VRC Wall & Mitigation Report

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Melbourne Water Corporation

Melbourne Water Lower Maribyrnong Flood Mapping Study
14 March 2024

VRC Wall & Mitigation Report

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Jacobs Group (Australia) Pty Ltd

Floor 13, 452 Flinders Street
Melbourne, VIC 3000
PO Box 312, Flinders Lane
Melbourne, VIC 8009
Australia

T +61 3 8668 3000
F +61 3 8668 3001
www.jacobs.com

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MEM_006	Draft Memorandum - VRC Flood Wall & Mitigation Analysis	14/02/24	Melbourne Water	Initial Technical Memorandum for Client Comment.
001	Draft Report – revised based on client feedback	04/03/24	Melbourne Water	Deliverable changed from Technical Memorandum to Report. Client comments on memorandum incorporated.
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Executive Summary

On 14 October 2022 significant flooding occurred within the Maribyrnong River catchment.

Melbourne Water engaged Jacobs to model and present the potential impacts of the installation of the Victorian Racing Club (VRC) flood wall, and associated mitigation measures, on the extent, water level, and duration of flooding experienced in the Lower Maribyrnong catchment during the October 2022 flood event.

Jacobs developed a 2024 Maribyrnong River Flood Model. Although the final reporting for the 2024 Maribyrnong River Flood Model is not yet completed, the model calibrates well to the October 2022 flood event and forms the basis of the following results and reporting. The 2024 Maribyrnong River Flood Model is reflective of current catchment conditions, using 2023 survey and terrain data, revised guidance from the introduction of ARR2019 (Australian Rainfall and Runoff 2019), Melbourne Water Flood Mapping Project Specifications (Melbourne Water AM STA 6200, 2023) and developments in modelling methodology. It is considered the best available information at the time of this report. This calibrated model was used to compare two hydraulic model scenarios under October 2022 flow conditions:

- Base Case – with the VRC flood wall and with the associated mitigation measures. This represents the current catchment conditions.
- Scenario 1 – without the VRC flood wall and associated mitigation measures.

The associated mitigation measures are modifications at Footscray Road bridge and downstream of the Footscray Rail culverts. The aim of these mitigation measures was to offset any increase in flood depths resulting from the construction of the VRC flood wall, by allowing flows to move through bridge and culvert locations with less constraints. The modelling results were analysed with regards to changes to flood extent, flood level and duration of flooding. Comparison of the results indicates:

Performance of the VRC flood wall

- The VRC flood wall performed as designed (protection of Flemington Racecourse under events more frequent than the 1% annual exceedance probability (AEP) event) and Flemington Racecourse was not inundated during the October 2022 event.

Impact on Flood Extent

- There are increases in the flood extent at various locations within the catchment due to the presence of the VRC flood wall and associated mitigation measures. The flood extent (area) in the Base Case is increased by a little over 1%, when compared to Scenario 1. This increase is likely a result of localised topographic features and the flood extent increases will be revised if detailed lot-level investigation was used to validate flood extents. Of the 1% calculated increase, it was calculated that 4% of the flood extent increase is in residential land use areas.

Impact on Flood Depth

- As a result of the VRC flood wall and the associated mitigation measures (Base Case compared to Scenario 1), there is a general increase in flood depths across the wider area, varying from:
  - An average water depth increase of approximately 17mm within residential land uses in the Maribyrnong Township. The water depth increase varies across land uses from 7mm to 30mm within this locality. Note: the average flood depth, in the Base Case, in this area was approximately 800mm.
  - An average water depth increase of approximately 51mm within industrial/commercial properties in Kensington. Excluding localised effects, the water depth increase varies from 30mm to 70mm. Note: the average flood depth, in the Base Case, in this area was approximately 450mm.

- Approximately 80mm increase in water depth, within the Maribyrnong River itself, near the VRC wall Note: the flood depth in the Base Case, within this area (the Maribyrnong River itself), was approximately 5160mm.
- Greater than 300mm on the land immediately adjacent to the VRC flood wall, which is grassed land use with access roads on private land (assumed to be in the control of VRC), and greater than 300mm on land immediately above the access track downstream of the Footscray Rail culverts, which is local parks and gardens land use with an access track. This increase in flood depth is expected due to topographic modifications. This increase in flood depth is localised and does not extend to the wider floodplain.

