub-area 5

B2 XP-RAFTS subcatchment parameters

B2.1 ADOPTED XP-RAFTS PARAMETERS FOR EACH LAND-USE TYPE

Table B.1 - XP-RAFTS parameters for each land-use type

Land-use type (refer to Council planning scheme)	Percentage Impervious (%)	Manning's 'n'
Centre	90	0.025
Specialised centre	90	0.025
Commercial	50	0.050
Emerging community	50	0.050
Environmental management	0	0.080
Low-density residential	50	0.050
Low-impact industry	90	0.025
Low to medium-density residential	70	0.038
Medium-density residential	85	0.028
Medium-impact industry	90	0.025
Mixed use	90	0.025
Recreation and open space	0	0.080
Roads	75	0.035
Rural residential	15	0.060
Rural	5	0.075

B2.2 ADOPTED XP-RAFTS SUBCATCHMENT PARAMETERS FOR EXISTING CATCHMENT CONDITIONS

Table B.2 - XP-RAFTS subcatchment parameters, existing catchment conditions

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC001	28.17	43.92	2.6	0.054
SC002	18.74	52.74	3.0	0.048
SC003	20.94	49.53	2.2	0.050
SC004	28.40	45.65	1.9	0.053
SC005	15.24	48.45	2.7	0.050
SC006	26.62	18.63	2.5	0.065
SC007	25.50	40.18	2.8	0.056
SC008	11.95	39.24	2.6	0.056
SC009	14.62	37.59	3.4	0.057
SC010	21.36	55.08	4.0	0.047
SC011	29.40	45.50	2.5	0.053
SC012	13.14	47.32	2.5	0.052

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC013	20.93	26.13	2.7	0.064
SC014	19.02	26.56	2.2	0.064
SC015	29.79	54.89	3.4	0.047
SC016	16.45	55.87	4.2	0.046
SC017	17.81	55.99	4.8	0.046
SC018	22.78	55.38	4.2	0.047
SC019	14.55	42.66	3.1	0.054
SC020	30.60	55.46	3.1	0.047
SC021	33.49	46.75	3.2	0.052
SC022	30.02	32.29	2.4	0.061
SC023	22.03	53.90	1.3	0.048
SC024	11.05	28.27	2.4	0.054
SC025	22.95	71.73	3.4	0.036
SC026	33.76	26.24	2.5	0.055
SC027	29.27	15.68	1.9	0.060
SC028	22.24	45.80	2.0	0.053
SC029	23.56	26.14	3.1	0.057
SC030	15.03	48.65	3.4	0.051
SC031	31.92	47.98	2.1	0.051
SC032	20.35	49.27	4.1	0.050
SC033	26.32	49.47	4.4	0.050
SC034	27.58	61.04	1.7	0.043
SC035	13.50	54.21	3.5	0.047
SC036	14.55	64.28	2.8	0.041
SC037	31.04	54.65	2.5	0.047
SC038	20.18	45.66	2.5	0.053
SC039	22.25	49.25	4.0	0.050
SC040	26.73	45.23	2.9	0.053
SC041	16.59	53.10	4.4	0.048
SC042	24.36	49.99	3.0	0.050
SC043	23.88	44.88	3.0	0.053
SC044	32.76	41.36	3.3	0.055
SC045	21.56	46.99	3.6	0.052
SC046	19.08	34.00	1.8	0.060
SC047	20.28	43.55	2.0	0.054
SC048	20.45	55.62	2.2	0.047
SC049	10.47	56.33	3.5	0.046
SC050	28.95	47.88	2.8	0.051
SC051	35.94	62.33	4.3	0.042
SC052	10.73	57.59	3.3	0.045
SC053	25.30	48.77	2.7	0.051

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning’s 'n'
SC054	25.15	54.56	3.8	0.047
SC055	21.51	69.42	6.3	0.038
SC056	24.66	6.84	4.1	0.076
SC057	18.58	80.58	2.5	0.031
SC058	20.90	50.22	3.4	0.050
SC060	26.97	45.83	3.5	0.052
SC061	21.35	77.36	2.8	0.033
SC062	5.47	56.39	6.3	0.046
SC063	7.98	77.79	3.6	0.033
SC064	28.97	68.76	0.1	0.038
SC065	22.67	82.87	0.8	0.030
SC066	7.53	81.95	4.6	0.030
SC067	23.14	14.16	6.6	0.072
SC068	30.95	34.85	3.2	0.059
SC069	21.49	19.14	3.6	0.069
SC070	25.98	42.62	4.1	0.054
SC071	24.87	14.77	3.1	0.071
SC072	23.14	19.93	4.2	0.068
SC073	30.20	52.96	2.9	0.048
SC074	31.65	78.42	3.6	0.032
SC075	25.55	84.59	0.6	0.029
SC076	33.21	75.37	3.3	0.034
SC077	14.97	50.47	5.5	0.050
SC078	29.58	54.07	3.7	0.048
SC079	19.70	48.05	3.0	0.051
SC080	23.29	52.84	1.8	0.048
SC081	29.15	35.44	1.7	0.059
SC082	18.72	45.72	3.1	0.053
SC083	28.72	44.57	2.1	0.053
SC084	29.10	24.29	2.4	0.057
SC085	14.88	16.41	1.3	0.060
SC086	24.65	19.50	2.6	0.059
SC087	26.62	18.06	2.4	0.059
SC088	27.98	15.00	3.2	0.060
SC089	19.49	17.05	2.0	0.059
SC090	35.88	13.40	2.5	0.064
SC091	35.23	7.51	2.0	0.070
SC092	12.05	19.10	5.4	0.058
SC093	27.53	14.77	1.9	0.061
SC094	34.96	7.65	1.8	0.071
SC095	26.49	44.77	1.4	0.053

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC096	28.91	54.24	2.6	0.047
SC097	31.71	17.77	3.1	0.059
SC098	15.93	44.80	3.4	0.053
SC099	34.78	51.64	3.9	0.049
SC100	13.12	50.04	2.8	0.050
SC101	20.89	42.25	3.0	0.055
SC102	36.70	53.05	3.3	0.048
SC103	39.80	49.05	2.8	0.051
SC104	37.88	19.41	2.2	0.068
SC105	24.97	24.98	2.1	0.065
SC107	35.15	53.40	4.5	0.048
SC108	25.41	42.15	1.8	0.055
SC109	19.25	26.55	3.3	0.064
SC110	37.07	0.00	2.5	0.080
SC111	14.85	7.28	2.8	0.076
SC112	26.13	4.03	1.5	0.078
SC113	32.71	59.37	3.8	0.044
SC114	32.22	62.01	4.3	0.043
SC115	30.27	35.66	3.0	0.058
SC116	25.59	6.30	1.5	0.076
SC117	29.31	21.01	4.6	0.058
SC118	21.61	15.42	2.4	0.062
SC119	24.12	1.58	1.9	0.078
SC120	18.21	0.28	2.8	0.080
SC121	26.83	40.23	1.6	0.056
SC122	24.54	16.01	3.0	0.060
SC123	25.79	19.61	1.8	0.058
SC124	26.21	12.22	3.3	0.064
SC125	38.85	0.43	2.2	0.080
SC126	25.00	8.03	1.1	0.075
SC127	28.29	39.10	2.1	0.057
SC128	29.41	37.66	2.6	0.057
SC129	31.78	31.63	1.6	0.061
SC130	21.82	79.76	2.9	0.031
SC131	22.84	85.90	2.8	0.028
SC132	29.27	80.14	2.2	0.031
SC133	33.08	87.82	1.7	0.026
SC134	29.90	54.65	0.9	0.047
SC135	30.15	12.13	0.7	0.073
SC136	13.43	85.29	1.8	0.028
SC137	25.02	31.51	1.3	0.061

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC138	22.09	63.79	5.1	0.041
SC139	22.19	52.83	2.7	0.048
SC140	32.83	53.97	3.8	0.048
SC141	13.41	50.81	2.4	0.050
SC143	15.34	55.31	1.8	0.047
SC144	26.51	56.09	2.4	0.046
SC145	29.42	53.96	3.2	0.048
SC146	35.82	45.51	1.4	0.053
SC147	15.12	12.66	4.5	0.072
SC148	20.98	54.36	3.1	0.047
SC149	34.51	47.75	2.1	0.051
SC150	25.98	36.31	2.8	0.058
SC151	23.30	0.82	4.1	0.080
SC152	36.26	43.61	2.5	0.054
SC153	13.04	46.85	4.7	0.052
SC154	16.17	53.68	4.3	0.048
SC155	25.36	36.91	1.3	0.058
SC156	42.84	52.34	2.6	0.049
SC157	27.62	5.53	3.4	0.077
SC158	28.54	30.86	2.9	0.061
SC159	36.13	28.09	0.8	0.063
SC160	48.42	0.00	2.8	0.080
SC162	28.80	20.46	6.2	0.068
SC163	25.72	0.00	3.9	0.080
SC164	24.15	0.00	3.6	0.080
SC165	21.21	0.00	4.4	0.080
SC166	28.67	0.00	1.4	0.080
SC167	27.09	1.83	1.9	0.079
SC168	28.29	19.96	1.6	0.068
SC169	27.21	1.78	1.0	0.079
SC170	54.15	10.82	2.4	0.074
SC173	57.84	0.91	2.0	0.079
SC174	27.55	0.00	3.1	0.080
SC175	34.91	0.84	0.8	0.079
SC176	35.47	6.69	1.8	0.075
SC177	27.14	18.14	2.8	0.068
SC178	40.08	82.54	1.3	0.030
SC179	18.12	30.22	5.5	0.061
SC180	34.85	49.23	3.8	0.050
SC182	28.13	48.03	2.5	0.051
SC183	22.95	30.10	7.9	0.061

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC184	27.41	38.34	2.5	0.056
SC185	26.99	55.60	2.4	0.047
SC186	20.86	58.43	2.6	0.045
SC187	22.18	45.67	1.0	0.053
SC188	29.99	45.58	3.3	0.053
SC189	28.63	20.76	1.9	0.068
SC190	40.64	13.55	0.7	0.072
SC192	17.54	78.12	2.1	0.032
SC193	18.36	53.73	3.4	0.047
SC194	21.40	50.89	2.6	0.049
SC195	35.96	47.73	1.8	0.051
SC196	11.99	64.63	1.8	0.041
SC197	18.22	84.56	4.3	0.029
SC198	20.08	45.79	2.4	0.053
SC199	27.35	38.26	2.1	0.057
SC200	35.86	41.31	3.1	0.055
SC201	33.79	29.36	1.2	0.061
SC202	27.19	0.00	3.5	0.080
SC203	22.06	0.00	3.0	0.080
SC204	44.90	0.00	3.5	0.080
SC205	19.44	2.44	4.6	0.079
SC206	21.34	0.00	2.3	0.080
SC207	35.30	0.00	2.1	0.080
SC208	31.28	21.40	3.5	0.067
SC209	30.99	16.65	2.2	0.069
SC210	23.61	62.02	2.2	0.043
SC211	19.69	71.04	2.3	0.037
SC212	29.11	11.69	0.9	0.070
SC213	31.33	56.55	2.0	0.046
SC214	19.08	82.73	1.7	0.030
SC215	11.31	48.09	2.1	0.051
SC216	31.63	86.96	0.5	0.027
SC217	22.95	2.88	1.3	0.078
SC219	49.91	0.00	2.7	0.080
SC220	31.82	0.72	2.8	0.080
SC221	26.26	10.67	0.9	0.073
SC222	44.45	57.77	2.6	0.045
SC223	26.17	40.22	1.2	0.055
SC224	27.41	43.99	2.8	0.054
SC225	25.71	48.85	1.7	0.051
SC226	23.52	84.43	2.4	0.029

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC227	18.60	56.31	2.3	0.046
SC228	24.94	85.11	0.8	0.028
SC229	15.79	56.04	1.9	0.046
SC230	27.28	60.23	1.8	0.043
SC231	33.62	40.44	2.0	0.053
SC232	13.30	57.43	4.0	0.045
SC234	34.35	51.93	1.7	0.049
SC235	33.56	23.82	0.2	0.061
SC236	18.69	57.13	3.7	0.046
SC237	28.74	56.63	2.2	0.046
SC238	16.14	59.05	2.0	0.045
SC239	36.59	57.34	1.5	0.045
SC240	22.02	56.29	2.6	0.046
SC241	17.13	52.27	3.1	0.049
SC242	16.14	42.62	1.4	0.054
SC243	28.84	55.35	2.9	0.047
SC244	22.11	55.36	2.5	0.047
SC245	11.60	50.09	1.0	0.050
SC246	27.79	42.05	2.0	0.053
SC247	24.49	39.20	1.5	0.054
SC248	22.62	34.11	1.2	0.054
SC249	20.42	23.27	0.1	0.057
SC250	16.55	19.69	1.3	0.064
SC251	20.53	33.04	1.0	0.060
SC252	35.93	51.63	2.1	0.049
SC256	35.96	39.93	0.9	0.056
SC257	23.65	55.45	1.5	0.047
SC258	21.80	29.35	0.7	0.062
SC259	27.02	47.39	0.9	0.051
SC260	21.51	54.61	1.5	0.047
SC261	26.69	55.53	2.9	0.047
SC262	14.52	52.74	2.2	0.048
SC263	26.02	57.14	1.5	0.046
SC265	33.54	40.64	0.9	0.055
SC266	28.03	61.67	2.3	0.043
SC267	24.63	54.37	2.2	0.047
SC268	15.77	73.35	2.0	0.035
SC269	30.59	57.19	3.5	0.045
SC270	26.70	56.34	2.0	0.046
SC271	36.73	27.94	0.5	0.063
SC272	17.21	85.10	0.7	0.028

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning’s 'n'
SC273	32.69	58.27	0.7	0.045
SC274	14.26	0.00	3.4	0.080
SC275	19.51	0.02	3.5	0.080
SC276	17.35	47.79	3.2	0.051
SC277	49.30	53.24	1.3	0.048
SC280	27.55	51.71	0.7	0.049
SC281	34.54	51.98	2.2	0.049
SC282	32.47	54.80	2.8	0.047
SC285	39.70	53.86	2.5	0.048
SC287	31.47	66.98	3.2	0.040
SC288	24.39	52.74	0.1	0.048
SC289	21.78	65.05	3.1	0.041
SC290	14.34	55.07	2.9	0.047
SC291	21.10	54.26	2.2	0.047
SC292	17.45	41.42	0.9	0.055
SC293	26.22	62.38	1.2	0.042
SC294	37.55	60.94	0.8	0.042
SC295	33.79	11.10	0.2	0.073
SC296	33.72	38.10	0.3	0.057
SC297	24.52	56.24	2.7	0.046
SC298	16.09	56.23	5.3	0.046
SC299	22.41	42.24	3.9	0.055
SC300	27.98	15.30	0.4	0.071
SC301	14.98	60.87	4.9	0.043
SC302	32.54	86.91	0.8	0.027
SC303	20.23	25.03	2.4	0.063
SC304	23.41	23.00	2.0	0.066
SC305	31.25	43.31	0.8	0.050
SC306	20.13	72.44	1.0	0.036
SC307	23.14	69.19	1.3	0.038
SC308	3.77	81.09	1.5	0.031
SC309	11.08	80.96	1.0	0.031
SC310	14.42	80.88	0.7	0.031
SC311	14.31	82.96	0.6	0.030
SC312	31.57	54.87	0.8	0.043
SC313	31.60	40.48	0.3	0.052
SC314	22.21	11.03	0.6	0.072
SC315	15.81	6.88	0.3	0.074
SC316	22.81	45.21	3.7	0.053
SC317	20.28	66.33	3.9	0.040
SC318	25.16	54.54	1.6	0.047

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC319	43.26	58.34	2.4	0.045
SC320	14.59	57.50	3.6	0.045
SC321	28.93	16.12	2.6	0.060
SC322	48.60	0.00	1.4	0.080
SC323	16.10	51.44	5.6	0.049
SC324	24.75	47.86	3.1	0.051
SL001	30.58	40.80	6.8	0.056
SL002	21.82	26.28	3.4	0.064
SL003	26.72	0.16	4.3	0.080
SL004	20.90	1.50	4.2	0.079
SL006	31.71	11.93	4.2	0.073
SL007	22.27	9.24	2.9	0.074
SL008	30.55	0.00	4.2	0.080
SL010	36.78	12.23	2.4	0.073
SL012	26.41	54.50	3.6	0.047
SL014	11.09	23.72	0.9	0.065
SL015	36.23	27.10	2.2	0.064
SL016	31.16	43.45	2.0	0.054
SL017	18.06	1.28	5.9	0.079
SL018	21.74	39.73	0.7	0.056
SL019	29.44	47.85	2.4	0.051
SL020	20.63	54.25	2.1	0.047
SL021	41.44	36.61	3.4	0.057
SL023	36.23	30.18	2.9	0.061
SL024	33.59	61.03	2.6	0.043
SL025	31.17	54.78	2.1	0.047
SL026	28.20	68.06	1.9	0.039
SL027	23.56	55.43	3.1	0.047
SL028	21.44	74.01	1.8	0.035
SL029	25.56	46.34	3.8	0.052
SL030	24.75	53.88	0.9	0.047
SL031	27.78	50.98	4.1	0.049
SL032	21.26	52.87	4.4	0.048
SL033	21.31	69.38	5.1	0.038
SL034	27.85	56.06	4.2	0.046
SL035	17.29	59.10	4.3	0.045
SL036	27.95	54.29	3.7	0.047
SL037	10.70	59.02	4.9	0.044
SL038	10.53	52.83	3.0	0.048
SL039	21.38	58.72	2.1	0.045
SL040	28.25	58.52	5.1	0.045

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL041	12.33	54.65	2.8	0.047
SL042	33.93	81.61	3.0	0.030
SL043	30.53	59.93	2.8	0.044
SL044	25.50	57.23	4.5	0.046
SL045	22.94	55.57	6.3	0.047
SL046	29.56	65.05	5.3	0.040
SL047	2.05	74.90	4.7	0.035
SL048	4.35	80.26	3.4	0.031
SL049	3.33	78.00	3.5	0.032
SL050	13.88	72.60	3.7	0.036
SL051	6.07	86.88	1.6	0.027
SL052	2.48	84.48	2.9	0.029
SL053	34.71	76.53	1.2	0.033
SL054	27.59	64.10	4.0	0.041
SL055	10.69	86.22	3.2	0.028
SL056	1.99	83.84	3.2	0.029
SL057	2.75	81.07	9.2	0.031
SL058	11.68	46.54	4.7	0.052
SL059	11.27	72.03	3.8	0.036
SL060	9.02	82.54	3.2	0.030
SL061	20.38	61.35	1.6	0.043
SL062	13.70	58.07	8.3	0.045
SL063	9.51	53.51	2.3	0.047
SL064	23.30	85.37	5.1	0.028
SL065	4.55	85.71	1.7	0.028
SL066	3.38	89.91	2.2	0.025
SL067	10.39	83.10	2.2	0.029
SL068	22.59	57.06	3.7	0.046
SL069	10.60	87.50	2.8	0.027
SL070	8.56	69.73	3.0	0.038
SL071	30.82	56.29	2.6	0.046
SL072	30.09	80.25	2.4	0.031
SL073	28.13	47.03	6.3	0.052
SL074	21.51	59.85	3.2	0.044
SL075	21.84	63.07	2.4	0.042
SL076	30.09	59.60	3.4	0.044
SL077	29.05	67.13	3.4	0.040
SL078	21.20	61.75	2.1	0.043
SL079	18.71	69.68	2.2	0.038
SL080	30.36	60.36	3.6	0.044
SL081	20.89	52.18	3.8	0.049

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL082	38.36	58.64	2.5	0.045
SL083	17.86	43.28	2.8	0.054
SL084	20.29	61.41	4.4	0.043
SL085	29.56	46.79	1.3	0.052
SL086	30.72	60.25	1.6	0.044
SL089	18.84	64.64	1.9	0.041
SL090	30.28	51.67	7.0	0.049
SL091	18.45	9.74	8.3	0.074
SL092	17.84	54.24	5.1	0.047
SL093	10.62	65.38	3.2	0.040
SL094	37.76	59.92	2.2	0.044
SL095	23.80	74.78	3.3	0.035
SL096	29.44	63.81	2.7	0.041
SL097	32.76	54.94	3.2	0.047
SL098	25.22	53.47	2.0	0.048
SL099	30.83	64.47	3.5	0.041
SL101	27.35	25.87	5.5	0.064
SL102	20.57	51.82	3.3	0.049
SL103	17.15	52.04	4.0	0.049
SL104	17.46	53.83	5.9	0.048
SL105	19.52	53.28	4.3	0.048
SL106	20.17	66.06	3.0	0.040
SL107	29.96	52.26	7.5	0.049
SL108	28.10	52.89	1.0	0.048
SL109	20.60	54.66	2.6	0.047
SL110	23.04	50.96	1.4	0.049
SL111	15.38	49.38	2.5	0.050
SL112	17.06	55.49	2.5	0.047
SL113	15.73	55.71	2.7	0.047
SL114	22.48	67.94	3.6	0.039
SL115	17.89	53.21	2.1	0.048
SL116	28.84	79.34	3.0	0.032
SL117	24.61	57.32	3.0	0.045
SL118	18.49	53.77	2.0	0.048
SL120	16.25	54.52	2.6	0.047
SL121	16.55	63.37	2.8	0.042
SL122	20.14	79.14	3.2	0.032
SL124	27.36	59.85	2.6	0.044
SL125	21.04	62.06	2.1	0.043
SL126	29.49	54.06	2.2	0.048
SL127	36.01	52.93	2.6	0.048

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL128	26.12	45.56	1.4	0.053
SL129	44.75	53.29	1.0	0.048
SL130	23.01	18.83	0.4	0.069
SL131	9.85	46.55	2.9	0.052
SL132	23.75	61.11	2.7	0.043
SL133	32.30	47.78	2.1	0.051
SL135	16.45	28.66	2.0	0.063
SL136	27.95	3.18	0.6	0.078
SL137	7.59	55.64	5.8	0.046
SL138	13.40	70.23	1.8	0.038
SL139	29.28	29.49	1.1	0.062
SL140	31.72	22.52	1.3	0.065
SL141	29.78	4.65	6.8	0.077
SL142	22.42	2.80	5.2	0.078
SL143	29.38	36.92	4.4	0.058
SL144	28.45	0.00	5.0	0.080
SL145	20.30	0.00	5.3	0.080
SL146	17.33	39.75	3.0	0.056
SL147	16.21	24.50	1.8	0.065
SL148	15.00	44.40	3.9	0.053
SL149	17.51	48.07	4.0	0.051
SL150	19.06	44.03	1.3	0.054
SL151	16.64	29.92	0.9	0.062
SL152	27.04	0.23	8.2	0.080
SL153	21.20	11.17	14.3	0.073
SL154	16.24	15.26	12.5	0.071
SL155	18.67	16.24	4.3	0.070
SL156	25.37	6.60	10.4	0.076
SL157	13.89	15.47	5.3	0.071
SL158	28.20	14.10	3.5	0.072
SL159	29.87	54.12	4.4	0.048
SL160	18.06	54.53	4.1	0.047
SL161	21.21	53.95	2.1	0.048
SL162	28.55	50.86	3.3	0.049
SL163	23.76	44.36	2.0	0.053
SL164	8.41	44.55	2.2	0.053
SL165	28.04	36.35	0.9	0.058
SL166	15.40	53.90	4.7	0.048
SL167	19.72	40.70	1.7	0.053
SL168	25.53	53.54	3.6	0.048
SL169	12.28	51.78	2.4	0.049

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL170	18.82	49.14	1.9	0.050
SL171	11.40	50.80	1.0	0.050
SL173	30.23	56.31	2.6	0.046
SL174	13.80	47.40	0.5	0.052
SL175	28.69	49.22	0.9	0.050
SL176	36.17	5.76	0.3	0.076
SL177	13.42	25.90	1.5	0.064
SL178	7.74	25.73	0.4	0.064
SL179	26.06	55.56	3.8	0.047
SL180	27.68	15.65	0.3	0.071
SL181	35.60	1.58	0.1	0.079
SL182	21.80	53.69	1.5	0.048
SL183	14.46	48.80	0.7	0.051
SL184	18.78	54.31	1.2	0.047
SL185	20.36	56.87	0.5	0.046
SL186	24.16	58.90	1.6	0.045
SL187	7.65	71.21	1.3	0.037
SL188	11.34	56.75	1.5	0.046
SL189	29.88	44.02	0.7	0.054
SL190	13.62	13.58	0.8	0.072
SL191	27.87	7.52	1.4	0.075
SL192	28.41	53.47	3.8	0.048
SL193	9.74	55.20	4.5	0.047
SL194	23.88	56.74	3.0	0.046
SL195	20.53	57.70	4.0	0.045
SL196	12.53	84.87	1.9	0.028
SL197	24.03	64.76	5.0	0.041
SL198	4.65	74.20	6.6	0.035
SL199	20.59	85.53	1.9	0.028
SL200	21.37	64.23	3.7	0.041
SL201	14.98	61.59	3.0	0.043
SL202	31.92	56.78	4.4	0.046
SL203	18.91	26.32	8.8	0.064
SL204	51.76	40.44	1.5	0.055
SL206	28.36	9.53	1.8	0.074

B2.3 ADOPTED XP-RAFTS SUBCATCHMENT PARAMETERS FOR ULTIMATE CATCHMENT CONDITIONS

Table B.3 - XP-RAFTS subcatchment parameters, ultimate catchment conditions

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC001	28.17	43.92	2.6	0.054
SC002	18.74	52.74	3.0	0.048
SC003	20.94	49.53	2.2	0.050
SC004	28.40	45.65	1.9	0.053
SC005	15.24	52.06	2.7	0.049
SC006	26.62	48.13	2.5	0.051
SC007	25.50	42.51	2.8	0.054
SC008	11.95	39.24	2.6	0.056
SC009	14.62	53.44	3.4	0.048
SC010	21.36	55.08	4.0	0.047
SC011	29.40	45.50	2.5	0.053
SC012	13.14	47.32	2.5	0.052
SC013	20.93	26.13	2.7	0.064
SC014	19.02	26.56	2.2	0.064
SC015	29.79	54.89	3.4	0.047
SC016	16.45	55.87	4.2	0.046
SC017	17.81	55.99	4.8	0.046
SC018	22.78	55.38	4.2	0.047
SC019	14.55	42.66	3.1	0.054
SC020	30.60	55.46	3.1	0.047
SC021	33.49	46.75	3.2	0.052
SC022	30.02	32.29	2.4	0.061
SC023	22.03	53.90	1.3	0.048
SC024	11.05	56.93	2.4	0.046
SC025	22.95	72.37	3.4	0.036
SC026	33.76	80.64	2.5	0.031
SC027	29.27	67.09	1.9	0.039
SC028	22.24	45.80	2.0	0.053
SC029	23.56	57.72	3.1	0.045
SC030	15.03	48.65	3.4	0.051
SC031	31.92	47.98	2.1	0.051
SC032	20.35	49.27	4.1	0.050
SC033	26.32	49.47	4.4	0.050
SC034	27.58	61.04	1.7	0.043
SC035	13.50	54.21	3.5	0.047
SC036	14.55	64.28	2.8	0.041
SC037	31.04	54.65	2.5	0.047

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC038	20.18	45.66	2.5	0.053
SC039	22.25	49.25	4.0	0.050
SC040	26.73	45.23	2.9	0.053
SC041	16.59	53.10	4.4	0.048
SC042	24.36	49.99	3.0	0.050
SC043	23.88	44.88	3.0	0.053
SC044	32.76	41.36	3.3	0.055
SC045	21.56	46.99	3.6	0.052
SC046	19.08	34.00	1.8	0.060
SC047	20.28	43.55	2.0	0.054
SC048	20.45	55.62	2.2	0.047
SC049	10.47	56.33	3.5	0.046
SC050	28.95	47.88	2.8	0.051
SC051	35.94	62.33	4.3	0.042
SC052	10.73	57.59	3.3	0.045
SC053	25.30	48.77	2.7	0.051
SC054	25.15	54.56	3.8	0.047
SC055	21.51	69.42	6.3	0.038
SC056	24.66	6.84	4.1	0.076
SC057	18.58	80.58	2.5	0.031
SC058	20.90	50.22	3.4	0.050
SC060	26.97	45.83	3.5	0.052
SC061	21.35	77.36	2.8	0.033
SC062	5.47	56.39	6.3	0.046
SC063	7.98	77.79	3.6	0.033
SC064	28.97	68.76	0.1	0.038
SC065	22.67	82.87	0.8	0.030
SC066	7.53	81.95	4.6	0.030
SC067	23.14	14.16	6.6	0.072
SC068	30.95	34.85	3.2	0.059
SC069	21.49	19.14	3.6	0.069
SC070	25.98	42.62	4.1	0.054
SC071	24.87	14.77	3.1	0.071
SC072	23.14	19.93	4.2	0.068
SC073	30.20	52.96	2.9	0.048
SC074	31.65	78.42	3.6	0.032
SC075	25.55	84.59	0.6	0.029
SC076	33.21	75.37	3.3	0.034
SC077	14.97	50.47	5.5	0.050
SC078	29.58	54.07	3.7	0.048
SC079	19.70	48.05	3.0	0.051

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC080	23.29	52.84	1.8	0.048
SC081	29.15	35.44	1.7	0.059
SC082	18.72	45.72	3.1	0.053
SC083	28.72	44.57	2.1	0.053
SC084	29.10	53.61	2.4	0.048
SC085	14.88	50.00	1.3	0.050
SC086	24.65	50.62	2.6	0.050
SC087	26.62	51.22	2.4	0.049
SC088	27.98	47.13	3.2	0.052
SC089	19.49	50.85	2.0	0.049
SC090	35.88	65.64	2.5	0.040
SC091	35.23	34.92	2.0	0.059
SC092	12.05	51.70	5.4	0.049
SC093	27.53	82.27	1.9	0.030
SC094	34.96	26.36	1.8	0.064
SC095	26.49	44.77	1.4	0.053
SC096	28.91	54.24	2.6	0.047
SC097	31.71	52.77	3.1	0.048
SC098	15.93	44.80	3.4	0.053
SC099	34.78	51.64	3.9	0.049
SC100	13.12	50.04	2.8	0.050
SC101	20.89	42.25	3.0	0.055
SC102	36.70	53.05	3.3	0.048
SC103	39.80	49.05	2.8	0.051
SC104	37.88	19.41	2.2	0.068
SC105	24.97	24.98	2.1	0.065
SC107	35.15	53.40	4.5	0.048
SC108	25.41	42.15	1.8	0.055
SC109	19.25	26.55	3.3	0.064
SC110	37.07	0.00	2.5	0.080
SC111	14.85	7.28	2.8	0.076
SC112	26.13	4.03	1.5	0.078
SC113	32.71	59.37	3.8	0.044
SC114	32.22	62.01	4.3	0.043
SC115	30.27	35.66	3.0	0.058
SC116	25.59	6.30	1.5	0.076
SC117	29.31	43.19	4.6	0.054
SC118	21.61	55.77	2.4	0.046
SC119	24.12	49.37	1.9	0.050
SC120	18.21	48.48	2.8	0.050
SC121	26.83	40.26	1.6	0.056

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC122	24.54	50.42	3.0	0.050
SC123	25.79	88.66	1.8	0.026
SC124	26.21	89.78	3.3	0.025
SC125	38.85	89.92	2.2	0.025
SC126	25.00	76.23	1.1	0.034
SC127	28.29	39.10	2.1	0.057
SC128	29.41	37.66	2.6	0.057
SC129	31.78	31.63	1.6	0.061
SC130	21.82	81.98	2.9	0.030
SC131	22.84	85.90	2.8	0.028
SC132	29.27	86.55	2.2	0.027
SC133	33.08	87.82	1.7	0.026
SC134	29.90	54.65	0.9	0.047
SC135	30.15	12.13	0.7	0.073
SC136	13.43	85.29	1.8	0.028
SC137	25.02	31.51	1.3	0.061
SC138	22.09	63.79	5.1	0.041
SC139	22.19	52.83	2.7	0.048
SC140	32.83	53.97	3.8	0.048
SC141	13.41	50.81	2.4	0.050
SC143	15.34	55.31	1.8	0.047
SC144	26.51	56.09	2.4	0.046
SC145	29.42	53.96	3.2	0.048
SC146	35.82	45.51	1.4	0.053
SC147	15.12	12.66	4.5	0.072
SC148	20.98	54.36	3.1	0.047
SC149	34.51	47.75	2.1	0.051
SC150	25.98	36.31	2.8	0.058
SC151	23.30	0.82	4.1	0.080
SC152	36.26	43.61	2.5	0.054
SC153	13.04	46.85	4.7	0.052
SC154	16.17	53.68	4.3	0.048
SC155	25.36	36.91	1.3	0.058
SC156	42.84	52.34	2.6	0.049
SC157	27.62	5.53	3.4	0.077
SC158	28.54	30.86	2.9	0.061
SC159	36.13	28.09	0.8	0.063
SC160	48.42	0.00	2.8	0.080
SC162	28.80	20.46	6.2	0.068
SC163	25.72	0.00	3.9	0.080
SC164	24.15	0.00	3.6	0.080

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC165	21.21	0.00	4.4	0.080
SC166	28.67	0.00	1.4	0.080
SC167	27.09	1.83	1.9	0.079
SC168	28.29	19.96	1.6	0.068
SC169	27.21	1.78	1.0	0.079
SC170	54.15	10.82	2.4	0.074
SC173	57.84	0.91	2.0	0.079
SC174	27.55	0.00	3.1	0.080
SC175	34.91	0.84	0.8	0.079
SC176	35.47	6.69	1.8	0.075
SC177	27.14	18.14	2.8	0.068
SC178	40.08	82.54	1.3	0.030
SC179	18.12	30.22	5.5	0.061
SC180	34.85	49.23	3.8	0.050
SC182	28.13	48.03	2.5	0.051
SC183	22.95	30.10	7.9	0.061
SC184	27.41	38.34	2.5	0.056
SC185	26.99	55.60	2.4	0.047
SC186	20.86	58.43	2.6	0.045
SC187	22.18	45.67	1.0	0.053
SC188	29.99	45.58	3.3	0.053
SC189	28.63	20.76	1.9	0.068
SC190	40.64	13.55	0.7	0.072
SC192	17.54	85.56	2.1	0.028
SC193	18.36	54.54	3.4	0.047
SC194	21.40	50.89	2.6	0.049
SC195	35.96	47.73	1.8	0.051
SC196	11.99	64.63	1.8	0.041
SC197	18.22	84.56	4.3	0.029
SC198	20.08	45.79	2.4	0.053
SC199	27.35	38.26	2.1	0.057
SC200	35.86	41.31	3.1	0.055
SC201	33.79	29.36	1.2	0.061
SC202	27.19	0.00	3.5	0.080
SC203	22.06	0.00	3.0	0.080
SC204	44.90	0.00	3.5	0.080
SC205	19.44	2.44	4.6	0.079
SC206	21.34	0.00	2.3	0.080
SC207	35.30	0.00	2.1	0.080
SC208	31.28	21.40	3.5	0.067
SC209	30.99	16.65	2.2	0.069

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC210	23.61	62.02	2.2	0.043
SC211	19.69	71.04	2.3	0.037
SC212	29.11	11.69	0.9	0.070
SC213	31.33	56.55	2.0	0.046
SC214	19.08	82.73	1.7	0.030
SC215	11.31	48.09	2.1	0.051
SC216	31.63	86.96	0.5	0.027
SC217	22.95	2.88	1.3	0.078
SC219	49.91	0.00	2.7	0.080
SC220	31.82	0.72	2.8	0.080
SC221	26.26	10.67	0.9	0.073
SC222	44.45	57.77	2.6	0.045
SC223	26.17	40.22	1.2	0.055
SC224	27.41	43.99	2.8	0.054
SC225	25.71	48.85	1.7	0.051
SC226	23.52	84.43	2.4	0.029
SC227	18.60	56.31	2.3	0.046
SC228	24.94	85.11	0.8	0.028
SC229	15.79	56.04	1.9	0.046
SC230	27.28	60.23	1.8	0.043
SC231	33.62	40.44	2.0	0.053
SC232	13.30	57.43	4.0	0.045
SC234	34.35	51.93	1.7	0.049
SC235	33.56	23.82	0.2	0.061
SC236	18.69	57.13	3.7	0.046
SC237	28.74	56.63	2.2	0.046
SC238	16.14	59.05	2.0	0.045
SC239	36.59	57.34	1.5	0.045
SC240	22.02	56.29	2.6	0.046
SC241	17.13	52.27	3.1	0.049
SC242	16.14	42.62	1.4	0.054
SC243	28.84	55.35	2.9	0.047
SC244	22.11	55.36	2.5	0.047
SC245	11.60	50.09	1.0	0.050
SC246	27.79	42.05	2.0	0.053
SC247	24.49	39.20	1.5	0.054
SC248	22.62	34.11	1.2	0.054
SC249	20.42	23.27	0.1	0.057
SC250	16.55	19.69	1.3	0.064
SC251	20.53	33.04	1.0	0.060
SC252	35.93	51.63	2.1	0.049

