Mordialloc Freeway
Hydrologic and Hydraulic Modelling

Major Road Projects Authority

WSP
Level 15, 28 Freshwater Place
Southbank VIC 3006

Tel: +61 3 9861 1111
Fax: +61 3 9861 1144
wsp.com

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<tr>
<td>Reviewed by: Eric Lam</td>
<td>16/08/2018</td>
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<td>Approved by: Steve Horne</td>
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<tr>
<td>1D / 2D / 3D</td>
<td>One dimensional / two dimensional / three dimensional</td>
</tr>
<tr>
<td>AEP</td>
<td>Annual Exceedance Probability</td>
</tr>
<tr>
<td>AHD</td>
<td>Australian Height Datum</td>
</tr>
<tr>
<td>ARI</td>
<td>Average Recurrence Interval</td>
</tr>
<tr>
<td>ARR</td>
<td>Australian Rainfall and Runoff</td>
</tr>
<tr>
<td>BOM</td>
<td>Bureau of Meteorology</td>
</tr>
<tr>
<td>DEM</td>
<td>Digital Elevation Model</td>
</tr>
<tr>
<td>DS</td>
<td>Drainage Scheme</td>
</tr>
<tr>
<td>FI</td>
<td>Fraction Impervious</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>H-Q</td>
<td>Water level versus flow relationship</td>
</tr>
<tr>
<td>IWL</td>
<td>Initial Water Level</td>
</tr>
<tr>
<td>IFD</td>
<td>Intensity Frequency Duration (design rainfall data)</td>
</tr>
<tr>
<td>Kc</td>
<td>RORB routing parameter</td>
</tr>
<tr>
<td>LSIO</td>
<td>Land Subject to Inundation Overlay</td>
</tr>
<tr>
<td>m</td>
<td>RORB model exponent</td>
</tr>
<tr>
<td>MRPA</td>
<td>Major Road Projects Authority</td>
</tr>
<tr>
<td>MWC</td>
<td>Melbourne Water (Corporation)</td>
</tr>
<tr>
<td>SBO</td>
<td>Special Building Overlay</td>
</tr>
<tr>
<td>TIN</td>
<td>Triangulated Irregular Network</td>
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TERMINOLOGY

GENERAL

Definitions for phrases used throughout the report are provided below:

- **Study area** refers to the Mordialloc Freeway study area as covered by the extent of the hydraulic (Tuflow) model.
- **Flood modelling/models** is used to refer to both hydrologic and hydraulic modelling undertaken as part of this study.
- **2013 flood mapping project** or **2013 flood study** are both used to refer to the 2013 Melbourne Water flood study known as the Mordialloc Settlement Drain Flood Mapping project completed by consultant GHD.
- **The Dingley Bypass project** or **2014 flood study** are both used to refer to the 2014 VicRoads/Thiess transverse drainage hydraulic assessment for the Dingley Bypass project undertaken by consultant GHD.
- **Present flood study** refers to the Mordialloc Freeway hydrologic and hydraulic modelling study, i.e. this study.
- **Base case** refers to the setup of flood models under the existing built and natural environment of the study area, within the present timeframe and prior to the incorporation of the Mordialloc Freeway project.
- **Proposed case** refers to the setup of flood models incorporating the built features relevant to the Mordialloc Freeway project to create the proposed case conditions model, as well as any other specified features.

HYDROLOGIC

Consistent with advice in Australian Rainfall and Runoff (ARR) 2016, the terminology “Annual Exceedance Probability” (AEP) has been adopted when describing design rainfall events. However, where required for consistency with previous studies, design guidelines or software, “Average Recurrence Interval” (ARI) has also been used. These phrases are used to describe the rarity of a given rainfall event, but the new terminology is preferred as it is explicitly expressed in terms of probability and does not infer that a rainfall event occurs at set, regular intervals. The relationship between AEP and ARI is shown below.

Hydrologic terminology

<table>
<thead>
<tr>
<th>AEP (%)</th>
<th>AEP (1 IN X)</th>
<th>ARI (YEAR)</th>
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<tr>
<td>63.21</td>
<td>1.58</td>
<td>1</td>
</tr>
<tr>
<td>39.35</td>
<td>2.54</td>
<td>2</td>
</tr>
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<td>18.13</td>
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<tr>
<td>0.2</td>
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<tr>
<td>0.05</td>
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1 INTRODUCTION

A preliminary surface water impact assessment for the Mordialloc Freeway Upgrade was completed by WSP in June 2017 (at the time, proposed as an arterial). A key recommendation from the assessment of flood impacts was that a detailed quantitative assessment, through hydrologic and hydraulic modelling, be undertaken to define existing flood conditions and quantify the magnitude of flood impacts from the Mordialloc Freeway project (the project).

This report documents the hydrologic and hydraulic modelling (flood modelling) undertaken for a study area which captures the Mordialloc Freeway alignment and its contributing catchment. The purpose of flood modelling is to enable a detailed analysis of flood impacts and the subsequent investigation of flood mitigation options.

This report version, ‘Rev 02’, supersedes the previously issued ‘Rev 01’ version. Melbourne Water comments and the corresponding WSP responses are provided in Appendix B-1 of this report.

1.1 PROJECT DESCRIPTION

The project is the proposed construction and operation of a new freeway connecting the Dingley Bypass with the Mornington Peninsula Freeway; and is predominately within an existing road reservation (Figure 1.1). The project passes between the western boundary of Braeside Park and the eastern boundary of the Woodlands Estate (constructed) wetlands, traverses constructed wetlands at Waterways and approaches to within a kilometre of the Ramsar-listed Edithvale-Seaford Wetlands. The northern and southern ends of the project pass through or border the South East Green Wedge.

The project corridor is approximately 9.7 km in length, comprising two two-lane 7.5 km long carriageways (with a path for walking and cycling) along the greenfield alignment, and 2.2 km of roadworks required to integrate the project with the Mornington Peninsula Freeway. It is expected that each carriageway will provide for two 3.5 m wide lanes, with a 3.0 m wide outside shoulder and 1.0 m wide inside shoulder. The Mordialloc Freeway will also provide connections from the freeway onto the Dingley Bypass, Centre Dandenong Road, Lower Dandenong Road, Governor Road, Springvale Road and new north facing ramps at Thames Promenade. There will also be an overpass at Old Dandenong Road. Mordialloc Creek and the associated Waterways Wetlands will be spanned by twin 400 m long bridges.

The proposed alignment allows for a future upgrade of the project to a six lane freeway standard road within the construction footprint.

The proposed alignment is generally located within the existing road reservation, most of which is already covered by Public Acquisition Overlay, and some of which is already in VicRoads’ ownership.

The project area is shown in Figure 1.1. The proposed project consists of:

— Four lane freeway with two lanes in each direction and a divided centre median
— 3.5 metre wide lanes
— 100 km/hr posted speed
— A signalised T-intersection at Dingley Bypass
— Full diamond grade separated interchanges at Lower Dandenong Road, Governor Road and Springvale Road
— A bridge over Old Dandenong Road
— A half-diamond south facing grade separated interchange at Centre Dandenong Road
— Redirection of Woodlands Drive to Lower Dandenong Road via Tarnard Drive and Bell Grove
— An elevated structure over the Mordialloc Creek Wetlands and Bowen Parkway, between the Waterways Estate and Aspendale Gardens
— New north-facing ramps at Thames Promenade, connecting to the Mornington Peninsula Freeway
— A shared user path along the entire length of the Mordialloc Freeway to provide connection from Springvale Road to Dingley Bypass.
Figure 1.1 Project overview map
1.2 SCOPE

This report covers the hydrologic and hydraulic modelling (flood modelling) of the Project study area. It presents the methodology and output of flood mapping and flood mitigation. Flood modelling provided a means to undertake a flood impact assessment with the objective of informing the drainage reference design such that the requirements for the project are addressed (refer section 2).

The assessment of water quality as well as the broader drainage reference design is documented in the drainage strategy report for Mordialloc Freeway (WSP reference no. 2135645A-SE-26-WAT-REP-0002.docx).

1.3 CHANGES SINCE LAST REVISION

1.3.1 CHANGES FROM REV A TO REV B

The following key changes are noted since the issue of Revision A of this report:

1. Documentation of the Hydrologic and Hydraulic modelling of proposed case conditions.
2. The proposed case conditions Tuflow model and subsequent flood impact assessment is based on an arterial design alignment option.

1.3.2 CHANGES FROM REV B TO REV C

The following key changes are noted since the issue of Revision B of this report:

1. Dingley Bypass Project now accounted for in the base and proposed case RORB and Tuflow models.
2. Tuflow model extent optimised where flood modelling/mapping was not required.
3. The proposed case conditions Tuflow model and subsequent flood impact assessment is based on a freeway design alignment option which replaced the arterial alignment option.

1.3.3 CHANGES FROM REV C TO REV 00

The following key changes are noted since the issue of Revision C of this report:

1. High level flood impact assessment for proposed works at Thames Promenade
2. Options for flood mitigation in the Braeside Park area were modelled and assessed in the proposed case conditions Tuflow model.
3. Tidal inundation mapping and recommendations outlined for the downstream tail water condition set in the Tuflow model.

1.3.4 CHANGES FROM REV 00 TO REV 01

Report updated to address most Melbourne Water comments provided from Revision 00.

1.3.5 CHANGES FROM REV 01 TO REV 02

The following key changes are noted since the issue of Revision 01 of this report:

1. Update all Tuflow models to the latest build of Tuflow (2018-AB-03)
2. Update the Northern Tuflow model’s downstream boundary condition to be a varying tail water condition over time type boundary instead of a static tail water boundary (refer section 7.5).
2 REQUIREMENTS AND GUIDELINES

This section summarises the requirements and guidelines considered in this study.

2.1 MAJOR ROAD PROJECTS AUTHORITY

The Major Road Projects Authority (MRPA) adopted flood immunity standard for the Project mainline is the 1% AEP or 100 year ARI event relative to the edge of shoulder.

2.2 MELBOURNE WATER

The project is located within the Port Phillip and Westernport Catchment Management Authority region. Under the Water Act 1989, the designated waterways, regional drainage and floodplain management authority for the Port Phillip and Westernport catchment region is Melbourne Water.

Consultation with Melbourne Water involved discussion of performance objectives, flood modelling methodology as well as the exchange of data and documentation. Melbourne Water have developed a series of technical requirements documents specifically for the project, including performance criteria related to flood management objectives.

2.2.1 PERFORMANCE CRITERIA REQUIREMENTS

The Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass (Melbourne Water, June 2017) document outlines the flooding performance criteria for the project and is provided in Appendix A.

Key Melbourne Water flood management requirements include:

- No increase in 1% Annual Exceedance Probability (AEP) flood level/velocities as a result of the Project.
- No loss of floodplain storage volume.
- Application of blockage factors as per AR&R 2016 guidelines:
  - If an existing road level is being raised, then assessment of the 200 and 500 year ARI events should be considered.
- For new bridges:
  - Bridge soffit should be at least 0.6 metres above 100 year ARI flood level
  - Piers within waterways should be minimised
  - Pier scour rock protection must be provided to avoid scouring of natural surface within waterway
  - Maintenance access to be considered, including flood protection
  - Set pile caps below surface level.
- For underground drainage systems, the 5, 10, 20 and 50 year ARI events, in addition to the 100 year ARI event should be assessed to demonstrate no impacts as a result of proposed works.
- Stormwater runoff rates are to be controlled such that there is no significant increase in peak flows across a wide range of ARIs as well as to ensure no adverse impacts on downstream properties resulting from increased runoff volumes.
- Any proposed works associated with this project within Melbourne Water Drainage Schemes should not be built in way to preclude future Drainage Scheme works. This would be developed further in detail after Road alignment and associated works and flood mitigations works are set for Schemes area.
Include provision for climate change with the following criteria to be considered in a climate change assessment:

- Sea Level Rise (SLR) of 0.8 m by the Year 2100
- Rainfall intensity increase of 19% by Year 2100
- The project must be delivered in a way that does not limit Melbourne Water and other land managers and city planners from delivering on long term responsibilities and objectives for waterways, including responsibilities for working with communities to achieve place-based outcomes.

### 2.2.2 CONSTRUCTION PHASE REQUIREMENTS

Melbourne Water have outlined additional requirements during the construction phase related to flooding (Melbourne Water, June 2017). Construction activities, such as the undertaking of temporary works or the placement of equipment/plant, should carefully consider impact on flood conveyance or floodplain storage.

The following requirements apply:

- Prior to the commencement of any works, hydraulic modelling is to be submitted to Melbourne Water demonstrating minimum flood impacts as a result of the temporary works.
- Where there is a temporary impact on the floodplain, the project will be required to submit a method of mitigation to eliminate or reasonably manage such risk.

### 2.3 REFERENCE GUIDELINES

The following guidelines are relevant to this study:

- Australian Rainfall and Runoff (Institute of Engineers Australia, 1987): The adopted guideline for hydrologic modelling considerations, most notably, in the determination design storm rainfall (hydrologic modelling).
- Australian Rainfall and Runoff (Ball et al., 2016): Guideline used as a supplement to ARR 1987, for example, in determining hydraulic model blockage factors to apply at proposed transverse drainage locations.
- RORB User manual – RORB version 6 (Laurenson et al., 2010).
- Tuflow User Manual (BMT WBM, 2010).
3 METHODOLOGY

It was discussed with Melbourne Water that the approach to flood modelling in the study area was to undertake hydrologic modelling using RORB, a runoff-routing software; and hydraulic modelling using Tuflow, a two dimensional modelling tool.

The flood impact assessment for the project comprised the creation of base case and proposed case hydrologic and hydraulic models. This consisted of the following tasks:

— Consultation with Melbourne Water to inform them of the modelling methodology and input data.
— Review the available data and information which define the basis of modelling (Section 4), including:
  — Outline how two previously undertaken studies were used to aid in the setup of the RORB and Tuflow models for the study area.
— Define hydrologic modelling methodology and undertake modelling using RORB (Section 5).
— Define hydraulic modelling methodology and undertake modelling using Tuflow (Sections 6 to 8).
— Presentation of flood mapping, followed by discussion and analysis of the output (Section 9).
— Outlining the assumptions, limitations and recommendations applicable to the flood modelling (Section 10).

3.1 DESIGN STORM EVENT MODELLING

Base case and proposed case conditions hydraulic modelling were each investigated for the hydrologic scenarios and design AEP storm events listed under Table 3.1.

Table 3.1 Hydrologic and hydraulic modelling scenarios

<table>
<thead>
<tr>
<th>MODEL SCENARIO</th>
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<tr>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Existing</td>
<td>Estimation of flooding from design storm event modelling. The generation of IFD data was based on methodology prescribed in the 1987 edition Australian Rainfall and Runoff (IEAust, 1987).</td>
<td>✓</td>
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</tbody>
</table>
| Climate Change (2100) | Estimation of flooding by applying climate change considerations to the 1% AEP flood event. The following climate change considerations were required by Melbourne Water:  
  — An allowance for Sea Level Rise (SLR) of 0.8 m by the Year 2100 for the 1% AEP; and  
  — Rainfall intensity increase of 19% by Year 2100. | ✓  | N/A |
4 BASIS OF MODELLING

This section details how various input data and information were used in the flood modelling undertaken for the study area. The following key inputs were used:

- Melbourne Water schemes and assets that interfaced with the project area (refer 4.1).
- Topographic data (refer 4.2).
- GIS (Geographic Information System) data (refer 4.3) consisting of:
  - Project and cadastral boundaries
  - Drainage infrastructure including waterways, underground pipes and levee embankments
  - Melbourne Water flood extents and flood level contour data.
- As-built drawings and CAD data (refer 4.4).
- Feature survey data (refer 4.5).
- Proposed conditions design data (refer 4.6).
- Previous studies – reports and models (refer 4.7).

4.1 PROJECT INTERFACE

4.1.1 MELBOURNE WATER DRAINAGE LINES AND ASSETS

The Project crosses several Melbourne Water drainage lines and assets. These are listed under Table 4.1. Appendix D provides maps with an overview of the drainage lines that are crossed by the project and the presence of existing flood planning overlays.

Table 4.1 Form South to North: major drainage lines/assets crossed by the project

<table>
<thead>
<tr>
<th>DRAINAGE ASSET</th>
<th>DESCRIPTION</th>
<th>LOCATION</th>
<th>INTERCEPTED FLOOD OVERLAY</th>
<th>MWC ASSET ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smythes Drain</td>
<td>Open channel</td>
<td>Under Springvale Road and South of Mordialloc Creek</td>
<td>LSIO</td>
<td>1116-07</td>
</tr>
<tr>
<td>Mordialloc Creek</td>
<td>Waterway</td>
<td>Under Springvale Road and South of the Waterways estate wetlands</td>
<td>LSIO</td>
<td>1125-62</td>
</tr>
<tr>
<td>Parkway Lagoon</td>
<td>Wetland</td>
<td>Waterways residential estate</td>
<td>LSIO</td>
<td>1120-01</td>
</tr>
<tr>
<td>Braeside West D.S.</td>
<td>Open channel</td>
<td>Tarnard Drive extension, south of Lower Dandenong Road</td>
<td>LSIO</td>
<td>1102</td>
</tr>
<tr>
<td>Dingley Drain</td>
<td>Open channel</td>
<td>East of Woodlands Wetlands</td>
<td>LSIO</td>
<td>1128</td>
</tr>
<tr>
<td>Gartsides D.S.</td>
<td>Underground drain</td>
<td>Lower Dandenong Road</td>
<td>SBO</td>
<td>1108-01</td>
</tr>
<tr>
<td>Gartsides South D.S</td>
<td>Open channel</td>
<td>North of Lower Dandenong Road</td>
<td>SBO</td>
<td>1107-02</td>
</tr>
<tr>
<td>Gartsides D.S.</td>
<td>Underground drain</td>
<td>Charwick Reserve</td>
<td>SBO</td>
<td>1107-01</td>
</tr>
<tr>
<td>Old Dandenong Rd Drain</td>
<td>Open channel</td>
<td>Centre Dandenong Road and South of Dingley Bypass</td>
<td>SBO</td>
<td>1113</td>
</tr>
</tbody>
</table>
4.1.2 DRAINAGE SCHEMES

The Project crosses two drainage schemes, has a short interface with a further two schemes and will occur downstream of one scheme:

- Bowen Road DS (numerical identifier 1124) – shows planned channel on Smythes Drain across project alignment.
- Gartsides South DS (numerical identifier 1107) – scheme has been completed.
- Gartsides North DS (numerical identifier 1111) – upstream of Project.
- Carrum Lowlands DS (numerical identifier 1101).
- Braeside South DS (numerical identifier 1128) – shows planned wetland on northern side of Mordialloc Creek to west of project area.

The known planned works which interface with the project include a proposed channel along Smythes Drain which crosses the project alignment. Refer to Table 8.1 for details.

4.1.3 SITE INSPECTION

A site inspection was undertaken within the project boundary for the purpose of developing an understanding for the various site drainage conditions, with a particular focus on the drainage lines and the assets listed in Table 4.1. Table 4.2 provides a list of the key photos taken.

<table>
<thead>
<tr>
<th>DRAINAGE ASSET</th>
<th>DESCRIPTION</th>
<th>LOCATION</th>
<th>INTERCEPTED FLOOD Overlay</th>
<th>MWC ASSET ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Dandenong Rd Drain</td>
<td>Underground drain</td>
<td>Underground drain running east to west parallel to Centre Dandenong Road</td>
<td>SBO</td>
<td>1113-01</td>
</tr>
<tr>
<td>Gartsides North D.S</td>
<td>Underground drain</td>
<td>South of Centre Dandenong Road</td>
<td>SBO</td>
<td>1111-17</td>
</tr>
</tbody>
</table>

Table 4.2 Form South to North: photos captured during site inspection

<table>
<thead>
<tr>
<th>DRAINAGE ASSET OR LOCATION</th>
<th>PHOTO</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smythes Drain</td>
<td><img src="https://via.placeholder.com/150" alt="Image" /></td>
<td>Drainage configuration at the confluence of two Melbourne Water open drains: Smythes Drain and the Bowen Road DS system</td>
</tr>
<tr>
<td>DRAINAGE ASSET OR LOCATION</td>
<td>PHOTO</td>
<td>COMMENT</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Bowen Road D.S.</td>
<td><img src="image1.jpg" alt="Photo" /></td>
<td>Looking East from Bowen Parkway – The Bowen Road DS open drain</td>
</tr>
<tr>
<td>Mordialloc Creek at Waterways estate</td>
<td><img src="image2.jpg" alt="Photo" /></td>
<td>First Waterways estate outlet configuration: 0.6 metre dia.; Located under Bowen Parkway near ‘Parkway’ Lagoon.</td>
</tr>
<tr>
<td>Mordialloc Creek at Waterways estate</td>
<td><img src="image3.jpg" alt="Photo" /></td>
<td>Second Waterways estate outlet configuration: Twin 1.8 x 1.2 metre box culverts</td>
</tr>
<tr>
<td>DRAINAGE ASSET OR LOCATION</td>
<td>PHOTO</td>
<td>COMMENT</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Mordialloc Creek and Smythes Drains</td>
<td><img src="image1.jpg" alt="Photo" /></td>
<td>Mordialloc Creek levee embankment (Centre); Mordialloc Creek (Left, Waterways estate); and Smythes Drain (Right)</td>
</tr>
<tr>
<td>Dingley Drain</td>
<td><img src="image2.jpg" alt="Photo" /></td>
<td>Partially submerged Dingley drain outlet structure upstream of Woodlands wetlands: 5 no. 0.9 metre dia circular culverts</td>
</tr>
<tr>
<td>DRAINAGE ASSET OR LOCATION</td>
<td>PHOTO</td>
<td>COMMENT</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Braeside Park</td>
<td>![Photo of Braeside Park]</td>
<td>Contrast of shrubs implies presence of floodplain area West of 'The Parkway' Road.</td>
</tr>
<tr>
<td>Braeside West D.S.</td>
<td>![Photo of Braeside West D.S.]</td>
<td>Braeside West drain, South of Lower Dandenong Road, is lined with dense vegetation</td>
</tr>
<tr>
<td>Gartsides South D.S</td>
<td>![Photo of Gartsides South D.S.]</td>
<td>Vegetation outline along Gartsides South DS open drain, located North of Lower Dandenong Road</td>
</tr>
<tr>
<td>DRAINAGE ASSET OR LOCATION</td>
<td>PHOTO</td>
<td>COMMENT</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>Old Dandenong Rd Drain</td>
<td></td>
<td>Transverse drainage configuration at Old Dandenong Drain (also known as Dunlops drain) under Centre Dandenong Road: Twin 1.2 x 0.9 metre box culverts</td>
</tr>
<tr>
<td>Old Dandenong Rd Drain</td>
<td></td>
<td>Large open drain which runs parallel to Grange Road; Created as part of the Dingley Bypass Project (2017) and connects with Old Dandenong Road drain</td>
</tr>
</tbody>
</table>

### 4.2 BASE TOPOGRAPHIC DATA

Grid based elevation points from the Mordialloc Settlement Drain Flood Mapping Project were used as the base topographic input in the Tuflow hydraulic model. The points data is based on 2007 LiDAR aerial survey. An additional area of LiDAR (dated 2007) south of the Mordialloc Creek levee was also sourced separately for use in the project.

### 4.3 GIS DATA

GIS data for Melbourne Water managed assets including waterways, open channels, underground pipes, levee embankments were provided by Melbourne Water. Data for pits and pipes from the City of Kingston was obtained from VicRoads. GIS infrastructure layers were provided in either MapInfo table or ESRI shape format and contained dimensional attribute data, for example, most Melbourne Water underground pipe data contained values for pipe diameters and invert levels. The supplied Mordialloc Settlement drain Tuflow model (GHD, 2013) used various Council and Melbourne Water GIS drainage asset data; this data was also used in the study.

GIS data for culverts and underground pipes was reviewed against as-built information (refer section 4.4) and feature survey (refer section 4.5) within the project area boundary.
In addition to drainage asset data, GIS data of flood layers was supplied by Melbourne Water. This included flood extents and flood contour information for the 1% Annual Exceedance Probability (AEP) flood event. More detailed flood modelling output was also available from the 2013 flood mapping project (GHD, 2013) and included water level, flood depth and point velocities for five AEP events being the, 20%, 10%, 5%, 2% and 1% AEP events.

4.4 AS-BUILT DRAWINGS AND DATA

Several as-built drawings of drainage assets have been provided by Melbourne Water and VicRoads. They were used to confirm that the various dimensional attribute information for GIS asset data was correctly captured in the hydraulic model.

4.5 FEATURE SURVEY

Three-dimensional (X, Y and Z co-ordinates) survey of key features within the project area was provided by VicRoads and utilised in the hydraulic modelling. Features of interest to the hydraulic modelling from the feature survey included underground pipe and pit drainage (with invert levels and size), key open drains (e.g. Grange Road and Springvale Road drains), as well as several ridge (e.g. road crests) and gully lines (e.g. swales) expected to notably influence hydraulic behaviour.

4.6 PROPOSED CONDITIONS DESIGN DATA

The proposed case conditions Tuflow model used drainage design and topographic model data from the 12D and InRoads models. The proposed case conditions data used in this flood study is current as of 8 May 2018 and includes the following:

- Triangulated Irregular Network (TIN) grid of the project mainline and ramp embankments. TIN grid and 3D strings of road side design swales
- Proposed cross sectional elevation data for two Melbourne Water drains that were modified as part of the project drainage design
- Proposed Mordialloc Creek wetlands bridge design; and
- Proposed transverse drainage with invert levels.

4.7 REVIEW OF PREVIOUS STUDIES

This section describes how previous studies were used to aid the setup of the RORB and Tuflow models for the study area.

Previous studies relevant to this work are listed below. A summary of relevant findings from each of these studies is provided in Appendix E.

- Smythes drain/springs drain Bangholme Flooding Investigation Discussion paper, Draft version 3 (E4) (Craigie, 2011).
- The Waterways – Mordialloc creek floodplain wetland system, hydrologic, hydraulic, water quality and environmental performance (E5) (Craigie et. al., 2000).
4.7.1 FLOOD MODELS

A summary of the supplied RORB and Tuflow models which were used in this project are provided in Table 4.3.

Table 4.3 Summary of flood models

<table>
<thead>
<tr>
<th>STUDY</th>
<th>HYDROLOGY</th>
<th>HYDRAULICS</th>
<th>COMMENTS</th>
</tr>
</thead>
</table>
| MWC Mordialloc Settlement Drain Flood Mapping (GHD, May 2013) | RORB models:  
— Braeside West D.S. (MWC ID 1102)  
— Waterways (MWC ID 1120); and  
— Mordialloc Settlement Drain (MWC ID 5020). | Tuflow model of the MWC project study area | Does not cover Mordialloc Freeway project extent south of Mordialloc Creek |
| VicRoads Dingley Bypass Cross-drainage hydraulic assessment (GHD, 2014) | RORB models:  
— Braeside West D.S. (MWC ID 1102) modified for Dingley Bypass project; and  
— Mordialloc Settlement Drain (MWC ID 5020) modified for Dingley Bypass Project. | Tuflow model of the Dingley Bypass project and surrounding area | This study used the 2013 Mordialloc Settlement Drain Tuflow model as a basis for the Dingley Bypass flood modelling. |

4.7.2 REPORT – MELBOURNE WATER MORDIALLOC SETTLEMENT DRAIN FLOOD MAPPING (GHD, MAY 2013)

GHD (2013) completed flood modelling and mapping for Melbourne Water of the Mordialloc Settlement drain catchment and its surrounds; referred to in this report as the 2013 flood study. This also included a large area of the Mordialloc Freeway Project catchment between Dingley Bypass and Mordialloc Creek.