Impact on Flood Duration

- Based on the comparison of Base Case and Scenario 1 models at various points within the Maribyrnong River, the duration of the flood peak did not change within the model reporting tolerance of 5 minutes by the presence of the VRC flood wall.

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1. Introduction

Jacobs was approached in March 2023 and then commissioned by Melbourne Water in April 2023 to undertake flood modelling of the Lower Maribyrnong River for provision of updated flood information for the Lower Maribyrnong River. As part of this provision of updated flood information in the Lower Maribyrnong Flood Mapping project a new TUFLOW model (along with updated hydrological models) is being developed that is reflective of current catchment conditions, 2023 survey and terrain data, revised guidance from the introduction of ARR2019 (Australian Rainfall and Runoff 2019), modelled climate change scenarios, Melbourne Water Flood Mapping Project Specifications (Melbourne Water 2023) and developments in modelling methodology. This model is hereafter referred to as the 2024 Maribyrnong River Flood Model and will replace previous 2003 1D HEC-RAS models for the Lower and Mid Maribyrnong River. This work is currently in-progress and is due for completion in April 2024.

For the purpose of this report, Jacobs used the 2024 Maribyrnong River Flood Model developed for the Lower Maribyrnong Flood Mapping Project to assess the impact of the Flemington Racecourse flood protection wall (hereafter referred to as the VRC (Victorian Racing Club) flood wall) and associated mitigation measures, on the Lower Maribyrnong catchment, when subject to the October 2022 flood event.

1.1 Purpose of the project

The purpose of the project is to model and present the effects of the VRC flood wall and associated mitigation measures on the extent, level and duration of flooding experienced in the Lower Maribyrnong catchment as a result of the October 2022 flood event using the 2024 Maribyrnong River Flood Model.

The 2024 Maribyrnong River Flood Model is calibrated to the October 2022 event and this calibrated model forms the basis of this report. Details on the model setup and the calibration can be found in:

- A summary in Appendix A 2024 Maribyrnong River Flood Model.
- The draft calibration report (Jacobs, 2023i).
- The final report (Jacobs, 2024a)[1].

The provision of this updated flood information also assists in Melbourne Water addressing Maribyrnong River Flood Event Independent Review Panel recommendations of the *Maribyrnong River Flood Event – Independent Review* (August 2023).

[1] Although the final reporting of the 2024 Maribyrnong River Flood Model is not yet complete, inputs to the model have been prioritised. The 2024 Maribyrnong River Flood Model has been calibrated to the October 2022 flood event to enable delivery of the results presented in this report, prior to finalisation of the 2024 Maribyrnong River Flood Model documentation.

1.2 Background

The VRC flood wall was constructed in 2007 with the purpose of mitigating flooding to Flemington Racecourse assets from the Maribyrnong River for events up to the 1% Annual Exceedance Probability event (GHD, 2003b). As part of the package of works associated with the VRC flood wall, mitigation measures were also delivered with the aim of not increasing flood depth, in the lower Maribyrnong River floodplain, due to the addition of the VRC flood wall for events up to the 1% AEP event. Details of these infrastructure changes and information on how they are represented within a 1D HEC-RAS model is contained in GHD's 2003 report on the Flemington Racecourse (GHD, 2003b). These changes in the GHD 2003 report can be summarised as:

- Works to lower the access track immediately downstream of the Footscray Rail culverts.
- Removal of the bluestone abutment on the eastern bank of Footscray Road Bridge.
- Construction of a flow 'training wall' on the eastern abutment at Footscray Road Bridge.

These measures were implemented to meet Melbourne Water flood criteria and permit conditions by mitigating the effect that the VRC flood wall may have on water levels along the Maribyrnong River. The mitigation measures aim to offset any increase in flood depth by allowing the flood wave to move through the bridge and culvert locations more effectively thereby enabling water to flow more easily down the lower reach of the Maribyrnong River.

