Scotchmans Creek Flood Mapping
Final Report

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Synopsis :	This report presents the methodology and findings for the hydrologic and hydraulic modelling and flood mapping undertaken for the Scotchmans Creek Flood Mapping Project.

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1 INTRODUCTION

1.1 Background

BMT (formerly BMT WBM) was commissioned by Melbourne Water (MW) to undertake Floodplain Mapping of the Scotchmans Creek catchment. As part of this study, hydrological and hydraulic modelling was undertaken for the catchment.

The Scotchmans Creek catchment, as illustrated in Figure 1-1, is located in the south-eastern suburbs of Greater Melbourne approximately 17km south east of the city centre. The Scotchmans Creek catchment is distributed across four city councils; Boroondara, Monash, Stonnington and Whitehorse.

The majority of the catchment is zoned residential. Other land use types within the catchment include public use, industrial and commercial. The Scotchman's Creek catchment drains to Gardiners Creek via a network of underground pipes and constructed and natural open channels.

This report describes the development of the hydrologic and hydraulic models, and presents the flood mapping for the Scotchmans Creek catchment. In 2013, BMT issued the Scotchmans Creek Flood Mapping Final Report (BMT WBM 2013). Subsequent to the issuing of this report, MW revised the modelling methodologies applied for this study. This report presents the revised methodology and findings for the hydrologic and hydraulic modelling and flood mapping undertaken for the Scotchmans Creek Flood Mapping Project.

1.2 Catchment Description

The Scotchmans Creek catchment (Figure 1-2) includes the suburbs of Chadstone, Mount Waverley, Glen Waverley, Notting Hill and Oakleigh East. The 21.7km^2 catchment drains from north of Highbury Road through to the outlet into Gardiners Creek at the Malvern Valley Public Golf Course.

The catchment is comprised of the:

- 4860 - Scotchmans Creek,
- 4861 - Oakleigh North,
- 4863 - Macrina Street,
- 4863 – Mount Waverley,
- 4865 - Glen Waverley,
- 4866 - Tally-Ho,
- 4867 - Mountain View, and
- 4868 - Montclair Avenue Main Drains.

The Melbourne Water Main Drains within the Scotchmans Creek catchment consist of approximately 10.7km of pipe and 7km of open channel. The open channel sections occur along the central

Scotchmans Creek Main Drain, comprised of lined channel and unlined channel of varying riparian vegetation density, and the lower end of the Glen Waverley Main Drain, comprised of unlined open channel with relatively dense riparian vegetation.

The Scotchmans Creek Catchment contains two major retarding basins located at Waverley Road and Huntingdale Road (Figure 1-2). These retarding basins both contain constructed wetland systems. The Scotchmans Creek Catchment also contains the Sienna Falls Estate, a redevelopment of a former quarry located on Highbury Rd. This development site drains to a lake in the low point of the development before it is pumped at a rate of $0.1m^3/s$ into the council drainage system upstream of the Scotchmans Creek Main Drain.

The majority of the catchment is zoned residential. Other land use types within the catchment include public use, industrial and commercial.

1.3 Previous Reports

Two previous flood study reports on various sub-catchments within the Scotchmans Creek catchment were provided by MW as part of the study inception. These are the:

- Melbourne Water Drainage Survey 1996/97, City of Monash (CMPS&F 1998), and
- Glen Waverley Main Drain Flood Mapping Study Report, Report No. J130/R01 Draft D, December 2004 (Water Technology 2004).

The reports were reviewed, and where applicable, used to provide inputs to the current study.

1.4 Objectives

The objective of the study was to undertake flood mapping of the catchment for the events and Scenarios outlined in the MW Technical Specifications (MW 2008a), as listed in Table 1-1.

Table 1-1 Required Modelling Scenarios

ARI	5 yr	10 yr	20 yr	50 yr	100 yr	PMP
Base Case	✓	✓	✓	✓	✓	✓
Climate Change	✓		✓		✓	

To achieve this, the following key tasks were undertaken:

- develop a RORB hydrological model of the catchment to provide inflow boundaries to a hydraulic model of the study area;
- develop a 1D/2D linked hydraulic model covering the Melbourne Water (MW) assets and assess the events and Scenarios outlined in Table 1-1;
- prepare the required flood mapping and assessments for the required 5, 10, 20, 50 and 100 year Annual Recurrence Interval (ARI) events and for the Probable Maximum Precipitation (PMP) event; and

- prepare a report documenting the hydraulic modelling and required flood mapping and assessments.

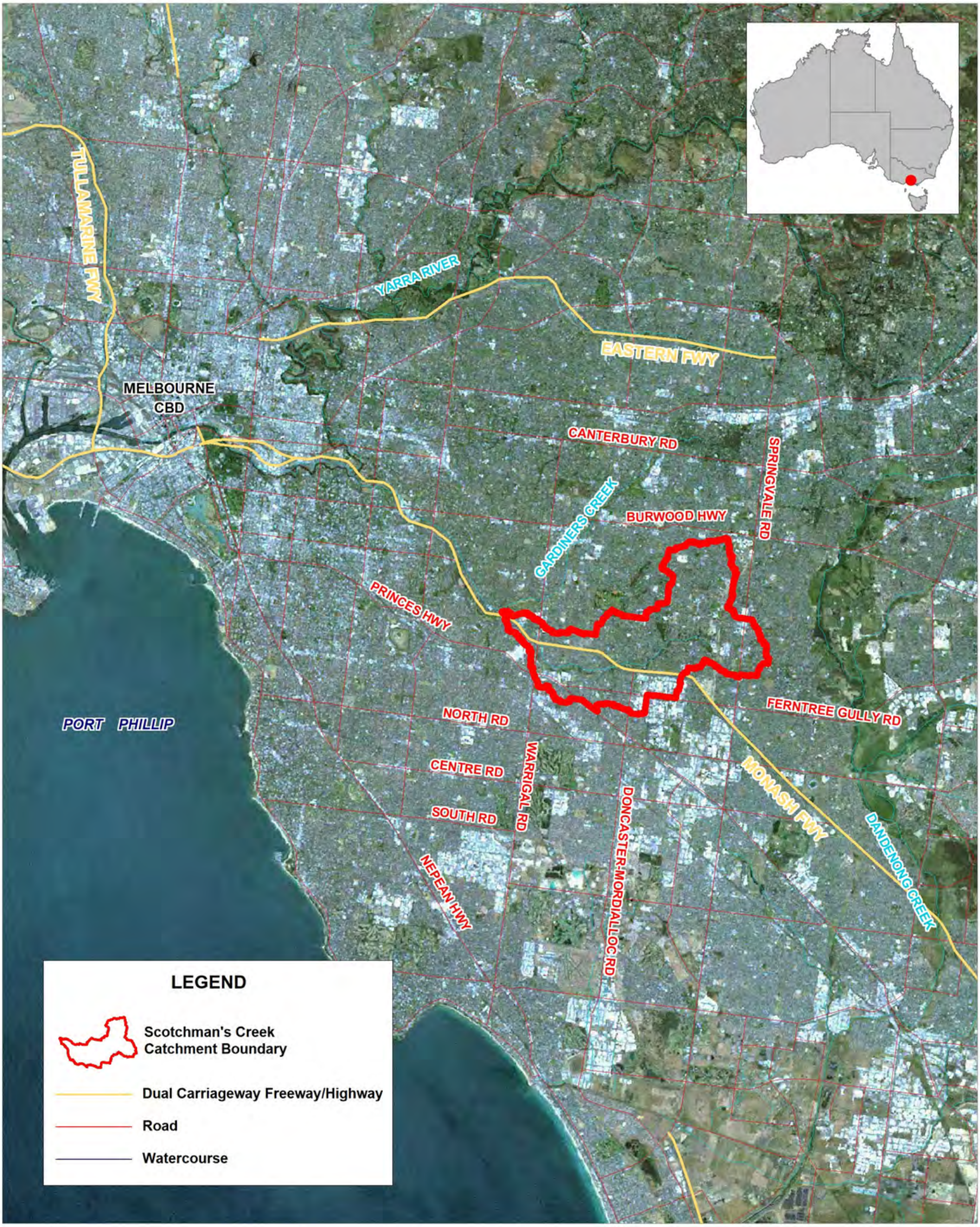
1.5 Study Approach

The study involved the following five key stages:

- data collection;
- hydrologic modelling;
- hydraulic modelling;
- flood mapping and deliverables; and
- reporting.

The modelling stages of this study were undertaken in accordance with Melbourne Water's 2008 Flood Mapping, Redevelopment Services Schemes and Mitigation: Technical Specifications and Requirements (Melbourne Water 2008). As a result, it should be noted that modelling is not consistent with the 2016 revision of Australian Rainfall and Runoff.

To the extent that the model outputs allowed, all mapping products have been developed in accordance to the 2016 Flood Mapping Projects Guidelines and Technical Specifications (Melbourne Water 2016).



Title:

Scotchmans Creek Locality Plan

Figure: 1-1

Rev: B

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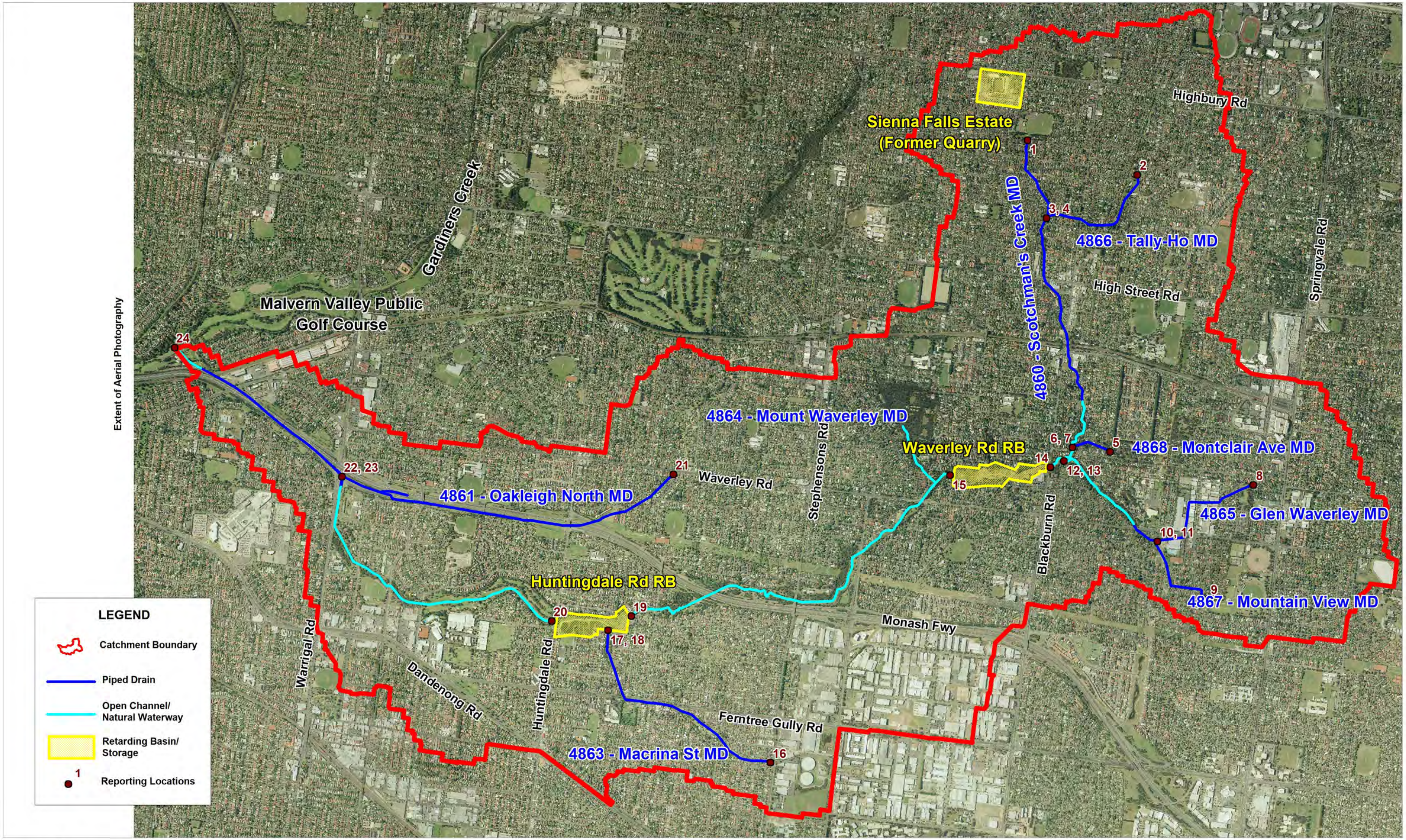

Reporting Locations

1. Scotchmans Creek Inflow
2. Tally-Ho Inflow
3. Tally-Ho Outflow
4. Scotchmans Creek - Tally-Ho Junction
5. Montclair Ave Inflow
6. Montclair Ave Outflow
7. Scotchmans Creek - Montclair Ave Junction
8. Glen Waverley Inflow
9. Mountain View Inflow
10. Mountain View Outflow
11. Glen Waverley - Mountain View Junction
12. Glen Waverley Outflow
13. Scotchmans Creek - Glen Waverley Junction
14. Waverley Rd RB Inflow
15. Waverley Rd RB Outflow
16. Macrina St Inflow
17. Macrina St Outflow
18. Scotchmans Creek - Macrina St Junction
19. Huntingdale Rd RB Inflow
20. Huntingdale Rd RB Outflow
21. Oakleigh North Inflow
22. Oakleigh North Outflow
23. Scotchmans Creek - Oakleigh North Junction
24. Scotchmans Creek Outflow

Title:
Scotchmans Creek Catchment Plan

Figure: **1-2**

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2 DATA COLLECTION AND REVIEW

MW supplied data for the Scotchmans Creek Flood Mapping study in GIS format, including MW assets, Council drainage assets and topographic information. Following data reviews and preliminary development of the hydraulic model, data gaps were identified. An approach to infilling the data gaps through interpolation and/or the collection of additional information was discussed and further data was subsequently provided by MW. This section provides an overview of the data provided and any infill undertaken.

2.1 Drainage Data and MW Assets

MW supplied details of the underground (pipe) network for the catchment in GIS format. A review indicated 114 pipes were missing invert data and that many of the known inverts were incorrect. There were 28 pipes missing dimensions and nine pipes with irregular shapes, for example arch and horseshoe shaped pipes.

In order to infill the missing data and adjust the incorrect data in the pipe network, MW provided plans of their assets in the catchment. These plans were used to infill the missing data and adjust/review existing data. The missing inverts which were not able to be filled using the plans or adjacent pipes were then filled using linear interpolation. For further details of the method used to develop the 1D pipe network (refer to Section 4.3.1).

In addition to the underground pipe network, there is also a significant length of constructed open channels within the catchment. Details of a small section of the open channels were provided in plans, while the remaining sections relied on LiDAR terrain information. For further details of the method used to model the open channel network, refer to Section 4.3.2.

The Scotchmans Creek catchment contains two large retarding basins (RBs) which accommodate constructed wetlands. Full plans were provided of these retarding basins/wetlands and their attached litter traps. This enabled these critical structures to be incorporated into the hydraulic model (refer to Section 4.2.4).

2.2 Non-MW Asset Data

Throughout the Scotchmans Creek catchment there are hydraulically significant assets located along the main flow paths which are not MW assets. These include road bridges over Scotchmans Creek and the Monash Freeway, council and/or private footbridges across Scotchmans Creek and a set of culverts under Lang Mews, which crosses the Oakleigh North MD's overland flowpath. Plans of the road bridges over the Monash Freeway were provided, however there were no plans available of the road and footbridges over Scotchmans Creek or the culvert. As these are hydraulically significant structures, survey was required (refer to Section 2.5).

2.3 Topographic Data and GIS Data Sets

MW supplied a thinned LiDAR dataset (AAMHatch 2007) of ground levels covering the catchment. From the LiDAR data, BMT created a Triangulated Integrated Network (TIN) of the ground surface using 12D. The TIN was subsequently imported into MapInfo and converted into a raster format digital elevation model (DEM). The DEM was reviewed and adopted for the study. The resulting DEM is shown in Figure 2-1.

In addition to the pipe asset and LiDAR topographic information, MW provided a range of GIS data. Key information included aerial photography, cadastre and planning zones. The data was used in the development of both the hydrological and hydraulic models. The applicable datasets and how they were utilised is discussed in more detail as part of the modelling methodologies outlined in Sections 3 and 4.

2.4 Site Inspection

The study team from BMT and Suresh Bajracharya (MW) undertook a site inspection at the commencement of the study. The site inspection allowed the study team to obtain an understanding of the drainage network and to obtain a photographic record to assist in the development of the hydraulic model.

2.5 Survey Data

Following a review of the available data supplied by MW, it was necessary to gain additional survey data in order to complete the hydraulic model. The survey data required was:

- details of all footbridges that cross Scotchmans Creek,
- details of the Park Road and Stanley Avenue road bridges that cross Scotchmans Creek, and
- invert levels and dimensions of the set of culverts under Lang Mews.

Existing survey commissioned by MW and undertaken by Connell Wagner in 2007, provided the required dimensions for the Stanley Avenue road bridge. This existing survey also provided details of the Huntingdale Road RB litter trap, the culvert under the Monash Freeway and the culverts under Forster Road. This survey allowed for a cross check of GIS data and assumptions. Channel cross-sections were also provided between upstream of Forster Road and the Huntingdale Road RB. This allowed for the open channel in this area to be modelled in 1D. For further details, refer to Section 4.3.2.

MW commissioned SMEC Urban to undertake a survey of the dimensions and cross section directly upstream and downstream the missing bridges and culverts. This survey was delivered to BMT in AutoCAD DWG and/or PDF formats. This allowed for the remaining structures to be included into the hydraulic model.

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LiDAR DEM

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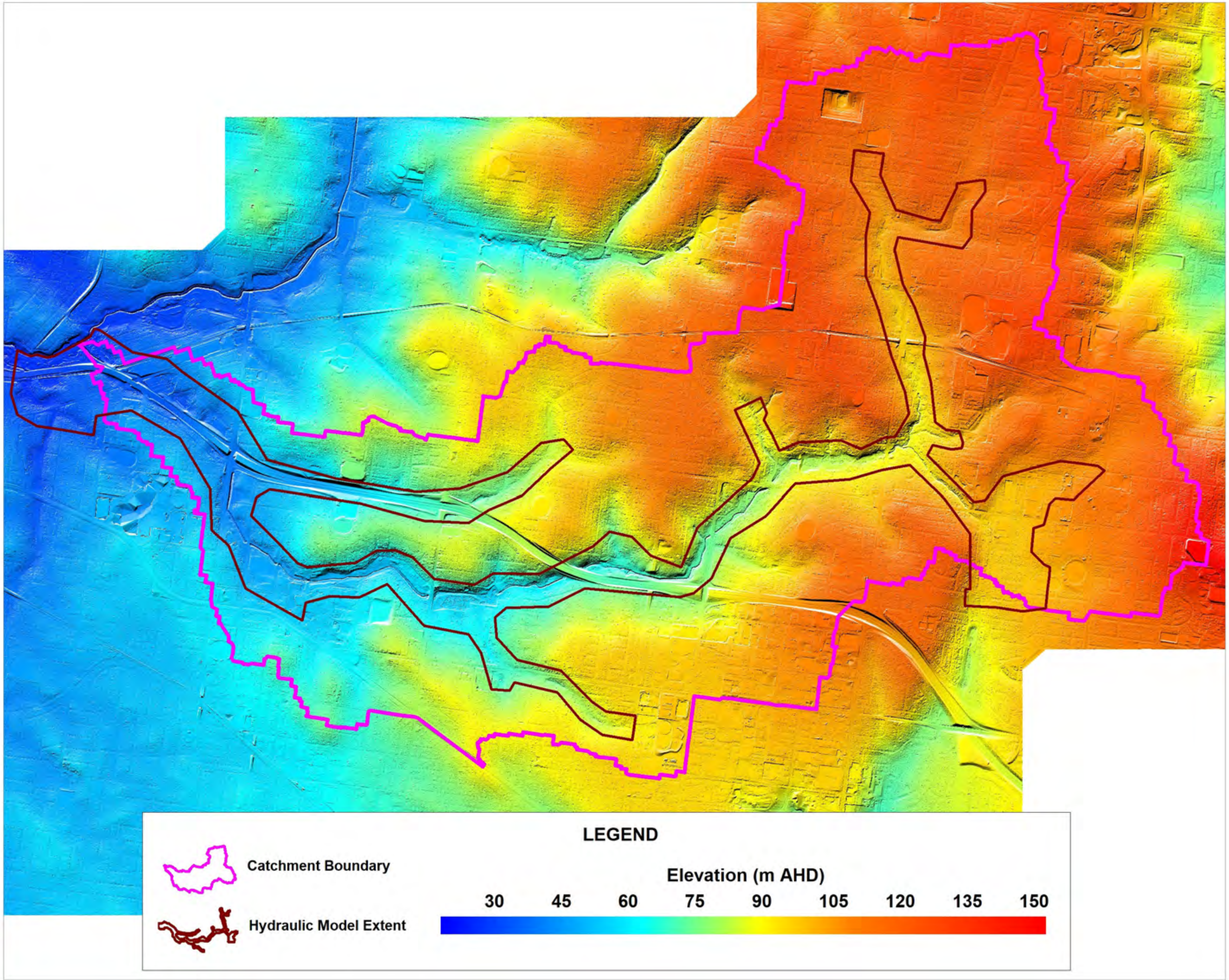


3 HYDROLOGIC MODELLING

The Hydrological modelling was undertaken to determine catchment flows for the 5, 10, 20, 50 and 100 year Average Recurrence Interval (ARI) and the probable maximum precipitation (PMP) design flood events. These flow rates were used as inputs into the hydraulic modelling of the base case and climate change scenarios. A summary of the required flow outputs is shown in Table 1-1.

Table 3-1 Required RORB Modelling Scenarios

ARI	5 yr	10 yr	20 yr	50 yr	100 yr	PMP
Base Case	✓	✓	✓	✓	✓	✓
Climate Change	✓		✓		✓	

RORB and the Rational Method approaches were used to undertake the hydrological modelling of the catchment as per MW Technical Specifications and Requirements (MW 2008). RORB simulates the hydrological behaviour of a catchment by dividing the area into a series of sub-catchments joined by a series of reaches. Rainfall-runoff is simulated for each sub-catchment with the hydrographs routed through the stream network using a non-linear storage routing procedure. The Rational Method approach calculates the peak flow rate based on the catchment area, land use, the catchment response time and design rainfall intensity.

Base case, base case without storage (retarding basins), base case 'calibration', and climate change scenario RORB models have been prepared for the catchment. The base case calibration RORB model was 'calibrated' to the Rational Method.

3.1 Fraction Impervious

3.1.1 Adopted Fraction Impervious Values

As part of the development of the RORB hydrologic model, BMT were required to conduct a review of the relationship between fraction impervious (FI) and block size for residential properties in the Scotchmans Creek catchment. Following a review of the “typical" inner and outer suburb relationships (using aerial photography provided by MW), it was concluded that neither relationship was appropriate for use in the Scotchmans Creek catchment. The outer FI values were deemed too low and the inner values were deemed too high.

BMT recommended a set of FI values per block size band which were supplied to MW. The calculated FI values adopted for the planning model are shown in Figure 3-1.

3.1.2 Fraction Impervious Review

Melbourne Water provided BMT with a MapInfo table of all properties that fall within the Scotchmans Creek catchment. This table contained information regarding the FI values for each property under current (existing) and future development conditions. BMT reviewed all properties that were assigned an existing FI value equal to 0 (882 polygons in total). As required by MW Technical Specification, the FI values at these locations were updated with more suitable values which represent the site-use. The adopted FI values per property were provided to MW for final review and approval (ref: R.M7586.001.00.FI_Review.docx).

3.1.3 Additional Amendments

Following a review by Melbourne Water of the updated fraction impervious data supplied by BMT, a further six properties with zero FI were identified and required updating. These updates are summarised in Table 3-2.

Table 3-2 Additional FI Amendments

RORB Sub-Area	Area (ha)	Existing FI	Ultimate FI	Comments and Reasons
CP	0.06	0.1	0.1	Zoned PUZ6, best represented as PPRZ, clear flow path, unlikely to be developed.
CP	0.08	0.1	0.1	Zoned PUZ6, best represented as PPRZ, clear flow path, unlikely to be developed.
AK	0.13	0.1	0.1	Zoned as UFZ ultimate FI unchanged.
AK	0.17	0.1	0.1	Zoned as UFZ ultimate FI unchanged.
EG	0.63	0.4	0.4	Wetland. Existing and ultimate have higher FI then PPRZ to account for permanent pools.
BS	1.72	0.7	0.7	Aquatic Centre, PUZ6.