As part of the present study, the RORB and Tuflow models were provided by Melbourne Water. The modelling methodology was reviewed (Refer Appendix E – E3). It was discussed with Melbourne Water that the general approach of the current flood study is to adopt the modelling approach applied in the 2013 flood mapping project. Furthermore, GHD (2015) have also recommended that ‘detailed modelling using the existing Tuflow model (prepared for the Mordialloc Settlement Drain Flood Mapping Project) will be required to confirm (the desktop analysis)’ (Mordialloc Bypass Desktop Hydrology Assessment, 2015). Notable features in the approach to modelling include:

— The use of RORB to generate rainfall excess and routed inflows for input into Tuflow
— The adopted Tuflow model cell size of 4 metres
— Melbourne Water open channels, i.e. major open drains, modelled within the 1D network instead of the 2D domain.

Under this approach, the 2013 RORB and Tuflow models were used for this study however with updates carried out to the models’ setup layers and files in order to best reflect the current physical and built environment (e.g. dimensional drainage data or ground elevation information). This approach ensures consistency with the methodology adopted in the previous Melbourne Water study.

The extent of the 2013 Mordialloc Settlement drain Tuflow model is depicted in Appendix F. Separate RORB and Tuflow models were created to account for the project catchment south of the Mordialloc Creek levee (South models). The modelling methodology adopted in the southern RORB and Tuflow models is identical to that adopted in the models North of the Mordialloc Creek levee (North models).
4.7.3 REPORT – VICROADS / THIESS DINGLEY BYPASS CROSS-DRAINAGE HYDRAULIC ASSESSMENT (GHD, OCT 2014)

4.7.3.1 BACKGROUND – DINGLEY BYPASS MOTORWAY

The Dingley Bypass motorway, completed in 2017, is a major arterial road which intersects the northern extent of the Mordialloc Freeway Project. It was constructed after the completion of the Melbourne Water 2013 flood mapping project (refer section 4.7.2) and so was not accounted in the model setup of the 2013 RORB and Tuflow models.

During the detailed design phase of the project, GHD (2014) completed a flood modelling impact assessment for the Dingley Bypass project. This study has been referred to as the 2014 flood study in this report. Study findings that were relevant to the Mordialloc Freeway study are summarised in Appendix E (E2).

The 2014 flood study utilised the RORB and Tuflow models previously developed in 2013 (refer section 4.7.2) to develop the 2014 Dingley Bypass RORB and Tuflow models. The Dingley Bypass 2014 models were each provided by GHD and were used in the RORB and Tuflow model setups of this study.

4.7.3.2 ADOPTED METHODOLOGY

The following setup components from the 2014 models were adopted in the present study:

— The re-delineated and increased imperviousness of RORB subareas intersecting the Dingley Bypass
— Digital elevation data of the roadway embankment outside of the project feature survey (issued for construction status)
— Definition of road side swales and road crests that were outside of the project feature survey via Tuflow z-lines
— Re-distribution of inflow throughout the 1D and 2D domains within the Tuflow model as a result of updated RORB model configuration
— Pipe, pit and transverse culverts that were outside of the project feature survey were incorporated into the Tuflow 1D domain
— Terrain shaping and smoothing assumptions, most notably upstream and downstream of the Old Dandenong Road drain crossing.
5 HYDROLOGIC MODELLING

This section summarises the input and methodology associated with hydrologic modelling in the Mordialloc Freeway study area.

5.1 CATCHMENTS DESCRIPTION

The Project is located within the Braeside West, Mordialloc Creek wetlands (also referred to as ‘Waterways’) and Smythes Drain surface water catchments. These three catchment areas are described below and shown in Figure 5.1.

The Braeside West catchment covers an area of approximately 21 km² within the municipalities of Kingston and Greater Dandenong (GHD, 2013). It consists of several different land use types including residential, industrial, special use and green wedge zones. The main drainage asset within this catchment is the Braeside West drainage line which discharges to the Mordialloc Creek approximately 1 km east of the Wells Road Bridge.

The Mordialloc Creek Wetlands catchment is very flat and covers an area under two square kilometres within the municipality of Kingston. It consists of medium to high density development surrounding a wetland and lake system. Drainage is through the network of wetlands and eventual discharge into the Mordialloc Creek.

Both the Braeside West and Mordialloc Wetlands contribute flows to and are bounded by Mordialloc Creek to the south. Mordialloc Creek can be described as an artificial estuarine waterway which discharges to Port Phillip Bay and is bounded by levee embankments (Craigie et al., 2000).

A southern portion of the project boundary will occur within the Smythes Drain catchment area which is separated from Mordialloc Creek via a levee bank and drains to the ‘Bowen Road DS’ open channel drain. Smythes Drain occurs within the municipalities of Greater Dandenong and Kingston and has a catchment area of approximately seven square kilometres. The catchment consists predominantly of green wedge conservation zones and is described as being very flat with no external stream or drain flow to enter across its boundaries, particularly from neighbouring Mordialloc Creek (Craigie, 2011). The Smythes/Bowen Road DS catchments are separated from Mordialloc Creek by a constructed levee and there is a Melbourne Water pump station near Wells Road that pumps water from this catchment into Mordialloc Creek (Craigie, 2011). It is assumed that backflow through the pump station is not possible, therefore the Bowen Road DS open channel is not considered tidally influenced like its neighbour. There is also no interaction between Patterson River and the Smythes drain catchment up to and including a 1% AEP flood event (River banks read from LiDAR topography were higher than 1% AEP flood level contours provided by Melbourne Water).
Figure 5.1 Mordialloc Freeway surface water catchments
5.2 SOFTWARE

All hydrologic modelling for the surface water catchments described above was undertaken in the RORB software package – version 6.18. RORB is described in the software user manual as being ‘an interactive runoff and streamflow routing program that calculates catchment losses and streamflow hydrographs resulting from rainfall events and/or other forms of inflow to channel networks’ (Laurenson et al., 2010, p1). A given catchment is firstly divided into subareas and rainfall excess is calculated at the centroid of a given subarea with allowances made for infiltration and other losses. Rainfall excess is added to any existing flow in the network, and the combined flow is routed through a storage routing procedure based on a continuity and storage function given as \( S = kQ^m \), where ‘\( m \)’ is the model exponent and ‘\( k \)’ is the product of two factors including an empirical user-defined coefficient, \( k_c \), known as the RORB routing parameter.

5.3 MODELLING APPROACH

Altogether four RORB models, as listed in Table 5.1, were used in the hydrologic modelling. Each RORB model corresponds to the surface water catchments described in section 5.1, as well as an additional catchment located adjacent to Braeside West, known as the Mordialloc Settlement Drain catchment. It was included in the hydrologic assessment due to its hydraulic interface with the project.

Table 5.1 List of RORB models used or created

<table>
<thead>
<tr>
<th>RORB MODEL GIVEN NAME</th>
<th>MWC IDENTIFIER</th>
<th>CREATED / USED FROM PREVIOUS STUDY</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mordialloc Settlement Drain</td>
<td>5020 (created 2013; updated in 2014)</td>
<td>Supplied from 2013 and 2014 flood studies</td>
<td>Mordialloc Settlement Drain Flood Mapping project (GHD, May 2013) and Dingley Bypass cross-drainage Hydraulic Assessment (GHD, 2014)</td>
</tr>
<tr>
<td>Braeside West</td>
<td>1102 (created 2013; updated in 2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waterways</td>
<td>1120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Model (Smythes Drain catchment)</td>
<td>1116 and 1124</td>
<td>Created</td>
<td>N/A</td>
</tr>
</tbody>
</table>

5.3.1 SOUTH MODEL

As discussed under section 4.7.2, a new RORB model was required to capture hydrologic inflows from the southern catchment of the project. New RORB and Tuflow (refer section 6.1) models were created as part of the present study, each having the same extent between the two. Accordingly, the RORB ‘South model’ was used only to produce rainfall excess hydrographs from each delineated subarea, which in turn, were applied to the South Tuflow hydraulic model where all routing is undertaken. As no RORB streamflow routing was required, it is noted that the final hydrologic modelling output was relatively insensitive to the value of \( k_c \), the RORB routing parameter.

5.3.2 2013 AND 2014 RORB MODELS

The 2013 RORB models and their corresponding printout locations, parameters and applied diversions were generally left unchanged and adopted in the present flood study.

The 2013 flood mapping project completed by GHD produced RORB subareas that were delineated from LiDAR thinned ground points and later modified as part of the Dingley Bypass transverse drainage hydraulic assessment project (GHD, 2014, refer heading 4.7.3.2) to account for the effect of this project. In both projects, subareas had the general purpose of producing inflow hydrographs for input in the Tuflow model (GHD, 2013). However, in contrast to the South RORB
model described above, some streamflow routing was required. GHD (2013) had noted that this was needed where inflow was required at the tops of Melbourne Water drains (GHD, 2013). In addition to routed flows, rainfall excess hydrographs were still used. These were ‘printed’ from their respective subarea centroids, prior to the application of streamflow routing in the RORB model. Where streamflow routing was required in RORB, peak flow validation against rational method estimates was undertaken at their respective locations. This resulted in several rational method flow estimates at various locations across the different RORB catchments, which was followed by a sensitivity analysis to determine final values for the RORB routing parameter, ‘Kc’, to adopt in each RORB catchment model. The 2013 Flood Mapping project report provides further details on the validation process (refer sections 3.3.7 to 3.3.9).

5.4 SUBAREA DELINEATION

Appendix H depicts a map of the RORB subareas delineated for the South model only.\(^1\)

RORB subarea delineation in the South model was based on LiDAR survey points, flood level information, as well as Melbourne Water and City of Kingston drainage assets. The delineation process as well as the assignment of fraction impervious in the South model was undertaken in MapInfo using the add-on tool mi-RORB.

5.5 FRACTION IMPERVIOUS

5.5.1 BASE CASE CONDITIONS

5.5.1.1 SOUTH MODEL

Within the South model area, fraction impervious (FI) was assigned to individual cadastre/parcel shapes based on planning scheme zone areas. Each cadastre shape was assigned FI based on the respective planning zone within which the parcel fell. The applied data was reviewed for varying lot sizes and checked against aerial imagery to ensure that existing conditions are accurately represented. The aerial was only used in minor instances to increase the FI where the planning zone FI based assignment was too low. For example, Green Wedge Zones were assigned a default zone FI of 0.1 (as they are unlikely to be developed), however, this was increased in some instances where there were impervious surfaces observed within the RORB subarea.

Appendix H lists the adopted fraction impervious values for each subarea in the South model.

5.5.1.2 2013 AND 2014 RORB MODELS

According to the Mordialloc Settlement Drain Flood Mapping project (GHD, 2013), FI values adopted in the RORB modelling were allocated using planning scheme zones. These FI values were carried over to the current study and reviewed against 2016 aerial imagery. The purpose of the review was to identify significant changes in development density since completion of the 2013 flood study. Updates to fraction impervious were then applied to the corresponding RORB model.

The following notable changes to development since 2013 were identified:

- **Constructed Dingley Bypass arterial motorway**: To account for the effect of increased subarea fraction impervious from the Dingley Bypass project, the 2014 RORB models for Braeside West and Mordialloc Settlement Drain replaced the 2013 versions of each respective model and were adopted in this study.

\(^1\) The delineation of 2013 RORB subareas is not shown in this report as their original layout was retained. A map layout of the 2013 RORB subareas is available in Appendix B7 of the Mordialloc Settlement Drain Flood Mapping Final report (GHD, May 2013)
Expansion of development in the Moorabbin Airport development: FI values for respective RORB subareas in the Moorabbin Airport development were updated to reflect present developed conditions. Table 5.2 lists the RORB subareas which have been updated.

Table 5.2 Update of base case conditions RORB subareas

<table>
<thead>
<tr>
<th>RORB MODEL IDENTIFIER</th>
<th>DEVELOPMENT</th>
<th>SUBAREA RORB IDENTIFIER (GHD, 2014)</th>
<th>IMPERVIOUS FRACTION (GHD, 2014)</th>
<th>2018 IMPERVIOUS FRACTION</th>
<th>DIFFERENCE IMPERVIOUS FRACTION</th>
<th>PERCENTAGE INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YD</td>
<td>0.218</td>
<td>0.500</td>
<td>0.282</td>
<td>129%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>WQ</td>
<td>0.100</td>
<td>0.600</td>
<td>0.500</td>
<td>500%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>WR</td>
<td>0.100</td>
<td>0.900</td>
<td>0.800</td>
<td>800%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YI</td>
<td>0.100</td>
<td>0.600</td>
<td>0.500</td>
<td>500%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YE</td>
<td>0.145</td>
<td>0.800</td>
<td>0.655</td>
<td>452%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YK</td>
<td>0.119</td>
<td>0.400</td>
<td>0.281</td>
<td>236%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YG</td>
<td>0.100</td>
<td>0.800</td>
<td>0.700</td>
<td>700%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>WP</td>
<td>0.100</td>
<td>0.900</td>
<td>0.800</td>
<td>800%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>WN</td>
<td>0.272</td>
<td>0.900</td>
<td>0.628</td>
<td>231%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>WO</td>
<td>0.172</td>
<td>0.300</td>
<td>0.128</td>
<td>74%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YH</td>
<td>0.105</td>
<td>0.200</td>
<td>0.095</td>
<td>90%</td>
</tr>
<tr>
<td>5020</td>
<td>Moorabbin Airport</td>
<td>YC</td>
<td>0.348</td>
<td>0.900</td>
<td>0.552</td>
<td>159%</td>
</tr>
</tbody>
</table>

5.5.2 PROPOSED CASE CONDITIONS

Under proposed case conditions, fraction impervious (FI) was increased for RORB subareas which intercepted the project. Several FI values between 40% and 65% were used to define the imperviousness of the road corridor based on an arterial road alignment option with a wide central median. It does not reflect the latest freeway design alignment which actually has a reduced road formation width, between the back of kerb of each carriageway. Minor updates to FI may be required to reflect the updated formation. Table 5.3 lists the RORB subareas and corresponding FI values that have been adopted for proposed case conditions hydrologic modelling.
<table>
<thead>
<tr>
<th>RORB MODEL IDENTIFIER</th>
<th>SUBAREA IDENTIFIER</th>
<th>BASE CASE IMPERVIOUS FRACTION</th>
<th>PROPOSED CASE IMPERVIOUS FRACTION</th>
<th>DIFFERENCE</th>
<th>PERCENTAGE INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1102</td>
<td>FF</td>
<td>0.137</td>
<td>0.22</td>
<td>0.083</td>
<td>61%</td>
</tr>
<tr>
<td>1102</td>
<td>FG</td>
<td>0.240</td>
<td>0.309</td>
<td>0.069</td>
<td>29%</td>
</tr>
<tr>
<td>1102</td>
<td>FM</td>
<td>0.150</td>
<td>0.186</td>
<td>0.036</td>
<td>24%</td>
</tr>
<tr>
<td>1102</td>
<td>FP</td>
<td>0.189</td>
<td>0.224</td>
<td>0.035</td>
<td>19%</td>
</tr>
<tr>
<td>1102</td>
<td>GB</td>
<td>0.091</td>
<td>0.131</td>
<td>0.040</td>
<td>44%</td>
</tr>
<tr>
<td>1102</td>
<td>GD</td>
<td>0.081</td>
<td>0.145</td>
<td>0.064</td>
<td>79%</td>
</tr>
<tr>
<td>1102</td>
<td>GE</td>
<td>0.083</td>
<td>0.103</td>
<td>0.020</td>
<td>24%</td>
</tr>
<tr>
<td>1102</td>
<td>GH</td>
<td>0.361</td>
<td>0.366</td>
<td>0.005</td>
<td>1%</td>
</tr>
<tr>
<td>1102</td>
<td>GI</td>
<td>0.230</td>
<td>0.281</td>
<td>0.051</td>
<td>22%</td>
</tr>
<tr>
<td>1102</td>
<td>GJ</td>
<td>0.328</td>
<td>0.386</td>
<td>0.058</td>
<td>18%</td>
</tr>
<tr>
<td>1102</td>
<td>GK</td>
<td>0.162</td>
<td>0.217</td>
<td>0.055</td>
<td>34%</td>
</tr>
<tr>
<td>1102</td>
<td>GL</td>
<td>0.599</td>
<td>0.602</td>
<td>0.003</td>
<td>1%</td>
</tr>
<tr>
<td>1102</td>
<td>GM</td>
<td>0.285</td>
<td>0.304</td>
<td>0.019</td>
<td>7%</td>
</tr>
<tr>
<td>1102</td>
<td>GO</td>
<td>0.322</td>
<td>0.394</td>
<td>0.072</td>
<td>22%</td>
</tr>
<tr>
<td>1102</td>
<td>GP</td>
<td>0.260</td>
<td>0.33</td>
<td>0.070</td>
<td>27%</td>
</tr>
<tr>
<td>1102</td>
<td>GT</td>
<td>0.561</td>
<td>0.564</td>
<td>0.003</td>
<td>1%</td>
</tr>
<tr>
<td>1102</td>
<td>JQ</td>
<td>0.358</td>
<td>0.367</td>
<td>0.009</td>
<td>3%</td>
</tr>
<tr>
<td>1102</td>
<td>NL</td>
<td>0.221</td>
<td>0.249</td>
<td>0.028</td>
<td>13%</td>
</tr>
<tr>
<td>1102</td>
<td>NM</td>
<td>0.115</td>
<td>0.28</td>
<td>0.165</td>
<td>143%</td>
</tr>
<tr>
<td>1102</td>
<td>NZ</td>
<td>0.342</td>
<td>0.404</td>
<td>0.062</td>
<td>18%</td>
</tr>
<tr>
<td>1102</td>
<td>OB</td>
<td>0.409</td>
<td>0.464</td>
<td>0.055</td>
<td>13%</td>
</tr>
<tr>
<td>1102</td>
<td>TT</td>
<td>0.100</td>
<td>0.201</td>
<td>0.101</td>
<td>101%</td>
</tr>
<tr>
<td>1102</td>
<td>TV</td>
<td>0.129</td>
<td>0.195</td>
<td>0.066</td>
<td>51%</td>
</tr>
<tr>
<td>1102</td>
<td>TW</td>
<td>0.118</td>
<td>0.175</td>
<td>0.057</td>
<td>48%</td>
</tr>
<tr>
<td>1102</td>
<td>TZ</td>
<td>0.100</td>
<td>0.156</td>
<td>0.056</td>
<td>56%</td>
</tr>
<tr>
<td>1102</td>
<td>UA</td>
<td>0.107</td>
<td>0.160</td>
<td>0.053</td>
<td>50%</td>
</tr>
<tr>
<td>1102</td>
<td>UB</td>
<td>0.100</td>
<td>0.171</td>
<td>0.071</td>
<td>71%</td>
</tr>
<tr>
<td>1102</td>
<td>UH</td>
<td>0.311</td>
<td>0.373</td>
<td>0.062</td>
<td>20%</td>
</tr>
<tr>
<td>1102</td>
<td>WA</td>
<td>0.177</td>
<td>0.191</td>
<td>0.014</td>
<td>8%</td>
</tr>
<tr>
<td>1102</td>
<td>WB</td>
<td>0.142</td>
<td>0.224</td>
<td>0.082</td>
<td>58%</td>
</tr>
</tbody>
</table>
5.6 DESIGN RAINFALL

Design Rainfall applied in the RORB modelling was determined based on the methodology prescribed in the 1987 edition of Australian Rainfall and Runoff (ARR87) (Book 2, IEAust 1987). This is consistent with the design rainfall determination methodology used in the 2013 Melbourne Water study.

5.6.1 EVENTS AND DURATIONS

A range of design rainfall events have been assessed in RORB being the 20, 10, 5, 2 and 1 percent AEPs respectively. At the same time, twenty standard ARR87 storm durations between 10 minutes and 72 hours were assessed for each AEP. An additional scenario assessing climate change for a 1% AEP event was also considered.

5.6.2 DESIGN RAINFALL INTENSITIES

Design rainfall intensities were obtained from the Bureau of meteorology’s webpage for IFD creation (BoM, 2010) and are based on four sets of Intensity-Frequency-Duration (IFD) charts for each RORB model. IFD parameters are listed in Table 5.4. IFD rainfall intensity parameters for the 1% AEP climate change scenario were increased by 19%, while skew was retained, and F2/F50 parameters calculated separately based on a Melbourne Water supplied spreadsheet.

Table 5.4 Adopted IFD parameters to generate IFD data (based on methodology prescribed in 1987 edition of ARR)

<table>
<thead>
<tr>
<th>CLIMATE SCENARIO</th>
<th>IFD PARAMETER</th>
<th>5020</th>
<th>1102</th>
<th>1120</th>
<th>SOUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing scenario</td>
<td>2y 1h (mm/hr)</td>
<td>18.09</td>
<td>18.14</td>
<td>17.74</td>
<td>17.66</td>
</tr>
<tr>
<td></td>
<td>2y 12h (mm/hr)</td>
<td>3.97</td>
<td>3.92</td>
<td>3.87</td>
<td>3.84</td>
</tr>
<tr>
<td></td>
<td>2y 72h (mm/hr)</td>
<td>1.15</td>
<td>1.12</td>
<td>1.12</td>
<td>1.11</td>
</tr>
<tr>
<td></td>
<td>50y 1h (mm/hr)</td>
<td>36.13</td>
<td>36.37</td>
<td>35.38</td>
<td>35.11</td>
</tr>
<tr>
<td></td>
<td>50y 12h (mm/hr)</td>
<td>7.18</td>
<td>7.13</td>
<td>7.17</td>
<td>7.18</td>
</tr>
<tr>
<td></td>
<td>50y 72h (mm/hr)</td>
<td>2.26</td>
<td>2.25</td>
<td>2.25</td>
<td>2.23</td>
</tr>
<tr>
<td></td>
<td>Skewness (‘G’)</td>
<td>0.37</td>
<td>0.37</td>
<td>0.38</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>F2 value</td>
<td>4.28</td>
<td>4.28</td>
<td>4.27</td>
<td>4.27</td>
</tr>
<tr>
<td></td>
<td>F50 value</td>
<td>14.96</td>
<td>14.95</td>
<td>14.95</td>
<td>14.95</td>
</tr>
</tbody>
</table>
### 5.6.3 COMPARISON WITH ARR 2016 DESIGN RAINFALL INTENSITY

ARR 1987 has been adopted for design storm event calculation for consistency with previous studies, however IFD values for ARR 2016 were obtained for comparison. 1% AEP design rainfall depths from ARR 1987 and ARR 2016 were compared for several critical storm durations (refer section 7.8). For durations less than or equal to 1 hour, it was found that the ARR 2016 rainfall depths are at least 5% higher (up to 11% for the 15 minute duration event) than ARR 1987, while for durations greater than 1 hour ARR 2016 rainfall depths are generally less than ARR1987, with a maximum of 15% calculated difference for the 72 hour storm event. The determined critical durations storm events for the study area (refer section 7.8) are mostly greater than 1 hour (except for the 25 minute storm) therefore the presented results are more likely to be conservative.

Other hydrologic properties, e.g. temporal patterns and rainfall losses, may vary between ARR 1987 and ARR 2016, however these were not compared.

### 5.7 RORB MODEL PARAMETERS

The initial loss/runoff coefficient model was used in all specified RORB models including all AEP design storm runs in RORB. The RORB model parameters used those applied in the 2013 flood mapping project, which in turn, are consistent with advice provided in the Melbourne Water flood mapping guidelines and technical specifications (Melbourne Water, 2012).

As such, the following key RORB modelling parameters were applied:

- Initial loss = 10 mm.
- Runoff coefficients for pervious areas:
  - 100 year ARI (1% AEP) = 0.6
  - 50 year ARI (2% AEP) = 0.55
  - 20 year ARI (5% AEP) = 0.45
  - 10 year ARI (10% AEP) = 0.35
  - 5 year ARI (20% AEP) = 0.25.
- Model exponent, ‘m’, was adopted as 0.8 throughout.
- Areal reduction factor of 1.0 adopted throughout.
Adopted values for the RORB routing parameter, ‘Kc’, are listed in Table 5.5 and the determination methodology/source described below:

- **South model**: In the case for the South model, created as part of this study, ‘Kc’ was determined using RORB equation 2.5, given as \(2.2 \times \text{Catchment Area (sq km)}^{0.5}\). As explained in section 5.3.1, no routed prints would be required in the Southern RORB model, and as such, the final Tuflow hydraulic modelling output was insensitive to the value of the adopted Kc.

- **2013 RORB models**: Kc values were adopted from the 2013 flood mapping study. The 2013 study undertook validation with several rational method flow estimates at the tops of various Melbourne Water drains across the four RORB catchments. This was followed by a sensitivity analysis to determine final Kc values which varied for each RORB catchment model. Kc values are particularly relevant to the study where streamflow routing was required in the RORB model, as opposed to being undertaken in the Tuflow model which was predominantly the case.

### Table 5.5 Adopted routing parameters ‘Kc’ for each RORB model

<table>
<thead>
<tr>
<th>RORB MODEL</th>
<th>KC</th>
<th>SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mordialloc Settlement Drain (5020)</td>
<td>16</td>
<td><em>Table 3-2 of the Mordialloc Settlement Drain Flood Mapping Final Report (GHD, 2013)</em></td>
</tr>
<tr>
<td>Braeside West (1102)</td>
<td>9.98</td>
<td><em>Table 3-2 of the Mordialloc Settlement Drain Flood Mapping Final Report (GHD, 2013)</em></td>
</tr>
<tr>
<td>Waterways (1120)</td>
<td>2.87</td>
<td><em>Table 3-2 of the Mordialloc Settlement Drain Flood Mapping Final Report (GHD, 2013)</em></td>
</tr>
<tr>
<td>Heatherton Main Drain (5002)</td>
<td>11</td>
<td><em>Table 3-2 of the Mordialloc Settlement Drain Flood Mapping Final Report (GHD, 2013)</em></td>
</tr>
<tr>
<td>South model</td>
<td>6.82</td>
<td>RORB equation 2.5, given as (2.2 \times \text{Catchment Area (sq km)}^{0.5})</td>
</tr>
</tbody>
</table>
6 HYDRAULIC MODELLING – OVERVIEW

Hydraulic modelling was undertaken using the 1D/2D hydrodynamic modelling package Tuflow to determine flood behaviour under base case and proposed case conditions. Two Tuflow models were used as part of the present study:

— The Tuflow North model is based on the 2013 Mordialloc Settlement drain Tuflow model which is referred to as the 2013 Tuflow model in this report. It covers the section of the project between Dingley Bypass and Mordialloc Creek; and incorporates external inflows upstream of Dingley Bypass.
— The Tuflow South model is a new Tuflow model created as part of this study and covers the section of the Mordialloc Freeway between Mordialloc Creek and Thames Promenade.