Jacobs is currently completing the Lower Maribyrnong Flood Mapping project. Various memoranda and reports (Jacobs 2023a through 2023h) have been produced which detail the key decisions and inputs to the 2024 Maribyrnong River Flood Model, such as bathymetry and survey, schematisation, and flood frequency analysis. A brief summary of relevant reports can be found in Appendix B Supporting Reports. Calibration of the 2024 Maribyrnong River Flood Model is complete with the draft calibration report submitted in 2023 (Jacobs, 2023i) and final reporting currently in progress (Jacobs, 2024a). Model runs using this calibrated model form the basis of this report. A brief overview of the 2024 Maribyrnong River Flood Model setup and calibration is provided in Appendix A. Further details on the model setup and the calibration can be found in:

- A summary in Appendix A 2024 Maribyrnong River Flood Model.
- The draft calibration report (Jacobs, 2023i).
- The final report (Jacobs, 2024a).

Although the final reporting is not yet completed, the model is calibrated and while further changes may be anticipated these are expected to be minor and unlikely to impact the results being generated for the purposes of this report.

1.3 Modelling Approach

The purpose of the wider study is to produce flood mapping products to support a variety of Melbourne Water business functions and these flood mapping products will be produced from a flood model, that is, the flood model will underpin all the wider study outcomes.

The flood model of the Lower Maribyrnong, known as the 2024 Maribyrnong River Flood Model, is a combination of an event-based rainfall runoff model (RORB) and hydraulic model (TUFLOW). The purpose of the rainfall-runoff model is to calculate the catchment's response to runoff for observed events and to calculate the runoff for a given probability of occurrence. The runoff is then applied to the hydraulic model which calculates the flood extent, level, depth, velocity, and other hydraulic outputs. These modelling activities are augmented by empirical analysis of other flood forming variables such as tidal levels and baseflow and verification of key input datasets such as rainfall, topographic data, and rating curves.

A 2D TUFLOW hydraulic model with embedded 1D elements was developed for the Lower Maribyrnong River and extends from the Keilor gauge to downstream of Footscray Road near the confluence with the Yarra River. This extent covers the Lower Maribyrnong River and its floodplain including Maribyrnong Township, Ascot Vale, Kensington, Footscray, and the surrounding areas. The Maribyrnong River flow is applied to the upstream extent of the model with a downstream boundary set as a tidal level. The 2024 Maribyrnong River Flood Model incorporates 2023 catchment conditions and the more recent data available (including rainfall data, topographic and bathymetric). The modelling has been undertaken in alignment with the guidance in ARR2019, Melbourne Water Flood Mapping Project Specifications (Melbourne Water 2023) along with recent developments in modelling methodology.

The 2024 approach differs from the previous 2003 1D HEC-RAS model approach in several respects. Key differences are summarised in Table 1-1.

Table 1-1: Key differences between 2003 1D HEC-RAS model and 2024 Maribyrnong River Flood Model

	2003 1D HEC-RAS Model	2024 Maribyrnong River Flood Model
Software	1D HEC-RAS Model	1D/2D linked TUFLOW Model
Survey Data	1m contour maps, 2000 bathymetry and photogrammetry.	2023 0.5m floodplain LiDAR and river bathymetric data.
Model Representation of Floodplain and Inundation	Interpolated data between 1D cross sections of the Maribyrnong River and the floodplain.	Comprehensive Digital Elevation Model (DEM) representation of Maribyrnong River and the floodplain topography.
Model Representation of River Channel	River channel roughness applied at 1D cross section locations at approximately 50m intervals.	2D roughness maps applied throughout the extents of the river channel.
Losses at Bridge Structures	Contraction and expansion losses estimated and applied at 1D bridge structures.	Macro Contraction and Expansion losses captured explicitly within 2D domain. Micro energy losses due to piers estimated and applied at bridge structure.
Numerical Method	1D Steady Flow.	2D Unsteady Flow.
Upstream hydrograph	Adopted a 1991 Melbourne Water 100 ARI design hydrograph at Maribyrnong Village.	October 2022 Event at Keilor Gauge.
Applicable industry Guidance	Australian Rainfall and Runoff 1987 Melbourne Water guidance for flood mapping at the time	Australian Rainfall and Runoff 2019 Melbourne Water Flood Mapping Project Specifications (2023)