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning’s 'n'
SC256	35.96	39.93	0.9	0.056
SC257	23.65	55.45	1.5	0.047
SC258	21.80	29.35	0.7	0.062
SC259	27.02	47.39	0.9	0.051
SC260	21.51	54.61	1.5	0.047
SC261	26.69	55.53	2.9	0.047
SC262	14.52	52.74	2.2	0.048
SC263	26.02	57.14	1.5	0.046
SC265	33.54	40.64	0.9	0.055
SC266	28.03	61.67	2.3	0.043
SC267	24.63	54.37	2.2	0.047
SC268	15.77	73.35	2.0	0.035
SC269	30.59	57.19	3.5	0.045
SC270	26.70	56.34	2.0	0.046
SC271	36.73	41.08	0.5	0.055
SC272	17.21	85.10	0.7	0.028
SC273	32.69	58.27	0.7	0.045
SC274	14.26	50.00	3.4	0.050
SC275	19.51	50.00	3.5	0.050
SC276	17.35	48.48	3.2	0.051
SC277	49.30	53.24	1.3	0.048
SC280	27.55	51.71	0.7	0.049
SC281	34.54	51.98	2.2	0.049
SC282	32.47	54.80	2.8	0.047
SC285	39.70	53.86	2.5	0.048
SC287	31.47	66.98	3.2	0.040
SC288	24.39	52.74	0.1	0.048
SC289	21.78	65.05	3.1	0.041
SC290	14.34	55.07	2.9	0.047
SC291	21.10	54.26	2.2	0.047
SC292	17.45	41.42	0.9	0.055
SC293	26.22	62.38	1.2	0.042
SC294	37.55	60.94	0.8	0.042
SC295	33.79	11.10	0.2	0.073
SC296	33.72	38.10	0.3	0.057
SC297	24.52	56.24	2.7	0.046
SC298	16.09	56.23	5.3	0.046
SC299	22.41	42.24	3.9	0.055
SC300	27.98	15.30	0.4	0.071
SC301	14.98	60.87	4.9	0.043
SC302	32.54	86.91	0.8	0.027

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SC303	20.23	25.03	2.4	0.063
SC304	23.41	23.00	2.0	0.066
SC305	31.25	43.31	0.8	0.050
SC306	20.13	72.44	1.0	0.036
SC307	23.14	69.19	1.3	0.038
SC308	3.77	81.09	1.5	0.031
SC309	11.08	80.96	1.0	0.031
SC310	14.42	80.88	0.7	0.031
SC311	14.31	82.96	0.6	0.030
SC312	31.57	54.87	0.8	0.043
SC313	31.60	40.48	0.3	0.052
SC314	22.21	11.03	0.6	0.072
SC315	15.81	6.88	0.3	0.074
SC316	22.81	57.84	3.7	0.045
SC317	20.28	66.33	3.9	0.040
SC318	25.16	54.54	1.6	0.047
SC319	43.26	58.34	2.4	0.045
SC320	14.59	57.50	3.6	0.045
SC321	28.93	88.97	2.6	0.026
SC322	48.60	90.00	1.4	0.025
SC323	16.10	51.44	5.6	0.049
SC324	24.75	47.86	3.1	0.051
SL001	30.58	40.80	6.8	0.056
SL002	21.82	26.28	3.4	0.064
SL003	26.72	0.16	4.3	0.080
SL004	20.90	1.50	4.2	0.079
SL006	31.71	11.93	4.2	0.073
SL007	22.27	9.24	2.9	0.074
SL008	30.55	0.00	4.2	0.080
SL010	36.78	12.23	2.4	0.073
SL012	26.41	54.50	3.6	0.047
SL014	11.09	23.72	0.9	0.065
SL015	36.23	27.10	2.2	0.064
SL016	31.16	43.45	2.0	0.054
SL017	18.06	1.28	5.9	0.079
SL018	21.74	39.73	0.7	0.056
SL019	29.44	47.85	2.4	0.051
SL020	20.63	54.25	2.1	0.047
SL021	41.44	36.61	3.4	0.057
SL023	36.23	30.18	2.9	0.061
SL024	33.59	61.03	2.6	0.043

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL025	31.17	54.78	2.1	0.047
SL026	28.20	68.06	1.9	0.039
SL027	23.56	55.43	3.1	0.047
SL028	21.44	74.01	1.8	0.035
SL029	25.56	46.34	3.8	0.052
SL030	24.75	53.88	0.9	0.047
SL031	27.78	50.98	4.1	0.049
SL032	21.26	52.87	4.4	0.048
SL033	21.31	69.38	5.1	0.038
SL034	27.85	56.06	4.2	0.046
SL035	17.29	59.10	4.3	0.045
SL036	27.95	54.29	3.7	0.047
SL037	10.70	59.02	4.9	0.044
SL038	10.53	52.83	3.0	0.048
SL039	21.38	58.72	2.1	0.045
SL040	28.25	58.52	5.1	0.045
SL041	12.33	54.65	2.8	0.047
SL042	33.93	81.61	3.0	0.030
SL043	30.53	59.93	2.8	0.044
SL044	25.50	57.23	4.5	0.046
SL045	22.94	55.57	6.3	0.047
SL046	29.56	65.05	5.3	0.040
SL047	2.05	74.90	4.7	0.035
SL048	4.35	80.26	3.4	0.031
SL049	3.33	78.00	3.5	0.032
SL050	13.88	72.60	3.7	0.036
SL051	6.07	86.88	1.6	0.027
SL052	2.48	84.48	2.9	0.029
SL053	34.71	76.53	1.2	0.033
SL054	27.59	64.10	4.0	0.041
SL055	10.69	86.22	3.2	0.028
SL056	1.99	83.84	3.2	0.029
SL057	2.75	81.07	9.2	0.031
SL058	11.68	46.54	4.7	0.052
SL059	11.27	72.03	3.8	0.036
SL060	9.02	82.54	3.2	0.030
SL061	20.38	61.35	1.6	0.043
SL062	13.70	58.07	8.3	0.045
SL063	9.51	53.51	2.3	0.047
SL064	23.30	85.37	5.1	0.028
SL065	4.55	85.71	1.7	0.028

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL066	3.38	89.91	2.2	0.025
SL067	10.39	83.10	2.2	0.029
SL068	22.59	57.06	3.7	0.046
SL069	10.60	87.50	2.8	0.027
SL070	8.56	69.73	3.0	0.038
SL071	30.82	56.29	2.6	0.046
SL072	30.09	80.25	2.4	0.031
SL073	28.13	47.03	6.3	0.052
SL074	21.51	59.85	3.2	0.044
SL075	21.84	63.07	2.4	0.042
SL076	30.09	59.60	3.4	0.044
SL077	29.05	67.13	3.4	0.040
SL078	21.20	61.75	2.1	0.043
SL079	18.71	69.68	2.2	0.038
SL080	30.36	60.36	3.6	0.044
SL081	20.89	52.18	3.8	0.049
SL082	38.36	58.64	2.5	0.045
SL083	17.86	43.28	2.8	0.054
SL084	20.29	61.41	4.4	0.043
SL085	29.56	46.79	1.3	0.052
SL086	30.72	60.25	1.6	0.044
SL089	18.84	64.64	1.9	0.041
SL090	30.28	51.67	7.0	0.049
SL091	18.45	9.74	8.3	0.074
SL092	17.84	54.24	5.1	0.047
SL093	10.62	65.38	3.2	0.040
SL094	37.76	59.92	2.2	0.044
SL095	23.80	74.78	3.3	0.035
SL096	29.44	63.81	2.7	0.041
SL097	32.76	54.94	3.2	0.047
SL098	25.22	53.47	2.0	0.048
SL099	30.83	64.47	3.5	0.041
SL101	27.35	25.87	5.5	0.064
SL102	20.57	51.82	3.3	0.049
SL103	17.15	52.04	4.0	0.049
SL104	17.46	53.83	5.9	0.048
SL105	19.52	53.29	4.3	0.048
SL106	20.17	66.06	3.0	0.040
SL107	29.96	52.26	7.5	0.049
SL108	28.10	52.89	1.0	0.048
SL109	20.60	54.66	2.6	0.047

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL110	23.04	50.96	1.4	0.049
SL111	15.38	49.38	2.5	0.050
SL112	17.06	55.49	2.5	0.047
SL113	15.73	55.71	2.7	0.047
SL114	22.48	67.95	3.6	0.039
SL115	17.89	53.21	2.1	0.048
SL116	28.84	79.34	3.0	0.032
SL117	24.61	57.32	3.0	0.045
SL118	18.49	53.77	2.0	0.048
SL120	16.25	54.52	2.6	0.047
SL121	16.55	63.37	2.8	0.042
SL122	20.14	79.14	3.2	0.032
SL124	27.36	59.85	2.6	0.044
SL125	21.04	62.06	2.1	0.043
SL126	29.49	54.06	2.2	0.048
SL127	36.01	52.93	2.6	0.048
SL128	26.12	45.56	1.4	0.053
SL129	44.75	53.29	1.0	0.048
SL130	23.01	18.83	0.4	0.069
SL131	9.85	46.55	2.9	0.052
SL132	23.75	61.11	2.7	0.043
SL133	32.30	47.78	2.1	0.051
SL135	16.45	28.66	2.0	0.063
SL136	27.95	3.18	0.6	0.078
SL137	7.59	55.64	5.8	0.046
SL138	13.40	70.23	1.8	0.038
SL139	29.28	29.49	1.1	0.062
SL140	31.72	22.52	1.3	0.065
SL141	29.78	4.65	6.8	0.077
SL142	22.42	2.80	5.2	0.078
SL143	29.38	36.92	4.4	0.058
SL144	28.45	0.00	5.0	0.080
SL145	20.30	0.00	5.3	0.080
SL146	17.33	39.75	3.0	0.056
SL147	16.21	24.50	1.8	0.065
SL148	15.00	44.40	3.9	0.053
SL149	17.51	48.07	4.0	0.051
SL150	19.06	44.03	1.3	0.054
SL151	16.64	29.92	0.9	0.062
SL152	27.04	0.23	8.2	0.080
SL153	21.20	11.17	14.3	0.073

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL154	16.24	15.26	12.5	0.071
SL155	18.67	16.24	4.3	0.070
SL156	25.37	6.60	10.4	0.076
SL157	13.89	15.47	5.3	0.071
SL158	28.20	14.10	3.5	0.072
SL159	29.87	54.12	4.4	0.048
SL160	18.06	54.53	4.1	0.047
SL161	21.21	53.95	2.1	0.048
SL162	28.55	50.86	3.3	0.049
SL163	23.76	44.36	2.0	0.053
SL164	8.41	44.55	2.2	0.053
SL165	28.04	36.35	0.9	0.058
SL166	15.40	53.90	4.7	0.048
SL167	19.72	40.70	1.7	0.053
SL168	25.53	53.54	3.6	0.048
SL169	12.28	51.78	2.4	0.049
SL170	18.82	49.14	1.9	0.050
SL171	11.40	50.80	1.0	0.050
SL173	30.23	56.31	2.6	0.046
SL174	13.80	47.40	0.5	0.052
SL175	28.69	49.22	0.9	0.050
SL176	36.17	5.76	0.3	0.076
SL177	13.42	25.90	1.5	0.064
SL178	7.74	25.73	0.4	0.064
SL179	26.06	55.56	3.8	0.047
SL180	27.68	15.65	0.3	0.071
SL181	35.60	1.58	0.1	0.079
SL182	21.80	53.69	1.5	0.048
SL183	14.46	48.80	0.7	0.051
SL184	18.78	54.31	1.2	0.047
SL185	20.36	56.87	0.5	0.046
SL186	24.16	58.90	1.6	0.045
SL187	7.65	71.21	1.3	0.037
SL188	11.34	56.75	1.5	0.046
SL189	29.88	44.02	0.7	0.054
SL190	13.62	13.58	0.8	0.072
SL191	27.87	7.52	1.4	0.075
SL192	28.41	53.47	3.8	0.048
SL193	9.74	55.20	4.5	0.047
SL194	23.88	56.74	3.0	0.046
SL195	20.53	57.70	4.0	0.045

Subcatchment Name	Total Area (ha)	Percentage Impervious (%)	Catchment Slope (%)	Catchment Manning's 'n'
SL196	12.53	84.87	1.9	0.028
SL197	24.03	64.76	5.0	0.041
SL198	4.65	74.20	6.6	0.035
SL199	20.59	85.53	1.9	0.028
SL200	21.37	64.23	3.7	0.041
SL201	14.98	61.59	3.0	0.043
SL202	31.92	56.78	4.4	0.046
SL203	18.91	26.32	8.8	0.064
SL204	51.76	40.44	1.5	0.055
SL206	28.36	9.53	1.8	0.074

B3 XP-RAFTS routing link parameters

Table B.4 - XP-RAFTS routing link parameters

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC001	SC001	SC003	Routing	0.09	0.25	-
L_SC002	SC002	SC003	Routing	0.02	0.50	-
L_SC003	SC003	SC004	Routing	0.20	0.25	-
L_SC004	SC004	SC007	Routing	0.17	0.25	-
L_SC005	SC005	SC006	Lagging	-	-	0.00
L_SC006	SC006	SC007	Routing	0.07	0.50	-
L_SC007	SC007	SC008	Routing	0.15	0.25	-
L_SC008	SC008	SC010	Lagging	-	-	0.22
L_SC009	SC009	SC010	Lagging	-	-	0.00
L_SC010	SC010	SC011	Routing	0.19	0.25	-
L_SC011	SC011	SC013	Routing	0.15	0.25	-
L_SC012	SC012	SC011	Lagging	-	-	0.00
L_SC013	SC013	SC014	Routing	0.19	0.25	-
L_SC014	SC014	SC023	Routing	0.15	0.25	-
L_SC015	SC015	SC016	Lagging	-	-	0.00
L_SC016	SC016	SC017	Lagging	-	-	0.00
L_SC017	SC017	SC019	Routing	0.20	0.25	-
L_SC018	SC018	SC016	Lagging	-	-	0.00
L_SC019	SC019	SC021	Routing	0.13	0.25	-
L_SC020	SC020	SC019	Lagging	-	-	0.00
L_SC021	SC021	SC022	Routing	0.26	0.25	-
L_SC022	SC022	SC023	Routing	0.14	0.25	-
L_SC023	SC023	SC024	Routing	0.17	0.25	-
L_SC024	SC024	SC028	Routing	0.14	0.25	-
L_SC025	SC025	SC026	Routing	0.17	0.25	-
L_SC026	SC026	SC027	Routing	0.25	0.25	-
L_SC027	SC027	SC028	Routing	0.10	0.25	-
L_SC028	SC028	SC030	Routing	0.08	0.25	-
L_SC029	SC029	SC030	Lagging	-	-	0.00
L_SC030	SC030	SC031	Routing	0.23	0.25	-
L_SC031	SC031	SC038	Routing	0.15	0.25	-
L_SC032	SC032	SC033	Lagging	-	-	0.00
L_SC033	SC033	SC318	Routing	0.07	0.00	-
L_SC034	SC034	SC035	Lagging	-	-	1.69
L_SC035	SC035	SC036	Routing	0.16	0.25	-
L_SC036	SC036	SC037	Routing	0.28	0.25	-
L_SC037	SC037	SC038	Routing	0.19	0.25	-
L_SC038	SC038	SC039	Routing	0.14	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC039	SC039	SC040	Routing	0.17	0.25	-
L_SC040	SC040	SC044	Routing	0.21	0.25	-
L_SC041	SC041	SC042	Routing	0.14	0.25	-
L_SC042	SC042	SC043	Routing	0.24	0.25	-
L_SC043	SC043	SC040	Lagging	-	-	0.00
L_SC044	SC044	SC045	Routing	0.10	0.25	-
L_SC045	SC045	SC046	Routing	0.19	0.25	-
L_SC046	SC046	SC081	Routing	0.15	0.25	-
L_SC047	SC047	SC050	Routing	0.05	0.50	-
L_SC048	SC048	SC047	Routing	0.01	0.50	-
L_SC049	SC049	SC047	Routing	0.03	0.50	-
L_SC050	SC050	SC051	Routing	0.07	0.50	-
L_SC051	SC051	SC053	Routing	0.05	0.50	-
L_SC052	SC052	SC054	Routing	0.08	0.00	-
L_SC053	SC053	SC054	Routing	0.06	0.25	-
L_SC054	SC054	SC064	Routing	0.13	0.50	-
L_SC055	SC055	SC057	Routing	0.11	0.50	-
L_SC056	SC056	SC057	Routing	0.10	0.25	-
L_SC057	SC057	SC061	Routing	0.04	0.50	-
L_SC058	SC058	SC060	Routing	0.11	0.25	-
L_SC060	SC060	SC061	Routing	0.08	0.50	-
L_SC061	SC061	SC062	Routing	0.03	0.50	-
L_SC062	SC062	SC064	Routing	0.03	0.50	-
L_SC063	SC063	SC064	Lagging	-	-	0.00
L_SC064	SC064	SC319	Routing	0.09	0.25	-
L_SC065	SC065	SC076	Lagging	-	-	3.63
L_SC066	SC066	SC075	Lagging	-	-	5.32
L_SC067	SC067	SC068	Routing	0.20	0.25	-
L_SC068	SC068	SC070	Routing	0.21	0.25	-
L_SC069	SC069	SC070	Routing	0.16	0.25	-
L_SC070	SC070	SC072	Routing	0.16	0.25	-
L_SC071	SC071	SC072	Routing	0.16	0.25	-
L_SC072	SC072	SC073	Routing	0.21	0.25	-
L_SC073	SC073	SC074	Routing	0.02	0.50	-
L_SC074	SC074	SC075	Lagging	-	-	4.46
l_SC075	SC075	SC065	Lagging	-	-	0.51
L_SC076	SC076	SC080	Routing	0.27	0.25	-
L_SC077	SC077	SC078	Lagging	-	-	3.46
L_SC078	SC078	SC079	Routing	0.04	0.00	-
L_SC079	SC079	SC080	Lagging	-	-	0.00
L_SC080	SC080	SC081	Routing	0.23	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC081	SC081	SC082	Routing	0.10	0.25	-
L_SC082	SC082	SC083	Routing	0.25	0.25	-
L_SC083	SC083	SC104	Routing	0.28	0.25	-
L_SC084	SC084	SC085	Routing	0.14	0.25	-
L_SC085	SC085	SC086	Routing	0.24	0.25	-
L_SC086	SC086	SC090	Routing	0.21	0.25	-
L_SC087	SC087	SC088	Routing	0.14	0.25	-
L_SC088	SC088	SC089	Routing	0.19	0.25	-
L_SC089	SC089	SC090	Routing	0.20	0.25	-
L_SC090	SC090	SC091	Routing	0.31	0.25	-
L_SC091	SC091	SC094	Routing	0.27	0.25	-
L_SC092	SC092	SC093	Routing	0.34	0.25	-
L_SC093	SC093	SC091	Lagging	-	-	0.00
L_SC094	SC094	SC095	Routing	0.24	0.25	-
L_SC095	SC095	SC096	Routing	0.15	0.25	-
L_SC096	SC096	SC101	Routing	0.17	0.25	-
L_SC097	SC097	SC098	Routing	0.08	0.50	-
L_SC098	SC098	SC100	Routing	0.17	0.25	-
L_SC099	SC099	SC100	Routing	0.11	0.25	-
L_SC100	SC100	SC101	Routing	0.06	0.25	-
L_SC101	SC101	SC102	Routing	0.10	0.25	-
L_SC102	SC102	SC103	Routing	0.27	0.25	-
L_SC103	SC103	SC083	Routing	0.02	0.25	-
L_SC104	SC104	SC105	Routing	0.19	0.25	-
L_SC105	SC105	SC108	Routing	0.14	0.25	-
L_SC107	SC107	SC108	Routing	0.34	0.25	-
L_SC108	SC108	SC111	Routing	0.17	0.25	-
L_SC109	SC109	SC110	Routing	0.10	0.50	-
L_SC110	SC110	SC111	Routing	0.14	0.25	-
L_SC111	SC111	SC112	Routing	0.21	0.25	-
L_SC112	SC112	SC114	Routing	0.20	0.25	-
L_SC113	SC113	SC114	Routing	0.18	0.25	-
L_SC114	SC114	SC115	Routing	0.19	0.25	-
L_SC115	SC115	SC116	Routing	0.24	0.25	-
L_SC116	SC116	SC190	Routing	0.61	0.25	-
L_SC117	SC117	SC118	Routing	0.25	0.25	-
L_SC118	SC118	SC119	Routing	0.17	0.25	-
L_SC119	SC119	SC120	Routing	0.12	0.25	-
L_SC120	SC120	SC121	Routing	0.22	0.25	-
L_SC121	SC121	SC127	Routing	0.19	0.25	-
L_SC122	SC122	SC123	Routing	0.23	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC123	SC123	SC125	Routing	0.27	0.25	-
L_SC124	SC124	SC125	Routing	0.24	0.25	-
L_SC125	SC125	SC322	Routing	0.25	0.25	-
L_SC126	SC126	SC121	Routing	0.04	0.25	-
L_SC127	SC127	SC128	Routing	0.18	0.25	-
L_SC128	SC128	SC129	Routing	0.26	0.25	-
L_SC129	SC129	SC134	Routing	0.36	0.25	-
L_SC130	SC130	SC127	Routing	0.14	0.25	-
L_SC131	SC131	SC129	Lagging	-	-	0.00
L_SC132	SC132	SC133	Lagging	-	-	5.40
L_SC133	SC133	SC134	Routing	0.12	0.50	-
L_SC134	SC134	SC135	Routing	0.10	0.25	-
L_SC135	SC135	SC137	Routing	0.41	0.25	-
L_SC136	SC136	SC137	Routing	0.29	0.25	-
L_SC137	SC137	SC190	Routing	0.58	0.25	-
L_SC138	SC138	SC139	Routing	0.09	0.50	-
L_SC139	SC139	SC324	Routing	0.09	0.25	-
L_SC140	SC140	SC141	Lagging	-	-	0.00
L_SC141	SC141	SC143	Routing	0.13	0.25	-
L_SC143	SC143	SC144	Routing	0.04	0.25	-
L_SC144	SC144	SC146	Routing	0.30	0.25	-
L_SC145	SC145	SC144	Routing	0.02	0.50	-
L_SC146	SC146	SC149	Routing	0.13	0.25	-
L_SC147	SC147	SC149	Routing	0.19	0.50	-
L_SC148	SC148	SC149	Routing	0.11	0.25	-
L_SC149	SC149	SC159	Routing	0.30	0.25	-
L_SC150	SC150	SC151	Routing	0.06	0.25	-
L_SC151	SC151	SC152	Routing	0.21	0.25	-
L_SC152	SC152	SC155	Routing	0.28	0.25	-
L_SC153	SC153	SC155	Routing	0.41	0.25	-
L_SC154	SC154	SC153	Routing	0.03	0.25	-
L_SC155	SC155	SC156	Routing	0.08	0.25	-
L_SC156	SC156	SC159	Routing	0.29	0.25	-
L_SC157	SC157	SC158	Routing	0.13	0.25	-
L_SC158	SC158	SC159	Routing	0.13	0.25	-
L_SC159	SC159	SC168	Routing	0.18	0.25	-
L_SC160	SC160	SC167	Routing	0.35	0.25	-
L_SC162	SC162	SC167	Routing	0.30	0.25	-
L_SC163	SC163	SC164	Routing	0.16	0.25	-
L_SC164	SC164	SC166	Routing	0.33	0.25	-
L_SC165	SC165	SC166	Routing	0.22	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC166	SC166	SC169	Routing	0.34	0.25	-
L_SC167	SC167	SC168	Routing	0.11	0.25	-
L_SC168	SC168	SC169	Routing	0.29	0.25	-
L_SC169	SC169	SC173	Routing	0.28	0.25	-
L_SC170	SC170	SC173	Routing	0.25	0.25	-
L_SC173	SC173	SC174	Routing	0.25	0.25	-
L_SC174	SC174	SC175	Routing	0.31	0.25	-
L_SC175	SC175	SC176	Routing	0.33	0.25	-
L_SC176	SC176	SC178	Routing	0.31	0.25	-
L_SC177	SC177	SC176	Lagging	-	-	0.00
L_SC178	SC178	SC187	Routing	0.20	0.25	-
L_SC179	SC179	SC182	Routing	0.28	0.25	-
L_SC180	SC180	SC182	Routing	0.24	0.25	-
L_SC182	SC182	SC184	Routing	0.25	0.25	-
L_SC183	SC183	SC184	Routing	0.16	0.25	-
L_SC184	SC184	SC185	Routing	0.12	0.25	-
L_SC185	SC185	SC186	Routing	0.25	0.25	-
L_SC186	SC186	SC187	Routing	0.27	0.25	-
L_SC187	SC187	SC189	Routing	0.42	0.25	-
L_SC188	SC188	SC187	Routing	0.08	0.00	-
L_SC189	SC189	SC190	Routing	0.53	0.25	-
L_SC190	SC190	SC200	Routing	0.29	0.25	-
L_SC192	SC192	SC133	Lagging	-	-	5.42
L_SC193	SC193	SC194	Routing	0.14	0.25	-
L_SC194	SC194	SC195	Routing	0.26	0.25	-
L_SC195	SC195	SC196	Routing	0.04	0.00	-
L_SC196	SC196	SC198	Routing	0.18	0.25	-
L_SC197	SC197	SC199	Routing	0.23	0.25	-
L_SC198	SC198	SC199	Routing	0.28	0.25	-
L_SC199	SC199	SC190	Routing	0.13	0.25	-
L_SC200	SC200	SC201	Routing	0.47	0.25	-
L_SC201	SC201	SC231	Routing	0.36	0.25	-
L_SC202	SC202	SC204	Routing	0.12	0.25	-
L_SC203	SC203	SC202	Lagging	-	-	0.00
L_SC204	SC204	SC205	Routing	0.09	0.25	-
L_SC205	SC205	SC206	Routing	0.06	0.25	-
L_SC206	SC206	SC207	Routing	0.30	0.25	-
L_SC207	SC207	SC209	Routing	0.21	0.25	-
L_SC208	SC208	SC207	Lagging	-	-	0.00
L_SC209	SC209	SC212	Routing	0.37	0.25	-
L_SC210	SC210	SC212	Routing	0.39	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC211	SC211	SC212	Routing	0.37	0.25	-
L_SC212	SC212	SC216	Routing	0.18	0.25	-
L_SC213	SC213	SC214	Routing	0.10	0.50	-
L_SC214	SC214	SC216	Routing	0.30	0.25	-
L_SC215	SC215	SC216	Routing	0.23	0.25	-
L_SC216	SC216	SC217	Routing	0.16	0.25	-
L_SC217	SC217	SC221	Routing	0.17	0.25	-
L_SC219	SC219	SC220	Routing	0.23	0.25	-
L_SC220	SC220	SC221	Routing	0.20	0.25	-
L_SC221	SC221	SC222	Routing	0.24	0.25	-
L_SC222	SC222	SC223	Routing	0.26	0.25	-
L_SC223	SC223	SC230	Routing	0.18	0.25	-
L_SC224	SC224	SC226	Routing	0.06	0.50	-
L_SC225	SC225	SC224	Lagging	-	-	0.00
L_SC226	SC226	SC228	Routing	0.09	0.50	-
L_SC227	SC227	SC226	Lagging	-	-	0.00
L_SC228	SC228	SC229	Routing	0.01	0.00	-
L_SC229	SC229	SC230	Routing	0.06	0.50	-
L_SC230	SC230	SC231	Routing	0.16	0.25	-
L_SC231	SC231	SC235	Routing	0.82	0.25	-
L_SC232	SC232	SC235	Routing	0.32	0.25	-
L_SC234	SC234	SC235	Routing	0.14	0.25	-
L_SC235	SC235	SC251	Routing	0.22	0.25	-
L_SC236	SC236	SC256	Routing	0.23	0.25	-
L_SC237	SC237	SC238	Lagging	-	-	0.00
L_SC238	SC238	SC239	Routing	0.28	0.25	-
L_SC239	SC239	SC240	Routing	0.02	0.50	-
L_SC240	SC240	SC241	Routing	0.05	0.50	-
L_SC241	SC241	SC242	Routing	0.05	0.50	-
L_SC242	SC242	SC246	Routing	0.07	0.50	-
L_SC243	SC243	SC245	Routing	0.06	0.50	-
L_SC244	SC244	SC243	Lagging	-	-	0.00
L_SC245	SC245	SC246	Routing	0.06	0.50	-
L_SC246	SC246	SC247	Routing	0.05	0.50	-
L_SC247	SC247	SC250	Routing	0.05	0.50	-
L_SC248	SC248	SC250	Routing	0.05	0.50	-
L_SC249	SC249	SC250	Routing	0.15	0.25	-
L_SC250	SC250	SC251	Routing	0.32	0.25	-
L_SC251	SC251	SC258	Routing	0.24	0.25	-
L_SC252	SC252	SC256	Routing	0.16	0.25	-
L_SC256	SC256	SC258	Routing	0.12	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC257	SC257	SC258	Lagging	-	-	0.00
L_SC258	SC258	SC259	Routing	0.36	0.25	-
L_SC259	SC259	SC265	Routing	0.44	0.25	-
L_SC260	SC260	SC265	Routing	0.38	0.25	-
L_SC261	SC261	SC262	Lagging	-	-	0.89
L_SC262	SC262	SC263	Routing	0.06	0.00	-
L_SC263	SC263	SC265	Routing	0.34	0.25	-
L_SC265	SC265	SC269	Routing	0.15	0.25	-
L_SC266	SC266	SC268	Routing	0.03	0.00	-
L_SC267	SC267	SC268	Routing	0.07	0.00	-
L_SC268	SC268	SC269	Routing	0.03	0.25	-
L_SC269	SC269	SC271	Routing	0.26	0.25	-
L_SC270	SC270	SC271	Routing	0.15	0.25	-
L_SC271	SC271	SC273	Routing	0.35	0.25	-
L_SC272	SC272	SC273	Routing	0.05	0.25	-
L_SC273	SC273	SC277	Routing	0.21	0.25	-
L_SC274	SC274	SC275	Routing	0.16	0.25	-
L_SC275	SC275	SC276	Routing	0.15	0.25	-
L_SC276	SC276	SC012	Routing	0.17	0.25	-
L_SC277	SC277	SC280	Routing	0.26	0.25	-
L_SC280	SC280	SC295	Routing	0.12	0.25	-
L_SC281	SC281	SC282	Lagging	-	-	0.00
L_SC282	SC282	SC285	Routing	0.05	0.50	-
L_SC285	SC285	SC288	Routing	0.23	0.25	-
L_SC287	SC287	SC295	Routing	0.44	0.25	-
L_SC288	SC288	SC287	Routing	0.07	0.25	-
L_SC289	SC289	SC295	Routing	0.44	0.25	-
L_SC290	SC290	SC291	Routing	0.05	0.00	-
L_SC291	SC291	SC292	Routing	0.05	0.50	-
L_SC292	SC292	SC293	Routing	0.05	0.50	-
L_SC293	SC293	SC294	Routing	0.13	0.50	-
L_SC294	SC294	SC280	Routing	0.02	0.25	-
L_SC295	SC295	SC296	Routing	0.40	0.25	-
L_SC296	SC296	SC300	Routing	0.41	0.25	-
L_SC297	SC297	SC300	Routing	0.41	0.25	-
L_SC298	SC298	SC300	Routing	0.25	0.25	-
L_SC299	SC299	SC300	Routing	0.33	0.25	-
L_SC300	SC300	SC303	Routing	0.22	0.25	-
L_SC301	SC301	SC300	Routing	0.29	0.25	-
L_SC302	SC302	SC303	Lagging	-	-	1.14
L_SC303	SC303	SC305	Routing	0.29	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SC304	SC304	SC315	Routing	0.23	0.25	-
L_SC305	SC305	SC313	Routing	0.56	0.25	-
L_SC306	SC306	SC308	Routing	0.03	0.50	-
L_SC307	SC307	SC309	Routing	0.04	0.50	-
L_SC308	SC308	SC309	Routing	0.04	0.50	-
L_SC309	SC309	SC310	Routing	0.03	0.50	-
L_SC310	SC310	SC311	Routing	0.04	0.50	-
L_SC311	SC311	SC312	Routing	0.37	0.25	-
L_SC312	SC312	SC313	Routing	0.11	0.25	-
L_SC313	SC313	SC314	Routing	0.40	0.25	-
L_SC314	SC314	SC315	Routing	0.37	0.25	-
L_SC315	SC315	SL137	Routing	0.07	0.25	-
L_SC316	SC316	SC317	Routing	0.12	0.25	-
L_SC317	SC317	SC025	Lagging	-	-	0.28
L_SC318	SC318	SC036	Routing	0.04	0.25	-
L_SC319	SC319	SC065	Routing	0.11	0.00	-
L_SC320	SC320	SC065	Lagging	-	-	1.49
L_SC321	SC321	SC118	Lagging	-	-	0.00
L_SC322	SC322	SC126	Routing	0.23	0.25	-
L_SC323	SC323	SC139	Lagging	-	-	0.00
L_SC324	SC324	SC141	Routing	0.12	0.25	-
L_SL001	SL001	SL002	Routing	0.15	0.25	-
L_SL002	SL002	SL206	Routing	0.28	0.25	-
L_SL003	SL003	SL004	Routing	0.20	0.25	-
L_SL004	SL004	SL206	Routing	0.18	0.25	-
L_SL006	SL006	SL007	Routing	0.17	0.25	-
L_SL007	SL007	SL014	Routing	0.19	0.25	-
L_SL008	SL008	SL010	Routing	0.34	0.25	-
L_SL010	SL010	SL007	Routing	0.13	0.25	-
L_SL012	SL012	SL019	Routing	0.28	0.25	-
L_SL014	SL014	SL021	Routing	0.16	0.25	-
L_SL015	SL015	SL016	Routing	0.17	0.25	-
L_SL016	SL016	SL018	Routing	0.29	0.25	-
L_SL017	SL017	SL018	Routing	0.24	0.25	-
L_SL018	SL018	SL021	Routing	0.15	0.25	-
L_SL019	SL019	SL021	Routing	0.18	0.25	-
L_SL020	SL020	SL019	Routing	0.30	0.25	-
L_SL021	SL021	SL023	Routing	0.19	0.25	-
L_SL023	SL023	SL024	Routing	0.11	0.25	-
L_SL024	SL024	SL026	Routing	0.14	0.25	-
L_SL025	SL025	SL027	Routing	0.10	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SL026	SL026	SL029	Routing	0.19	0.25	-
L_SL027	SL027	SL028	Lagging	-	-	5.66
L_SL028	SL028	SL030	Routing	0.18	0.25	-
L_SL029	SL029	SL028	Routing	0.09	0.25	-
L_SL030	SL030	SL042	Routing	0.14	0.25	-
L_SL031	SL031	SL032	Routing	0.23	0.25	-
L_SL032	SL032	SL034	Lagging	-	-	1.48
L_SL033	SL033	SL039	Routing	0.07	0.50	-
L_SL034	SL034	SL033	Routing	0.03	0.50	-
L_SL035	SL035	SL036	Lagging	-	-	3.96
L_SL036	SL036	SL039	Routing	0.09	0.50	-
L_SL037	SL037	SL040	Lagging	-	-	0.00
L_SL038	SL038	SL041	Routing	0.05	0.50	-
L_SL039	SL039	SL041	Routing	0.05	0.50	-
L_SL040	SL040	SL038	Routing	0.04	0.50	-
L_SL041	SL041	SL043	Routing	0.09	0.50	-
L_SL042	SL042	SL053	Routing	0.25	0.25	-
L_SL043	SL043	SL042	Routing	0.10	0.25	-
L_SL044	SL044	SL045	Lagging	-	-	2.53
L_SL045	SL045	SL046	Routing	0.06	0.50	-
L_SL046	SL046	SL049	Lagging	-	-	2.16
L_SL047	SL047	SL048	Lagging	-	-	0.00
L_SL048	SL048	SL049	Routing	0.02	0.50	-
L_SL049	SL049	SL052	Routing	0.06	0.25	-
L_SL050	SL050	SL049	Routing	0.01	0.50	-
L_SL051	SL051	SL055	Lagging	-	-	1.61
L_SL052	SL052	SL056	Routing	0.08	0.25	-
L_SL053	SL053	SL061	Routing	0.15	0.25	-
L_SL054	SL054	SL055	Lagging	-	-	3.79
L_SL055	SL055	SL056	Lagging	-	-	0.00
L_SL056	SL056	SL057	Lagging	-	-	1.20
L_SL057	SL057	SL061	Routing	0.07	0.00	-
L_SL058	SL058	SL063	Routing	0.23	0.25	-
L_SL059	SL059	SL060	Routing	0.05	0.00	-
L_SL060	SL060	SL061	Routing	0.05	0.00	-
L_SL061	SL061	SL071	Routing	0.19	0.25	-
L_SL062	SL062	SL063	Routing	0.20	0.25	-
L_SL063	SL063	SL060	Routing	0.05	0.00	-
L_SL064	SL064	SL072	Lagging	-	-	4.70
L_SL065	SL065	SL030	Routing	0.05	0.50	-
L_SL066	SL066	SL065	Routing	0.16	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SL067	SL067	SL066	Routing	0.07	0.25	-
L_SL068	SL068	SL067	Lagging	-	-	1.97
L_SL069	SL069	SL053	Routing	0.16	0.25	-
L_SL070	SL070	SL071	Routing	0.48	0.25	-
L_SL071	SL071	SL072	Routing	0.14	0.25	-
L_SL072	SL072	SL089	Routing	0.20	0.25	-
L_SL073	SL073	SL074	Routing	0.15	0.25	-
L_SL074	SL074	SL075	Routing	0.08	0.50	-
L_SL075	SL075	SL089	Routing	0.09	0.00	-
L_SL076	SL076	SL078	Routing	0.08	0.00	-
L_SL077	SL077	SL078	Routing	0.04	0.50	-
L_SL078	SL078	SL079	Routing	0.05	0.50	-
L_SL079	SL079	SL081	Routing	0.08	0.50	-
L_SL080	SL080	SL081	Routing	0.04	0.50	-
L_SL081	SL081	SL083	Routing	0.07	0.50	-
L_SL082	SL082	SL083	Routing	0.03	0.50	-
L_SL083	SL083	SL085	Routing	0.09	0.50	-
L_SL084	SL084	SL086	Lagging	-	-	0.00
L_SL085	SL085	SL086	Routing	0.11	0.50	-
L_SL086	SL086	SL094	Routing	0.12	0.25	-
L_SL089	SL089	SL094	Routing	0.17	0.25	-
L_SL090	SL090	SL073	Routing	0.15	0.25	-
L_SL091	SL091	SL090	Lagging	-	-	3.04
L_SL092	SL092	SL093	Routing	0.07	0.50	-
L_SL093	SL093	SL095	Routing	0.02	0.00	-
L_SL094	SL094	SL096	Routing	0.16	0.25	-
L_SL095	SL095	SL094	Routing	0.09	0.50	-
L_SL096	SL096	SL098	Routing	0.22	0.25	-
L_SL097	SL097	SL099	Routing	0.21	0.25	-
L_SL098	SL098	SL099	Routing	0.13	0.25	-
L_SL099	SL099	SL129	Routing	0.38	0.25	-
L_SL101	SL101	SL102	Lagging	-	-	3.39
L_SL102	SL102	SL103	Lagging	-	-	0.69
L_SL103	SL103	SL106	Routing	0.09	0.50	-
L_SL104	SL104	SL112	Routing	0.06	0.00	-
L_SL105	SL105	SL112	Lagging	-	-	0.00
L_SL106	SL106	SL114	Routing	0.14	0.25	-
L_SL107	SL107	SL104	Lagging	-	-	0.00
L_SL108	SL108	SL109	Routing	0.10	0.50	-
L_SL109	SL109	SL110	Routing	0.03	0.25	-
L_SL110	SL110	SL111	Routing	0.13	0.25	-