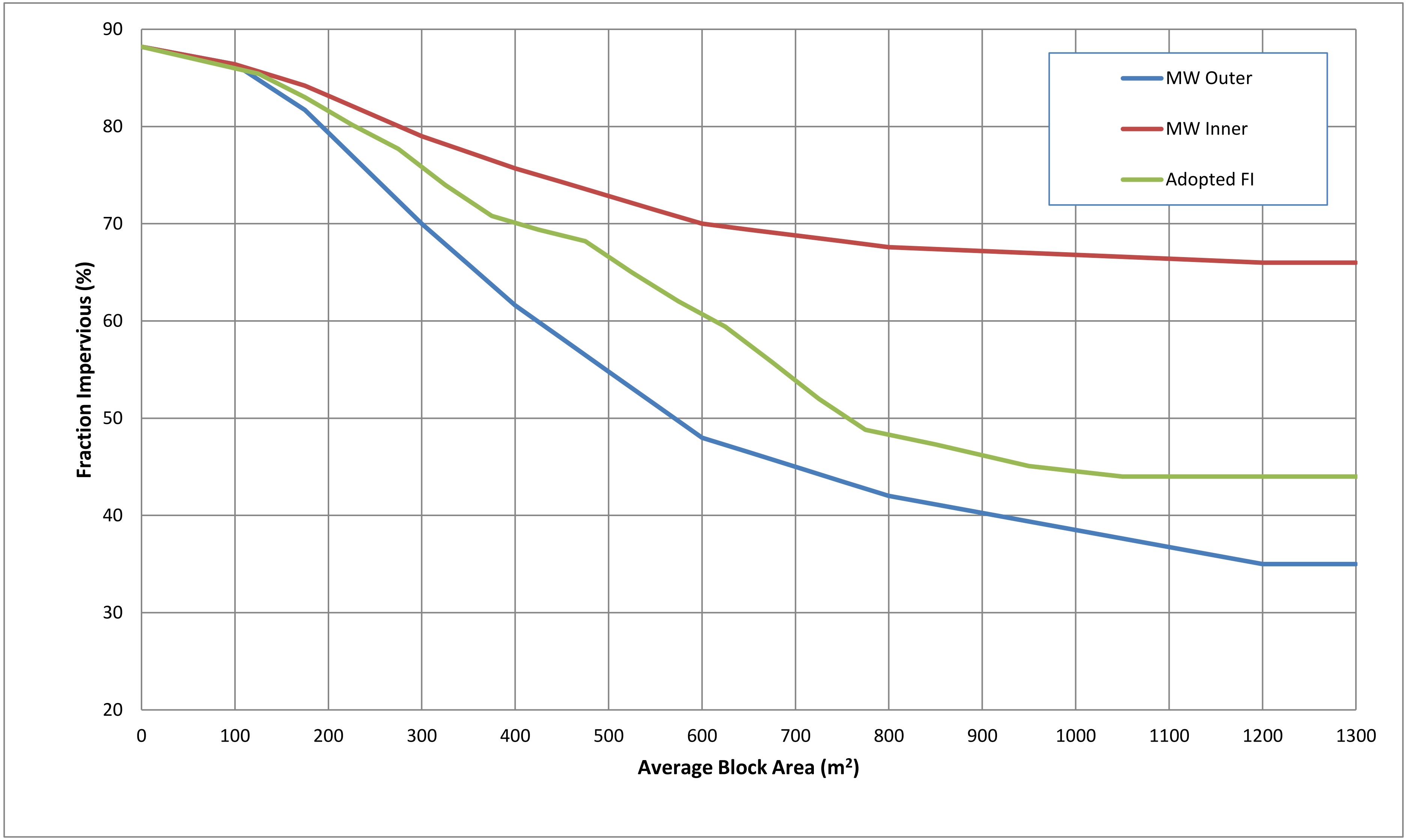


Figure 3-1 Relationship Between Block Size and FI Values

3.2 Rational Method

3.2.1 Description

The Rational Method, as outlined by Book VIII of Australian Rainfall and Runoff (AR&R) (IEA 1999), and the methods outlined in the MW Technical Specifications, have been used to calculate the peak flow from the catchment. The Rational Method is an established method for determining the peak flow from urban and rural catchments. Considering the land use in the Scotchmans Creek catchments, the urban approach to implementing the Rational Method has been used.

The Rational Method equation is:

$$Q_Y = C_Y I_{t_c,Y} A$$

where Q_Y is the peak flow with an Annual Recurrence Interval (ARI) of Y years, C_Y is the runoff coefficient for a flood with an ARI of Y years, I is the Y-year ARI rainfall intensity for a duration of t_c and A is the catchment area.

A description of each of these parameters and variables is provided below.

3.2.2 Time of Concentration

The time of concentration (t_c) used for the Rational Method calculations were based upon flow travel times through a number of reaches along the critical flow paths of the main drains which make up the Scotchmans Creek catchment.

In accordance with the technical specifications, several methods for calculating velocity were used to determine the catchment's t_c. Upstream of Melbourne Water assets it was assumed that, if there is a council pipe network, all flow is contained within this network. Where the council network pipe dimension data was not available an assumed pipe diameter of 600mm was adopted. Upstream of the council network flow was assumed to be contained within a 450mm pipe. Where flow was contained within open channels velocity was determined using manning's equation. In order to determine velocity and hence t_c, surface length and elevations were used to determine pipe and channel slopes. An additional 7min was added to the t_c calculations to account for the roof to gutter time.

For Melbourne Water assets, velocities from a 1D/2D hydraulic model were used to determine t_c. The hydraulic model was run using flows from the base case RORB model, run with default parameters, for the 100 year ARI 2 hour storm event. Where the Melbourne Water drainage system is piped the maximum velocities from the 1D domain were used. Where the drainage system consisted of open channel, maximum velocities from either the 1D or 2D domain were adopted depending on how each given section of open channel was modelled.

A summary of the time of concentrations adopted in the rational method calculations are presented in Table 3-4 and full details of the time of concentration method adopted for each flow path are contained in Appendix B.

3.2.3 Runoff Co-efficient

The Scotchmans Creek catchment is an entirely urban catchment therefore the 10 year ARI runoff coefficient (C_{10}) was derived from the relationship between C_{10} and fraction impervious presented in Book VIII of AR&R (1999). C for the 100 ARI were derived from the C_{10} using the frequency factors in Table 1.6 in AR&R Book VIII. The calculated C values are listed in Table 3-4.

3.2.4 Intensity

A summary of the IFD parameters used for the rational method calculations are summarised in Section 3.3.1.8 and the full IFD table is provided in Appendix A.

3.2.5 Partial Area Effect

The Partial Area Effect occurs where a smaller portion of the entire catchment, generally with a different flowpath and corresponding t_c value, results in a higher peak discharge than that from the entire catchment.

The Partial Area Effect was investigated, in particular, to determine whether flows from a smaller portion of the Glen Waverley and Mountain View catchments would result in a greater peak discharge than that previously determined for the entire Scotchmans Creek catchment. The upper area of the Glen Waverley catchment contains relatively flat topography resulting in a longer time of concentration to the Scotchmans Creek - Glen Waverley junction than that from the top of the Tally-Ho catchment. As a result, the Glen Waverley and Mountain View catchment were reduced in area and the critical path was from the top of the Tally-Ho catchment, refer to Figure 3-2. Table 3-3 presents a comparison between the Rational Method for the entire catchment and the partial area at the Scotchmans Creek outflow for the 100 year ARI event. For further calculation details and flow comparisons of the partial area effect see Appendix B.

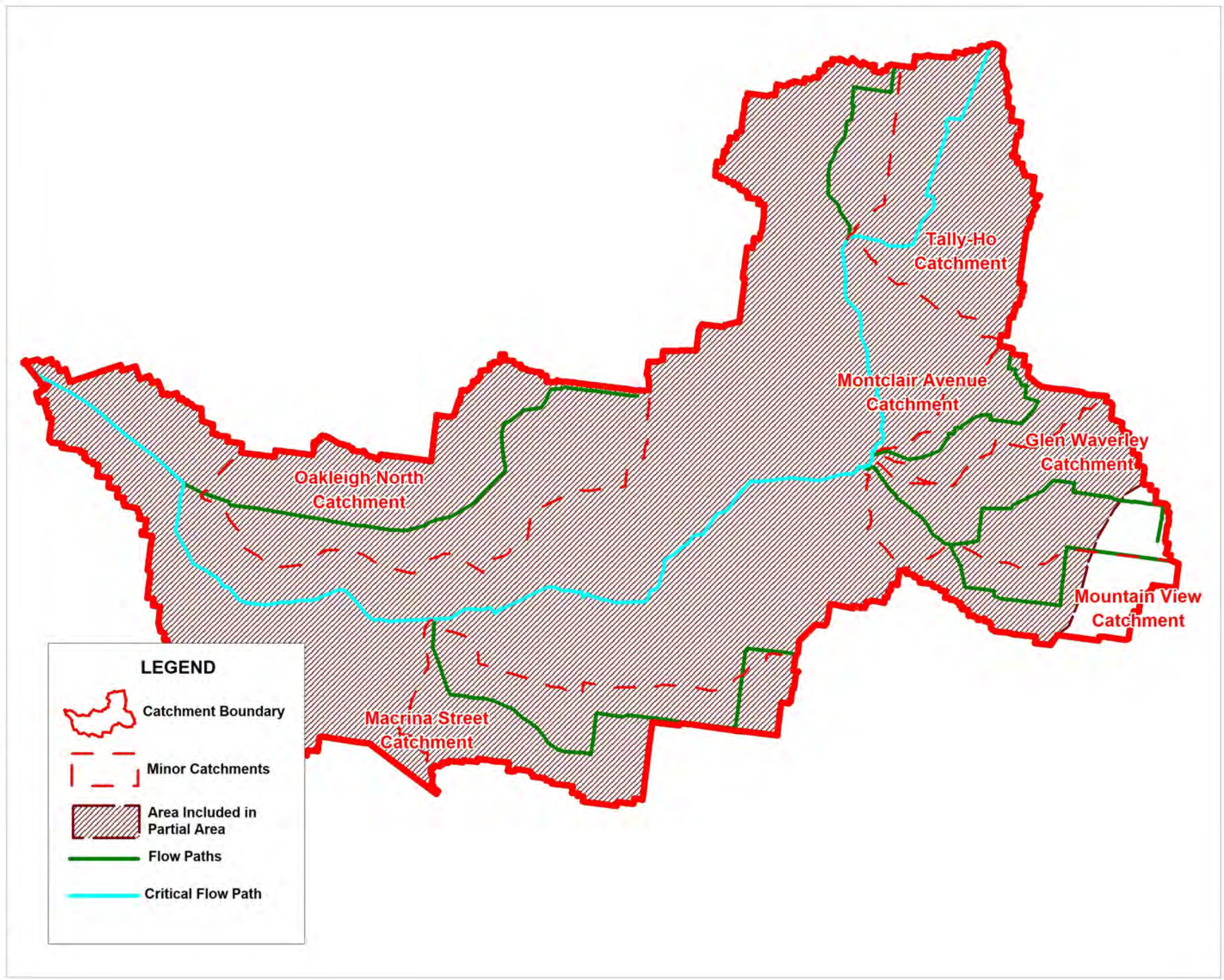
Table 3-3 Comparison of Rational Method Results for Full and Partial Catchment Areas

	Area (ha)	t_c (mins)	Intensity (mm/h)	C	Q (m^3/s)
Entire Catchment	2170	111.1	30.4	0.69	126.9
Partial Area	2117	104.6	31.6	0.69	128.9

Title:

Partial Area Effect

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



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Approx Scale

Figure: 3-2

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3.2.6 Rational Method Results

The 100 Year ARI Rational Method parameters and results are summarised in Table 3-4.

Table 3-4 100 Year ARI Rational Method Parameters and Results

Location*	Area (ha)	t_c (mins)	Intensity (mm/h)	C	Q (m^3/s)
Scotchmans Creek Inflow (1)	69	13.8	111.0	0.62	13
Tally-Ho Inflow (2)	109	14.7	107.3	0.68	22
Tally-Ho Outflow (3)	187	19.2	92.5	0.67	32
Scotchmans Creek - Tally-Ho Junction (4)	307	19.2	92.5	0.66	52
Montclair Ave Inflow (5)	67	16.2	101.3	0.72	11
Montclair Ave Outflow (6)	69	17.3	98.0	0.71	14
Scotchmans Creek - Montclair Ave Junction (7)	558	32.1	67.9	0.69	72
Glen Waverley Inflow (8)	59	14.1	109.7	0.75	14
Mountain View Inflow (9)	61	15.8	103.0	0.61	10.7
Mountain View Outflow (10)	89	21.7	85.8	0.64	14
Glen Waverley - Mountain View Junction (11)	220	21.7	85.8	0.71	37
Glen Waverley Outflow (12)	253	41.0	58.2	0.70	29
Scotchmans Creek - Glen Waverley Junction (13)	761	34.5	65.3	0.69	96
Macrina St Inflow (16)	81	25.4	78.2	0.87	15
Macrina St Outflow (17)	176	32.5	67.5	0.77	26
Scotchmans Creek - Macrina St Junction (18)	1476	69.2	41.6	0.69	118
Oakleigh North Inflow (21)	105	15.8	102.9	0.69	21
Oakleigh North Outflow (22)	277	24.6	79.8	0.68	42
Scotchmans Creek - Oakleigh North Junction (23)	2029	97.3	33.2	0.69	130
Scotchmans Creek Outflow (24)	2117	104.6	31.6	0.69	129

** Note: The location numbers and descriptions are displayed in Figure 1-2.*

.

3.3 Hydrological Model

Hydrologic modelling of the Scotchmans Creek catchment was undertaken using RORB. A RORB model of the catchment was established for the purpose of extracting total and sub-area hydrographs to be used as boundary conditions for the TUFLOW hydraulic model. As flow routing would be calculated in the hydraulic model, undiverted flow routing results from the RORB models were considered appropriate for the purpose of this study. For this reason, a diverted RORB model was not developed.

A description of the RORB modelling process and results are discussed in the following sections. The Existing Case RORB CATG files have been supplied to MW in electronic form and, in order to maintain brevity (each CATG file is of the order of 150 pages), have not been reproduced in the Appendices of this report.

3.3.1 RORB Model

RORB simulates the linkages between sub-catchments as reach storages with the storage discharge relationship defined by the following equation:

$$S = 3600kQ^m$$

where S represents the storage (m^3), Q is the discharge (m^3/s), m is a dimensionless exponent and k is non-dimensional empirical coefficient. k is defined by the product of the catchment value k_c and the individual reach k_i. Both m and k_c are defined as calibration parameters. As per the Technical Specification, in the absence of calibration events, an m value of 0.8 was adopted.

3.3.1.1 Model Description

Three RORB models have been developed for the hydrological modelling of the Scotchmans Creek catchment. These models are:

- Base Case Calibration - This model was used to 'calibrate' the RORB model to the rational method. The reach types were set to match the assumptions made in the rational method calculation (Section 3.2). The model included FI values based on existing conditions and excluded all storages. Further detail of the calibration process is provided in Section 3.3.1.10.

- Base Case Without Storage - This model is the same as the base case calibration model but with the reach types changed to reflect the predominant flow characteristics along a given reach. This model is used to compare flows without the influence of storages. This model is not used to provide flows for the hydraulic model.

- Base Case - Same as the base case without storage model but with the 2 formal retarding basins and the lake storage included. This RORB model is to be used for the base case and climate change scenario hydrological modelling and to provide flow boundary conditions for the hydraulic model.

The RORB models were developed in accordance with the Technical Specification.

3.3.1.2 Catchment Definition

The Scotchmans Creek catchment, shown in Figure 3-3, was defined using several techniques to determine the appropriate outer boundary. Initially the catchment boundary was defined by the CatchmentSIM computer program using the Digital Elevation Model (DEM) developed from the LiDAR data provided by MW. This boundary was then refined using contours and considering other influences including:

- major roads and flow paths;
- adjacent approved catchment boundaries;
- property boundaries; and
- the relevant council drainage networks.

The adjacent approved catchment boundaries which were taken into consideration were the: Damper Creek Main Drain (4872), Winbirra Parade Main Drain (4871), Murrumbeena Main Drain (4850) and Mile Creek Catchment. Where appropriate, the Scotchmans Creek catchment boundary was snapped to these adjacent boundaries. Following discussions with Melbourne Water it was agreed that the Mile Creek catchment boundary did not sufficiently represent the boundary of these two catchments and the Mile Creek catchment boundary would need to be altered to match the Scotchmans Creek boundary.

The catchment boundary was also snapped to residential property boundaries except for large properties (>1ha) as per the Technical Specification. In addition, the catchment boundary was not snapped to other land use types such as playing fields and reserves as following the property boundary could create a large discrepancy between the catchment boundary and topographic data.

The Scotchmans Creek catchment was determined to be approximately 21.7 square kilometres in size.

3.3.1.3 Sub-catchment Definition

The sub-catchments, shown in Figure 3-3, were defined using topographic data including roads and flow paths and Melbourne Water's drainage network. It was assumed that the flow was predominately overland therefore the council drainage networks were only used as guide when the topographic data was not clear. The sub-catchments were also defined in a manner which would allow for the flow boundaries into the hydraulic model to be applied correctly. The sub-catchment definition also allowed for flows to be extracted from the hydrological model at key flow locations such as the drain confluences, retarding basins, other hydraulic structures and major roads.

A minimum of three to four sub-catchments were defined upstream of any of Melbourne Water's assets, and where possible, uniformity in sub-catchment area and shape was sought after. The catchment was divided into 196 sub-catchments and 458 reaches.

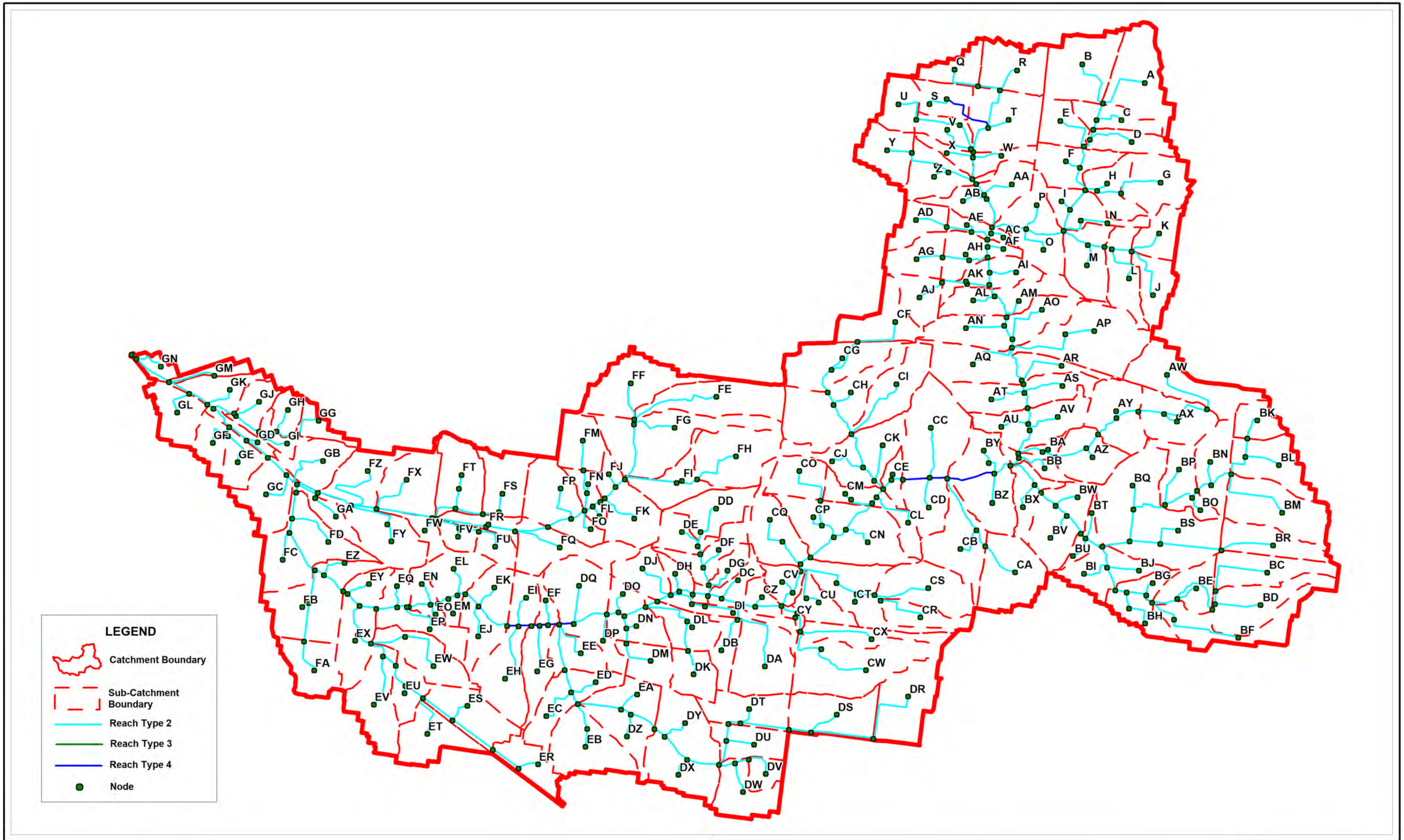
3.3.1.4 Reach Types

The following reach types were used in the RORB model setup:

- Reach Type 2 - for flow in excavated but unlined channels, roads and flow between properties.
- Reach Type 3 - for flow in lined channels and pipes.
- Reach Type 4 - drowned flow in the Huntingdale Rd and Waverley Rd retarding basins and the reach representing the pumped rising main from the Sienna Falls Estate development.

While there are sections of the Scotchmans Creek channel that are lined which could be modelled using Reach Type 3, it was assessed that during large flood events the capacity of the channel is exceeded resulting in out of bank flow. Therefore, these sections of channel have been modelled using Reach Type 2.

Reach alignments and types are shown in Figure 3-3.



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Scotchmans Creek RORB Model Schematisation

Figure: **3-3**

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3.3.1.5 Retarding Basins and Storages

Within the Scotchmans Creek catchment there are two major storages; the Waverley Rd and Huntingdale Rd retarding basins shown in Figure 1-2. These two retarding basins were included in the base case RORB model as special storages defined by storage-discharge and elevation-storage relationships. These relationships were derived from the stage-storage and stage-discharge curves shown in Drawings 4860/9 (49) (Waverley Rd) and 4860/11 (39) (Huntingdale Rd), which are summarised in Figure 3-4 and Figure 3-5. The portion of the curves shown in red have been extrapolated by extending the curves to gain the storage volumes required when modelling the larger storm events.

Sienna Falls Estate (refer Figure 1-2) is a redevelopment of a former quarry on Highbury Rd in the north of the catchment. This development, represented by sub-catchment "S" in the RORB model, drains to an internal lake which uses a pump and rising main system to maintain water levels. The rising main is connected to the council drainage network above the Scotchmans Creek Main Drain. The pump delivers flow at a rate of $0.1m^3/s$. This is represented in the RORB model as a special storage defined by a stage-discharge relationship with a constant discharge of $0.1m^3/s$.

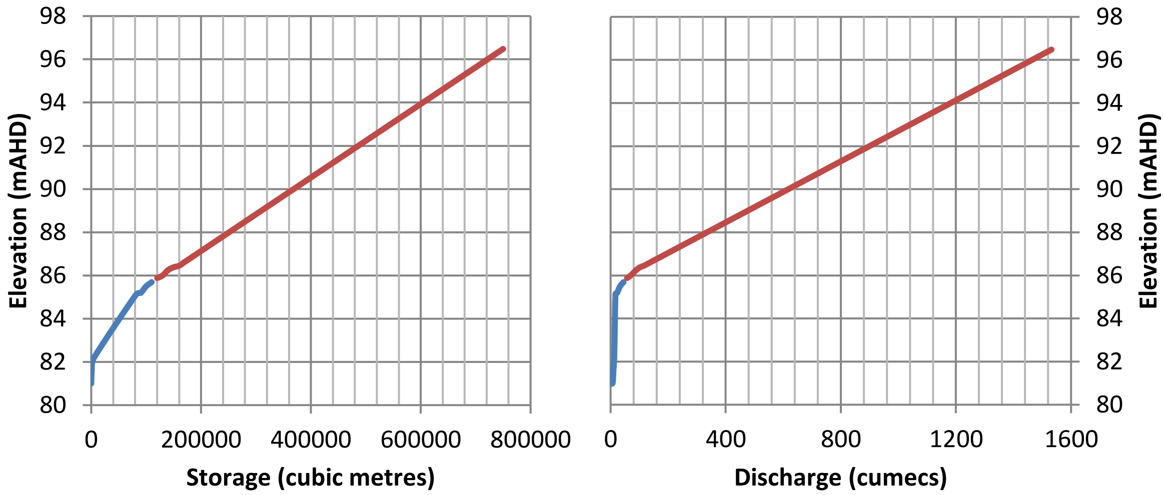


Figure 3-4 Waverley Rd RB Stage-Storage and Stage-Discharge Curves

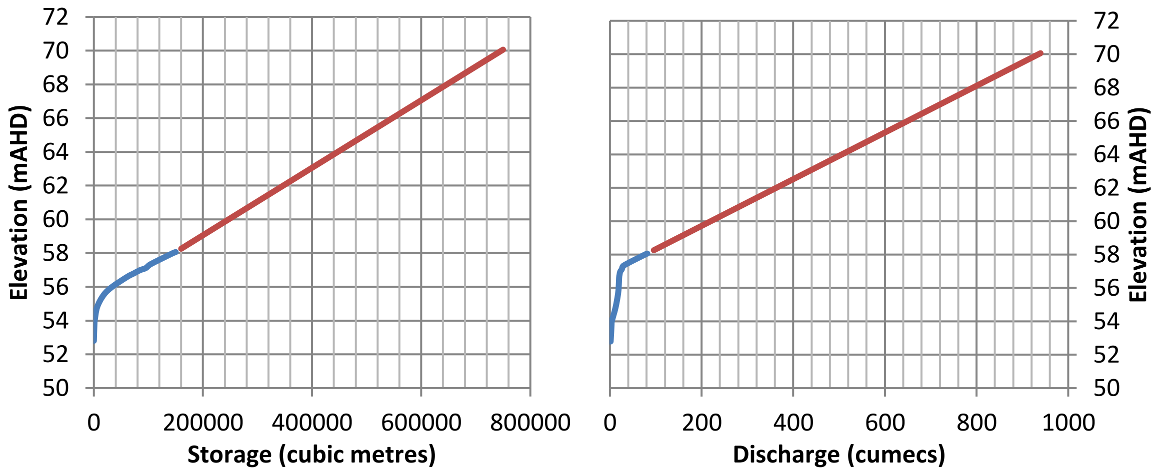


Figure 3-5 Huntingdale Rd RB Stage-Storage and Stage-Discharge Curves

3.3.1.6 Diversions

The Scotchmans Creek RORB model does not include any piped diversions. The TUFLOW model covers the entire extent of the Melbourne Water drainage system and any diversions will be accounted for dynamically within the 2D-1D hydraulic model.

3.3.1.7 Global Parameters

RORB model parameters used in the modelling of the Scotchmans Creek catchment are summarised in Table 3-5 and discussed further in subsequent sections.