2. Methodology

The assessment methodology was to compare two hydraulic model runs or scenarios using the calibrated 2024 Maribyrnong River Flood Model for the October 2022 flood event:

- Base Case – with the VRC flood wall and the catchment in its physical state in October 2022.
- Scenario 1 – removal of the VRC flood wall and removal of the associated mitigation from the model all of which were present in 2022.

The differences between the model runs were then investigated in terms of changes to flood extent, flood depth and duration of flooding.

With respect to the VRC flood wall, the 2024 Maribyrnong River Flood Model had incorporated the details of the VRC flood wall modifications and associated mitigation. Figure 2-1 shows the 2024 Maribyrnong River Flood Model extent, locations of boundary conditions and the location of the VRC flood wall and the associated mitigation measures. Further information is available in Appendix A.

The upstream inflow boundary at the Keilor gauge and the outflow tidal boundary, both of which can be seen in Figure 2-1, had the conditions that occurred during the October 2022 event applied for both the Base Case and Scenario 1.

To examine the effect of the VRC flood wall and associated mitigation measures a comparison of results for the Base Case scenario and Scenario 1 was undertaken. The two scenarios run were:

- <u>Base Case</u> – With Wall and With Mitigation: 2022 flood event under 2022 catchment conditions (i.e., with the VRC flood wall and with associated mitigation works in place).
- <u>Modified Scenario 1</u> – Without Wall and Without Mitigation: 2022 flood event under modified catchment conditions. Scenario 1 is otherwise the same as the Base Case with the below changes. As exact details of landforms and conditions pre-VRC flood wall construction were not available, various assumptions have been made about representation within the model.
    - Terrain around the VRC flood wall was modified to represent the landform pre-VRC flood wall construction.
    - The eastern bluestone abutment at Footscray Road bridge was added back into the model.
    - The access track modifications, downstream of the Footscray Rail culverts, are not represented in the model.
    - As there is limited data from this period, with respect to the flow 'training wall', there are several assumptions regarding alterations to the DEM to represent a pre-flow 'training wall' condition of the banks upstream and downstream of the eastern abutment of the Footscray Road bridge.

Legend

- TUFLOW model boundary
- Footscray Road bridge
- DEM (terrain) adjustments
- Outflow (Tidal) Boundary
- Inflow Boundary
- VRC floodwall
- Maribyrnong River

MGA Zone 55

Jacobs

0 0.5 1 1.5 km

Figure 2-1: Model extent, boundary conditions, and location of VRC and mitigation works

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3. Base Case Model Setup

The Base Case scenario represents a model with the VRC flood wall and with associated mitigation measures subject to the 2022 flood event under assumed 2022 catchment conditions. Details of this scenario are presented in Jacobs (2023g) and the key features with respect to this assessment are:

- The VRC flood wall was incorporated into the flood model with details for the wall being sourced from the recent 2023 survey in combination with information from 2013 survey plans.
- Ensuring that the access track immediately downstream of the Footscray Rail culverts was represented as available in 2023 LiDAR survey and is at 0.5m AHD or below in the DEM.
- Confirming that the eastern bluestone abutment under the Footscray Road bridge was not represented in the flood model.

3.1 VRC Flood Wall

The VRC flood wall is the wall that was erected around the Flemington Racecourse in 2007 with the understood intent to ensure that the racecourse is protected from floodwaters of events more frequent than the 1% AEP event. LiDAR and survey produced in 2023, along with available design drawings, were used to develop a Digital Elevation Model (DEM) that includes the VRC flood wall. The VRC flood wall varies in height from approximately 3m AHD to over 5m AHD along its alignment. Figure 3-1 is a photograph of the VRC flood wall.