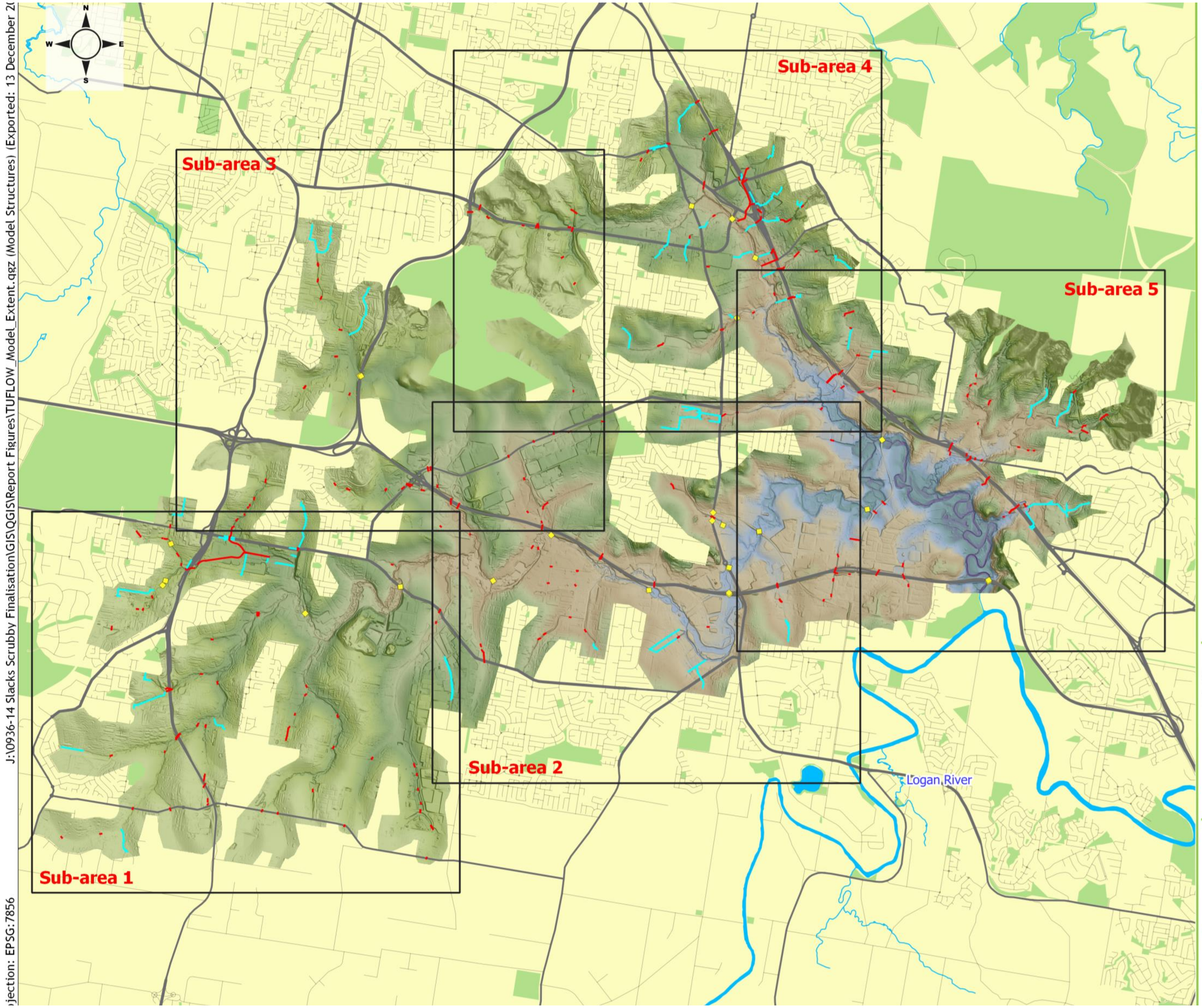
Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SL111	SL111	SL113	Routing	0.11	0.25	-
L_SL112	SL112	SL114	Routing	0.19	0.25	-
L_SL113	SL113	SL115	Routing	0.15	0.25	-
L_SL114	SL114	SL129	Routing	0.09	0.50	-
L_SL115	SL115	SL132	Routing	0.26	0.25	-
L_SL116	SL116	SL122	Lagging	-	-	5.13
L_SL117	SL117	SL118	Lagging	-	-	4.52
L_SL118	SL118	SL122	Lagging	-	-	4.83
L_SL120	SL120	SL122	Lagging	-	-	3.64
L_SL121	SL121	SL122	Lagging	-	-	3.29
L_SL122	SL122	SL125	Routing	0.05	0.50	-
L_SL124	SL124	SL122	Lagging	-	-	0.00
L_SL125	SL125	SL126	Routing	0.08	0.50	-
L_SL126	SL126	SL127	Routing	0.05	0.50	-
L_SL127	SL127	SL128	Routing	0.07	0.50	-
L_SL128	SL128	SL130	Routing	0.41	0.25	-
L_SL129	SL129	SL130	Routing	0.33	0.25	-
L_SL130	SL130	SL135	Routing	0.18	0.25	-
L_SL131	SL131	SL130	Routing	0.25	0.25	-
L_SL132	SL132	SL130	Routing	0.18	0.25	-
L_SL133	SL133	SL136	Routing	0.36	0.25	-
L_SL135	SL135	SL136	Routing	0.08	0.25	-
L_SL136	SL136	SL137	Routing	0.07	0.25	-
L_SL137	SL137	SL139	Routing	0.33	0.25	-
L_SL138	SL138	SL175	Routing	0.37	0.25	-
L_SL139	SL139	SL140	Routing	0.42	0.25	-
L_SL140	SL140	SL176	Routing	0.34	0.25	-
L_SL141	SL141	SL142	Routing	0.14	0.25	-
L_SL142	SL142	SL143	Routing	0.10	0.25	-
L_SL143	SL143	SL146	Routing	0.26	0.25	-
L_SL144	SL144	SL147	Routing	0.28	0.25	-
L_SL145	SL145	SL144	Lagging	-	-	0.00
L_SL146	SL146	SL148	Routing	0.14	0.25	-
L_SL147	SL147	SL146	Lagging	-	-	0.00
L_SL148	SL148	SL150	Routing	0.21	0.25	-
L_SL149	SL149	SL151	Routing	0.09	0.25	-
L_SL150	SL150	SL151	Routing	0.26	0.25	-
L_SL151	SL151	SL171	Routing	0.22	0.25	-
L_SL152	SL152	SL163	Routing	0.10	0.00	-
L_SL153	SL153	SL154	Routing	0.11	0.25	-
L_SL154	SL154	SL155	Routing	0.13	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SL155	SL155	SL162	Routing	0.09	0.00	-
L_SL156	SL156	SL157	Routing	0.14	0.25	-
L_SL157	SL157	SL160	Routing	0.02	0.00	-
L_SL158	SL158	SL161	Routing	0.14	0.25	-
L_SL159	SL159	SL161	Routing	0.14	0.25	-
L_SL160	SL160	SL158	Routing	0.04	0.00	-
L_SL161	SL161	SL164	Routing	0.12	0.25	-
L_SL162	SL162	SL164	Routing	0.02	0.25	-
L_SL163	SL163	SL165	Routing	0.07	0.50	-
L_SL164	SL164	SL165	Routing	0.13	0.50	-
L_SL165	SL165	SL167	Routing	0.06	0.50	-
L_SL166	SL166	SL167	Routing	0.11	0.50	-
L_SL167	SL167	SL170	Routing	0.07	0.50	-
L_SL168	SL168	SL169	Routing	0.06	0.50	-
L_SL169	SL169	SL170	Routing	0.12	0.50	-
L_SL170	SL170	SL174	Routing	0.10	0.25	-
L_SL171	SL171	SL170	Routing	0.09	0.25	-
L_SL173	SL173	SL138	Lagging	-	-	0.29
L_SL174	SL174	SL175	Routing	0.46	0.25	-
L_SL175	SL175	SL176	Routing	0.42	0.25	-
L_SL176	SL176	SL180	Routing	0.65	0.25	-
L_SL177	SL177	SC314	Routing	0.42	0.25	-
L_SL178	SL178	SC314	Routing	0.27	0.25	-
L_SL179	SL179	SL180	Routing	0.43	0.25	-
L_SL180	SL180	SL181	Routing	0.73	0.25	-
L_SL181	SL181	SL203	Routing	0.33	0.25	-
L_SL182	SL182	SL184	Lagging	-	-	2.75
L_SL183	SL183	SL184	Lagging	-	-	2.20
L_SL184	SL184	SL186	Routing	0.09	0.25	-
L_SL185	SL185	SL186	Routing	0.23	0.25	-
L_SL186	SL186	SL189	Routing	0.21	0.25	-
L_SL187	SL187	SC312	Routing	0.33	0.25	-
L_SL188	SL188	SL177	Routing	0.18	0.25	-
L_SL189	SL189	SL190	Routing	0.16	0.25	-
L_SL190	SL190	SL191	Routing	0.30	0.25	-
L_SL191	SL191	SL181	Routing	0.42	0.25	-
L_SL192	SL192	SL193	Lagging	-	-	1.40
L_SL193	SL193	SL194	Routing	0.05	0.00	-
L_SL194	SL194	SL195	Lagging	-	-	1.21
L_SL195	SL195	SL196	Lagging	-	-	3.17
L_SL196	SL196	SL199	Routing	0.04	0.25	-

Link name	Upstream subcatchment	Downstream subcatchment	Link type (Routing / lagging)	K	X	Hydrograph lag (mins)
L_SL197	SL197	SL199	Routing	0.06	0.00	-
L_SL198	SL198	SL197	Lagging	-	-	0.00
L_SL199	SL199	SL200	Routing	0.05	0.25	-
L_SL200	SL200	SL201	Lagging	-	-	0.43
L_SL201	SL201	SL202	Routing	0.21	0.25	-
L_SL202	SL202	SL181	Routing	0.02	0.25	-
L_SL203	SL203	SL204	Routing	0.53	0.25	-
L_SL206	SL206	SL010	Routing	0.12	0.25	-

Appendix C - TUFLOW model configuration

C1 Locations of hydraulic structures



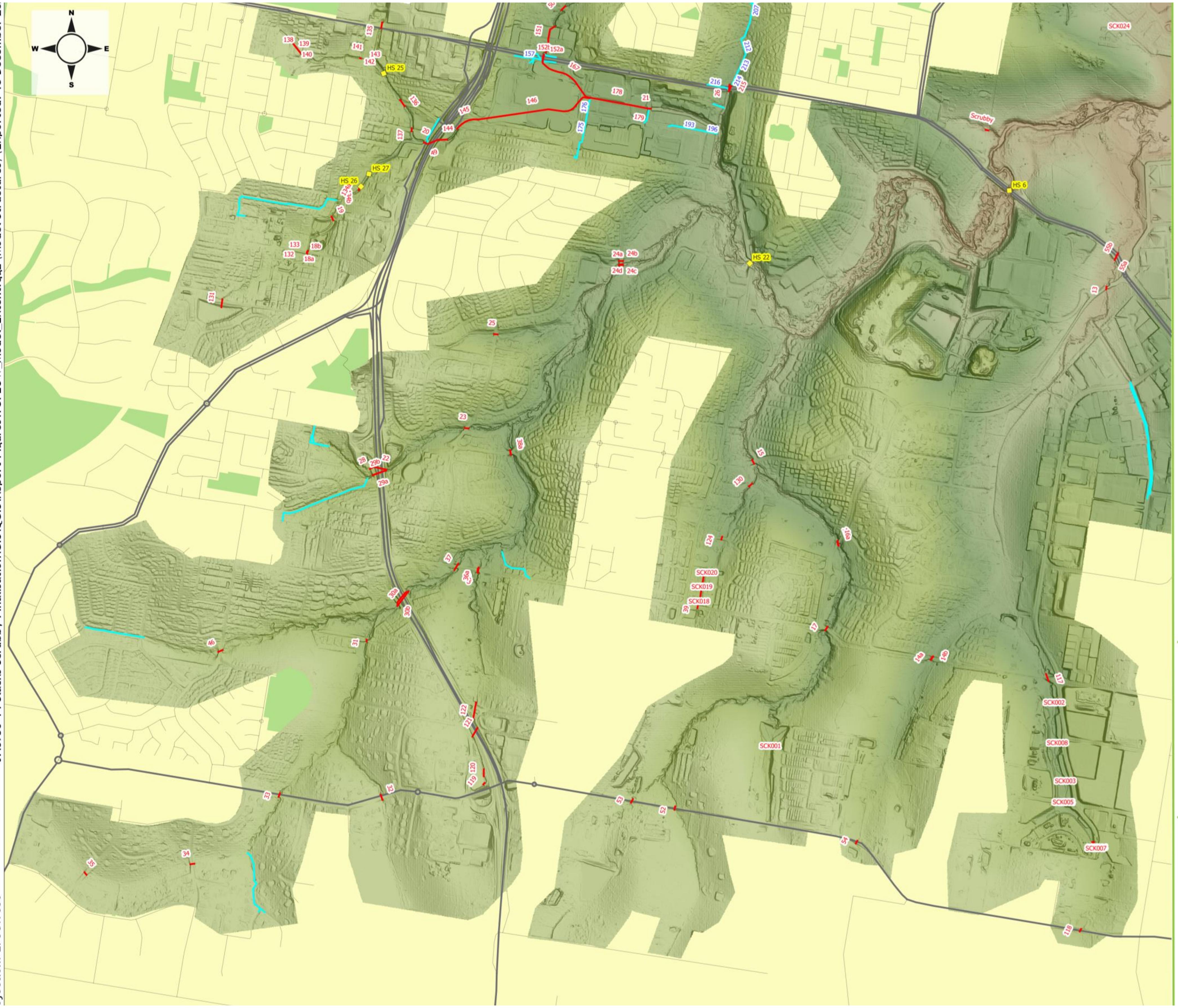
Slacks and Scrubby Creeks Flood Study

TUFLOW model structures

wrm water + environment

Figure C.1 – Locations of hydraulic structures in the TUFLOW model – Sub-area tile index

J:\0936-14 Slacks Scrubby Finalisation\GIS\QGIS\Report Figures\TUFLOW_Model_Extent.qgz (Model Structures) (Exported: 13 December 20



ojection: EPSG:7856

Legend

- Hydraulic structure modelled as 2d layered flow constriction
- Culvert
- Trunk stormwater pipe

Note: All culverts and 2d hydraulic structures are labelled, however for clarity, some trunk stormwater pipes have not been labelled.

0 0.25 0.5 0.75 1 1.25

Slacks and Scrubby Creeks Flood Study

TUFLOW model structures (sub-area 1)

wrm water + environment

Figure C.2 – Locations of hydraulic structures in the TUFLOW model – Sub-area 1

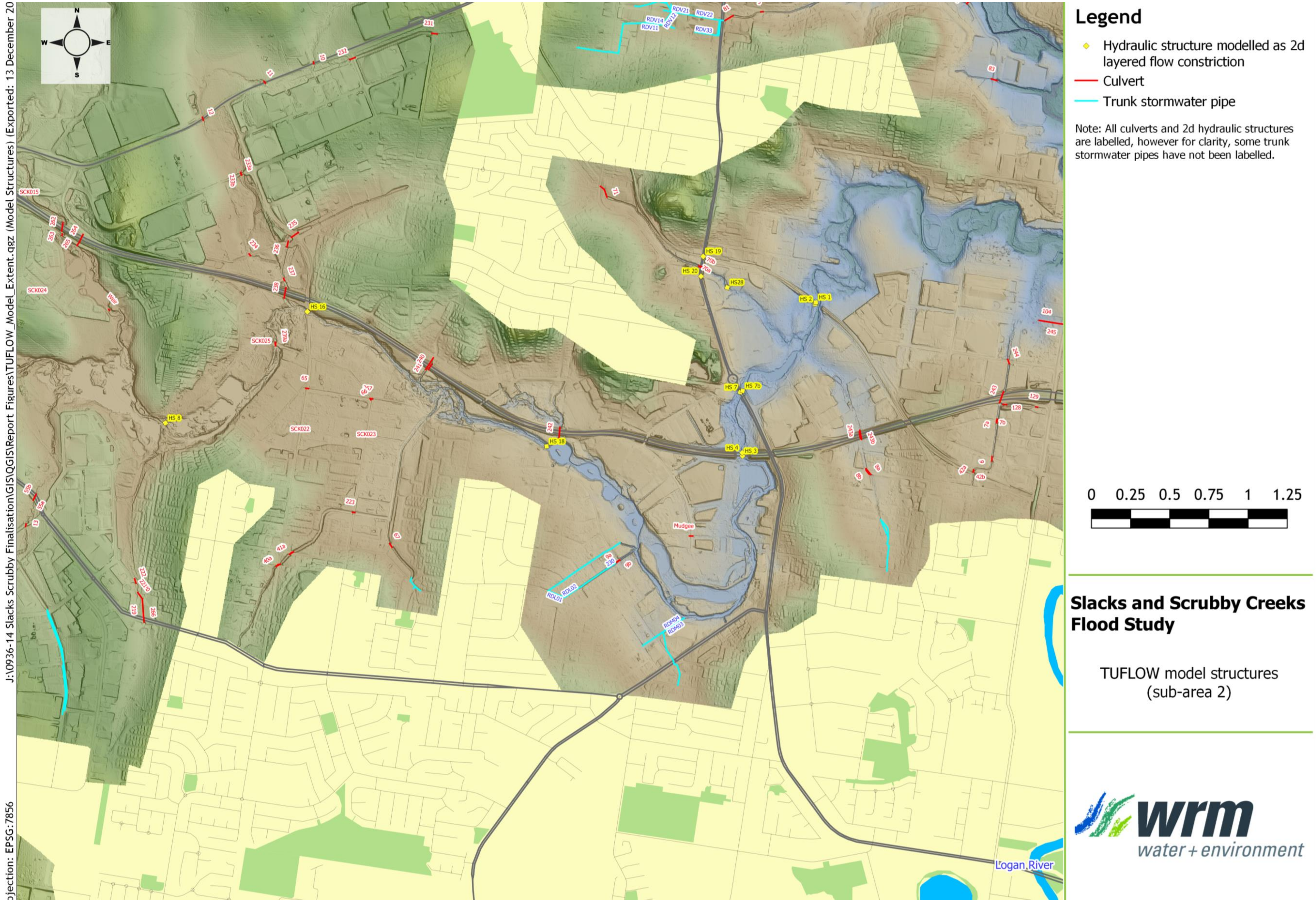


Figure C.3 – Locations of hydraulic structures in the TUFLOW model – Sub-area 2

Figure C.4 – Locations of hydraulic structures in the TUFLOW model – Sub-area 3

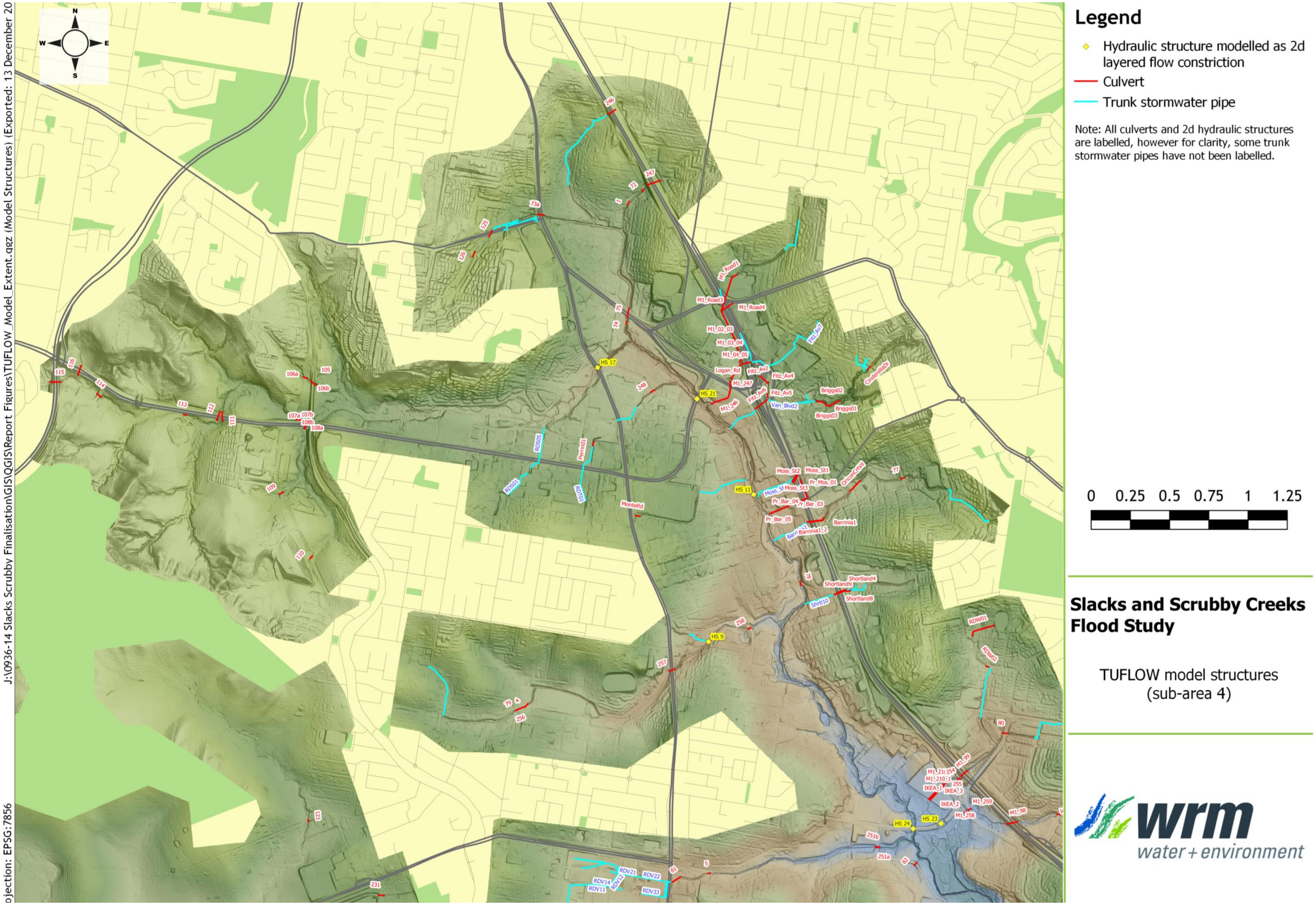


Figure C.5 – Locations of hydraulic structures in the TUFLOW model – Sub-area 4

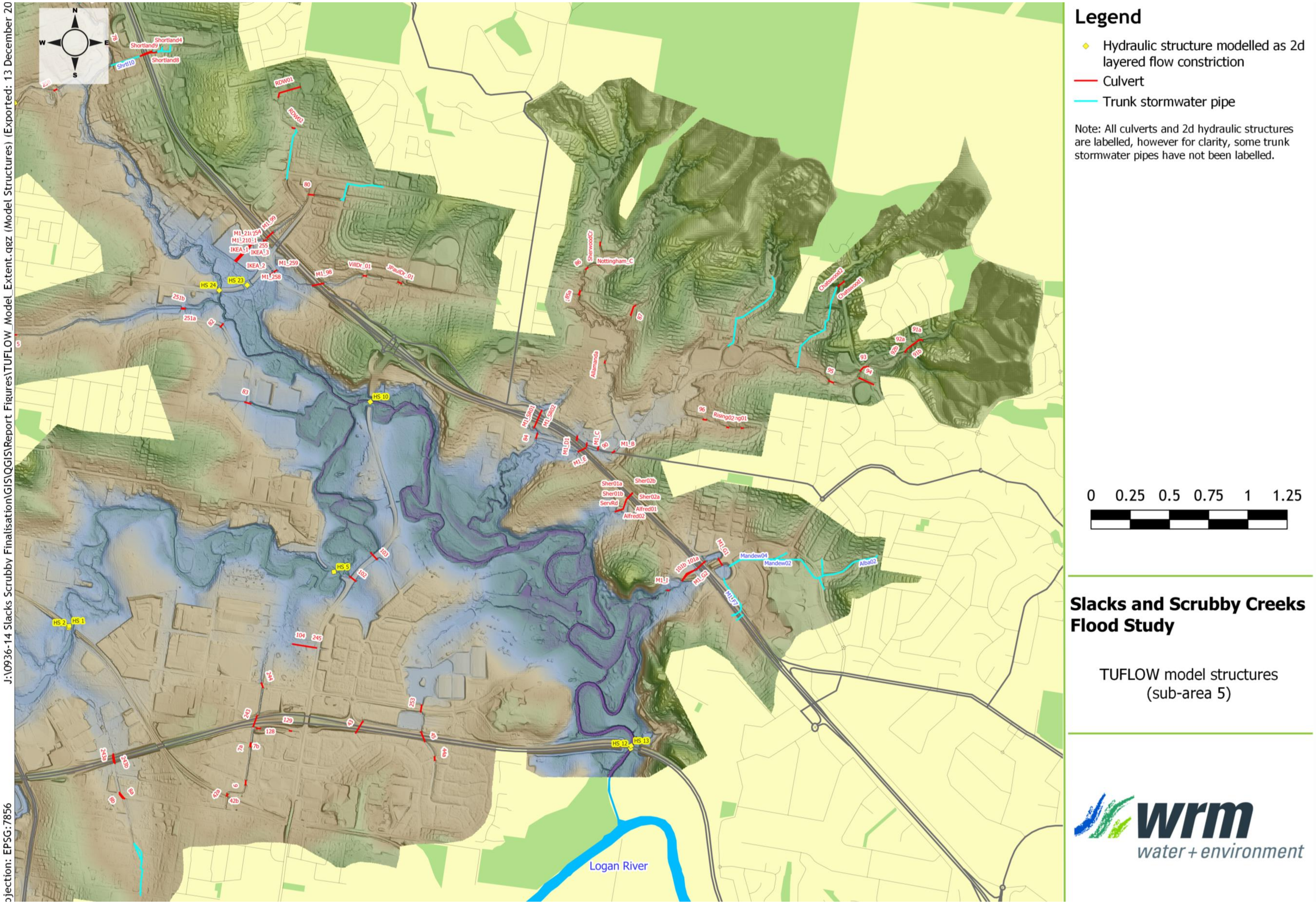


Figure C.6 – Locations of hydraulic structures in the TUFLOW model – Sub-area 5

C2 Cross-drainage culvert structures

Table C.1 – Configuration of cross-drainage culvert structures in the TUFLOW model