The decision to use two separate models was because it was not possible to extend the Northern model southward due to the format of the supplied digital elevation model (MID Zpts used in Tuflow). The South model is also hydraulically separated from the North model due to the levee along the southern side of Mordialloc Creek and the blocking of the Smythes drain flood gates with steel plates (Refer Appendix E – E4).

As discussed under section 4.7.2, the agreed approach for flood modelling was to adopt the modelling approach applied in the 2013 flood mapping project. Under this approach, the Tuflow North model was based on the 2013 Tuflow model however with updates carried out to the models’ setup layers and files in order to best reflect the current physical and built environment (e.g. dimensional drainage data or ground elevation information). Please refer to section 7 and Appendix G for detailed information on the updates undertaken.

The Tuflow South model was created as part of this study and applied the same modelling methodology to that used in the Tuflow North model.

6.1 EXTENT OF HYDRAULIC MODELLING

The extent of hydraulic modelling was defined for each Tuflow model such that adequate hydraulic coverage was achieved for the Mordialloc Freeway project boundary. Figure 6.1 shows the extent of hydraulic modelling. An enlarged map is also provided in Appendix F. The logic behind the adopted model extents is described below:

— In the Tuflow North model, key changes from the 2013 Tuflow model extent included excluding the nearby Heatherton Main drain catchment as that catchment does not contribute to catchment flows in the study area nor was it needed for adequate hydraulic coverage, up to and including a 1% AEP flood event. This was determined from inspection of the 1% AEP flood extent output GIS layer supplied by Melbourne Water which showed non-interactive flooding with the study area flood extents. Furthermore, the Tuflow model extent was clipped to exclude an area North of the Dingley Bypass where flood modelling/mapping was not required. Several external inflows were applied to the final Tuflow extent at the location of the clip (refer section 7.4.2 for further information).

— In the Tuflow South model, the final model extent matched the RORB model extent. Catchment areas for the adjacent Springs and Carrum outfall drains were excluded from both the hydrologic and hydraulic modelling extents. This was determined from preliminary modelling output which showed that these catchments did not contribute to catchment flows in the study area, up to and including a 1% AEP flood event.
Figure 6.1  Adopted extent of flood modelling for the Mordialloc Freeway study area
6.2 TUFLOW MODEL BUILD

It is noted that previous revisions of this report have been based on the ‘2010-10-AC-iSP’ (2010 build) version of Tuflow, which was the version used by the 2013 Flood Mapping Project. Melbourne Water have stated that the latest build of Tuflow should be used for flood modelling (Appendix B-1, reviewer comment no. 40). As of July 2018, Tuflow modelling was undertaken using the ‘2018-03-AB-iSP’ (2018 build) build of Tuflow. Furthermore, there was no objection to the use of the relatively new HPC (Heavily Parallelised Computing) solution scheme (which can utilise GPU hardware) as opposed to the Classic solver (Appendix B-5). The HPC solver was adopted for model runs to date due to its increased speed of modelling computations (approximately ten fold the speed under Classic). Whilst the two solvers solve the same fundamental equations (2D shallow water), mathematical solutions differ and will give different results due to different in-built approaches. As such, WSP have assessed and compared Tuflow model output for 2018 Classic versus 2018 HPC solvers as well as for 2018 Classic versus 2010 Classic – each with identical setup (eg. TCF/ECF..etc). The results of this assessment with discussion are provided in email correspondence with Tuflow support available in Appendix T. The results generally indicate minor differences (up to 10% of flood depth) between the Classic and HPC solvers of Tuflow, within the same build, however larger differences are noted between different builds of Tuflow (2018 versus 2010). Recommendations going forward on this regard are provided under section 10.2.

It is noted that Melbourne Water requested that model runs should ultimately be simulated using Tuflow’s traditional ‘Classic’ solver (2018 build), however, WSP understands that this is just to ensure that there are no significant differences in the output between the two solvers.

6.3 MODEL CELL SIZE

A model cell size of four metres was used for all Tuflow modelling. This is also the same model cell size used in the Tuflow models associated with the Mordialloc Settlement Drain Flood Mapping Project as well as the transverse drainage hydraulic assessment of the Dingley Bypass project (GHD, 2014).

6.4 COMPUTATIONAL TIMESTEP

The 1D domain of the model was run on a 0.5 second computational timestep whilst the 2D domain used the default adaptive time-stepping feature available with Tuflow HPC.
HYDRAULIC MODELLING – BASE CASE

Base case conditions Tuflow modelling of the study area comprised the following steps:

- Digital elevation model set-up (refer section 7.1).
- 1D network set-up (refer section 7.2).
- Surface roughness parameter set-up (refer section 7.3).
- Inflow boundary conditions set-up (refer section 7.4).
- Downstream boundary conditions set-up (refer sections 7.5 and 7.6).
- Initial water level conditions set-up (refer section 7.7).
- Critical duration analysis (refer section 7.8).

A layout of the base case Tuflow digital elevation model, 1D network and key model boundary conditions is provided in Appendix I.

The base case conditions Tuflow model was based on the 2013 and 2014 Tuflow models. For a detailed outline of data input changes between this study’s Tuflow model and the aforementioned Tuflow models, please refer to Appendix G.

7.1 DIGITAL ELEVATION MODEL

7.1.1 TUFLOW NORTH MODEL

Within the Tuflow North model, the digital elevation model (DEM) was based on a modified LiDAR dataset which was available from the 2013 Tuflow model. Some supplementation of LiDAR data as part of the 2013 flood study was undertaken. It was based on several sources of data including detailed survey, design drawings or as discussed Melbourne Water^2. These were retained in the current modelling. Additional terrain supplements that were previously applied to the LiDAR data, e.g. the filling of depressions, were also adopted in the present study.

As part of developing the base case conditions Tuflow North model, further terrain supplements were required. A list of supplements to the LiDAR data made as part of the present flood study are listed under Appendix G. The most significant of these are listed below:

- **The Moorabbin Airport Retarding Basin** and associated Mordialloc Settlement drain diversion (constructed in 2015 – refer Appendix G for as-constructed drawing). To define the retarding basin into the DEM, a smoothed TIN was created in 12D based on the supplied as-constructed drawing, and incorporated into the Tuflow DEM. Other changes such as the backfilling of a section of Mordialloc Settlement Drain was undertaken using z-shape/line functionality in Tuflow, whereas the open drain diversion was modelled as part of the 1D domain (refer heading 7.2.2).

- **The Dingley Bypass alignment**, which was constructed in 2017. Digital elevation data was extracted from the 2014 Dingley Bypass Tuflow model, which contained a TIN and Tuflow z-lines at issued for construction status. Additional z-lines included Dingley Bypass road side drains, which were also incorporated into the final digital elevation model.

^2 For further information and specific locations of supplemented data, refer to heading 3.2 of the 2013 flood mapping project (GHD, 2013)
— **Surveyed topographic features** captured by the project feature survey including open drains and earth bunds. Of note was the large open drain parallel to Grange Road (apx 40 metres width), constructed in 2016 as part of the Dingley Bypass project. The drain was incorporated as a smoothed TIN with Tuflow z-lines overlayed on to the TIN.

### 7.1.2 TUFLOW SOUTH MODEL

Within the Tuflow South model, the digital elevation model was based on a purchased area of LiDAR (DELWP, 2007) south of the Mordialloc Creek, encompassing the catchments of Smythes Drain and Bowen Road Drainage Scheme. In developing the base case conditions Tuflow South model, minor terrain supplements to the LiDAR data were required as part of the present flood study. These changes have been included under the asset assumptions and updates log in Appendix G. Surveyed topographic features captured by the project feature survey were also incorporated into the digital elevation model. Notable surveyed locations where z-lines and z-shapes were required included the confluence of the Smythes and Bowen Road DS drains as well as a section of the Springvale Road median drain which formed part of the Melbourne Water Smythes drain route.

### 7.2 1D NETWORK

#### 7.2.1 UNDERGROUND DRAINS

Underground drains were modelled as part of the 1D network in Tuflow. Available GIS dimensional data, mainly invert levels and sizes, were cross-checked with the supplied as-built drawings and project feature survey. The focus of cross-checking was generally on Melbourne Water drainage assets within a 100-metre buffer from the project boundary. In the unusual instance that there was insufficient information to define asset data, i.e. no GIS attribute data or no as-built drawings available, informed assumptions were made for the modelled assets. This was generally required to minor Council drainage assets outside of the project survey area. The following is a summary of the available underground drains data in each Tuflow model:

— In the Tuflow North model, the supplied Mordialloc Settlement drain Tuflow model (GHD, 2013) had incorporated Council drains as well as all of Melbourne Water drains but did not include most private drainage (e.g. Moorabbin Airport drainage). It is understood that Council drains smaller than 0.45 metres were not included in the Tuflow model. This data was retained in the hydraulic modelling undertaken for the present study, but with updates made to the asset information to match information available from as-built drawings. Additional underground drainage for Moorabbin Airport was also incorporated, sourced from as built drawings.

— In the Tuflow South model, City of Kingston (Council), VicRoads and Melbourne Water underground drains were all incorporated into the model. Pipe and culvert sizes as well as invert levels were generally available for the Melbourne Water network whereas most Council and some VicRoads drains generally did not contain invert level information. For these networks, invert levels were assumed based on a standard cover of 0.6 metres below ground level.

A full list of updates and additions (e.g. pipe diameter or invert levels) made to underground drains from the 2013/2014 Tuflow models is provided in Appendix G.

#### 7.2.2 OPEN CHANNELS

The 2013 flood study represented most open channels (Melbourne Water owned) as one-dimensional (1D) elements with 2D boundary condition interface cells defined along the channel banks to facilitate the interchange of flow between the 1D network and wider 2D domain. A small number of swale and gully drainage was defined in the 2D domain where the 2D topographic representation was deemed appropriate. 1D open channels were modelled as ‘S’ type channels in Tuflow, representing a sloping channel that can handle steep, super-critical flows (BMT WBM, 2010).

1D-modelled open channels were retained in their supplied form within the Tuflow North model, with three newly incorporated channels created as part of this study. In each case, as-constructed drawings were used to define cross-
sectional profiles along the open channel alignment. The three newly incorporated 1D open channels are listed in Table 7.1.

Table 7.1 Additional 1D based open channels represented into the Tuflow models for as part of this study

<table>
<thead>
<tr>
<th>OPEN CHANNEL NAME.</th>
<th>TUFLOW MODEL</th>
<th>MWC ASSET IDENTIFIER</th>
<th>AS CONSTRUCTED SOURCE PLAN</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>North</td>
<td>5020</td>
<td>Moorabbin Airport Corporation – Mordialloc Settlement Drain (5020/09)</td>
<td>An open channel drain constructed in 2015 adjacent Moorabbin Airport. In addition, the former alignment of Mordialloc Settlement Drain was backfilled.</td>
</tr>
<tr>
<td>Bowen Road DS</td>
<td>South</td>
<td>1124</td>
<td>Bowen Road Drainage Scheme Stages 6 to 10 (1124/06-10)</td>
<td>1D representation between the inception of the drain and its confluence with Smythes drain. The remainder of the channel was deemed appropriate for representation in the 2D domain due to its wider cross section.</td>
</tr>
<tr>
<td>Smythes Drain</td>
<td>South</td>
<td>1116</td>
<td>Cross sections of Smythes Drain (1116/06) Smythes Drain Outfall Improvement Works (1116/07)</td>
<td>Full 1D representation of channel with minor 2D representation at the crossing with Springvale Road. A TIN sourced from project area feature survey was used (July 2017).</td>
</tr>
</tbody>
</table>

In addition to newly incorporated channels, one existing Melbourne Water channel – Old Dandenong drain – was modified at two locations to reflect changes to its vertical alignment and configuration as part of the Dingley Bypass project. Feature survey was used to inform the latest configuration of the Melbourne Water channel at the intersection with Grange Road drain, while the 2014 Dingley Bypass Tuflow model was used to inform the channel configuration at the crossing location with Dingley Bypass, being the best available information to this study.

7.2.3 BRIDGES

The 2013 flood study represented bridges along open channels within the Tuflow 1D network either as ‘B’ type ‘channels’, where the bridge deck is modelled in the 2D domain, or ‘BW’ channels, where the bridge deck is modelled as a weir in the 1D network. As part of the present flood study, no new bridges were required in the base case conditions Tuflow model.

7.2.4 STRUCTURE LOSSES

7.2.4.1 PIPE JUNCTIONS

It is noted that the calculation of entrance and exit losses in the 1D network, i.e. head losses at pipe junctions, varied in methodology between the North and Tuflow South models. The Tuflow North model retained the losses applied in the 2013 flood study. An alternative losses calculation method was required for pipe junctions in the Tuflow South model since the methodology employed in the 2013 flood study was not available to WSP. As such, the adopted approach was to have Tuflow automatically calculate the losses based on the Engelhund loss deduction method, which creates a manhole at every pipe junction and allows losses to vary according to the approach and departure velocities upstream and downstream of the junction for a given model time step. This approach is documented in the Tuflow manual (BMT WBM, 2010) and is widely accepted in the absence of reliable junction loss information.
7.3 MANNING’S ‘N’ BED RESISTANCE VALUES

7.3.1 GENERAL

Baseline Manning’s ‘n’ values assigned to the 2D domain were copied from Table 3-3 of the Mordialloc Settlement Drain Flood Mapping Project (GHD, 2013). This table has been extracted from the report and provided below (Table 7.2). An additional land use category was added to suit some farming land use areas in the Tuflow South model.

Appendix I depicts the delineation of surface roughness under base case conditions in each Tuflow model.

Table 7.2 Adopted bed resistance values in the Tuflow 2D domain

<table>
<thead>
<tr>
<th>LAND USE</th>
<th>MANNING’S ‘N’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Area</td>
<td>0.2</td>
</tr>
<tr>
<td>Road Reserve (including nature strip and footpath)</td>
<td>0.02</td>
</tr>
<tr>
<td>Open Space – mostly grass</td>
<td>0.03</td>
</tr>
<tr>
<td>Open Space – some brush</td>
<td>0.04</td>
</tr>
<tr>
<td>Open Space – mostly dense bush</td>
<td>0.07</td>
</tr>
<tr>
<td>Creek or open space – mostly dense brush</td>
<td>0.05</td>
</tr>
<tr>
<td>Railway</td>
<td>0.05</td>
</tr>
<tr>
<td>Low Density Residential</td>
<td>0.1</td>
</tr>
<tr>
<td>Commercial Area</td>
<td>0.35</td>
</tr>
<tr>
<td>“Blocked out” buildings</td>
<td>0.5</td>
</tr>
<tr>
<td>Open space – some trees</td>
<td>0.035</td>
</tr>
<tr>
<td>Industrial Area</td>
<td>0.2</td>
</tr>
<tr>
<td>Lakes</td>
<td>0.05</td>
</tr>
<tr>
<td>Rural/farm sheds</td>
<td>0.08</td>
</tr>
<tr>
<td>Wetlands</td>
<td>0.05</td>
</tr>
<tr>
<td>Channel safety fence</td>
<td>0.1</td>
</tr>
<tr>
<td>Farming/agricultural use</td>
<td>0.06</td>
</tr>
</tbody>
</table>

In the 1D domain, i.e. open channels and underground pipes or culverts, the assignment of Manning’s ‘n’ values also depended on the type of surface or material. As all newly incorporated open channels were grassed, the manning’s ‘n’ applied ranged between 0.03 to 0.04 with typically lower values applied away from the base of the channel. A value of 0.013 was assigned for all newly incorporated pipes and culverts (assumed concrete based).
## 7.3.2 ALLOCATION

The following is a summary of the approach to Manning’s ‘n’ allocation in each Tuflow model:

— **Tuflow North model**: The approach adopted was to review the already allocated Manning’s ‘n’ values per 2013 Tuflow modelling against recent aerial imagery (2016). This approach is suitable as the project catchment is mostly already developed and the purpose of the review was to identify significant changes in development density since completion of the 2013 flood study and update the Manning’s ‘n’ accordingly. As such, this was only required at Moorabbin Airport owing to significant development in this area since 2013. For the Dingley Bypass area, Manning’s ‘n’ per 2014 Tuflow modelling (Dingley Bypass cross drainage assessment, 2014) was retained.

— **Tuflow South model**: Manning’s ‘n’ values in the Tuflow South model were allocated by assigning individual Manning’s ‘n’ to each cadastre/parcel polygon within the southern model extension area. The assignment was firstly based on the respective planning zone which the parcel falls within. The applied data was reviewed for varying residential lot sizes and checked against aerial imagery to ensure that existing conditions are correctly represented.

Refer to the Tuflow surface roughness map (Appendix I) for a distribution of adopted manning’s ‘n’ values in both the North and South models.

## 7.4 INFLOW BOUNDARY CONDITIONS

### 7.4.1 STUDY AREA (INTERNAL) INFLOW

#### 7.4.1.1 OVERVIEW

As described under section 5.3, printed hydrographs from RORB were such that both routed and non-routed (rainfall excess) hydrographs were used in the Tuflow North model, while only rainfall excess hydrographs were used in the Tuflow South model. It is noted that all RORB inflows used as part of this study are ‘internal’, i.e. within the Tuflow model extent, and there were no external RORB inflows used as part of this study. There are, however, external inflows provided from the wider Tuflow model (refer section 7.4.2) and from Mordialloc Creek at Springvale Road (refer section 7.4.3).

The RORB inflows were applied either direct to 1D elements (e.g. pipes and open channels) through a 1D boundary condition (1D BC) polygon or within the 2D domain via 2D SA polygons (lowest cell). If 1D elements were present, for example a 1D pipe network or open channel, 1D BC polygons were preferred over SA polygons.

It is also noted that two ‘SA all’ type polygons were used for a floodplain area of the Smythes drain catchment (West of Springvale Road) which allows for the application of inflow evenly to all cells within the polygons.

#### 7.4.1.2 INTERNAL INFLOW DISTRIBUTION

As RORB sub-catchment delineation was not changed as part of this study, an alternative method was required such that 1D and 2D inflows remained largely unchanged between base case and propose case conditions. This is especially the case where the Mordialloc Freeway intercepts RORB sub-catchments, therefore necessitating a re-distribution of inflow magnitude to properly reflect the ‘disruption’ of flow caused by the roadway embankment. An example of an area where inflow magnitude re-distribution was undertaken is depicted in Figure 7.1.
7.4.2 EXTERNAL INFLOW FROM BROADER 2013 TUFLOW MODEL

As the Tuflow model extent was clipped to exclude an area North of the Dingley Bypass where flood modelling/mapping was not required, several external inflow boundaries were required to represent flow occurring upstream of the clipped area. Multiple 1D and 2D Flow versus time (Q-T) plot outputs were extracted from simulations of the broader 2013 Tuflow model and applied as Q-T inflow boundary conditions to the clipped model extent. The locations where the external inflows had been applied is depicted in Appendix I.

7.4.3 EXTERNAL INFLOW FROM MORDIALLOC CREEK

The Mordialloc Creek enters the Tuflow North model at Springvale Road near the South-Eastern corner of the Tuflow boundary. AEP event based inflow hydrographs from Mordialloc Creek were required at this location. In this respect, the 2013 flood mapping project report notes that whilst most inflows from external catchments were analysed by GHD, the Mordialloc Creek inflows at Springvale Road were provided by Melbourne Water\(^3\). The inflow hydrographs were also adopted in the current study due to being the best available information at the time of this study. Correspondence between Melbourne Water and WSP on this regard is provided in Appendix B-2.

For the climate change scenario, a 1.19 multiplier was factored to each time incremented discharge in the hydrograph before application. This method was adopted given the absence of other reliable flow versus time information and assumes that the increase in rainfall intensity is directly proportional to the increase in flow rate. Correspondence between Melbourne Water and WSP on this regard is provided in Appendix B-4.

\(^3\) Mordialloc Settlement Drain Flood Mapping Project (GHD, 2013)
7.5 DOWNSTREAM BOUNDARY CONDITIONS – TUFLOW NORTH MODEL

7.5.1 MORDIALLOC CREEK INTERFACE (BACKGROUND)

Flood behaviour in the Waterways estate catchment and Braeside Park areas is dominated by the level of the downstream boundary and initial water levels set up for the Tuflow North model at the Mordialloc Creek boundary interface. Table 7.3 lists the flood levels that were used in the 2013 flood study (GHD, 2013). The 2013 Tuflow model applied the flood levels as a static tail water (constant with time) versus time boundary condition at the Mordialloc Creek interface.

Table 7.3 Adopted flood levels at the Mordialloc Creek interface

<table>
<thead>
<tr>
<th>ARI (YEAR)</th>
<th>AEP (%)</th>
<th>EXISTING SCENARIO FLOOD LEVEL (mAHD)</th>
<th>CLIMATE CHANGE SCENARIO FLOOD LEVEL (mAHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
<td>2.70</td>
<td>3.5</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>1.85</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>1.70</td>
<td></td>
</tr>
</tbody>
</table>

THE WATERWAYS REPORT (CRAIGIE ET AL., 2000)

The source or derivation method of the above flood levels was not available to WSP. As such, WSP have undertaken a desktop search of past flood level information that has been adopted for design purposes in the Waterways estate area and Mordialloc Creek. Findings of the desktop search were discussed with Melbourne Water through email provided under Appendix B-5. Much of the available information was extracted from The Waterways report by Craigie et al (2000), which is summarised under Appendix E (E5). Table 7.4 below lists (1) the water levels provided in Table 7.3; (2) the corresponding Tuflow peak results from dynamic tail water simulation in this study (refer section 7.5.2 for method); and finally (3) Peak flood levels for design purposes per the Waterways report by Craigie et al. (2000). When comparing design flood levels between (2) and (3), 1% AEP flood levels almost match, however (2) is slightly more conservative than (3) for more frequent events. This result arguably increases confidence in this study’s Tuflow output given its relative consistency with the design flood levels adopted in the Waterways report by Craigie et al. (2000).

Table 7.4 Comparison summary of flood level information

<table>
<thead>
<tr>
<th>ARI (YEAR)</th>
<th>AEP (%)</th>
<th>ADOPTED TAIL WATER LEVEL (mAHD)</th>
<th>PEAK FLOOD LEVEL IN THE WATERWAYS PER MODELLING IN THIS REPORT</th>
<th>PEAK FLOOD LEVELS IN THE WATERWAYS AS PROVIDED IN THE CRAIGIE ET AL. (2000) REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
<td>2.70</td>
<td>2.87</td>
<td>2.85</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>1.85</td>
<td>Required, however not yet assessed.</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>1.85</td>
<td>2.56</td>
<td>2.40</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>1.70</td>
<td>Required, however not yet assessed.</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>1.70</td>
<td>2.39</td>
<td>2.05</td>
</tr>
</tbody>
</table>
Following this, Melbourne Water have provided a letter of no objection (Appendix B-5) to the use of the flood levels listed in Table 7.3. An additional flood level for climate change was calculated by adding a sea level rise of 0.8 metres (Table 3.1).

7.5.2 DYNAMIC TAIL WATER

In addition to the appropriateness of flood levels investigated above, the static versus dynamic application of tail water levels was also discussed. While a static application of tail water levels is considered appropriate for a flood mapping study, a more realistic downstream boundary, based on a sinusoidal relationship is probably more appropriate for design purposes. Furthermore, Melbourne Water’s preference was to adopt a dynamic downstream tail water condition at the Mordialloc Creek interface as listed in Appendix B-1 (reviewer comments 16 and 51).

The following steps were proposed by WSP and undertaken to derive a dynamic water level versus time curve for the Tuflow North model’s interface with Mordialloc Creek:

1. Obtain sea level data for Williamstown, being the nearest location where records are available, from the Bureau of Meteorology (BoM).

2. Note highest recorded sea level in supplied data set – 24/06/2014. Extract 48 hours of sea level data either side of peak occurrence (Refer Appendix M for the data record). For reference, this data was graphed as shown in Figure 7.2 with the time and value of the peak sea level also marked.

![Figure 7.2](image-url)

**WILLIAMSTOWN RECORDED SEA LEVELS (22/06/2014 - 26/06/2014)**

3. Derive 5 tail water level curves, one for each AEP, by translating the recorded dataset such that the peak level of derived curves matches the tail water levels provided Table 7.3. For example, the 1% AEP derived tail water level curve is shown in Figure 7.3.
The Tuflow model is run without rainfall for 24 hours with the derived tail water curves for each AEP in order to produce a restart file of initial flood conditions. The 24 hour dataset period was between 22/06/2014 7:00 PM and 23/06/2014 7:00 PM, the latter being nine hours prior to the occurrence of the peak tail water level.

The restart files are applied to all subsequent design runs, with the simulation starting nine hours prior to the peak tail water level. Nine hours corresponds to the critical storm duration in The Waterways and Braeside Park areas determined from previous model runs. Although the critical storm duration varies spatially within Braeside Park, the 9 hour event is the most widespread for all three AEPs assessed. This is considered a conservative approach where the coastal and fluvial peaks are matched.

Separate restart files are produced for each flood level listed in Table 7.3.

7.6 DOWNSTREAM BOUNDARY CONDITIONS – TUFLOW SOUTH MODEL

7.6.1 BOWEN ROAD D.S. OPEN CHANNEL

In the Tuflow South model, an interface boundary condition was required at the Bowen Road D.S. open channel, being the Melbourne Water open drain downstream of Smythes drain. The known mechanisms of flooding within the Bowen Road D.S. open channel were investigated. The Bowen Road D.S. catchment is separated from Mordialloc Creek by a constructed levee and there is a Melbourne Water pump station near Wells Road that pumps water from this catchment into Mordialloc Creek (Craigie, 2011). It is assumed that backflow through the pump station is not possible, therefore a tidally influenced tail water condition as applied for the Tuflow North model is not appropriate in this case. A normal outflow (2D) boundary condition (Tuflow ‘H-Q’ boundary) has been adopted approximately two kilometres upstream of the pump station.

For outflow from the 1D network, a static water level condition was applied to the most downstream pipe. The applied water level was equal to the obvert level of the pipe for all design AEP storm event simulations.
7.6.2 CROSS CATCHMENT FLOWS (HQ AND HT)

Two instances of cross catchment flow in the Tuflow South model were required. The first was at the Mornington Peninsula Freeway, south of Springvale Road where an existing 0.3 metre diameter road culvert diverts flow out of the study area and into the Carrum Outfall DS catchment. A static water level condition was applied at the pipe outlet with the water level equal to the obvert level of the pipe for all design AEP storm event simulations. The second was at the south west boundary of the model at Wells Road where a normal outflow (2D) boundary condition (Tuflow ‘H-Q’ boundary) was adopted for an overland flow path flowing south of Wells Road, which did not interact with the remainder of the modelled area.