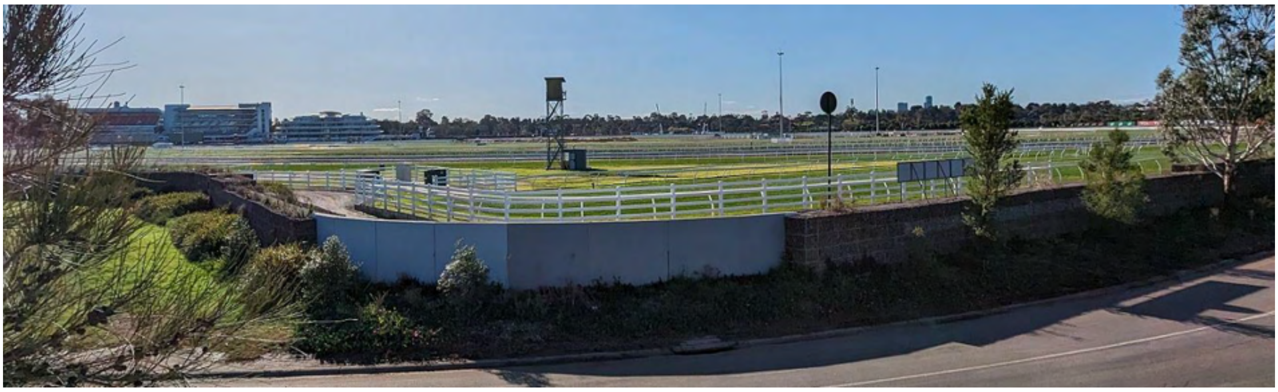


Figure 3-1: Picture of the VRC flood wall taken at the southern edge of the wall, along Chiquita Drive, looking north.

3.2 Access track downstream of Footscray Rail culverts

The LiDAR (2023), that formed the basis of the 2024 Maribyrnong River Flood Model, captured the levels downstream of the Footscray Rail culverts and confirmed that the access track was 0.5m AHD or below. The LiDAR confirmed the access track in this location generally varies from 0.4-0.5m AHD. These levels were confirmed as represented in the DEM of the Base Case model. Small 'balancing' culverts under the access track are also incorporated into the model. Figure 3-2 and Figure 3-3 are photos taken in 2023 of this area.

Figure 3-2: Access Track (gravel) downstream of the Footscray Rail culverts (photo taken in 2023).

Figure 3-3: Downstream of the Footscray Rail culverts: facing west (left) and east (right). Balancing culverts under the access track circled in red (photos taken in 2023).

3.3 Footscray Road Bridge

The Footscray Road bridge was surveyed as part of the bridges and structures survey in the data collection phase of the 2024 Maribyrnong River Flood Model build (Jacobs 2023i). Using an empirical method contained within a publication by the US Division of Hydraulic Research (Bradley,1978) the losses at the bridge were calculated taking into account the two (2) existing piers at this bridge, the existing pier's oblong 'strip' shape (visible on Figure 3-5) and the cross sectional area the piers represent as a percentage of the overall waterway cross sectional area, the pier loss factor was set at 0.11 and blockage factor set as 6% for the Base Case.

The presence of a bluestone abutment on the western abutment was represented within the 2D domain of the model.

Figure 3-4: Bluestone abutment under Footscray Road bridge on the eastern bank removed as mitigation works (left) (GHD, 2003b) and the abutment that remains on the western bank (right) (photo taken in 2023).

Figure 3-5: Footscray Road bridge from the western bank, facing east towards the eastern bank (photo taken in 2023)

Additionally, a flow ‘training wall’ on the upstream and downstream banks of the eastern abutment of Footscray Road bridge has been represented within the 2D domain of the model. This can be seen on Figure 3-6 and Figure 3-7. These figures clearly demonstrate that the flow ‘training wall’ is in poor condition and will not currently be functioning as designed or intended. As such an assumption has been made in the model that the flow ‘training wall’ is represented in the 2D DEM.

Figure 3-6: Footscray Road bridge from the western bank, facing east where the downstream 'training wall' is visible (photo taken in 2023).

Figure 3-7: Footscray Road bridge from the western bank, facing east where the upstream flow 'training wall' is visible (photo taken in 2023).