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
1	511,432	6,946,591	RCBC	2.12	1.22	13.81	2	24.14	24.03	[1]
4	510,783	6,943,393	RCP	1.20	0.00	20.51	3	20.08	19.00	[2]
5	511,946	6,942,322	RCBC	1.20	0.61	9.76	3	10.26	10.10	[1]
6	513,413	6,939,470	RCP	1.65	0.00	26.46	4	8.73	8.56	[1]
10	509,083	6,941,996	RCBC	2.20	0.70	13.00	4	20.59	20.53	[1]
11	508,771	6,941,872	RCBC	2.45	0.92	14.40	3	19.00	18.93	[1]
12	508,377	6,941,639	RCBC	2.50	0.92	14.00	3	16.73	16.64	[1]
13	507,247	6,939,046	RCBC	3.00	2.10	20.37	4	17.10	16.99	[7]
15	505,225	6,938,051	RCBC	2.40	2.10	18.00	4	23.20	22.36	[2]
17	505,644	6,937,097	RCBC	3.00	2.10	24.40	3	30.33	30.28	[2]
19	502,817	6,939,445	RCP	1.05	0.00	24.40	5	39.80	39.50	[1], [9]
20	503,348	6,939,876	RCBC	3.10	2.40	15.00	2	32.88	32.88	[1], [4]
21	504,635	6,940,072	RCBC	2.70	2.10	10.32	5	24.52	24.24	[2], [4]
22	503,091	6,938,014	RCP	1.20	0.00	71.35	1	37.39	36.94	[1]
23	503,586	6,938,244	RCP	1.65	0.00	23.89	4	31.65	31.47	[1]
25	503,752	6,938,782	RCBC	2.40	1.02	20.37	2	32.90	32.77	[1]
26	505,088	6,940,190	RCP	1.20	0.00	34.82	3	27.75	27.27	[4]
28	503,042	6,938,016	RCBC	1.80	0.65	23.14	2	8.14	7.89	[1]
31	503,014	6,937,029	RCBC	3.00	1.70	11.00	5	36.40	36.30	[1], [3]
32	503,099	6,936,132	RCP	1.80	0.00	26.84	1	47.30	47.19	[2]
33	502,513	6,936,145	RCP	1.60	0.00	19.07	2	42.80	42.83	[1]
34	502,015	6,935,750	RCP	1.10	0.00	13.24	4	52.71	52.62	[1]
35	501,404	6,935,695	RCP	0.90	0.00	17.03	3	60.84	60.60	[1]
37	503,527	6,937,451	RCBC	3.60	1.80	20.94	7	32.75	32.70	[2]
39	504,907	6,937,222	RCBC	2.40	0.60	12.88	1	38.64	38.55	[1]
43	514,138	6,939,824	RCP	0.90	0.00	86.00	3	8.27	7.80	[1]
45	514,543	6,939,764	RCP	1.15	0.00	61.90	8	7.95	7.50	[1]
46	502,176	6,936,969	RCP	1.65	0.00	25.00	4	43.43	43.22	[1]
49	503,394	6,939,883	RCBC	3.90	4.20	69.00	2	32.88	32.45	[1]
50	504,138	6,940,648	RCP	1.65	0.00	31.67	2	30.29	30.02	[1]
51	504,587	6,941,256	RCBC	8.85	1.73	38.00	1	36.21	35.73	[1]
52	504,777	6,936,070	RCP	1.07	0.00	13.39	1	44.16	43.98	[1]
53	504,531	6,936,110	RCBC	1.20	0.50	22.88	2	47.43	47.35	[1]
54	505,817	6,935,875	RCBC	1.20	0.60	12.20	3	45.60	45.45	[1]
58	505,897	6,942,610	RCP	0.52	0.00	19.20	3	33.17	33.02	[1]
59	505,756	6,943,612	RCBC	2.70	1.20	29.70	5	34.91	34.71	[1]
60	505,453	6,944,111	RCBC	2.40	1.50	23.60	5	37.55	37.40	[1]
63	505,669	6,941,204	RCP	0.80	0.00	27.40	5	44.65	44.55	[1]
65	509,043	6,939,919	RCBC	1.20	0.50	13.42	1	13.04	12.99	[1], [3]
66	509,454	6,939,849	RCBC	1.20	0.50	10.47	1	11.98	11.92	[1]
67	509,577	6,938,918	RCP	1.66	0.00	24.29	3	11.53	11.46	[1]
71	510,939	6,941,188	RCBC	1.80	1.15	81.22	3	12.40	12.30	[1]
72	511,523	6,946,673	RCP	1.05	0.00	10.48	2	26.02	25.67	[1], [2]
74	511,420	6,945,829	RCBC	3.55	3.50	12.28	3	14.14	14.08	[1]
75	511,429	6,945,892	RCBC	3.05	2.50	69.00	2	16.40	16.02	[1]
77	513,180	6,944,838	RCP	1.88	0.00	17.73	2	21.29	20.91	[1]
78	512,528	6,944,167	RCBC	3.70	3.70	23.00	3	7.18	6.98	[1]
79	510,717	6,943,361	RCP	1.20	0.00	12.26	3	20.31	19.84	[1]
80	513,832	6,943,214	RCP	1.80	0.00	27.36	2	11.07	10.90	[1]
81	511,735	6,942,281	RCBC	2.05	1.25	62.46	5	-99999[c]	10.87	[1]
82	513,261	6,942,382	RCBC	1.20	0.60	24.00	1	5.44	4.85	[11]
83	513,428	6,941,888	RCP	0.90	0.00	36.50	4	3.47	3.24	[1]
84	515,269	6,941,680	RCP	1.20	0.00	33.50	3	4.45	4.15	[1]
86	515,587	6,942,745	RCP	1.50	0.00	15.32	3	14.90	14.70	[1]
87	515,892	6,942,506	RCP	1.25	0.00	66.17	1	17.04	14.94	[1]
90	515,758	6,941,577	RCBC	2.10	0.90	21.70	4	7.04	6.84	[1]
93	517,352	6,942,117	RCP	1.65	0.00	48.86	2	19.64	18.83	[1]
94	517,329	6,942,045	RCP	1.65	0.00	93.57	2	18.63	18.56	[2]
95	517,144	6,942,023	RCP	1.80	0.00	20.30	2	16.59	16.08	[1]
96	516,339	6,941,782	RCP	1.05	0.00	19.54	6	10.18	9.83	[1]
102	514,096	6,940,769	RCP	1.50	0.00	48.58	1	2.59	2.54	[1]
103	514,231	6,940,913	RCP	1.40	0.00	27.61	1	2.55	1.88	[1]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
104	513,718	6,940,352	RCP	1.05	0.00	81.09	1	-99999.00	5.57	[1], [3]
105	509,422	6,945,444	RCP	1.20	0.00	40.00	1	32.40	32.30	[1]
109	509,219	6,944,743	RCP	1.50	0.00	25.47	2	34.43	34.18	[1]
110	509,409	6,944,334	RCP	0.80	0.00	20.00	2	38.04	38.00	[1]
111	508,842	6,945,232	RCP	1.80	0.00	57.65	3	32.34	32.59	[1]
112	508,817	6,945,234	RCBC	2.40	2.40	55.00	1	32.80	32.94	[1]
113	508,605	6,945,241	RCBC	3.00	1.50	15.60	2	37.19	37.15	[1]
114	508,056	6,945,366	RCP	1.80	0.00	32.30	1	44.56	44.41	[1]
115	507,779	6,945,451	RCP	1.00	0.00	64.00	3	52.00	51.20	[1]
116	507,932	6,945,524	RCBC	2.50	2.40	58.00	1	53.01	52.81	[1]
117	506,908	6,936,817	RCBC	1.21	0.46	43.00	1	29.24	29.05	[1]
118	507,098	6,935,371	RCBC	1.20	0.60	16.36	2	43.10	43.06	[1]
119	503,684	6,936,210	RCBC	3.40	1.20	10.00	1	49.69	49.11	[1]
120	503,684	6,936,272	RCBC	3.50	1.20	39.00	1	50.34	50.25	[1]
121	503,633	6,936,504	RCP	1.17	0.00	55.00	3	44.93	44.70	[1]
122	503,631	6,936,627	RCP	1.35	0.00	92.00	4	42.76	42.29	[1], [2]
123	509,390	6,942,658	RCP	0.90	0.00	10.17	3	24.53	24.50	[1]
124	505,045	6,937,615	RCBC	3.60	0.85	14.00	2	31.88	31.78	[1]
125	510,553	6,946,397	RCP	1.50	0.00	42.14	3	33.63	33.43	[1], [2]
126	510,446	6,946,266	RCP	1.50	0.00	28.56	3	36.86	36.50	[1]
128	513,495	6,939,816	RCP	1.60	0.00	21.60	6	8.14	7.89	[1]
129	513,699	6,939,800	RCP	0.60	0.00	9.00	2	9.64	9.61	[1]
130	505,210	6,937,918	RCBC	3.00	1.20	19.50	3	24.90	24.70	[2]
131	502,185	6,938,959	RCBC	0.75	0.30	40.10	2	51.09	49.86	[4]
132	502,582	6,939,257	RCBC	2.10	0.60	7.00	1	43.01	42.87	[4]
133	502,594	6,939,254	RCBC	1.20	0.60	7.00	1	42.87	42.61	[4]
135	503,099	6,940,550	RCP	1.50	0.00	34.00	2	40.88	40.66	[4]
136	503,218	6,940,104	RCP	1.20	0.00	42.00	6	35.34	35.01	[4]
137	503,271	6,939,952	RCBC	2.50	1.80	15.00	4	34.18	34.16	[4]
138	502,587	6,940,452	RCP	1.20	0.00	34.45	1	53.54	52.51	[4]
139	502,605	6,940,428	RCP	1.20	0.00	23.90	1	52.47	51.75	[4]
140	502,625	6,940,404	RCP	1.20	0.00	8.63	1	51.41	51.02	[4]
141	502,978	6,940,361	RCBC	2.80	1.60	4.60	1	41.15	41.13	[4]
142	503,015	6,940,352	RCP	0.60	0.00	7.20	2	40.45	40.30	[4]
143	503,045	6,940,348	RCP	0.83	0.00	4.80	2	39.36	39.21	[4]
144	503,453	6,939,895	RCBC	2.70	2.25	39.00	2	32.45	32.45	[4], [10]
145	503,599	6,940,007	RCBC	3.30	3.00	136.70	2	32.30	32.16	[4]
146	504,191	6,940,071	RCBC	6.25	3.91	680.90	1	32.16	26.23	[4]
147	504,408	6,940,978	RCP	1.20	0.00	19.40	2	33.70	33.70	[4]
148	504,340	6,940,877	RCP	1.20	0.00	8.00	1	32.43	32.42	[4]
149	504,313	6,940,841	RCP	1.20	0.00	8.00	1	31.34	31.33	[4]
150	504,258	6,940,731	RCP	0.68	0.00	5.00	1	31.22	31.17	[4]
151	504,053	6,940,458	RCBC	3.30	2.10	181.44	2	28.65	28.37	[4]
167	504,109	6,940,283	RCP	2.70	0.00	360.78	3	27.73	26.23	[4]
178	504,409	6,940,114	RCBC	3.60	2.40	234.15	4	26.23	25.00	[4]
179	504,576	6,940,083	RCBC	3.60	2.40	74.50	4	25.00	24.91	[4]
215	505,093	6,940,188	RCP	1.65	0.00	33.50	1	27.16	26.97	[4]
219	507,994	6,938,520	RCBC	3.00	1.80	115.90	2	19.60	18.76	[1]
220	507,984	6,938,586	RCBC	4.70	1.70	20.25	2	18.76	18.42	[1]
221	507,970	6,938,605	RCBC	2.10	0.90	28.50	4	18.42	18.28	[1]
222	507,945	6,938,690	RCBC	2.40	0.90	29.39	4	17.50	17.45	[1]
223	509,339	6,939,129	RCBC	2.10	1.50	15.16	8	10.85	10.80	[2]
231	509,855	6,942,182	RCBC	1.50	0.60	18.00	3	28.47	28.37	[1]
232	509,331	6,942,023	RCBC	2.70	0.75	37.00	4	20.90	20.82	[1]
234	508,676	6,940,772	RCP	0.75	0.00	11.50	3	12.50	12.30	[7]
235	508,964	6,940,898	RCP	2.10	0.00	52.34	7	11.75	11.72	[7]
236	508,918	6,940,840	RCP	1.20	0.00	34.62	8	11.54	11.38	[7]
237	508,895	6,940,614	RCP	0.75	0.00	13.00	3	10.30	9.90	[7]
238	508,901	6,940,528	RCBC	3.60	2.70	60.50	5	9.96	9.66	[7]
240	509,824	6,940,077	RCP	1.80	0.00	66.43	2	11.42	8.88	[1]
241	509,826	6,940,056	RCBC	2.40	2.40	35.00	1	10.94	10.71	[1]
242	510,653	6,939,638	RCP	1.20	0.00	61.50	4	6.82	6.44	[7]
243	513,474	6,939,863	RCP	1.65	0.00	26.29	6	10.00	9.00	[7]
244	513,519	6,940,091	RCBC	2.10	2.10	28.00	3	6.94	6.89	[2], [7]
245	513,831	6,940,334	RCP	1.05	0.00	66.29	1	5.77	-99999[c]	[1], [3]
246	511,323	6,947,169	RCP	1.50	0.00	56.12	1	37.22	36.56	[1]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
247	511,582	6,946,716	RCP	1.50	0.00	63.44	3	28.17	26.78	[8]
248	511,584	6,945,392	RCBC	3.60	1.20	21.00	1	15.70	15.50	[2], [7]
253	514,532	6,939,943	RCP	2.10	0.00	41.20	3	7.50	7.20	[2], [7]
254	513,535	6,942,923	RCP	1.80	0.00	10.98	5	6.40	6.29	[1]
255	513,475	6,942,911	RCBC	1.80	1.80	14.17	5	5.87	5.81	[1]
256	510,749	6,943,374	RCP	1.20	0.00	56.81	3	19.53	18.20	[1]
257	511,708	6,943,616	RCBC	2.40	1.20	25.00	5	13.50	13.00	[2]
258	512,201	6,943,881	RCBC	1.80	1.20	14.00	4	8.38	8.28	[2]
259	506,817	6,941,206	RCP	1.20	0.00	40.45	3	25.00	24.50	[5], [7]
260	507,118	6,941,455	RCBC	2.20	2.40	50.00	1	18.89	18.88	[5], [7]
262	507,479	6,940,949	RCBC	3.70	2.55	50.00	6	14.69	14.58	[5], [7]
263	507,479	6,940,900	RCBC	2.40	2.40	17.50	5	14.41	14.36	[5], [7]
264	507,599	6,940,875	RCP	0.38	0.00	54.60	1	17.26	16.68	[5], [7]
265	507,580	6,940,839	RCP	0.75	0.00	17.00	1	16.60	16.00	[5], [7]
266	508,000	6,938,445	RCBC	2.40	0.90	34.30	3	19.73	19.60	[1]
267	509,452	6,939,853	RCBC	1.20	0.50	16.20	1	11.99	11.92	[1], [10]
101a	516,223	6,940,801	RCBC	2.75	2.30	117.20	2	3.41	3.35	[1]
101b	516,228	6,940,795	RCBC	2.50	2.60	117.20	1	3.41	3.35	[1]
106a	509,372	6,945,479	RCP	0.45	0.00	24.00	1	34.63	34.06	[1]
106b	509,372	6,945,478	RCBC	1.20	0.45	24.00	1	34.63	34.06	[1]
107a	509,329	6,945,218	RCP	1.05	0.00	26.20	1	28.55	28.36	[1]
107b	509,328	6,945,218	RCP	0.90	0.00	26.20	1	28.55	28.36	[1]
108a	509,374	6,945,177	RCBC	2.60	1.20	47.28	4	30.41	28.41	[1]
108b	509,372	6,945,177	RCBC	2.60	1.45	47.28	3	30.41	28.41	[1]
134a	502,970	6,939,611	RCBC	2.50	2.00	10.00	1	37.49	37.34	[4]
134b	502,969	6,939,611	RCBC	2.50	1.70	10.00	4	37.79	37.64	[4]
14a	506,248	6,936,928	RCBC	2.40	0.90	21.60	4	29.95	29.88	[1]
14b	506,246	6,936,929	RCBC	2.40	1.15	21.60	3	29.95	29.88	[1]
152a	504,024	6,940,362	RCBC	2.40	1.50	41.37	3	28.37	27.73	[1]
152b	504,022	6,940,363	RCP	1.50	0.00	42.45	2	28.37	27.73	[1]
16a	505,711	6,937,586	RCBC	2.60	2.40	22.00	2	29.54	29.56	[1]
16b	505,709	6,937,584	RCBC	3.50	2.90	22.00	1	29.54	29.56	[1]
18a	502,675	6,939,251	RCBC	2.40	0.75	14.29	2	42.03	42.02	[1]
18b	502,671	6,939,251	RCBC	1.20	0.75	14.29	1	42.03	42.02	[1]
233a	508,621	6,941,289	RCBC	3.60	1.75	18.00	4	15.00	14.55	[2], [7]
233b	508,620	6,941,288	RCBC	3.65	2.10	18.00	3	15.00	14.55	[2], [7]
239a	508,841	6,940,203	RCBC	2.70	2.10	17.50	2	9.70	9.65	[7]
239b	508,838	6,940,204	RCBC	2.70	2.35	17.50	1	9.70	9.65	[7]
243a	512,575	6,939,623	RCBC	1.80	0.75	53.50	5	8.42	8.05	[7]
243b	512,570	6,939,619	RCBC	1.80	1.00	53.50	4	8.42	8.05	[7]
24a	504,468	6,939,201	RCBC	2.20	2.10	22.31	1	23.29	23.23	[1]
24b	504,468	6,939,178	RCBC	2.80	2.70	22.31	2	23.29	23.23	[1]
24c	504,467	6,939,181	RCBC	3.67	2.90	22.31	1	23.29	23.23	[1]
24d	504,467	6,939,155	RCBC	2.20	2.10	22.31	1	23.29	23.23	[1]
251a	513,015	6,942,492	RCBC	3.10	1.50	23.78	2	3.59	3.58	[1]
251b	513,014	6,942,487	RCBC	3.10	1.70	23.78	1	3.59	3.58	[1]
29a	503,085	6,937,989	RCBC	2.40	2.10	76.66	2	39.87	39.92	[1]
29b	503,085	6,937,989	RCBC	2.40	2.35	76.66	1	39.87	39.92	[1]
30a	503,221	6,937,268	RCBC	2.70	2.40	90.00	3	33.88	33.31	[1], [9]
30b	503,214	6,937,278	RCBC	2.70	2.65	90.00	2	33.88	33.31	[1], [9]
36a	503,652	6,937,431	RCBC	2.70	1.50	20.00	2	32.70	32.65	[1]
36b	503,648	6,937,433	RCBC	2.70	1.70	20.00	1	32.70	32.65	[1]
38a	503,836	6,938,105	RCBC	3.75	2.96	26.00	3	28.61	28.28	[1]
38b	503,836	6,938,105	RCBC	3.75	3.12	26.00	2	28.61	28.28	[1]
40a	508,856	6,938,795	RCBC	2.10	1.80	24.12	2	14.73	14.86	[1]
40b	508,857	6,938,791	RCBC	2.70	2.00	24.12	1	14.73	14.86	[1]
41a	508,943	6,938,872	RCBC	2.70	1.80	27.92	2	13.82	13.85	[1]
41b	508,942	6,938,868	RCBC	3.35	2.30	27.92	1	13.82	13.85	[1]
42a	513,297	6,939,392	RCP	1.05	0.00	13.00	3	10.06	10.01	[1], [10]
42b	513,293	6,939,393	RCBC	1.22	0.92	13.00	2	10.58	10.54	[1], [10]
44a	514,618	6,939,624	RCBC	2.13	0.95	20.00	2	8.89	8.83	[1]
44b	514,618	6,939,624	RCBC	2.17	1.15	20.00	1	8.89	8.83	[1]
55a	507,303	6,939,225	RCBC	2.70	1.47	42.00	3	16.57	16.36	[1]
55b	507,303	6,939,225	RCBC	2.77	1.67	42.00	2	16.57	16.36	[1]
56a	505,201	6,942,718	RCBC	2.15	1.20	24.30	4	38.19	37.50	[1]
56b	505,195	6,942,722	RCBC	2.15	0.60	24.30	1	38.19	37.50	[1]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
57a	505,689	6,943,199	RCBC	1.80	1.20	20.60	3	31.62	31.57	[1]
57b	505,688	6,943,194	RCBC	1.80	1.35	20.60	2	31.62	31.57	[1]
61a	505,407	6,944,381	RCBC	2.70	1.70	24.99	2	39.12	39.08	[1]
61b	505,401	6,944,383	RCBC	2.70	1.90	24.99	1	39.12	39.08	[1]
62a	505,399	6,944,629	RCBC	2.40	1.50	33.00	2	42.08	41.67	[1]
62b	505,409	6,944,631	RCBC	2.50	1.70	33.00	1	42.08	41.67	[1]
64a	505,884	6,941,121	RCBC	1.80	0.90	13.42	2	44.20	44.13	[1]
64b	505,889	6,941,117	RCP	1.20	0.00	13.42	4	42.55	42.50	[1]
64c	505,874	6,941,125	RCP	1.50	0.00	13.42	1	39.81	37.20	[1]
70a	511,564	6,940,694	RCBC	2.75	1.80	50.81	2	7.08	7.08	[1]
70b	511,560	6,940,688	RCBC	2.85	2.00	50.81	1	7.08	7.08	[1]
73a	510,872	6,946,517	RCBC	1.90	1.97	35.42	2	27.31	27.09	[1]
73b	510,872	6,946,517	RCBC	2.00	1.97	35.42	1	27.31	27.09	[1]
7a	513,446	6,939,711	RCBC	2.40	1.46	22.50	2	8.33	8.23	[1]
7b	513,442	6,939,711	RCBC	2.40	1.65	22.50	1	8.33	8.23	[1]
85a	515,540	6,942,590	RCBC	3.35	2.25	25.58	1	13.68	13.58	[1]
85b	515,542	6,942,589	RCBC	3.10	2.00	25.58	2	13.68	13.58	[1]
8a	512,625	6,939,388	RCBC	2.13	0.60	45.00	3	8.77	8.74	[1]
8b	512,619	6,939,385	RCBC	1.20	0.60	45.00	1	8.77	8.74	[1]
91a	517,721	6,942,291	RCP	1.50	0.00	17.21	3	24.91	-99999[c]	[1]
91b	517,681	6,942,272	RCP	1.65	0.00	57.91	3	-99999[c]	-99999[c]	[1]
92a	517,645	6,942,245	RCP	1.80	0.00	33.97	3	-99999[c]	-99999[c]	[1]
92b	517,618	6,942,217	RCP	1.80	0.00	21.34	3	-99999[c]	23.67	[1]
9a	511,028	6,938,817	RCBC	2.70	1.50	26.61	1	5.54	5.54	[1]
9b	511,026	6,938,818	RCP	1.50	0.00	26.61	1	5.64	5.64	[1]
Alfred01	515,830	6,941,244	RCP	0.75	0.00	38.20	1	8.10	7.11	[8]
Alfred02	515,795	6,941,205	RCP	0.90	0.00	33.90	1	6.39	5.87	[8]
Allamanda	515,703	6,942,149	RCP	1.80	0.00	6.52	3	9.32	9.08	[2]
Barrinia1	512,625	6,944,567	RCP	1.65	0.00	110.30	1	14.35	12.01	[8]
Barrinia1_2	512,625	6,944,567	RCP	1.65	0.00	110.30	2	14.35	12.01	[8]
Briggs01	512,773	6,945,331	RCBC	1.80	1.20	79.36	2	25.91	23.37	[2], [12]
Briggs02	512,699	6,945,301	RCBC	3.60	2.40	12.84	1	23.37	23.34	[2], [12]
Briggs03	512,664	6,945,324	RCBC	1.80	1.20	80.97	2	23.34	21.44	[2], [12]
Chatswood1	517,212	6,942,649	RCP	1.50	0.00	41.57	2	27.25	-99999[c]	[2]
Chatswood2	517,193	6,942,633	RCP	1.80	0.00	8.46	2	-99999[c]	24.95	[2]
CinderellaDr	512,963	6,945,539	RCP	0.60	0.00	18.90	1	37.84	36.84	[1]
Fitz_Av2	512,179	6,945,571	RCP	1.50	0.00	64.08	2	17.52	17.12	[8]
Fitz_Av4	512,294	6,945,466	RCP	1.80	0.00	67.70	1	18.44	18.33	[8]
Fitz_Av5	512,318	6,945,364	RCBC	3.30	2.10	18.95	1	18.13	18.05	[8]
Fitz_Av6	512,277	6,945,308	RCP	1.50	0.00	95.98	2	17.97	16.83	[8]
IKEA_1	513,433	6,942,887	RCP	1.80	0.00	149.00	3	4.60	4.15	[8]
IKEA_2	513,395	6,942,840	RCP	1.80	0.00	144.00	3	4.60	4.15	[8]
IKEA_3	513,440	6,942,881	RCP	1.80	0.00	140.00	3	4.60	4.15	[8]
JPaulDr_01	514,395	6,942,654	RCBC	2.40	0.90	30.00	9	11.60	11.50	[2]
Logan_Rd	512,113	6,945,514	RCBC	2.70	1.80	96.93	2	15.87	14.88	[8]
M1_02_03	512,065	6,945,818	RCBC	2.40	2.40	184.22	3	21.78	19.76	[13]
M1_03_04	512,128	6,945,670	RCBC	2.40	2.40	129.73	3	19.66	18.23	[13]
M1_04_05	512,146	6,945,594	RCBC	2.40	2.40	31.01	3	18.13	17.79	[13]
M1_210_1	513,446	6,942,896	RCBC	1.50	0.90	18.00	7	5.70	5.50	[8]
M1_210_2	513,448	6,942,892	RCBC	1.50	0.90	18.00	4	5.70	5.50	[8]
M1_246	512,064	6,945,351	RCBC	3.60	3.00	163.00	1	14.40	11.65	[8]
M1_247	512,080	6,945,435	RCBC	3.00	3.00	35.58	1	14.62	14.40	[8]
M1_258	513,578	6,942,710	RCBC	2.10	2.10	12.10	4	3.85	3.79	[8]
M1_259	513,603	6,942,729	RCBC	2.10	2.10	17.30	4	4.20	4.01	[8]
M1_98	513,874	6,942,643	RCP	1.80	0.00	72.00	4	6.78	5.83	[8]
M1_99	513,569	6,942,958	RCP	1.80	0.00	57.00	4	6.85	6.54	[8]
M1_B	515,660	6,941,600	RCP	0.60	0.00	13.40	1	6.82	6.69	[8]
M1_C	515,587	6,941,622	RCP	0.60	0.00	14.40	1	6.31	6.15	[8]
M1_D1	515,527	6,941,665	RCP	0.60	0.00	17.20	2	6.21	6.11	[8]
M1_D2	515,524	6,941,666	RCP	0.45	0.00	17.20	1	6.21	6.11	[8]
M1_E	515,557	6,941,590	RCBC	2.40	2.16	55.40	6	5.57	5.29	[8]
M1_G1	516,438	6,940,876	RCP	1.80	0.00	50.57	4	5.08	4.87	[8]
M1_G2	516,314	6,940,854	RCP	1.80	0.00	72.29	3	4.60	3.54	[8]
M1_I	516,105	6,940,695	RCP	1.20	0.00	6.00	2	1.39	1.35	[8]
M1_Road1	512,090	6,946,116	RCBC	1.80	1.20	259.03	5	26.37	22.81	[8]
M1_Road3	511,982	6,945,969	RCP	0.75	0.00	38.47	1	24.08	23.88	[8]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
M1_Road4	512,058	6,945,927	RCBC	1.80	1.20	85.54	1	24.00	22.79	[8]
M1_SR01	515,293	6,941,823	RCP	1.20	0.00	38.54	2	5.32	5.03	[8]
M1_SR02	515,268	6,941,768	RCP	1.20	0.00	83.51	2	5.03	4.40	[8]
MonteRd	511,490	6,944,598	RCP	0.83	0.00	21.46	2	31.75	31.58	[8]
Moss_St1	512,492	6,944,842	RCP	1.20	0.00	63.20	1	14.40	14.13	[8]
Moss_St2	512,497	6,944,835	RCP	0.90	0.00	57.53	2	14.74	13.70	[8]
Moss_St3	512,479	6,944,813	RCP	1.20	0.00	9.75	1	13.50	13.47	[8]
Mudgee	511,493	6,938,978	RCBC	0.75	0.30	17.42	2	8.86	8.67	[7]
Nottingham_C	515,661	6,942,771	RCP	1.80	0.00	15.32	3	15.12	15.04	[2]
OriconCrtVil	512,874	6,944,788	RCBC	8.00	1.60	90.98	1	18.30	17.40	[8]
Perrin01	511,205	6,945,057	RCBC	2.10	1.50	23.90	2	23.53	23.44	[2]
Pr_Bar_03	512,511	6,944,687	RCP	1.65	0.00	-1.00[d]	2	13.97	12.28	[13]
Pr_Bar_04	512,415	6,944,647	RCP	2.40	0.00	-1.00[d]	1	11.53	8.91	[13]
Pr_Bar_05	512,358	6,944,624	RCBC	3.30	1.50	-1.00[d]	1	8.91	8.50	[13]
Pr_Mos_01	512,550	6,944,771	RCBC	3.60	1.20	-1.00[d]	1	14.30	13.97	[13]
RDW01	513,683	6,943,877	RCP	1.50	0.00	164.10	1	24.01	22.00	[13]
RDW02	513,719	6,943,639	RCBC	1.20	0.60	13.84	2	18.25	18.10	[13]
Rising01	516,578	6,941,729	RCBC	1.20	0.90	6.10	3	14.00	13.80	[13]
Rising02	516,486	6,941,734	RCBC	3.00	1.20	9.60	1	11.94	11.83	[13]
SCK001	505,324	6,936,427	RCBC	1.50	1.50	-1.00	4	38.45	37.64	[2]
SCK002	506,948	6,936,676	RCBC	1.50	0.90	-1.00	1	30.11	29.99	[2]
SCK003	507,012	6,936,226	RCBC	2.40	1.20	-1.00	1	32.30	32.19	[2]
SCK004	507,004	6,936,105	RCP	2.40	0.00	33.91	1	33.60	32.68	[2]
SCK005	506,999	6,936,106	RCBC	2.40	0.90	-1.00	1	34.93	33.96	[2]
SCK006	507,187	6,935,854	RCP	1.80	0.00	54.02	1	36.92	36.37	[2]
SCK007	507,182	6,935,850	RCBC	1.80	0.90	-1.00	1	38.10	37.50	[2]
SCK008	506,966	6,936,445	RCBC	1.80	1.20	-1.00	1	32.19	31.25	[2]
SCK009	506,463	6,941,121	RCP	1.95	0.00	-1.00	1	27.68	27.64	[2]
SCK010	506,465	6,941,120	RCP	1.95	0.00	19.76	1	27.66	27.65	[2]
SCK011	506,466	6,941,120	RCP	1.95	0.00	19.74	1	27.66	27.65	[2]
SCK012	506,461	6,941,123	RCP	1.95	0.00	19.67	1	27.68	27.66	[2]
SCK013	506,461	6,941,123	RCP	1.95	0.00	19.64	1	27.66	27.65	[2]
SCK014	506,732	6,941,146	RCP	1.20	0.00	41.44	2	24.40	24.00	[2]
SCK015	507,269	6,941,174	RCBC	3.60	2.40	-1.00[d]	7	16.27	16.00	[2]
SCK016	507,162	6,941,449	RCBC	3.60	2.40	-1.00[d]	7	17.75	17.30	[2]
SCK017	506,817	6,941,185	RCP	1.80	0.00	62.92	2	22.50	22.01	[2]
SCK018	504,918	6,937,261	RCP	1.35	0.00	30.67	2	36.28	35.60	[2]
SCK019	504,933	6,937,338	RCP	1.35	0.00	115.30	2	35.59	33.87	[2]
SCK020	504,952	6,937,408	RCBC	1.20	1.20	28.62	3	33.82	33.69	[2]
SCK021	507,039	6,941,112	RCP	1.80	0.00	41.72	4	18.70	18.50	[2]
SCK022	508,998	6,939,662	RCBC	1.20	0.45	25.56	1	13.05	13.00	[2]
SCK023	509,421	6,939,629	RCP	0.60	0.00	14.98	2	12.40	12.30	[2]
SCK024	507,321	6,940,546	RCBC	2.40	0.60	-1.00[d]	5	19.33	19.27	[12]
SCK025	508,750	6,940,224	RCBC	0.90	0.45	-1.00[d]	1	12.16	12.06	[2]
Scrubby	506,563	6,939,950	RCP	1.05	0.00	9.39	1	16.34	16.19	[2], [3]
ServRd	515,844	6,941,278	RCP	0.60	0.00	16.40	2	9.37	9.19	[8]
Sher01a	515,870	6,941,304	RCP	0.60	0.00	20.00	1	10.58	9.96	[8]
Sher01b	515,855	6,941,289	RCP	0.60	0.00	20.00	1	9.77	9.37	[8]
Sher02a	515,874	6,941,311	RCP	0.75	0.00	20.00	1	10.58	9.96	[8]
Sher02b	515,851	6,941,287	RCP	0.75	0.00	20.00	1	9.77	9.37	[8]
SherwoodCr	515,673	6,942,901	RCP	1.50	0.00	20.51	3	18.40	17.60	[8]
Shortland4	512,820	6,944,119	RCP	2.00	0.00	105.87	1	13.97	12.15	[8]
Shortland8	512,796	6,944,121	RCP	1.05	0.00	39.46	3	15.70	15.30	[8]
Shortland9	512,760	6,944,106	RCBC	1.20	0.90	38.36	2	15.30	14.90	[8]
VillDr_01	514,173	6,942,698	RCP	1.80	0.00	25.00	4	9.25	8.90	[8]
Weir	507,779	6,940,420	RCBC	2.70	0.60	2.80	7	14.00	14.03	[5]

[a] - 'RCBC' = Reinforced concrete box culvert; 'RCP' = Reinforced concrete pipe

[b] - Culvert details were obtained from one or more of the following sources:

[1] - LCC hydraulic structures survey (2017)

[2] - LCC GIS hydraulic structures database

[3] - LCC (2017) and BCC (2017) LiDAR data

[4] - Fern Street and Johnson Road Local Flood Study (Engeny, 2013)

[5] - Wembley Road Interchange (Berrinba) Flood Study (WRM, 2014b)

[6] - Logan- Albert Rivers Flood Study Peer Review (WRM, 2014a)

[7] - Slacks and Scrubby Creeks Flood Study Peer Review (WRM, 2015)

[8] – M1 Motorway Upgrade Hydraulic Study (WRM, 2017)

[9] – WRM site visit (2017)

[10] – Other information (e.g. photos, sketches) supplied by LCC

[11] – Aerial photo + street view

[12] – PD online

[13] – M1 Motorway Upgrade Stage 2 Hydraulic Study

[c] – Invert level was interpolated based on known invert levels of upstream and/or downstream structures

[d] – Structure length based on LCC GIS hydraulic structure shape length.

C3 Trunk stormwater drainage structures

Table C.2 – Configuration of trunk stormwater drainage structures in the TUFLOW model