Table 3-5 RORB Parameters

	Scotchmans Creek MD
Storm Data	See Section 3.3.1.8
Catchment Area (km^2)	21.7
Initial Loss (mm)	10
Runoff Coefficient	See Section 3.3.1.9
m	0.8
k_c	10.0
Fraction Impervious	See Section 3.1
Reach Type	2, and 4

3.3.1.8 Intensity Frequency Duration (IFD) Parameters

Storm data was based on IFD parameters sourced from the Bureau of Meteorology (BoM 2009) website using the co-ordinates at the centre of the catchment, MGA Zone 55 (GDA 94), easting 335152, northing 5805833. These parameters were then compared to those used in the Oakleigh North Main Drain Pilot Study (email dated 15/03/2010) and the Glen Waverley Main Drain Flood Mapping Study (Water Technology 2004) and were found to be similar. The adopted values for the catchment are presented in Table 3-6. The full IFD table is presented in Appendix A.

Table 3-6 IFD Parameters

IFD Parameter		Adopted Value
Rainfall Intensity (mm/hr)	2 Year ARI, 1 Hour Duration	18.74
	2 Year ARI, 12 Hour Duration	4.18
	2 Year ARI, 72 Hour Duration	1.19
	50 Year ARI, 1 Hour Duration	36.86
	50 Year ARI, 12 Hour Duration	7.24
	50 Year ARI, 72 Hour Duration	2.28
Skew Coefficient		0.36
Geographical Factor F2		4.28
Geographical Factor F50		14.97
Zone		1

3.3.1.9 Loss Model

RORB generates excess runoff by subtracting losses at each time-step from the rainfall occurring in that time period. The “initial loss followed by a runoff co-efficient” loss model was adopted. The adopted initial loss was 10 mm for urban catchments and the runoff-coefficient was varied with ARI as indicated in Table 3-7. The parameters used are as specified in MW Technical Specifications. For impervious areas, RORB has a “hardwired” initial loss of 0 mm and runoff coefficient of 0.9.

Table 3-7 Runoff-coefficients with ARI

	5 Yr ARI	10 Yr ARI	20 Yr ARI	50 Yr ARI	100 Yr ARI	PMP
Runoff Coefficient	0.25	0.35	0.45	0.55	0.6	0.9

3.3.1.10 Model Calibration

For the purposes of calibration, a base case calibration RORB model was developed. This model was developed with Reach Types to match the assumptions made in the Rational Method calculation and excluded storages. Where the velocities used in the Rational Method calculation were derived from assuming pipe flow, these reaches were modelled using Reach Type 3. Where the velocities were derived assuming open channel, Reach Types 2 or 3 were used depending on the channel characteristics.

RORB can be calibrated by varying the pervious area, initial loss and RORB parameters k_c and m. An initial loss of 10 mm was adopted and m set to 0.8 as per the requirements of the technical specification. Consequently, the k_c parameter was the only parameter adjusted during the calibration process.

A k_c of 10.00 was adopted for the Scotchmans Creek RORB model after comparison of the peak discharge at the catchment outlet with the Rational Method. Table 3-8 compares the calibrated RORB model results to the Rational Method at various locations within the catchment. As the Scotchmans Creek catchment is greater than 20km^2 in area the possibility of varying k_c throughout the model was investigated however, as the flows from the base case calibration RORB model compared favourably with Rational Method Flows, this was considered unnecessary. A k_c value of 10.00 resulted in a k_c/D_{av} ratio of 6.94 km. This k_c/D_{av} ratio could be preserved when the same parameters were applied to the base case RORB model.

A review of existing hydrological studies was performed in order to gain any useful information which may aid in the calibration of the Scotchmans Creek RORB model. The existing hydrological studies performed in the catchment included the:

- Melbourne Water Drainage Survey 1996/97, City of Monash (CMPS&F 1998),
- Glen Waverley Main Drain Flood Mapping Study Report, Report No. J130/R01 Draft D, December 2004 (Water Technology 2004), and
- Oakleigh North RSS Pilot Study Hydrologic Modelling (Unpublished GHD 2009).

Following a review of the available information, it was concluded that it was not applicable to calibrate the new RORB model to the information contained in these studies. The CMPS&F study reported diverted RORB model results which were not able to be compared with any of the undiverted RORB models developed for this study. The Water Technology and GHD studies were incomplete leaving a high level of uncertainty in relation to the applicability of the results which would be used for comparison. All three existing studies also had FI values which varied significantly from those used in this study.

Table 3-8 Rational Method and RORB Comparisons

Location*	100y ARI Peak Flow (m^3/s)	
	Rational Method	Base Case Calibration RORB Model
Scotchmans Creek Inflow (1)	13.3	14.7
Tally-Ho Inflow (2)	22.1	29.8
Tally-Ho Outflow (3)	32.2	31.5
Scotchmans Creek - Tally-Ho Junction (4)	52.3	51.0
Montclair Ave Inflow (5)	13.4	14.3
Montclair Ave Outflow (6)	13.5	15.1
Scotchmans Creek - Montclair Ave Junction (7)	72.3	76.5
Glen Waverley Inflow (8)	13.5	16.7
Mountain View Inflow (9)	10.7	13.6
Mountain View Outflow (10)	13.5	14.3
Glen Waverley - Mountain View Junction (11)	37	39.6
Glen Waverley Outflow (12)	28.7	36.1
Scotchmans Creek - Glen Waverley Junction (13)	95.5	111.4
Macrina St Inflow (16)	15.1	17.3
Macrina St Outflow (17)	25.6	29.0
Scotchmans Creek - Macrina St Junction (18)	118.3	125.1
Oakleigh North Inflow (21)	20.6	26.9
Oakleigh North Outflow (22)	42	43.5
Scotchmans Creek - Oakleigh North Junction (23)	129.7	129.9
Scotchmans Creek Outflow (24)	128.6	128.6

** Note: The location numbers and descriptions are displayed in Figure 1-2.*

*** Note: The parameters and results for the rational method are not reported at the retarding basin inflow and outflow locations as the impacts of storages are not included in rational method calculations.*

3.3.2 Calculation of PMP

The probable maximum precipitation (PMP) was derived using the Generalised Short-Duration Method (GSDM) (BoM 2003). The PMP storms modelled in RORB were spatially and temporally distributed in accordance with the GSDM method. Figure 6 of BoM (2003) provides a spatial distribution template with the zones being labelled alphanumerically. The catchments under consideration in this study fell within Zones A, B and C. The PMP mean rainfall depths are provided in Table 3-9.

Table 3-9 Summary of PMP Values

Ellipse	Mean Rainfall Depths (mm)								
	15m	30m	45m	1h	1.5h	2h	2.5h	3h	4h
A	128	185	234	271	310	345	368	388	424
B	111	164	208	246	280	315	335	351	388
C	102	151	193	228	262	293	312	328	367

Refer to Appendix C for the completed GSDM worksheet. Please note that the catchment falls within the intermediate zone as define by Figure 2 in the GSDM. Accordingly, the maximum GSDM storm duration to be used is interpolated between the 3 and 6 hour events based on the catchments location. For Melbourne catchments, the maximum duration is approximately the 4 hour storm.

For large catchments with significant storage, longer durations may be critical. The PMP for longer duration storms are derived using the Generalised Southeast Australia Method (GSAM). Following an analysis of the critical storm durations in the hydraulic model, the longer duration PMP events did not need to be derived for the Scotchmans Creek catchment.

3.3.3 Climate Change Modelling

The climate change scenario was assessed using the base case RORB model, but with the design rainfall intensity increased by a factor of 32% and the F2 and F50 values factored for the increased rainfall using the MW F2 and F50 calculation spreadsheet for increased rainfall, as per the Consultancy Services Brief (MW 2008). A summary of the IFD parameters used for the climate change scenario are summarised in Table 3-10.

Table 3-10 Climate Change Scenario IFD Parameters

IFD Parameter		Adopted Value
Rainfall Intensity (mm/hr)	2 Year ARI, 1 Hour Duration	24.74
	2 Year ARI, 12 Hour Duration	5.52
	2 Year ARI, 72 Hour Duration	1.57
	50 Year ARI, 1 Hour Duration	48.66
	50 Year ARI, 12 Hour Duration	9.56
	50 Year ARI, 72 Hour Duration	3.01
Skew Coefficient		0.36
Geographical Factor F2		4.40
Geographical Factor F50		16.73
Zone		1

Other than the different IFD parameters, all other files and parameters, i.e. catg, k_c and m, were the same used for the base case scenario.

3.3.4 RORB Results Summary

The following results table has been compiled from the Base Case RORB model which includes all appropriate adjustments to reach types to reflect the predominant flow characteristics along each given reach. The final RORB model also includes the storages within the catchment. This has resulted in a lower peak discharge than the 'calibration' model.

3.3.4.1 Base Case

A summary of the peak flows for the Base Case are shown below in Table 3-11. The critical storm duration hydrographs at the top of the main drains (hydraulic model upstream boundaries) and the catchment outlet are shown in Figure 3-6 to Figure 3-13. Figure 3-14 and Figure 3-15 show the critical PMP hydrographs at the same locations.

Table 3-11 Base Case RORB Model Results

Location*	Peak Flow (m^3/s)					
	5yr	10yr	20yr	50yr	100yr	PMP
Scotchmans Creek Inflow (1)	4.3	5.4	7.0	9.9	12.2	66.1
Tally-Ho Inflow (2)	9.8	13.1	17.5	24.2	29.8	142.0
Tally-Ho Outflow (3)	8.9	11.6	15.3	20.3	25.0	151.6
Scotchmans Creek - Tally-Ho Junction (4)	14.9	19.3	25.7	34.2	41.3	249.0
Montclair Ave Inflow (5)	3.6	4.5	6.0	7.8	9.5	60.1
Montclair Ave Outflow (6)	3.6	4.6	6.0	7.9	9.6	61.7
Scotchmans Creek - Montclair Ave Junction (7)	19.7	25.6	33.8	45.2	55.8	401.4
Glen Waverley Inflow (8)	5.2	6.8	9.0	12.0	14.7	71.3
Mountain View Inflow (9)	3.4	4.5	6.0	7.9	9.6	58.0
Mountain View Outflow (10)	4.1	5.4	7.4	9.9	12.1	76.7
Glen Waverley - Mountain View Junction (11)	11.3	14.7	19.3	25.2	30.3	191.4
Glen Waverley Outflow (12)	10.8	13.9	18.5	24.6	30.0	196.7
Scotchmans Creek - Glen Waverley Junction (13)	29.8	38.5	51.3	68.8	84.8	596.3
Waverley Rd RB Inflow (14)	31.3	40.4	53.6	72.1	87.2	645.6
Waverley Rd RB Outflow (15)	14.9	16.4	27.4	46.8	61.5	594.5
Macrina St Inflow (16)	6.9	8.7	11.2	14.5	17.3	93.0
Macrina St Outflow (17)	8.2	10.4	13.4	17.8	21.4	138.3
Scotchmans Creek - Macrina St Junction (18)	28.1	33.2	39.7	55.7	73.6	769.9
Huntingdale Rd RB Inflow (19)	28.7	33.9	40.6	56.1	74.2	781.3
Huntingdale Rd RB Outflow (20)	20.0	23.3	32.5	51.9	67.6	714.3
Oakleigh North Inflow (21)	6.7	8.6	11.2	14.8	17.9	106.4
Oakleigh North Outflow (22)	11.0	14.5	19.7	26.4	32.3	225.3
Scotchmans Creek - Oakleigh North Junction (23)	31.3	36.8	42.7	60.2	74.7	804.6
Scotchmans Creek Outflow (24)	33.7	38.8	44.9	61.6	75.4	816.2