4. Scenario 1 Model Setup

Scenario 1 represents a model without the VRC flood wall impacts and without the associated mitigation measures, when subject to the 2022 flood event[2]. This scenario was the same as the Base Case with the only difference being the VRC flood wall and associated mitigation were removed, specifically:

- The VRC flood wall was removed in the area of influence of the 2022 event[1] and the terrain that replaced this area is an interpolation of the ground levels on either side of the wall. No other terrain modifications were made.
- The access track immediately downstream of the Footscray Rail culverts was reinstated at a level of 0.8m AHD and this was reinforced this in the hydraulic model.
- The eastern bluestone abutment under the Footscray Road bridge was reinstated and areas of adjacent fill, both upstream and downstream, were removed. As there was a lack of available data for these mitigation measures, assumptions about the abutment and terrain modifications have been made.

4.1 VRC Flood Wall removal

The LiDAR that was used to develop the Digital Elevation Model (DEM) was flown in 2023 (Jacobs 2023f) and contains elevation data points representing the flood wall. Modifications were necessary to remove this for the scenarios without the wall in place. These modifications were implemented by removing the area of the DEM where the wall influenced flow behaviour during the 2022 event[3] and interpolating the ground level between either side of the wall. As no information about the ground levels in 2003 was available this was considered a reasonable assumption.

4.2 Access track downstream of Footscray Rail culverts

The LiDAR adopted in the model captured the levels downstream of the culverts in 2023. GHD, 2003b reported that the pre-mitigation landform downstream of the Footscray Rail culverts included a road embankment at 0.8m AHD. Modifications in the terrain were necessary to increase the level of the access track for Scenario 1. A photograph with levels of the access track can be seen in Figure 4-1. The balancing culverts within the model during the Base Case have also been removed from Scenario 1 as it is assumed these were constructed as part of the reduction in level of the access track.

[2] Where there is reference to the 'wall' in map figures this refers to the impact of the wall and mitigation measures as per Scenario 1.

[3] A modelling efficiency decision was to only remove sections of the VRC flood wall which had an impact on the results presented within this report. A residual section of wall to the north-west of Flemington Racecourse was left within Scenario 1 but has no impact on the presented results.

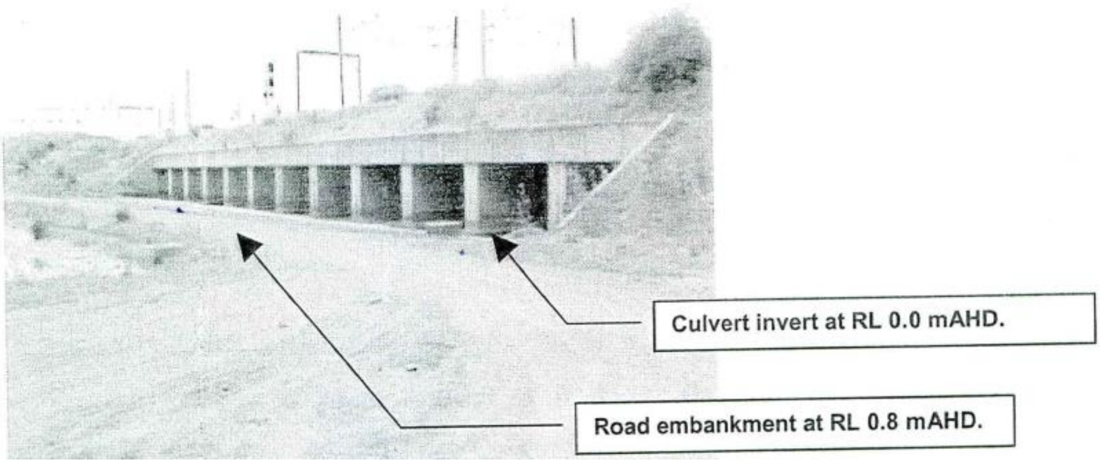


Figure 4-1: Annotated photo of downstream of the Footscray rail culverts showing the pre-mitigation elevations (GHD, 2003b).