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
154	503,970	6,940,388	RCBC	2.10	0.60	43.18	1	30.34	29.53	[4]
155	503,995	6,940,377	RCBC	1.20	0.45	16.00	2	29.53	28.80	[4]
156	504,007	6,940,361	RCP	1.50	0.00	23.00	1	28.80	28.13	[4]
157	503,944	6,940,364	RCP	1.35	0.00	57.76	1	30.58	29.88	[4]
158	503,994	6,940,357	RCP	1.35	0.00	41.34	1	29.88	28.13	[4]
159	503,956	6,940,343	RCP	0.38	0.00	26.20	1	30.45	30.31	[4]
160	503,966	6,940,343	RCP	0.38	0.00	17.30	1	30.45	30.31	[4]
161	503,970	6,940,357	RCP	1.05	0.00	13.30	1	30.31	29.88	[4]
162	504,017	6,940,348	RCP	1.65	0.00	11.00	1	28.13	27.73	[4]
163	504,087	6,940,368	RCP	0.53	0.00	20.48	1	29.20	29.12	[4]
164	504,041	6,940,376	RCP	1.05	0.00	47.62	1	29.12	28.37	[4]
165	504,084	6,940,338	RCP	0.75	0.00	19.84	1	29.75	29.45	[4]
166	504,047	6,940,341	RCP	1.05	0.00	51.25	1	29.45	27.73	[4]
168	504,204	6,939,794	RCP	0.53	0.00	4.51	1	36.68	36.60	[4]
169	504,205	6,939,798	RCP	0.38	0.00	5.38	1	37.22	36.60	[4]
170	504,211	6,939,794	RCP	0.53	0.00	11.63	1	36.60	36.50	[4]
171	504,216	6,939,791	RCP	1.05	0.00	3.81	1	36.60	36.50	[4]
172	504,221	6,939,817	RCP	1.05	0.00	48.47	1	36.50	-99999[c]	[4]
173	504,228	6,939,859	RCP	1.05	0.00	38.40	1	-99999[c]	33.79	[4]
174	504,239	6,939,881	RCP	1.20	0.00	15.37	1	33.79	33.54	[4]
175	504,260	6,939,961	RCP	1.20	0.00	157.89	1	33.46	30.05	[4]
176	504,282	6,940,078	RCP	1.20	0.00	79.00	1	30.05	29.44	[4]
177	504,291	6,940,126	RCP	1.20	0.00	18.48	1	29.44	26.23	[4]
180	504,610	6,940,001	RCP	1.65	0.00	22.13	1	25.19	25.10	[4]
181	504,620	6,940,027	RCP	1.65	0.00	37.24	1	25.08	-99999[c]	[4]
182	504,626	6,940,059	RCP	1.65	0.00	28.08	1	-99999[c]	24.52	[4]
187	505,016	6,940,093	RCP	0.53	0.00	38.88	1	28.93	27.43	[4]
188	505,043	6,940,083	RCP	0.75	0.00	13.43	1	27.43	26.46	[4]
189	505,055	6,940,079	RCP	0.60	0.00	8.00	1	24.46	26.32	[4]
190	504,751	6,939,974	RCP	0.38	0.00	19.76	1	26.15	25.96	[4]
191	504,783	6,939,973	RCP	0.45	0.00	50.00	1	25.96	25.66	[4]
192	504,816	6,939,967	RCP	0.60	0.00	14.36	1	25.49	25.22	[4]
193	504,857	6,939,960	RCP	1.05	0.00	64.70	1	25.00	24.68	[4]
194	504,907	6,939,951	RCBC	1.60	1.00	34.90	1	24.66	24.49	[4]
195	504,942	6,939,944	RCBC	1.60	1.00	38.60	1	24.47	24.21	[4]
196	504,989	6,939,935	RCBC	1.60	1.00	50.70	1	24.25	24.00	[4]
197	505,143	6,940,898	RCP	1.20	0.00	48.99	1	44.20	43.00	[4]
198	505,139	6,940,873	RCP	1.20	0.00	3.57	1	42.94	42.89	[4]
199	505,155	6,940,869	RCP	1.20	0.00	32.92	1	42.87	41.70	[4]
200	505,180	6,940,823	RCP	1.20	0.00	85.29	1	41.61	39.46	[4]
201	505,190	6,940,775	RCP	1.20	0.00	10.81	1	39.38	39.10	[4]
202	505,202	6,940,722	RCP	1.20	0.00	98.71	1	38.99	35.22	[4]
203	505,219	6,940,675	RCP	1.20	0.00	11.94	1	35.17	34.68	[4]
204	505,190	6,940,817	RCP	0.75	0.00	103.97	1	44.20	40.01	[4]
205	505,205	6,940,748	RCP	0.75	0.00	34.45	1	40.01	39.12	[4]
206	505,217	6,940,704	RCP	0.75	0.00	60.87	1	38.22	35.64	[4]
207	505,219	6,940,639	RCP	1.05	0.00	69.62	1	34.34	33.90	[4]
208	505,209	6,940,583	RCP	1.05	0.00	40.38	1	33.20	32.64	[4]
209	505,200	6,940,550	RCP	1.50	0.00	31.75	1	31.64	31.50	[4]
210	505,185	6,940,510	RCP	1.50	0.00	51.79	1	31.40	31.02	[4]
211	505,167	6,940,477	RCP	1.50	0.00	24.71	1	31.02	30.51	[4]
212	505,170	6,940,427	RCP	1.50	0.00	90.68	1	29.68	29.06	[4]
213	505,162	6,940,338	RCP	1.50	0.00	108.20	1	29.03	28.21	[4]
214	505,121	6,940,247	RCP	1.50	0.00	77.53	1	28.18	27.39	[4]
216	505,011	6,940,203	RCP	0.60	0.00	96.69	1	33.36	29.33	[4]
217	505,070	6,940,192	RCP	0.68	0.00	23.70	1	27.93	27.33	[4]
218	505,084	6,940,181	RCP	0.75	0.00	16.50	1	27.25	26.25	[4]
224	510,787	6,938,653	RCP	0.60	0.00	25.00	2	7.96	7.90	[1]
225	510,805	6,938,665	RCP	0.60	0.00	25.00	2	7.90	7.60	[1]
226	510,830	6,938,683	RCP	0.60	0.00	50.00	2	7.60	7.30	[1]
227	510,865	6,938,707	RCP	0.60	0.00	50.00	2	7.30	6.78	[1]
228	510,902	6,938,732	RCP	0.60	0.00	50.00	2	6.78	6.37	[1]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
229	510,941	6,938,758	RCP	0.60	0.00	50.00	2	6.37	5.90	[1]
230	510,990	6,938,790	RCP	0.60	0.00	30.00	2	5.90	5.72	[1]
157b	503,888	6,940,371	RCP	1.35	0.00	54.99	1	31.75	30.58	[1]
Alba01	517,433	6,940,910	RCP	1.20	0.00	13.27	1	21.15	20.60	[2]
Alba02	517,374	6,940,894	RCP	1.35	0.00	109.46	1	18.90	18.69	[2]
Alba03	517,303	6,940,878	RCP	1.35	0.00	39.75	1	18.69	18.11	[2]
Alba04a	517,252	6,940,843	RCP	0.45	0.00	85.97	1	18.11	16.57	[1], [2]
Alba04b	517,190	6,940,807	RCP	0.45	0.00	62.10	1	16.57	16.32	[2]
Alba04c	517,133	6,940,795	RCP	0.45	0.00	54.42	1	16.32	-99999[c]	[2]
Alba05	517,099	6,940,789	RCP	0.53	0.00	14.93	1	-99999[c]	15.28	[2]
Anzac01	503,417	6,939,999	RCP	0.53	0.00	37.13	1	37.48	36.31	[2]
Anzac02	503,390	6,939,954	RCP	0.45	0.00	67.42	1	35.36	34.74	[2]
Anzac03	503,366	6,939,913	RCP	0.75	0.00	27.58	1	34.74	34.02	[2]
Anzac04	503,362	6,939,881	RCP	1.05	0.00	21.35	1	34.02	33.21	[2]
Barrinia2	512,477	6,944,494	RCP	1.80	0.00	186.53	3	10.67	9.45	[8]
Barrinia3	512,364	6,944,445	RCP	1.80	0.00	59.78	3	8.61	8.46	[8]
Beenleigh1	510,573	6,946,425	RCP	2.10	0.00	31.61	1	29.80	29.56	[2]
Beenleigh2	510,624	6,946,447	RCP	2.10	0.00	82.10	1	29.43	28.67	[2]
Beenleigh3	510,695	6,946,470	RCP	2.10	0.00	65.89	1	28.64	27.95	[2]
Beenleigh4	510,649	6,946,422	RCP	0.38	0.00	20.58	1	33.40	33.30	[2]
Beenleigh5	510,656	6,946,433	RCP	0.38	0.00	42.42	1	33.00	32.50	[2]
Beenleigh6	510,677	6,946,449	RCP	0.75	0.00	49.21	1	31.60	30.66	[2]
Beenleigh7	510,793	6,946,482	RCP	0.75	0.00	148.09	1	29.86	27.50	[2]
Beenleigh8	510,709	6,946,470	RCP	0.38	0.00	43.71	1	28.84	28.64	[2]
BeenRd01	510,841	6,946,499	RCP	1.05	0.00	23.64	1	27.61	27.50	[2]
BeenRd02	510,837	6,946,491	RCP	1.05	0.00	21.47	1	28.60	27.50	[2]
Blackthorn01	517,070	6,940,770	RCP	0.38	0.00	50.48	1	19.76	18.22	[2]
Chatswood3	517,162	6,942,576	RCP	0.45	0.00	105.63	1	23.55	21.83	[2]
Chatswood4	517,140	6,942,505	RCP	0.45	0.00	46.98	1	21.63	21.40	[2]
Chatswood5	517,132	6,942,451	RCP	1.20	0.00	62.81	1	21.20	20.20	[2]
Chatswood6	517,118	6,942,413	RCP	1.35	0.00	22.66	1	19.52	19.37	[2]
Chatswood7	517,107	6,942,383	RCP	1.35	0.00	47.48	1	19.37	18.70	[2]
Chatswood8	517,098	6,942,353	RCP	1.35	0.00	21.19	1	18.70	18.28	[2]
Chatswood9	517,052	6,942,328	RCP	1.35	0.00	83.85	1	18.28	15.75	[2]
Cind01	512,887	6,945,610	RCP	0.38	0.00	15.06	1	41.24	40.34	[13]
Cind02	512,885	6,945,598	RCP	0.45	0.00	9.92	1	40.27	39.56	[13]
Cind03	512,884	6,945,587	RCP	0.45	0.00	10.60	1	39.56	39.28	[13]
Cind04	512,888	6,945,579	RCP	0.68	0.00	10.15	1	39.06	39.01	[13]
Cind05	512,892	6,945,570	RCP	0.75	0.00	10.02	1	38.93	38.88	[13]
Cind06	512,912	6,945,558	RCP	0.75	0.00	40.48	1	38.88	38.68	[13]
Cind07	512,943	6,945,589	RCP	0.38	0.00	14.59	1	42.92	42.07	[13]
Cind08	512,938	6,945,576	RCP	0.45	0.00	13.15	1	42.00	40.93	[13]
Cind09	512,954	6,945,598	RCP	0.38	0.00	10.20	1	43.52	42.93	[13]
Cind10	512,948	6,945,582	RCP	0.45	0.00	24.65	1	42.85	41.23	[13]
Cind11	512,939	6,945,570	RCP	0.53	0.00	7.91	1	40.37	40.21	[13]
Cind12	512,933	6,945,566	RCP	0.75	0.00	10.03	1	39.98	39.90	[13]
Cind13	512,936	6,945,561	RCP	0.38	0.00	11.22	1	40.03	39.80	[13]
Cind14	512,931	6,945,556	RCP	0.90	0.00	10.42	1	39.65	39.45	[13]
Cind15	512,932	6,945,537	RCP	1.05	0.00	29.76	1	38.38	38.23	[13]
Cind16	512,950	6,945,548	RCP	0.30	0.00	11.78	1	41.45	41.34	[13]
Cind17	512,947	6,945,538	RCP	0.38	0.00	14.23	1	41.34	38.50	[13]
Dendron01	517,088	6,940,845	RCP	1.65	0.00	90.79	1	16.80	16.15	[2]
Dendron02	517,092	6,940,793	RCP	1.65	0.00	14.88	1	15.81	15.59	[2]
Doretta01	516,776	6,942,676	RCP	0.38	0.00	29.00	1	20.80	19.91	[2]
Doretta02	516,783	6,942,629	RCP	0.38	0.00	47.00	1	19.90	19.60	[2]
Doretta03	516,782	6,942,616	RCP	1.50	0.00	11.51	2	19.60	18.49	[2]
Doretta04	516,767	6,942,583	RCP	2.10	0.00	49.29	1	18.44	17.71	[2]
Doretta05	516,737	6,942,544	RCP	2.10	0.00	51.31	1	17.71	16.02	[2]
Doretta06	516,679	6,942,501	RCP	2.10	0.00	93.59	1	16.02	14.65	[2]
Doretta07	516,610	6,942,455	RCP	2.10	0.00	71.82	1	14.20	13.73	[2]
Doretta08	516,560	6,942,431	RCP	2.10	0.00	42.31	1	13.73	13.56	[2]
Doretta09	516,534	6,942,377	RCP	2.10	0.00	99.27	1	13.56	12.01	[2]
Doretta10	516,521	6,942,273	RCP	2.10	0.00	91.54	1	12.01	11.81	[2]
Fitz_Av1	512,210	6,945,601	RCP	1.35	0.00	46.97	1	18.97	18.14	[8]
Fitz_Av10	512,476	6,945,654	RCP	1.80	0.00	45.16	1	24.70	24.27	[8]
Fitz_Av13	512,354	6,945,563	RCP	1.65	0.00	86.03	1	21.31	20.10	[8]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
Fitz_Av14	512,291	6,945,567	RCP	1.65	0.00	50.48	1	20.00	19.50	[8]
Fitz_Av3	512,242	6,945,581	RCP	1.35	0.00	62.12	2	19.00	18.05	[8]
Fitz_Av7	512,574	6,945,724	RCP	1.35	0.00	204.68	1	35.00	28.55	[8]
Fitz_Av8	512,502	6,945,722	RCP	1.50	0.00	62.31	1	27.05	26.49	[8]
Fitz_Av9	512,489	6,945,681	RCP	1.65	0.00	24.63	1	25.01	24.79	[8]
FitzAv11	512,439	6,945,620	RCP	1.65	0.00	56.06	1	24.25	23.53	[8]
FitzAv12	512,404	6,945,589	RCP	1.65	0.00	36.51	1	22.90	22.47	[8]
Herbert01	511,899	6,944,748	RCP	1.20	0.00	90.93	2	19.43	17.61	[2]
Herbert02	511,983	6,944,747	RCP	1.35	0.00	31.89	1	17.61	16.99	[2]
Herbert03	512,011	6,944,771	RCP	1.35	0.00	49.32	1	16.95	15.94	[2]
Herbert04	512,035	6,944,793	RCP	1.50	0.00	11.21	1	15.94	-99999[c]	[2]
Herbert05	512,056	6,944,799	RCP	1.35	0.00	44.55	1	-99999[c]	14.96	[2]
Herbert06	512,102	6,944,814	RCP	1.35	0.00	62.92	1	14.96	14.64	[2]
Herbert07	512,153	6,944,825	RCP	1.35	0.00	62.92	1	12.35	11.93	[2]
Jardine01	513,722	6,944,568	RCP	1.35	0.00	4.88	1	38.00	-99999[c]	[2]
Jardine02	513,711	6,944,564	RCP	1.35	0.00	19.96	1	-99999[c]	37.71	[2]
Jardine03	513,693	6,944,578	RCP	1.35	0.00	41.90	1	36.01	34.11	[2]
Jardine05	513,642	6,944,632	RCP	1.50	0.00	71.83	1	33.62	32.22	[2]
Jardine06	513,583	6,944,677	RCP	1.50	0.00	76.77	1	32.22	30.30	[2]
Jardine07	513,517	6,944,701	RCP	1.80	0.00	67.46	1	30.30	28.78	[2]
Jardine08	513,485	6,944,732	RCP	1.80	0.00	56.17	1	28.78	28.59	[2]
Jardine09	513,478	6,944,762	RCP	1.35	0.00	12.74	1	28.54	28.50	[2]
Judds_Ct1	512,232	6,945,265	RCP	1.20	0.00	32.71	2	16.00	15.91	[8]
Judds_Ct2	512,177	6,945,233	RCP	1.05	0.00	101.12	2	14.80	12.48	[8]
Judds_Ct3	512,106	6,945,187	RCP	1.05	0.00	75.13	2	11.36	10.70	[8]
Kameruka01	506,202	6,944,262	RCP	1.65	0.00	78.01	1	55.61	53.42	[2]
Kameruka02	506,181	6,944,226	RCP	1.65	0.00	46.20	1	52.80	51.66	[2]
Kameruka03	506,172	6,944,199	RCP	1.65	0.00	13.30	1	50.50	50.16	[2]
Kameruka04	506,163	6,944,186	RCP	1.65	0.00	20.00	1	48.87	49.51	[2]
Kameruka05	506,153	6,944,168	RCP	1.65	0.00	22.50	1	48.60	48.34	[2]
Kameruka06	506,135	6,944,144	RCP	1.65	0.00	35.53	1	48.02	46.10	[2]
Kameruka07	506,119	6,944,118	RCP	1.65	0.00	23.20	1	45.76	45.64	[2]
Kameruka08	506,117	6,944,096	RCP	1.65	0.00	23.10	1	45.54	45.44	[2]
Kameruka09	506,120	6,944,073	RCP	1.80	0.00	23.10	1	45.25	45.16	[2]
Kameruka10	506,128	6,944,049	RCP	1.80	0.00	27.80	1	45.00	44.80	[2]
Kameruka11	506,142	6,944,021	RCP	1.80	0.00	35.40	1	44.78	44.55	[2]
Kameruka12	506,152	6,944,001	RCP	1.80	0.00	9.00	1	44.52	-99999[c]	[2]
Kameruka13	506,160	6,943,940	RCP	1.80	0.00	104.30	1	44.52	43.05	[2]
Kameruka14	506,154	6,943,883	RCP	1.80	0.00	104.30	1	43.05	42.64	[2]
Kameruka15	506,153	6,943,857	RCP	1.80	0.00	19.70	1	42.94	42.18	[2]
Kameruka16	506,134	6,943,828	RCP	1.80	0.00	50.00	1	41.97	41.32	[2]
Kameruka17	506,118	6,943,803	RCP	1.80	0.00	12.70	1	41.29	40.84	[2]
Kameruka18	506,105	6,943,777	RCP	1.80	0.00	45.50	1	40.64	40.20	[2]
Kameruka19	506,090	6,943,728	RCP	1.80	0.00	59.60	1	40.03	38.65	[2]
Kameruka20	506,080	6,943,682	RCP	1.80	0.00	32.70	1	38.63	37.62	[2]
Kameruka21	506,063	6,943,648	RCP	1.80	0.00	45.40	1	37.57	37.06	[2]
Kameruka22	506,035	6,943,613	RCP	1.80	0.00	45.40	1	37.04	36.48	[2]
Kameruka23	505,994	6,943,584	RCP	1.80	0.00	55.60	1	36.46	34.77	[2]
Kameruka24	505,947	6,943,562	RCP	1.80	0.00	48.10	1	34.75	33.27	[2]
Kameruka25	505,916	6,943,549	RCP	1.80	0.00	48.10	1	34.75	33.27	[2]
Kameruka26	505,902	6,943,542	RCP	1.80	0.00	6.40	1	32.84	32.67	[2]
Kingston01	511,375	6,945,211	RCBC	1.20	0.90	32.79	4	21.60	19.71	[2], [3]
Kingston02	511,447	6,945,223	RCBC	2.40	1.80	135.90	2	19.71	18.70	[2], [3]
M1_F1	516,548	6,940,509	RCP	0.38	0.00	12.22	1	11.12	10.95	[8]
M1_F2	516,568	6,940,526	RCBC	1.20	0.60	34.72	1	10.91	10.75	[8]
M1_F3	516,521	6,940,539	RCP	0.45	0.00	21.53	2	11.00	10.72	[8]
M1_F4	516,526	6,940,538	RCBC	0.90	0.45	11.52	1	11.06	10.93	[8]
M1_F5	516,549	6,940,550	RCBC	1.20	0.60	35.41	2	10.62	10.29	[8]
M1_F6	516,570	6,940,582	RCBC	1.20	0.60	34.96	3	10.08	9.41	[8]
M1_F7	516,529	6,940,657	RCP	1.50	0.00	146.60	2	9.41	6.62	[8]
M1_F8	516,469	6,940,738	RCBC	3.00	1.50	53.58	1	6.62	5.59	[8]
M1_RD1	512,020	6,946,014	RCP	0.45	0.00	53.61	1	26.00	25.00	[8]
M1_Road2	511,996	6,945,976	RCP	0.38	0.00	16.13	1	24.49	24.05	[8]
M1_Road5	512,008	6,945,979	RCP	0.45	0.00	38.72	1	25.00	24.05	[8]
M1_Road6	511,996	6,945,966	RCP	0.38	0.00	13.85	1	24.68	24.05	[8]
Mandew01	517,078	6,940,780	RCBC	3.00	1.80	28.68	1	15.28	14.96	[1], [8]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
Mandew02	516,959	6,940,883	RCP	1.95	0.00	634.16	2	14.96	6.18	[1], [8]
Mandew03	516,824	6,940,912	RCP	1.50	0.00	82.32	1	11.44	-99999[c]	[8]
Mandew04	516,566	6,940,891	RCP	1.95	0.00	299.21	1	-99999[c]	6.18	[8]
Moss_St4	512,468	6,944,816	RCP	1.65	0.00	14.42	2	12.40	12.35	[8]
Moss_St5	512,364	6,944,782	RCP	1.65	0.00	205.34	2	12.32	11.65	[8]
Moss_St6	512,262	6,944,735	RCP	2.10	0.00	27.79	1	10.33	10.10	[8]
Moss_St7	512,467	6,944,832	RCP	0.75	0.00	21.03	1	14.00	13.00	[8]
RDA01	502,400	6,935,487	RCP	0.60	0.00	19.14	1	51.56	51.34	[2]
RDA02	502,418	6,935,484	RCP	0.90	0.00	47.62	1	51.89	50.99	[2]
RDA03	502,390	6,935,507	RCP	1.05	0.00	38.64	1	50.94	50.90	[2]
RDA04	502,372	6,935,523	RCP	1.05	0.00	9.48	1	51.00	50.90	[2]
RDA05	502,368	6,935,548	RCP	1.05	0.00	41.49	1	50.90	49.77	[2]
RDA06	502,365	6,935,588	RCP	1.05	0.00	38.86	1	49.67	49.44	[2]
RDA07	502,373	6,935,623	RCP	1.05	0.00	36.48	1	49.34	48.58	[2]
RDA08	502,377	6,935,645	RCP	1.35	0.00	17.94	1	48.58	48.54	[2]
RDA09	502,369	6,935,701	RCP	0.60	0.00	88.00	1	48.54	47.98	[2]
RDA10	502,359	6,935,772	RCP	0.60	0.00	47.00	1	47.90	47.52	[2]
RDA11	502,341	6,935,804	RCP	0.60	0.00	25.50	1	47.47	47.30	[2]
RDB01	501,435	6,937,098	RCP	1.65	0.00	61.89	1	53.40	52.41	[2]
RDB02	501,490	6,937,089	RCP	1.65	0.00	49.34	1	52.11	51.68	[2]
RDB03	501,540	6,937,081	RCP	1.65	0.00	51.72	1	51.18	50.41	[2]
RDB04	501,601	6,937,069	RCP	1.80	0.00	73.43	1	49.56	49.20	[2]
RDB05	501,687	6,937,055	RCP	1.80	0.00	101.65	1	48.40	46.98	[1], [2]
RDC01	503,935	6,937,394	RCP	1.50	0.00	26.43	1	36.94	36.24	[2]
RDC02	503,921	6,937,417	RCP	1.50	0.00	29.06	1	36.22	35.87	[2]
RDC03	503,916	6,937,434	RCP	1.50	0.00	6.88	1	35.87	35.83	[2]
RDC04	503,878	6,937,440	RCP	1.50	0.00	70.99	1	35.83	34.69	[2]
RDC05	503,827	6,937,453	RCP	1.50	0.00	38.88	1	34.69	33.16	[2]
RDC06	503,790	6,937,529	RCP	1.50	0.00	70.31	1	32.66	31.75	[2]
RDD01	502,709	6,938,227	RCP	1.80	0.00	54.06	1	44.75	44.58	[2]
RDD02	502,708	6,938,180	RCP	0.50	0.00	41.67	1	44.58	-99999[c]	[2]
RDD03	502,734	6,938,153	RCP	0.50	0.00	41.67	1	-99999[c]	42.71	[2]
RDD04	502,702	6,938,201	RCP	0.50	0.00	5.27	1	44.80	44.80	[2]
RDD06a	502,695	6,938,182	RCP	1.80	0.00	41.13	1	44.80	44.50	[2]
RDD06b	502,724	6,938,155	RCP	1.80	0.00	69.11	1	44.50	42.71	[2]
RDD07	502,776	6,938,144	RCP	2.40	0.00	36.27	1	42.71	41.90	[2]
RDE01	502,535	6,937,738	RCP	0.90	0.00	44.97	1	46.00	44.52	[2]
RDE02	502,548	6,937,759	RCP	1.20	0.00	20.25	1	-99999[c]	-99999[c]	[2]
RDE03	502,567	6,937,758	RCP	1.20	0.00	18.07	1	-99999[c]	44.25	[2]
RDE04	502,585	6,937,760	RCP	1.20	0.00	16.31	1	44.15	43.83	[2]
RDE05	502,603	6,937,764	RCP	1.20	0.00	19.57	1	43.73	43.24	[2]
RDE06a	502,630	6,937,775	RCP	1.20	0.00	40.15	1	43.24	--99999[c]	[2]
RDE06b	502,658	6,937,787	RCP	1.20	0.00	20.63	1	-99999[c]	42.85	[2]
RDE07a	502,721	6,937,814	RCP	1.20	0.00	116.00	1	42.85	41.19	[2]
RDE07b	502,819	6,937,852	RCP	1.20	0.00	94.97	1	41.19	39.83	[2]
RDE07c	502,893	6,937,881	RCP	1.20	0.00	63.25	1	39.83	38.92	[2]
RDE10	502,960	6,937,903	RCBC	2.40	1.50	78.46	1	38.92	38.01	[2]
RDE11	503,008	6,937,934	RCBC	2.63	1.30	48.22	1	38.01	37.51	[1], [2]
RDF01	502,292	6,939,565	RCP	0.83	0.00	17.28	1	54.16	54.11	[2]
RDF02	502,342	6,939,563	RCP	0.83	0.00	88.87	1	54.10	53.01	[2]
RDF03	502,425	6,939,548	RCP	0.83	0.00	79.56	1	52.52	51.95	[2]
RDF04	502,508	6,939,533	RCP	0.83	0.00	79.56	1	52.52	51.95	[2]
RDF05	502,558	6,939,527	RCP	0.83	0.00	9.11	1	51.15	51.05	[2]
RDF06	502,608	6,939,522	RCP	0.90	0.00	91.18	1	50.48	48.82	[2]
RDF07	502,679	6,939,510	RCP	1.05	0.00	52.98	1	47.38	45.41	[2]
RDF08	502,723	6,939,502	RCP	1.05	0.00	36.19	1	43.95	42.47	[2]
RDF09	502,755	6,939,508	RCP	1.05	0.00	34.28	1	42.27	41.63	[2]
RDF10	502,779	6,939,537	RCP	1.05	0.00	41.91	1	41.46	41.21	[2]
RDF11	502,792	6,939,556	RCP	1.20	0.00	6.03	1	39.94	39.77	[2]
RDF12	502,835	6,939,549	RCP	1.20	0.00	42.40	1	39.75	39.50	[2]
RDF13	502,285	6,939,520	RCP	0.38	0.00	99.27	1	53.23	53.23	[2]
RDF14	502,277	6,939,463	RCP	0.60	0.00	5.07	1	53.23	53.22	[2]
RDF15	502,311	6,939,459	RCP	0.75	0.00	31.61	1	53.22	52.54	[2]
RDG01	503,323	6,940,952	RCP	1.80	0.00	54.90	1	56.49	55.53	[2]
RDG02	503,313	6,940,892	RCP	1.80	0.00	64.90	1	54.76	53.52	[2]
RDG03	503,303	6,940,836	RCP	1.80	0.00	48.90	1	52.19	51.53	[2]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
RDG04	503,297	6,940,802	RCP	1.80	0.00	20.80	1	49.32	48.87	[2]
RDG05	503,292	6,940,770	RCP	1.95	0.00	44.20	1	48.83	47.96	[2]
RDG06	503,286	6,940,735	RCP	2.10	0.00	27.00	1	47.92	47.34	[2]
RDG07	503,276	6,940,719	RCP	2.10	0.00	15.20	1	16.49	46.25	[2]
RDG08	503,210	6,940,725	RCP	2.10	0.00	120.00	1	46.13	45.35	[2]
RDG09	503,143	6,940,728	RCP	2.10	0.00	22.10	1	44.45	44.13	[2]
RDH01	505,314	6,945,223	RCP	1.35	0.00	50.47	1	58.81	57.43	[2]
RDH02	505,306	6,945,176	RCP	1.35	0.00	36.11	1	57.00	55.93	[2]
RDH03	505,301	6,945,141	RCP	1.35	0.00	25.24	1	55.88	55.23	[2]
RDH04	505,297	6,945,117	RCP	1.35	0.00	13.97	1	55.20	54.89	[2]
RDH05	505,293	6,945,102	RCP	1.35	0.00	8.05	1	54.86	54.66	[2]
RDH06	505,288	6,945,080	RCP	1.50	0.00	29.01	1	54.51	54.27	[2]
RDH07	505,279	6,945,046	RCP	1.50	0.00	31.62	1	54.19	53.94	[2]
RDH08	505,293	6,945,024	RCP	1.50	0.00	33.75	1	52.95	52.64	[2]
RDH09	505,325	6,945,015	RCP	1.50	0.00	23.34	1	52.61	52.25	[2]
RDH10	505,349	6,945,009	RCP	1.65	0.00	17.37	1	52.61	52.25	[2]
RDH11	505,363	6,944,997	RCP	1.65	0.00	13.92	1	50.78	50.69	[2]
RDH12	505,366	6,944,969	RCP	1.65	0.00	34.40	1	50.52	50.16	[2]
RDH13	505,371	6,944,919	RCP	1.65	0.00	57.30	1	49.22	48.35	[2]
RDH14	505,383	6,944,872	RCP	1.80	0.00	35.52	1	47.93	47.82	[2]
RDH15	505,386	6,944,846	RCP	1.80	0.00	14.66	1	47.67	47.60	[2]
RDH16	505,387	6,944,831	RCP	1.80	0.00	10.71	1	47.55	47.50	[2]
RDI01	505,610	6,945,202	RCP	1.35	0.00	8.07	1	60.98	60.85	[2]
RDI02	505,608	6,945,182	RCP	1.35	0.00	26.97	1	60.49	59.69	[2]
RDI03	505,608	6,945,146	RCP	1.35	0.00	35.93	1	59.59	58.60	[2]
RDI04	505,603	6,945,116	RCP	1.35	0.00	24.90	1	58.36	57.72	[2]
RDI05	505,591	6,945,087	RCP	1.35	0.00	34.93	1	57.42	56.42	[2]
RDI06	505,590	6,945,053	RCP	1.35	0.00	26.31	1	56.06	55.33	[2]
RDI07a	505,600	6,945,027	RCP	1.35	0.00	26.14	1	54.59	53.84	[2]
RDI07b	505,609	6,945,012	RCP	1.35	0.00	5.61	1	53.66	53.59	[2]
RDI08	505,600	6,944,994	RCP	1.50	0.00	31.92	1	52.38	52.01	[2]
RDI09	505,579	6,944,959	RCP	1.65	0.00	41.17	1	51.63	51.18	[2]
RDI10	505,562	6,944,908	RCP	1.65	0.00	57.73	1	51.71	50.11	[2]
RDI11	505,547	6,944,867	RCP	1.65	0.00	22.45	1	49.70	49.38	[2]
RDI12	505,526	6,944,844	RCP	1.65	0.00	31.62	1	48.99	48.68	[2]
RDI13	505,494	6,944,827	RCP	1.80	0.00	31.62	1	48.99	48.68	[2]
RDI14	505,461	6,944,822	RCP	1.35	0.00	24.75	2	48.05	47.87	[2]
RDI15	505,423	6,944,827	RCP	1.35	0.00	42.87	2	47.82	47.59	[2]
RDI16	505,395	6,944,829	RCP	1.35	0.00	9.91	2	47.56	47.50	[2]
RDJ01	507,502	6,937,905	RCP	1.50	0.00	76.90	1	24.72	24.03	[2]
RDJ02	507,508	6,937,970	RCP	1.50	0.00	53.88	1	24.33	23.35	[2]
RDJ03	507,506	6,938,026	RCP	1.50	0.00	59.17	1	23.40	22.70	[2]
RDJ04	507,499	6,938,085	RCP	1.50	0.00	60.34	1	22.90	22.30	[2]
RDJ05	507,492	6,938,140	RCP	1.50	0.00	51.25	1	22.50	21.50	[2]
RDJ06	507,488	6,938,176	RCP	1.80	0.00	51.25	1	21.50	21.44	[2]
RDJ07	507,483	6,938,221	RCP	1.80	0.00	71.16	1	21.44	-99999[c]	[2]
RDJ08	507,474	6,938,269	RCP	1.80	0.00	26.08	1	-99999[c]	20.29	[2]
RDJ09	507,463	6,938,303	RCP	1.80	0.00	45.86	1	20.10	20.29	[2]
RDJ10	507,450	6,938,338	RCP	1.80	0.00	28.68	1	20.29	-99999[c]	[2]
RDJ11	507,432	6,938,388	RCP	1.80	0.00	78.91	1	-99999[c]	19.10	[2]
RDJ12	507,401	6,938,466	RCP	1.80	0.00	88.70	1	19.10	18.53	[2]
RDJ13	507,487	6,937,885	RCP	1.20	0.00	87.91	1	25.60	24.23	[2]
RDJ14	507,497	6,937,947	RCP	1.20	0.00	38.79	1	24.23	24.21	[2]
RDJ15	507,499	6,937,978	RCP	1.20	0.00	23.50	1	24.11	23.54	[2]
RDJ16	507,495	6,938,030	RCP	1.20	0.00	81.05	1	23.54	22.88	[2]
RDJ17	507,487	6,938,107	RCP	1.20	0.00	75.47	1	22.88	22.24	[2]
RDJ18a	507,485	6,938,155	RCP	1.80	0.00	21.61	1	22.24	21.50	[2]
RDJ18b	507,477	6,938,217	RCP	1.80	0.00	105.71	1	21.50	20.51	[2]
RDJ19	507,454	6,938,302	RCP	1.80	0.00	70.92	1	20.51	-99999[c]	[2]
RDJ20	507,426	6,938,378	RCP	1.80	0.00	92.12	1	-99999[c]	-99999[c]	[2]
RDJ21	507,399	6,938,445	RCP	1.80	0.00	53.47	1	-99999[c]	-99999[c]	[2]
RDJ22	507,386	6,938,488	RCP	1.80	0.00	36.96	1	-99999[c]	18.53	[2]
RDK01	509,727	6,938,650	RCP	1.80	0.00	15.39	1	12.80	12.06	[2]
RDK02	509,749	6,938,641	RCP	1.80	0.00	40.95	1	14.17	12.06	[2]
RDK03	509,717	6,938,674	RCP	1.80	0.00	40.95	2	12.06	-99999[c]	[2]
RDK04	509,707	6,938,702	RCP	1.80	0.00	13.05	2	-99999[c]	12.00	[2]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
RDL01	510,633	6,938,607	RCP	1.65	0.00	114.05	2	8.90	8.44	[2]
RDL02	510,730	6,938,615	RCP	1.65	0.00	107.71	3	8.44	8.00	[2]
RDL03	510,619	6,938,654	RCP	1.50	0.00	92.46	1	9.21	8.80	[2]
RDL04	510,667	6,938,686	RCP	1.35	0.00	21.74	1	8.70	8.44	[2]
RDL05	510,696	6,938,707	RCP	1.35	0.00	50.52	1	8.44	7.97	[2]
RDL06	510,742	6,938,740	RCP	1.35	0.00	62.42	1	7.97	7.53	[2]
RDL07	510,808	6,938,786	RCP	1.50	0.00	98.85	1	7.23	6.99	[2]
RDL08	510,890	6,938,841	RCP	1.50	0.00	98.43	1	6.99	6.96	[2]
RDL09	510,933	6,938,871	RCP	1.65	0.00	57.18	1	6.86	6.76	[2]
RDL10	511,010	6,938,915	RCP	1.65	0.00	66.70	1	6.76	6.65	[2], [3]
RDM01	511,289	6,938,349	RCP	1.50	0.00	59.11	1	7.40	5.78	[2]
RDM02	511,290	6,938,348	RCP	1.20	0.00	59.55	1	7.40	5.78	[2]
RDM03	511,382	6,938,409	RCP	1.50	0.00	163.10	2	5.78	5.40	[2]
RDM04	511,381	6,938,411	RCP	1.20	0.00	162.74	1	5.78	5.40	[2]
RDM05	511,224	6,938,305	RCP	1.20	0.00	95.07	1	7.64	7.40	[2]
RDN01	511,415	6,938,063	RCP	1.95	0.00	69.52	1	9.90	-99999[c]	[2]
RDN02	511,404	6,938,154	RCP	1.95	0.00	69.52	1	-99999[c]	9.89	[2]
RDN03	511,381	6,938,175	RCP	1.35	0.00	27.48	2	-99999[c]	-99999[c]	[2]
RDN04	511,356	6,938,221	RCP	1.95	0.00	27.48	1	-99999[c]	9.42	[2]
RDN05	511,325	6,938,310	RCP	1.35	0.00	27.48	2	9.42	5.78	[2]
RDO01	512,744	6,938,794	RCP	1.65	0.00	82.31	1	11.10	10.75	[2]
RDO02	512,749	6,938,866	RCP	1.65	0.00	78.54	1	10.75	9.83	[2]
RDO03	512,750	6,938,920	RCP	1.35	0.00	15.57	2	9.83	-99999[c]	[2]
RDO04	512,748	6,938,948	RCP	1.35	0.00	46.75	2	-99999[c]	9.72	[2]
RDO05a	512,727	6,939,023	RCP	1.05	0.00	122.78	1	9.72	9.55	[2]
RDO05b	512,749	6,939,027	RCP	1.05	0.00	127.17	1	9.72	9.55	[2]
RDQ01	511,270	6,947,135	RCP	1.20	0.00	58.39	1	36.65	35.02	[2]
RDQ02	511,226	6,947,118	RCP	1.20	0.00	32.58	1	34.70	34.37	[2]
RDQ04	511,205	6,947,099	RCP	1.35	0.00	32.58	1	34.70	34.37	[2]
RDQ05	511,195	6,947,076	RCP	1.35	0.00	18.99	1	34.37	33.25	[2]
RDQ06	511,176	6,947,062	RCP	1.35	0.00	49.69	1	33.25	32.14	[2]
RDQ07	511,145	6,947,026	RCP	1.35	0.00	66.50	1	32.14	30.23	[2]
RDQ08	511,117	6,946,988	RCP	1.35	0.00	29.00	1	30.23	27.49	[2]
RDQ09	511,097	6,946,967	RCP	1.35	0.00	30.31	1	27.96	27.49	[2]
RDQ10	511,072	6,946,945	RCP	1.35	0.00	33.90	1	27.38	27.21	[2]
RDQ11	511,048	6,946,918	RCP	1.65	0.00	39.02	1	27.13	26.80	[2]
RDQ12	511,034	6,946,880	RCP	1.80	0.00	47.92	1	26.69	25.95	[2]
RDQ13	511,038	6,946,835	RCP	1.80	0.00	44.61	1	25.81	25.31	[2]
RDQ14	511,049	6,946,805	RCP	1.80	0.00	19.20	1	25.30	25.22	[2]
RDQ15	511,047	6,946,766	RCP	1.80	0.00	60.37	1	25.22	25.10	[2]
RDQ16	511,046	6,946,722	RCP	1.80	0.00	28.18	1	25.10	24.20	[2]
RDR01	512,511	6,946,434	RCP	1.95	0.00	91.73	1	39.86	38.23	[2]
RDR02	512,499	6,946,354	RCP	1.95	0.00	71.99	1	38.23	36.79	[2]
RDR03	512,474	6,946,323	RCP	2.40	0.00	40.14	1	36.79	33.85	[2]
RDR04	512,441	6,946,310	RCP	2.10	0.00	40.06	2	33.85	32.30	[2]
RDS01	510,741	6,944,824	RCBC	6.10	1.80	194.50	1	26.90	24.00	[2]
RDS02	510,838	6,944,930	RCBC	6.10	1.80	64.12	1	23.20	21.17	[2]
RDS03	510,860	6,944,952	RCP	1.50	0.00	23.33	3	21.17	-99999[c]	[2]
RDS04	510,864	6,944,969	RCP	1.50	0.00	7.85	3	-99999[c]	21.28	[2]
RDS05	510,879	6,945,067	RCP	1.80	0.00	188.94	4	21.28	19.40	[2]
RDT01	511,157	6,944,701	RCP	1.20	0.00	98.60	1	30.34	-99999[c]	[2], [3]
RDT02	511,145	6,944,921	RCP	1.35	0.00	130.76	1	-99999[c]	25.98	[2], [3]
RDT03[d]	511,132	6,944,840	RCP	0.90	0.00	44.02	5	26.77	25.97	[13]
RDT04[d]	511,169	6,944,941	RCP	0.90	0.00	42.00	6	25.50	23.97	[13]
RDT05[d]	510,195	6,945,00	RCP	1.05	0.00	86.00	6	23.95	23.55	[13]
RDU01	510,177	6,943,629	RCP	1.65	0.00	38.69	1	29.95	29.06	[2]
RDU02	510,220	6,943,589	RCP	0.60	0.00	77.74	1	28.86	27.60	[2]
RDU03	510,258	6,943,546	RCP	0.60	0.00	36.55	1	27.60	26.49	[2]
RDU04	510,273	6,943,516	RCP	0.60	0.00	34.66	1	26.49	26.22	[2]
RDU05a	510,278	6,943,487	RCP	0.60	0.00	24.79	1	26.22	26.03	[2]
RDU05b	510,275	6,943,461	RCP	0.60	0.00	24.79	1	26.22	26.03	[2]
RDU06	510,267	6,943,427	RCP	1.65	0.00	43.20	1	25.75	25.31	[2]
RDU07	510,262	6,943,387	RCP	1.65	0.00	39.56	1	25.81	25.04	[2]
RDU08	510,256	6,943,348	RCP	1.05	0.00	36.02	2	24.54	23.85	[2]
RDV01	510,795	6,942,089	RCP	1.50	0.00	53.91	1	22.22	22.10	[2]
RDV02[e]	510,829	6,942,084	RCP	1.05	0.00	14.10	1	22.10	21.28	[2]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
RDV03	510,858	6,942,079	RCP	1.05	0.00	48.74	1	21.28	20.75	[2]
RDV04	510,914	6,942,071	RCP	1.65	0.00	64.65	1	20.75	19.46	[2]
RDV05	510,958	6,942,066	RCP	1.65	0.00	64.65	1	18.56	18.09	[2]
RDV06	511,000	6,942,062	RCP	2.10	0.00	57.46	1	17.22	17.19	[2]
RDV07	511,037	6,942,107	RCP	2.10	0.00	99.99	1	16.24	15.99	[2]
RDV08	511,052	6,942,202	RCP	2.10	0.00	91.79	1	15.99	15.75	[2]
RDV09	511,107	6,942,247	RCP	1.80	0.00	96.07	2	15.75	15.51	[2]
RDV11	511,207	6,942,251	RCP	1.95	0.00	141.34	1	15.51	-99999[c]	[2]
RDV12	511,334	6,942,257	RCP	1.95	0.00	95.74	1	-99999[c]	14.22	[2]
RDV13	511,181	6,942,251	RCP	1.80	0.00	52.40	2	15.51	-99999[c]	[2]
RDV14	511,311	6,942,238	RCP	1.95	0.00	195.64	1	-99999[c]	14.22	[2]
RDV15	511,115	6,942,413	RCP	1.50	0.00	47.45	1	16.67	16.35	[2]
RDV16	511,162	6,942,406	RCP	1.50	0.00	48.39	1	16.35	16.02	[2]
RDV17	511,233	6,942,395	RCP	1.50	0.00	95.85	1	16.02	15.34	[2]
RDV18	511,291	6,942,385	RCP	1.50	0.00	19.76	1	15.23	15.06	[2]
RDV19	511,320	6,942,379	RCP	1.80	0.00	40.12	1	14.64	14.36	[2]
RDV20	511,354	6,942,348	RCP	1.85	0.00	63.80	1	13.73	13.42	[2]
RDV21	511,423	6,942,312	RCP	1.95	0.00	116.85	2	13.42	12.90	[2]
RDV22	511,575	6,942,286	RCP	1.95	0.00	198.95	3	12.90	11.00	[2]
RDV23	511,677	6,942,268	RCBC	2.10	1.20	6.36	5	11.00	10.95	[2]
RDV24	511,694	6,942,266	RCBC	2.10	1.20	27.84	5	10.95	-99999[c]	[2]
RDV25	511,265	6,942,393	RCP	0.45	0.00	32.51	1	16.59	16.16	[2]
RDV26	511,147	6,942,356	RCP	0.45	0.00	25.00	1	17.15	17.00	[2]
RDV27	511,198	6,942,363	RCP	0.60	0.00	79.01	1	16.77	16.41	[2]
RDV28	511,258	6,942,379	RCP	0.75	0.00	34.42	1	16.20	16.00	[2]
RDV30	511,344	6,942,326	RCP	0.30	0.00	53.79	1	15.90	15.44	[2]
RDV31	511,374	6,942,221	RCP	0.45	0.00	28.50	1	15.54	15.29	[2]
RDV32	511,373	6,942,306	RCP	0.45	0.00	92.34	1	14.79	13.79	[2]
RDV33	511,572	6,942,184	RCP	0.45	0.00	111.42	2	13.99	13.54	[2]
RDV34	511,642	6,942,173	RCP	0.90	0.00	31.15	1	13.23	12.62	[2]
RDV35	511,660	6,942,177	RCP	0.90	0.00	17.87	1	12.62	12.10	[2]
RDV36	511,666	6,942,204	RCP	1.20	0.00	42.72	1	11.82	11.25	[2]
RDV37	511,671	6,942,247	RCP	1.20	0.00	43.68	1	11.16	11.00	[2]
RDV38	511,675	6,942,214	RCP	1.50	0.00	89.75	1	12.40	-99999[c]	[2]
RDV39	511,680	6,942,263	RCP	1.50	0.00	10.51	1	-99999[c]	10.95	[2]
RDV40	511,367	6,942,345	RCP	0.30	0.00	45.10	1	15.70	14.95	[2]
RDW03	513,732	6,943,628	RCBC	1.20	0.60	21.17	2	18.10	17.50	[2]
RDW03b	513,734	6,943,609	RCBC	2.10	1.20	28.55	3	17.50	16.49	[2]
RDW04a	513,708	6,943,539	RCBC	1.20	0.60	95.92	3	16.49	15.29	[2]
RDW04b	513,697	6,943,469	RCBC	1.20	0.60	47.05	3	15.29	14.89	[2]
RDW04c	513,691	6,943,423	RCBC	1.20	0.60	46.70	3	14.86	14.76	[2]
RDW04d	513,685	6,943,383	RCBC	1.20	0.60	33.47	3	14.76	14.53	[2]
RDW05	513,679	6,943,341	RCBC	1.80	0.90	49.04	3	14.53	12.05	[2]
RDX01	511,834	6,943,840	RCP	1.50	0.00	23.97	2	14.09	13.21	[2]
RDX02	511,855	6,943,825	RCP	1.50	0.00	30.03	2	12.80	12.21	[2]
RDX03	511,933	6,943,802	RCP	1.50	0.00	70.70	2	12.12	11.34	[2]
RDX04	513,675	6,944,601	RCP	1.35	0.00	18.15	1	34.11	33.62	[2]
RDY01	514,251	6,943,270	RCP	1.35	0.00	72.34	1	19.60	18.82	[2]
RDY02	514,181	6,943,272	RCP	1.65	0.00	69.07	1	17.72	16.79	[2]
RDY03	514,104	6,943,277	RCP	1.65	0.00	86.04	1	16.29	15.44	[2]
RDY04	514,053	6,943,247	RCP	1.65	0.00	76.65	1	15.44	14.63	[2]
RDY05	514,040	6,943,195	RCP	1.65	0.00	30.41	1	14.53	14.52	[2]
RDY06	514,023	6,943,184	RCP	1.80	0.00	15.17	1	14.52	14.00	[2]
Rochedale01	512,158	6,945,731	RCP	0.90	0.00	62.70	1	19.87	19.47	[2]
Rochedale02	512,191	6,945,664	RCP	1.20	0.00	87.62	1	19.47	18.97	[2]
Shortland5	512,878	6,944,136	RCBC	1.57	1.37	11.07	1	16.14	16.08	[8]
Shortland1	512,934	6,944,162	RCP	1.50	0.00	37.49	1	17.94	17.58	[8]
Shortland2	512,900	6,944,127	RCP	1.50	0.00	63.89	1	16.56	16.13	[8]
Shortland3	512,856	6,944,125	RCP	1.80	0.00	23.56	1	14.95	14.14	[8]
Shortland5a	512,881	6,944,146	RCP	1.35	0.00	10.32	1	16.16	16.14	[8]
Shortland6	512,860	6,944,128	RCP	1.65	0.00	30.05	1	16.05	16.00	[8]
Shortland7	512,830	6,944,126	RCP	1.20	0.00	30.55	2	16.00	15.74	[8]
Shrtl10	512,650	6,944,068	RCP	1.35	0.00	194.43	3	12.18	10.03	[8]
SW_Road7	511,988	6,945,955	RCP	0.45	0.00	19.10	1	24.05	23.87	[8]
Trinette1	516,982	6,942,279	RCP	1.35	0.00	88.00	1	15.75	15.11	[2]
Trinette2	516,947	6,942,230	RCP	1.05	0.00	38.92	2	14.83	14.07	[2]