7.7 INITIAL FLOOD CONDITIONS

— In the Tuflow North model – Restart files were used (refer section 7.5.2).
— In the Tuflow South model, initial water levels were applied to the 1D network upstream of the Bowen Road D.S. and Mornington Peninsula Freeway outlets. The applied water level was equal to the 1D static water level condition (refer sections 7.6.1 and 7.6.2 respectively) applied at these locations for all design AEP storm event simulations.

7.8 CRITICAL STORM DURATION ANALYSIS

A critical duration analysis has been completed for 20 standard ARR 1987 storm durations. The results presented are based on an envelope assessment of the 1% and 20% AEP flood events for a static tail water condition. Maximum water levels were compared at each grid point from the range of storm durations assessed, hence the results are peak-peak results being the peak water level from all storm durations assessed.

The results of the critical duration analysis are presented in Table 7.5. A storm duration was considered critical if it lead to at least 5% of the proportion of peak water levels within a 500-metre buffer extent from the project boundary.

1% and 20% AEP critical duration storms were adopted for all design AEP storm simulations.

Table 7.5 Critical duration analysis results for an area within a 500-metre buffer from the project boundary

<table>
<thead>
<tr>
<th>TUFLOW MODEL</th>
<th>CRITICAL DURATIONS</th>
<th>ADOPTED FOR ALL DESIGN AEP SIMULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 PERCENT AEP</td>
<td>20 PERCENT AEP</td>
</tr>
<tr>
<td></td>
<td>25 minute</td>
<td>2 hour</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>3 hour</td>
</tr>
<tr>
<td></td>
<td>2 hour</td>
<td>6 hour</td>
</tr>
<tr>
<td></td>
<td>3 hour</td>
<td>9 hour</td>
</tr>
<tr>
<td></td>
<td>6 hour</td>
<td>12 hour</td>
</tr>
<tr>
<td></td>
<td>9 hour</td>
<td>48 hour</td>
</tr>
<tr>
<td></td>
<td>36 hour</td>
<td></td>
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<td></td>
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</tbody>
</table>
7.9 FLOOD MODEL PERFORMANCE

The purpose of this section is to summarise the data and information available in the project study area which may be used in flood model calibration or validation.

7.9.1 TUFLOW/RORB NORTH MODELS

Within the North modelling area, validation against Rational Method flow estimates was undertaken as part of the 2013 RORB models in the 2013 flood study. Melbourne Water maintains that a RORB model must be validated to a Rational Method estimated flow, unless it is specifically agreed with Melbourne Water that sufficient data is available to warrant a calibration to historic data (Melbourne Water, 2012). Its noted that the study area contained four known rainfall and stream monitoring stations as listed under Table 7.6, however, as calibration to these monitors was not undertaken in the 2013 flood study, WSP assumed that the validation against Rational method flow estimates was a sufficient undertaking.

Table 7.6 Rainfall and streamflow monitoring stations in the North Tuflow/RORB modelling region

<table>
<thead>
<tr>
<th>MONITORING STATION</th>
<th>VARIABLE MONITORED</th>
<th>APPROXIMATE PERIOD OF RECORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clayton South Drain at Clayton Retarding Basin</td>
<td>Stream level and Rainfall</td>
<td>1980 – 2017</td>
</tr>
<tr>
<td>Dunlops Road Drain at Citrus St, Braeside</td>
<td>Stream level</td>
<td>1975 – 2017</td>
</tr>
<tr>
<td>Notting Hill RG</td>
<td>Rainfall</td>
<td>Unknown</td>
</tr>
<tr>
<td>Braeside RG</td>
<td>Rainfall</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

7.9.2 TUFLOW/RORB SOUTH MODELS

There are no declared rainfall and stream monitoring stations in the South modelling region as per the available GIS data from Melbourne Water. According to the Smythes Drain/Springs Drain Bangholme - Flooding Investigation Discussion Paper (Craigie, 2011), however, survey of flood debris marks was undertaken after the 4th / 5th of February 2011 flood event. The surveyed flood level in the Soden Road area reportedly reached 2.2 metres AHD on average on 5 February 2011. The February 2011 storm event over Bangholme was classified as a 500 year ARI storm event (or 0.2% AEP) for storm durations between 1.5 and 14.5 hours (Craigie, 2011). For future design phases, it may be appropriate to simulate the 500 year ARI flood event to provide a direct comparison with this flood study.

<table>
<thead>
<tr>
<th>TUFLOW MODEL</th>
<th>CRITICAL DURATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 PERCENT AEP</td>
</tr>
<tr>
<td>South</td>
<td>15 minute</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>2 hour</td>
</tr>
<tr>
<td></td>
<td>9 hour</td>
</tr>
<tr>
<td></td>
<td>12 hour</td>
</tr>
<tr>
<td></td>
<td>30 hour</td>
</tr>
<tr>
<td></td>
<td>48 hour</td>
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<td></td>
<td>72 hour</td>
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</tr>
</tbody>
</table>
HYDRAULIC MODELLING – PROPOSED CASE

The following steps were undertaken to setup the proposed case conditions hydraulic model:

— Incorporate proposed design embankment elevation to the digital elevation model (refer section 8.1).
— Incorporate proposed transverse drainage structures to the 1D network (refer section 8.2).
— Incorporate proposed changes to the delineation of surface roughness (refer section 8.3).

A layout of the proposed case Tuflow digital elevation model, 1D network and key model boundary conditions are provided in Appendix J. The road 3D geometry and proposed transverse drainage used in the flood modelling is current as of 8 May 2018. It is noted that updates were undertaken to both the road 3D geometry and transverse drainage layout after 8 May 2018 with these updates not included in this report.

8.1 DIGITAL ELEVATION MODEL

8.1.1 ROAD 3D GEOMETRY

The 3D geometric design of the roadway includes the main line embankment as well as proposed ramps. The design is current as of 8 May 2018 and was incorporated into the Tuflow digital elevation model as a TIN grid. Some changes to the mainline and ramp geometry have taken place after 8 May 2018, with these updates not included in the modelling presented in this report. Furthermore, the side roads of the project road intersections are also not included in the modelling presented in this report. Full project intersections and all design changes should be captured in the final digital elevation model of subsequent iterations of the proposed case Tuflow model.

The following logical assumptions have been applied to the digital elevation model at project intersections under proposed case conditions:

— Raising of Governor Road and a minor longitudinal section of the Freeway in Braeside Park to achieve 1% AEP flood immunity. Road design formations after 8 May 2018, have already raised Governor Road and the freeway to achieve 1% AEP immunity (therefore this won’t be required for future iterations of modelling)
— Substitution of approximately 25 metres of open channel with road embankment fill in line with the proposed extension to Tarnard Drive
— Thin z-line representation of a proposed road side swale North of Centre Dandenong Road.

8.1.2 ROAD SIDE SWALES

The design of proposed road side swales varied based on two intended functions of the swales – flow conveyance and flood storage.

8.1.2.1 SWALES FOR FLOW CONVEYANCE

Several locations were identified where road side swales are needed to properly convey flood waters toward proposed transverse culverts. These were appropriately graded to match in with the proposed invert levels of the proposed culverts. The modelling package 12D was used to complete basic topographic modelling of selected flood mitigation swales. Catch drain modelling was undertaken with a minimum swale depth of 0.3 metres⁴, while mimicking the grade of the existing surface as much as possible before finally matching in at the upstream invert level of a given transverse drain. The product of 12D modelling was then converted to a TIN and represented within the Tuflow digital elevation model in

⁴ Sizing based on VicRoads standard drawing – Catch Drain Type A (Principal Road Design Engineer’s Department, 1994)
the same manner as the design road surface, i.e. via TIN overlay. 3D swale centreline strings were also used as Tuflow z-lines to enable a defined thalweg to be modelled along the swale centrelines. All swale z-lines are depicted in Appendix J.

8.1.2.2 SWALES FOR FLOODPLAIN STORAGE

As part of the mitigation options analysis, loss in floodplain storage was determined to be the main cause of observed flood impact within the Waterways estate and Braeside Park areas rather than obstruction to conveyance area. A flood mitigation options assessment was undertaken for Braeside Park as detailed in section 8.8.

8.2 PROPOSED CASE TRANSVERSE DRAINAGE

As described under section 4.1, the project proposal crosses several Melbourne Water drainage lines. It also intercepts several 1% AEP overland flow routes, according to the base case conditions flood mapping (Appendix O).

Several iterations of proposed case conditions modelling were undertaken with proposed transverse drainage structures incorporated. Road surface drainage, i.e. longitudinal drainage, was generally not included in the Tuflow modelling. As such, any inflow from the road surface was applied directly to its respective transverse drain.

8.2.1 TRANSVERSE STRUCTURES

The layout of proposed transverse structures used in this iteration of Tuflow modelling is depicted under the proposed case Tuflow model setup maps in Appendix J. A list of these proposed structures is also provided in Table 8.1. The transverse drainage layout depicted is current as of 8 May 2018. Subsequent changes to drainage design and other transverse structures, for example, the shared user under pass (Appendix L-2) and fauna passage culverts, are not included in the modelling presented in this report.

Table 8.1 Adopted transverse culverts as of 8 May 2018

<table>
<thead>
<tr>
<th>ASSET IDENTIFIER</th>
<th>DRAINAGE SYSTEM</th>
<th>TUFLOW MODEL</th>
<th>MODELLLED BLOCKAGE (%)</th>
<th>SIZE – NO. X WIDTH/DIAMETER X HEIGHT (m)</th>
<th>GRADE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD A1</td>
<td>Old Dandenong Rd Drain</td>
<td>North</td>
<td>40</td>
<td>2 no. 3.6 x 2.7</td>
<td>0.3</td>
</tr>
<tr>
<td>CD C1</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>2 no. 1.2 x 0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>CD D1</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 1.05 dia</td>
<td>0.6</td>
</tr>
<tr>
<td>CD D2</td>
<td>Old Dandenong Rd Drain</td>
<td>North</td>
<td>40</td>
<td>3 no. 3 x 1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>CD D3.1</td>
<td>Gartsides North D.S.</td>
<td>North</td>
<td>0</td>
<td>2 no. 1.5 dia</td>
<td>0.9</td>
</tr>
<tr>
<td>CD D3.2</td>
<td>Gartsides North D.S.</td>
<td>North</td>
<td>0</td>
<td>2 no. 1.5 dia</td>
<td>0.2</td>
</tr>
<tr>
<td>CD D3.3</td>
<td>Gartsides North D.S.</td>
<td>North</td>
<td>0</td>
<td>1 no. 1.2 dia</td>
<td>0.2</td>
</tr>
<tr>
<td>CD D4.1</td>
<td>Old Dandenong Rd Drain</td>
<td>North</td>
<td>0</td>
<td>1 no. 1.05 dia</td>
<td>0.9</td>
</tr>
<tr>
<td>CD D4.2</td>
<td>Old Dandenong Rd Drain</td>
<td>North</td>
<td>0</td>
<td>1 no. 1.05 dia</td>
<td>0.6</td>
</tr>
<tr>
<td>CD E1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>3 no. 1.5 x 0.75</td>
<td>0.3</td>
</tr>
<tr>
<td>CD E2</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>3 no. 1.2 x 0.75</td>
<td>0.4</td>
</tr>
<tr>
<td>CD E3</td>
<td>Gartsides D.S.</td>
<td>North</td>
<td>0</td>
<td>1 no. 1.65 dia</td>
<td>0.5</td>
</tr>
<tr>
<td>CD E3.1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>1 no. 1.2 x 0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>CD E4.1</td>
<td>Gartsides South D.S.</td>
<td>North</td>
<td>15</td>
<td>1 no. 0.375 dia</td>
<td>0.5</td>
</tr>
<tr>
<td>ASSET IDENTIFIER</td>
<td>DRAINAGE SYSTEM</td>
<td>TUFLOW MODEL</td>
<td>MODELLED BLOCKAGE (%)</td>
<td>SIZE – NO. X WIDTH/DIAMETER X HEIGHT (m)</td>
<td>GRADE (%)</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>-----------------------</td>
<td>-----------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>CD E4.3</td>
<td>Gartsides South D.S.</td>
<td>North</td>
<td>0</td>
<td>2 no. 1.5 dia</td>
<td>0.6</td>
</tr>
<tr>
<td>CD E4.4</td>
<td>Gartsides South D.S.</td>
<td>North</td>
<td>0</td>
<td>2 no. 1.5 dia</td>
<td>0.4</td>
</tr>
<tr>
<td>CD E4.5</td>
<td>Gartsides South D.S.</td>
<td>North</td>
<td>15</td>
<td>2 no. 1.35 dia</td>
<td>0.7</td>
</tr>
<tr>
<td>CD E4.6</td>
<td>Gartsides South D.S.</td>
<td>North</td>
<td>0</td>
<td>1 no. 1.2 dia</td>
<td>0.7</td>
</tr>
<tr>
<td>CD E5</td>
<td>Braeside West D.S.</td>
<td>North</td>
<td>15</td>
<td>3 no. 1.5 x 1.5</td>
<td>0.3</td>
</tr>
<tr>
<td>CD F1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>4 no. 1.2 x 1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>CD F2</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>1 no. 0.6 dia</td>
<td>0.7</td>
</tr>
<tr>
<td>CD F3</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 1.2 dia</td>
<td>1</td>
</tr>
<tr>
<td>CD F4</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>2 no. 1.2 x 1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>CD F5</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>1 no. 1.2 x 1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>CD G1</td>
<td>Dingley Drain</td>
<td>North</td>
<td>15</td>
<td>3 no. 2.4 x 2.1</td>
<td>0.1</td>
</tr>
<tr>
<td>CD H1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>2 no. 1.8 x 1.8</td>
<td>0</td>
</tr>
<tr>
<td>CD H1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>2 no. 1.8 x 1.8</td>
<td>0</td>
</tr>
<tr>
<td>CD H1</td>
<td>Unnamed</td>
<td>North</td>
<td>15</td>
<td>2 no. 1.8 x 1.8</td>
<td>0.1</td>
</tr>
<tr>
<td>CD I1</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 0.75 dia</td>
<td>0.2</td>
</tr>
<tr>
<td>CD I2</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 0.75 dia</td>
<td>0.1</td>
</tr>
<tr>
<td>CD I3</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 0.75 dia</td>
<td>0.1</td>
</tr>
<tr>
<td>CD J1</td>
<td>Waterways wetlands</td>
<td>North</td>
<td>15</td>
<td>2 no. 2.4 x 1.2</td>
<td>0</td>
</tr>
<tr>
<td>CD J2</td>
<td>Unnamed</td>
<td>North</td>
<td>25</td>
<td>1 no. 0.6 dia</td>
<td>0.1</td>
</tr>
<tr>
<td>CD K1</td>
<td>Smythes drain</td>
<td>South</td>
<td>15</td>
<td>2 no. 1.5 x 1.2</td>
<td>0.1</td>
</tr>
<tr>
<td>CD M1</td>
<td>Unnamed</td>
<td>South</td>
<td>15</td>
<td>1 no. 0.375 dia</td>
<td>0.1</td>
</tr>
</tbody>
</table>

8.2.1.1 BLOCKAGE

The blockage of proposed transverse drain culverts was assessed using the 2016 guidelines version of Australian Rainfall and Runoff as required by Melbourne Water. A case by case assessment of blockage factors was undertaken at each transverse drain location with the product being several blockage factors that were applied in the proposed case Tuflow modelling.

Within Tuflow, percentage blockage was assigned to 1D culverts. For rectangular culverts, the culvert width is reduced by the nominated percentage blockage, while for circular culverts the pipe diameter is reduced by the square root of the percentage blockage (BMT WBM, 2010).

The mechanisms of blockage which were considered are inlet blockage and debris deposition blockage. Each mechanism of blockage considered a combination of debris availability, mobility and transportability to collectively determine the

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5 Sizing of this drain has been determined based on correspondence with Melbourne Water provided under Appendix B-3.
potential for debris at the culvert. Once a Debris potential was determined, it was combined with the following factors to determine a design culvert blockage to apply in Tuflow:

- For inlet blockage: the clear width of the inlet, i.e. the width (rectangular) or diameter (circular) of a culvert was considered.
- For depositional blockage: the peak velocity through the structure (determined from Tuflow) as well as the mean sediment size were considered.

This formulation yields one design blockage percentage per blockage mechanism. Between the two, the one which produced the higher design blockage was adopted. Table 8.1 lists the adopted blockage factors for each proposed transverse culvert. For a detailed example of how design blockage was determined, refer to Appendix K which outlines an example of this process.

### 8.2.2 OPEN CHANNELS

As part of the drainage design of the Mordialloc Freeway, altogether seven existing Melbourne Water open channels will be impacted by the project. Table 8.2 provides a list of the Melbourne Water open channels with proposed changes as part of the drainage design of the project. Updated cross-sectional profiles (for 1D open channels) and alignment layouts were obtained and incorporated into the proposed case Tuflow model as depicted in the proposed Tuflow setup map (Appendix J).

<table>
<thead>
<tr>
<th>OPEN CHANNEL IDENTIFIER</th>
<th>LOCATION OF PROPOSED CHANGE WITHIN PROJECT BOUNDARY</th>
<th>DESCRIPTION OF CHANGE(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old Dandenong Road Drain</td>
<td>Near Grange Road</td>
<td>Substitute approximately 70 metres of open channel section with 2 no. 3.6 x 2.7 metre box culverts.</td>
</tr>
</tbody>
</table>
| Braeside West Drain           | Centre Dandenong Road                               | 1. Widening and westward re-alignment of open channel downstream of Centre Dandenong Road.  
                              |                                                      | 2. Upgrade existing crossing from 2 no. 1.2 metre dia. to 3 no. 3 x 1.5 metre box culverts.    |
| Gartsides South D.S.          | North of Lower Dandenong Road                       | Substitute approximately 100 metres of open channel with 2 no. 1.35 metre dia followed by 2 no. 1.5 metre dia diversion pipelines. |
| Braeside West D.S.            | Tarnard Drive (extension)                           | Substitute approximately 25 metres of open channel with 3 no. 1.5 x 1.5 metre dia crossing culverts. |
| Dingley Drain                 | Braeside Park                                       | 1. Eastward re-alignment of open channel.                                                 
                              |                                                      | 2. Provide new 3 no. 2.4 x 2.1 metre box culverts.                                        |
| Smythes Drain                 | Near confluence with Bowen Road D.S. open channel    | 1. Southward re-alignment of open channel.                                               
                              |                                                      | 2. Provide new 2 no. 1.5 x 1.2 metre box culverts.                                        |
| Bowen Road D.S.               | Near confluence with Smythes drain open channel      | Widening of existing Bowen Road D.S. channel and merger with newly re-aligned Smythes drain. |
8.2.3 MORDIALLOC WETLANDS BRIDGE

A 400 metre long bridge is proposed over the Mordialloc Creek wetlands area in the Waterways estate catchment. Two separate carriageway structures are proposed based on the general arrangement drawings of the proposed bridge provided in Appendix L-1. 1% AEP peak velocity in the area of the bridge is a minor 0.1 metres per second under base case conditions modelling indicating that low magnitude energy losses are expected where the proposed bridge piers intercept the wetlands.

The Mordialloc Creek Wetlands Bridge was modelled in Tuflow via two parallel layered flow constriction thick lines in the 2D domain, representing the two separate carriageways respectively. These are depicted in the Tuflow setup map (Appendix J). The form loss coefficient is the most sensitive user defined component of this layer. It is applied as an energy loss in Tuflow by solving the dynamic head equation, given below (BMT WBM, 2010):

$$\Delta h = \frac{\zeta_a Y^2}{2g}$$

where $\zeta_a$ is the form loss coefficient.

By choosing to use a layered flow constriction, the form loss coefficient can be made to vary vertically between different layers of a bridge structure, as this more realistically represents the varying layers which the flood water may interact with. Altogether, three different layers were defined for the bridge structure, each being assigned a different form loss coefficient as listed in Table 8.3.

For the bridge deck and railing layers, a conservatively large form loss coefficient of 1.56 was adopted from the Tuflow manual (BMT WBM, 2016). Its noted, however, that the peak flood level for a 1% AEP design storm event is approximately 2.86 metres AHD near the bridge under base case conditions. Based on their trigger elevations, both the second and third regions of the bridge structure (the bridge deck and rails respectively) would not be engaged for design events equal to or less than a 1% AEP flood event (A minimum flood level of 5.2 metres AHD would be required). It is noted that the bridge design is current as of 8 May 2018 and subsequent changes to the soffit level are noted (Appendix L-1).

<table>
<thead>
<tr>
<th>DEFINED LAYERS FOR BRIDGE STRUCTURE (BOTTOM TO TOP)</th>
<th>DEPTH OR OBVERT</th>
<th>ADOPTED FORM LOSS COEFFICIENT</th>
<th>BASIS OF CALCULATION / ADOPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wetlands bed level to bridge soffit</td>
<td>Obvert ranges between 5.2 and 8.9 metres AHD (estimate)</td>
<td>0.241</td>
<td>Calculated via purpose built spreadsheet sourced from BMT WBM for Tuflow users (beta edition supplied, 2017) which bases calculations from the methodology prescribed in Hydraulics of Bridge waterways (Bradley, 1978). Based on (a) a skewed pier width of 3 metres (i.e. width which is perpendicular to the direction of flow); (b) Average pier span width of 24.5 metres; and (c) Piles and pile cap located below ground level. Refer Appendix L-1 for layout.</td>
</tr>
</tbody>
</table>

6 The geometric design of the Wetlands bridge from which Tuflow modelling is based, is current as of May 2018.
8.3 MANNING’S ‘N’ BED RESISTANCE VALUES

Surface roughness under proposed case conditions was changed so that the project mainline carried a Manning’s ‘n’ value of 0.02. This is consistent with the manning’s ‘n’ previously assigned for the roads category as per Table 7.2 and is based on the proposed road reserve being predominantly paved. Delineation of surface roughness under proposed case conditions was based on the road geometric design dated 8 May 2018. Surface roughness of ramps has not yet been defined and updates to the road geometric design have taken place after 8 May 2018, which will need to be accounted for subsequent iterations of the Tuflow modelling.

8.4 INFLOW BOUNDARY CONDITIONS

Inflow boundary conditions between base case and proposed case conditions models were kept unchanged as described under section 7.4.

8.5 DOWNSTREAM BOUNDARY CONDITIONS

The locations of adopted downstream boundary conditions are provided in the setup maps for Appendix I. Its noted that there were no changes to downstream boundary conditions between base case and proposed case conditions modelling.

8.6 CRITICAL STORM DURATIONS

1% and 20% AEP critical duration storms determined under base case conditions modelling (Table 7.5) were adopted for all proposed case conditions Tuflow simulations.

8.7 MITIGATION OVERVIEW

Two key requirements for the project is that there is no increase in 1% AEP (Annual Exceedance Probability) flood level and velocities as a result of the project as well as no loss in floodplain storage volume (Melbourne Water, 2017). A separate requirement also provides that there should be no impact for more frequent flood events, i.e. the 2%, 5%, 10% and 20% AEPs events respectively.

Flood impact mitigation via both transverse drainage (conveyance) and flood storage (retention/detention) were assessed in the flood model.

<table>
<thead>
<tr>
<th>DEFINED LAYERS FOR BRIDGE STRUCTURE (BOTTOM TO TOP)</th>
<th>DEPTH OR OBVERT</th>
<th>ADOPTED FORM LOSS COEFFICIENT</th>
<th>BASIS OF CALCULATION / ADOPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>The bridge rails</td>
<td>0.75 metre depth</td>
<td>1.56</td>
<td>Adopted from the Tuflow manual (BMT WBM, 2016) which uses discharge equation in Waterway Design - A Guide to the Hydraulic Design of Bridges, Culverts and Floodways (Aust Roads, 1994).</td>
</tr>
</tbody>
</table>
8.7.1 TRANSVERSE DRAINAGE ASSESSMENT

As the project intercepts several overland flood routes (in all AEPs), there were several locations where obstructions to flow paths were noted in the early stages of modelling. This generally occurred West or upstream of the project as the direction of flow was predominantly North East to South West. Extensive proposed case modelling was required to determine the sizing and positioning of transverse culverts. Similarly, the standard depth of some swales was modified in order to maintain existing flood conditions.

The current drainage arrangement has largely mitigated flood impact across the project, however some minor changes to drainage will still be needed to address outstanding impact areas. Refer to section 9.5 for mitigation recommendations.

8.7.2 FLOOD STORAGE ASSESSMENT

It was determined that loss in floodplain storage, rather than obstruction to conveyance area, is the cause of observed flood impact within the Braeside Park and Waterways estate areas. The following section describes the assessment of flooding in Braeside Park.

8.8 FLOOD ASSESSMENT AT BRAESIDE PARK

This section summaries the investigation of mitigation options within the Braeside Park and Woodlands Industrial Estate wetlands area (Braeside area), including residual flood impacts.

8.8.1 OVERVIEW

The Braeside area floodplain is wide and shallow, with water depths across the project boundary generally between 0.5 and 1.0 m deep. The 1% AEP floodplain covers approximately 800 m of the freeway alignment north of Governor Road. The proposed freeway embankment results in a loss of floodplain storage volume of 50,200 m³, equal to approximately 8% of the total floodplain storage volume within Braeside area. The Proposed case design includes 4 sets of large multi-cell box transverse drainage culverts and cut areas to provide compensatory storage (essentially wide, shallow swales). The compensatory storage areas provide approximately 18,000 m³ flood storage. Therefore, the net loss of floodplain storage is 32,200 m³ or approximately 5% of the total floodplain storage volume.

The Proposed case afflux (Proposed Scenario peak water level minus Base-case Scenario peak water level) for the 1% AEP design flood event is shown in Appendix Q-1 and given below in Figure 8.1.

Within Braeside Park, the project works result in increases in peak flood levels (afflux) up to 0.046 metres in the 1% AEP event. This afflux occurs due to loss of floodplain storage rather than obstruction to conveyance area, hence providing additional transverse-drainage capacity will have a negligible impact on the results.
8.8.2 SENSITIVITY ANALYSIS

ARR 2016 provides guidance on the joint probability between riverine and coastal processes. The results presented in Figure 8.1 represent a 1% AEP rainfall with a 1% AEP tidal event with the peak values of each being aligned. This scenario assumes the full dependence case where both a fluvial flood and a coastal flood occur simultaneously.

A sensitivity analysis with a lower tail water level was completed where 1% AEP rainfall was paired with the 10% AEP tidal tail water value given in Table 7.3. Afflux results are shown in Figure 8.2. It shows that there is a reduction in afflux of approximately 0.01 m compared to the 1% AEP rainfall with 1% AEP tail water.
8.8.3 MITIGATION OPTIONS

Several options have been investigated to mitigate the flood impact to the Braeside area, as discussed below.