4.3 Footscray Road Bridge

The Footscray Road bridge mitigation measures involved the removal of a bluestone abutment and the construction of a flow 'training wall' on the eastern embankment upstream and downstream of Footscray Road bridge (Fargue spiral design to minimise the energy losses through the bridge). The aim of these measures was to improve hydraulic performance in this area which was documented in GHD's report on the Flemington Racecourse (GHD, 2003b).

As detailed of the pre-wall conditions were limited, various assumptions were needed to be made. Scenario 1 included:

- The insertion into the DEM, a 2m wide bluestone abutment on the eastern abutment of the Footscray Road bridge (in red in Figure 4-2). As no details of the dimensions of this bluestone abutment were available it was assumed to that the dimensions of this abutment were the same as the bluestone abutment on the opposite bank.
- Removal of a section of bank upstream of the eastern abutment. The upstream removal is based on Figure 4-2 which shows a receded bank on the left of the photograph (purple). The DEM modifications are assumed to represent the removal of a flow 'training wall' that was constructed in this location as part of VRC flood wall associated mitigation measures.
- The lowering of a section of bank downstream of the eastern abutment. The downstream removal is based on Figure 4-3 which shows a constructed bank (purple). The DEM modifications are assumed to represent the removal of a 'training wall' that was constructed in this location as part of VRC flood wall associated mitigation measures.