Structure ID	Easting	Northing	Culvert type [a]	Width / diameter (m)	Height (m)	Length (m)	No. of barrels	U/S invert level (mAHD)	D/S invert level (mAHD)	Source (see footnote [b])
Trinette3	516,938	6,942,164	RCP	1.35	0.00	38.92	2	14.07	13.30	[2]
Van_Blvd1	512,593	6,945,325	RCP	1.65	0.00	80.77	2	21.44	20.59	[8]
Van_Blvd2	512,456	6,945,308	RCP	1.80	0.00	229.49	2	20.47	18.00	[8]
Van_Blvd3	512,571	6,945,323	RCP	1.50	0.00	79.53	1	21.00	20.60	[8]
154	503,970	6,940,388	RCBC	2.10	0.60	43.18	1	30.34	29.53	[4]
155	503,995	6,940,377	RCBC	1.20	0.45	16.00	2	29.53	28.80	[4]
156	504,007	6,940,361	RCP	1.50	0.00	23.00	1	28.80	28.13	[4]

[a] – 'RCBC' = Reinforced concrete box culvert; 'RCP' = Reinforced concrete pipe

[b] – Culvert details were obtained from one or more of the following sources:

[1] – LCC hydraulic structures survey (2017)

[2] – LCC GIS hydraulic structures database

[3] – LCC (2017) and BCC (2017) LiDAR data

[4] – Fern Street and Johnson Road Local Flood Study (Engeny, 2013)

[5] – Wembley Road Interchange (Berrinba) Flood Study (WRM, 2014b)

[6] – Logan- Albert Rivers Flood Study Peer Review (WRM, 2014a)

[7] – Slacks and Scrubby Creeks Flood Study Peer Review (WRM, 2015)

[8] – M1 Motorway Upgrade Hydraulic Study (WRM, 2017)

[9] – WRM site visit (2017)

[10] – Other information (e.g. photos, sketches) supplied by LCC

[11] – Aerial photo + street view

[12] – PD online

[13] – As-constructed drawings supplied by LCC

[c] – Invert level was interpolated based on known invert levels of upstream and/or downstream structures

[d] – These culverts were included for design event modelling, but were excluded for the calibration events.

[e] – Information in the LCC GIS hydraulic structures database (1.05 m RCP) appear inconsistent with connecting pipes. Therefore, an assumed size of 1.5 m RCP was adopted.