8.8.3.1 FLOOD GATES

Providing flood gates on the transverse culverts (both drainage and fauna passage culverts) within the Braeside area prevents storm tide backwater from crossing the freeway from west to east. This allows large areas on the eastern side of the freeway to be utilised for flood storage for water from the fluvial flood event, with the flood gates opening to allow water to drain from east to west.

To allow for fauna passage, flood gates would need to be mechanical, with automatic control based on water level sensors on either side of the freeway.

Afflux for the Flood Gates option, modelled as unidirectional culverts in TUFLOW, for the 1% AEP design flood event is shown in Figure 8.3.

![Figure 8.3 Proposed flood gate option afflux, 1% AEP event](image)

The results in Figure 8.3 show the flood gates option results in ‘no change’ on the eastern side of the proposed freeway, however afflux on the western side of the freeway is higher than the no flood gate option. Previous model runs with a static downstream boundary resulted in negative afflux on the eastern side with ‘no change’ on the western side. This indicates that the timing of the flood gates operation is critical for successful flood management. The concept of operations for the flood gates would need to be developed in consultation with MRPA, VicRoads and Melbourne Water to determine design requirements.

FLOOD GATES FAILURE ASSESSMENT

The following flood gate failure scenarios have been identified:

- Gates fail to close as a result of blockage, power failure, mechanical failure, level sensors failure, or lack of maintenance, testing or lack of critical spares
- Gates close but then fail to open
- Gates close in smaller storm events as a result of level sensor errors.
For the implementation of the flood gates, the following would need to be considered:

- Integration with wider VicRoads infrastructure (power, ITS infrastructure), and impact to road operations
- Flood warnings trigger level or triggers by Vic SES or Melbourne Water
- Monitoring during operation
- Manual deployment of the flood gates
- Asset ownership, testing and maintenance responsibilities

For this flood assessment, two flood gate failure scenarios have been modelled:

1. Gates fail to close: flood impact reverts back to standard culverts, as shown in Figure 8.1
2. Gates close but then fail to open: modelled in TUFLOW as fully-blocked culverts and shown in Figure 8.4.

![Figure 8.4 Flood gates option, failure scenario two afflux, 1% AEP event](image)

Figure 8.4 shows that afflux on the western side of the freeway would be similar under this failure scenario. However, afflux on the eastern side of the freeway would be approximately 0.250 m higher compared to the proposed scenario shown in Figure 8.1.

Furthermore, the use of flood gates will likely to substantially reduce the ability of culverts to facilitate fauna passage, and hence may limit their ability to mitigate some of the fauna fragmentation impacts of the project.

### 8.8.3.2 ADDITIONAL STORAGE WITHIN RIGHT OF WAY

#### BRIDGE (ONLY) OPTION

A bridge structure alone would need to span the entire floodplain to completely reinstate the loss of floodplain storage.

Based on storage volumes (i.e. no TUFLOW modelling), a bridge with a total span of approximately 440 m would be required to reduce afflux to 0.01 m.
BRIDGE AND RETAINING WALLS (HYBRID) OPTION

A hybrid option of extending the Governor Road overpass bridge by approximately 200 m and providing retaining walls to reduce fill into the floodplain has been modelled in TUFLOW. Retaining walls would be located on the road verge line on either side of the freeway, extending from just north of Governor Road to approximately 780 m north of Governor Road. Retaining walls would also be located on the insides of north facing ramps. Afflux for this option, for the 1% AEP design flood event is shown in Figure 8.5.

Figure 8.5 Additional storage within ROW option afflux, 1% AEP event

Figure 8.5 shows the option of extending the Governor Road bridge and providing retaining walls to reduce the loss of floodplain storage results in no change on the western side of the freeway and approximately 0.013 m positive afflux on the eastern side. With increased transverse drainage capacity, it is likely that this afflux can be balanced across the floodplain to around 0.01 m.

8.8.3.3 ADDITIONAL STORAGE OUTSIDE RIGHT OF WAY

Additional storage outside of the Right of Way has not been investigated as this was anticipated to result in delays to the overall project and trigger the need for significant additional work. The main foreseeable delays relate to the need to include any new areas within the:

- EES referral, and subsequent studies relating to environmental, social and economic impacts
- EPBC referral, and subsequent additional studies and reporting on Matters of National Environmental Significance (particularly on listed threatened species and communities and listed migratory birds)
- Cultural Heritage Management Plan, including the possibility of additional complex (intrusive) assessment.

8.8.4 RESIDUAL IMPACT AND MELBOURNE WATER CONSULTATION

Although afflux is present in Braeside with the current proposed design solution (flood mapping presented in Figure 8.1 and Appendix Q-1), it is considered to provide the best overall outcome for the project, balancing flood risk with cost, ecology and program impacts.

The residual increase in flood level does not impact any private property up to and including in the 1% AEP event. Flood risk to two private industrial properties on Park Way, north of the Woodlands Industrial Estate Wetlands, is predicted to reduce due to the project. Changes to peak velocity are minor (Appendix Q-2), and all afflux impacted areas fall below the Melbourne Water limiting Depth & Velocity product value of 0.35 m²/s (Appendix Q-3).

Melbourne Water have been consulted specifically regarding flood impacts within the Braeside area and have provided feedback as shown in Appendix B-6.
9 FLOOD MAPPING

9.1 OVERVIEW

Flood mapping provided in this report was based on the output of Tuflow modelling from both the North and South models. Water level (mAHD), flood depth (m), velocity (m/s) and flood hazard (m²/s) modelling outputs were collectively used to present results and measure flood impact. Flood mapping in this study assessed the scenarios and AEPs listed in Table 9.1 and is provided in Appendix O for base case conditions and Appendix Q for proposed case conditions. Moreover, Table 9.2 lists the latest Tuflow model setup files used to build the base and proposed case conditions models.

Table 9.1 Basis of flood mapping

<table>
<thead>
<tr>
<th>MODEL SCENARIO</th>
<th>BASE CASE CONDITIONS</th>
<th>PROPOSED CASE CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing</td>
<td>Existing</td>
</tr>
<tr>
<td>AEP</td>
<td>1%, 5%, 20%</td>
<td>1%, 5%, 20%</td>
</tr>
</tbody>
</table>

Table 9.2 Tuflow model setup files

<table>
<thead>
<tr>
<th>MODEL IDENTIFIER</th>
<th>NORTH</th>
<th>SOUTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case conditions</td>
<td>MB_Nth_BASE_009_<del>e1</del>_<del>e2</del>_RESTART</td>
<td>MB_Sth_BASE_003_<del>e1</del><em><del>e2</del></em><del>e3</del></td>
</tr>
<tr>
<td>Proposed case conditions (1)</td>
<td>MB_Nth_D203_123_<del>e1</del>_<del>e2</del>_RESTART</td>
<td>MB_Sth_D203_102_<del>e1</del><em><del>e2</del></em><del>e3</del></td>
</tr>
<tr>
<td>Proposed case conditions (2)</td>
<td>MB_Nth_D203_126_<del>e1</del>_<del>e2</del>_RESTART</td>
<td>MB_Sth_D203_103_<del>e1</del><em><del>e2</del></em><del>e3</del></td>
</tr>
</tbody>
</table>

(1) 8 May 2018 design (Report based on this design)
(2) 7 July 2018 design (Should be adopted for future iterations)

9.2 TIDAL INUNDATION MAPPING

1% AEP tidal inundation mapping, i.e. inundation by tidal processes only, is provided in Appendix N.

9.2.1 BASIS OF MAPPING

Flooding in the Mordialloc Freeway study area is knowingly influenced by tail water levels in the Mordialloc Creek, which in turn is influenced by the tidal regime of Port Phillip Bay. A climate change adaptation study prepared for the Municipal Association of Victoria (AECOM, 2012) includes the calculation of 100 year ARI (equivalent to a 1% AEP) extreme sea levels near the mouth of Mordialloc Creek. The 100 year ARI computed sea level was 1.65 metres AHD, which was calculated from SBEACH software modelling at Mordialloc. It accounts for three main tidal setup components being astronomical tide, storm surge and wave setup. As the Mordialloc Freeway study area is located approximately three kilometres upstream of this location, it is expected that the maximum 1% AEP tidal level will be higher at the study area. In the absence of a detailed model, however, it cannot be known by how much.
9.2.2 MAPPING RANGE

When taking into account the 1% AEP tail water level used in the Tuflow model, an estimated range for tidal inundation can be developed. Tail water values used in Tuflow modelling (Table 7.3) most likely comprise of both fluvial and tidal processes, therefore a lower water level would be expected for purely tidal processes. As such, a working range for tidal inundation mapping was developed with the 1% AEP modelled tail water value of 2.7 metres AHD considered as the upper limiting value. The resulting range used in the mapping was between 1.65 and 2.7 metres AHD. Moreover, climate change was accounted for by adding the Melbourne Water given sea level rise value of 0.8 metres to the upper limiting value of the adopted range. The resulting upper limiting tidal water level for climate change is 3.5 metres AHD.

Accordingly, three possible extents for tidal inundation are depicted in Appendix N. The area south of the Mordialloc Creek levee is not subject to tidal inundation. This is because backflow from Mordialloc Creek into the Bowen Road D.S. catchment is assumed not possible (refer heading 7.6.1) and therefore tidal inundation is not applicable.

9.3 BASE CASE MAPPING

The flood mapping output for base case conditions flood modelling is provided in Appendix O. Table 9.3 summarises the flood map types presented for base case conditions.

<table>
<thead>
<tr>
<th>FLOOD MAP TYPE</th>
<th>UNIT OF MEASUREMENT</th>
<th>DESIGN STORM EVENT (AEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Peak flood (water) levels map</td>
<td>Metres relative to the Australian Height Datum (mAHD)</td>
<td>✓</td>
</tr>
<tr>
<td>Peak flood depths map</td>
<td>Metres (m)</td>
<td>✓</td>
</tr>
</tbody>
</table>

9.3.1 COMPARISON MAPPING WITH 2013 FLOOD STUDY MAPPING

An annotated flood map depicting the difference in peak water level output between the 2013 Tuflow model and the project base case Tuflow model (this study) is provided in Appendix P. The difference map is based on a comparison of 1% AEP critical design storm flood events, namely those listed under Table 7.5 and is also based on the simulation of static tail water conditions (rather than the dynamic condition adopted in this study) so that an impartial comparison can be undertaken. Differences in flood mapping are notable in areas that have undergone significant development since the conclusion of Mordialloc Settlement drain flood mapping in 2013. The following areas, where differences are most visible, are noted:

— **Moorabbin Airport**: Changes to Manning’s ‘n’ and fraction impervious; the incorporation of the Airport retarding basin; and the diversion of Mordialloc Settlement Drain are each contributing to the observed differences in flood conditions. Refer to Appendix I-1 and Appendix I-3 for a detailed schematic of the digital elevation model and the delineation of Manning’s roughness in Moorabbin Airport respectively. Figure 9.1 and Figure 9.2 depict a comparison of flow hydrographs for critical storm durations upstream and downstream of the retarding basin respectively. Upstream of the basin, a larger area under the graph for 2018 conditions indicates that a greater cumulative volume of inflow is being allowed through the pipeline (constructed in 2016) and into the basin, when compared to the 2013 open drain arrangement. This explains the reduced extent of flooding upstream of Centre Dandenong Road. At Lower Dandenong Road, i.e. downstream of the basin, similar volumes between both conditions is noted with some variance in flow rates over time; thus reflective of the relatively similar downstream flooding conditions observed at this location between the base case (2018) and 2013 models.
— **Dingley Bypass:** Significant topographic, drainage and fraction impervious changes applied in the base case model can be cited as causes for the observed differences in flood mapping observed in this development’s contributing catchment area as well as further downstream. For details refer to section 4.7.3.2 and Appendix G.

— **Old Dandenong Road:** The base case model incorporated an existing 0.6 metre transverse culvert under Old Dandenong Road in addition to further z-lines incorporated at this location using feature survey data.

— **Braeside park:** The base case model applied a global initial water level condition across the Tuflow model extent, which covered Braeside Park for a 1% AEP simulation and was equal in value to the statically applied tail water level. This, however, was not the case for the 2013 model where the applied initial water level polygons/points did not cover Braeside Park. Consequentially, base case model flood levels are more than 0.1 metres greater than the 2013 model flood levels in the Braeside Park area (North of Governor Road).

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**Figure 9.1**  
1% AEP flow hydrograph comparison between 2018 and 2013 simulations at Centre Dandenong Road (9 hour critical design storm)
9.4 PROPOSED CASE MAPPING

The flood mapping output for proposed case conditions flood modelling is provided in Appendix Q (existing climate scenario) and Appendix S (climate change scenario). Table 9.4 and Table 9.5 each summarise the flood map types presented for existing and climate change scenarios respectively. Furthermore, Appendix R provides 1% AEP flood level plots over time at various key locations across the project study area as requested by Melbourne Water.

Table 9.4 Flood mapping output for proposed case conditions – Existing climate scenario

<table>
<thead>
<tr>
<th>FLOOD MAP TYPE</th>
<th>UNIT OF MEASUREMENT</th>
<th>DESIGN STORM EVENT (AEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Peak Flood level impact maps</td>
<td>Metres (m)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required, however not yet assessed</td>
</tr>
<tr>
<td>Peak Velocity impact maps</td>
<td>Metres per second (m/s)</td>
<td>✓</td>
</tr>
<tr>
<td>Peak Flood Hazard Maps</td>
<td>Metres squared per second (m²/s) (Combined ARR 2016 and Melbourne Water Thresholds)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Required, however not yet assessed</td>
</tr>
</tbody>
</table>
Table 9.5  Flood mapping output for proposed case conditions – Climate change 2100 scenario

<table>
<thead>
<tr>
<th>FLOOD MAP TYPE</th>
<th>UNIT OF MEASUREMENT</th>
<th>DESIGN STORM EVENT (AEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Flood level impact</td>
<td>Metres (m)</td>
<td>1%</td>
</tr>
</tbody>
</table>

Peak flood hazard mapping, a product of peak velocity and depth, is presented to provide context for safety in design. Table 6.7.4 of Book 6, Chapter 7 in ARR 2016 was used to categorise hazard categories/thresholds. An additional custom value of 0.35 m²/s was also included, as requested by Melbourne Water (Appendix B-1, reviewer comment no. 67).

9.4.1 CLIMATE CHANGE IMPACT ASSESSMENT (1% AEP)

In accounting for 2100 climate change conditions, 1% AEP inflow and downstream boundary conditions (sections 7.4 and 7.5 respectively) have each been altered. This included accounting for a 19% increase in rainfall intensity and a 0.8 metre sea level rise (Tuflow North model). Proposed versus base case impact mapping was then completed as shown in Appendix S. The locations of impact (i.e. where afflux is greater than 0.01 metres) are generally consistent with the outstanding impact locations listed in Table 9.6 for the 1% AEP under existing climate conditions. The extent of impact, however, is to some extent larger in Braeside Park (location 3) and an additional location of impact at Centre Dandenong Road is also observed.

9.4.2 VERY RARE TO EXTREME EVENTS

For the reference design, a qualitative overland flow path assessment has been completed and is summarised below. For detailed design, the 0.5 and 0.2% AEP events will need to be modelled using Tuflow during detailed design, together with 0.05% AEP event which is required for the structural design of bridge structures.

— Old Dandenong Road Drain south of Dingley Bypass

There is a low point in the mainline between Old Dandenong Road Drain and the Dingley Bypass where overland flow can overtop the mainline at approximately 27.2 mAHD. This spill level is approximately 0.9 m higher than the base-case 1% AEP peak flood level upstream of the proposed freeway. The area to the east of the proposed freeway is currently undeveloped.

— Old Dandenong Road Drain at Centre Dandenong Road

Centre Dandenong Road overtops in the 1% AEP event under base-case conditions and the proposed road will largely remain at existing levels. The low point is located to the east of Old Dandenong Road Drain, so consideration of minor regrading should be given in detailed design to avoid impacts to the overpass bridge abutment.

— Gartsides D.S. at Lower Dandenong Road

Lower Dandenong Road overtops in the 1% AEP event under base-case conditions and the proposed road will largely remain at existing levels. Overland flow from the north-east will be able to flow through the intersection below the overpass bridge and discharge into the Braeside West D.S. open channel drain. A low point in the mainline north of Lower Dandenong Road provides a secondary overland flow path, however the spill level is approximately 2.2 m higher at this location.

— Dingley Drain at Braeside Park

Governor Road is dry in the 1% AEP event under base-case conditions, however has limited freeboard. There is an overland flow path along the north side Governor Road, under the overpass bridge. This spill level is approximately 0.4 m higher than the base-case 1% AEP event peak flood level upstream of the proposed freeway. A low point in the mainline towards the northern end of the Woodlands Industrial Estate Wetlands provides a secondary overland flow path, however the spill level is approximately 1.2 m higher than the 1% AEP peak flood level.
— **Mordialloc Creek**

The proposed waterways bridge soffit level is currently set 1.0 metres above the 1% AEP peak flood level (refer Appendix L for cross sectional layout with flood levels). Therefore, it is unlikely that very rare to extreme events will be obstructed through Mordialloc Creek.

— **Smythes Drain**

Under extreme events or a fully blocked culvert scenario, it is possible that floodwater from the Smythes Drain catchment may back-up to Springvale Road. The spill level at Springvale Road, under the overpass bridge, is approximately 2.8 mAHĐ, which is approximately 1.0 metres above the 1% AEP flood level calculated in Tuflow (1.85 mAHĐ). A low point in the mainline approximately midway between the Mordialloc Creek levee and Springvale Road provides a secondary overland flow path, however the spill level is approximately 0.4 m higher than the Springvale Road flow path. During detailed design, it is recommended that the 0.5 and 0.2% AEP events are modelled using the Tuflow model and consideration given to additional capacity at the Smythes Drain culvert under the proposed freeway or provision of a secondary overflow culvert.

### 9.5 OUTSTANDING FLOOD IMPACTS

This section details areas of outstanding flood impacts (Table 9.6) and recommendations to address these impacts (Table 9.7). The analysis of flooding was completed for the 1%, 5% and 20% AEP design storm events only. Subsequent report revision(s) should eventually document an analysis of flood impact for the full range of design storm AEP events, including the 2% and 10% AEP flood.

Table 9.6 Summary of outstanding impact locations and determined causes across the study area

<table>
<thead>
<tr>
<th>NO. ID</th>
<th>LOCATION Description</th>
<th>DRAINAGE SYSTEM</th>
<th>IMPACT Description</th>
<th>DETERMINED CAUSE(S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>South of Lower Dandenong Road</td>
<td>Braeside West D.S.</td>
<td>Occurrence Upstream of the proposed Tarnard Drive crossing and within the banks of the Braeside West D.S. open channel</td>
<td>Overland flow diversion from predominantly East-West under base case conditions to East-South (i.e. toward Braeside West drain) under proposed case conditions. Diversion occurs via proposed swale drainage which increases the total volume of incoming flow in Braeside West drain.</td>
</tr>
<tr>
<td>2.</td>
<td>Braeside Park / Governor Road drain</td>
<td>Dingley Drain / Governor Road drain</td>
<td>Occurrence Extent of impact is outside of project boundary area, however contained within Braeside Parklands.</td>
<td>1. Across All AEP events: Net reduction, through embankment earthworks, of the available area for floodplain storage. 2. For the 5% and 20% AEPs: inadequate East-West conveyance in the area North of Governor Road.</td>
</tr>
<tr>
<td>NO. ID</td>
<td>LOCATION</td>
<td>DRAINAGE SYSTEM</td>
<td>IMPACT</td>
<td>DETERMINED CAUSE(S)</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>-----------------</td>
<td>--------</td>
<td>---------------------</td>
</tr>
<tr>
<td>3.</td>
<td>East of the Bowen Parkway road</td>
<td>Bowen Road D.S.</td>
<td><strong>Occurrence</strong>&lt;br&gt;Downstream of the proposed Smythes drain crossing. Impact within banks of the Bowen Road D.S. open channel.  &lt;br&gt;<strong>Magnitude</strong>&lt;br&gt;1% AEP – Between 0.01 and 0.055 metres.&lt;br&gt;1% AEP – Between 0.01 and 0.06 metres.&lt;br&gt;20% AEP – Between 0.01 and 0.05 metres.</td>
<td>Increased upstream flow rates sourced from transverse drain CD K1</td>
</tr>
<tr>
<td>4.</td>
<td>Woodlands drive</td>
<td>Braeside West D.S.</td>
<td><strong>Occurrence</strong>&lt;br&gt;Road reserve area of Woodlands drive  &lt;br&gt;<strong>Magnitude</strong>&lt;br&gt;1% AEP – impact complies with requirements. (no change)&lt;br&gt;5% AEP – Between 0.01 and 0.05 metres.&lt;br&gt;20% AEP – New overland flow path (appx 0.1 metres average depth).</td>
<td>Increased overland flow rate originating from the proposed CD E4 network of pipes servicing the Gartsides South D.S. area</td>
</tr>
<tr>
<td>5.</td>
<td>The Waterways catchment</td>
<td>Mordialloc Creek Wetlands</td>
<td><strong>Occurrence</strong>&lt;br&gt;Even distribution across the Mordialloc Wetlands surface area  &lt;br&gt;<strong>Magnitude</strong>&lt;br&gt;1% AEP – impact complies with requirements. (no change)&lt;br&gt;5% AEP – Approximately 0.0105 metres&lt;br&gt;20% AEP – Between 0.013 and 0.0145 metres</td>
<td>Net reduction, through embankment earthworks, of the available area for floodplain storage (across all AEPs).</td>
</tr>
<tr>
<td>NO. ID</td>
<td>LOCATION</td>
<td>MITIGATION RECOMMENDATION(S)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>-----------------------------</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1.     | South of Lower Dandenong Road | 1. **Recommended option – Revise conveyance/diversion layout:** Reduce Braeside West drain incoming flow rates back to base case levels by replicating base case conditions flow behaviour upstream of Lower Dandenong Road. This will likely include a slight reduction in the size of culvert CD E3 and allowing spill from the western swale to reinstate an existing overland flow path to the west of the proposed freeway.

2. **Supplementary option – Retardation or detention:** Provide offline underground detention or retard upstream flow rates back to base case levels by expanding the surface area of proposed swale drains North of Lower Dandenong Road. |
| 2.     | Braeside Park | 1. **1% AEP:** No mitigation measure is proposed. This is because any feasible mitigation measures are likely to result in undesirable side effects on other aspects of the environmental impact such as ecology. The current design solution is considered to provide the best overall outcome, balancing flood risk with cost, ecology and program impacts. In fact, the areas with flood impact more than 0.01 metres (i.e. no change) are parklands and grasslands. While some of the footpaths in the park are inundated during flooding, the flood impact at these inundated zones are less than 0.01 metres increase in water level (i.e. no change). Thus, flood impacts is anticipated to have minimal adverse consequence and damages.

2. **5% and 20% AEPs:** The negative afflux for these AEPs on the Western side of the freeway (North of Governor Road) indicates that increased East-West conveyance (via increasing capacity of transverse drainage) will be required to restore flood levels, in particular the 20% AEP, back to base case conditions. |
| 3.     | East of the Bowen Parkway road | The sizing of CD K1 has been determined based on correspondence with Melbourne Water (Appendix B-3). As such no further action is recommended. |
| 4.     | Woodlands drive | Check the flood safety/hazard of the 5% and 20% AEP overland flow paths along Woodlands drive. If any drainage changes are required, the impact this has on flow behaviour for the 1% AEP should also be investigated. |
| 5.     | The Waterways | Minor increase in the capacity of the proposed depression storage on the eastern side of the freeway, or a new depression storage on the western side is highly expected to mitigate the residual impact observed in the 5% and 20% AEP flood events and restore flood levels back to base case conditions. |
Figure 9.3  Flooding impact non-compliance Location 1 (1% AEP mapping shown)

Figure 9.4  Flooding impact non-compliance Location 2 (1% AEP mapping shown)
Figure 9.5  Flooding impact non-compliance Location 3 (1% AEP mapping shown)
Figure 9.6  Flooding impact non-compliance Location 4 (1% compliant; 5% and 20% AEPs are non-compliant)

Figure 9.7  Flooding impact non-compliance Location 5 (1% compliant; 5% and 20% AEPs are non-compliant)
10 CONCLUSION

This section provides a summary of the key study assumptions and limitations with relation to the flood modelling setup and output. It also documents recommendations for detailed design.

10.1 ASSUMPTIONS AND LIMITATIONS

The following general assumptions and limitations apply to the base case and proposed case conditions flood modelling assessment for the project study area, in addition to the assumptions and modelling techniques documented throughout this report:

— The accuracy of the final model output is reliant upon the accuracy of the supplied digital elevation information and dimensional attribute of drainage infrastructure.

— Tuflow modelling, including the definition of model extent and model boundary conditions (inflows and downstream water levels), is based on the analysis of 1% AEP flood conditions and is appropriate for use on events up to and including this storm magnitude. For very rare to extreme events, e.g. 0.05% AEP, a review of the Tuflow model extent (eg. at Heatherton Main drain catchment) and update of (internal/external) inflow information will be required. Refer to section 7.4 and 7.5 for a detailed description of the boundary conditions used in this study.

— The final model output is sensitive to the type and value of the downstream boundary level at the interface with Mordialloc Creek. The tail water levels adopted in this flood study are based on the Melbourne Water 2013 study – Mordialloc Settlement Drain Flood mapping project (GHD, 2013).

— For the climate change scenario, a 1.19 multiplier was applied to the Mordialloc Creek external Inflow at Springvale Road. This method was adopted given the absence of other reliable flow versus time information and assumes that the increase in rainfall intensity is directly proportional to the increase flow rate.

— It is assumed that future projects occurring upstream of the project will include appropriate on-site detention measures to prevent any net change in contributing flows to the project.

— City of Kingston has suggested that a proposed pipeline diversion from Council’s Deals Road Drainage Scheme be incorporated into the modelling assessment (refer Appendix C). GHD (2014) have assessed the effect of the proposed diversion as part of the Dingley Bypass Transverse drainage Assessment and found that there was no significant increase in 100 year ARI flood levels (refer Appendix E, E1) as a result of the proposal. To date, it has not been accounted for in the project flood modelling.

— The south RORB model created as part of the present flood study did not utilise the routing capability available in RORB (as this was not needed) nor has it been calibrated or validated, as such is only suitable for the purpose outlined under section 5.3.1.

— The adopted fraction impervious values for RORB subareas intersecting the Freeway are based on the road design developed in November 2017. As the road design has since been updated, fraction impervious may need to undergo minor updates to reflect the latest road design.

— The design road geometry (section 8.1.1) and Waterways wetlands bridge, adopted in the proposed case conditions modelling is current as of 8 May 2018.

— The drainage design adopted in the proposed case conditions modelling, particularly for transverse culverts (section 8.2.1) and open channels (section 8.2.2), is current as of 8 May 2018.