** Note: The location numbers and descriptions are displayed in Figure 1-2.*

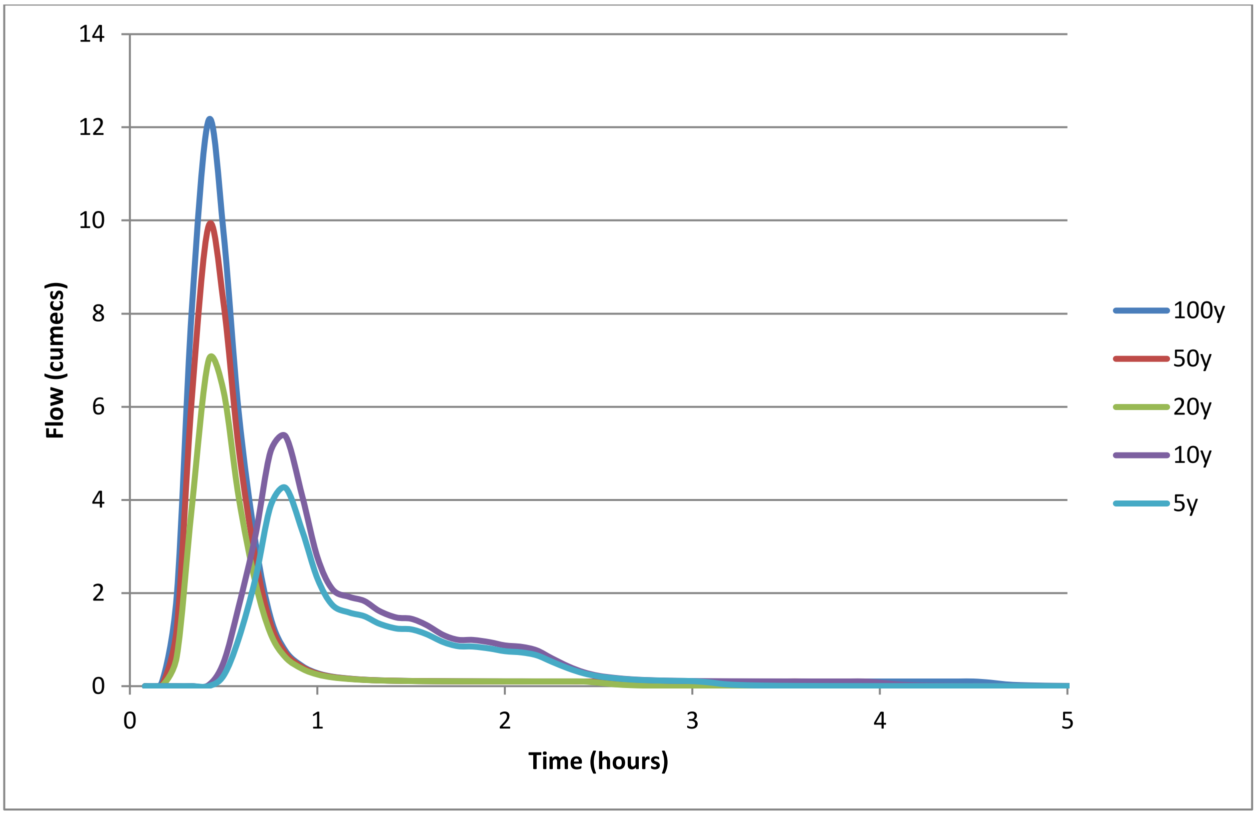


Figure 3-6 Critical Duration Hydrographs at Scotchmans Creek Inflow

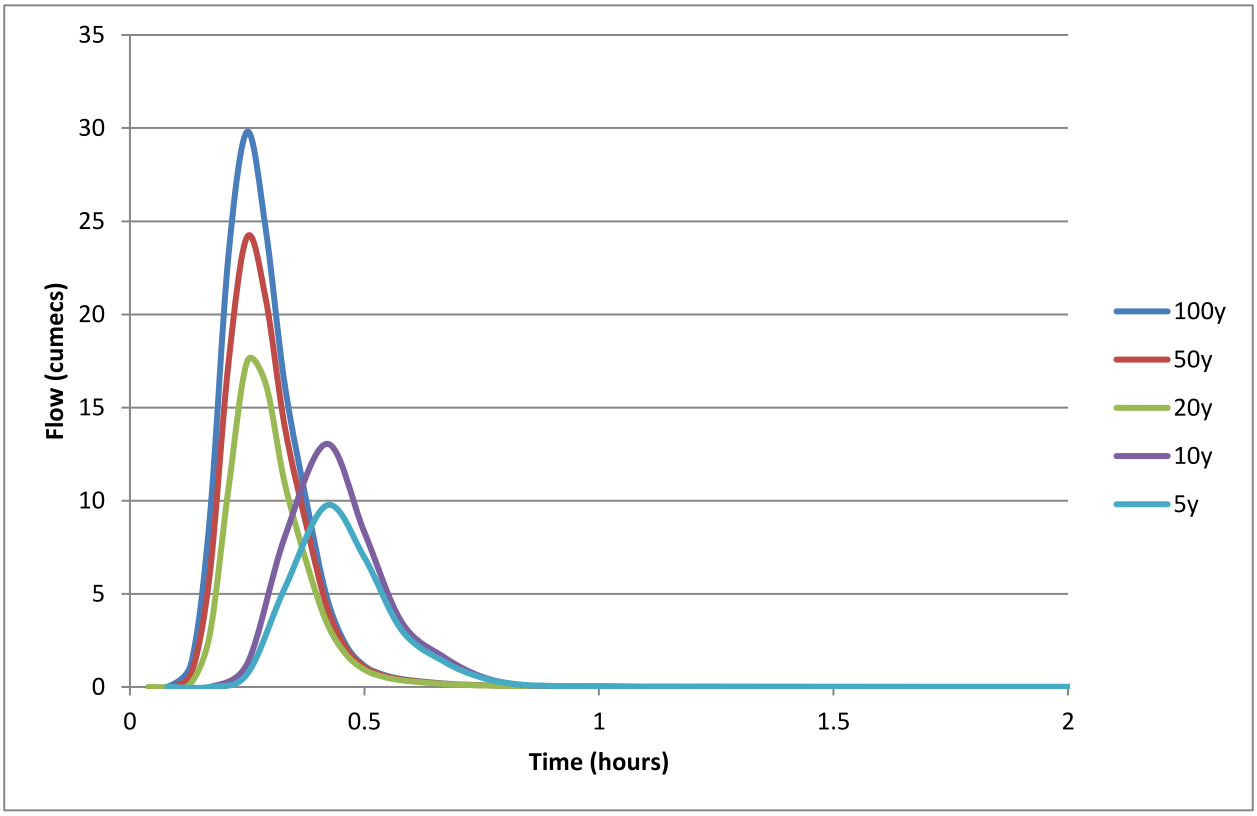


Figure 3-7 Critical Duration Hydrographs at Tally-Ho Inflow

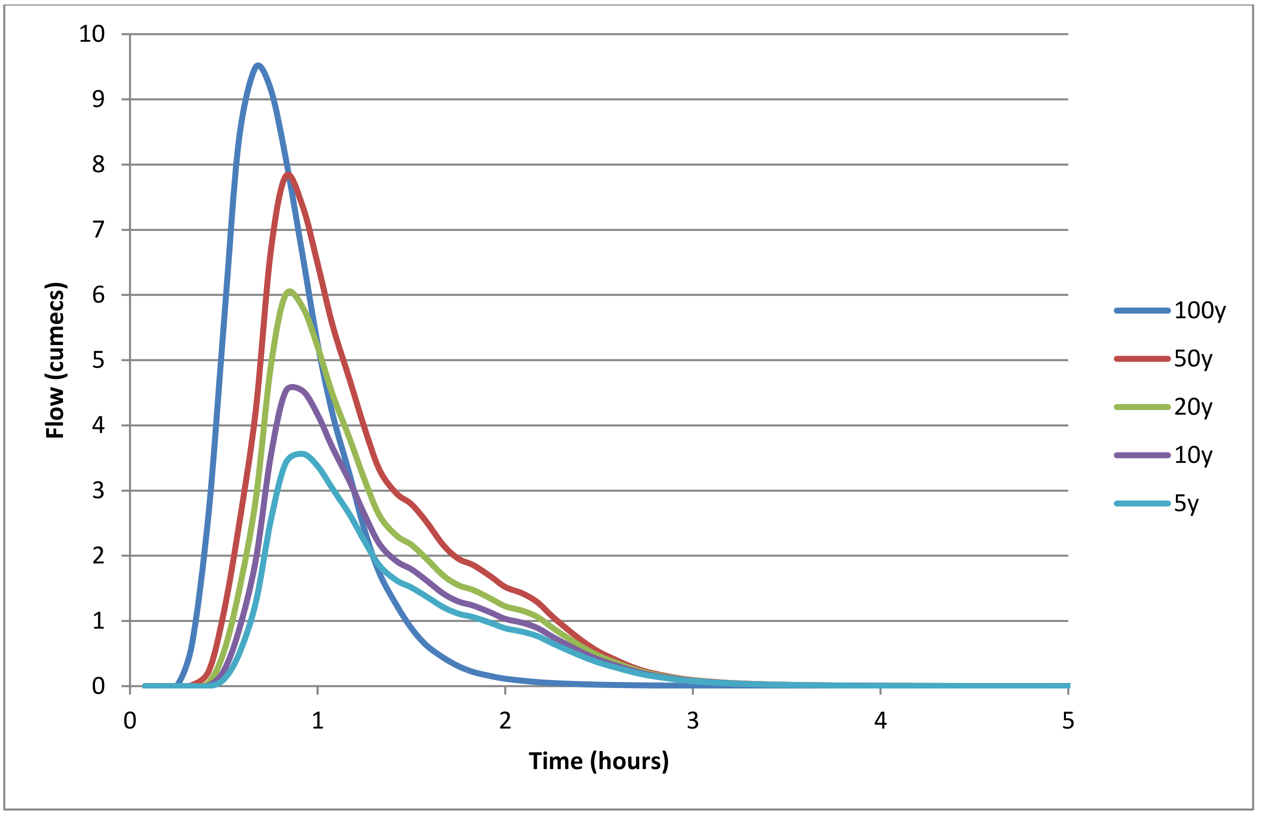


Figure 3-8 Critical Duration Hydrographs at Montclair Avenue Inflow

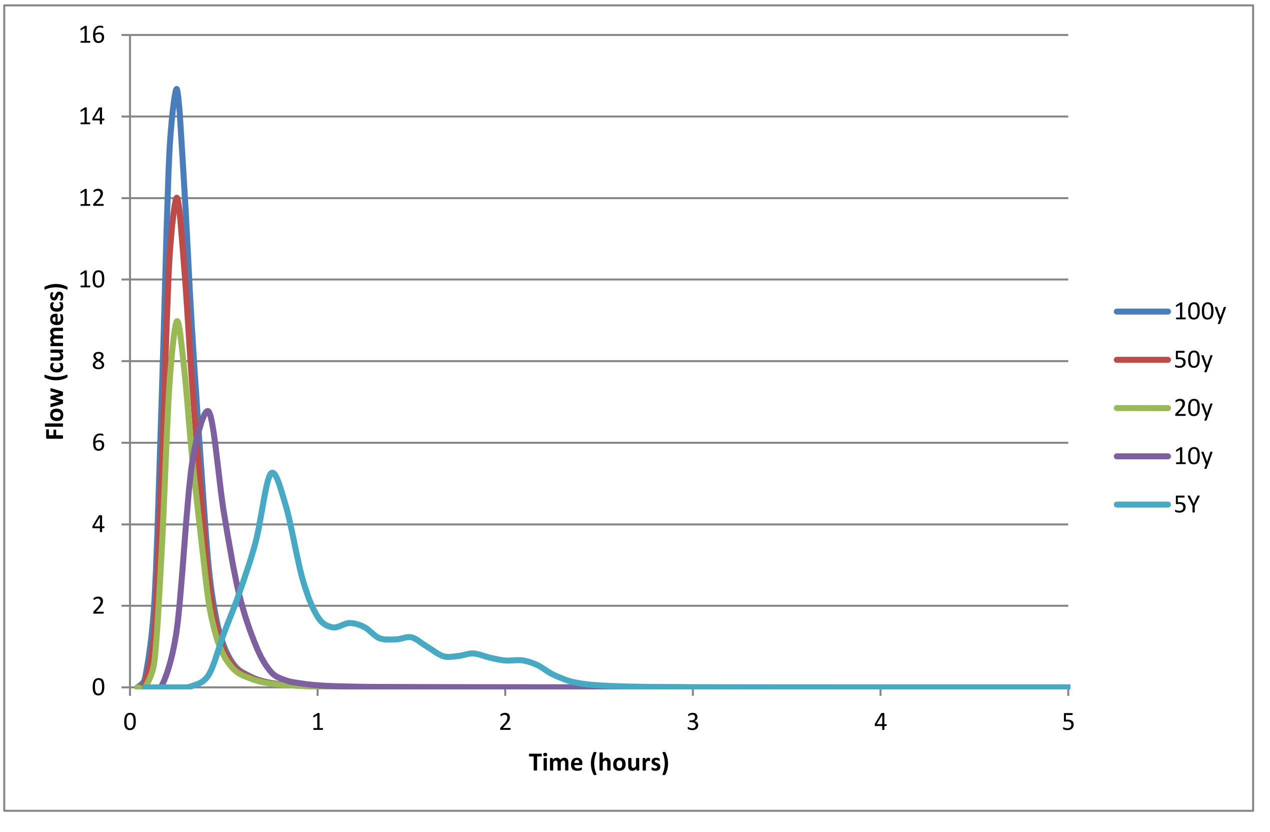


Figure 3-9 Critical Duration Hydrographs at Glen Waverley Inflow

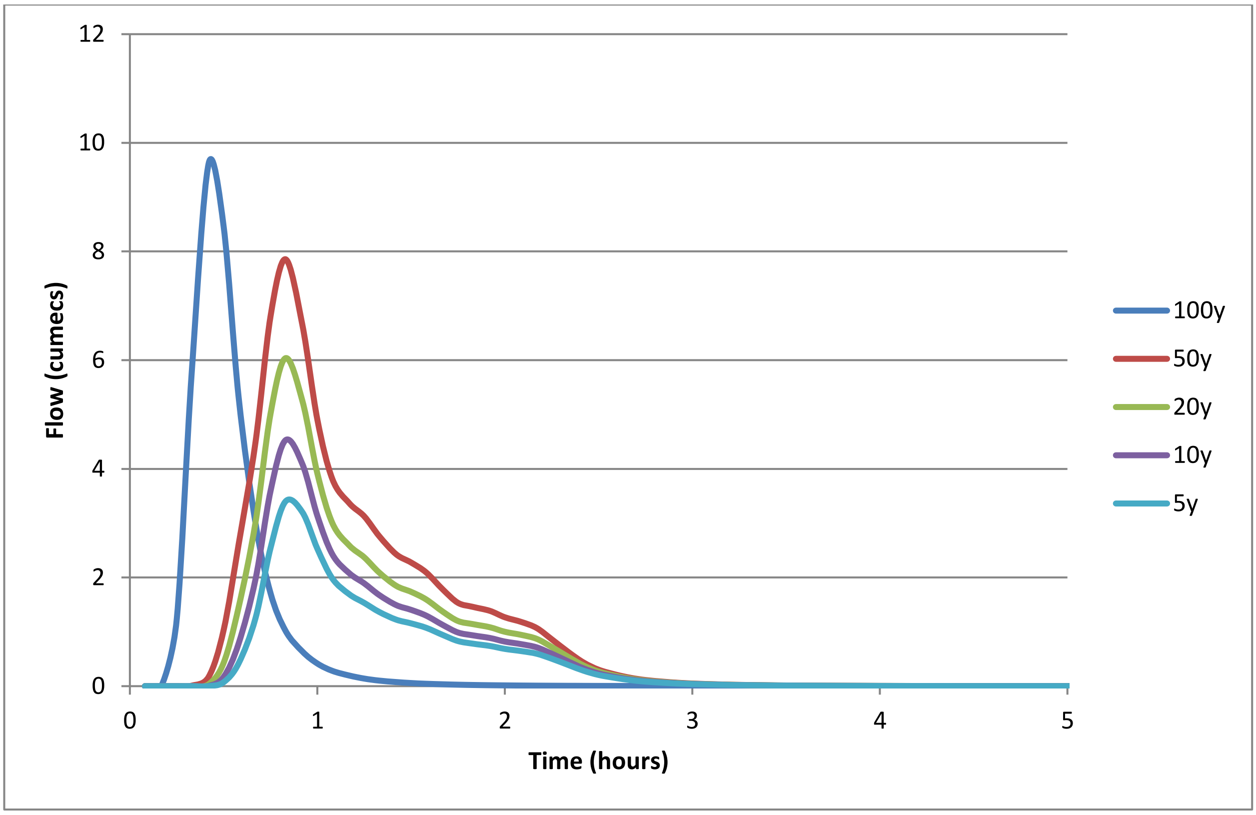


Figure 3-10 Critical Duration Hydrographs at Mountain View Inflow

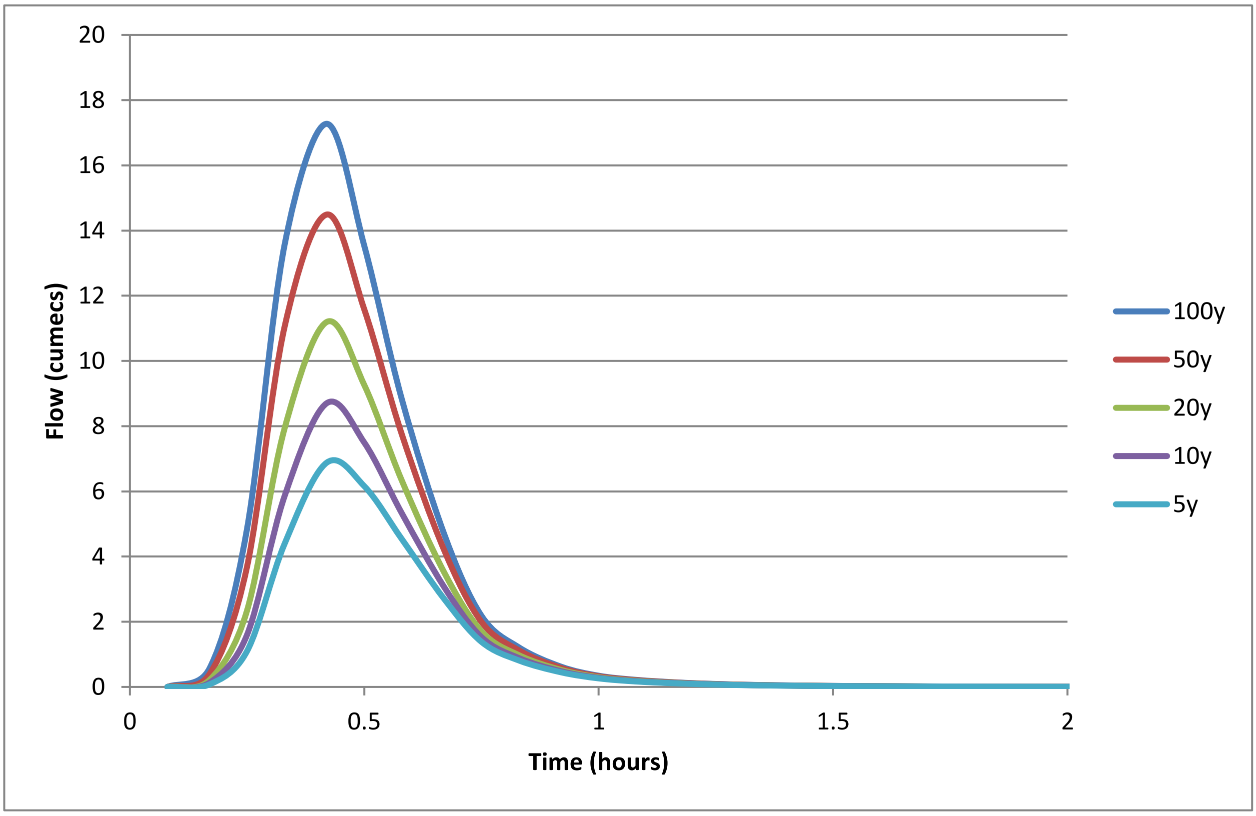


Figure 3-11 Critical Duration Hydrographs at Macrina Street Inflow

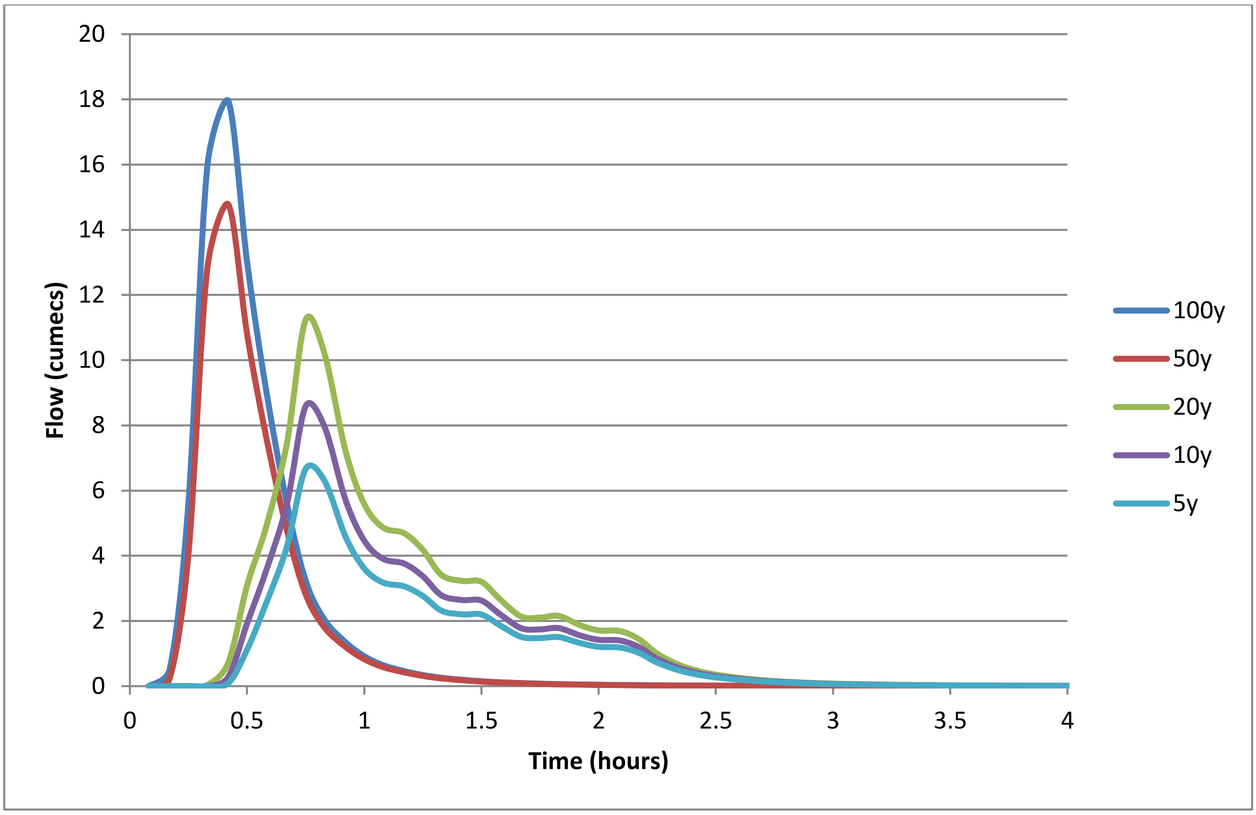


Figure 3-12 Critical Duration Hydrographs at Oakleigh North Inflow

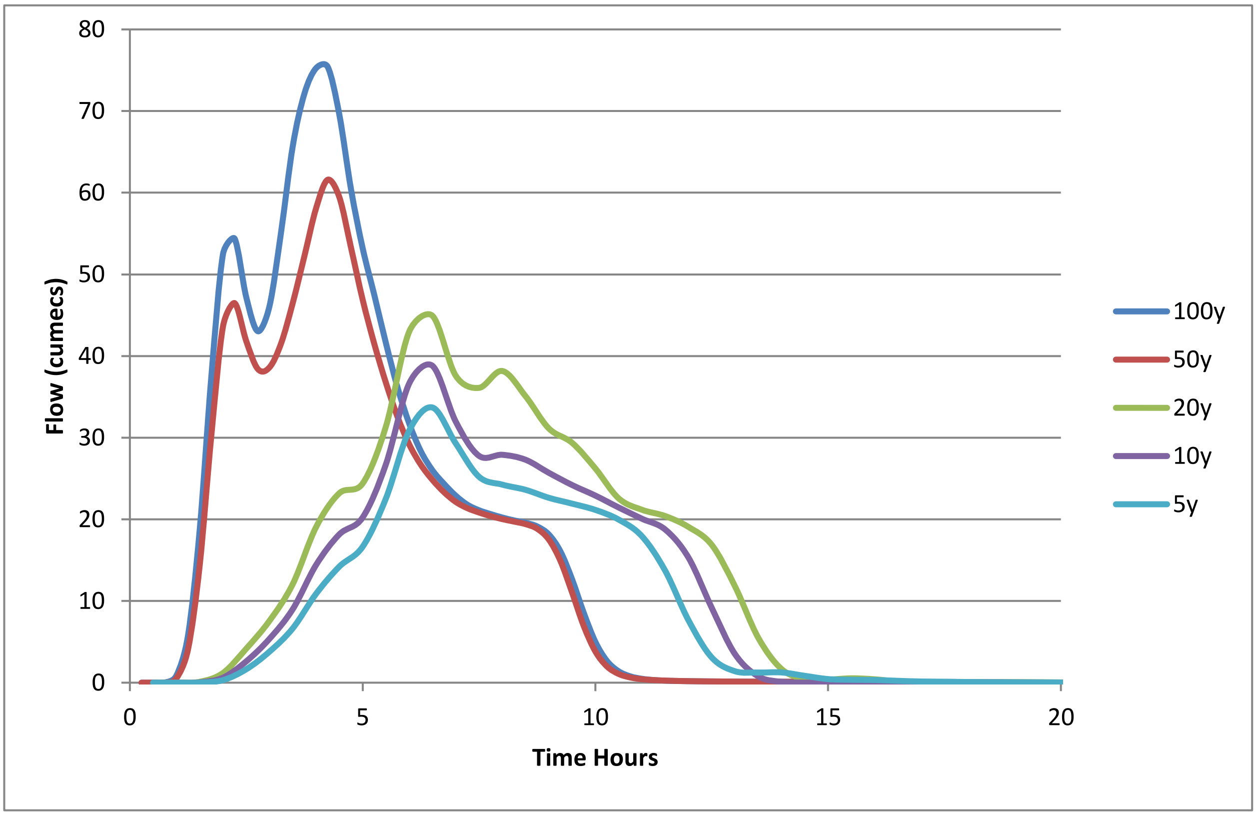


Figure 3-13 Critical Duration Hydrographs at Scotchmans Creek Outflow

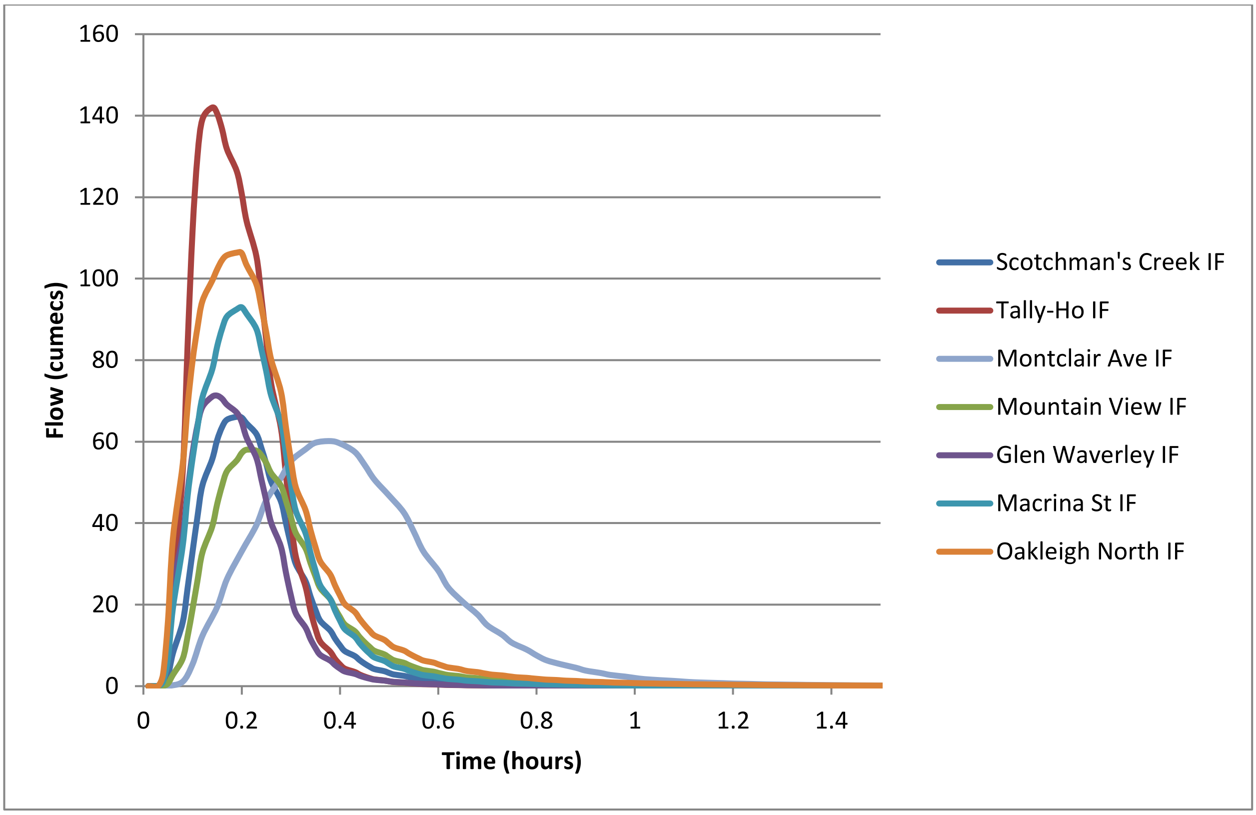


Figure 3-14 Critical Duration PMP Hydrographs

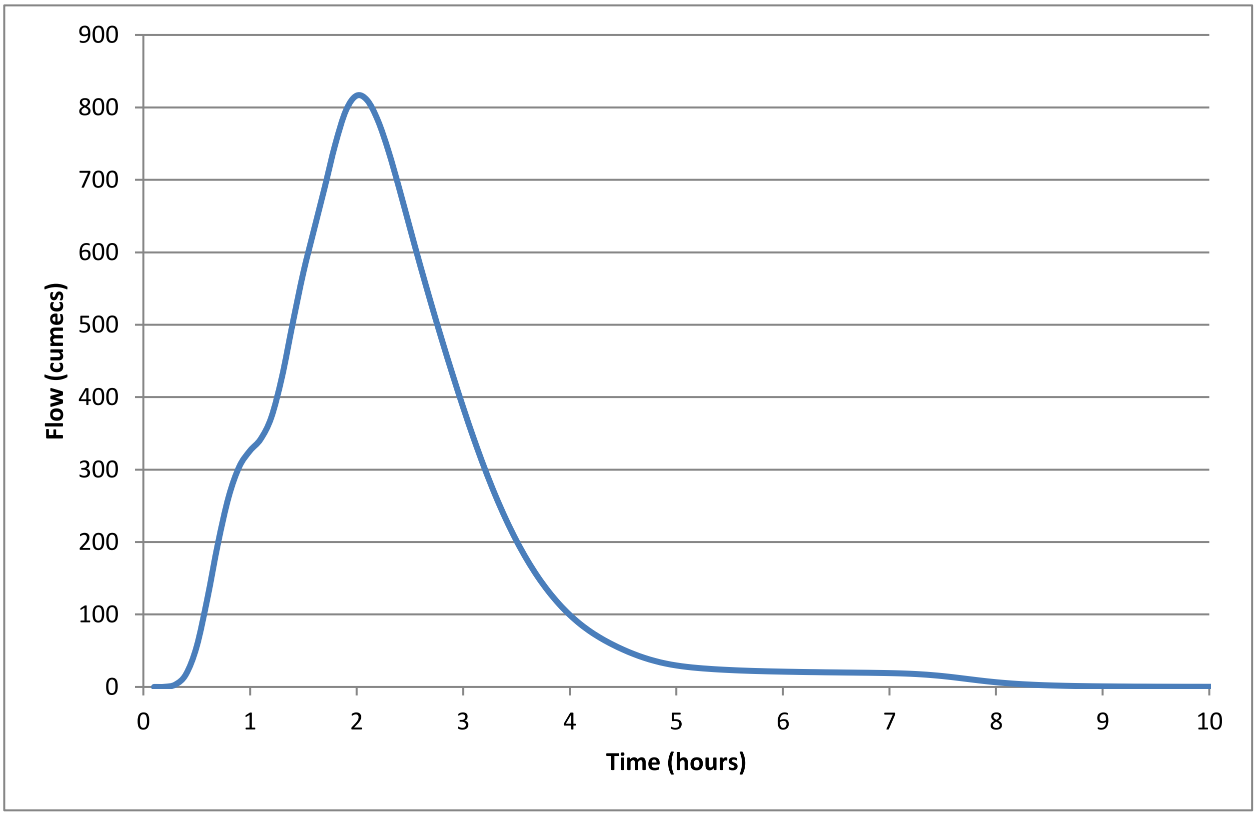


Figure 3-15 Critical Duration PMP Hydrograph at Scotchmans Creek Outflow

3.3.4.2 Climate Change Case

A summary comparison of the 100 year ARI Base Case and Climate Change peak flows are shown in Table 3-12. Figure 3-16 shows comparison hydrographs for all ARI's s9at the Scotchmans Creek Outflow.

Table 3-12 100 Year ARI Base Case and Climate Change Comparison

Location*	Peak Flow (m^3/s)	
	Base Case	Climate Change
Scotchmans Creek Inflow (1)	12.2	16.7
Tally-Ho Inflow (2)	29.8	40.4
Tally-Ho Outflow (3)	25.0	34.6
Scotchmans Creek - Tally-Ho Junction (4)	41.3	56.6
Montclair Ave Inflow (5)	9.5	13.2
Montclair Ave Outflow (6)	9.6	13.2
Scotchmans Creek - Montclair Ave Junction (7)	55.8	78.3
Glen Waverley Inflow (8)	14.7	20.1
Mountain View Inflow (9)	9.6	13.9
Mountain View Outflow (10)	12.1	16.6
Glen Waverley - Mountain View Junction (11)	30.3	42.9
Glen Waverley Outflow (12)	30.0	42.2
Scotchmans Creek - Glen Waverley Junction (13)	84.8	118.1
Waverley Rd RB Inflow (14)	87.2	124.1
Waverley Rd RB Outflow (15)	61.5	96.0
Macrina St Inflow (16)	17.3	23.5
Macrina St Outflow (17)	21.4	29.4
Scotchmans Creek - Macrina St Junction (18)	73.6	114.8
Huntingdale Rd RB Inflow (19)	74.2	115.9
Huntingdale Rd RB Outflow (20)	67.6	106.1
Oakleigh North Inflow (21)	17.9	25.0
Oakleigh North Outflow (22)	32.3	45.4
Scotchmans Creek - Oakleigh North Junction (23)	74.7	111.4
Scotchmans Creek Outflow (24)	75.4	113.3

** Note: The location numbers and descriptions are displayed in Figure 1-2.*

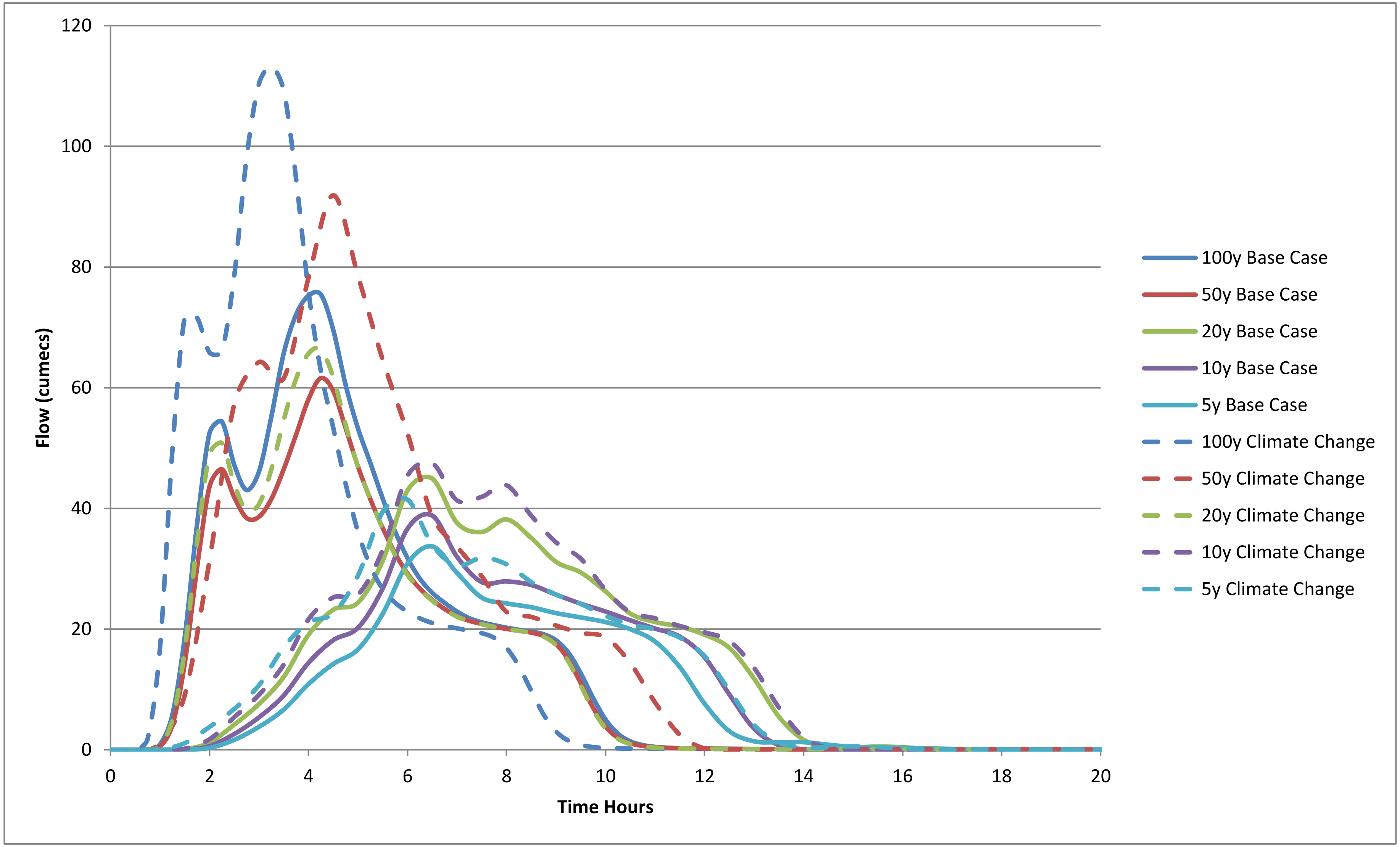


Figure 3-16 Critical Duration Climate Change Hydrograph Comparisons at Scotchmans Creek Outflow

4 HYDRAULIC MODELLING

This section provides a description of the TUFLOW modelling process for the Scotchmans Creek catchment. A 1D/2D dynamically linked TUFLOW hydraulic model of the Scotchmans Creek Catchment was developed as part of this study with the aim of, ultimately, flood mapping the catchment for the events and Scenarios outlined in the Study Brief, as listed in Table 4-1.

Table 4-1 Required Hydraulic Modelling Scenarios

ARI	5 yr	10 yr	20 yr	50 yr	100 yr	PMP
Base Case	✓	✓	✓	✓	✓	✓
Climate Change	✓		✓		✓	

This report accompanies the flood mapping for the 5, 10, 20, 50 and 100 year ARI and PMP events for the base case and climate change scenarios, as required by the Technical Specification. The following sections detail the development of the hydraulic model used to produce the flood mapping for the Scotchmans Creek catchment. The inflows to this hydraulic model were taken from the hydrologic RORB model of the catchment, details and results of which were provided in the *Scotchmans Creek Flood Mapping Hydrology Report* (BMT WBM, 2010b), and are reproduced in the previous sections of this report.