C4 Stormwater inlet pits and manholes

Table C.3 – Configuration of stormwater inlet pits in the TUFLOW model

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote a)
Barr_DS	512,409	6,944,471	L (large) lintel pit	1	12.29	8.61	[8]
Bunnings1	511,142	6,944,934	0.9x0.9	1	27.16	25.50	[13]
Bunnings2	511,150	6,944,929	0.9x0.9	1	27.16	25.50	[13]
CindPit01	512,888	6,945,617	S (small) lintel pit	1	42.67	41.24	[13]
CindPit02	512,886	6,945,602	S (small) lintel pit	1	41.76	40.26	[13]
CindPit03	512,884	6,945,593	S (small) lintel pit	1	41.06	39.56	[13]
CindPit04	512,884	6,945,582	S (small) lintel pit	1	40.58	39.05	[13]
CindPit05	512,891	6,945,575	L (large) lintel pit	1	41.00	38.93	[13]
CindPit06	512,893	6,945,565	M (medium) lintel pit	1	41.08	38.88	[13]
CindPit07	512,946	6,945,595	S (small) lintel pit	1	44.40	42.92	[13]
CindPit08	512,940	6,945,582	S (small) lintel pit	1	43.55	42.00	[13]
CindPit09	512,956	6,945,603	S (small) lintel pit	1	44.99	43.51	[13]
CindPit10	512,953	6,945,593	S (small) lintel pit	1	44.40	42.85	[13]
CindPit11	512,943	6,945,571	M (medium) lintel pit	1	42.78	40.37	[13]
CindPit12	512,935	6,945,570	M (medium) lintel pit	1	42.48	39.98	[13]
CindPit13	512,942	6,945,561	S (small) lintel pit	1	41.93	40.03	[13]
CindPit15	512,931	6,945,552	M (medium) lintel pit	1	41.95	38.38	[13]
CindPit16	512,953	6,945,551	S (small) lintel pit	1	0.05	41.45	[13]
CindPit17	512,946	6,945,545	S (small) lintel pit	1	0.05	41.34	[13]
CR1	517,180	6,942,625	0.9 m x 0.6 m grated field inlet	1	24.95	23.55	[2], [3]
D1	502,714	6,938,254	L (large) lintel pit	1	48.13	44.75	[2]
D2	502,704	6,938,200	L (large) lintel pit	1	45.60	44.58	[2]
Fitz_US	512,516	6,945,747	L (large) lintel pit	1	31.79	27.05	[8]
Fitz_US2	512,493	6,945,670	L (large) lintel pit	1	29.77	24.70	[8]
Fitz_US3	512,459	6,945,639	L (large) lintel pit	1	28.84	24.25	[8]
Fitz_US4	512,390	6,945,578	L (large) lintel pit	1	28.28	21.31	[8]
Fitz_US5	512,272	6,945,585	L (large) lintel pit	1	22.32	19.00	[8]
Fitz_US9a	512,144	6,945,759	L (large) lintel pit	1	23.50	19.87	[8]
Fitz_US9b	512,210	6,945,625	L (large) lintel pit	1	23.00	18.97	[8]
Jacaranda01	510,915	6,941,208	L (large) lintel pit	1	14.80	12.40	[2]
Judd_DS	512,129	6,945,217	L (large) lintel pit	1	15.24	11.36	[8]
Judd_DS1	512,225	6,945,250	L (large) lintel pit	1	18.16	14.80	[8]
P_BP01	503,861	6,940,376	L (large) lintel pit	1	33.76	31.75	[4]
P_BP02	503,949	6,940,393	L (large) lintel pit	1	32.54	30.34	[4]
P_BP03	504,097	6,940,366	L (large) lintel pit	1	30.74	29.20	[4]
P_BP04	504,093	6,940,336	L (large) lintel pit	1	30.97	29.75	[4]
P_BP05	504,203	6,939,792	L (large) lintel pit	1	38.42	36.68	[4]
P_BP06	504,205	6,939,800	L (large) lintel pit	1	38.40	36.68	[4]
P_BP07	504,215	6,939,789	L (large) lintel pit	1	38.59	36.60	[4]
P_BP08	503,946	6,940,335	L (large) lintel pit	1	31.34	30.45	[4]
P_BP09	503,965	6,940,335	L (large) lintel pit	1	31.53	30.45	[4]
P_Loganlea1	513,864	6,940,329	L (large) lintel pit	1	8.12	5.77	[1], [2]
P_Mandew1	517,066	6,940,774	L (large) lintel pit	1	18.90	14.96	[1], [2]
P_Mandew2	516,862	6,940,932	L (large) lintel pit	1	13.44	11.44	[1]
P_Velorum1	509,848	6,940,114	L (large) lintel pit	1	12.94	11.42	[2]
Pit_F1	516,543	6,940,505	0.9 m x 0.6 m grated field inlet	1	11.93	11.12	[2]
Pit_F2	516,553	6,940,513	0.9 m x 0.6 m grated field inlet	1	11.55	10.91	[2]
Pit_F3	516,513	6,940,536	0.9 m x 0.6 m grated field inlet	1	12.67	11.00	[2]
Pit_F4	516,520	6,940,535	0.9 m x 0.6 m grated field inlet	1	12.26	11.06	[2]
Pit_RDT01	511,140	6,944,886	3.6 m x 1.2 m grated field inlet	1	28.27	27.07	[11]
Pit_SR01	515,285	6,941,806	0.9 m x 0.6 m grated field inlet	1	7.03	5.03	[8]
Shrtl1-2	512,932	6,944,126	L (large) lintel pit	1	20.60	16.13	[8]
shrtl3-4	512,845	6,944,123	L (large) lintel pit	1	18.18	12.15	[8]
Shrtl7-8	512,815	6,944,128	L (large) lintel pit	1	18.50	15.30	[8]
ShrtlGP1	512,882	6,944,151	2.4 m x 1.2 m grated field inlet	1	18.47	16.16	[8]
ShtlGP2	512,881	6,944,141	3.6 m x 1.2 m grated field inlet	1	18.47	16.14	[8]
SP1030	509,773	6,938,633	S (small) lintel pit	1	15.89	14.79	[2], [3]
SP1032	509,769	6,938,621	S (small) lintel pit	1	15.96	14.86	[2], [3]
SP1034	509,740	6,938,655	S (small) lintel pit	1	15.40	14.50	[2], [3]
SP1035	509,735	6,938,659	S (small) lintel pit	1	15.35	14.35	[2], [3]
SP1036	509,740	6,938,639	S (small) lintel pit	1	15.49	14.59	[2], [3]
SP1038	509,722	6,938,639	S (small) lintel pit	1	15.11	13.91	[2], [3]
SP1039	509,715	6,938,646	S (small) lintel pit	1	15.08	14.08	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
SP1041	509,700	6,938,681	S (small) lintel pit	1	15.06	14.06	[2], [3]
SP10469	510,836	6,942,063	S (small) lintel pit	1	24.81	23.46	[2], [3]
SP10470	510,830	6,942,076	M (medium) lintel pit	1	24.80	22.60	[2], [3]
SP10471	510,822	6,942,085	M (medium) lintel pit	1	25.01	22.51	[2], [3]
SP10477	511,029	6,942,052	M (medium) lintel pit	1	20.83	17.48	[2], [3]
SP10479	511,053	6,942,059	S (small) lintel pit	1	20.57	19.77	[2], [3]
SP10501	510,761	6,942,093	M (medium) lintel pit	1	26.18	23.58	[2], [3]
SP10502	510,763	6,942,103	M (medium) lintel pit	1	26.21	23.96	[2], [3]
SP10521	511,204	6,942,222	M (medium) lintel pit	1	17.67	15.42	[2], [3]
SP10526	511,309	6,942,224	S (small) lintel pit	1	17.13	15.18	[2], [3]
SP10527	511,303	6,942,222	S (small) lintel pit	1	17.25	15.75	[2], [3]
SP10676	510,264	6,943,407	S (small) lintel pit	1	26.87	25.77	[2], [3]
SP10678	510,274	6,943,398	S (small) lintel pit	1	26.69	25.59	[2], [3]
SP10891	505,177	6,940,866	S (small) lintel pit	1	45.66	44.56	[2], [3]
SP10892	505,194	6,940,852	S (small) lintel pit	1	45.43	44.63	[2], [3]
SP10893	505,180	6,940,865	S (small) lintel pit	1	45.63	44.43	[2], [3]
SP10895	505,185	6,940,784	S (small) lintel pit	1	42.05	40.70	[2], [3]
SP10896	505,180	6,940,775	S (small) lintel pit	1	41.66	40.86	[2], [3]
SP10898	505,207	6,940,680	S (small) lintel pit	1	38.14	37.44	[2], [3]
SP10899	505,204	6,940,674	S (small) lintel pit	1	37.88	37.28	[2], [3]
SP10901	505,217	6,940,608	S (small) lintel pit	1	35.71	34.76	[2], [3]
SP10903	505,201	6,940,579	S (small) lintel pit	1	34.68	33.78	[2], [3]
SP10904	505,183	6,940,563	S (small) lintel pit	1	34.54	33.59	[2], [3]
SP10905	505,190	6,940,570	S (small) lintel pit	1	34.45	32.65	[2], [3]
SP10906	505,196	6,940,571	S (small) lintel pit	1	34.38	33.68	[2], [3]
SP10908	505,207	6,940,522	S (small) lintel pit	1	33.95	32.90	[2], [3]
SP10909	505,209	6,940,529	S (small) lintel pit	1	34.03	32.78	[2], [3]
SP10917	505,201	6,940,538	S (small) lintel pit	1	33.78	32.63	[2], [3]
SP10919	505,176	6,940,504	S (small) lintel pit	1	32.58	31.68	[2], [3]
SP10920	505,179	6,940,490	S (small) lintel pit	1	32.38	31.58	[2], [3]
SP10921	505,169	6,940,494	S (small) lintel pit	1	32.37	31.62	[2], [3]
SP10922	505,167	6,940,491	S (small) lintel pit	1	32.40	31.75	[2], [3]
SP10924	505,145	6,940,477	S (small) lintel pit	1	32.98	32.23	[2], [3]
SP10925	505,154	6,940,470	S (small) lintel pit	1	32.74	29.84	[2], [3]
SP10975	504,965	6,940,218	S (small) lintel pit	1	33.43	32.83	[2], [3]
SP10976	504,976	6,940,218	S (small) lintel pit	1	33.37	32.87	[2], [3]
SP11016	505,113	6,940,876	S (small) lintel pit	1	47.78	47.18	[2], [3]
SP11099	505,048	6,940,080	S (small) lintel pit	1	27.99	26.99	[2], [3]
SP11101	505,031	6,940,095	S (small) lintel pit	1	28.57	27.42	[2], [3]
SP11102	504,997	6,940,099	S (small) lintel pit	1	30.19	28.54	[2], [3]
SP11116	504,635	6,940,064	S (small) lintel pit	1	27.41	25.96	[2], [3]
SP11126	504,742	6,939,971	S (small) lintel pit	1	27.25	26.30	[2], [3]
SP11128	504,757	6,939,980	S (small) lintel pit	1	27.18	26.33	[2], [3]
SP11129	504,806	6,939,971	S (small) lintel pit	1	26.88	25.88	[2], [3]
SP11130	504,797	6,939,962	S (small) lintel pit	1	26.94	26.09	[2], [3]
SP12408	502,431	6,935,473	M (medium) lintel pit	1	53.94	51.89	[2], [3]
SP12409	502,428	6,935,469	S (small) lintel pit	1	54.15	52.80	[2], [3]
SP12410	502,405	6,935,495	M (medium) lintel pit	1	53.41	50.91	[2], [3]
SP12411	502,396	6,935,478	S (small) lintel pit	1	53.16	51.56	[2], [3]
SP12412	502,390	6,935,483	S (small) lintel pit	1	53.18	52.03	[2], [3]
SP12417	502,374	6,935,519	S (small) lintel pit	1	52.81	50.71	[2], [3]
SP12418	502,370	6,935,527	M (medium) lintel pit	1	52.67	50.57	[2], [3]
SP12419	502,366	6,935,568	M (medium) lintel pit	1	51.94	49.74	[2], [3]
SP12420	502,359	6,935,567	S (small) lintel pit	1	52.05	50.60	[2], [3]
SP12421	502,364	6,935,607	M (medium) lintel pit	1	51.41	49.11	[2], [3]
SP12422	502,370	6,935,605	S (small) lintel pit	1	51.42	50.12	[2], [3]
SP12423	502,383	6,935,638	M (medium) lintel pit	1	51.01	48.71	[2], [3]
SP12424	502,386	6,935,632	S (small) lintel pit	1	51.05	49.95	[2], [3]
SP12425	502,396	6,935,644	S (small) lintel pit	1	51.09	49.79	[2], [3]
SP13083	501,406	6,937,113	S (small) lintel pit	1	57.74	56.64	[2], [3]
SP13092	501,462	6,937,096	S (small) lintel pit	1	55.60	54.40	[2], [3]
SP13093	501,456	6,937,085	S (small) lintel pit	1	55.83	54.43	[2], [3]
SP13095	501,503	6,937,077	S (small) lintel pit	1	54.42	52.77	[2], [3]
SP13097	501,549	6,937,069	S (small) lintel pit	1	53.39	52.14	[2], [3]
SP13098	501,564	6,937,089	S (small) lintel pit	1	53.23	52.23	[2], [3]
SP13100	501,555	6,937,085	S (small) lintel pit	1	53.04	51.64	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
SP13116	501,620	6,937,070	S (small) lintel pit	1	51.93	50.78	[2], [3]
SP13117	501,631	6,937,074	S (small) lintel pit	1	51.55	50.70	[2], [3]
SP13118	501,633	6,937,079	S (small) lintel pit	1	51.65	50.60	[2], [3]
SP13119	501,640	6,937,078	S (small) lintel pit	1	51.62	50.32	[2], [3]
SP13183	501,709	6,937,057	S (small) lintel pit	1	50.23	48.78	[2], [3]
SP13184	501,703	6,937,056	S (small) lintel pit	1	50.30	48.95	[2], [3]
SP13185	501,706	6,937,042	S (small) lintel pit	1	50.35	49.45	[2], [3]
SP1340	503,917	6,937,421	S (small) lintel pit	1	39.61	38.21	[2], [3]
SP1341	503,925	6,937,423	S (small) lintel pit	1	39.48	38.28	[2], [3]
SP1344	503,810	6,937,463	M (medium) lintel pit	1	35.45	32.55	[2], [3]
SP1345	503,843	6,937,443	M (medium) lintel pit	1	36.59	34.19	[2], [3]
SP13497	517,137	6,942,482	0.9 m x 0.6 m grated field inlet	1	22.64	20.84	[2], [3]
SP13508	517,143	6,942,528	0.9 m x 0.6 m grated field inlet	1	22.98	21.38	[2], [3]
SP13586	511,404	6,938,172	S (small) lintel pit	1	12.11	10.91	[2], [3]
SP13988	512,170	6,945,708	S (small) lintel pit	2	23.61	22.71	[2], [3]
SP14091	514,225	6,943,285	S (small) lintel pit	1	20.42	19.32	[2], [3]
SP14092	514,235	6,943,278	S (small) lintel pit	1	20.82	19.77	[2], [3]
SP14094	514,296	6,943,269	S (small) lintel pit	1	21.98	20.68	[2], [3]
SP14118	514,080	6,943,277	S (small) lintel pit	1	18.02	16.92	[2], [3]
SP14119	514,086	6,943,276	S (small) lintel pit	1	18.09	17.04	[2], [3]
SP15043	511,480	6,942,193	S (small) lintel pit	2	15.49	14.39	[2], [3]
SP15045	511,484	6,942,192	S (small) lintel pit	1	15.32	14.22	[2], [3]
SP15046	511,489	6,942,181	S (small) lintel pit	1	15.71	14.61	[2], [3]
SP15069	512,526	6,946,481	S (small) lintel pit	1	41.24	39.84	[2], [3]
SP15077	512,519	6,946,392	S (small) lintel pit	1	40.19	38.79	[2], [3]
SP15078	512,519	6,946,386	S (small) lintel pit	1	40.27	38.87	[2], [3]
SP15133	511,355	6,938,172	S (small) lintel pit	1	11.99	10.79	[2], [3]
SP15134	511,373	6,938,154	S (small) lintel pit	1	11.94	10.74	[2], [3]
SP15165	503,422	6,940,018	S (small) lintel pit	1	38.15	36.85	[2], [3]
SP15166	503,431	6,940,023	S (small) lintel pit	1	38.64	37.34	[2], [3]
SP15345	504,948	6,940,213	S (small) lintel pit	1	34.28	33.28	[2], [3]
SP15511	510,167	6,943,636	M (medium) lintel pit	1	31.27	29.27	[2], [3]
SP15512	510,176	6,943,629	M (medium) lintel pit	1	31.25	28.00	[2], [3]
SP15515	510,173	6,943,598	S (small) lintel pit	1	31.17	29.97	[2], [3]
SP15592	511,151	6,944,893	S (small) lintel pit	1	27.95	26.75	[2], [3]
SP15593	511,146	6,944,894	S (small) lintel pit	1	27.93	26.73	[2], [3]
SP15600	510,858	6,944,941	S (small) lintel pit	1	24.01	22.01	[2], [3]
SP15806	512,104	6,945,976	S (small) lintel pit	1	26.38	24.98	[2], [3]
SP1592	517,707	6,942,280	S (small) lintel pit	1	29.09	27.59	[2], [3]
SP1595	517,701	6,942,268	S (small) lintel pit	1	29.88	27.67	[2], [3]
SP1597	517,673	6,942,275	S (small) lintel pit	1	28.39	27.23	[2], [3]
SP1598	517,670	6,942,273	S (small) lintel pit	1	28.29	26.55	[2], [3]
SP1599	517,659	6,942,273	S (small) lintel pit	1	27.90	26.51	[2], [3]
SP16370	511,671	6,942,150	S (small) lintel pit	1	15.33	12.83	[2], [3]
SP16372	511,680	6,942,258	S (small) lintel pit	1	13.39	12.39	[2], [3]
SP16373	511,680	6,942,269	S (small) lintel pit	1	13.00	12.00	[2], [3]
SP16374	511,681	6,942,276	S (small) lintel pit	1	13.31	12.31	[2], [3]
SP16561	503,358	6,939,905	S (small) lintel pit	1	35.38	34.18	[2], [3]
SP16563	503,369	6,939,938	S (small) lintel pit	1	35.41	34.01	[2], [3]
SP16564	503,365	6,939,937	S (small) lintel pit	1	35.30	33.90	[2], [3]
SP16565	503,353	6,939,929	S (small) lintel pit	1	35.35	34.55	[2], [3]
SP16567	503,379	6,939,942	S (small) lintel pit	1	35.89	34.69	[2], [3]
SP16934	502,537	6,937,761	S (small) lintel pit	1	46.93	45.93	[2], [3]
SP16943	502,611	6,937,766	S (small) lintel pit	1	44.59	42.89	[2], [3]
SP16944	502,609	6,937,776	S (small) lintel pit	1	44.53	43.83	[2], [3]
SP16947	502,664	6,937,799	S (small) lintel pit	1	43.73	42.73	[2], [3]
SP16948	502,768	6,937,825	S (small) lintel pit	1	42.32	41.32	[2], [3]
SP16949	502,751	6,937,822	S (small) lintel pit	1	42.71	41.71	[2], [3]
SP16950	502,757	6,937,824	S (small) lintel pit	1	42.61	41.41	[2], [3]
SP16951	502,762	6,937,838	S (small) lintel pit	1	42.47	41.47	[2], [3]
SP16952	502,769	6,937,841	S (small) lintel pit	1	42.38	41.18	[2], [3]
SP16953	502,851	6,937,873	S (small) lintel pit	1	40.91	40.21	[2], [3]
SP16955	502,864	6,937,867	S (small) lintel pit	1	40.81	39.81	[2], [3]
SP16956	502,862	6,937,866	S (small) lintel pit	1	40.83	40.03	[2], [3]
SP16958	502,919	6,937,901	S (small) lintel pit	1	40.05	39.05	[2], [3]
SP16959	502,923	6,937,892	S (small) lintel pit	1	40.04	38.94	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
SP16960	503,003	6,937,904	S (small) lintel pit	1	40.34	39.14	[2], [3]
SP16961	502,988	6,937,902	S (small) lintel pit	1	40.40	39.20	[2], [3]
SP17175	516,479	6,940,718	S (small) lintel pit	1	10.02	8.82	[2], [3]
SP17177	516,485	6,940,701	S (small) lintel pit	1	10.21	8.81	[2], [3]
SP17179	516,564	6,940,611	S (small) lintel pit	1	10.68	9.48	[2], [3]
SP17180	516,571	6,940,599	S (small) lintel pit	1	10.72	9.52	[2], [3]
SP17181	516,573	6,940,581	S (small) lintel pit	1	11.16	10.36	[2], [3]
SP17627	502,274	6,939,462	S (small) lintel pit	1	54.23	53.23	[2], [3]
SP17628	502,280	6,939,464	S (small) lintel pit	1	54.22	53.22	[2], [3]
SP17629	502,275	6,939,471	S (small) lintel pit	1	54.22	53.23	[2], [3]
SP17630	502,286	6,939,501	S (small) lintel pit	1	54.65	53.65	[2], [3]
SP17631	502,283	6,939,539	S (small) lintel pit	1	55.57	54.57	[2], [3]
SP17646	513,742	6,943,634	S (small) lintel pit	1	19.05	18.15	[2], [3]
SP17647	513,714	6,943,605	S (small) lintel pit	1	18.63	17.53	[2], [3]
SP17652	513,678	6,943,387	S (small) lintel pit	1	16.03	14.23	[2], [3]
SP17653	513,690	6,943,383	S (small) lintel pit	1	16.03	14.33	[2], [3]
SP17654	513,693	6,943,400	S (small) lintel pit	1	16.08	14.68	[2], [3]
SP17658	513,681	6,943,403	S (small) lintel pit	1	16.07	14.67	[2], [3]
SP17659	513,699	6,943,450	S (small) lintel pit	1	16.51	15.61	[2], [3]
SP17660	513,699	6,943,447	S (small) lintel pit	1	16.46	15.26	[2], [3]
SP17664	513,694	6,943,494	S (small) lintel pit	1	16.99	15.89	[2], [3]
SP17669	513,716	6,943,552	S (small) lintel pit	1	17.96	17.26	[2], [3]
SP17670	513,715	6,943,548	S (small) lintel pit	1	17.92	17.02	[2], [3]
SP17672	513,704	6,943,550	S (small) lintel pit	1	17.97	17.07	[2], [3]
SP17678	517,160	6,940,798	0.9 m x 0.6 m grated field inlet	1	18.32	16.32	[2], [3]
SP17679	517,219	6,940,815	0.9 m x 0.6 m grated field inlet	1	18.54	16.54	[2], [3]
SP17946	510,815	6,946,466	S (small) lintel pit	1	30.40	29.40	[2], [3]
SP17949	510,860	6,946,463	S (small) lintel pit	1	30.08	29.38	[2], [3]
SP18563	517,105	6,940,714	S (small) lintel pit	1	20.12	19.42	[2], [3]
SP18564	517,106	6,940,706	S (small) lintel pit	1	20.21	19.51	[2], [3]
SP18565	517,099	6,940,704	S (small) lintel pit	1	20.11	19.41	[2], [3]
SP19010	511,409	6,938,027	M (medium) lintel pit	1	13.71	10.21	[2], [3]
SP19541	512,744	6,938,916	S (small) lintel pit	1	12.31	10.02	[2], [3]
SP19546	512,756	6,938,834	S (small) lintel pit	1	13.46	11.68	[2], [3]
SP19547	512,742	6,938,831	S (small) lintel pit	1	13.56	11.95	[2], [3]
SP19554	512,732	6,938,758	S (small) lintel pit	1	14.84	12.80	[2], [3]
SP19560	512,747	6,938,747	M (medium) lintel pit	1	14.64	12.10	[2], [3]
SP19584	512,751	6,938,922	S (small) lintel pit	1	12.21	10.58	[2], [3]
SP19820	517,201	6,942,650	S (small) lintel pit	1	32.82	30.75	[2], [3]
SP20202	510,876	6,944,965	M (medium) lintel pit	1	24.14	22.50	[2], [3]
SP20204	511,156	6,944,919	S (small) lintel pit	1	27.69	26.42	[2], [3]
SP20685	517,422	6,942,002	M (medium) lintel pit	1	22.69	19.30	[2], [3]
SP21700	512,525	6,946,492	S (small) lintel pit	1	41.78	40.38	[2], [3]
SP21746	503,369	6,939,898	S (small) lintel pit	1	35.25	34.05	[2], [3]
SP2193	516,534	6,942,330	S (small) lintel pit	1	15.32	14.02	[2], [3]
SP2194	516,532	6,942,318	S (small) lintel pit	1	15.26	14.21	[2], [3]
SP2215	517,107	6,942,365	S (small) lintel pit	1	20.78	19.89	[2], [3]
SP2216	517,100	6,942,367	S (small) lintel pit	1	20.80	20.15	[2], [3]
SP2218	517,083	6,942,347	S (small) lintel pit	1	21.83	20.88	[2], [3]
SP2219	517,085	6,942,354	S (small) lintel pit	1	21.89	20.84	[2], [3]
SP2220	517,107	6,942,342	S (small) lintel pit	1	20.71	19.96	[2], [3]
SP22356	504,821	6,939,956	S (small) lintel pit	1	26.85	25.08	[2], [3]
SP22357	504,882	6,939,946	S (small) lintel pit	1	26.51	24.73	[2], [3]
SP22358	504,886	6,939,957	S (small) lintel pit	1	26.43	24.91	[2], [3]
SP22359	504,920	6,939,939	S (small) lintel pit	1	26.27	24.83	[2], [3]
SP22360	504,920	6,939,951	S (small) lintel pit	1	26.23	24.75	[2], [3]
SP22361	504,959	6,939,930	S (small) lintel pit	1	25.85	24.60	[2], [3]
SP22825	503,955	6,937,388	S (small) lintel pit	1	40.69	39.02	[2], [3]
SP2297	516,544	6,942,423	S (small) lintel pit	1	16.14	14.79	[2], [3]
SP2298	516,536	6,942,440	S (small) lintel pit	1	15.95	14.55	[2], [3]
SP2299	516,543	6,942,438	S (small) lintel pit	1	15.91	14.51	[2], [3]
SP2301	516,582	6,942,434	S (small) lintel pit	1	16.50	15.20	[2], [3]
SP2302	516,581	6,942,442	S (small) lintel pit	1	16.57	15.83	[2], [3]
SP2304	516,642	6,942,482	S (small) lintel pit	1	17.39	16.14	[2], [3]
SP2305	516,645	6,942,475	S (small) lintel pit	1	17.30	16.15	[2], [3]
SP2307	516,720	6,942,533	S (small) lintel pit	1	19.08	17.58	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote a)
SP2308	516,721	6,942,525	S (small) lintel pit	1	18.98	17.63	[2], [3]
SP23161	512,350	6,945,331	S (small) lintel pit	1	20.50	20.50	[2], [3]
SP23162	512,327	6,945,334	S (small) lintel pit	1	20.35	19.18	[2], [3]
SP23167	512,541	6,945,316	S (small) lintel pit	1	23.42	23.42	[2], [3]
SP23170	512,562	6,945,320	0.9 m x 0.6 m grated field inlet	1	23.51	22.51	[2], [3]
SP23589	510,859	6,944,967	S (small) lintel pit	1	24.24	22.70	[2], [3]
SP2367	516,957	6,942,214	S (small) lintel pit	1	16.40	15.77	[2], [3]
SP2370	516,960	6,942,268	S (small) lintel pit	1	17.21	16.50	[2], [3]
SP2394	517,446	6,942,015	S (small) lintel pit	1	23.07	22.36	[2], [3]
SP2395	517,449	6,941,991	S (small) lintel pit	1	22.67	21.91	[2], [3]
SP2397	517,437	6,941,990	S (small) lintel pit	1	22.80	21.87	[2], [3]
SP24107	510,685	6,946,450	S (small) lintel pit	1	32.19	29.14	[2], [3]
SP24109	510,714	6,946,479	S (small) lintel pit	1	30.97	28.65	[2], [3]
SP24110	510,700	6,946,475	S (small) lintel pit	1	31.04	29.45	[2], [3]
SP24111	510,687	6,946,479	0.9 m x 0.6 m grated field inlet	1	32.73	29.93	[2], [3]
SP24265	511,126	6,946,999	0.9 m x 0.6 m grated field inlet	1	31.23	30.23	[2], [3]
SP24266	511,163	6,947,053	0.9 m x 0.6 m grated field inlet	1	33.84	32.14	[2], [3]
SP24267	511,189	6,947,071	0.9 m x 0.6 m grated field inlet	1	34.43	33.25	[2], [3]
SP24268	511,109	6,946,976	0.9 m x 0.6 m grated field inlet	1	30.50	27.96	[2], [3]
SP24276	505,081	6,940,202	S (small) lintel pit	1	29.46	28.00	[2], [3]
SP24277	505,081	6,940,189	S (small) lintel pit	1	29.79	27.62	[2], [3]
SP24278	505,092	6,940,180	S (small) lintel pit	1	29.81	28.10	[2], [3]
SP24656	510,573	6,938,634	S (small) lintel pit	1	11.31	10.46	[2], [3]
SP24954	511,331	6,938,235	S (small) lintel pit	1	10.62	9.68	[2], [3]
SP24958	511,254	6,938,345	S (small) lintel pit	1	8.27	7.47	[2], [3]
SP3100	514,040	6,943,176	S (small) lintel pit	1	16.21	15.21	[2], [3]
SP3101	514,029	6,943,179	S (small) lintel pit	1	16.19	15.19	[2], [3]
SP3288	513,680	6,944,613	S (small) lintel pit	1	36.79	36.08	[2], [3]
SP3289	513,677	6,944,610	S (small) lintel pit	1	36.67	35.82	[2], [3]
SP3290	513,675	6,944,619	S (small) lintel pit	1	36.82	35.91	[2], [3]
SP3292	513,677	6,944,591	S (small) lintel pit	1	37.46	36.21	[2], [3]
SP3293	513,701	6,944,556	S (small) lintel pit	1	40.18	39.20	[2], [3]
SP3322	513,611	6,944,655	S (small) lintel pit	1	34.51	33.58	[2], [3]
SP3323	513,615	6,944,653	S (small) lintel pit	1	34.55	33.71	[2], [3]
SP3324	513,617	6,944,660	S (small) lintel pit	1	34.51	33.26	[2], [3]
SP3325	513,549	6,944,695	S (small) lintel pit	1	33.13	32.07	[2], [3]
SP3326	513,547	6,944,689	S (small) lintel pit	1	33.27	32.33	[2], [3]
SP3327	513,498	6,944,707	S (small) lintel pit	1	32.32	31.46	[2], [3]
SP3328	513,499	6,944,699	S (small) lintel pit	1	32.36	31.75	[2], [3]
SP3329	513,487	6,944,689	S (small) lintel pit	1	33.16	32.52	[2], [3]
SP37395	504,602	6,940,007	S (small) lintel pit	1	28.21	26.79	[2], [3]
SP37410	504,577	6,940,010	S (small) lintel pit	1	28.38	26.89	[2], [3]
SP37415	504,602	6,939,981	S (small) lintel pit	1	28.16	26.27	[2], [3]
SP37417	504,624	6,940,063	S (small) lintel pit	1	27.34	26.13	[2], [3]
SP37629	510,958	6,942,074	S (small) lintel pit	1	21.98	20.70	[2], [3]
SP37631	510,972	6,942,082	S (small) lintel pit	1	21.48	19.38	[2], [3]
SP37632	510,980	6,942,090	S (small) lintel pit	1	21.44	20.20	[2], [3]
SP37634	510,946	6,942,066	M (medium) lintel pit	1	22.22	18.56	[2], [3]
SP37635	510,881	6,942,076	M (medium) lintel pit	1	23.58	20.75	[2], [3]
SP37636	510,880	6,942,100	S (small) lintel pit	1	23.99	22.73	[2], [3]
SP37637	510,873	6,942,099	M (medium) lintel pit	1	23.97	21.73	[2], [3]
SP37639	510,861	6,942,089	S (small) lintel pit	1	24.04	22.63	[2], [3]
SP37640	510,869	6,942,090	S (small) lintel pit	1	23.89	22.20	[2], [3]
SP37884	501,545	6,937,083	S (small) lintel pit	1	53.49	52.29	[2], [3]
SP37885	501,558	6,937,092	S (small) lintel pit	1	53.35	52.45	[2], [3]
SP37886	501,701	6,937,043	S (small) lintel pit	1	50.41	49.56	[2], [3]
SP37887	501,624	6,937,057	S (small) lintel pit	1	51.85	50.75	[2], [3]
SP37999	512,512	6,946,397	S (small) lintel pit	1	39.63	38.23	[2], [3]
SP38024	512,499	6,946,324	S (small) lintel pit	1	38.27	38.27	[2], [3]
SP38033	512,491	6,946,326	S (small) lintel pit	1	38.22	38.22	[2], [3]
SP38044	516,774	6,942,611	S (small) lintel pit	1	21.81	21.06	[2], [3]
SP38071	512,511	6,946,404	S (small) lintel pit	1	39.74	39.74	[2], [3]
SP39061	511,050	6,942,045	S (small) lintel pit	1	20.68	0.60	[2], [3]
SP39218	502,734	6,939,506	S (small) lintel pit	1	44.74	43.04	[2], [3]
SP39219	502,737	6,939,495	S (small) lintel pit	1	44.52	43.00	[2], [3]
SP39220	502,764	6,939,518	S (small) lintel pit	1	43.25	41.55	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
SP39223	502,474	6,939,551	S (small) lintel pit	1	54.05	52.26	[2], [3]
SP39224	502,474	6,939,551	S (small) lintel pit	1	54.04	52.26	[2], [3]
SP39238	502,775	6,939,539	S (small) lintel pit	1	43.10	41.69	[2], [3]
SP39239	502,779	6,939,548	S (small) lintel pit	1	43.06	41.48	[2], [3]
SP39240	502,784	6,939,558	S (small) lintel pit	1	43.06	40.75	[2], [3]
SP39242	502,795	6,939,556	S (small) lintel pit	1	42.92	39.75	[2], [3]
SP39243	502,773	6,939,515	S (small) lintel pit	1	43.14	41.59	[2], [3]
SP39341	502,376	6,939,568	S (small) lintel pit	1	55.25	53.86	[2], [3]
SP39344	502,285	6,939,550	S (small) lintel pit	1	56.00	54.73	[2], [3]
SP39364	502,472	6,939,541	S (small) lintel pit	1	54.00	53.19	[2], [3]
SP39365	502,564	6,939,536	S (small) lintel pit	1	53.02	51.90	[2], [3]
SP39366	502,643	6,939,522	S (small) lintel pit	1	50.65	49.19	[2], [3]
SP39367	502,650	6,939,510	S (small) lintel pit	1	50.24	48.90	[2], [3]
SP40796	516,966	6,942,250	S (small) lintel pit	1	17.56	16.67	[2], [3]
SP40797	516,970	6,942,262	S (small) lintel pit	1	17.69	16.66	[2], [3]
SP41134	517,100	6,940,887	S (small) lintel pit	1	19.72	17.70	[2], [3]
SP41135	517,097	6,940,880	S (small) lintel pit	1	19.91	17.95	[2], [3]
SP4172	517,334	6,940,869	S (small) lintel pit	1	21.55	20.68	[2], [3]
SP4173	517,335	6,940,875	S (small) lintel pit	1	21.43	20.35	[2], [3]
SP4174	517,345	6,940,882	S (small) lintel pit	1	21.25	20.28	[2], [3]
SP4175	517,342	6,940,882	S (small) lintel pit	1	21.23	20.03	[2], [3]
SP4176	517,340	6,940,909	S (small) lintel pit	1	21.89	20.61	[2], [3]
SP4177	517,339	6,940,903	S (small) lintel pit	1	21.57	20.24	[2], [3]
SP4178	517,330	6,940,893	S (small) lintel pit	1	21.30	19.59	[2], [3]
SP4179	517,347	6,940,892	S (small) lintel pit	1	21.21	20.21	[2], [3]
SP4180	517,342	6,940,893	S (small) lintel pit	1	21.11	19.96	[2], [3]
SP4188	517,426	6,940,888	S (small) lintel pit	1	24.67	23.62	[2], [3]
SP4189	517,431	6,940,916	S (small) lintel pit	1	23.70	22.65	[2], [3]
SP4191	517,440	6,940,912	S (small) lintel pit	1	23.52	22.52	[2], [3]
SP4192	517,438	6,940,909	S (small) lintel pit	1	23.60	22.65	[2], [3]
SP41951	517,096	6,940,902	M (medium) lintel pit	1	19.81	17.10	[2], [3]
SP41956	517,086	6,940,899	M (medium) lintel pit	1	19.85	17.25	[2], [3]
SP42408	502,594	6,937,760	S (small) lintel pit	1	45.00	43.50	[2], [3]
SP42794	511,421	6,942,204	S (small) lintel pit	1	16.60	15.73	[2], [3]
SP42795	511,409	6,942,192	S (small) lintel pit	1	16.88	15.83	[2], [3]
SP42797	511,387	6,942,216	S (small) lintel pit	1	16.67	15.54	[2], [3]
SP43188	501,726	6,937,046	M (medium) lintel pit	1	50.40	48.71	[2], [3]
SP43208	511,193	6,938,260	S (small) lintel pit	1	9.11	7.85	[2], [3]
SP43211	511,184	6,938,255	S (small) lintel pit	1	9.19	7.81	[2], [3]
SP4499	511,243	6,947,132	S (small) lintel pit	1	37.35	35.80	[2], [3]
SP4502	511,264	6,947,107	S (small) lintel pit	2	36.90	35.87	[2], [3]
SP4504	511,217	6,947,116	S (small) lintel pit	1	36.11	34.73	[2], [3]
SP4505	511,215	6,947,117	S (small) lintel pit	1	36.11	34.60	[2], [3]
SP4506	511,218	6,947,124	S (small) lintel pit	1	36.16	34.78	[2], [3]
SP4507	511,215	6,947,124	S (small) lintel pit	1	36.16	34.71	[2], [3]
SP4520	511,037	6,946,888	S (small) lintel pit	1	29.15	28.15	[2], [3]
SP4748	512,122	6,944,862	S (small) lintel pit	1	16.73	15.86	[2], [3]
SP4750	512,114	6,944,840	S (small) lintel pit	2	16.49	15.09	[2], [3]
SP4753	512,118	6,944,829	S (small) lintel pit	2	16.51	15.26	[2], [3]
SP4754	512,065	6,944,823	S (small) lintel pit	1	16.76	15.65	[2], [3]
SP4755	512,026	6,944,819	S (small) lintel pit	1	17.61	16.70	[2], [3]
SP4756	512,030	6,944,791	S (small) lintel pit	1	17.19	15.65	[2], [3]
SP4758	512,045	6,944,762	S (small) lintel pit	1	17.28	16.30	[2], [3]
SP4850	511,831	6,943,849	S (small) lintel pit	1	16.34	14.50	[2], [3]
SP4851	511,838	6,943,844	S (small) lintel pit	1	16.21	14.36	[2], [3]
SP4852	511,841	6,943,815	S (small) lintel pit	1	15.99	13.81	[2], [3]
SP56569	513,761	6,943,906	0.9 m x 0.6 m grated field inlet	1	26.41	25.55	[2], [3]
SP56813	510,796	6,938,658	1.7 m x 0.6 m grated field inlet	1	9.00	7.90	[2], [3]
SP56814	510,814	6,938,672	1.7 m x 0.6 m grated field inlet	1	8.78	7.60	[2], [3]
SP56815	510,845	6,938,693	1.7 m x 0.6 m grated field inlet	1	8.46	7.30	[2], [3]
SP56816	510,885	6,938,720	1.7 m x 0.6 m grated field inlet	1	8.13	6.78	[2], [3]
SP56817	510,919	6,938,744	1.7 m x 0.6 m grated field inlet	1	7.66	6.37	[2], [3]
SP56818	510,964	6,938,773	1.7 m x 0.6 m grated field inlet	1	7.29	5.90	[2], [3]
SP57690	511,038	6,946,897	S (small) lintel pit	1	29.16	28.26	[2], [3]
SP57945	517,637	6,942,240	S (small) lintel pit	1	27.51	26.50	[2], [3]
SP57946	517,721	6,942,291	S (small) lintel pit	1	29.63	27.63	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote a)
SP57947	517,649	6,942,263	S (small) lintel pit	1	27.75	25.12	[2], [3]
SP57950	517,632	6,942,246	S (small) lintel pit	1	27.62	25.52	[2], [3]
SP59397	510,756	6,938,761	S (small) lintel pit	1	10.04	9.27	[2], [3]
SP59907	510,753	6,938,616	0.9 m x 0.6 m grated field inlet	1	11.23	10.25	[2], [3]
SP59908	510,764	6,938,623	0.9 m x 0.6 m grated field inlet	1	11.14	10.03	[2], [3]
SP60163	516,769	6,942,689	0.9 m x 0.6 m grated field inlet	1	21.88	20.80	[2], [3]
SP60164	516,784	6,942,663	0.9 m x 0.6 m grated field inlet	1	21.24	19.90	[2], [3]
SP60590	511,089	6,942,420	S (small) lintel pit	1	19.25	18.54	[2], [3]
SP60591	511,135	6,942,413	S (small) lintel pit	1	19.00	18.05	[2], [3]
SP60592	511,185	6,942,409	S (small) lintel pit	1	18.77	17.70	[2], [3]
SP60593	511,232	6,942,407	S (small) lintel pit	1	18.46	16.89	[2], [3]
SP60594	511,225	6,942,363	S (small) lintel pit	1	18.45	16.85	[2], [3]
SP60595	511,131	6,942,354	S (small) lintel pit	1	18.60	17.31	[2], [3]
SP60596	511,126	6,942,355	S (small) lintel pit	1	18.60	17.21	[2], [3]
SP60598	511,332	6,942,392	S (small) lintel pit	1	17.53	16.37	[2], [3]
SP60599	511,318	6,942,331	S (small) lintel pit	1	17.13	15.90	[2], [3]
SP60600	511,364	6,942,368	S (small) lintel pit	1	16.99	15.70	[2], [3]
SP60601	511,249	6,942,405	S (small) lintel pit	1	18.31	17.01	[2], [3]
SP9059	507,402	6,938,475	S (small) lintel pit	1	21.87	20.92	[2], [3]
SP9060	507,388	6,938,469	S (small) lintel pit	1	21.84	20.99	[2], [3]
SP9061	507,373	6,938,478	S (small) lintel pit	1	21.85	20.65	[2], [3]
SP9069	507,478	6,937,842	M (medium) lintel pit	1	28.02	25.52	[2], [3]
SP9070	507,493	6,937,929	M (medium) lintel pit	1	27.03	24.73	[2], [3]
SP9071	507,498	6,937,966	M (medium) lintel pit	1	26.62	24.22	[2], [3]
SP9072	507,498	6,937,989	M (medium) lintel pit	1	26.40	24.10	[2], [3]
SP9073	507,489	6,938,071	M (medium) lintel pit	1	25.53	23.13	[2], [3]
SP9074	507,481	6,938,145	M (medium) lintel pit	1	24.76	22.36	[2], [3]
SP9086	507,494	6,937,851	M (medium) lintel pit	1	27.74	25.74	[2], [3]
SP9095	507,509	6,937,943	M (medium) lintel pit	1	26.81	24.36	[2], [3]
SP9096	507,511	6,937,998	M (medium) lintel pit	1	26.22	23.57	[2], [3]
SP9097	507,504	6,938,056	M (medium) lintel pit	1	25.65	22.95	[2], [3]
SP9098	507,498	6,938,115	M (medium) lintel pit	1	25.06	22.56	[2], [3]
SP9099	507,489	6,938,187	M (medium) lintel pit	1	24.37	22.17	[2], [3]
SP9100	507,479	6,938,257	S (small) lintel pit	1	23.67	22.17	[2], [3]
SP9102	507,457	6,938,326	S (small) lintel pit	1	22.95	21.35	[2], [3]
SP9103	507,447	6,938,353	S (small) lintel pit	1	22.64	21.39	[2], [3]
SP9104	507,421	6,938,426	S (small) lintel pit	1	22.15	21.30	[2], [3]
SP9106	507,378	6,938,501	S (small) lintel pit	1	21.27	20.37	[2], [3]
SP9107	507,407	6,938,420	S (small) lintel pit	1	22.17	21.32	[2], [3]
SP9108	507,441	6,938,333	S (small) lintel pit	1	22.83	21.43	[2], [3]
SP9109	507,464	6,938,267	S (small) lintel pit	1	23.59	21.89	[2], [3]
SP9193	510,670	6,938,700	S (small) lintel pit	1	10.47	9.17	[2], [3]
SP9203	510,655	6,938,683	S (small) lintel pit	1	10.80	10.10	[2], [3]
SP9206	510,723	6,938,717	S (small) lintel pit	1	10.09	9.34	[2], [3]
SP9211	510,849	6,938,814	S (small) lintel pit	1	9.13	8.23	[2], [3]
SP9212	510,851	6,938,800	S (small) lintel pit	1	9.02	7.97	[2], [3]
SP9213	510,838	6,938,791	S (small) lintel pit	1	8.94	8.04	[2], [3]
SP9215	510,930	6,938,869	S (small) lintel pit	1	9.49	7.89	[2], [3]
SP9216	510,958	6,938,907	S (small) lintel pit	1	9.92	8.92	[2], [3]
SP9217	510,968	6,938,911	S (small) lintel pit	1	9.85	8.85	[2], [3]
SP9530	509,720	6,938,695	S (small) lintel pit	1	14.77	13.97	[2], [3]
SP9531	509,714	6,938,699	S (small) lintel pit	1	14.82	13.42	[2], [3]
SW_Bridge1	512,002	6,945,982	S (small) lintel pit_L (large)	1	25.30	24.49	[8]
SW_Bridge2	512,001	6,945,961	S (small) lintel pit_L (large)	1	25.43	24.68	[8]
SW_US1	512,093	6,945,951	L (large) lintel pit	1	26.00	24.00	[8]
SW_US2	512,014	6,946,040	S (small) lintel pit_L (large)	1	26.99	26.00	[8]
V17000299	505,377	6,944,889	0.9 m x 0.6 m grated field inlet	1	51.15	48.35	[2], [3]
V17122439	505,340	6,945,248	S (small) lintel pit	1	62.26	61.06	[2], [3]
V17122440	505,299	6,945,256	S (small) lintel pit	1	62.77	61.57	[2], [3]
V17122452	505,305	6,945,265	S (small) lintel pit	1	62.65	61.45	[2], [3]
V17122453	505,322	6,945,259	S (small) lintel pit	1	62.10	60.90	[2], [3]
V17122454	505,343	6,945,260	S (small) lintel pit	1	62.26	61.06	[2], [3]
V17122461	505,595	6,945,218	S (small) lintel pit	2	63.73	62.53	[2], [3]
V17122462	505,626	6,945,213	S (small) lintel pit	1	63.79	62.59	[2], [3]
V17122526	505,618	6,945,004	S (small) lintel pit	1	56.10	54.90	[2], [3]
V17122528	505,596	6,944,982	S (small) lintel pit	2	55.15	53.95	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
V17122530	505,579	6,944,954	S (small) lintel pit	2	54.23	53.03	[2], [3]
V17122531	505,584	6,944,940	S (small) lintel pit	2	53.70	52.50	[2], [3]
V17122533	505,587	6,944,931	S (small) lintel pit	1	53.97	52.77	[2], [3]
V17122535	505,564	6,944,885	S (small) lintel pit	2	52.58	51.38	[2], [3]
V17122537	505,526	6,944,835	S (small) lintel pit	2	51.24	50.04	[2], [3]
V17122538	505,462	6,944,815	S (small) lintel pit	1	49.88	48.68	[2], [3]
V17122539	505,401	6,944,827	S (small) lintel pit	1	49.82	48.62	[2], [3]
V17122540	505,369	6,944,835	S (small) lintel pit	1	50.19	48.99	[2], [3]
V17122548	505,271	6,945,039	S (small) lintel pit	2	57.03	55.83	[2], [3]
V17122550	505,279	6,945,068	S (small) lintel pit	1	57.04	55.84	[2], [3]
V17122551	505,281	6,945,078	S (small) lintel pit	1	57.10	55.90	[2], [3]
V17122552	505,289	6,945,118	S (small) lintel pit	1	57.54	56.34	[2], [3]
V17122553	505,295	6,945,131	S (small) lintel pit	1	57.82	56.62	[2], [3]
V17122554	505,298	6,945,160	S (small) lintel pit	1	58.66	57.46	[2], [3]
V17122557	505,310	6,945,157	S (small) lintel pit	1	58.92	57.72	[2], [3]
V17122558	505,305	6,945,129	S (small) lintel pit	1	58.03	56.83	[2], [3]
V17122559	505,290	6,945,067	S (small) lintel pit	1	57.16	55.96	[2], [3]
V17122561	505,312	6,945,022	S (small) lintel pit	2	55.47	54.27	[2], [3]
V17122563	505,335	6,945,017	S (small) lintel pit	2	54.67	53.47	[2], [3]
V17122565	505,361	6,945,009	S (small) lintel pit	2	54.16	52.96	[2], [3]
V17122566	505,365	6,944,987	S (small) lintel pit	2	54.03	52.83	[2], [3]
V17122569	505,343	6,945,007	S (small) lintel pit	2	54.57	53.37	[2], [3]
V17122571	505,371	6,944,846	S (small) lintel pit	1	50.04	48.84	[2], [3]
V17122572	505,401	6,944,839	S (small) lintel pit	2	49.64	48.44	[2], [3]
V17122574	505,484	6,944,829	S (small) lintel pit	2	50.27	49.07	[2], [3]
V17122576	505,519	6,944,844	S (small) lintel pit	2	50.99	49.79	[2], [3]
V17122578	505,567	6,944,952	S (small) lintel pit	2	53.99	52.79	[2], [3]
V17122580	505,600	6,945,018	S (small) lintel pit	1	56.05	54.85	[2], [3]
V17122581	505,598	6,945,021	S (small) lintel pit	1	56.13	54.93	[2], [3]
V17122582	505,586	6,945,078	S (small) lintel pit	2	58.58	57.38	[2], [3]
V17122584	505,593	6,945,117	S (small) lintel pit	1	59.89	58.69	[2], [3]
V17122585	505,618	6,945,133	S (small) lintel pit	1	60.69	59.49	[2], [3]
V17122586	505,612	6,945,020	S (small) lintel pit	1	55.99	54.79	[2], [3]
V17122587	505,622	6,945,020	S (small) lintel pit	2	56.14	54.94	[2], [3]
V17122636	505,383	6,944,849	S (small) lintel pit	1	49.83	48.63	[2], [3]
V17122637	505,387	6,944,861	S (small) lintel pit	1	50.01	48.81	[2], [3]
V17122641	505,322	6,945,094	S (small) lintel pit	1	57.14	55.94	[2], [3]
V17122642	505,324	6,945,102	S (small) lintel pit	1	57.03	55.83	[2], [3]
V17122666	505,267	6,945,111	S (small) lintel pit	1	58.22	57.02	[2], [3]
V17122667	505,266	6,945,103	S (small) lintel pit	1	58.34	57.14	[2], [3]
V17123740	505,370	6,944,950	0.9 m x 0.6 m grated field inlet	1	53.04	51.84	[2], [3]
V17123770	505,378	6,944,888	0.9 m x 0.6 m grated field inlet	1	51.18	49.98	[2], [3]
V17190462	505,613	6,945,205	S (small) lintel pit	1	63.72	62.52	[2], [3]
Van_US	512,564	6,945,367	L (large) lintel pit	1	25.31	21.00	[8]
W17048780	506,147	6,943,848	0.9 m x 0.6 m grated field inlet	1	46.12	41.97	[2], [3]
W17141068	506,061	6,943,622	M (medium) lintel pit	2	39.65	38.21	[2], [3]
W17141069	506,020	6,943,594	M (medium) lintel pit	1	39.14	37.92	[2], [3]
W17141070	506,016	6,943,600	M (medium) lintel pit	1	39.16	37.92	[2], [3]
W17141071	505,926	6,943,550	M (medium) lintel pit	1	35.96	34.71	[2], [3]
W17141072	505,923	6,943,557	M (medium) lintel pit	1	35.91	34.71	[2], [3]
W17141073	505,899	6,943,554	M (medium) lintel pit	1	35.99	34.53	[2], [3]
W17141509	506,078	6,943,665	L (large) lintel pit	1	40.43	39.23	[2], [3]
W17141510	506,071	6,943,669	L (large) lintel pit	1	40.53	39.33	[2], [3]
W17141511	506,116	6,943,695	L (large) lintel pit	1	42.90	41.70	[2], [3]
W17145230	506,130	6,943,781	M (medium) lintel pit	1	45.02	43.82	[2], [3]
W17145232	506,131	6,943,792	M (medium) lintel pit	1	45.00	43.80	[2], [3]
W17145233	506,091	6,943,807	M (medium) lintel pit	1	43.84	42.64	[2], [3]
W17145234	506,097	6,943,813	M (medium) lintel pit	1	43.90	42.70	[2], [3]
W17154940	506,133	6,944,091	M (medium) lintel pit	1	49.08	47.88	[2], [3]
W17154941	506,134	6,944,082	M (medium) lintel pit	1	49.04	47.84	[2], [3]
W17154942	506,112	6,944,110	M (medium) lintel pit	1	48.89	47.69	[2], [3]
W17154943	506,118	6,944,108	M (medium) lintel pit	1	48.80	47.60	[2], [3]
W17154944	506,117	6,944,061	M (medium) lintel pit	1	48.61	47.41	[2], [3]
W17154945	506,125	6,944,063	M (medium) lintel pit	1	48.51	47.31	[2], [3]
W17154946	506,130	6,944,036	M (medium) lintel pit	1	48.81	47.61	[2], [3]
W17155337	506,167	6,944,008	M (medium) lintel pit	1	48.91	47.71	[2], [3]

Pit ID	Easting	Northing	Pit type	No. of pits	Surface level (mAHD)	Invert level (mAHD)	Source (see footnote [a])
W17155338	506,169	6,944,003	M (medium) lintel pit	1	48.89	47.69	[2], [3]
W17155339	506,153	6,943,899	M (medium) lintel pit	1	47.12	45.92	[2], [3]
W17155340	506,159	6,943,896	M (medium) lintel pit	1	47.05	45.85	[2], [3]
W17159901	506,177	6,943,853	M (medium) lintel pit	1	46.67	45.47	[2], [3]
W17159902	506,163	6,943,871	M (medium) lintel pit	1	46.10	44.90	[2], [3]
W17159903	506,150	6,943,875	M (medium) lintel pit	1	46.31	45.11	[2], [3]
W17180025	506,199	6,944,204	M (medium) lintel pit	1	54.80	53.43	[2], [3]
W17180027	506,206	6,944,266	M (medium) lintel pit	1	56.44	55.61	[2], [3]
W17180028	506,156	6,944,180	M (medium) lintel pit	1	51.88	51.32	[2], [3]
W17180029	506,144	6,944,160	M (medium) lintel pit	1	53.21	50.20	[2], [3]
W17180030	506,154	6,944,165	M (medium) lintel pit	1	51.48	50.58	[2], [3]
W17180031	506,121	6,944,132	M (medium) lintel pit	1	49.78	48.27	[2], [3]
W17180052	506,192	6,944,199	M (medium) lintel pit	1	54.75	53.10	[2], [3]
Y16156871	503,299	6,940,768	S (small) lintel pit	1	52.72	51.52	[2], [3]
Y16156872	503,311	6,940,737	S (small) lintel pit	1	51.69	50.49	[2], [3]
Y16156878	503,306	6,940,991	S (small) lintel pit	1	62.02	60.82	[2], [3]
Y16156879	503,315	6,940,865	S (small) lintel pit	1	56.81	55.61	[2], [3]
Y16156880	503,301	6,940,867	S (small) lintel pit	1	57.04	55.84	[2], [3]
Y16156881	503,351	6,940,983	S (small) lintel pit	1	61.89	60.69	[2], [3]
Y16167898	503,277	6,940,722	S (small) lintel pit	1	51.52	50.30	[2], [3]
Barr_DS	512,409	6,944,471	L (large) lintel pit	1	12.29	8.61	[8]
Bunnings1	511,142	6,944,934	0.9x0.9	1	27.16	25.50	[13]
Bunnings2	511,150	6,944,929	0.9x0.9	1	27.16	25.50	[13]

[a] –Stormwater pit details were obtained from one or more of the following sources:

[1] – LCC hydraulic structures survey (2017)

[2] – LCC GIS hydraulic structures database

[3] – LCC (2017) and BCC (2017) LiDAR data

[4] – Fern Street and Johnson Road Local Flood Study (Engeny, 2013)

[5] – Wembley Road Interchange (Berrinba) Flood Study (WRM, 2014b)

[6] – Logan- Albert Rivers Flood Study Peer Review (WRM, 2014a)

[7] – Slacks and Scrubby Creeks Flood Study Peer Review (WRM, 2015)

[8] – M1 Motorway Upgrade Hydraulic Study (WRM, 2017)

[9] – WRM site visit (2017)

[10] – Other information (e.g. photos, sketches) supplied by LCC

[11] – Aerial photo + street view

[12] – PD online

[13] – As-constructed drawings

[b] – These stormwater pits were included for design event modelling, but were excluded for the calibration events.

Table C.4 – Configuration of manually created stormwater manholes in the TUFLOW model

Manhole ID	Easting	Northing	Pit type	Flow width / diameter (m)	Flow length (m)	Invert level (mAHD)	Source (see footnote [a])
IKEA	513,441	6,942,887	Rectangular	27.50	1.80	4.60	[8]
MH_94	517,414	6,942,005	Circular	2.10	-	18.63	[2]
MH_Alba01	517,438	6,940,915	Circular	2.10	-	21.15	[2]
MH_Alf01	515,840	6,941,274	Rectangular	2.55	2.10	8.10	[8]
MH_Alf02	515,819	6,941,213	Circular	1.05	-	6.39	[8]
MH_B1	501,405	6,937,104	Circular	2.30	-	53.40	[2]
MH_Beenleigh	510,563	6,946,414	Circular	7.30	-	29.80	[2]
MH_Bunnings1 [b]	511,150	6,944,927	Rectangular	15.0	6.70	25.50	[13]
MH_Bunnings2 [b]	511,188	6,944,954	Rectangular	15.0	7.05	23.95	[13]
MH_Bunnings3 [b]	511,204	6,945,045	Rectangular	15.0	2.30	23.53	[13]
MH_C1	503,946	6,937,385	Circular	2.30	-	39.94	[2]
MH_D1	502,758	6,938,147	Circular	2.70	-	42.71	[2]
MH_F7	516,572	6,940,598	Rectangular	3.80	0.90	9.41	[2]
MH_F8	516,485	6,940,716	Rectangular	3.20	0.90	9.41	[2]
MH_G1	503,328	6,940,978	Circular	1.80	-	56.49	[2]
MH_H1	505,318	6,945,249	Circular	1.50	-	58.81	[2]
MH_H2	505,610	6,945,207	Circular	1.50	-	60.98	[2]
MH_J1	507,496	6,937,867	Circular	2.10	-	24.72	[2]
MH_J2	507,480	6,937,841	Circular	2.10	-	25.60	[2]
MH_K1	509,765	6,938,627	Circular	2.10	-	14.17	[2]
MH_K2	509,721	6,938,644	Circular	2.10	-	12.80	[2]
MH_L1	510,581	6,938,628	Circular	3.00	-	8.90	[2]
MH_M1	511,263	6,938,331	Circular	2.80	-	7.40	[2]
MH_M2	511,315	6,938,366	Circular	3.54	-	5.78	[2]
MH_Mandew01	517,066	6,940,773	Circular	4.90	-	14.96	[2]
MH_O1	512,743	6,938,755	Circular	1.88	-	11.10	[2]
MH_R1	512,518	6,946,479	Circular	2.10	-	39.86	[2]
MH_ServRd	515,848	6,941,281	Rectangular	1.50	0.90	-	[8]
MH_Sher01	515,863	6,941,296	Circular	2.70	-	9.77	[8]
MH_Sher02	515,862	6,941,297	Circular	1.05	-	9.77	[8]
MH_V1	511,279	6,942,386	Circular	2.80	-	15.23	[2]
MH_V2	511,302	6,942,382	Circular	2.80	-	14.64	[2]
MH_W1	513,760	6,943,900	Circular	1.50	-	24.01	[2]
MH_Y1	514,287	6,943,264	Circular	1.50	-	19.60	[2]
RD_Mh1	512,025	6,945,987	Circular	1.05	-	25.00	[8]
Shrtlnd_DS	512,743	6,944,097	Rectangular	6.50	5.00	12.18	[8]
SW_BridgeMH	511,991	6,945,970	Circular	1.05	-	24.05	[8]

[a] -Stormwater manhole details were obtained from one or more of the following sources:

[1] – LCC hydraulic structures survey (2017)

[2] – LCC GIS hydraulic structures database

[3] – LCC (2017) and BCC (2017) LiDAR data

[4] – Fern Street and Johnson Road Local Flood Study (Engeny, 2013)

[5] – Wembley Road Interchange (Berrinba) Flood Study (WRM, 2014b)

[6] – Logan- Albert Rivers Flood Study Peer Review (WRM, 2014a)

[7] – Slacks and Scrubby Creeks Flood Study Peer Review (WRM, 2015)

[8] – M1 Motorway Upgrade Hydraulic Study (WRM, 2017)

[9] – WRM site visit (2017)

[10] – Other information (e.g. photos, sketches) supplied by LCC

[11] – Aerial photo + street view

[12] – PD online

[13] – As-constructed drawings

[b] - These stormwater manholes were included for design event modelling, but were excluded for the calibration events.