— Some auxiliary project features have not yet been accounted for in the Tuflow modelling as their design is still progressing. Refer to recommendation number 2 under section 10.2 for a list of these features.
Flood levels upstream and downstream of the Wetlands bridge have not been validated against any other model. Refer to recommendation number 3 under section 10.2.

Proposed detention systems are required at four road drainage outfalls, however, these were not modelled in Tuflow. For detention system sizing, please refer to the Mordialloc Freeway drainage strategy (WSP reference no. 2135645A-SE-26-WAT-REP-0002.docx).

All limitations and assumptions associated with the Mordialloc Settlement drain flood mapping project (GHD, 2013) and the Dingley Bypass cross-drainage Hydraulic assessment report (GHD, 2014) apply to this project.

10.2 RECOMMENDATIONS

10.2.1 DETAILED DESIGN

The following recommendations apply for outstanding issues and task items applicable to the flood modelling that should be undertaken during detailed design:

1 Incorporate the latest geometric and drainage design configurations to proposed case RORB and Tuflow models. To ensure the latest proposed case design Tuflow setup files are used, please refer to Table 9.2. Updates to the following setup features after 8 May 2018 should be captured in the Tuflow model:
   a Topographic formation and transverse drainage
   b Surface roughness changes including detailed works, eg. rockwork and planting
   c RORB fraction impervious updates
   d Re-do the critical duration analysis and check simulation end times.

2 Obtain design data and information for auxiliary project features and incorporate into Tuflow model where applicable. Design data and information for the following notable project features should be obtained when available and incorporated into the proposed case conditions Tuflow model:
   a Pier/pile design (with caps where applicable) for multi-span bridges at freeway intersections
   b Surface elevation of proposed shared use paths with transverse drainage structures where applicable; and
   c Design and invert details of proposed shared use underpass near the ‘The Parkway’ Road. (Available in Appendix L-2).

3 Undertake validation of proposed Wetlands bridge hydraulics. Under proposed case modelling, a pier loss coefficient of 0.241 was calculated and adopted for the hydraulically engaged area beneath the soffit of the proposed Waterways wetlands bridge (refer section 8.2.3). It is firstly recommended that the latest geometric bridge design be used to reflect updates carried out after 8 May 2018, and secondly that the flood level output of the Tuflow model be validated against an independent HEC-RAS model, as requested by Melbourne Water (Appendix B-1, reviewer comment 16), to further analyse the effect of the pier loss coefficient on hydraulic modelling output.

4 It is noted that Melbourne Water requested that model runs should ultimately be simulated using Tuflow’s traditional ‘Classic’ solver (2018 build), however, WSP understands that this is just to ensure that there are no significant differences in the output between the two solvers. In this study, the largest differences in flood mapping came about when upgrading from Tuflow build 2010-10-AC-iSP (used in previous iterations of this report) to build 2018-03-AB-iSP while still using the same solver in each case (Classic). In an effort to rationalise the differences, WSP has contacted Tuflow support. A key recommendation of the correspondence, which is provided in Appendix T of this report but not yet completed, was to undertake sensitivity testing using the latest build against older default parameters (these change progressively with the release of new Tuflow builds) and determine if this has any effect on output.
5 **Undertake flood modelling and mapping of the 2% and 10% AEP flood events as well as mitigation development where required.** This should include:
   a. The resolution of outstanding flood impacts listed under Table 9.6. For mitigation recommendations going forward it is recommended that the consultant refers to Table 9.7
   b. The assessment of flood hazard and safety of shared user paths, the pedestrian underpass, roads and other features at risk of flooding.

6 **Obtain RORB model for Haileybury drain located upstream of Springvale Road and use this together with the supplied Keysborough RORB model to determine the magnitude of external boundary inflow at Mordialloc Creek for the 0.5%, 0.2% and 0.05% AEP flood events (refer recommendations 7 and 8).** To date Melbourne Water have only provided the Keysborough RORB model (Appendix B-2).

7 **Undertake flood modelling for a 0.05% AEP (appx 1 in 2000 year) design storm event for Wetlands bridge ultimate limit state design.** The 0.05% AEP design storm event is the flood event standard for structural ultimate limit state design as provided in AS5100. This will also require new values for upstream and downstream boundary conditions (refer sections 7.4 and 7.5 for details).

8 **Undertake flood modelling for a 0.5% (1 in 200 year) and 0.2% (1 in 500 year) AEP.** This will also require new values for upstream and downstream boundary conditions (refer sections 7.4 and 7.5 for details).

9 **Per Melbourne Water reviewer comment nos. 4 and 69, consider running local Tuflow model(s) with a cell size less than 4 metres at locations of sensitive 1D/2D interfaces, particularly where these are close to areas of sensitivity (e.g. residential development).** This may occur at locations of small drains tying into 2D cells.

### 10.2.2 PRIOR TO CONSTRUCTION

The following recommendations apply for outstanding issues and task items applicable to the flood modelling that should eventually be undertaken prior to construction:

1 **Undertake flood modelling to determine impact during the construction phase(s).** This requirement is outlined under Melbourne Water’s requirements for the Mordialloc Freeway (Appendix A) and would involve the setup of a separate proposed case scenario(s) to include temporary works and staging planned for the construction phase of the Mordialloc Freeway; and investigating the impact of these on flooding.
11 REFERENCES


APPENDIX A
MELBOURNE WATER REQUIREMENTS

Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass, June 2017
Performance Criteria for Waterways and Floodplain Planning and Management – Mordialloc Bypass, June 2017

June 2017
Melbourne Water
## Version History

<table>
<thead>
<tr>
<th>Date</th>
<th>Version</th>
<th>Description</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>30/06/2016</td>
<td>1.1</td>
<td>Draft for internal Review</td>
<td>M Coffey</td>
</tr>
<tr>
<td>13/06/2018</td>
<td>1.2</td>
<td>Issue for Mordialloc Bypass</td>
<td>S Kelly</td>
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</tbody>
</table>
1. General

1.1 Wider Context of Assets

Melbourne Waters drainage assets function within a wider context of floodplain management including:

- Floodplains and flood ways requiring consultation with Melbourne Water as a floodplain planning referral agency.
- Catchments which are managed either by MW or local councils.
- Council owned drainage assets (requiring engagement with the other asset owners)
- Major water courses
- Flood ways
- Development and/or Redevelopment Drainage Schemes which are administered or managed by MW, Development Agencies or Local Government where provision for drainage services and Water Sensitive Urban Design is needed to service growing communities.(*Notes under in respect to road and rail networks within the Melbourne catchment.)

*Drainage Schemes are initiated through development planning which conceptualise drainage and flood conveyances both within the development precinct and in the wider catchment context.

An important aspect of Schemes is the creation of the funding or “contributions“ systems supporting the capital works.

Where transport networks are concerned, whilst the project initiators (Authorities) are generally exempted from participating or making financial contributions to a Development Drainage Scheme, they nonetheless are required to meet the needs of Schemes in two general ways:

1. Conveying flows across a road reserve meeting the requirements of existing and proposed Drainage Schemes as instructed by the Drainage Authority.
2. Designing and creating Water Sensitive Urban Design Water treatment works meeting Best Environmental Practice Management standards (or compensating for an impact as equivalent through an offsetting mechanism.)


1.2 Limitations of Advice

The Performance Criteria provided in this document is general advice only. Melbourne Water does not warrant or guarantee that the information provided is exhaustive or without omissions or errors.

Prior to commencing any works on or near any of MW’s assets the Contractor will be required to obtain MW’s written consent to the works and enter into an Asset Interface Agreement with MW.

For the avoidance of doubt, nothing in this Performance Criteria document is to be taken as consent to any works being undertaken on or near MW’s assets.

1.3 Communication, Review and Response Times

All correspondence with MW should initially be directed to the nominated Major Infrastructure Projects interface manager. As the project progresses, a communication protocol will be developed appropriate to the circumstance and timing of the project.

Once a communication protocol is established, MW generally meets the following response times:

- Review of design documentation – 28 working days
- Responses to minor queries, RFI’s and the like– 10 working days unless otherwise advised

1.4 Melbourne Water Standard Documents

MW asset management standards shall be followed, including but not limited to, those listed in the table below. These are available on request from MW.

<table>
<thead>
<tr>
<th>Standards and Related Procedures /Guides</th>
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<tbody>
<tr>
<td>CORP AM P005 Asset Numbering, Labelling &amp; Data Capture</td>
</tr>
<tr>
<td>CORP AM P006 Preparation of Drawing Documents</td>
</tr>
<tr>
<td>CORP AM P007 Documenting Operation &amp; Maintenance Manuals</td>
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<tr>
<td>CORP AM P008 Documenting Standard Maintenance Instructions</td>
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<tr>
<td>CORP CW P062 Safety in Design</td>
</tr>
<tr>
<td>CORP CW P085 Quality Plans</td>
</tr>
<tr>
<td>MELBOURNE WATER SURVEY STANDARDS AND GUIDELINES</td>
</tr>
</tbody>
</table>

1.5 Standards

All works on MW assets shall comply with current MW’s Land Development Manual, Australian Standards and Industry Codes of Practice unless otherwise agreed. All new MW underground drains and structures must comply with the Melbourne Water Standard Drawings (Dwg. 7251/08/404 to 7251/08/426. These are available on request from MW.
2. Existing Assets

2.1 Asset Information

MW has a range of information available on the waterways and floodplain e.g.:

- GIS data (Indicative alignments only)
- Hydraulic models
- Drawings

The accuracy of positional and condition data is not a warranty of MW. On-site investigations are required to confirm the accuracy of all information relevant to the proposed design or construction.

It should be noted that the true position of the MW underground drain will require an asset proving survey to be undertaken by the project prior to design. This may involve MW in-drain Confined Space Entry procedures.

2.2 Ownership of assets

Drainage assets may be owned by a range of entities other than MW including local councils and road authorities. Typically ownership depends on the catchment size and type of flow (such as confined, overland or open channel). The ownership of assets impacted by a project needs to be confirmed sufficiently early in the process to allow the engagement and consent of the actual asset owners.

MW will not accept ownership of new drains unless part of a modification of an existing MW Main Drain asset or where it is within its Agency floodplain management responsibility. Any asset created to convey purely overland flows will not be accepted to be owned by MW. In particular, assets created to convey overland flow under rail and roads will become the responsibility of the applicable authority.

Where it has been agreed that the drainage structure is to be owned by MW, then it shall be structurally independent of the rail/road and operationally accessible. If it is not structurally independent of the road/rail, the drainage asset will remain under the ownership of the applicable road/rail authority (incl. Local Government for council roads). Melbourne Waters responsibilities in these cases is for maintenance of the hydraulic capacity of the asset.

Design drawings must define the proposed ownership of all new and modified drainage assets.

¹ The accuracy of data is not warranted by Melbourne Water, inaccuracies are likely to be present. On site investigation is required to confirm all information relevant to design or construction elements. It should be noted that the true alignment and depth of the Melbourne Water underground drains will require asset proving and a survey to be undertaken by the project prior to design. This may involve in-drain confined space survey.
2.3 Availability Requirements

No interruption to flow from any catchment may be caused by the project. (Typically there is no alternative flow path for storm water in the MW drainage network. Construction plans shall be submitted to MW and consider the impacts to drainage and demonstrate that the risk to public and property outside the transport reserve is mitigated. Dry flow works should be planned for in ‘cut overs’.

2.4 Health and Safety

All works associated with the project shall accord with MW’s Health and Safety policies.
3. Waterways and Floodplain Planning and Management Performance Criteria

Climate Change Provisions – General Note

These criteria should be understood in the context that Climate Change is defined as:

1. Sea Level Rise (SLR) of 0.8m by the Year 2100
   Rainfall intensity increase of 19% by Year 2100

2. The role of waterways in climate adaptation and resilience is becoming increasingly important for city-wide planning and resilience strategies. The Mordialloc Bypass project must be delivered in a way that does not limit Melbourne Water and other land managers and city planners from delivering on long term responsibilities and objectives for waterways, including responsibilities for working with communities to achieve place-based outcomes.

3.1 Floodplain Management Requirements

The following requirements shall be met for all works occurring in the project area:

- No increase in 1% year AEP (Annual Exceedance Probability) flood level / velocities as a result of the project.
- No loss of floodplain storage volume.
- Stormwater runoff rates are to be controlled such that there is no significant increase in peak flows across a wide range of AEP’s as well as to ensure no adverse impacts on downstream properties resulting from increased runoff volumes. The hydraulic assessment, in additional to the 1% AEP (1 in 100 year ARI) extent should model outputs for storm events including the 20%, 10%, 5%, 2% AEP (1 in 5, 1 in 10, 1 in 20, 1 in 50 year ARI) storm demonstrating no impacts as a result of proposed works.
- No polluted discharge is permitted into the existing stormwater system.
- If an existing the road level was to be raised then the following assessment is required to determine the potential flood risk to upstream properties.
  - Hydraulic modelling will be required to be undertaken considering 0.5% and 0.2% AEP (1 in 200 and 1 in 500 year ARI) storm event.
  - Application of a blockage factor as per AR&R guidelines 2016.
  - If u/s properties are flooded as a result of the raising of road surfaces, flood mitigation works will be required to be undertaken.
- Whilst every effort has been made to develop a clear and consistent document, it remains the responsibility of the Service Provider to identify any key deficiencies based on their understanding of Melbourne Water’s project objectives and requirements and seek clarification from Melbourne Water as required.
- Additional information and details of requirements are contained in the Melbourne Water documents “Guideline for Development in Flood Prone Areas” from the Melbourne Water website.
• Modifications to the existing Watercourses must be approved by Melbourne Water. This includes new or upgrading connections to the Watercourses.
• Any proposed works associated this project within MWC Drainage Schemes should not be built in way to preclude future Drainage Scheme works. This would be developed further in detail after road alignment and associated works and flood mitigations works are set for Schemes area.
• The above should be read in conjunction with Melbourne Waters “Performance Criteria for Modifications to and Protection of MW Drainage Assets”

Modelling criteria:

• The following 1D and 2D hydraulic models are approved for use by Melbourne Water:
  o 1D models: HEC-RAS
  o 2D model: TUFLOW


3.2 Waterway Asset Requirements

The guiding principles in determining the design of a waterway/watercourse crossing consists of:

• Minimisation of environmental impacts
• No increase in flood levels to surrounding properties
• Maintenance access
• Safety and risk criteria

Environmental requirements:

The following requirements shall be met for all works occurring in the project area that may have an impact on waterways/ watercourses:

• Detailed plans must be developed and submitted to Melbourne Water for approval that show:
  o Vegetation to be removed (appropriate authorisations from State and Federal governments for such removal/ impact may need to be obtained by the project i.e. EPBC Act); and
  o Associated site revegetation/ reinstatement plans.

• Development and submission of an acceptable Environmental Management Plan detailing how the project will mitigate impacts on the Waterways / Watercourses during construction including water quality monitoring procedures, sediment control systems and scour protection.

3.3 Waterway Bridge

In the case of widening an existing bridge or building a new bridge, the following conditions are to be satisfied.

**Existing Bridge**

- The existing cross sectional areas of waterways should not be reduced.
- Piers and abutment must be built in line with exiting piers.
- 1% AEP (1 in 100 year) storm flood level should not be increased by more than 30mm and shall be dissipated within 50m upstream. No freeboard loss will be accepted.

**New Bridge**

- Bridge underside should be set 600mm above the 1 in 100 year AEP flood levels.
- Piers within the waterways must be minimised.
- Bridge design shall include an assessment of scour and incorporate appropriate rock scour protection.
- Endeavour to provide a 4 m X 4 m minimum maintenance envelope under the bridge for maintenance purposes. The level of flood protection for maintenance access will be agreed by MW on a case by case basis; however the minimum flood protection standard is to the 1 in 5 year AEP.
- Pile caps of any piers within the Waterways or adjacent to river banks should be set below the natural surface or river bed profile to facilitate scour protection rockwork.

A Hydraulic and Hydrologic report and associated models will be required to demonstrate how the above conditions have been satisfied.

3.4 Retarding Basins

In the case where the proposed works impact on a Retarding Basins, the works are to be assessed against ANCOLD guidelines (Australian National Committee on Large Dams) with structures designed and reviewed by qualified dams engineers to the satisfaction of Melbourne Water.
4. Construction Phase Requirements

4.1 Construction Phase Planning

MW requires the following Construction Phase Documentation be prepared and submitted for MW’s review and comment prior to construction commencing:

1) Asset Protection Plan
2) Quality Management Plan, including Inspection and Test Plans, any commissioning requirements
3) Safety and Environmental Management Plan and where relevant Cultural and Heritage Management Plans.

4.2 Temporary Works (Construction phase)

Construction activities may impact MW’s systems and floodplain/overland flows.

The methodology for construction should be carefully considered in the planning of the works in order to minimize flood risk to properties and infrastructure.

Prior to the commencement of any works, detailed design plans and hydraulic modelling are required to be submitted to MW demonstrating minimum flood impacts as a result of the temporary works.

Where there is a temporary impact on the floodplain, the project will be required to submit a method of mitigation to eliminate or reasonably manage such risk.

The floodway including banks and beds of waterways will be re-instated after construction to Melbourne Waters satisfaction.

Additional links:

APPENDIX A- Drainage Summary Table
APPENDIX B
MELBOURNE WATER REVIEW
COMMENTS AND CORRESPONDENCE
APPENDIX B-1
MELBOURNE WATER REVIEW COMMENTS
23-Sep-17 12-Dec-17 WSP Zaki Matar

The research has shown that the Melbourne Water (MW) model is purpose-built for one form of output only - rainfall excess hydrographs from each delineated subarea. Rainfall excess hydrographs are applied to the

TUFLOW model showing comparisons between base case and proposed case conditions at 5 selected flood prone locations.

Modelling of the 2% and 10% AEP events should eventually be undertaken as per recommendation number 5. The Appendix provides 1% AEP flood level versus time graphs from the

Annotated map to be provided in Appendix P which will refer back to the discussion already provided in the report. Please refer to Appendix G which outlines, in detail, the list of terrain

In addition to a re-produced water level comparison map, a comparison of 1% AEP flow hydrographs is provided upstream and downstream of the Moorabbin Airport retarding basin (figure

The use of a substantially sized 1D network, which is largely independent of the model cell size adopted in the 2D domain.

To preserve the methodology of the 2013 GHD model; and

The report intended to explain that a later build of TUFLOW, Build 2016-03-AE, was used to serve a very limited purpose being - to generate a useful topographic check file that is

The RORB model.

TUFLOW hydraulic model which calculates peak flow and water level across the modelled area. As such, there would be no meaningful peak flows or flood levels that can be output from

The use of a substantial flow is incorrect. A similar topographic check file modelled by the ADF based on a similar shallow subarea. Noted. (31/1/2018)

The report has not explained why the 2013 GHD model used the Mordialloc Settlement Drain TUFLOW model.

Its also noted that the cross drainage hydraulic assessment for the Dingley Bypass project retained this cell size when it used the Mordialloc Settlement Drain TUFLOW model.

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The RORB model.

TUFLOW hydraulic model which calculates peak flow and water level across the modelled area. As such, there would be no meaningful peak flows or flood levels that can be output from
A review of Terrain modification should be undertaken in the future. You would need to review the GHD model first and then Melbourne Water TUFLOW model - Haven't reviewed the results yet until obtain and incorporate full topography and drainage as part of Dingley Bypass into base case and proposed case model, then we able to incorporate full topography and drainage as part of Dingley Bypass into base case and proposed case model, then we able to easily identify and accurately assess the impacts of the project. It has been discussed and captured in various other comments to assign a dynamic IWL at detailed design, therefore can close this comment. (18/07/2018)

Please refer comment 3.

Noted. Regarding model review, refer response to comment no. 69.

ZM (25/06/2018)

Note that RORB was only used to provide inflow hydrographs to the TUFLOW model. It was not used to generate flood levels and as such a flood level plot from RORB is not available.

Noted. Annotations now added to the comparison map in Appendix P. This refers back to the discussion in section 9.3.1 provided in the report.

For clarity, this comment is in relation to comparison mapping between the GHD (2013) and WSP (2018) flood mapping outputs. It does not depict flood impact as a result of the project. It is provided to show the changes WSP have undertaken to the model setup reflecting the several physical changes in the catchment, Please refer to section 9.3.1 for details.

Additionally, please refer to Appendix G which outlines - in detail - the list of terrain and 1D network changes undertaken between this study and the 2013 (Mordialloc Settlement Drain) study. Please provide further comment or close comment at detailed design phase.

The Dingley bypass TUFLOW model has been requested from GHD. Once it is received, the setup will be reviewed and used in the Mordialloc TUFLOW model where it represents a more realistic representation. Melbourne Water will be consulted for input.

The following is noted:

- WSP to undertake dynamic downstream boundary modelling based on methodology provided under section 8.10 summary email (provided in Appendix B6).
- WSP writes summary email following the meeting (29/06/2018). Feedback, if any, was also sought from Melbourne Water.
- WSP to undertake dynamic downstream boundary modelling based on methodology provided under section 8.10 in report and summary email (provided in Report Appendix B6).

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| Closed | Noted, refer recommendation number 3 under heading 10.2 of the report. | 2135645A-SE-26-WAT-REP-0003 | 30 | 20-Apr-18 | Zaki Matar | WSP | Melbourne Water | No change to wording. 

Noted, refer recommendation number 3 under heading 10.2 of the report. |

| Closed | Noted. WSP confirms that it has already adopted the approach suggested in the comment, i.e. that fraction impervious has been defined based on planning scheme overlays to ensure that future planning is consistent with the model inputs. | 2135645A-SE-26-WAT-REP-0003 | 30 | 22-Jun-18 | Zaki Matar | WSP | Melbourne Water | Noted. WSP confirms that it has already adopted the approach suggested in the comment, i.e. that fraction impervious has been defined based on planning scheme overlays to ensure that future planning is consistent with the model inputs. |

| Closed | Noted, this has been changed. | 2135645A-SE-26-WAT-REP-0003 | 30 | 27-Jun-18 | Zaki Matar | WSP | Melbourne Water | Noted, this has been changed. |


| Closed | Noted, WSP confirms that it has reviewed the modelling methodology applied in the 2013 and 2014 flood studies and has regarded the method employed as acceptable for the modelling report. | 2135645A-SE-26-WAT-REP-0003 | 30 | 10-Aug-18 | Zaki Matar | WSP | Melbourne Water | Noted, WSP confirms that it has reviewed the modelling methodology applied in the 2013 and 2014 flood studies and has regarded the method employed as acceptable for the modelling report. |

| Closed | Noted, this has been removed. | 2135645A-SE-26-WAT-REP-0003 | 30 | 27-Jun-18 | Zaki Matar | WSP | Melbourne Water | Noted, this has been removed. |

| Closed | Noted, this has been changed. | 2135645A-SE-26-WAT-REP-0003 | 30 | 27-Jun-18 | Zaki Matar | WSP | Melbourne Water | Noted, this has been changed. |

| Closed | Noted, the 2D cells representing the road are dry for the entire Tuflow simulation. 1. As the Freeway mainline itself is not flooded, the roughness value assigned to the road reserve will have little to no impact on the hydraulic modelling results and flood mapping output. | 2135645A-SE-26-WAT-REP-0003 | 30 | 27-Jun-18 | Zaki Matar | WSP | Melbourne Water | Noted, the 2D cells representing the road are dry for the entire Tuflow simulation. 1. As the Freeway mainline itself is not flooded, the roughness value assigned to the road reserve will have little to no impact on the hydraulic modelling results and flood mapping output. |


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**Document Title:** Mordialloc Freeway Hydrologic and Hydraulic modelling report

**Specialist:** WSP - Zaki Matar

**Project:** Mordialloc Freeway

**Date:** 22-Jun-18

---

**Comment:** There is an assumption of 0.05 Manning's value for the 'Lakes' that is considered very high (27/07/2018)

**Comment:** It is recommended that detailed surveys be undertaken rather than assuming a depth. Assuming a depth may result in incorrect estimates (27/07/2018)

**Comment:** Differences in flood depths are insignificant (27/07/2018)

**Comment:** Additional run times. Please run the base case and all proposed cases (27/07/2018)

**Comment:** There will be no routed flows required from the RORB South model - only rainfall excess hydrographs are printed from RORB and used in Tuflow. This is explained under: In conclusion, rainfall excess and RORB routed flows in the Tuflow North model were applied as SAs (lowest cell) however some rainfall excess hydrographs were also applied as SAs.

**Comment:** Some waterbodies are vegetated, so a Manning's value of 0.05 is considered appropriate and is consistent with the Melb Water Flood Mapping Guidelines and Technical Specifications. These correspond to the Woodlands and the Waterways estates wetlands and were retained from the Melbourne Water 2013 study. From aerial and site inspection, tiles have been classified to be defined as 'Lakes' with Manning's values.

**Comment:** For a full list of assumed data elements, please refer to Appendix G where Column 1 in the table lists 'A' for assumptions.

**Comment:** The critical duration analysis has not been re-done for proposed conditions. There will be a total of nine storm durations being considered in the assessment.

**Comment:** The model employed by WSP for the South model; and by referring to the flood mapping completed by GHD (2013) for the North model. Tuflow modelling undertaken by WSP for the South model and South Model Build completed using the Tuflow Classic solver. Appendix T provides difference maps between output from HPC and Classic solvers for Mordialloc Freeway using the latest build of Tuflow. Differences in flood depths are in the order of 5 to 10%.

---

**Comment:** Increased the inlet/outlet capacity of pits near the instability area; and

**Comment:** Noted. Recommendation 4 states that although the HPC solver can be used for intermediary runs (to achieve time optimisation) - final modelling output should be completed using the Tuflow Classic solver. A recommendation for the HPC output is at the 0.005% level of significance, which is insignificant differences.

**Comment:** Agreement reached. It is considered necessary to refer to earlier locations of 1D data in the survey. These waterbodies are vegetated, so a Manning's value of 0.05 is considered appropriate and is consistent with the Melb Water Flood Mapping Guidelines and Technical Specifications.

---

**Comment:** While the critical duration analysis has not been re-done for proposed conditions, there are a total of nine storm durations being considered in the assessment.

**Comment:** This depended on the presence of 1D elements. If 1D elements were present, 1D BC polygons were preferred over SA polygons. In conclusion, rainfall excess and RORB routed flows in the Tuflow North model were applied as SAs (lowest cell) however some rainfall excess hydrographs were also applied as SAs.

**Comment:** All RORB inflow types were applied either as 1D BC (pipes/open channels) or 2D SA polygons (lowest 2D cell)

**Comment:** The differences are insignificant (27/07/2018)

---

**Comment:** Noted. Recommendation 4 states that although the HPC solver can be used for intermediary runs (to achieve time optimisation) - final modelling output should be completed using the Tuflow Classic solver. Appendix T provides difference maps between output from HPC and Classic solvers for Mordialloc Freeway using the latest build of Tuflow. Differences in flood depths are in the order of 5 to 10%.