4.1 Hydraulic Modelling Methodology

Typical drainage in a catchment is through a complex system of major and minor underground pipes, open channels, overland flowpaths and retarding basins. Current minor drainage practice would require that a pipe network have a capacity of typically the 5 to 10 year ARI and that surcharging flows in larger events, up to the 100 year ARI event, be managed through defined overland flowpaths. Development in the overland flowpaths is generally restricted.

In older areas, such as the Scotchmans Creek catchment, the underground drainage will often have a capacity less than the 5 year ARI event. Surcharging flow will be conveyed in the streets until the conveyance capacity of the street is exceeded, beyond which the flow will often spill in an uncontrolled manner into residential and commercial areas. To model these complexities, TUFLOW, a fully 2D hydraulic modelling package with the ability to dynamically nest 1D elements, was adopted.

Overland flow paths and storages were modelled in the 2D domain and underground drainage structures were represented as 1D elements dynamically linked to the 2D domain.

A further consideration in catchments such as Scotchmans Creek is the representation of storages, including retarding basins, natural storage in overland flowpaths, and the timing of the rainfall inflows. To represent these effects, a model using flow varying with time (unsteady state) rather than peak flow (steady state) is required. For these reasons an unsteady model was developed.

4.1.1 Model Schematisation

The Scotchmans Creek model was schematised as a dynamically linked 1D/2D TUFLOW model. The model was designed to cover the area at risk of flooding from MW assets. The area modelled was extended in certain areas to minimise boundary effects and incorporate adjacent catchments likely to influence flooding from MW assets.

The underground drainage system was represented as a 1D network in the hydraulic model. For Scotchmans Creek, this included the modelling of approximately 10.7km of MW pipe assets. Approximately 2km of open channel between the Huntingdale Road RB and upstream of Forster Road was also represented as a 1D network embedded in the 2D domain.

The floodplain topography and other significant hydraulic features, such as retarding basins, were represented within the 2D domain. A 2D domain was developed using a 3m grid resolution (refer to Section 4.2). Elevation data was derived from the LiDAR data provided by MW.

External inflow boundaries were applied directly to the 1D pipe network at the upstream end of MW assets. Internal inflow boundaries were distributed throughout the model to ensure a "realistic" distribution of rainfall throughout the study area. The internal boundaries were distributed between the 1D and 2D domains as appropriate. The downstream boundary (Gardiners Creek) for the TUFLOW model was provided by MW and was set to a fixed water level.

Details of the model setup and application are described below and shown in Figure 4-1 and Figure 4-2.

4.1.2 TUFLOW Version

Model runs were performed with the 2009-07-DB-iDP-64 build of TUFLOW. The elevations in the model exceed 100 mAHD, hence in accordance with the TUFLOW manual, the double precision version of TUFLOW was required. Due to the large size of the TUFLOW model the 64 bit version was required for the model to compile.

4.1.3 Design Event Modelling

During the model development process, all ARI and PMP events were modelled in TUFLOW for a number of storm durations encompassing the critical storm durations identified during the RORB hydrological modelling of the catchment. This initially resulted in the modelling of all storm durations up to the 24 hour for the ARI events and the 4hour for the PMP event, as summarised in Table 4-2 and Table 4-3.

Table 4-2 ARI Storm Durations for Initial Hydraulic Modelling

Storm Duration	15 min	20 min	25 min	30 min	45 min	1 hr	1.5 hr	2 hr	3 hr	4.5 hr	6 hr	9 hr	12 hr	18 hr	24 hr

Table 4-3 PMP Storm Durations for Initial Hydraulic Modelling

Storm Duration	15 min	30 min	45 min	1 hr	2 hr	2.5 hr	3 hr	4 hr

The hydraulic model results for the storm durations listed above were reviewed to identify the critical storms throughout the catchment. This analysis indicated that the 25 minute duration storm generally resulted in peak flood height at the top of the main drains. As expected, further downstream longer duration storms resulted in higher peak flood levels. Within the Waverley Road RB, the 2 hour storm duration resulted in peak flood levels, while in the Huntingdale Road RB it was the 4.5 hour storm. The 9 hour storm duration resulted in the peak flood level at the Monash Freeway / Warrigal Road interchange. Following this analysis, the 13 storm durations listed in Table 4-4 were modelled for the design events, except for the PMP event where all durations were simulated (Table 4-5).

Table 4-4 ARI Storm Durations for Design Hydraulic Modelling

Storm Duration	15 min	20 min	25 min	30 min	45 min	1 hr	1.5 hr	2 hr	3 hr	4.5 hr	6 hr	9 hr	12 hr

Table 4-5 PMP Storm Durations for Design Hydraulic Modelling

Storm Duration	15 min	30 min	45 min	1 hr	2 hr	2.5 hr	3 hr	4 hr

A peak flood height envelope was developed from the 13 durations and the peak envelope flood surface and extent mapped for each ARI and the PMP. The mapping is presented in Section 5.

4.1.4 Model Extent

The TUFLOW model's 2D domain extends from upstream of MW assets to the downstream boundary where Scotchmans Creek flows into Gardiners Creek. Additional domain area above MW assets was included to ensure that "boundary" effects did not impact on flooding within the flood mapping area.

In addition, preliminary investigations indicated that in the PMP event flow breaks out into the adjacent Murrumbeena Main Drain and Mile Creek Main Drain catchments. At the downstream boundary the extent of the 2D domain was extended west along Gardiners Creek to incorporate the drainage path which runs parallel with The Rialto, which in turn conveys the break out flow into the Murrumbeena Main Drain catchment, then into Gardiners Creek as shown in Figure 4-1. The model boundary was also extended south of the Mountain View sub-catchment inflow, into the Mile Creek Main Drain catchment to ensure that flow boundary at this location could be correctly represented.

4.2 2D Domain

The 2D model domain, along with the 1D pipe network, are shown in Figure 4-1. The 2D domain covers an area of approximately 5.1 km^2. The geometry of the 2D model was established by constructing a uniform grid of square elements. One of the key considerations in establishing a 2D hydraulic model relates to the selection of an appropriate grid element size. Element size effects the resolution, or degree of accuracy, of the representation of the physical properties of the study area as well as the size, and thus memory request, of the computer model and its resulting run times. Selecting a very fine grid element size will result in both higher resolution results and longer model run times.

The adopted 3 m grid size resulted in approximately 570,000 grid elements and provided a good definition of topography and floodplain storage, whilst keeping run times to an acceptable length. Each square grid element contains information on ground topography sampled from the DEM at 1.5 m spacing, surface resistance to flow (Manning's 'n' value) and initial water level.

To maintain an acceptable Courant number, the 2D domain of the model was run on a 0.75 second timestep for the 5, 10, 20, 50 and 100 year ARI events. However, the increased flood depths of the PMP event required that the 2D domain be run at a 0.5 second timestep.

4.2.1 Breaklines

Breaklines are often incorporated into TUFLOW models to add detail on course grids, such as gutters, roads, railways, or to ensure that certain aspects of the terrain that would act as hydraulic controls are included, such as levees, embankments or other solid walls.

The z-point layer used by TUFLOW was reviewed and found to represent key flow paths, such as roadways, in acceptable detail given the 3m grid adopted for the model. For this reason, only minor 2D breaklines needed to be incorporated into the model.

4.2.2 2D Hydraulic Structures

It is important to ensure that large (2D grid size or larger) impediments and constrictions to flow are properly incorporated in the TUFLOW model. 2D hydraulic structures include features such as bridges, large weirs and spillways.

There are a variety significant 2D hydraulic structures within the Scotchmans Creek catchment, including the Waverley Road RB spillway, that were not adequately represented in the underlying 2D domain, requiring further definition. There were also several bridge structures within the catchment that were represented using TUFLOW's Flow Constriction Shape and Layered Flow Constriction Shape features, based on supplied data (Section 2).

Where the deck soffit levels were significantly above the maximum PMP flood height, bridge decks were not included in the model. The appropriate form losses were gained from AUSROADS *Waterway Design: A Guide to the Hydraulic Design of Bridges, Culverts and Floodways* (AUSROADS 1994).

4.2.3 Significant Topography Features

Significant topographic features, such as road embankments that effect flood flows, should be incorporated into the 2D domain. Conversely, where the original data underlying the DEM is erroneous due to the procedure in which the data is collected and/or filtered, it is good practice to correct these issues.

As noted above, significant barriers to flows such as road embankments should be reinforced in the 2D domain if they are not accurately represented by the model grid. There were three instances where this occurred in the Scotchmans Creek topography. Consequently, the topography was altered to remove these deficiencies.

Due to the majority of the open channel within the Scotchmans Creek catchment being represented within the 2D domain, it was important that any restrictions to flow due to deficiencies in the underlying DEM were smoothed. A number of locations where the topography resulted in 2D negative depth warnings were subsequently 'smoothed' to improve model performance.

4.2.4 Retarding Basins

Retarding basins are designed to attenuate a significant volume of water, therefore ensuring that the capacity of a retarding basin is represented in TUFLOW is important. This includes ensuring that embankments and spillways are accurately detailed to ensure the correct volume and spill rate from the retarding basin is represented in TUFLOW.

There are two retarding basins within the Scotchmans Creek catchment at Waverley Road and at Huntingdale Road (Figure 4-1). Both retarding basins incorporate constructed wetland systems. To represent these complex hydraulic systems, they have incorporated into both the 1D and 2D domains, with the geometry and secondary spillways (weirs) being represented within the 2D domain and the pipes represented in the 1D domain. There are also several other hydraulic structures associated with the retarding basins which have been represented within the 1D or 2D domains as appropriate. For further details on the modelling of the 1D elements within the retarding basins, refer to Section 4.3.

The resolution of the 2D grid elements was sufficient to model the embankments and general topography of the retarding basins. However, greater representation of spillways, litter traps and inlet structures was required. This was achieved through the manipulation of the grid element elevations to better represent these structures.

4.2.5 Roughness Layer or Manning's *n*

The roughness layer, or Manning' s 'n' layer, was based on areas of different land-use type determined from planning maps, aerial photography and site inspections. The adopted Manning's 'n' values are summarised in Table 4-6 and the layer is shown in Figure 4-1. The values used are based on standard texts such as *Open Channel Hydraulics* (Chow 1959).

To improve model stability in the PMP events the roughness along the Monash Freeway was increased from 0.02 to 0.05 and the roughness downstream of the 1D open channel network and within the litter trap at the inlet of the Huntingdale Road RB was increased to 0.06 to match the surrounding vegetation. These alterations were only included in the PMP model runs.

Table 4-6 2D Domain Manning's 'n' Coefficients

Land Use	Manning's 'n'
Roads	0.02
Railway Easements	0.035
Residential	0.2
High Density Residential/ Commercial/ Industrial	0.4
Grass Maintained	0.03
Grass Unmaintained/ Sports Ovals	0.04
Low Density Vegetation	0.045
Medium Density Vegetation	0.06
High Density Vegetation	0.1
Water Bodies	0.035
Concrete Lined Channel	0.017
Stone Lined Channel	0.025
Clean Straight Stream	0.035
Stream with Stones and Vegetation	0.05
Sluggish Stream with Pools and Vegetation	0.07
Heavily Vegetated Stream	0.1

4.3 1D Network

4.3.1 1D Pipe Network

The underground pipe network makes up a significant part of the Scotchmans Creek drainage system. The pipe network and associated pits were modelled in 1D, and were dynamically linked to the 2D domain using TUFLOW's 'pit' feature. A Manning's 'n' of 0.013 was adopted for the stormwater pipes. All MW pipes that form the Scotchmans Creek catchment were modelled, with the addition of selected council pipes to correctly model the flood behaviour at the top of MW water assets to remove uncertainties, thereby reducing the influence of any boundary effects.

Where available, dimensions and invert levels were adopted from the MW GIS pipe data set. The supplied plans were used to fill missing data and check the validity of the GIS data where possible. For those pipes where pipe information was still missing, through discussion with MW, it was agreed that they could be derived from adjacent pipes or by interpolation.

In some instances, the GIS pipe data was also graphically altered. This occurred where the location of the 1D network did not align with 2D topography allowing for proper representation of the 1D/2D linking. There were also many instances where structures, such as pits and manholes, within the 1D pipe network were represented as short pipe segments. This impacted upon model performance and subsequently these short sections of the network were modelled as 'connecting' elements or amalgamated into the adjacent pipes.

The 1D domain of the model was run with a 0.375 second timestep for the 5, 10, 20, 50 and 100 year ARI events and 0.25 second timestep for the PMP event. These timesteps were required to keep Courant numbers within the range recommended in the TUFLOW manual.

4.3.2 Embedded 1D Channels

The majority of Scotchmans Creek downstream of the end of piped section at Flander Avenue is open channel, except for the RBs, road crossings and the piped section which runs under the Monash Freeway from Warrigal Road. As the open channel is defined in acceptable detail due to the 3m grid size adopted for the study, the majority was not incorporated into the model as a 1D embedded open channel. Survey that included cross-sections (Section 2.5), was available for a section of open channel between upstream of Forster Road and the Huntingdale Road RB. This section was modelled as a 1D channel embedded in the 2D domain.

Each section of 1D open channel was given an appropriate Manning's 'n' value to define the channel roughness, based on aerial photography, site inspections and plans. The adopted Manning's 'n' values are summarised in Table 4-7. The values used are based on standard texts such as *Open Channel Hydraulics* (Chow 1959) and contain some composite values where the channel cross-sections are partially concrete lined.

Table 4-7 1D Open Channel Manning's 'n' Coefficients

Land Use	Manning's 'n'
Concrete Lined Channel	0.02
Concrete Lined/Vegetation Composite	0.023-0.024
Clean, Winding Stream	0.04
Stream with Stones and Vegetation	0.045-0.055
Sluggish Stream with Pools and Vegetation	0.065-0.07

4.3.3 Other Hydraulic Structures

Within the Scotchmans Creek catchment there are a variety of additional hydraulic structures that were accurately represented as 1D elements, rather than within the 2D domain. These include road culverts, weirs and bridges embedded within the 1D open channel network. These 1D elements were incorporated into the TUFLOW using the appropriate 1D element type and attributes.

4.3.4 Structure Losses

Pipe pit and junction losses were modelled as fixed form losses on the downstream pipe(s) connected to the junction or pit by applying the appropriate loss at that node. Losses at pits and junctions were estimated and set on an individual per pit basis. These losses were set in accordance with those in the Melbourne Water Land Development Manual Appendix E (MW 2006).

For the section of culverts under the Monash Freeway between Warrigal Road and Gardiners Creek, junction losses were not applied as it was assumed that local council pipes likely discharged into the culverts prior to the catchment wide flow reaching the lower end of the catchment and the relatively small size, and hence flow, of the council pipes in comparison to the MW assets.

For pipe segments with bends (mitred or curved) or that had intermediate council lateral inflows, an appropriate bend or pressure loss coefficient was also incorporated into the TUFLOW model by applying them directly to the 1D pipe element as a form loss. Additional losses were applied as appropriate to drop pits and large gradient changes in the pipe network.

4.4 Boundary Conditions

A hydraulic model requires the specification of inflow boundaries and outlet boundaries to allow water into and out of the model in a realistic manner. Often 2D hydraulic models will have external and internal inflow boundaries. The external inflow boundaries account for flow generated from outside of the model extents (external boundaries) whereas internal boundaries account for the runoff generated from, and to be applied within, the model extents. Flow is removed from the model through downstream boundaries, which are generally a fixed water level or a rating curve.

The Scotchmans Creek model had external upstream inflow boundaries, internal inflow boundaries, an automatically generated stage-flow boundary with the Mile Creek catchment and a downstream water level boundary.

4.4.1 External Boundaries

There were seven upstream external boundaries applied to the model at the upstream end of the Main Drains as indicated in Figure 4-1. In all cases, flow was applied directly to the first node in each branch as a flow-time series (hydrograph), and allowed to surcharge directly to the 2D domain. This was done to minimise boundary effects and ensure realistic flow patterns.

The Scotchmans Creek catchment discharges to Gardiners Creek. MW supplied a fixed water level of 27.64 metres AHD. This water level, based on a 10 year ARI flood event in Gardeners Creek was applied to all ARIs and the PMP for both the base case and climate change scenarios. The boundary was applied as a fixed water level boundary 'snapped' to the model boundary running along Gardiners Creek for a distance required to remove any break out flows into the Murrumbeena Main Drain catchment. The downstream boundary was also extended to provide a flow boundary on the inundated Gardiners Creek floodplain.

In the PMP event, flow breaks out of the Scotchmans Creek catchment into the adjacent Mile Creek catchment directly south of the Mountain View inflow. To allow for this flow to be removed from the model, preventing an accumulation of water that would greatly overestimate the extent of flooding in the area, an additional external flow boundary was incorporated.

The Mile Creek catchment flow boundary was modelled using an automatically generated stage-flow boundary. For TUFLOW to automatically generate a stage-flow curve, a slope must be specified. As a result, the model boundary was extended into the Mile Creek catchment far enough to establish a constant slope. This also ensured that any potential boundary effects were removed from within the mapping limits.

4.4.2 Internal Boundaries

Internal inflow boundaries represent runoff occurring within, and/or to be applied within, the model bounds. In total 139 internal inflow boundaries were applied. For the Scotchmans Creek TUFLOW model, the internal boundaries were applied by distributing the flow directly to the pipe network and into the 2D domain as appropriate.

In applying flow directly to the pipe network, it is assumed that the runoff can enter the pipe, and once the capacity of the pipe is exceeded, can surcharge to the surface through the pits. Flow is also applied directly to the 1D open channel where appropriate. To ensure that the application of flow best represented the characteristics of the catchment, flow was distributed between nodes based on topography, land use, and the layout of the council drainage system.

Where it is appropriate, such as in retarding basins and open channel modelled in the 2D domain, flow is applied into the 2D domain. The same considerations were considered when distributing the flow in the 2D domain as in the 1D network.

4.4.3 1D/2D Linking

The 1D network was dynamically linked to the 2D domain through boundary cells. These boundary cells pass water from one domain to the other. In urban models it is usual for the exchange of water between the 1D pipe network and the 2D domain to occur at pits. Accordingly, boundaries were set at these locations in the Scotchmans Creek model.

To ensure a sufficient inlet capacity all pipe segments along the major pipe networks were connected to pits with the following exceptions; when two or more pits fell within the proximity of a couple of 2D grid cells or on the segment of pipe which runs under the Monash Freeway. When the former occurred, only one of the pits was connected to the 2D domain.

The connection between the pipes and the 2D domain was through the TUFLOW pit node feature. Pits were modelled within TUFLOW as 'weirs' 6 m wide (two grid cells). The large size was adopted to ensure, as much as practicable, the free interchange of water between the 1D and 2D domains.

Culverts under roads, 1D structures within the retarding basins and the 1D open channel were dynamically linked to the 2D domain on an individual basis to ensure that flow is transferred in a manner that correctly represents the characteristics of the structures and the topography.

4.4.4 Initial Water Levels

Initial water levels can be set within a TUFLOW model to reduce the risk of initial model instability caused by large differences between water level in the downstream boundary and adjacent ground levels (e.g. from Gardiners Creek into the adjacent floodplain and the lower reaches of Scotchmans Creek). Initial water levels can also vary spatially using one or more GIS layers. This is particularly useful for setting initial water levels in lakes, dams, wetlands, etc such that excess flood storage volume is not being generated within the model.

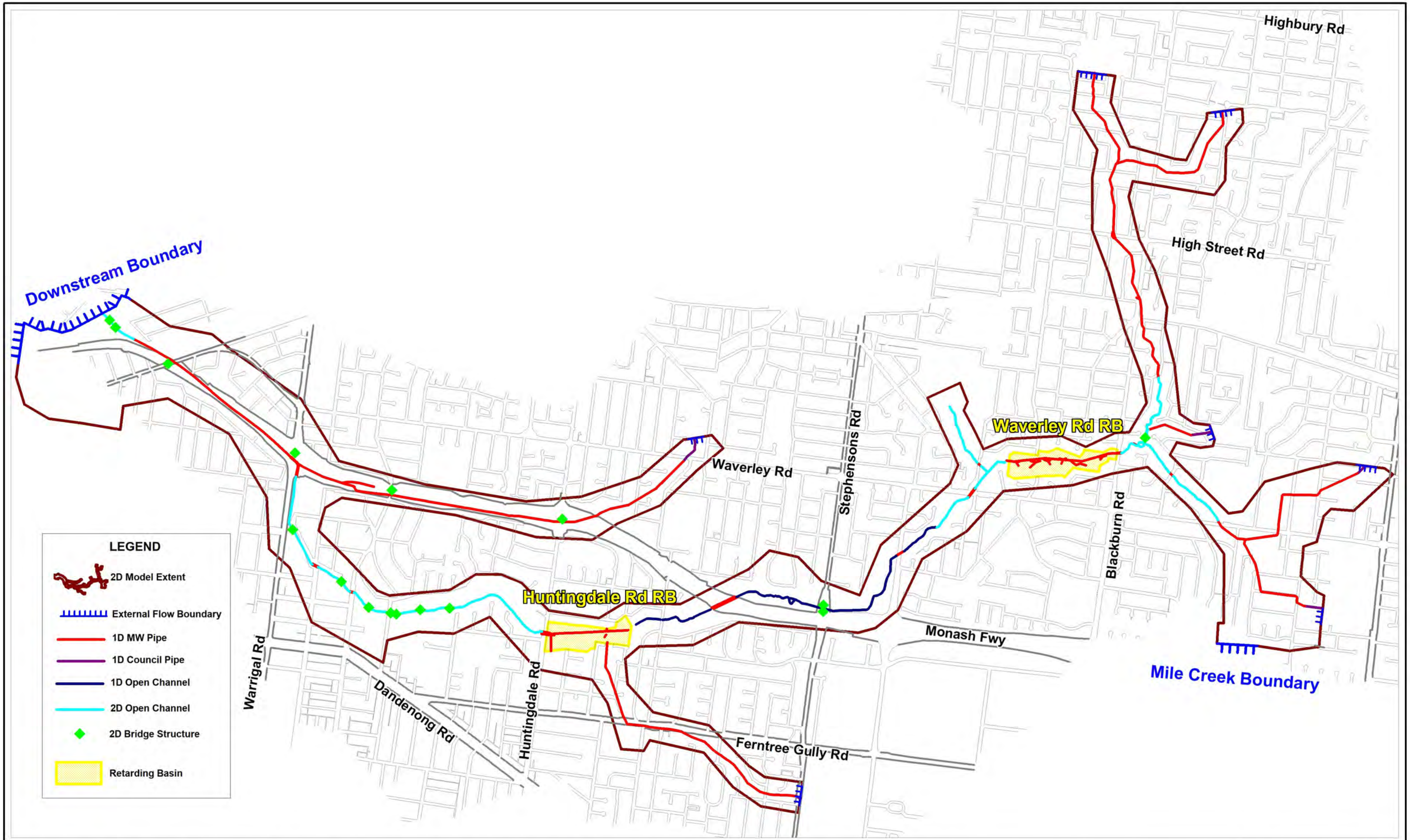
An underlying initial water level of 27.64 m AHD was applied to the Scotchmans Creek. This level represents the fixed water level adopted for the downstream boundary (Gardiners Creek). Within the retarding basin wetland systems, initial water levels were set that represent the operating water levels specified in the provided plans.

4.5 Probable Maximum Flood

The peak flow generated by the PMP is nearly an order of magnitude greater than the peak flow from 100 year ARI storm event. With this large increase in the in the volume of water modelled it is often necessary to adopt different techniques to ensure the PMP model is stable. These techniques may include introducing additional nodal storage, reduced timesteps and other techniques as required.

In the case of the Scotchmans Creek model it was necessary to reduce the 2D timestep to 0.5 seconds. It was also necessary to set the minimum nodal area storage to $10m^2$. The Manning's roughness coefficient was also increased in some small areas, as discussed in Section 4.2.5.

In all other respects the TUFLOW model used in the PMP is identical to those used for more frequent events (100 year ARI and below).



*Note: Internal inflow boundaries have not been included in the TUFLOW Model Schematisation figure in order to achieve clarity in the figure.
For further details of the internal inflow boundaries, refer to Section 4.4.2.

Title:
Scotchmans Creek TUFLOW Model Schematisation

Figure: 4-1

Rev: B

N

0 0.5 1km
Approx. Scale

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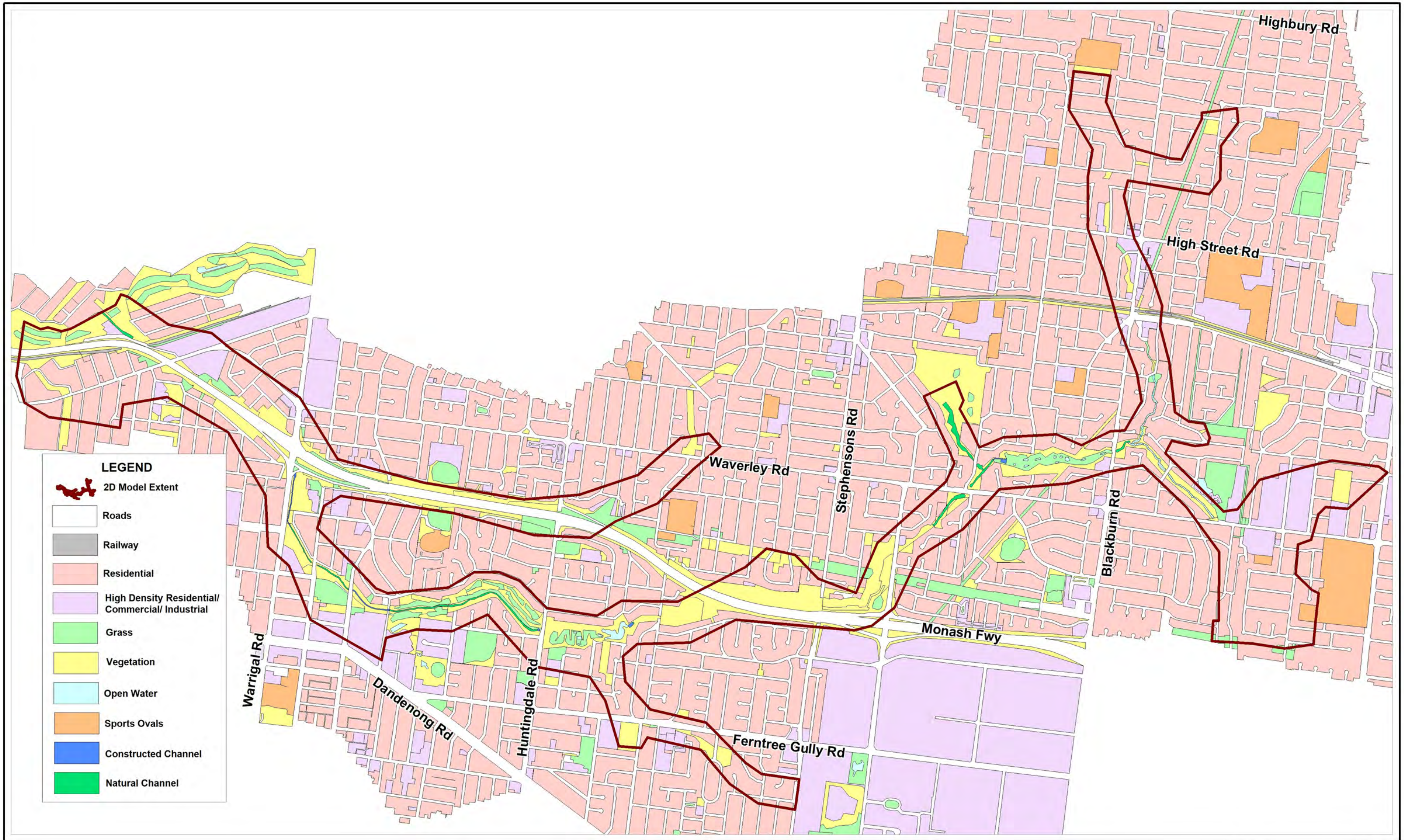

Title:
Scotchmans Creek Manning's Roughness Distribution

Figure: 4-2

Rev: B

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4.6 Quality Assurance

To ensure that the Scotchmans Creek TUFLOW model was producing acceptable results it was comprehensively reviewed. This section outlines the Quality Assurance (QA) measures undertaken.