C5 2D hydraulic structures (bridges and large box culverts)

Table C.5 – Configuration of 2D hydraulic structures (bridges and large box culverts) in the TUFLOW model

Structure ID	Easting	Northing	Watercourse	Road	Length (m)	Width (m)	Road deck level (mAHD)	Deck thickness (m)	Guard rail height (m)	Pier configuration	Comments	Source (see footnote [a])
HS 1	512,289	6,940,469	Scrubby Creek	Railway	113.0	6.0	10.33	1.66	n/a	Unknown [b]	Parallel with bridge #2	[7]
HS 2	512,285	6,940,458	Scrubby Creek	Railway	112.4	6.0	10.33	1.66	n/a	Unknown [b]	Parallel with bridge #1	[7]
HS 3	511,816	6,939,489	Scrubby Creek	Logan Motorway	109.9	11.3	16.07 - 18.40	1.33	0.74	Unknown [b]	Parallel with bridge #4	[7]
HS 4	511,813	6,939,509	Scrubby Creek	Logan Motorway	108.4	11.3	16.07 - 18.40	1.33	n/a	Unknown [b]	Parallel with bridge #3	[7]
HS 5	513,976	6,940,813	Scrubby Creek	Queens Road	116.7	8.5	7.15	0.80	1.50	4 x 0.4 m diameter pillars	-	[13]
HS 6	506,691	6,939,604	Scrubby Creek	Browns Plains Road	45.6	24.5	20.2	0.65	1.50	2 x 0.4 m wide pillars	-	[7]
HS 7	511,807	6,939,895	Scrubby Creek	Kingston Road	64.7	27.5	7.93	0.72	1.30	4 x 0.4 m diameter pillars	-	[13]
HS 7b [h]	511,821	6,939,904	Scrubby Creek	Kingston Road	54.6	4.0	8.35 - 8.40	0.98	1.40	4 x 0.55 m octagonal pillars	Pedestrian bridge parallel to #7	[13]
HS 8	508,137	6,939,699	Scrubby Creek	Near Fifth Avenue	83.6	3.5	15.50	0.35	1.40	2 x 1.0 m wide pillars	Pedestrian bridge	[7]
HS 9	511,941	6,943,798	Slacks Creek	Near Samantha Way	26.2	3.4	14.49	0.40	1.50	2 x 0.7 m diameter pillars	Pedestrian bridge	[7]
HS 10	514,208	6,941,896	Slacks Creek	Loganlea Road	80.3	20.0	8.25 - 8.47	0.39	0.94	4 x 0.45 m diameter pillars		[13]
HS 11	512,230	6,944,734	Slacks Creek	Moss Street	31.6	10.0	14.10 - 14.20	0.80	0.90	2 x 0.25 m wide pillars		[1], [10]
HS 12	515,867	6,939,687	Slacks Creek	Logan Motorway	134.2	10.0	13.74 - 16.2	1.30	1.30	Unknown [c]	Parallel with bridge #13	[6]
HS 13	515,870	6,939,705	Slacks Creek	Logan Motorway	134.6	10.0	13.74 - 16.2	1.30	1.30	Unknown [c]	Parallel with bridge #12	[6]
HS 14	506,054	6,942,883	Scrubby Creek	Gateway Motorway	181.9	12.5	37.30 - 37.43	1.30	1.30	7 x 0.57 m diameter pillars	Parallel with bridge #15	[13]
HS 15	506,075	6,942,878	Scrubby Creek	Gateway Motorway	178.1	12.5	37.00 - 37.26	1.30	1.30	7 x 0.57 m diameter pillars	Parallel with bridge #14	[13]
HS 16	509,043	6,940,409	Scrubby Creek	Third Avenue	48.8	19.0	13.05	0.35	0.95	3 x 0.45 m diameter pillars	-	[13]
HS 17	511,235	6,945,543	Slacks Creek	Kingston Road	32.0	20.0	20.61	0.85	1.00	1 x 0.45 m diameter pillar	-	[13]
HS 18	510,571	6,939,550	Scrubby Creek	D/S of Marsden gauge	19.1	3.0	8.00	0.20	1.20	none	Pedestrian bridge	[11]
HS 19	511,569	6,940,762	n/a	Kingston Road	24.0	14.0	17.60	2.00	n/a	Unknown [b]	Road overpass	[7]
HS 20	511,554	6,940,636	n/a	Kingston Road	38.4	17.0	16.00	1.00	n/a	Unknown [b]	Road overpass	[7]
HS 21 [e]	511,872	6,945,346	Slacks Creek	Compton Road	31.0	25.7	16.80	2.67	0.70	see footnote [e]	Large box culverts	[2]
HS 22	505,204	6,939,189	Scrubby Creek	Waller Road	61.0	16.0	25.00	1.35	1.00	2 x 0.3 m wide pillars	-	[1], [13]
HS 23 [f]	513,421	6,942,637	Slacks Creek	Paradise Road	25.5	53.8	7.13 - 7.40	1.00	0.75	see footnote [f]	Large box culverts	[8]
HS 24 [g]	513,244	6,942,606	Slacks Creek	Paradise Road	27.1	22.6	6.98 - 7.25	1.15	0.75	see footnote [g]	Large box culverts	[8]

Structure ID	Easting	Northing	Watercourse	Road	Length (m)	Width (m)	Road deck level (mAHD)	Deck thickness (m)	Guard rail height (m)	Pier configuration	Comments	Source (see footnote [a])
HS 25	503,111	6,940,274	Slacks Creek	Near Elliott Court	22.3	2.0	39.20	0.48	1.30	Unknown [d]	Pedestrian bridge	[4]
HS 26	502,981	6,939,627	Slacks Creek	Near Helen Street	17.1	2.0	38.98	0.40	1.00	Unknown [d]	Pedestrian bridge	[4]
HS 27	503,027	6,939,699	Slacks Creek	Near Helen Street	14.7	2.0	38.35	0.42	1.00	Unknown [d]	Pedestrian bridge	[4]
HS 28[h]	511,725	6,940,564	Scrubby Creek	Near Jacaranda Avenue	13.7	10.0	9.00	0.79	1.00	No piers	Pedestrian bridge	[14]

[a] –Bridge structure details were obtained from one or more of the following sources:

[1] – LCC hydraulic structures survey (2017)

[2] – LCC GIS hydraulic structures database

[3] – LCC (2017) and BCC (2017) LiDAR data

[4] – Fern Street and Johnson Road Local Flood Study (Engeny, 2013)

[5] – Wembley Road Interchange (Berrinba) Flood Study (WRM, 2014b)

[6] – Logan- Albert Rivers Flood Study Peer Review (WRM, 2014a)

[7] – Slacks and Scrubby Creeks Flood Study Peer Review (WRM, 2015)

[8] – M1 Motorway Upgrade Hydraulic Study (WRM, 2017)

[9] – WRM site visit (2017)

[10] – Other information (e.g. photos, sketches) supplied by LCC

[11] – Aerial photo + street view

[12] – PD online

[13] – As-constructed drawings supplied by LCC

[14] - Kingston Butter Factory Redelopment (WRM, 2019)

[b] – As information on the pier configurations of these structures was not provided, the blockage factors that represent pier blockage for these structures were unchanged from the LCC (2015) (Slacks Creek) hydraulic model.

[c] – As information on the pier configurations of these structures was not provided, the blockage factors that represent pier blockage for these structures were unchanged from the LCC (2014) (Logan River) hydraulic model.

[d] – As information on the pier configurations of these structures was not provided, the blockage factors that represent pier blockage for these structures were unchanged from the Engeny (2013) hydraulic model.

[e] - The large culverts at the Compton Road crossing in Slacks Creek (7 x 3.3 m x 3.3 m RCBCs) were modelled as a 2D bridge structure to improve the TUFLOW model stability at this location. The pier blockage assigned to this structure represents the culvert walls.

[f] - The large culverts at the Paradise Road crossing in Slacks Creek (12 x 3.6 m x 2.4 m RCBCs) were modelled as a 2D bridge structure to improve the TUFLOW model stability at this location. The pier blockage assigned to this structure represents the culvert walls.

[g] - The large culverts at the Paradise Road crossing in Slacks Creek (4 x 3.6 m x 3.0 m RCBCs + 1 x 2.4 m x 2.1 m RCBC) were modelled as a 2D bridge structure to improve the TUFLOW model stability at this location. The pier blockage assigned to this structure represents the culvert walls.

[h] – This pedestrian bridge did not exist during the three calibration events (January 2013, May 2015 and March 2017), hence it was not included in the calibration event TUFLOW model. However, this bridge was included for design event hydraulic modelling.

Appendix D - Box and whisker plots of XP-RAFTS peak discharges

D1 Marsden stream gauge (Scrubby Creek)

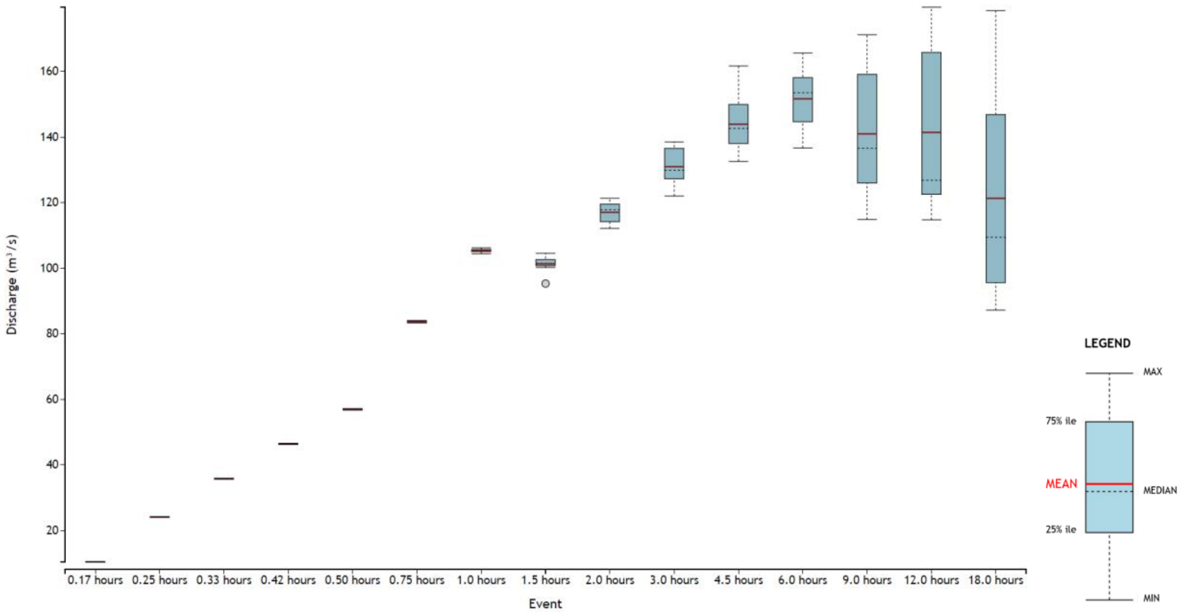


Figure D.1 – Box and whisker plots of XP-RAFTS 50% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

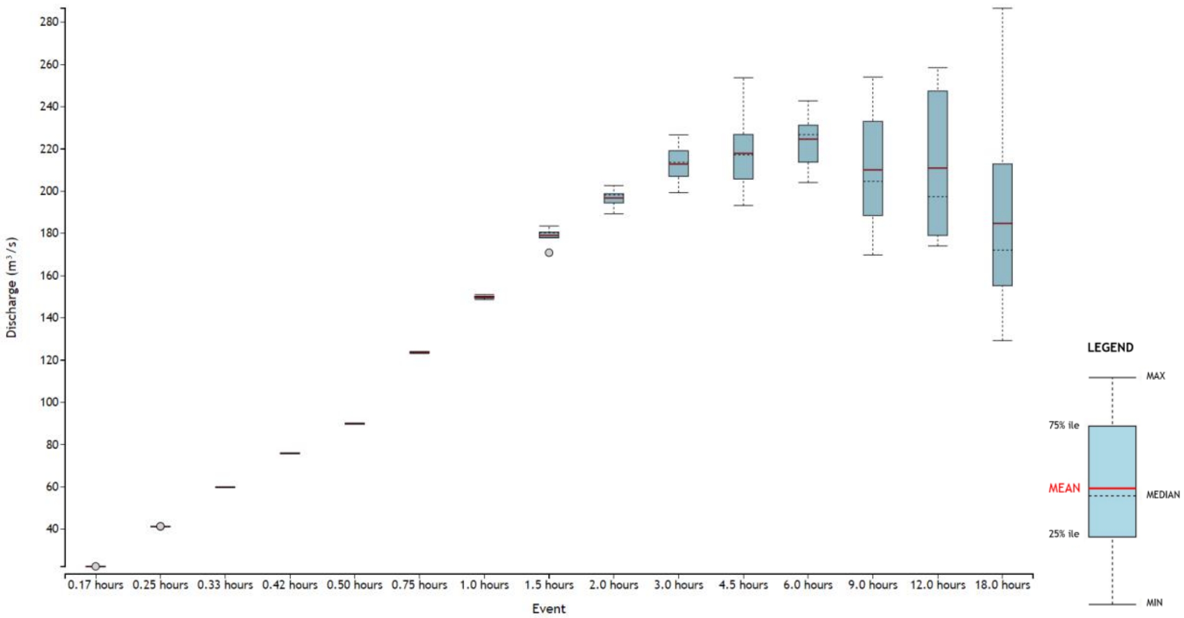


Figure D.2 – Box and whisker plots of XP-RAFTS 20% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

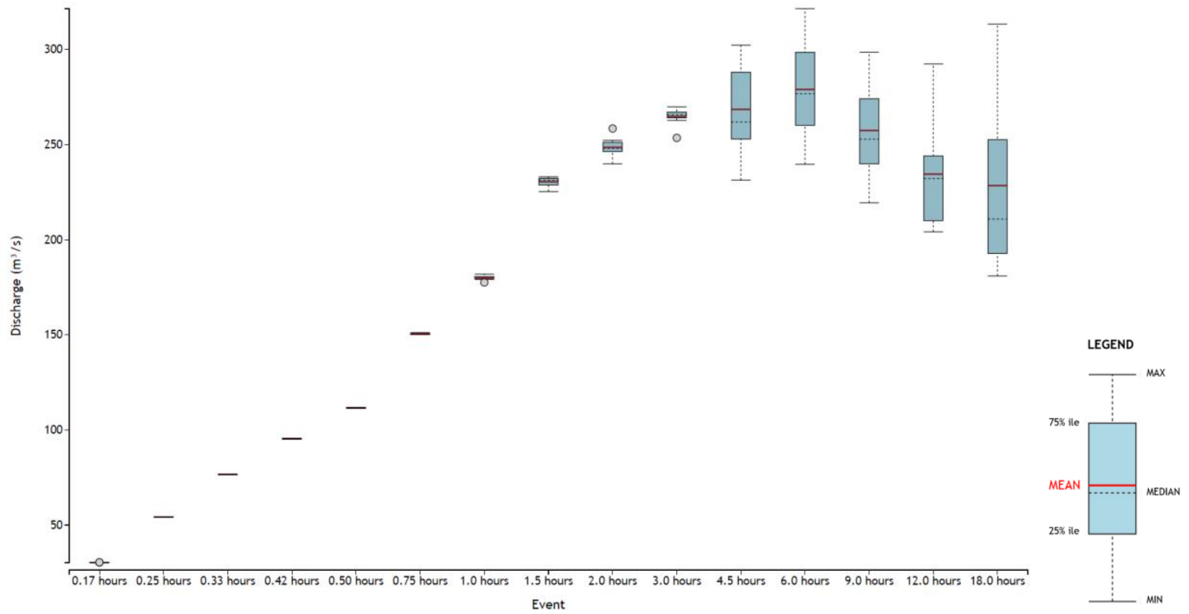


Figure D.3 – Box and whisker plots of XP-RAFTS 10% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

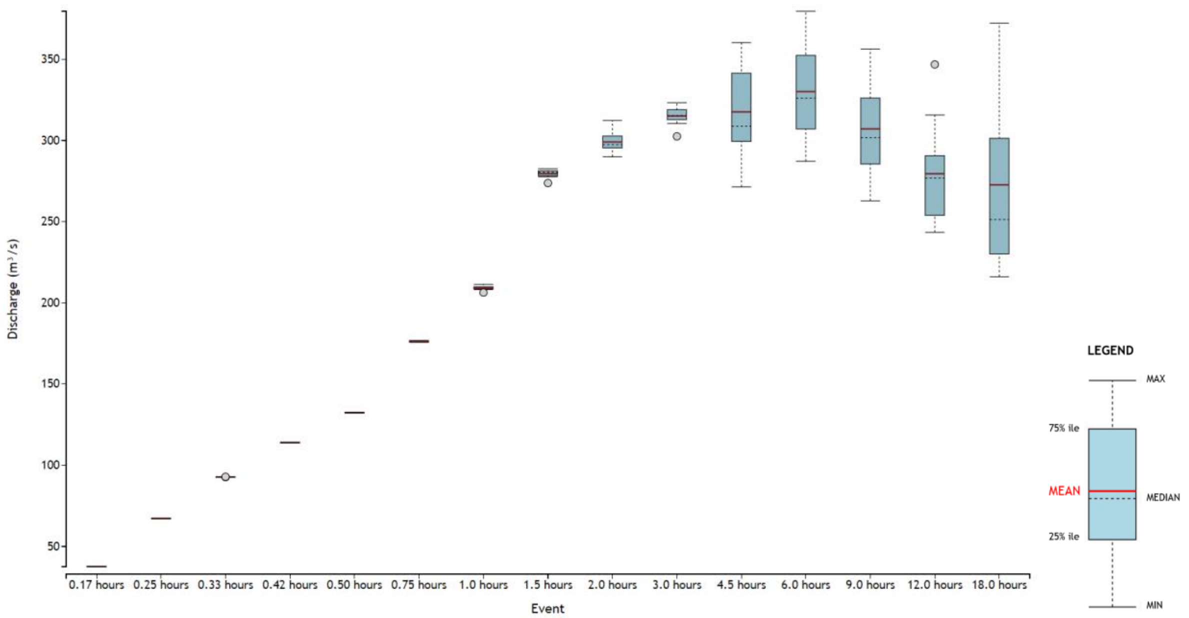


Figure D.4 – Box and whisker plots of XP-RAFTS 5% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

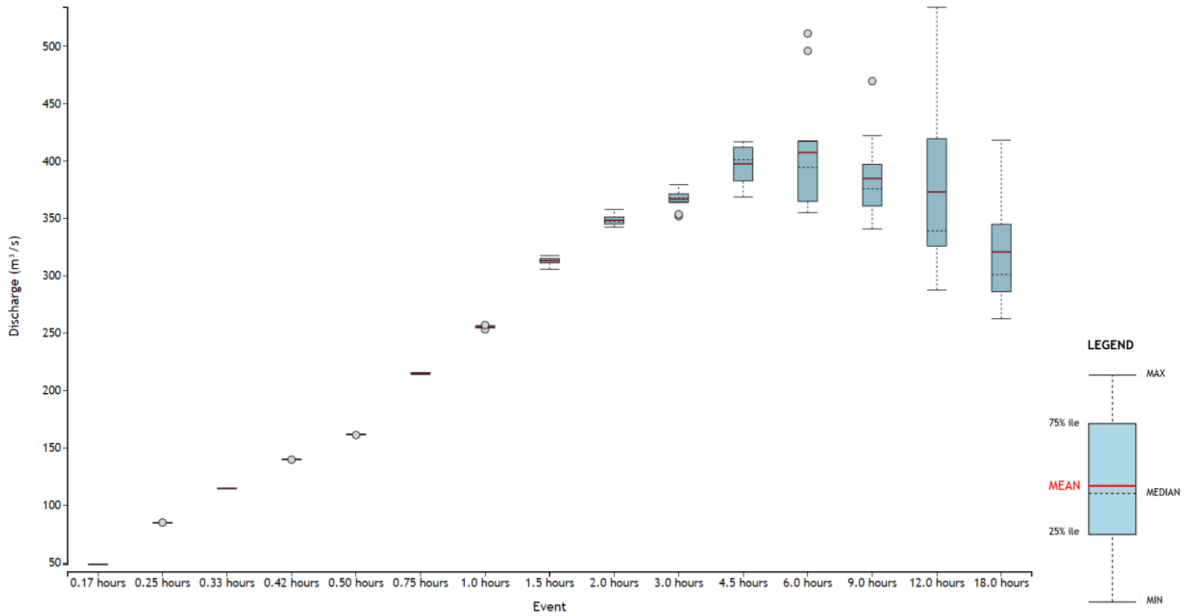


Figure D.5 - Box and whisker plots of XP-RAFTS 2% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

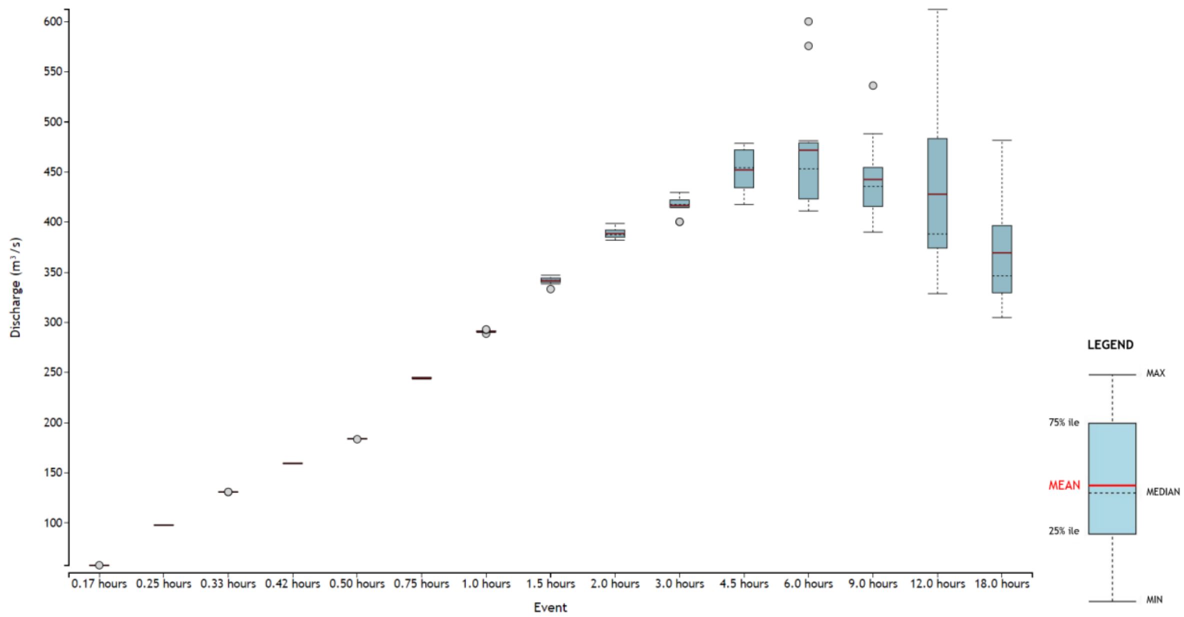


Figure D.6 - Box and whisker plots of XP-RAFTS 1% AEP predicted peak discharges in Scrubby Creek at the Marsden stream gauge (XP-RAFTS Subcatchment SC251)

D2 Reserve Park stream gauge (Slacks Creek)

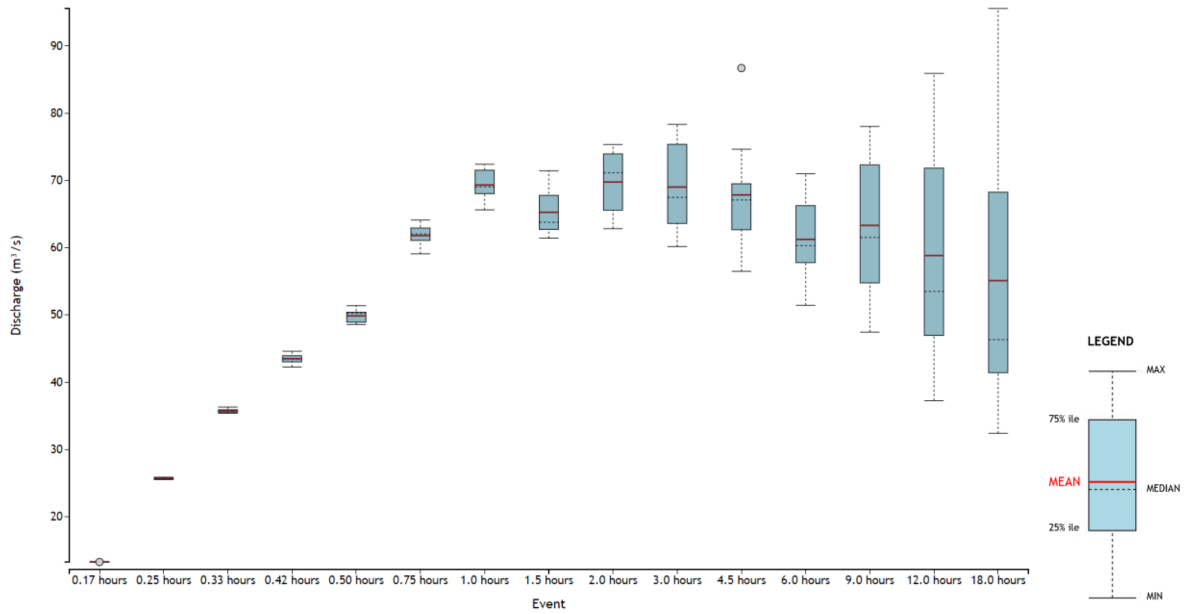


Figure D.7 – Box and whisker plots of XP-RAFTS 50% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

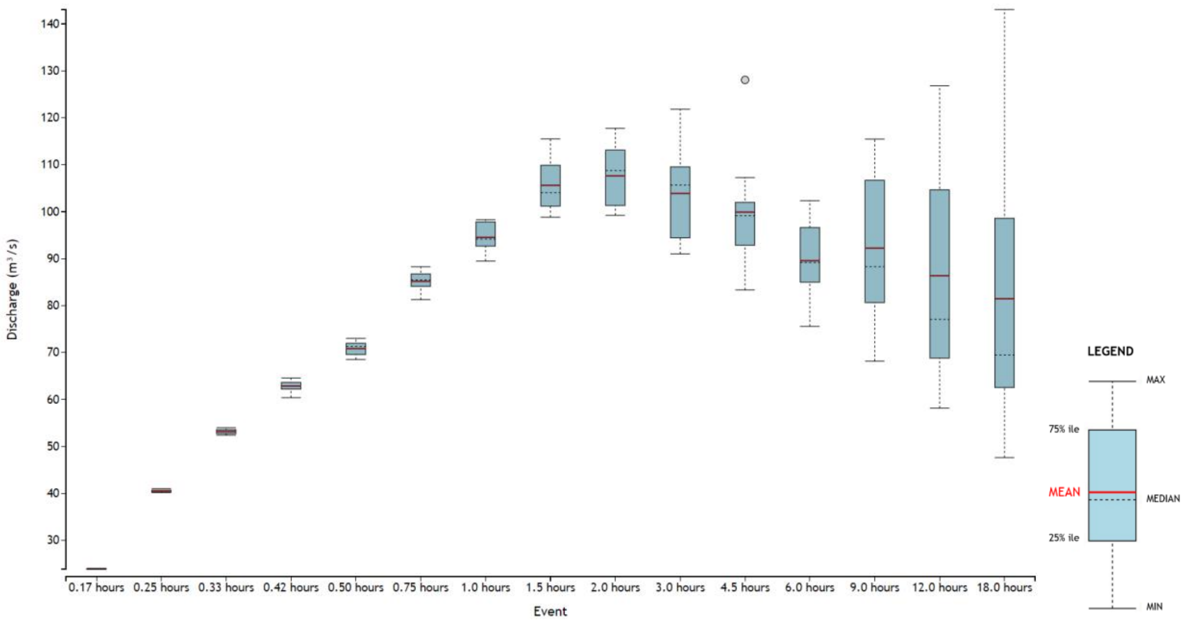


Figure D.8 - Box and whisker plots of XP-RAFTS 20% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

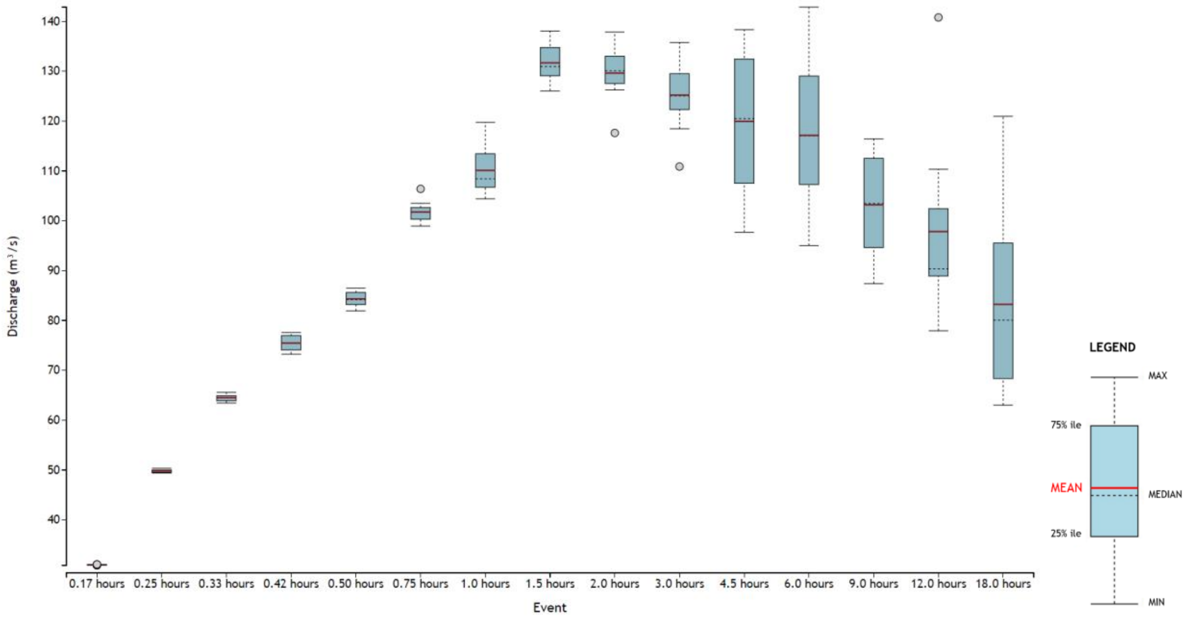


Figure D.9 – Box and whisker plots of XP-RAFTS 10% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

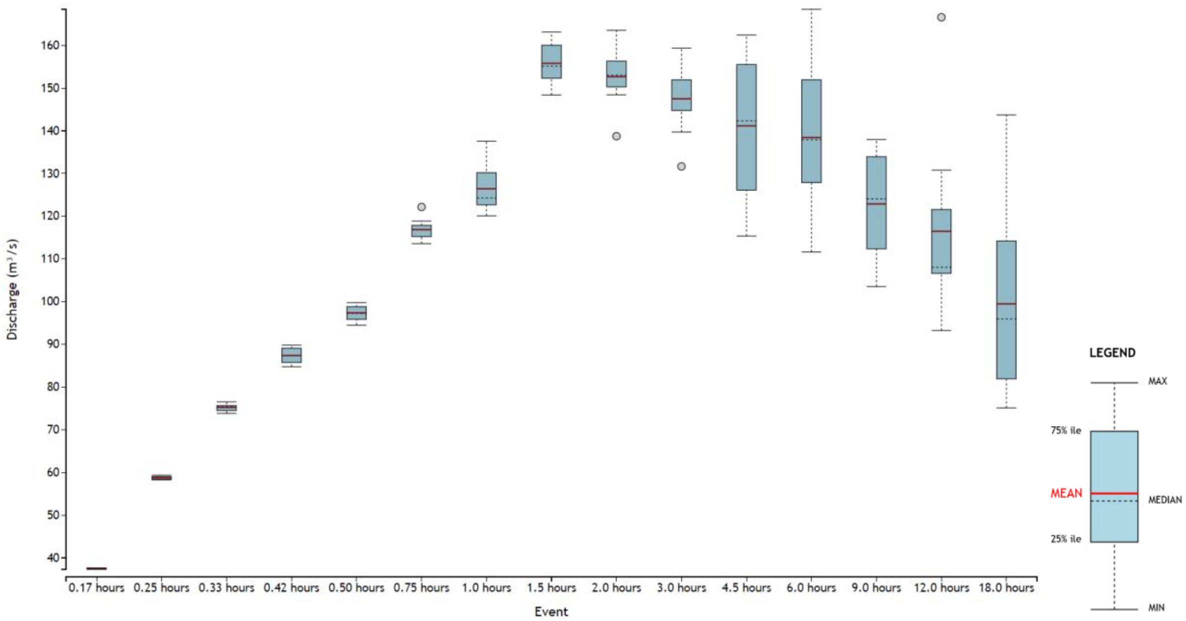


Figure D.10 – Box and whisker plots of XP-RAFTS 5% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

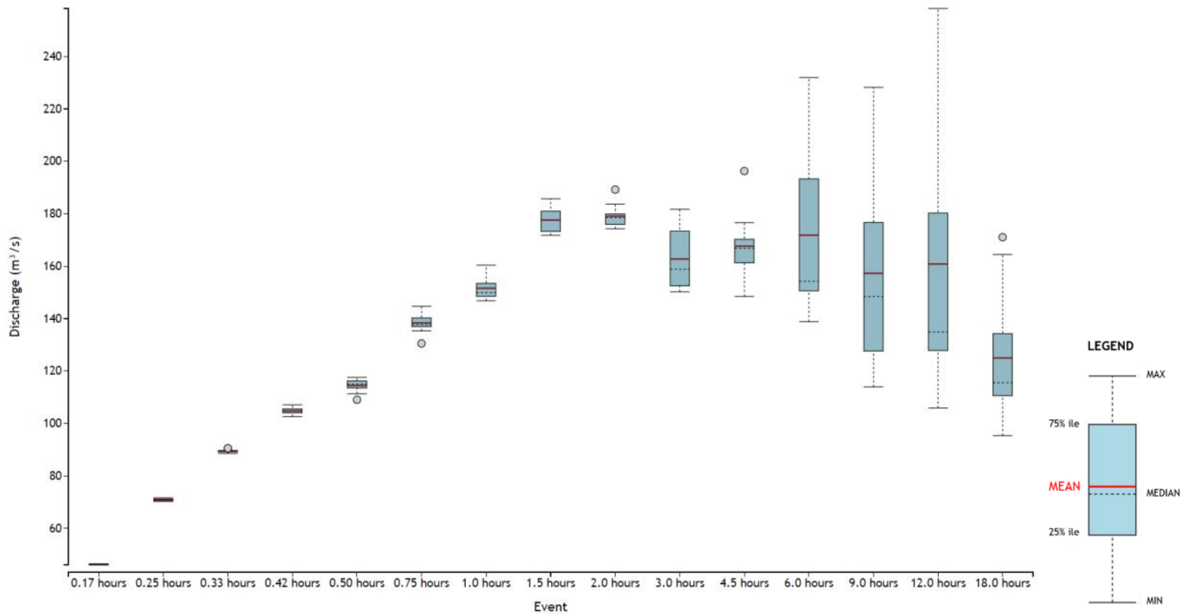


Figure D.11 – Box and whisker plots of XP-RAFTS 2% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

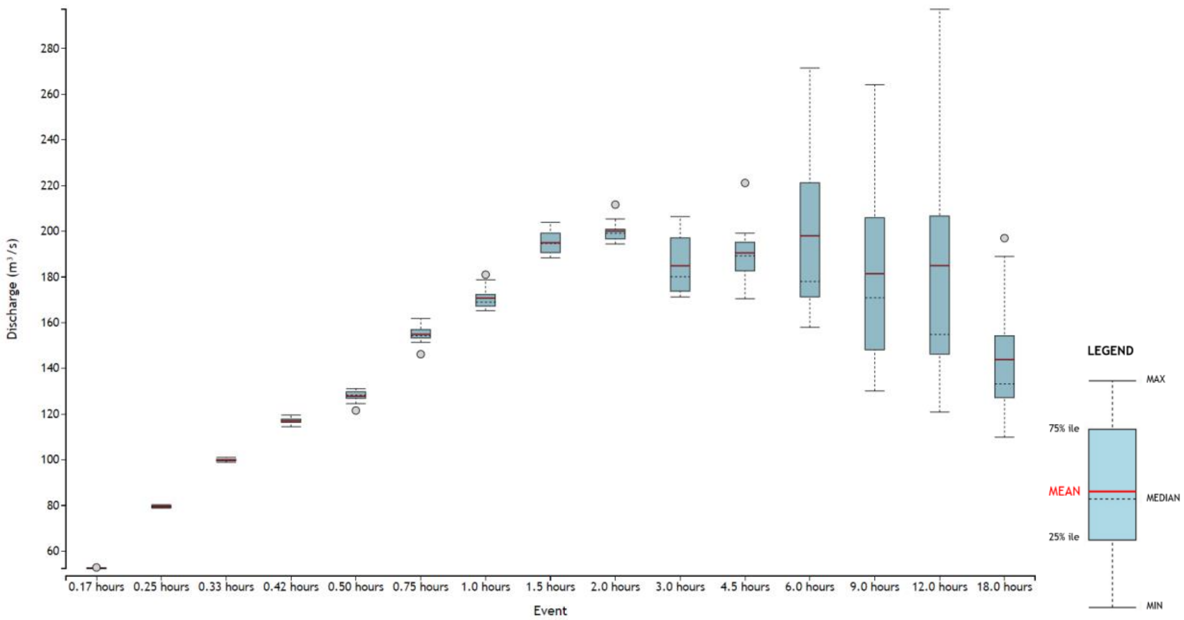


Figure D.12 – Box and whisker plots of XP-RAFTS 1% AEP predicted peak discharges in Slacks Creek at the Reserve Park stream gauge (XP-RAFTS Subcatchment SL096)

Appendix E – Flood maps