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**Comment:** The differences are insignificant (27/07/2018)
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<td>Maree Micozzi Section 10.1 passage Assumptions and Limitations, comment: All models should be reviewed and assessed to appropriately model the project interface.</td>
<td>WSP Zaki Matar</td>
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<td>South East</td>
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<td>Maree Micozzi Section 9.3 passage Table 9.3, comment: All information (including depths) will be required for lower storm event analyses.</td>
<td>WSP Zaki Matar</td>
<td>Melbourne Water</td>
<td>South East</td>
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<td>Maree Micozzi Section 9.1 passage Overview, comment: Please include velocity in the opening statement as one of the required criteria.</td>
<td>WSP Zaki Matar</td>
<td>Melbourne Water</td>
<td>South East</td>
<td>Mordialloc Freeway</td>
<td>Minor</td>
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<td>2135645A-SE-26-WAT-REP-0003</td>
<td>Maree Micozzi Section 7.7 passage Critical Storm Duration Analysis, comment: Flood storage should also be considered when designing infrastructure.</td>
<td>WSP Zaki Matar</td>
<td>Melbourne Water</td>
<td>South East</td>
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<td>Minor</td>
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<td>2135645A-SE-26-WAT-REP-0003</td>
<td>Maree Micozzi Section 7.4.3 passage ..a 1.19 multiplier was factored to each time incremented discharge in the hydrograph</td>
<td>WSP Zaki Matar</td>
<td>Melbourne Water</td>
<td>South East</td>
<td>Mordialloc Freeway</td>
<td>Minor</td>
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<td>Closed</td>
<td>Closed</td>
<td>South East Freeway Hydrology and Hydraulic modelling report</td>
<td>16/08/2018</td>
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</tbody>
</table>

**Note:** The above comments are representative of the feedback received during the review process. Each comment is associated with a specific section in the project report, and每個批評都與報告中的特定部分相關聯。
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<th>Response</th>
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</table>

The document clearly stated the risks and potential impacts of failure and the flood event should be considered. The document also stated that the flood management plan should be reviewed and amended as necessary. As noted in the Melbourne Water correspondence on the Braeside Park provided in Appendix B-6 and added to this spreadsheet under comments 73-75.

Modelling studies show that there are a number of outstanding impacts that remain to be addressed. The comment is in reference to the memorandum provided to Melbourne Water on 31/07/2018.

Please refer comments 40 which is related to this comment.
APPENDIX B-2
CORRESPONDENCE WITH MELBOURNE WATER

Correspondence regarding:
Deals Road diversion pipeline
Mordialloc Creek inflows upstream of the project at Springvale Road
Mordialloc Creek interface boundary condition
Hi Steve,

Further to your email below (22 February 2018), Melbourne Water has no objection to the suggested approach, subject to the outstanding issues being included in the information provided to the next phase of the project.

Happy to discuss as required.

Regards, Stephen.

---

From: Stephen Woods
Sent: Tuesday, 6 March 2018 1:31 PM
To: Horne, Steve
Cc: Matar, Zaki; Lam, Eric; Shane Kelly; Mark Warren; Joe Pang; Greenberger, Adam; Knight, Jay; Matheson, Dave; Lavan Nathan (lavan.nathan@roads.vic.gov.au); Mark Warren; Joe Pang
Subject: RE: Transmittal 148 - Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - re Issued for Review

Hi Steve,

Further to your email below (22 February 2018), Melbourne Water has no objection to the suggested approach, subject to the outstanding issues being included in the information provided to the next phase of the project.

Happy to discuss as required.

Regards,

Stephen Woods
Project Manager (Major Infrastructure Projects), Asset Management Services, Service Delivery Group, Melbourne Water
T: 9679 7162 | M: 0417 595 806 | 990 Latrobe Street, Docklands, 3008 | PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

---

From: Horne, Steve
Sent: Thursday, 22 February 2018 9:45 AM
To: Stephen Woods
Cc: Matar, Zaki; Lam, Eric; Shane Kelly; Mark Warren; Joe Pang; Greenberger, Adam; Knight, Jay; Matheson, Dave; Lavan Nathan (lavan.nathan@roads.vic.gov.au)
Subject: RE: Transmittal 148 - Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - re Issued for Review

Hi Steve

Thanks for your responses. We have the following comments / suggested approach:

1. Eric has emailed Alan West at Kingston City Council to confirm the status of the Deals Road diversion pipe. Due to the timing of the Mordialloc Bypass EES, possible inclusion of this diversion pipe into the Mordialloc Bypass TUFLOW model (either as base-case or as a sensitivity run) will be completed during detailed design.

2. There are files / information missing (e.g. RORB subarea identifiers, IFD parameters, and TUFLOW model files) needed for WSP to review the provided RORB model and report and determine if and how it should be used to determine Mordialloc Creek inflows for the Mordialloc Bypass TUFLOW model. We will note this as an outstanding issue in our modelling report to be resolved during detailed design. However, for the purposes of the Mordialloc Bypass EES, we will continue to use the Mordialloc Creek inflow hydrographs used in the Mordialloc Settlement Drain Flood Mapping project (GHD, 2013), being the best available information.

3. Checking the downstream boundary levels would require modelling Mordialloc Creek downstream of the current boundary location. This would require bathymetry data of Mordialloc Creek that is not available. We will note this as an outstanding issue in our modelling report to be resolved during detailed design. However, for the purposes of the Mordialloc Bypass EES, we will continue to use the tailwater levels used in the Mordialloc Settlement Drain Flood Mapping project (GHD, 2013), being the best available information. We will also complete a sensitivity analysis scenario using a downstream boundary level equal to 1.60mAHD, corresponding to a 1% AEP Port Phillip Bay level. 1.60mAHD also matches the 5 year ARI water level downstream of the Waterways wetlands as documented in "The Waterways": Mordialloc Creek Floodplain...
Hi Steve,

Further to your email below, Melbourne Water provides the following responses to the queries raised, viz:-

1. The Deals Road diversion pipeline is a Council proposal so we have no information as to its status. If it is still a proposal / option under consideration, then it will need to be included in the Mordialloc Bypass modelling. If it has been abandoned, then the natural catchment only needs to be allowed for.

2. With respect to the inflow hydrograph for Mordialloc Creek applied at Springvale Road, as the staff involved in the 2013 GHD Mordialloc Settlement Drain modelling are no longer working at Melbourne Water, it would take at least two more weeks to determine the source of the original work and assess it. Attached is a RORB model and in-house report for the Mordialloc Creek catchment upstream of Springvale Road that was created to evaluate the impacts of the existing and proposed development in the catchment. This is provided for your information and use as you determine to be appropriate.

Whilst all due skill and attention has been used Melbourne Water Corporation shall not be liable in anyway for loss of any kind including, damages, costs, interest, loss of profits or special loss or damage, arising from any error, inaccuracy, incompleteness or other defect in this information. By receiving and accepting this information the recipient acknowledges that

---

Sent: Friday, 16 February 2018 4:01 PM
To: Horne, Steve <Steve.Horne@wsp.com>
Cc: Matar, Zaki <Zaki.Matar@wsp.com>; Lam, Eric <Eric.C.Lam@wsp.com>; Shane Kelly <Shane.Kelly@melbournewater.com.au>; Mark Warren <mark.warren@melbournewater.com.au>; Joe Pang <Joe.Pang@melbournewater.com.au>
Subject: RE: Transmittal 148 - Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - re Issued for Review

Hi Steve,

Further to your email below, Melbourne Water provides the following responses to the queries raised, viz:-

1. The Deals Road diversion pipeline is a Council proposal so we have no information as to its status. If it is still a proposal / option under consideration, then it will need to be included in the Mordialloc Bypass modelling. If it has been abandoned, then the natural catchment only needs to be allowed for.

2. With respect to the inflow hydrograph for Mordialloc Creek applied at Springvale Road, as the staff involved in the 2013 GHD Mordialloc Settlement Drain modelling are no longer working at Melbourne Water, it would take at least two more weeks to determine the source of the original work and assess it. Attached is a RORB model and in-house report for the Mordialloc Creek catchment upstream of Springvale Road that was created to evaluate the impacts of the existing and proposed development in the catchment. This is provided for your information and use as you determine to be appropriate.

Whilst all due skill and attention has been used Melbourne Water Corporation shall not be liable in anyway for loss of any kind including, damages, costs, interest, loss of profits or special loss or damage, arising from any error, inaccuracy, incompleteness or other defect in this information. By receiving and accepting this information the recipient acknowledges that
Melbourne Water Corporation makes no representations as to the accuracy or completeness of this information and ought carry out its own investigations if appropriate.

3. The Mordialloc Bypass TUFLOW modelling boundary location and boundary conditions need to be determined by the modellers undertaking the work. The boundary needs to be located sufficiently clear of the area of interest that the modelling is focussing on so that the modelling results are independent of any variation or error in setting the boundary conditions. When AEP varied fixed tailwater levels are adopted for TUFLOW modelling, there can be unexpected backflow filling of the model from the downstream fixed level which can cause problems in flat gradient models.

Am available to discuss.

Regards, Stephen.

Stephen Woods | Project Manager (Major Infrastructure Projects), Asset Management Services, Service Delivery Group | Melbourne Water
T: 9679 7162 | M: 0417 595 806 | 990 Latrobe Street, Docklands, 3008 | PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

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From: Horne, Steve [mailto:Steve.Horne@wsp.com]
Sent: Wednesday, 24 January 2018 6:30 PM
To: Shane Kelly; Stephen Woods
Cc: Matar, Zaki; Lam, Eric
Subject: RE: Transmittal 148 - Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - re Issued for Review

Hi Shane and Stephen

Per Comment No. 9 in the Melbourne Water comments register (2135645A-SE-26-WAT-MWR-0001 RevB), WSP have sought and obtained a copy of the Dingley Bypass TUFLOW model, which was created by GHD as part of the report – *Design and Construction of Dingley Bypass, Cross-drainage hydraulic assessment* (GHD, 2014).

Please find attached meeting minutes for a meeting arranged between WSP, GHD and VicRoads on the 21st of December. The aim of the meeting was to clarify and discuss modelling assumptions and setup items related to the Dingley Bypass model, so that WSP could make informed decisions related to incorporating elements into the Mordialloc Bypass TUFLOW model. As part of this meeting, GHD also outlined further considerations for the project, associated with the Mordialloc Settlement Drain TUFLOW model, which, as you know, was originally created by GHD (2013) and provided for use in the Mordialloc Bypass flood modelling and impact assessment.

**We require feedback from Melbourne Water regarding the following actions provided in the attached minutes:**

**Queries linked to the Dingley Bypass TUFLOW model (GHD, 2014):**

1. WSP would like to enquire on the status of the Deals Road diversion pipe previously assessed in the Dingley Bypass RORB (and subsequent TUFLOW) modelling. In particular, can Melbourne Water please advise whether to include this diversion pipe as part of the Mordialloc Bypass TUFLOW modelling?

**Queries linked to the Mordialloc Settlement Drain TUFLOW model (GHD, 2013):**

2. The external inflows for Mordialloc Creek applied at Springvale Road were provided by Melbourne Water for GHD to use in the study. Given the age of the RORB models from which these flows were produced, GHD recommended enquiring on current applicability of these inflow hydrographs as there has been much development and change in the catchment. Can Melbourne Water please confirm the external inflows for
Mordialloc Creek applied at Springvale Road, as used in the 2013 GHD study, are still applicable to the Mordialloc Bypass TUFLOW modelling?

3. AEP varying fixed tail water levels were adopted as the downstream boundary for Mordialloc Creek. Melbourne Water provided tailwater levels (TWLS) at the end of Heatherton Drain and Mordialloc Settlement Drain based on internal modelling, and advised that the Mordialloc Settlement Drain TWL should be used for all upstream drains (including Mordialloc Creek). Given the proximity of the model downstream boundary to the Mordialloc Bypass works, can Melbourne Water please confirm that the fixed TWL approach used in the 2013 study is still applicable to the Mordialloc Bypass TUFLOW modelling?

Please discuss the above directly with Zaki if clarification is required.

Also, a friendly reminder that comments on the Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report Rev B report are due next Wednesday, 31st Jan. I also understand that the EES TRG comments on the existing conditions report are due next Friday 2nd Feb.

Thanks,

Steve Horne
Senior Civil Engineer

T: +61 8 84054360
M: +61 437 167235
Steve.Horne@wsp.com

WSP Australia Pty Limited
Level 1
1 King William Street
Adelaide, SA
5000 Australia

wsp.com

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From: Ryan, Cherie
Sent: Thursday, 14 December 2017 3:19 PM
To: 'Gina.Solomon@roads.vic.gov.au' ; 'Austin.Manning@roads.vic.gov.au' ; 'Paramvir.Singh@roads.vic.gov.au' ; 'Lavan.Nathan@roads.vic.gov.au'
Cc: Shane.Kelly@melbournewater.com.au; Stephen.Woods@melbournewater.com.au;
'Hemangkumar.Patel@roads.vic.gov.au'; Berry, Alex ; Horne, Steve ; Matar, Zaki ; Knight, Jay ; Matheson, Dave ; Smith, Matt
Subject: Transmittal 148 - Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - re Issued for Review

Good Afternoon,

Please find attached, revised Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report – re Issued for Review.
The Report can be accessed at the link below:


Please also find attached WSP responses to Melbourne Water reviewer comments in excel spreadsheet format, which were provided as part of Revision ‘A’ of this document.

Kind regards,

Cherie Ryan
Document Controller
APPENDIX B-3
CORRESPONDENCE WITH
MELBOURNE WATER

Correspondence regarding:

Flow allowance for future Smythes Drain crossing
Hi Steve,

Melbourne Water has reviewed the details and can confirm that the flow allowance should be for an ultimate Q100 of **3.6 cumecs** for the future Smythes drain under the Mordialloc ByPass take off ramp.

In relation to the alignments, our primary concern is the access for maintenance of the hydraulics of these assets. Given the more perpendicular alignment you are suggesting is of a shorter overall length this would be preferable to that alongside the embankment. It does bring with it some issues around scour analysis given the bends introduced (especially on the D/S end) and scour protection if required.

- Preference for minimal maintenance activities
- Scouring protection and monitoring requirements
- Maintenance access leading to the culverts U/S and D/S end will need to be facilitated
- Semi Submerged culvert/ wet base to insure culvert IL level is not restricting U/S catchment from free draining.
- Designed in accordance with submerged structure requirements to insure Asset life (VR asset)
- Any land impact/ownership impacts would need to be managed by the Project
- A copy of VicRoads letter acknowledging acceptance of culvert structure as VicRoads asset for MW future reference should be submit.

Happy to discuss any of the above

Kind regards

**Shane Kelly** | Interface Manager - Outer Suburban Arterial Roads Project (OSAR) | Major Infrastructure Projects | Asset Management Services | **Melbourne Water**

**T:** (03) 9679 7943 | **M:** 043 849 1530 | 990 LaTrobe Street, Docklands, 3008.

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side of the bypass that will intercept some overland flow and direct it to the upstream side of the proposed Smythes Drain culvert (this swale will be included in our next proposed scenario model run so can confirm flows then)

- Existing Smythes Drain culvert under Springvale Road is a 1 no. x 1200 x 900 and 1 no. x 375mm dia (as per VicRoads survey, similar in MW GIS) and does not overtop in Q100 event

Considering the difference between the two design flows, can Melb Water please confirm the ultimate design flow requirement for this crossing? I’m happy to assist with providing any details you need.

The current design of this crossing is shown in the below screenshot. It includes a 95 m long, 3 no. x 1800 mm (W) x 1200 mm (H) box culvert (sized based on 8 cumecs) and channel works downstream. I note that you have previously provided a couple of sketches that show the proposed culvert with increased skew (i.e. culvert alignment parallel to existing channel), although this would increase the length of the culvert to around 120 m. Interested to get your thoughts on this.

FYI – we should have drainage layout check prints for Mordialloc in a week or so. I will transfer to you, as per Plenty Road Stage 2, when ready.

Thanks,
APPENDIX B-4
CORRESPONDENCE WITH
MELBOURNE WATER

Correspondence regarding:
Flood impact at Braeside Park
Thanks Joe.

That’s right, we’ve used pre-2016 ARR methodology for our hydrology in Mordialloc Bypass. So we’re ideally after the Melbourne Water F2 and F50 spreadsheet, typically used in pre-2016 ARR climate change flooding assessments.

Regarding the methodology for the external inflow hydrographs at Mordialloc Creek –
As an alternative to output from a detailed flood model, we simply propose to factor up the supplied existing conditions hydrographs by 19% (which is equal to the increase in rainfall intensity for a climate change scenario per Melbourne Water performance criteria). That is to multiply each incremental discharge in the hydrograph by 1.19

Let me know if you have any queries.

Regards,
Zaki

Zaki Matar
Professional Water Resources Engineer

D: +61 3 98611136
Zaki.Matar@wsp.com

WSP Australia Pty Limited
Level 15, 28 Freshwater Place
Southbank VIC
3006 Australia

wsp.com

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climate change scenario. I will speak to technical spec from Flood Mapping Team for acceptable parameters.

- Recall this inflow is applied as two external inflow hydrographs to the TUFLOW model (H'graphs are labelled with 'KEYS100_2008' and 'Haileybury') – Please submit the methodology to proportion/ratio from 32% to 19% see whether is the appropriate way to adopt the inflow hydrographs in particular locations. Melbourne Water would provide further comments once the methodology being submitted.

Please feel free to contact me if you need to discuss further.

Regards,

Joe Pang  |  Catchment Strategies Investigations, Development Services  |  Melbourne Water
T: (03) 9679 7818  |  990 La Trobe St, Docklands VIC 3008  |  PO Box 4342 Melbourne VIC 3001  |  melbournewater.com.au

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From: Matar, Zaki [mailto:Zaki.Matar@wsp.com]
Sent: Monday, 21 August 2017 2:38 PM
To: Joe Pang
Cc: Shane Kelly; Horne, Stephen
Subject: Climate Change assessment for Mordialloc Bypass

Hi Joe,

Hope you’ve been well. We’re currently working through the climate change assessment for Mordialloc Bypass and would like to request input from Melbourne Water.

To undertake this assessment, can you provide us with:

- The Melbourne Water spreadsheet used to determine F2 and F50 IFD parameters for climate change
- 1% AEP inflow hydrographs for Mordialloc Creek at Springvale Road for a climate change scenario which sees an increase in rainfall intensity by 19%

Regarding inflow at this location:
  - The 2013 Mordialloc flood mapping report states that ‘While most inflows from external catchments were analysed by GHD, the Mordialloc Creek flows at Springvale Road were provided by Melbourne Water’
  - Recall this inflow is applied as two external inflow hydrographs to the TUFLOW model (H'graphs are labelled with ‘KEYS100_2008’ and ‘Haileybury’)
  - The climate change hydrographs available from the 2013 model are likely based on a 32% increase in rainfall intensity rather than the 19% increase required for the Mordialloc Bypass assessment

Please feel free to contact me to discuss or clarify either of the above
APPENDIX B-5
CORRESPONDENCE WITH
MELBOURNE WATER

Correspondence regarding:
Climate change considerations for external inflow from Mordialloc Creek
Hi Steve,
Melbourne Water have no objections with the tail water levels given the project have provided the supportive evidence detailed below.

Re: **HPC version of TUFLOW** – We have no objections to the use of this version, however as discussed in our meeting the final submissions and final runs would need to be run in the ‘classic version’ for submission. Where there are any significant inconsistencies between the 2 results, these should be made clear in the report and discussed/justified.

Please feel free to contact us should you have any further queries

Shane Kelly | Interface Manager | Major Infrastructure Projects | Asset Management Services | Melbourne Water
T: (03) 9679 7943 | M: 043 849 1530 | 990 LaTrobe Street, Docklands, 3008.
PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au
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Please note that I am not available on Tuesdays.

Hi Shane

As discussed, one of the shortlisted contractors mentioned yesterday that they think Melbourne Water have an old HEC-2 hydraulic model of Mordialloc Creek, and that historical recorded water or tide levels may also be available at the creek outlet to the bay.

Can you please follow up internally and with Keith Boniface (if possible) to confirm if this information is available?

Thanks,
Steve
Hi Shane and Maree,

Thanks again for your time yesterday. Below are some notes on the main items we discussed yesterday. It would be appreciated if you could provide your feedback on the proposed approach.

In parallel with the below model updates, WSP will update the flood modelling report to address Melbourne Water comments where possible prior to the updating modelling being completed.

**MW review of model files**

- Clarified that Melbourne Water don’t need to review the actual flood model files at the moment. However, this will likely be required during detailed design and will likely be completed by a 3rd party consultant engaged by MW, but paid for by the project.

**Tuflow model downstream boundary**

- In principal, there is no objection to the proposed methodology of adopting a dynamic downstream boundary.
- The main concern is the actual tailwater levels:
  - It was noted that tailwater levels have been retained from the MW Mordialloc Settlement Drain 2013 flood mapping study, however the original source of these levels is unknown.
  - Subsequent to our meeting yesterday, WSP have double-checked two reports previously provided by MW in order to provide some additional confidence in the tailwater levels. Key extracts from these reports are provided below:
    - *Smythes Drain/Springs Drain, Bangholme - Flooding Investigation Discussion Paper (Craigie, 2011)*
      - Dot point 6, page 21: Peak levels in The Waterways were reached late evening on Saturday 5 February 2011 at about 3.0 m. This level compares with the 100 year ARI level of 2.85 m and the 500 year ARI level of 3.22 m.
    - *The Waterways - Mordialloc creek floodplain wetland system, hydrologic, hydraulic, water quality and environmental performance (Craigie et. al., 2000)*
      - Page 2: Melbourne Water Corporation (Waterways and Drainage Group) have specified that….. the adopted 100 year ARI flood level of 2.85 m AHD.
      - MIKE 11 and MIKE 21 models were established by Lawson & Treloar Pty Ltd, to assess wetland performance, hydraulic structure dimensions and levels, and major flood levels:
        - An average 5 year ARI design flood level of 2.05 m AHD can be adopted for all of the urban precincts in “The Waterways”.
        - An average 20 year ARI design flood level of 2.40 m AHD can be adopted for all of the urban precincts in “The Waterways”.
        - The predicted 100 year ARI design flood level of 2.82 m AHD is marginally lower than the MWC figure of 2.85 m so the latter level can be safely adopted for all of the urban precincts in “The Waterways”.
        - The modelling predicted that in the 500 year ARI event… On the west side of Springvale Road, throughout “The Waterways”, maximum predicted flood level is 3.22 m.
  
  - The Mordialloc Freeway flood modelling (WSP, 2018) adopted tail water levels and corresponding Tuflow peak-peak results (based on a static downstream boundary) at The Waterways are summarised below:

<table>
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<th>ARI (YEAR)</th>
<th>AEP (%)</th>
<th>TAIL WATER LEVEL (MAHD)</th>
<th>TUFLOW PEAK RESULTS (MAHD) AT THE WATERWAYS</th>
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<td>2.70</td>
<td>2.91</td>
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<td>50</td>
<td>2</td>
<td>1.85</td>
<td>Required, however not yet assessed.</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>1.85</td>
<td>2.65</td>
</tr>
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</table>
Therefore, when compared to the above studies, it can be concluded that the adopted tailwater levels, when using a static downstream boundary, are probably slightly conservative. However, it is anticipated that peak water levels in The Waterways will be slightly lower when using a dynamic downstream boundary.

- The proposed methodology for adopting a dynamic downstream boundary is as follows:
  - Obtain sea level data for Williamstown, being the nearest location where records are available, from the Bureau of Meteorology (BoM).
  - Note highest recorded sea level in supplied data set. Extract 48 hours of sea level data either side of peak occurrence.
  - Derive 5 tailwater level curves, one for each AEP, by translating the recorded dataset such that the peak level matches the adopted peak tailwater levels (as per above table). The 1% AEP tailwater level curve is shown below:

  ![Example curve derivation](image)

  - The Tuflow model is run without rainfall for 24 hours with the derived tailwater curves for each AEP in order to produce a restart file of initial flood conditions. The 24 hour dataset period will be between 22/06/2014 7:00 PM and 23/06/2014 7:00 PM, the latter being nine hours prior to the occurrence of the peak tailwater level.
  - The restart files are applied to all subsequent design runs, with the simulation starting 9 hours prior to the peak tailwater level. 9 hours corresponds to the critical storm duration in The Waterways and Braeside Park determined from previous model runs (while there is some spatial variation in critical duration in Braeside Park, the 9 hour event is the most widespread for all three AEPs assessed.) This is considered a conservative approach where the coastal and fluvial peaks are matched, however this approach can be reconsidered after model results are obtained.
  - The critical storm duration analysis is re-checked in Tuflow based on the updated results.
  - Separate restart files will be produced and used for the proposed scenario.

**Use of latest version of tuflow**

- In principal, there is no objection to using the latest build of Tuflow.
- Initially, results using the latest build (currently 2018-03-AB) using HPC solver will be compared against the 2010 build using Classic Solver. Provided there are no significant differences, the latest build using HPC solver will be adopted.
- During detailed design, the 2018 HPC solver and 2010 Classic Solver results will need to be compared against the 2018 Classic Solver version.
- Adopting fixed versus variable time-step will be determined based on model stability and run times.
- GPU hardware will be utilised to optimise run times.

**Flood hazard mapping**

- Flood hazard mapping will be updated to show a DxV value of 0.35 and using clearer colouring.

Thanks,
From: Shane Kelly [mailto:Shane.Kelly@melbournewater.com.au]
Sent: Friday, 22 June 2018 4:43 PM
To: Horne, Steve <Steve.Horne@wsp.com>; Matar, Zaki <Zaki.Matar@wsp.com>
Cc: Ryan, Cherie <Cherie.Ryan@wsp.com>; Matheson, Dave <Dave.Matheson@wsp.com>; Maree Micozzi <Maree.Micozzi@melbournewater.com.au>
Subject: Mordialloc Bypass - Hydrologic and Hydraulic Modelling Report - IRV 00 - Comments

Hi Stephen,

Please see attached comments on the Rev 00 of the Bypass Hydraulic Report. Also included is the updated comments spreadsheet with items closed out from Reb B. The Rev B and Rev OO are in 2 separate tables but you could consolidate if needs be.

Thanks

Shane Kelly | Interface Manager | Major Infrastructure Projects | Asset Management Services | Melbourne Water
T: (03) 9679 7943 | M: 043 849 1530 | 990 LaTrobe Street, Docklands, 3008.
PO Box 4342 Melbourne VIC 3001 | melbournewater.com.au

View Melbourne Water's 2016/17 Achievements Video

Enhancing Life and Liveability.

Please note that I am not available on Tuesdays.

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APPENDIX B-6
CORRESPONDENCE WITH MELBOURNE WATER

Correspondence regarding:

- Downstream boundary considerations for the Tuflow North model
- Adopting the latest build of Tuflow in this study
Hi Steve,

Thank you for your time on the phone on Wednesday, I just wanted to provide my review and comments ahead of our meeting this afternoon.