4.6.1 General Quality Assurance

As part of the quality control of the model, a review of the TUFLOW messages output was carried out. Messages during compiling of the model were reviewed and any issues resolved. Warnings produced by TUFLOW during the run were also investigated. Locations and structures causing recurring warnings were identified and a solution implemented to reduce or remove the cause of the issue.

4.6.2 1D Domain

As part of the QA process for the 1D domain, the following checks were performed:

- Pipe inverts were consistent with no reverse gradients and pipes generally met typical minimum cover requirements. The review was performed using miTools, a typical plot from which is shown in Figure 4-3.

- 1D/2D links were selecting the correct number of cells and allowing a 'free interchange' of water. This involved checking the 1d_to_2d_check file. The dH (change in water level) values in the 1d_mmH results file were checked for disproportionate changes in water levels between adjacent pipe elements.

- For the pipe network, the maximum percentage full and percentage of time flowing full were checked using the 1d_ccA results files for the 100 year ARI Base Case 2 hour event. All pipe assets in the model were found to be running full with some exceptions that were individually checked.

4.6.3 2D Domain

As part of the QA process for the 2D domain the following checks were performed:

- TINs were created from the zpts check file to ensure the 2D cell size resolution was appropriate to reproduce the topography in selected areas of interest. The TINs were compared to the LiDAR DEM, and were reviewed to ensure the correct implementation of any breaklines, z-shapes or other terrain altering layers. Key hydraulic controls were reviewed to ensure a continuous and appropriate representation in the model grid.

- Material roughness' were checked by importing and thematically mapping the uvpt_check file to ensure surface resistance was applied correctly.

- Initial water levels in the model were checked by reviewing the grd_check file.

- The extent of the 2D domain was reviewed to ensure it was not limiting flood extents in the larger flood events (i.e. PMP).

4.6.4 Volume Balance and Mass Conservation

Volume checks and conservation of mass are arguably the most important checks. Volume checks are important as they check that all the input hydrographs are being applied to, and interpreted correctly by, TUFLOW. Mass conservation is important as it's an indicator of model health and therefore the likely accuracy of the computed solution. As part of the QA process, the following checks were performed:

At external flow boundaries, the hydrograph shapes were checked to ensure they matched with the input flow hydrographs.

Volume balance checks of the model are shown for the 100 year ARI 2 hour event in Table 4-9. The total volume of excess rainfall reported by the RORB model was compared to the volume in the TUFLOW model. The volume in the TUFLOW model was determined by calculating the sum of the volumes from all the inflow boundaries in the 1D and 2D domains within the model. This table indicates a close agreement between the RORB volume and the TUFLOW volume.

Table 4-8 Volume Balance Check

Model	100yr 2hr
RORB Volume	888,667 m^3
TUFLOW Volume	891,284 m^3
% Difference	0.3

Conservation of mass was checked by reviewing the percentage cumulative mass error (%CE) reported by TUFLOW. These values were reviewed for all models and found to be well within the ± 1% range typical for a healthy model. The maximum percentage cumulative mass error for the 5, 100 year ARI and PMP events are summarised in Table 4-9.

Table 4-9 Mass Balance Error

Model	5yr 2hr	100yr 2hr	PMP 2hr
%CE Difference (TUFLOW Log File)	-0.1	+/-0.1	-0.1

4.6.5 Additional Model Checks

During the modelling process it became clear that the Waverley and Huntingdale Road Retarding Basins had a large influence on the flooding characteristics within the catchment. As a result, additional emphasis was placed on sensitivity testing the modelling of these hydraulic controls. Stage-discharge curves were derived from the hydraulic model and compared to the design curves, shown in Section 3.3.1.5. The performance of each retarding basin in the hydraulic model is discussed in the following section.

The Waverley Road RB outlet structure comprises of a large grated inlet pit which lies flush with the retarding basin embankment and an overflow spillway. Given the size of the pit structure it can pass a significant amount of flow resulting in the form loss applied having a significant influence on the flood levels within the catchment. Due to the unusual nature of this structure very limited literature on appropriate form losses could be found. As a result, sensitivity testing was undertaken to determine whether a lower form loss value of approximately 0.5, or higher value of 2.1, would result in higher 100 year ARI flood levels. While both values changed the flood levels within the basin and downstream, the change in flood levels in the 100 year event was generally less than 0.2m and contained within the existing waterway easement. It was agreed with MW to adopt the higher form loss value of 2.1 as it resulted in more conservative flood levels downstream.

The Huntingdale Road RB design stage-discharge curve predicts higher discharges than the TUFLOW model at all stages, but particularly at stages lower than the glory hole spillway level. A review of the capacity of the outflow pipes suggested that tailwater levels were not considered when the design stage–discharge curve was produced, therefore the discharge achieved within the hydraulic model was considered more appropriate. The inclusion of a wetland system within the retarding basin also restricts the performance of the outlet structure at low flows as water is diverted through the wetland system.

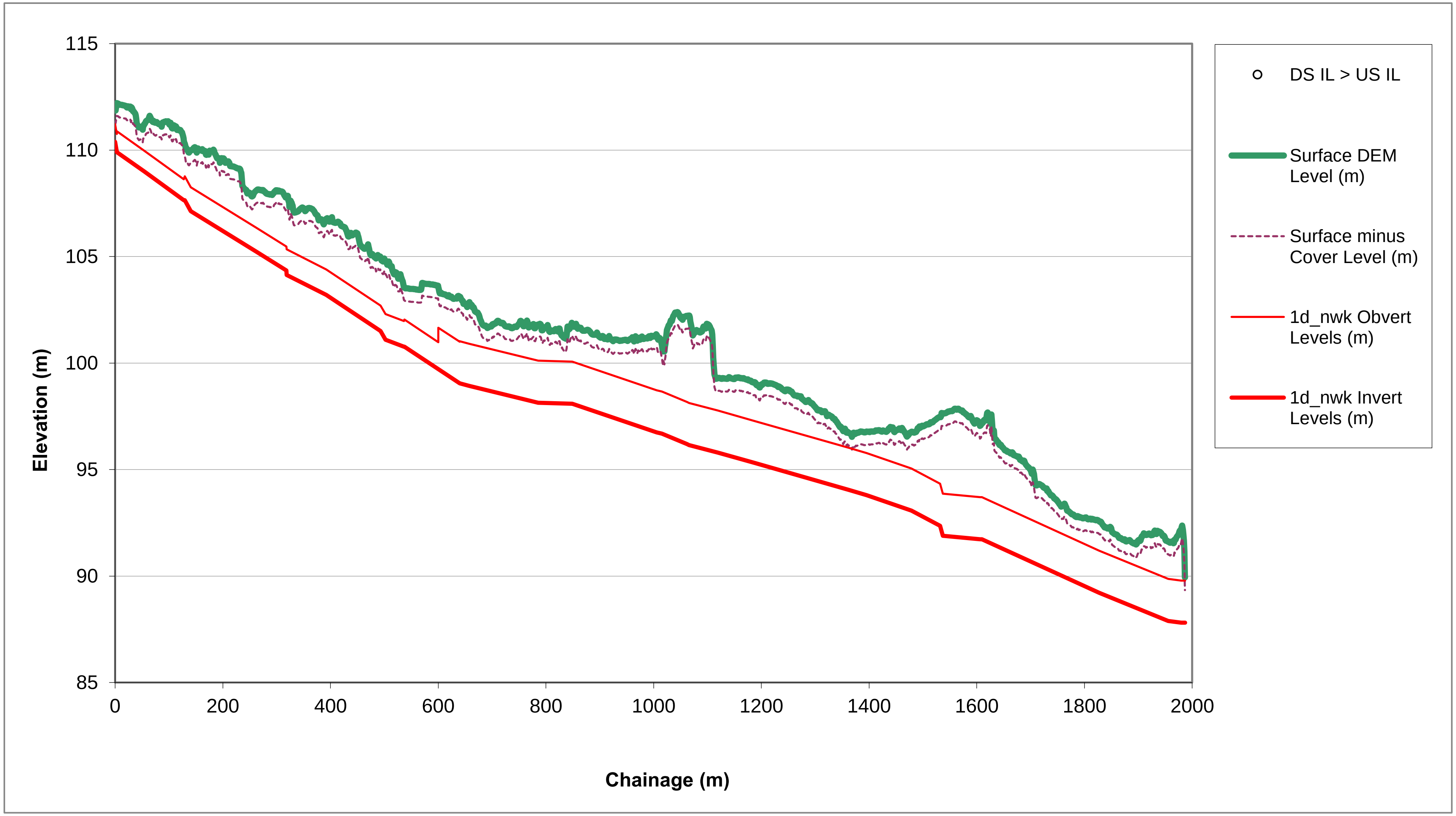

Figure 4-3 1D Pipe Network Long-Section Plot

** Note: This is a sample long-section taken from the Scotchmans Creek Inflow to Flander Avenue. Similar plots were created to check the inverts of all pipe sections.*

5 FLOOD MAPPING AND RESULTS

This section provides a brief overview of the flood mapping process used in this investigation and provides a summary of the flood mapping results. Flood mapping has been undertaken for all the events outlined in Table 1-1.

TUFLOW was used to produce geo-referenced datasets defining peak water levels, depths, velocities, depth-velocity (i.e. hazard) and critical duration throughout the model domain. For a Given ARI, the peak value from each of the storm durations was selected for each computational cell to generate peak envelopes. The data was imported into GIS to generate digital models of the above-mentioned flood properties and produce the required flood mapping outputs. Flow data was also extracted from TUFLOW at defined reporting locations.

The Base Case flood extents for the 5 to 100 year ARI events and the PMP event are illustrated in Figure 5-1 to Figure 5-6. Corresponding maps for the 5, 20 and 100 year ARI events for the Climate Change scenario are illustrated in Figure 5-7 to Figure 5-9 respectively.

Accompanying this report, all flood mapping and results requirements are supplied in GIS format.

5.1 Summary of Results

5.1.1 Flood Extent Mapping

The flood extents displayed in Figure 5-1 to Figure 5-9 were created by BMT using the TUFLOW_to_GIS utility to create ASCII grids, which were then directly imported into MapInfo. These extents were created for the purpose of reporting and may vary to the flood extents developed by MW.

5.1.1.1 Base Case Scenario

As can be seen in Figure 5-1 to Figure 5-9, the 5 Year ARI through to PMP flood extents extend from the top of Scotchmans Creek Drain at Tally Ho Reserve, the top of Tally Ho Drain at Cherry Street and the upstream limit of Glen Waverley Drain at Springvale Road, via Scotchmans Creek to the junction with Gardiners Creek within the Malvern Valley public golf course.

Throughout the catchment some overland flow does result in the inundation of residential property adjacent to Melbourne Water assets, however, for the majority of the drainage paths, flood extents up to the 100 year ARI event are confined to drainage easements.

Upstream of the intersection with Glen Waverley Drain, the rears of properties adjacent to Scotchmans Creek Drain and Tally Ho Drain are typically affected by the 5 year ARI flood event (and greater).

Overland flowpaths occur above Mountain View Drain and Glen Waverley Drain in the east of the catchment, with flow paths extending substantially through residential and commercial properties.

Glen Waverley Drain flood extents, downstream of Waverley Road to the junction with Scotchmans Creek Drain and into Waverley Road Retarding Basin, are confined within the channel except for the PMP, which effects adjoining residential properties.

Flows between Waverley Road and Monash Freeway, and through to Huntingdale Road Retarding Basin are confined to the channel.

Flows from Clayton Road along Macrina Street Drain inundate the rear of adjacent properties for the length of the drain.

Huntingdale Road Retarding Basin retains much of the flow and results in downstream flows generally confined to the drainage easement. Breakout flows occur in the 100 year ARI and overtops Huntingdale Road.

Flows are confined to the drainage easement downstream of Huntingdale Road Retarding Basin until Warrigal Road, where ponding of water occurs at the intersection of Warrigal Road and the Monash Freeway in events greater than the 50 Year ARI. Residential properties between Monash Freeway and Ivanhoe Grove are also inundated for events greater than the 50 Year ARI with several properties on Warrigal Road affected in the 100 year ARI.

The Monash Freeway at Atkinson Street also experiences ponding of water from the 5 year ARI and greater events.

Inundation of residential properties at the intersection of Waverley Road and the Monash Freeway also occurs in the 20 year ARI flood event.

Where Scotchmans Creek Drain joins Gardiners Creek at Malvern Valley Public Golf Course, flood extents are confined to the golf course except for the PMP event, which inundates Lomond Terrace.

5.1.1.2 Climate Change Scenario

Flood Extents from the 5 year ARI, 20 year ARI and 100 year ARI for the climate change sensitivity analysis show a general increase in flood extents throughout Scotchmans Creek Catchment.

Where flood extents were confined to the drainage easement in the Base Case Scenario, property adjacent to Melbourne Water assets are now impacted in many locations. There is an increase in overflow from Waverley Road and Huntingdale Road Retarding Basins. Ponding of water in the downstream reaches is also increased, particularly at the intersection of Warrigal Road and the Monash Freeway. Residential properties on the northern side of the Monash Freeway between Warrigal Road and Waverley Road are now significantly impacted.

5.1.2 Affected Parcels

MW provided a MapInfo table containing property parcels affected by flooding based on its mapping of the draft hydraulic modelling results. The table was then updated by BMT to represent the final mapping outputs. The number of residential and public, and commercial and industrial properties affected by each event has been provided in Table 5-1.

Table 5-1 Parcels Affected

Event	Number of Parcels Affected	
	Residential and Public	Commercial and Industrial
5yr	353	103
10yr	514	123
20yr	648	143
50yr	731	174
100yr	785	192
PMP	835	214

5.1.3 Affected Buildings

Melbourne Water provided a MapInfo table containing the building floor level survey with corresponding flood levels from its mapping of the draft hydraulic modelling results. The table was then updated by BMT to represent the final mapping outputs. The number of residential and public, and commercial and industrial floor levels flooded by each event has been provided in Table 5-2. The flood risk rating for the number of residential and public, and commercial and industrial floors flooded is provided in Table 5-3.

Table 5-2 Floors Flooded

Event	Number of Floor Levels Exceeded	
	Residential and Public	Commercial and Industrial
5yr	7	0
10yr	16	3
20yr	37	11
50yr	75	14
100yr	108	19
PMP*	427	54

Table 5-3 Flood Risk Rating

Flood Risk Rating	Number of Buildings*	
	Residential and Public	Commercial and Industrial
1	0	0
2	38	5
3	41	3
4	48	11

** Note: Building footprints not available for all flooded parcels.*

5.1.4 Flow Values

Peak flow values were extracted from the TUFLOW models at pre-determined locations. Combined flow, asset flow and overland flow, along with the corresponding critical duration were provided at each reporting location (refer to Section 5.2.7 for further details of extraction method). A summary of the peak flows is presented in Table 5-4. The reporting locations in Table 5-4 correspond with the hydrological reporting locations and are referred to throughout this report.

Appendix D includes the full list of recording locations and, as such, the reporting locations in Appendix D do not correspond with the reporting locations used within the body of the report, they correspond with supplied flow values MapInfo table.

The peak asset and overland flow are extracted at the time of peak combined flow (i.e. total flow) and may not be the same as the peak flow recorded in the TUFLOW 1D or 2D flow datasets. It is also important to note that overland flow reported by TUFLOW is calculated as the sum of flow in the positive and negative direction, i.e. flow in the downstream direction and backwater flow across the flood extent at a reporting location. As a result, the peak net flow is reported and may not accurately represent the amount of flow at a reporting location. Where backwater effects result in negative flows in either the 1D or 2D domain, the negative values have been included.

Table 5-4 Flow Values

Location*	Peak Flow (m3/s)										
	BASE CASE								CLIMATE CHANGE		
	5yr	10yr	20yr	50yr	100yr Total	100yr Asset	100yr Overland	PMP	5yr	20yr	100yr
Tally-Ho Outflow (3)	6.03	7.13	10.33	14.93	19.03	6.39	12.64	132.45	8.08	15.69	27.97
Scotchmans Creek - Tally-Ho Junction (4)	10.55	11.6	16.33	23.53	30.08	7.14	22.94	225.44	12.95	24.98	44.85
Montclair Ave Outflow (6)	2.66	3.39	4.07	5.35	7.03	3.58	3.45	130.19	3.73	5.71	10.31
Scotchmans Creek - Montclair Ave Junction (7)	14.70	16.22	18.98	26.73	34.90	-	34.90	329.18	16.82	28.52	52.57
Mountain View Outflow (10)	2.03	2.37	2.49	2.80	3.28	1.39	1.89	14.89	2.44	2.84	4.30
Glen Waverley - Mountain View Junction (11)	5.69	6.63	6.88	7.82	8.66	2.89	5.77	42.33	6.55	8.02	9.80
Glen Waverley Outflow (12)	6.62	7.08	7.82	8.44	9.48	-	9.48	51.68	7.31	8.64	10.95
Scotchmans Creek - Glen Waverley Junction (13)	21.22	23.23	26.44	35.00	42.56	-	42.56	371.34	24.04	36.7	61.44
Waverley Rd RB Outflow (15)	13.51	15.15	22.62	31.35	39.18	-	39.18	402.04	18.89	32.85	56.76
Macrina St Outflow (17)	7.42	8.37	9.78	12.80	15.17	7.33	7.84	122.20	8.84	13.36	20.16
Scotchmans Creek - Macrina St Junction (18)	27.98	32.43	39.83	51.72	61.46	1.56	59.9	459.3	34.83	54.14	78.48
Huntingdale Rd RB Outflow (20)	25.4	31.87	38.67	44.82	56.75	55.78	0.97	468.12	34.9	49.02	78.85
Oakleigh North Outflow (22)	16.20	19.64	23.55	27.31	31.15	31.15	0	157.22	20.49	28.86	34.74
Scotchmans Creek - Oakleigh North Junction (23)	34.08	43.39	55.01	64.27	67.86	67.86	0	78.44	48.9	65.87	73.38
Scotchmans Creek Outflow (24)	34.81	44.62	56.49	62.47	66.93	-	66.93	114.78	50.36	63.94	73.63

** Note: The location numbers and descriptions are displayed in Figure 1-2*

Title:

Base Case Scenario
5 Year ARI Flood Extent

Figure: **5-1**

Rev: **B**

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Approx. Scale

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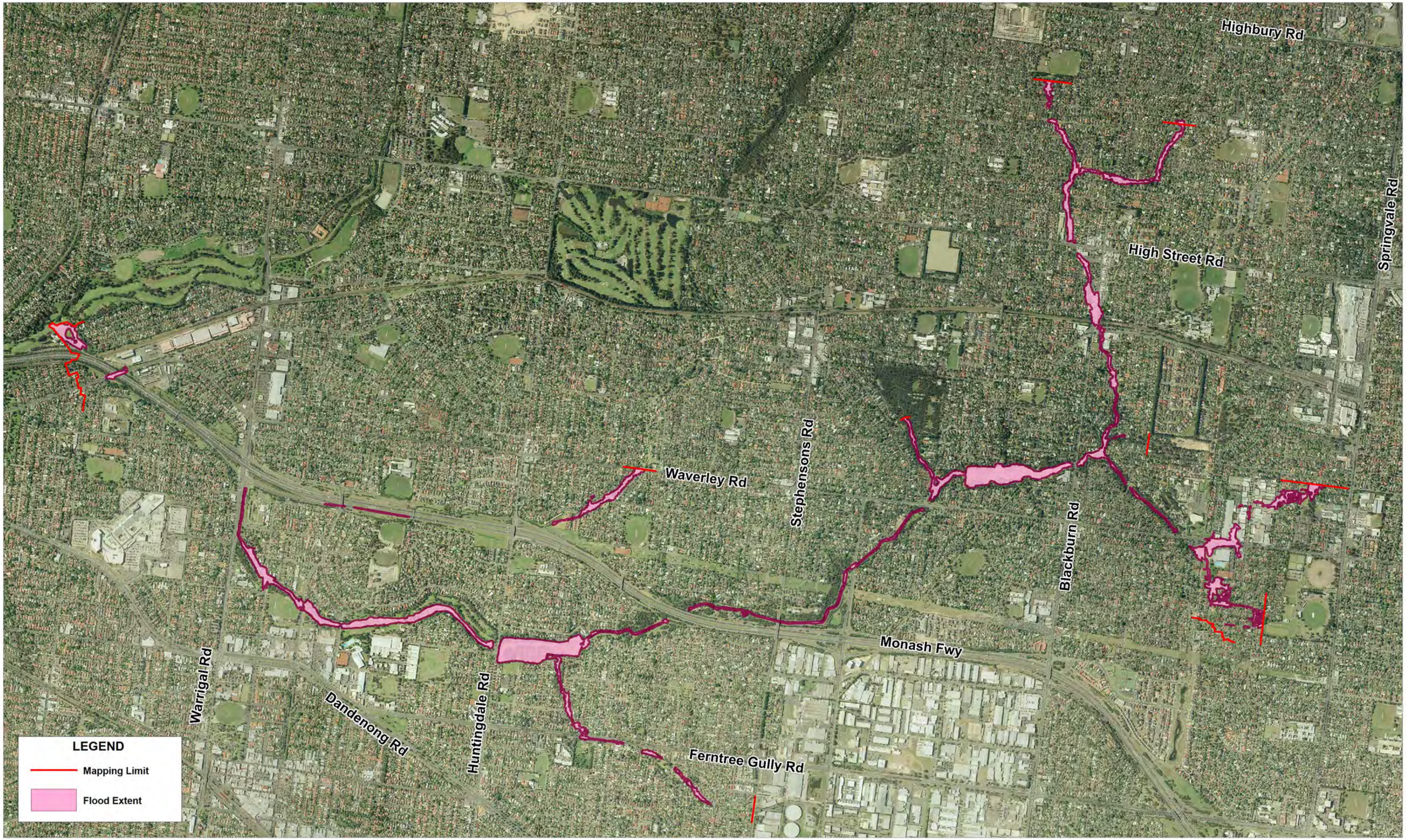

Title:

Base Case Scenario
10 Year ARI Flood Extent

Figure: 5-2

Rev: B

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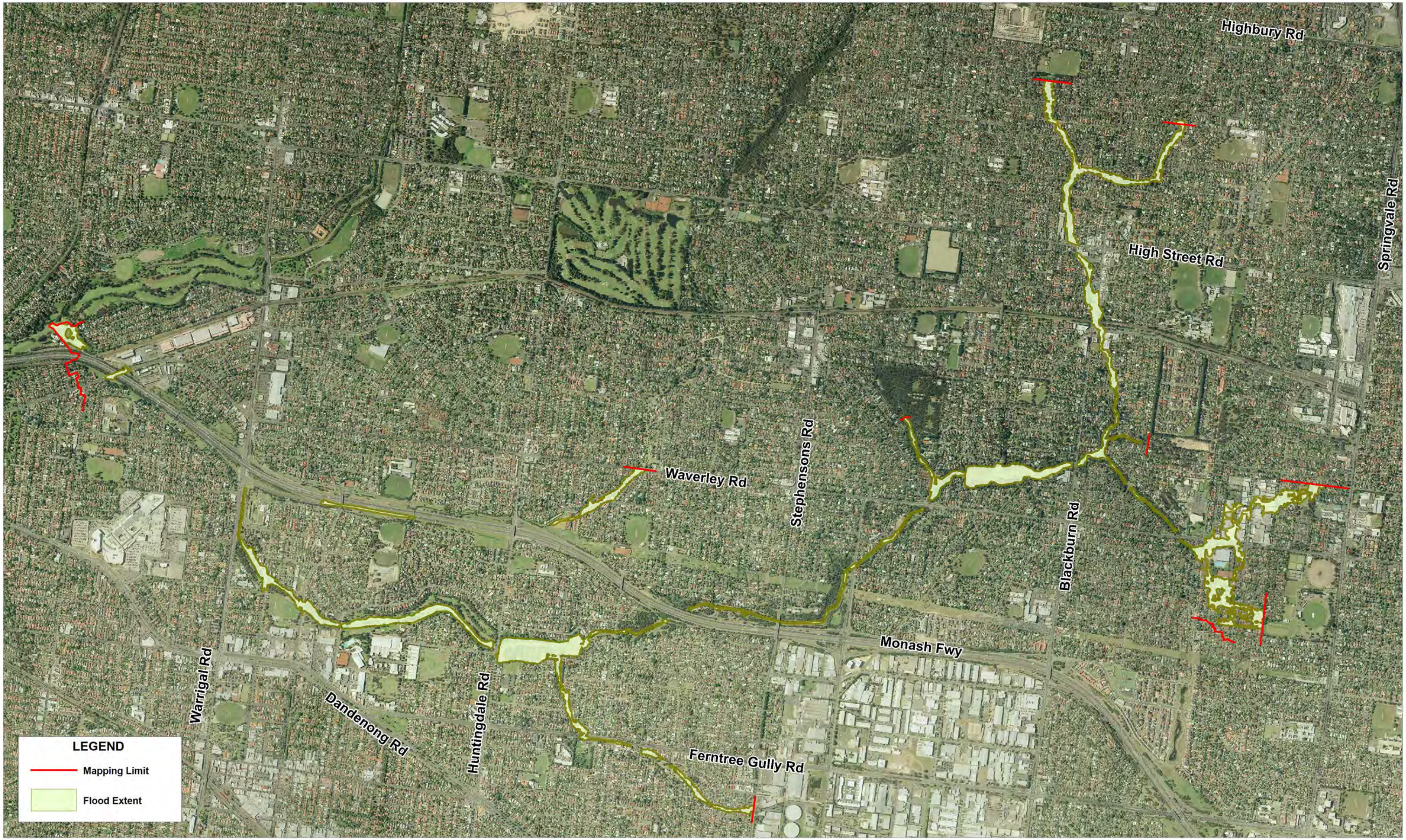

Title:

Base Case Scenario
20 Year ARI Flood Extent

Figure: 5-3

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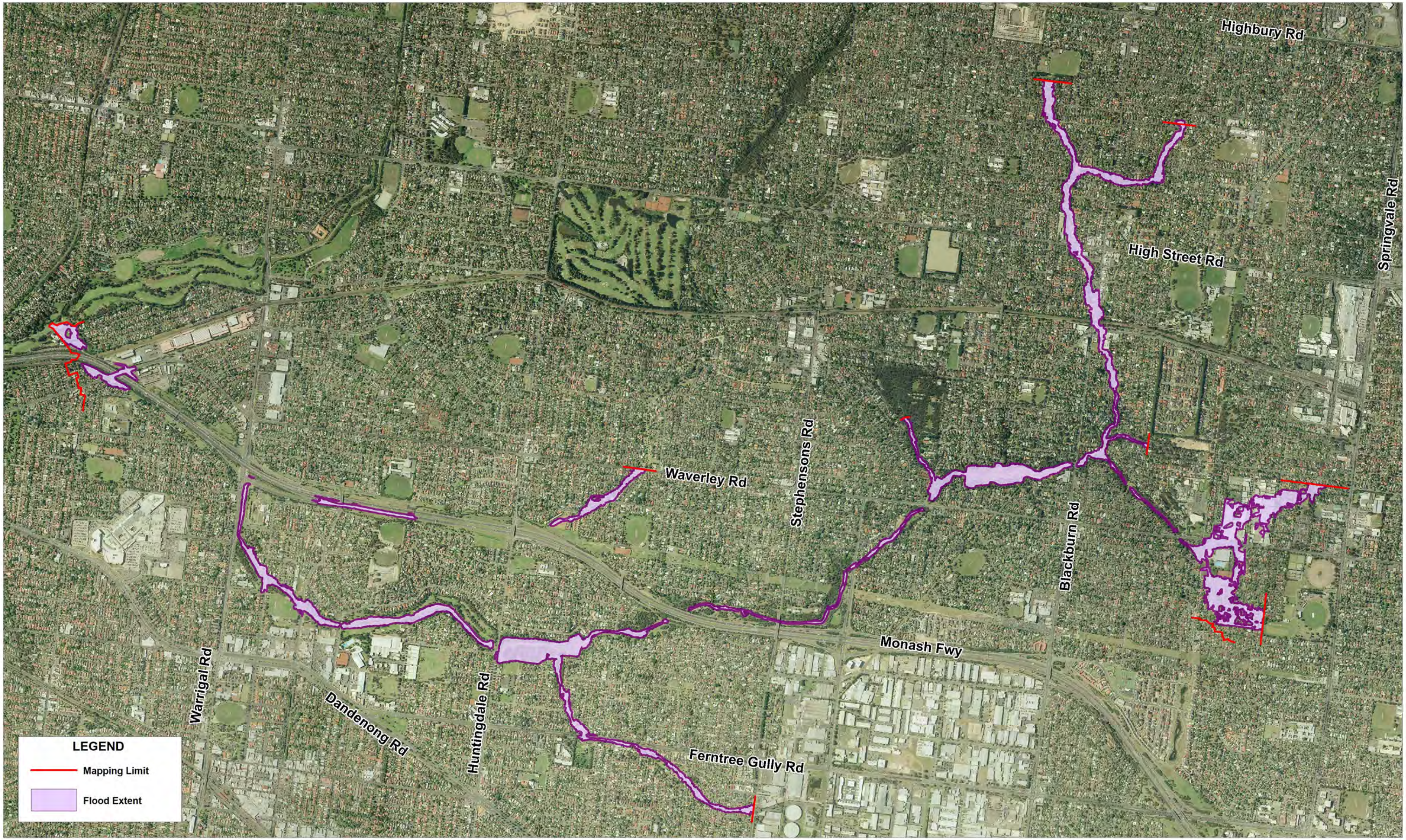

Title:

Base Case Scenario
50 Year ARI Flood Extent

Figure: **5-4**

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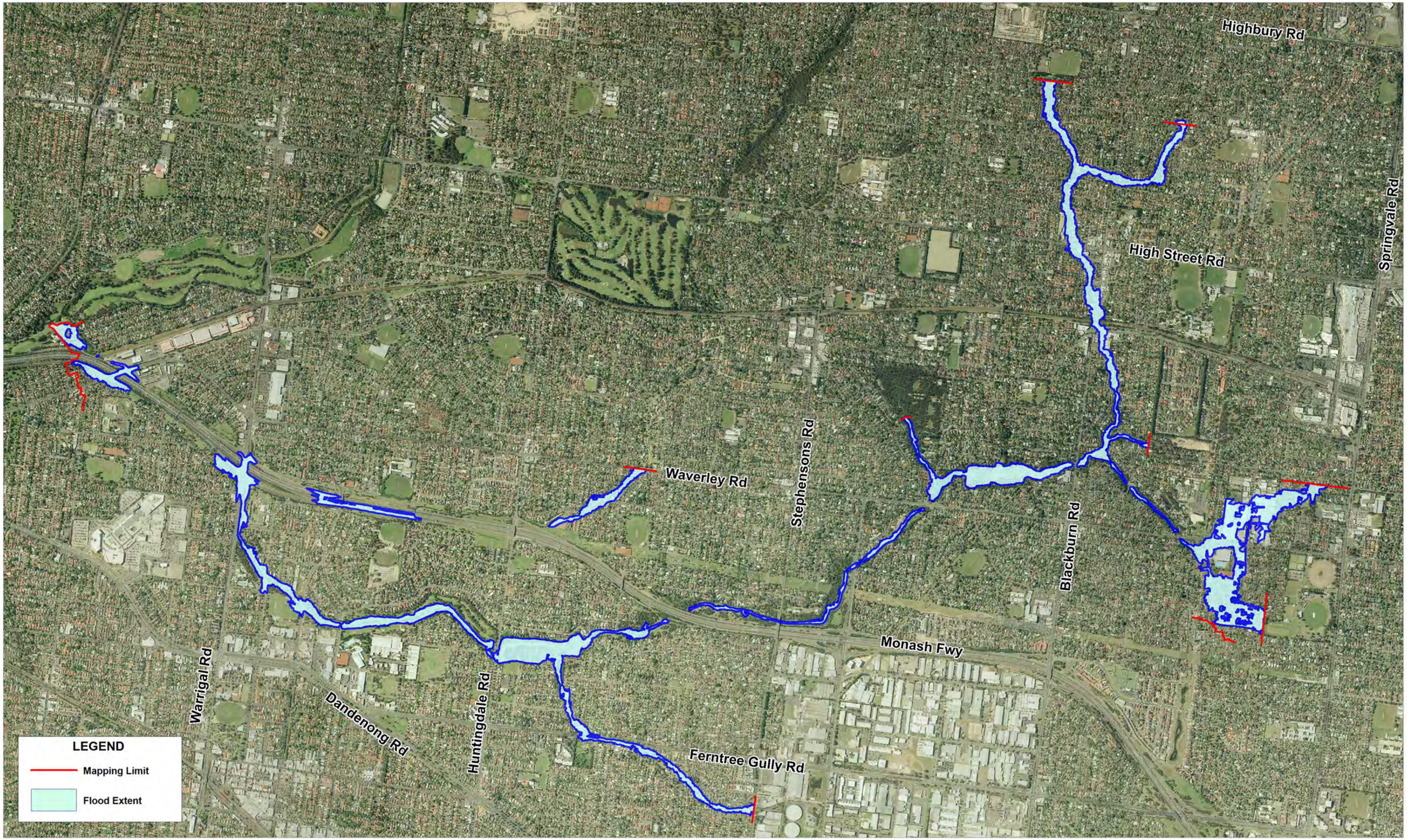

Title:

Base Case Scenario
100 Year ARI Flood Extent

Figure: **5-5**

Rev: **B**

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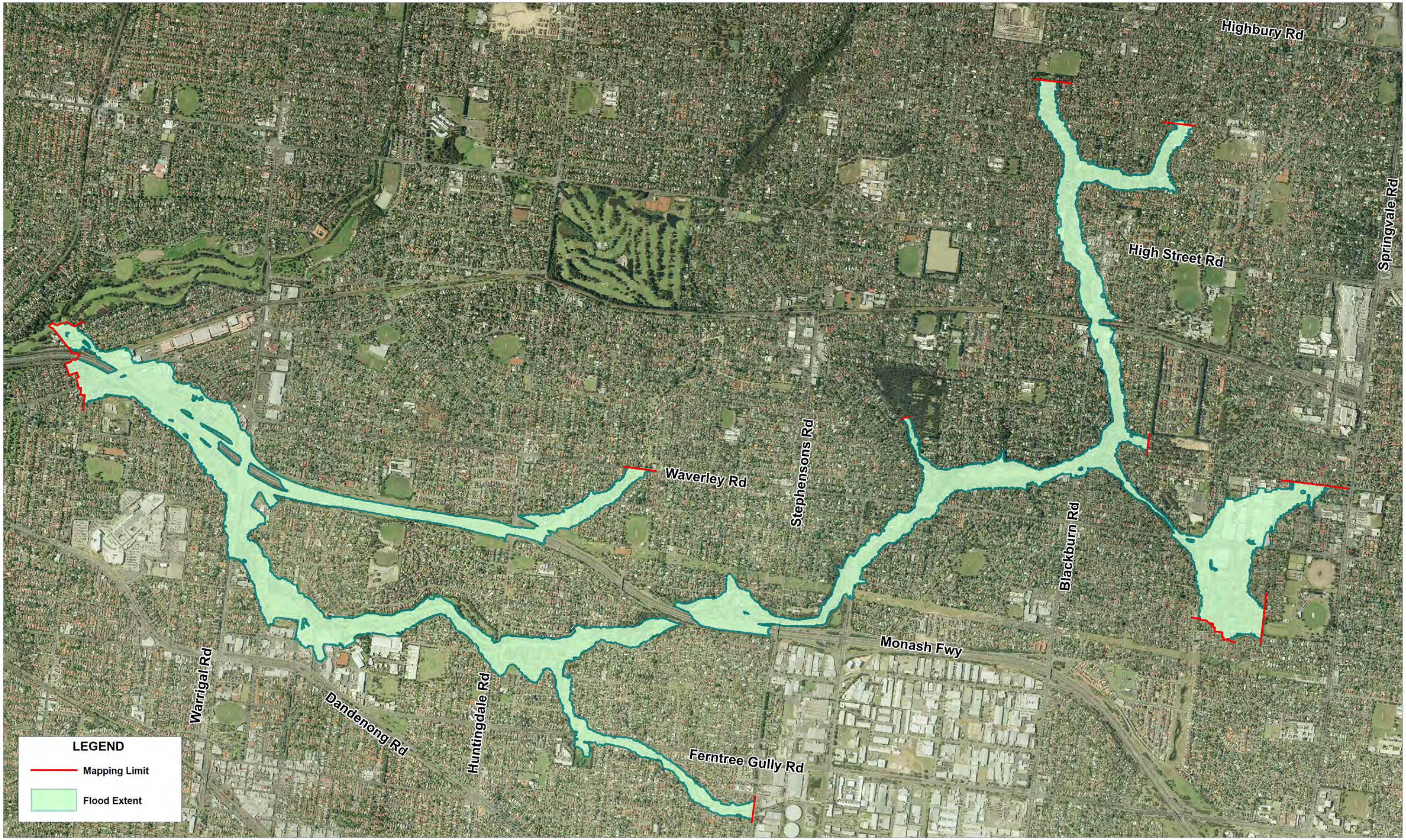

Title:

Base Case Scenario
PMP Flood Extent

Figure: 5-6

Rev: B

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Title:

Climate Change Scenario
5 Year ARI Flood Extent

Figure: **5-7**

Rev: **B**

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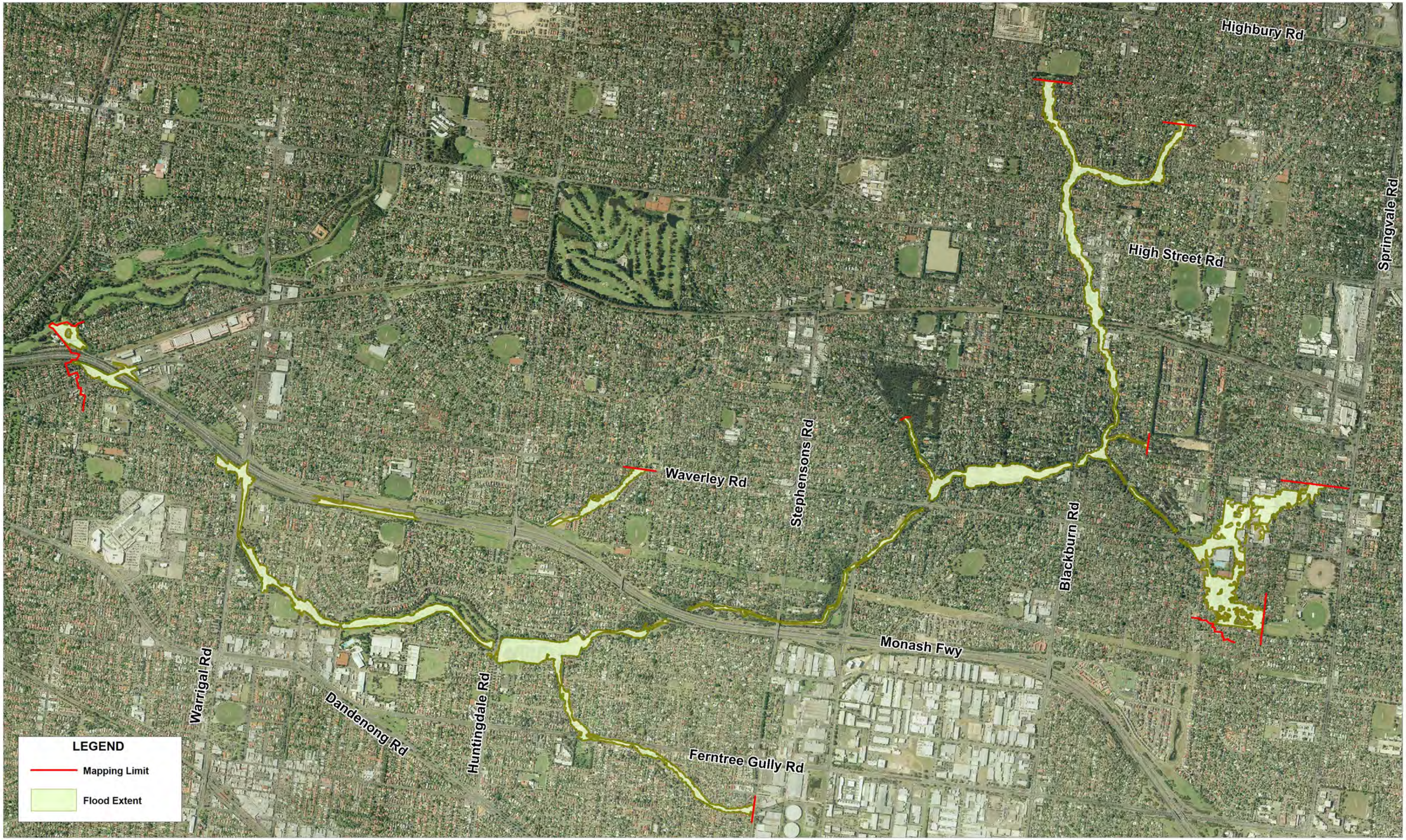

Title:

Climate Change Scenario 20 Year ARI Flood Extent

Figure: 5-8

Rev: B

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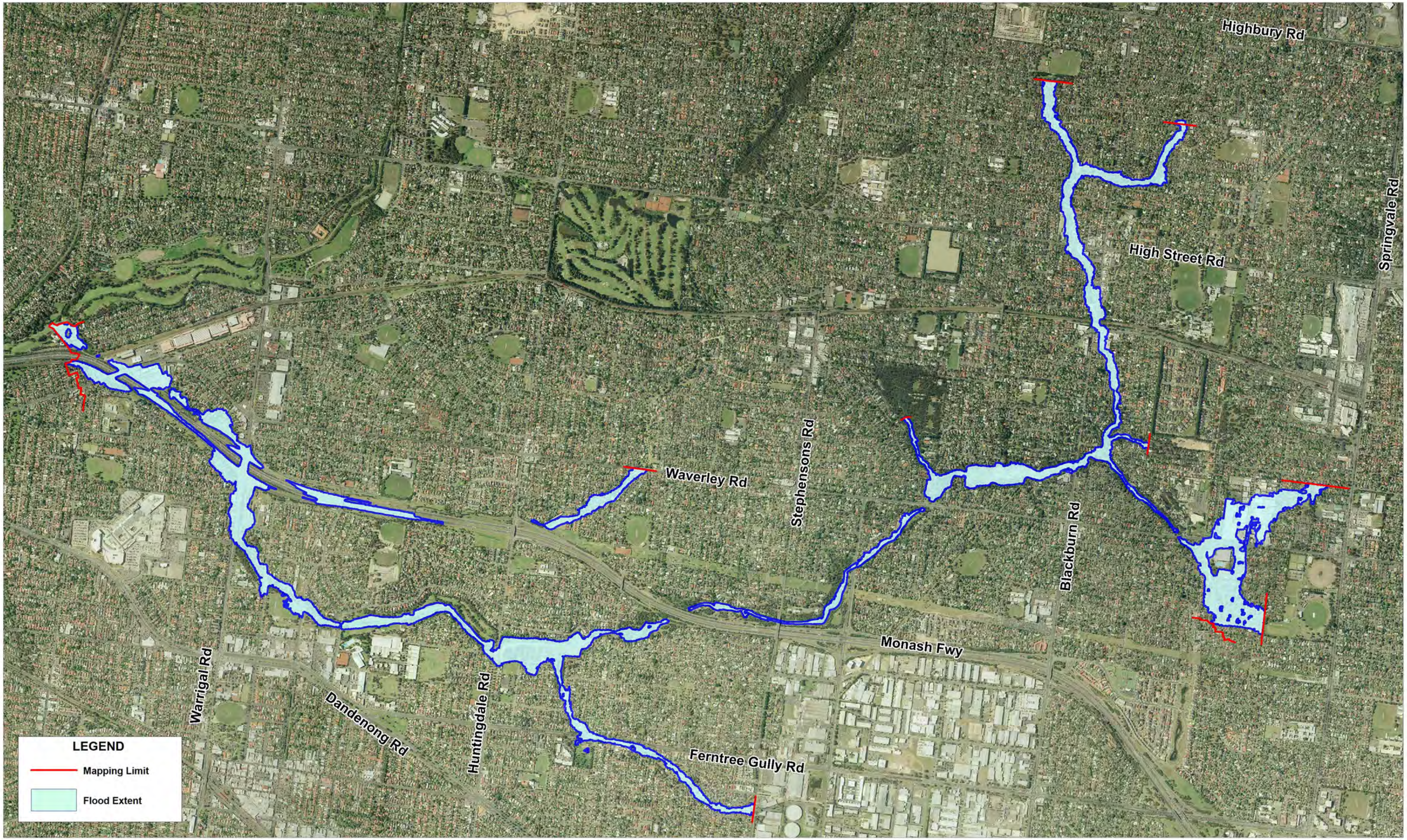

Title:

Climate Change Scenario
100 Year ARI Flood Extent

Figure: 5-9

Rev: B

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Approx. Scale

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5.2 Translation of Hydraulic Modelling Results into MapInfo Deliverables

TUFLOW results contain geo-referenced datasets of water depths and levels, velocities and floodplain hazard at each map output interval throughout the simulation. The processes undertaken to provide the MW mapping deliverables are outlined in the following section.

5.2.1 Points Tables

A number of "Points Tables", or MapInfo Tables containing flood information for the required flood events and scenarios at a 1m grid spacing, has been prepared in accordance with the Technical Specification. The Points Tables contain information on each of the following variables for a given ARI;

- Maximum water level in m AHD;
- Maximum water depth in m;
- Maximum flow velocity in m/s;
- Maximum floodplain hazard (Velocity x Depth) in m^2/s;
- Critical storm duration; and
- Other metadata as appropriate.

Initially a regular grid at 1m spacing was created using the TUFLOW_to_GIS utility, available from the TUFLOW website, for each of the required variables using the peak envelope data file. The water level grid was then imported into MapInfo and saved as a MapInfo Table which contained information at discrete points on a 1m grid. This table was then converted to the standard MW Points Table format.

The remaining variables peak envelopes were imported into MapInfo and a grid created. The variable columns in the Points Table were then updated by using the Point Inspection tool in Vertical Mapper. The critical storm duration variable was post processed by associating the numeric value obtained from the maximum critical duration surface with a storm duration in minutes.

5.2.2 Flood Extents

The Points Tables for of the required events and scenarios were provided to MW to undertake their own mapping of flood extents. The flood extents created by BMT, which have been presented in this report, were created for reporting purposes only.

5.2.3 Flood Contours

Flood contours at 0.5m intervals were developed for the 100 year base case scenario. These flood contours were created from an ASCII grid developed by BMT and trimmed to match the flood extent created by MW. The table has been populated with the relevant metadata and supplied to MW as part of the project deliverables.

5.2.4 Parcels Flooded

MW has provided a MapInfo table containing property parcels affected by flooding based on its mapping of the hydraulic modelling results. This table was populated by MW using the final Points Tables and has been included as part of the project deliverables.

5.2.5 Buildings Flooded

MW provided a MapInfo table containing the building floor level survey with corresponding flood levels from its mapping of the hydraulic modelling results. This table was populated by MW using the final Points Tables and has been included as part of the project deliverables.

Each property was assigned a flood risk rating that is based on how regularly the building is affected by above floor flooding as per MW Technical Specifications. The categories are outlined as follows:

- Flood risk rating = 1 – Building footprint is flooded in the 1% AEP flood event but floor level is unknown;
- Flood risk rating = 2 – Floor level is flooded in the 100 year ARI flood event;
- Flood risk rating = 3 – Floor level is flooded in the 50 year ARI flood event;
- Flood risk rating = 4 – Floor level is flooded in the 20 year ARI flood event;

5.2.6 Safety Risk in Roads

A set of MapInfo tables were created showing the Safety Risk in Roads. For the purposes of the tables 'roads' were determined to be all points within the flood extent other than within property parcels. Five categories for Safety Risk in Roads are defined in the MW Technical Specification in terms of the velocity and depth of floodwaters in the 100 year event, as follows:

- High Risk (Safety Risk value = 3) - velocity x depth greater than 0.8 $m^2/s/m$, or depth greater than 0.8 metres;
- Medium Risk (Safety Risk value = 2) - velocity x depth between 0.4 and 0.8 $m^2/s/m$, or depth between 0.4 and 0.8 metres;
- Low Risk (Safety Risk value = 1) - velocity x depth less than 0.4 $m^2/s/m$, or depth less than 0.4 metres.

A separate MapInfo Table was created for each of the defined safety risk categories.

5.2.7 Flow Values

A MapInfo table has been produced reporting peak flow values for all required scenarios at pre-determined locations by MW. The 1D flows were extracted from 1D time series outputs provided by TUFLOW while the 2D flows were extracted using plot output lines (PO lines), which enable flow to be extracted across a specified flow path from TUFLOW.

The peak asset and overland flow are extracted at the time of peak combined flow (i.e. total flow) and may not be the same as the peak flow recorded in the TUFLOW 1D or 2D flow datasets. It is also important to note that overland flow reported by TUFLOW is calculated as the sum of flow in the positive and negative direction across a PO line, i.e. flow in the downstream direction and backwater flow across the PO line. As a result, the peak net flow is reported and may not accurately represent the amount of flow at a reporting location. Where backwater effects result in negative flows in either the 1D or 2D domain, the negative values have been included.

Appendix D includes the full list of flow values as reported in the MapInfo table. The reporting locations in Appendix D do not correspond with the reporting locations used within the body of the report.

6 SUMMARY

BMT has successfully developed a flood model for the Scotchmans Creek catchment using a 'calibrated' RORB hydrological model and a TUFLOW hydraulic model. The modelling results have been mapped to produce a range of flood mapping and other GIS datasets. This process has been undertaken in accordance with the MW Technical Specifications and has undergone quality assurance. This report presents the methodology used to develop the flood model, and a summary of the model results and outputs.