**MORDIALLOC BYPASS**

As discussed, I have now reviewed the *Mordialloc Bypass, Braeside Park and Woodlands Industrial Estate wetlands flood impacts summary memo [2135645A-SE-26-WAT-MEM-004 RevB.PDF]* and don’t have a significant number of comments to provide. The document clearly stated the risks and potential impacts of failure of the flood gates and for the most part provided sufficient justification to demonstrate that they are not the optimal solution. As was made clear in the report, the preferred outcome would be a simple culvert solution, where approximately 40mm afflux would be experienced by the park area.

Please see my general observations below relating to the hydraulics only (further comments may need to be provided in response to the ecological impact assessment):

- Given that this is not Melbourne Water land, acceptance of the addition to flood levels and potential risk will need to be sought from the relevant landowner (presumably ParksVic?). Also please quantify the maximum depth, velocity and v*d of the SUP under the proposed conditions so the landowner is aware.

- Section 2 of the report states that the latest version 2018 HPC TUFLOW has been used. As previously discussed, comparison of the classic version versus the HPC version should be included. The final results should also be presented in classic version.

- Also in section 2 as part of the updates, “reduced extent” has been listed as a model change. Is this reduced flood extent or model extent? Could you please explain further?
We can all of the above further in the meeting this afternoon, I just wanted to get my response to you as soon as possible, given the short timeframes particularly for Mordialloc. If you have any questions, please just let me know.

Kindest regards,

Maree Micozzi  |  BEng (Hons) (Civil)  |  Asset Practitioner, Flood Information, Catchment Asset Management  |  Melbourne Water Corporation  |  T: (03) 9679 7088  |  990 LaTrobe Street Docklands, 3008  |  melbournewater.com.au

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APPENDIX C
CORRESPONDENCE REGARDING DEALS ROAD DIVERSION PIPELINE – CITY OF KINGSTON
Hi Eric,

I recommend that your drainage modelling for the Mordialloc Bypass project should allow for the flows from the proposed Deals Road drainage scheme.

As this project would be constructed under a Special Charge Scheme, the timing is subject to further consultation with land owners and subject to a formal Council approvals process in accordance with the Local Government Act.

Nevertheless, the proposed scheme is the current preferred drainage solution for this area albeit with unspecified timeframes at this stage.

Regards,
Alan West
City of Kingston
Team Leader, Engineering Design

Sent from my iPhone

On 19 Feb 2018, at 2:07 pm, Lam, Eric <Eric.C.Lam@wsp.com> wrote:

Hi Alan,

I would like to seek your advice on the status of the Deals Road Diversion Pipeline.

Melbourne Water advised us that the Deals Road Diversion Pipeline is a Council proposal. If it is still a proposal / option under consideration, then it will need to be included in the Mordialloc Bypass modelling. If has been abandoned, then the natural catchment only needs to be allowed for in the model.

Please advise if this proposal remains alive or not so that we can finalise our models.

Many Thanks for your help!

Regards
APPENDIX E
REVIEW OF PREVIOUS STUDIES
GHD completed the Mordialloc Bypass Desktop Hydrology Assessment for VicRoads in October 2016. The purpose of the report was to provide preliminary sizing for cross-drainage to enable the development of a business case proposal for the Mordialloc Bypass. It follows previous work undertaken for the concept design completed for VicRoads (GHD, 2013) and utilises the flood modelling and mapping completed for Melbourne Water (GHD, 2013).

A key recommendation from the assessment was that ‘Further more detailed modelling using the existing TUFLOW model (prepared for the Mordialloc Settlement Drain Flood Mapping Project) will be required to confirm (that proposed cross drainage is sufficient to the hydraulic performance criteria)’ (GHD, 2015).

Key points from the draft report include:

- The proposed bypass crosses 11 identified existing flow paths, as listed in Table E.1.
- Existing conditions flood levels and flows for the transverse drainage assessment have been adopted from the Melbourne Water 2013 flood mapping project, which included a Tuflow hydraulic model covering most of the alignment of the Mordialloc Bypass Project.
- A short southern section of the Mordialloc Bypass project was not captured in the extent of the Tuflow model. The assessment assumed it did not correspond to any major flow path or overland flooding.
- One-dimensional hydraulic modelling using HEC-RAS steady state and/or SWMM was undertaken to determine preliminary sizes for transverse drainage structures. Features and assumptions of the modelling include:
  - Model extent was limited to within the road corridor
  - The Tuflow ‘model geometry’ was adopted
  - Flow and flood levels were extracted from the Tuflow model to use as upstream and downstream boundary conditions.

Outstanding issues and limitations outlined in the report include:

- Effects of loss in floodplain storage not accounted
- Consultation with Melbourne Water and Kingston City Council potential for works within Braeside Park (Waterways Area)
- Consultation with Melbourne Water about works close to the sewer pump station on the southern side of Lower Dandenong Road
- Consultation with Melbourne Water, Kingston City Council and land owners about the potential for works outside the project boundary, specifically upstream and downstream of Centre Dandenong Road (proposed swale option)
- Confirmation of afflux and blockage requirements by Melbourne Water is needed.
<table>
<thead>
<tr>
<th>GENERAL LOCATION</th>
<th>EXISTING FLOW PATH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterways</td>
<td>— MC1 – Mordialloc Creek</td>
</tr>
<tr>
<td></td>
<td>— MC2 – Waterways Wetland</td>
</tr>
<tr>
<td>Governor Road</td>
<td>— DD1 – Dingley Drain (via Braeside wetlands)</td>
</tr>
<tr>
<td></td>
<td>— DD2 – Dingley Drain</td>
</tr>
<tr>
<td></td>
<td>— DD3 – Dingley Drain breakaway</td>
</tr>
<tr>
<td>Lower Dandenong Road</td>
<td>— G1 – Gartsides South</td>
</tr>
<tr>
<td></td>
<td>— G2 – Gartsides</td>
</tr>
<tr>
<td></td>
<td>— G3 – Gartsides breakaway 1</td>
</tr>
<tr>
<td></td>
<td>— G4 – Gartsides breakaway 2</td>
</tr>
<tr>
<td>Centre Dandenong Road</td>
<td>— OD1 – Old Dandenong Road Drain</td>
</tr>
<tr>
<td>Dingley Bypass</td>
<td>— OD2 – Old Dandenong Road Drain</td>
</tr>
</tbody>
</table>
GHD completed a transverse drainage hydraulic assessment for the Dingley Bypass detailed design. The purpose of the report was to confirm the hydraulic design of transverse drainage for review and acceptance by Melbourne Water.

Key points from the report include:

— The existing conditions flood levels and flows for cross-drainage were adopted from the Mordialloc Settlement Drain flood mapping project (GHD, 2013).

— A table extract of transverse drainage infrastructure is shown in the table below. Only Cross-drainage occurring near Mordialloc Bypass project is shown.

— Regarding the transverse drainage culvert at location ‘G’ (adjacent Grange Road), it was noted that ‘at some point in the future a new pipe will be constructed that will divert flood flows from the Deals Road Drainage Scheme to crossing ‘G’. The impact of the diversion on 100 year ARI flood levels was noted to be 10 millimetres upstream of crossing ‘G’, and deemed to be an insignificant increase.

— Flows from Crossing ‘G’ will be conveyed to Dunlop’s Drain along a proposed channel running parallel to Grange Road.

— Tuflow hydraulic modelling was undertaken for a 1% AEP (100 year ARI) flood conditions. The design case scenario assessed four cross-drainage culverts and found that there is limited increase in 100 year ARI flood levels downstream of the bypass. Furthermore, there was generally no significant increase in 100 year ARI flood levels upstream of the bypass.

— It was recommended that Grange Road is lowered to increase the conveyance of flood flows in Dunlops Drain for the 100 year ARI event. This would in turn lower the increase in flood levels upstream of the Road which currently acts as a partial barrier. Tuflow modelling indicated that Grange Road would need to be lowered by 200 mm and its verges by 500 mm, where it crosses the drain, to prevent the upstream afflux in flooding.

Table E.2 Identified locations of existing crossings along the Dingley Bypass Project, and within the Mordialloc Bypass study area

<table>
<thead>
<tr>
<th>WATERWAY CROSSING</th>
<th>STRUCTURE TYPE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing ‘F’ for Mordialloc Settlement Drain</td>
<td>Bridge</td>
<td></td>
</tr>
<tr>
<td>Crossing ‘G’ to accommodate Deals Road Drainage Scheme</td>
<td>Culvert</td>
<td>Channel required downstream to connect into Dunlop’s Drain adjacent to Grange Road.</td>
</tr>
<tr>
<td>Crossing ‘I’ at Dunlops Drain / Old Dandenong Road Drain</td>
<td>Culvert</td>
<td></td>
</tr>
<tr>
<td>Crossing ‘J’</td>
<td>Culvert</td>
<td>An unnamed drain, west of Tootal Road. Not included in MWC supplied GIS</td>
</tr>
</tbody>
</table>
E3 MORDIALLOC SETTLEMENT DRAIN FLOOD MAPPING (GHD, MAY 2013)

GHD completed flood modelling and mapping for Melbourne Water in 2013 for the Mordialloc Settlement drain catchment and its surrounds (2013 flood study). Hydrologic modelling was undertaken through RORB models of the assessed catchments, with the main purpose of providing inflow hydrographs for input into a Tuflow hydraulic model. The Tuflow model consisted mainly of Melbourne Water drainage assets, including open channels and underground pipes, as well as select inclusion of Council pipe networks. The Tuflow digital elevation model used LiDAR-based terrain data which was supplemented by design drawings and survey.

A high level review of the modelling methodology associated with the previous RORB and Tuflow models was completed. A summary of this review is provided in the Table E.3.

Table E.3 Summary of the key model set-up components and the methodology applied to each component

<table>
<thead>
<tr>
<th>MODEL</th>
<th>KEY MODELLING COMPONENT</th>
<th>METHODOLOGY SUMMARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrology</td>
<td>RORB model purpose</td>
<td>Four RORB models were created for the purpose of providing hydrograph inflows for input into the Tuflow hydraulic model. Although most flow ‘routing’ was undertaken in Tuflow, some routing was adopted in RORB including within the Tuflow model extent, at the tops of Melbourne Water drains.</td>
</tr>
<tr>
<td></td>
<td>Validation</td>
<td>Each RORB model was validated with several rational method flow estimates at the tops of various Melbourne Water drains across the four RORB catchments. This was followed by a sensitivity analysis to determine final Kc values which were different in each RORB catchment model.</td>
</tr>
<tr>
<td></td>
<td>Impervious Fraction</td>
<td>Based on Planning Zones. Supplemented with values based on actual land use and aerial imagery.</td>
</tr>
<tr>
<td></td>
<td>Design Rainfall Intensities</td>
<td>Design Rainfall was determined based on the methods prescribed in the 1997 edition of ARR (IEAust 1997).</td>
</tr>
<tr>
<td></td>
<td>RORB Model parameters</td>
<td>Initial loss and runoff coefficients set as per MWC 2010 flood mapping guidelines and technical specifications. Parameters match with 2012 guidelines.</td>
</tr>
<tr>
<td>MODEL</td>
<td>KEY MODELLING COMPONENT</td>
<td>METHODOLOGY SUMMARY</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Hydraulic</strong></td>
<td>Initial elevation</td>
<td>In general, created using LiDAR-based thinned ground points. Supplemented by LiDAR first return points, ground survey and/or design drawings. Allowance was made for a temporary retarding basin near Moorabbin Airport while the permanent basin was being designed. The Clayton Road retarding basin (proposed at the time) was also modelled with available design details.</td>
</tr>
<tr>
<td></td>
<td>domain representation</td>
<td>Refinements to elevation domain Tuflow z-lines and shapes were used to define major roads, retarding basin crests, banks of open channels and a railway line, among other topographical modifications made.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1D network – Open channels and bridges Longitudinal profiles generated from LiDAR. Supplemented with design drawings (concrete – lined channels) and ground survey (natural channels). Generally modelled as ‘steep’ or ‘S’ channels in Tuflow. Drop structures along channels were modelled as weir or ‘W’ channels whereas bridge crossings were modelled as either ‘B’ channels (where the bridge deck is modelled in the 2D domain) or ‘BW’ channels (where the bridge deck was modelled as a weir in the 1D network).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1D network – Pipe network MWC and Council drainage less than 450mm in diameter were incorporated. Some invert levels were estimated where they were not readily available in GIS.</td>
</tr>
<tr>
<td></td>
<td>Inflows</td>
<td>Applied as flow versus time boundary conditions to either single nodes in the 1D network (1D_BC) or lowest cell application in 2D_SA polygons. One external catchment inflow, which was not analysed in the RORB model, was provided by MWC. This was the Mordialloc Creek flow at Springvale Road.</td>
</tr>
<tr>
<td></td>
<td>Tail water levels</td>
<td>Constant water levels were applied at 1D network and 2D domain outlets, and over entire model simulations for all assessed storm durations. The value of the water levels were determined following consultation with MWC.</td>
</tr>
</tbody>
</table>
E4 SMYTHES DRAIN/SPRINGS DRAIN
BANGHOLME FLOODING INVESTIGATION
DISCUSSION PAPER, DRAFT VERSION 3
(CRAIGIE, 2011)

An investigation was commissioned by Melbourne Water and the City of Greater Dandenong in response to the localised rain storm event that occurred in the Bangholme area in 4/5 February 2011. Conclusions from the paper that are relevant to the project by the author Neil M Craigie are provided below:

— The average rainfall conditions over the Bangholme area were likely equivalent to a 500 year ARI (apprx 0.02% AEP) event for durations between 1.5 and 14.5 hours.

— Catchment expected to be in a saturated condition at the time of the 4/5 February 2011 flood, and likely to have caused a high proportion of runoff.

— An estimated 41% of the rainfall input volume was stored upstream of Springvale Road emphasising how impeded surface drainage was for the study area. Private crossings are noted to interfere with the free passage of floodwaters in this area.

— Recorded peak flood levels 4/5 February 2011:
  — In the Soden Road and Riverend area flood levels reportedly reached 2.2 metres AHD based on survey of debris markings, given as being equivalent to a 500 year ARI (apprx 0.2% AEP) flood event. This recorded flood level was noted as being 0.74 metres below the Melbourne Water specified flood level for development applications, being 2.94 metres AHD for the Smythes Drain/ Springs Drain area upstream of Springvale Road.
  — A flood level of 2.01 mAHD was recorded for Smythes Drain immediately on the south side of the levee indicating that (a) little relief had occurred at Soden Road at this time and (b) about 200 mm of potential backflow head occurred across the twin 600 mm floodgates (now blocked, see preceding conclusions).
  — Peak levels in the Waterways area reached 3.0 metres AHD, given as being between the 100 year ARI (apprx 1% AEP) level of 2.85 metres AHD and 500 year ARI (apprx 0.2% AEP) level of 3.22 metres AHD.
  — Water levels in the levee banked waterways flanking the subject area were well below the levee crest and posed no threat in this event.
  — It has been noted that the ‘potential for incremental filling to create problems in the future is clear’.
  — The most critical flood response action taken by Melbourne Water was to divert the Smythes Drain overflow channel into the Bowen Road Drainage Scheme channel. After the diversion was cut, water levels started to drop slowly within the Soden Road area.
  — The Smythes drain floodgates were blocked by Melbourne Water by insertion of steel plates on 9 February 2011.
  — The prolonged surface flooding around the Southern Obedience Dog Club indicates that there is no effective low-level drainage serving the club property.
  — The author notes that high ponded levels in the Waterways during the 2011 flood event did not play any significant role in the flooding of the Bangholme area.
E5 THE WATERWAYS – MORDIALLOC CREEK FLOODPLAIN WETLAND SYSTEM, HYDROLOGIC, HYDRAULIC, WATER QUALITY AND ENVIRONMENTAL PERFORMANCE (CRAIGIE ET. AL., 2000)

The following information extracts are provided regarding working flood level information for the Waterways estate area:

— Page 2: Melbourne Water Corporation (Waterways and Drainage Group) have specified that ….. the adopted 100 year ARI flood level of 2.85 mAHD.

— MIKE 11 and MIKE 21 models were established by Lawson & Treloar Pty Ltd, to assess wetland performance, hydraulic structure dimensions and levels, and major flood levels. Text extract about design flood levels is given below:

— An average 5 year ARI design flood level of 2.05 mAHD ‘can be adopted for all of the urban precincts in “The Waterways”.’

— An average 20 year ARI design flood level of 2.40 mAHD ‘can be adopted for all of the urban precincts in “The Waterways”.’

— The predicted 100 year ARI design flood level of 2.82 mAHD ‘is marginally lower than the MWC figure of 2.85 m so the latter level can be safely adopted for all of the urban precincts in “The Waterways”.’

— The modelling predicted that in the 500 year ARI event… On the west side of Springvale Road, throughout “The Waterways”, maximum predicted flood level is 3.22 m.

Table E.4 below lists – (1) the peak tail water levels adopted per Tuflow modelling in this study; (2) the corresponding Tuflow peak results from the dynamic tail water simulation (this study); (3) Peak flood levels from the ‘The Waterways’ report.

Table E.4 Comparison summary of flood level information

<table>
<thead>
<tr>
<th>ARI (YEAR)</th>
<th>AEP (%)</th>
<th>ADOPTED TAIL WATER LEVEL (mAHD)</th>
<th>PEAK FLOOD LEVEL IN THE WATERWAYS PER MODELLING IN THIS REPORT</th>
<th>PEAK FLOOD LEVELS IN THE WATERWAYS AS PROVIDED IN THE CRAIGIE ET AL. (2000) REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1</td>
<td>2.70</td>
<td>2.87</td>
<td>2.85</td>
</tr>
<tr>
<td>50</td>
<td>2</td>
<td>1.85</td>
<td>Required, however not yet assessed</td>
<td>N/A</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>1.85</td>
<td>2.56</td>
<td>2.40</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>1.70</td>
<td>Required, however not yet assessed</td>
<td>N/A</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>1.70</td>
<td>2.39</td>
<td>2.05</td>
</tr>
</tbody>
</table>
APPENDIX F
ADOPTED EXTENT OF FLOOD MODELLING IN THE MORDIALLOC FREEWAY STUDY AREA
Legend
- Project boundary
- Mordialloc Settlement drain
- TUFLOW model extent
- Adopted flood modelling extent
- MWC open channel
- MWC natural waterway
- MWC underground pipe
- MWC levee embankment
- MWC waterbodies

Coordinate system: GDA 1994 MGA Zone 55
Scale ratio correct when printed at A3

Engineering and Technical Services for Mordialloc Freeway Upgrade
Adopted extent of flood modelling for the Mordialloc Freeway study area
APPENDIX G
TUFLOW SETUP LOG – ASSUMPTIONS AND UPDATES (TO 2013 AND 2014 MODELS)
Table G.1  Log of notable data setup updates and assumptions made to develop the base case conditions Tuflow North and South models

<table>
<thead>
<tr>
<th>ASSUMPTION OR UPDATE (A/U)</th>
<th>ACTION</th>
<th>MELBOURNE WATER SCHEME / ROAD NAME</th>
<th>AS CONS SOURCE</th>
<th>AS CONS ASSET ID</th>
<th>ASSET OWNERSHIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>0.525 m and 0.3 m feeder pipe connections to Old Dandenong drain created, upstream of Dingley Bypass</td>
<td>Old Dandenong road Drain (Dunlops Drain)</td>
<td>1112/07/003</td>
<td>Pits 2-1 and 4-3</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Dingley Bypass 1D network, i.e. underground drainage and Old Dandenong drain channel, was cross checked with the project feature survey and updated for cross-section, size and invert level data</td>
<td>Dunlops Drain (Dunlops Drain)</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>VicRoads</td>
</tr>
<tr>
<td>U</td>
<td>Create and incorporated TIN from project feature survey to define Grange Road drain within 2D domain between Dingley Bypass and Old Dandenong drain. Z-line supplements used to define banks and thalweg</td>
<td>Dunlops Drain (Dunlops Drain)</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>VicRoads</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of 0.6 m transverse culvert at Old Dandenong Road followed by downstream open channel representation with a z-line</td>
<td>Old Dandenong road Drain (Dunlops Drain)</td>
<td>Feature survey (July 2017) &amp; Issued for Construction drawings</td>
<td>N/A</td>
<td>VicRoads</td>
</tr>
<tr>
<td>U</td>
<td>3 no. 2.13 x 2.06 m culverts inserted at the Bowen Rd drain intersection with Bowen Parkway (road)</td>
<td>Bowen Road / Smythes drains</td>
<td>SES1561</td>
<td>Sheet 2 of 19</td>
<td>Unknown</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of Moorabbin Airport open channel diversion south of Centre Dandenong Road</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>CH250 - 1000</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Created artificial Moorabbin Airport Retarding Basin and incorporated as TIN (12da format) into digital elevation model, including Chifley drain extension, with levee bank representation via thin z-line.</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>As constructed sheets 40 to 43</td>
<td>MWC</td>
</tr>
<tr>
<td>ASSUMPTION OR UPDATE (A/U)</td>
<td>ACTION</td>
<td>MELBOURNE WATER SCHEME / ROAD NAME</td>
<td>AS CONS SOURCE</td>
<td>AS CONS ASSET ID</td>
<td>ASSET OWNERSHIP</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------</td>
<td>---------------------</td>
<td>------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of Moorabbin Airport diversion culverts: 3 no. 3 x 2.4 m south of Centre Dandenong Road</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>As constructed sheet 11</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of Moorabbin Airport Retarding basin outlet, 2 no. 3 x 2.1 m and 1 no. 3.6 x 2.1 m; lengths assumed</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>As constructed sheet 13</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Represent backfilling of partial section of Mordialloc Settlement Drain within Moorabbin Airport development</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>Design sheets 4 and 5</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of new 0.9 m pipe diversion # 1 (South of Centre Dandenong Road, Moorabbin Airport)</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>Design Sheet 6</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of new 0.9 m pipe diversion # 2 (Joseph Ave, Moorabbin Airport)</td>
<td>Mordialloc Settlement Drain (Moorabbin Airport)</td>
<td>5020/009</td>
<td>As constructed sheet 26</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Update Governor Road Drain culverts (Compkey 173,016) from 1 no. 2.44 x 0.9 m to 2 no. 1.8 x 1.2 m</td>
<td>Governor Road Drain (Moorabbin Airport)</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of 6 no. 0.3 m culverts adjacent to Woodlands wetlands</td>
<td>N/A</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>Unknown</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of 1 no. 1.15 m culvert adjacent to Woodlands wetlands</td>
<td>N/A</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>Unknown</td>
</tr>
<tr>
<td>U</td>
<td>Insertion of 3 no. of 0.45 m diameter pipe connections between Bowen Road underground pipe and open drain</td>
<td>Bowen Road DS</td>
<td>1124/08/001</td>
<td>Pits 15 – 17</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Backfill of an old section of the Bowen Road open drain which was re-aligned. Re-aligned drain represented in the 1D domain</td>
<td>Bowen Road DS</td>
<td>1124/10/002</td>
<td>N/A</td>
<td>MWC</td>
</tr>
<tr>
<td>ASSUMPTION OR UPDATE (A/U)</td>
<td>ACTION</td>
<td>MELBOURNE WATER SCHEME / ROAD NAME</td>
<td>AS CONS SOURCE</td>
<td>AS CONS ASSET ID</td>
<td>ASSET OWNERSHIP</td>
</tr>
<tr>
<td>----------------------------</td>
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<td>----------------</td>
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<td>----------------</td>
</tr>
<tr>
<td>A</td>
<td>Elevations of open channel banks were defined via Tuflow z-lines to facilitate stable 1D/2D flow interchange in the Smythes and Bowen Road open drains.</td>
<td>Smythes Drain &amp; Bowen Road DS</td>
<td>1124/06-10 and 1116/06-07</td>
<td>Miscellaneous chainages</td>
<td>MWC</td>
</tr>
<tr>
<td>A</td>
<td>Twin 0.6 m pipes connecting Smythes Drain with Mordialloc Creek have been excluded from the Tuflow model. This is based on them being reportedly blocked permanently (MWC post-meeting verbal correspondence, Wednesday 7th of June) so that Smythes Drain be completely disconnected from Mordialloc Creek following a recommendation from the Smythes Drain/Springs Drain, Bangholme - Flooding Investigation Discussion Paper (Craigie, 2011).</td>
<td>Smythes Drain</td>
<td>N/A</td>
<td>N/A</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Update invert levels of culverts along Springs Drain. Open channel bed levels defined in 2D domain</td>
<td>Springs Drain</td>
<td>SES1561</td>
<td>Sheets 14 to 17</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Created and incorporated TIN grid based on project feature survey to define a lowered section of Smythes Drain within the Springvale Road median</td>
<td>Smythes Drain &amp; Feature survey (July 2017)</td>
<td>1116/07</td>
<td>N/A</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>Several invert levels and culvert sizes were updated along Smythes Drain</td>
<td>Smythes Drain</td>
<td>SES1561</td>
<td>Sheets 2 to 13</td>
<td>MWC</td>
</tr>
<tr>
<td>A</td>
<td>50% blockage factor applied to the 1.05 m culvert along Smythes Drain to account for this drain being blocked</td>
<td>Smythes Drain</td>
<td>SES1561</td>
<td>Refer sheet 9</td>
<td>MWC</td>
</tr>
<tr>
<td>U</td>
<td>0.45 and 0.3 metre pipes inserted within the median strip of Springvale Road</td>
<td>Springvale Road</td>
<td>1116/07/008</td>
<td>N/A</td>
<td>VicRoads</td>
</tr>
<tr>
<td>A</td>
<td>An assumed series of 4 no. 0.75 m underground pipes were inserted rear of 369 Wells Road to allow for likely drainage continuity</td>
<td>Bowen Road DS catchment</td>
<td>Assumed</td>
<td>N/A</td>
<td>Private (assumed)</td>
</tr>
<tr>
<td>ASSUMPTION OR UPDATE (A/U)</td>
<td>ACTION</td>
<td>MELBOURNE WATER SCHEME / ROAD NAME</td>
<td>AS CONS SOURCE</td>
<td>AS CONS ASSET ID</td>
<td>ASSET OWNERSHIP</td>
</tr>
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<td>---------------------------</td>
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<td>--------------------------------------</td>
</tr>
<tr>
<td>U</td>
<td>3 no. 2.13 x 2.06 m culverts inserted at the Bowen Rd drain intersection with Bowen Parkway (road)</td>
<td>Bowen Road / Smythes drains</td>
<td>SES1561</td>
<td>Sheet 2 of 19</td>
<td>Municipal (City of Kingston)</td>
</tr>
<tr>
<td>U</td>
<td>Definition of road side swale and gully drainage, as well as key ridge lines (e.g. road strings), into the Tuflow digital elevation model at various locations along the project boundary</td>
<td>N/A</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>Miscellaneous</td>
</tr>
<tr>
<td>U</td>
<td>Definition of the confluence between Smythes and Bowen Road DS open drains within the 2D domain, via automatic TIN generation within Tuflow using feature survey lines as break lines</td>
<td>N/A</td>
<td>Feature survey (July 2017)</td>
<td>N/A</td>
<td>Melbourne Water</td>
</tr>
</tbody>
</table>