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APPENDIX A: IFD TABLE

Duration		Design Rainfalls for Average Recurrence Intervals (Years)						
		1	2	5	10	20	50	100
(min)	(hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)
5	0.083	46.8	62	85	101	122	153	178
5.5	0.092	45.2	60	82	98	118	147	171
6	0.100	43.8	58	80	94	114	142	165
6.5	0.108	42.5	57	77	91	110	137	159
7	0.117	41.3	55	75	88	106	133	154
7.5	0.125	40.2	53	73	86	103	129	149
8	0.133	39.1	52	71	83	100	125	145
8.5	0.142	38.2	51	69	81	98	121	141
9	0.150	37.3	49.5	67	79	95	118	137
9.5	0.158	36.4	48.3	66	77	93	115	134
10	0.167	35.6	47.3	64	75	91	112	131
11	0.183	34.2	45.3	61	72	87	107	125
12	0.200	32.9	43.6	59	69	83	103	119
13	0.217	31.7	42	57	67	80	99	114
14	0.233	30.6	40.5	55	64	77	95	110
15	0.250	29.6	39.2	53	62	74	92	106
16	0.267	28.7	38	51	60	72	88	102
17	0.283	27.9	36.9	49.5	58	69	86	99
18	0.300	27.1	35.8	48	56	67	83	96
19	0.317	26.4	34.9	46.7	55	65	80	93
20	0.333	25.7	33.9	45.4	53	63	78	90
21	0.350	25.1	33.1	44.3	52	62	76	88
22	0.367	24.5	32.3	43.2	50	60	74	85
23	0.383	23.9	31.6	42.1	49.2	59	72	83
24	0.400	23.4	30.9	41.2	48	57	70	81
25	0.417	22.9	30.2	40.2	46.9	56	69	79
26	0.433	22.4	29.6	39.4	45.9	55	67	77
27	0.450	22	29	38.5	44.9	53	66	76
28	0.467	21.6	28.4	37.8	44	52	64	74
29	0.483	21.2	27.9	37	43.1	51	63	72
30	0.500	20.8	27.3	36.3	42.3	50	62	71
32	0.533	20.1	26.4	35	40.7	48.4	59	68
34	0.567	19.4	25.5	33.8	39.2	46.6	57	66

Duration		Design Rainfalls for Average Recurrence Intervals (Years)						
		1	2	5	10	20	50	100
(min)	(hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)
36	0.600	18.8	24.7	32.7	37.9	45	55	63
38	0.633	18.2	23.9	31.6	36.7	43.6	53	61
40	0.667	17.7	23.2	30.7	35.6	42.2	52	59
45	0.750	16.6	21.7	28.6	33.1	39.2	47.8	55
50	0.833	15.6	20.4	26.8	31	36.7	44.7	51
55	0.917	14.7	19.3	25.3	29.2	34.5	42	48.1
60	1.000	14	18.3	23.9	27.6	32.6	39.7	45.4
75	1.250	12.3	16.1	20.9	24.1	28.4	34.4	39.3
90	1.500	11.1	14.4	18.7	21.5	25.3	30.6	34.9
105	1.750	10.1	13.2	17	19.5	22.9	27.6	31.5
120	2.000	9.35	12.1	15.7	17.9	21	25.3	28.8
135	2.250	8.71	11.3	14.5	16.6	19.5	23.4	26.6
150	2.500	8.18	10.6	13.6	15.5	18.2	21.8	24.8
165	2.750	7.73	10	12.8	14.6	17.1	20.5	23.2
180	3.000	7.34	9.5	12.1	13.8	16.1	19.3	21.9
195	3.250	7	9.05	11.5	13.1	15.3	18.3	20.8
210	3.500	6.69	8.65	11	12.5	14.6	17.5	19.8
225	3.750	6.42	8.3	10.5	12	13.9	16.7	18.9
240	4.000	6.18	7.98	10.1	11.5	13.4	16	18.1
270	4.500	5.76	7.43	9.4	10.7	12.4	14.8	16.7
300	5.000	5.4	6.97	8.79	9.95	11.6	13.8	15.5
360	6.000	4.84	6.24	7.84	8.85	10.3	12.2	13.7
420	7.000	4.42	5.68	7.12	8.02	9.28	11	12.4
480	8.000	4.08	5.24	6.55	7.36	8.5	10.1	11.3
540	9.000	3.8	4.88	6.08	6.83	7.88	9.31	10.5
600	10.000	3.57	4.58	5.69	6.39	7.36	8.69	9.74
660	11.000	3.37	4.32	5.36	6.01	6.91	8.16	9.14
720	12.000	3.2	4.1	5.08	5.68	6.53	7.7	8.62
840	14.000	2.89	3.7	4.6	5.16	5.95	7.02	7.87
960	16.000	2.64	3.39	4.23	4.75	5.48	6.48	7.27
1080	18.000	2.44	3.14	3.92	4.41	5.1	6.03	6.78
1200	20.000	2.27	2.92	3.66	4.13	4.77	5.66	6.37
1320	22.000	2.13	2.74	3.44	3.89	4.5	5.34	6.02
1440	24.000	2.01	2.59	3.26	3.68	4.26	5.06	5.71
1800	30.000	1.72	2.22	2.81	3.18	3.7	4.41	4.98

Duration		Design Rainfalls for Average Recurrence Intervals (Years)						
		1	2	5	10	20	50	100
(min)	(hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)	(mm/hr)
2160	36.000	1.51	1.96	2.49	2.82	3.29	3.93	4.44
2520	42.000	1.35	1.75	2.24	2.54	2.97	3.56	4.03
2880	48.000	1.23	1.59	2.04	2.32	2.71	3.25	3.69
3240	54.000	1.12	1.46	1.87	2.14	2.5	3	3.41
3600	60.000	1.03	1.34	1.73	1.98	2.32	2.79	3.17
3960	66.000	0.96	1.25	1.61	1.84	2.16	2.61	2.97
4320	72.000	0.89	1.16	1.5	1.73	2.03	2.45	2.79

APPENDIX B: TIME OF CONCENTRATION AND RATIONAL METHOD

Flow Path Option*	**Flow Path No.**	**Comments**	**Method**	**Area (ha)**	**Impervious Fraction (%)**	**T_c Adopted (minutes)**	**Interpolated Intensity (mm/hr)**	**C10**	**Runoff Coefficient**	**Estimated Flow (m^3/s)**
Scotchmans Creek Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	69	50%	13.8	111.00	0.52	0.62	13.3
Tally-Ho Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	109	57%	14.7	107.34	0.57	0.68	22.1
Tally-Ho Outflow	Total	Critical Path Tally-Ho Inflow.	1D Model Vel	187	56%	19.2	92.46	0.56	0.67	32.2
Scotchmans Creek - Tally-Ho Junction	Total	Critical Path Tally-Ho Outflow.	1D Model Vel	307	55%	19.2	92.46	0.55	0.66	52.3

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Montclair Ave Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	67	61%	16.2	101.34	0.60	0.72	13.4
Montclair Ave Outflow	Total	Critical Path Montclair Ave Inflow	1D Model Vel	69	60%	17.3	97.96	0.59	0.71	13.5
Scotchmans Creek - Montclair Ave Junction	1	Critical Path Scotchmans Creek - Tally-Ho Junction.	1D Model Vel	558	57%	26.4	76.61	0.57	0.69	81.6
Scotchmans Creek - Montclair Ave Junction	2		2D Model Vel	558	57%	32.1	67.90	0.57	0.69	72.3
Scotchmans Creek - Montclair Ave Junction	Total			558	57%	32.1	67.90	0.57	0.69	72.3
Glen Waverley Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	59	64%	14.1	109.68	0.62	0.75	13.5

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Mountain View Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	61	49%	15.8	102.97	0.51	0.61	10.7
Mountain View Outflow	Total	Critical Path Mountain View Inflow.	1D Model Vel	89	52%	21.7	85.83	0.53	0.64	13.5
Glen Waverley - Mountain View Junction	Total	Critical Path Mountain View Outflow.	1D Model Vel	220	59%	21.7	85.83	0.59	0.71	37.0
Glen Waverley Outflow	1	Critical Path Glen Waverley - Mountain View Junction.	1D Model Vel	253	59%	22.8	83.36	0.58	0.70	41.0
Glen Waverley Outflow	2		2D Model Vel	253	59%	33.7	66.31	0.58	0.70	32.6
Glen Waverley Outflow	3		2D Model Vel	253	59%	41.0	58.24	0.58	0.70	28.7
Glen Waverley Outflow	Total			253	59%	41.0	58.24	0.58	0.70	28.7

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Glen Waverley Junction	Total	Critical Path Glen Waverley Outflow.	2D Model Vel	815	58%	41.0	58.24	0.58	0.69	91.1
Scotchmans Creek - Glen Waverley Junction (PA)	Total	Critical Path Scotchmans Creek - Montclair Ave Junction. Area reduced to take into partial area effect on GW an MV MDs.	2D Model Vel	761	58%	34.5	65.32	0.58	0.69	95.5
Macrina St Inflow	Total	US MW assets. Council pipe diameter used. If Council info assumed 600mm.	Colebrook White	81	77%	25.4	78.20	0.72	0.87	15.1
Macrina St Outflow	Total	Critical Path Macrina St Inflow.	1D Model Vel	176	67%	32.5	67.52	0.64	0.77	25.6
Scotchmans Creek - Macrina St Junction	1	Critical Path Scotchmans Creek - Glen Waverley Junction.	2D Model Vel	1529	58%	44.0	55.81	0.58	0.69	164.4

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Macrina St Junction	2		1D Model Vel	1529	58%	47.3	53.15	0.58	0.69	156.6
Scotchmans Creek - Macrina St Junction	3		2D Model Vel	1529	58%	55.9	47.61	0.58	0.69	140.2
Scotchmans Creek - Macrina St Junction	4		2D Model Vel	1529	58%	58.6	46.16	0.58	0.69	136.0
Scotchmans Creek - Macrina St Junction	5		1D Model Vel	1529	58%	73.7	39.85	0.58	0.69	117.4
Scotchmans Creek - Macrina St Junction	6		1D Model Vel	1529	58%	75.7	39.08	0.58	0.69	115.1
Scotchmans Creek - Macrina St Junction	Total			1529	58%	75.7	39.08	0.58	0.69	115.1
Scotchmans Creek - Macrina St Junction (PA)	1	Critical Path Scotchmans Creek - Glen Waverley Junction (PA).	2D Model Vel	1476	58%	37.5	61.51	0.58	0.69	174.8

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Macrina St Junction (PA)	2		1D Model Vel	1476	58%	40.8	58.35	0.58	0.69	165.8
Scotchmans Creek - Macrina St Junction (PA)	3		2D Model Vel	1476	58%	49.4	51.47	0.58	0.69	146.3
Scotchmans Creek - Macrina St Junction (PA)	4		2D Model Vel	1476	58%	52.1	49.79	0.58	0.69	141.5
Scotchmans Creek - Macrina St Junction (PA)	5		1D Model Vel	1476	58%	67.2	42.49	0.58	0.69	120.7
Scotchmans Creek - Macrina St Junction (PA)	6		1D Model Vel	1476	58%	69.2	41.64	0.58	0.69	118.3
Scotchmans Creek - Macrina St Junction (PA)	Total			1476	58%	69.2	41.64	0.58	0.69	118.3
Oakleigh North Inflow	Total	US MW assets. Council pipe diameter used. If no council info assumed 600mm US assume 450mm.	Colebrook White	105	57%	15.8	102.93	0.57	0.69	20.6

Flow Path Option*	**Flow Path No.**	**Comments**	**Method**	**Area (ha)**	**Impervious Fraction (%)**	**T_c Adopted (minutes)**	**Interpolated Intensity (mm/hr)**	**C10**	**Runoff Coefficient**	**Estimated Flow (m^3/s)**
Oakleigh North Outflow	Total	Critical Path Oakleigh North Inflow.	1D Model Vel	277	57%	24.6	79.83	0.57	0.68	42.0
Scotchmans Creek - Oakleigh North Junction	1	Critical Path Scotchmans Creek - Macrina St Junction.	1D Model Vel	2082	58%	78.9	38.15	0.58	0.69	152.8
Scotchmans Creek - Oakleigh North Junction	2		2D Model Vel	2082	58%	86.3	35.99	0.58	0.69	144.1
Scotchmans Creek - Oakleigh North Junction	3		2D Model Vel	2082	58%	88.4	35.36	0.58	0.69	141.6
Scotchmans Creek - Oakleigh North Junction	4		2D Model Vel	2082	58%	90.7	34.74	0.58	0.69	139.1
Scotchmans Creek - Oakleigh North Junction	5		2D Model Vel	2082	58%	92.0	34.44	0.58	0.69	137.9
Scotchmans Creek - Oakleigh North Junction	6		2D Model Vel	2082	58%	93.9	34.02	0.58	0.69	136.2

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Oakleigh North Junction	7		2D Model Vel	2082	58%	94.9	33.78	0.58	0.69	135.3
Scotchmans Creek - Oakleigh North Junction	8		2D Model Vel	2082	58%	97.2	33.27	0.58	0.69	133.2
Scotchmans Creek - Oakleigh North Junction	9		2D Model Vel	2082	58%	99.9	32.66	0.58	0.69	130.8
Scotchmans Creek - Oakleigh North Junction	10		2D Model Vel	2082	58%	103.5	31.83	0.58	0.69	127.5
Scotchmans Creek - Oakleigh North Junction	11		1D Model Vel	2082	58%	103.8	31.77	0.58	0.69	127.2
Scotchmans Creek - Oakleigh North Junction	Total			2082	58%	103.8	31.77	0.58	0.69	127.2
Scotchmans Creek - Oakleigh North Junction (PA)	1	Critical Path Scotchmans Creek - Macrina St Junction (PA).	1D Model Vel	2029	58%	72.4	40.35	0.58	0.69	157.4

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Oakleigh North Junction (PA)	2		2D Model Vel	2029	58%	79.8	37.90	0.58	0.69	147.9
Scotchmans Creek - Oakleigh North Junction (PA)	3		2D Model Vel	2029	58%	81.9	37.26	0.58	0.69	145.4
Scotchmans Creek - Oakleigh North Junction (PA)	4		2D Model Vel	2029	58%	84.2	36.60	0.58	0.69	142.8
Scotchmans Creek - Oakleigh North Junction (PA)	5		2D Model Vel	2029	58%	85.5	36.21	0.58	0.69	141.3
Scotchmans Creek - Oakleigh North Junction (PA)	6		2D Model Vel	2029	58%	87.4	35.67	0.58	0.69	139.2
Scotchmans Creek - Oakleigh North Junction (PA)	7		2D Model Vel	2029	58%	88.4	35.36	0.58	0.69	138.0

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek - Oakleigh North Junction (PA)	8		2D Model Vel	2029	58%	90.7	34.74	0.58	0.69	135.6
Scotchmans Creek - Oakleigh North Junction (PA)	9		2D Model Vel	2029	58%	93.4	34.13	0.58	0.69	133.2
Scotchmans Creek - Oakleigh North Junction (PA)	10		2D Model Vel	2029	58%	97.0	33.30	0.58	0.69	129.9
Scotchmans Creek - Oakleigh North Junction (PA)	11		1D Model Vel	2029	58%	97.3	33.24	0.58	0.69	129.7
Scotchmans Creek - Oakleigh North Junction (PA)	Total			2029	58%	97.3	33.24	0.58	0.69	129.7
Scotchmans Creek Outflow	1	Critical Path Scotchmans Creek - Oakleigh North Junction.	1D Model Vel	2170	58%	108.1	30.94	0.58	0.69	129.1

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek Outflow	2		2D Model Vel	2170	58%	109.7	30.65	0.58	0.69	127.9
Scotchmans Creek Outflow	3		2D Model Vel	2170	58%	110.4	30.53	0.58	0.69	127.4
Scotchmans Creek Outflow	4		2D Model Vel	2170	58%	111.1	30.41	0.58	0.69	126.9
Scotchmans Creek Outflow	Total			2170	58%	111.1	30.41	0.58	0.69	126.9
Scotchmans Creek Outflow (PA)	1	Critical Path Scotchmans Creek - Oakleigh North Junction (PA).	1D Model Vel	2117	58%	101.6	32.27	0.58	0.69	131.4
Scotchmans Creek Outflow (PA)	2		2D Model Vel	2117	58%	103.2	31.90	0.58	0.69	129.9
Scotchmans Creek Outflow (PA)	3		2D Model Vel	2117	58%	103.9	31.76	0.58	0.69	129.3
Scotchmans Creek Outflow (PA)	4		2D Model Vel	2117	58%	104.6	31.60	0.58	0.69	128.6

Flow Path Option*	Flow Path No.	Comments	Method	Area (ha)	Impervious Fraction (%)	T_c Adopted (minutes)	Interpolated Intensity (mm/hr)	C10	Runoff Coefficient	Estimated Flow (m^3/s)
Scotchmans Creek Outflow (PA)	Total			2117	58%	104.6	31.60	0.58	0.69	128.6

** Note: The locations are displayed in Figure 1-2.*

*** Note: Flow path option (PA) has been adopted as the critical flow path as it takes into the partial area effect on the Glen Waverley and Mountain View Main Drains resulting in a higher flow at the Scotchmans Creek outflow.*

APPENDIX C: GSDM WORKSHEET

LOCATION INFORMATION

Catchment:	M7586_SC	Area:	21.7 km2
State:	VIC	Duration Limit:	5 hours
Latitude:	37.88159978° S	Longitude:	145.1242256° E
Portion of Area Considered:			
Smooth, **S** =	1	Rough, **R** =	0

ELEVATION ADJUSTMENT FACTOR (EAF)

Mean Elevation: 80 mAHD

Adjustment for Elevation (-0.05 per 300m above 1500m): 0.00

EAF = 1.00

GSDM MOISTURE ADJUSTMENT FACTOR (MAF)

GSDM MAF = 0.55

PMP VALUES (mm)

Duration (hours)	**Initial Depth - Smooth (D_S)**	**Initial Depth - Rough (D_R)**	**PMP Estimate = (D_SHS + D_RHR) H MAF H EAF**	**Rounded PMP Estimate (nearest 10 mm)**
0.25	199	199	109	**110**
0.5	293	293	161	**160**
0.75	372	372	205	**200**
1	439	439	241	**240**
1.5	502	563	276	**280**
2	563	656	310	**310**
2.5	599	726	329	**330**
3	628	791	346	**350**
4	698	903	384	**380**
5	752	992	414	**410**
6	0	0	0	**0**

Prepared by:	Michael South	Date:	14/04/2010
Checked by:	Michael Turnley	Date:	14/04/2010

APPENDIX D: FLOW VALUES

Appendix D includes the full list of flow values as reported in the MapInfo table. The reporting locations in Appendix D do not correspond with the reporting locations used within the body of the report.

Overland flow reported by TUFLOW is calculated as the sum of flow in the positive and negative direction, i.e. flow in the downstream direction and backwater flow across the flood extent at a reporting location. As a result, the peak net flow is reported and may not accurately represent the amount of flow at a reporting location. Where backwater effects result in negative flows in either the 1D or 2D domain, the negative values have been included. In the instance of there being no MW asset at a reporting location, i.e. all flow being overland flow the asset flow has denoted by a hyphen. Where there is no overland flow data extracted from the hydraulic model at a flow location, the overland flow component has been denoted as N/A.

Location	Peak Flow (m3/s)										
	BASE CASE								CLIMATE CHANGE		
	5yr	10yr	20yr	50yr	100yr Total	100yr Asset	100yr Overland	PMP	5yr	20yr	100yr
1	2.26	3.51	5.17	7.02	8.61	1.84	6.77	49.83	3.97	7.5	11.82
2	3.62	3.94	5.14	7.62	9.68	4.28	5.4	58.76	4.06	8.06	13.58
3	4.16	4.77	5.85	8.35	10.86	2.77	8.09	82.85	5.12	8.86	16.47
4*	4.63	6.83	9.24	12.28	14.96	3.76	11.2	98.09	7.54	13.05	22.15
5	4.74	6.13	8.72	12.14	15.02	3.83	11.19	94.19	6.9	12.81	21.45
6	6.03	7.17	10.46	15.14	19.21	5.75	13.46	132.87	8.12	15.87	28.25
7	6.03	7.13	10.33	14.93	19.03	6.39	12.64	132.45	8.08	15.69	27.97
8	10.55	11.6	16.33	23.53	30.08	7.14	22.94	225.44	12.95	24.98	44.85
9	10.62	12.11	14.97	21.95	28.12	15.25	12.87	242.12	13.08	23.29	43.35
10	10.92	12.34	15.27	22.27	28.68	8.85	19.83	248.19	13.35	23.71	43.68
11	10.99	12.7	16.21	23.07	29.86	12.87	16.99	271.37	14.09	24.57	45.33
12	11.71	13.23	16.9	23.91	30.89	10.19	20.7	288.15	14.7	25.39	47.3
13	12.17	13.41	17.17	24.22	31.01	-	31.01	216.01	14.92	25.7	47.34
14	2.61	3.43	4.17	5.44	7.1	4.46	2.64	49.85	3.68	5.78	10.51
15	2.66	3.41	4.02	5.38	7.04	3.43	3.62	57.88	3.75	5.75	10.34
16	2.66	3.39	4.07	5.35	7.03	3.58	3.45	130.19	3.73	5.71	10.31
17	14.7	16.22	18.98	26.73	34.9	-	34.9	329.18	16.82	28.52	52.57
18	3.27	4.22	5.69	7.29	8.86	2.56	6.3	51.39	4.77	7.82	12.07
19	2.7	2.95	4.05	5.61	7.19	2.87	4.32	57.72	3.39	6.07	11.07
20*	1.7	2.13	3.25	4.8	6.41	2.18	4.23	47.47	2.39	5.03	9.79
21	2.03	2.37	2.49	2.8	3.28	1.39	1.89	14.89	2.44	2.84	4.3
22	5.69	6.63	6.88	7.82	8.66	2.89	5.77	42.33	6.55	8.02	9.8
23	5.75	6.26	6.9	7.86	8.63	-	8.63	43.2	6.57	8.04	9.81
24	6.44	6.89	7.48	8.22	9.01	9.01	0	48.59	7.09	8.35	10.37
25	6.62	7.08	7.82	8.44	9.48	-	9.48	51.68	7.31	8.64	10.95
26	21.22	23.23	26.44	35	42.56	-	42.56	371.34	24.04	36.7	61.44
27	21.28	23.34	26.53	35.15	42.46	42.46	0	373.35	24.18	36.8	61.57
28	21.56	23.74	26.73	35.47	43.19	1.2	41.99	375.38	24.58	37.18	60.35

Location	Peak Flow (m3/s)										
	BASE CASE								CLIMATE CHANGE		
	5yr	10yr	20yr	50yr	100yr Total	100yr Asset	100yr Overland	PMP	5yr	20yr	100yr
29	23.04	25.74	28.65	34.07	41.48	1.15	40.33	390.57	27.08	35.84	59.68
30	13.51	15.15	22.62	31.35	39.18	-	39.18	402.04	18.89	32.85	56.76
31	4.15	5.48	7.26	9.61	12.26	-	12.26	86.11	5.81	9.88	17.21
32	4.82	6.54	8.73	11.51	14.54	-	14.54	108.27	6.94	12.07	20.31
33	14.83	16.42	24.11	33.27	41.24	-	41.24	438.74	20.1	35.24	56.74
34	15.13	16.82	24.48	33.69	41.91	-	41.91	440.79	20.46	35.75	57.45
35	15.84	17.48	24.67	33.72	41.86	41.86	0	419.64	20.59	35.98	55.36
36	20.61	22.01	26.57	36.21	44.93	44.93	0	469.7	23.28	38.78	61.68
37	21.31	23.36	27.68	36.89	45.64	45.64	0	435.04	24.83	39.5	62.64
38	22.71	26.69	31.94	40.61	48.49	48.49	0	359.12	28.55	43.3	64.59
39	23.08	26.84	31.93	41.16	49.27	0.83	48.44	397.33	28.57	43.74	67.87
40	4.15	4.36	6.25	8.2	9.77	3.81	5.96	58.7	5.14	8.96	13.55
41	4.33	4.54	6.05	8.64	10.56	4.65	5.91	64.11	4.85	9.62	14.71
42	5.07	5.35	5.79	8.49	10.79	4.58	6.21	78.83	5.45	9.37	15.82
43	5.1	5.47	5.98	8.27	10.86	5.35	5.5	92.08	5.68	9.16	16.72
44	7.42	8.37	9.78	12.8	15.17	7.33	7.84	122.2	8.84	13.36	20.16
45	27.98	32.43	39.83	51.72	61.46	1.56	59.9	459.3	34.83	54.14	78.48
46	25.4	31.87	38.67	44.82	56.75	55.78	0.97	468.12	34.9	49.02	78.85
47	25.92	32.45	39.79	46.26	63.65	-	63.65	387.97	35.59	53.98	80.58
48	27.66	34.88	43.17	50.45	61.59	-	61.59	506.23	38.55	53.46	84.69
49	28.22	35.59	44.1	51.95	62.83	30.18	32.65	513.61	39.36	55.38	86.35
50	29	36.03	45.36	52.26	62.37	-	62.37	521.35	39.71	55.75	78.27
51	5.01	6.98	9.51	12.41	15.04	4.2	10.84	96.11	7.67	13.22	21.11
52	4.85	6.68	9.47	13.39	16.69	4.93	11.76	113.7	7.55	14.14	23.62
53	7.67	9.02	10.69	13.76	15.06	15.06	0	133.61	9.25	14.09	17.1
54	14.49	17.32	20.11	25.57	29.84	19.77	10.07	189.13	17.75	26.45	38.67
55	16.2	19.64	23.55	27.31	31.15	31.15	0	157.22	20.49	28.86	34.74
56	34.08	43.39	55.01	64.27	67.86	67.86	0	78.44	48.9	65.87	73.38
57	34.25	43.7	55.44	64.75	68.29	68.29	0	84.35	49.26	66.48	73.88
58	34.86	44.75	56.62	62.63	67.11	67.11	0	95.06	50.48	64.11	73.87
59	34.81	44.62	56.49	62.47	66.93	-	66.93	114.78	50.36	63.94	73.63

** Note: Flow location lies all or partly outside of the flood mapping limits, therefore the results presented in the above table at these locations may not be suitably accurate as they could be subject to boundary condition influences (i.e. boundary effects).*

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