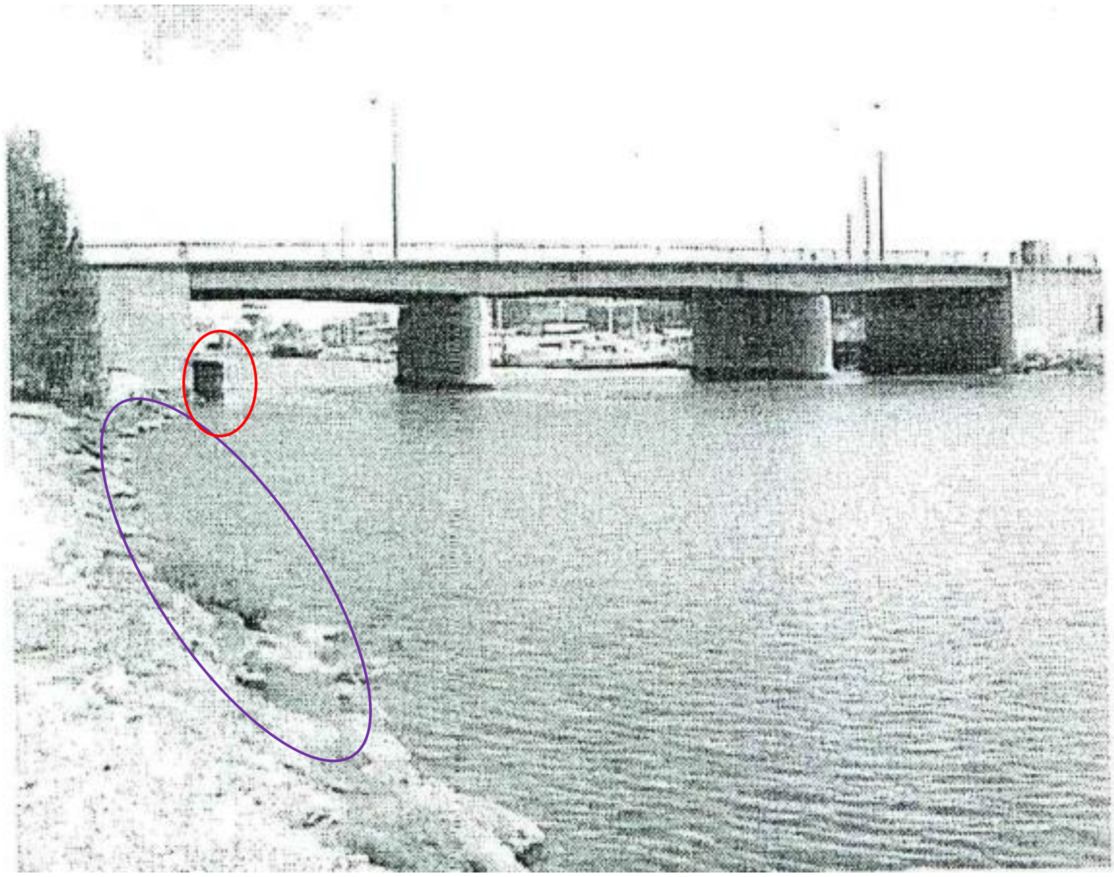


Figure 4-2: Photograph taken from the eastern bank looking downstream at the Footscray Road bridge. Eastern bluestone abutment circled in red and receded bank in purple (photograph taken pre-2003).

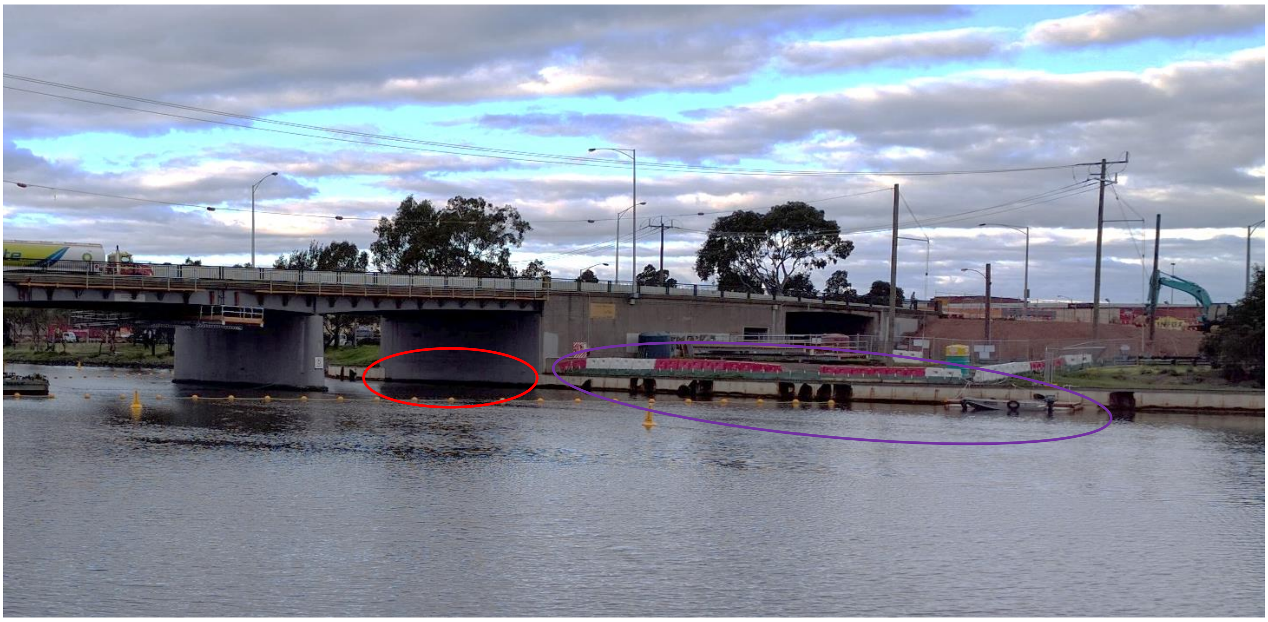


Figure 4-3: Photograph taken from the western bank of the eastern bank, upstream, at the Footscray Road bridge. Eastern bluestone abutment (removed) circled in red and 'training wall' bank in purple (photograph 11 September 2016).

5. Results

The results of the 2024 Maribyrnong River Flood Model are presented in Figure 5-1 to Figure 5-6.

Figure 5-1 presents the peak flood extent and depth for the Base Case (with VRC flood wall and with associated mitigations) model for the October 2022 event. This figure indicates flooded areas within Rivervue, Ascot Chase, Maribyrnong Township and Kensington. Figure 5-2 presents the peak flood extent and depth for Scenario 1 (without the VRC flood wall and without associated mitigations) during the October 2022 event.

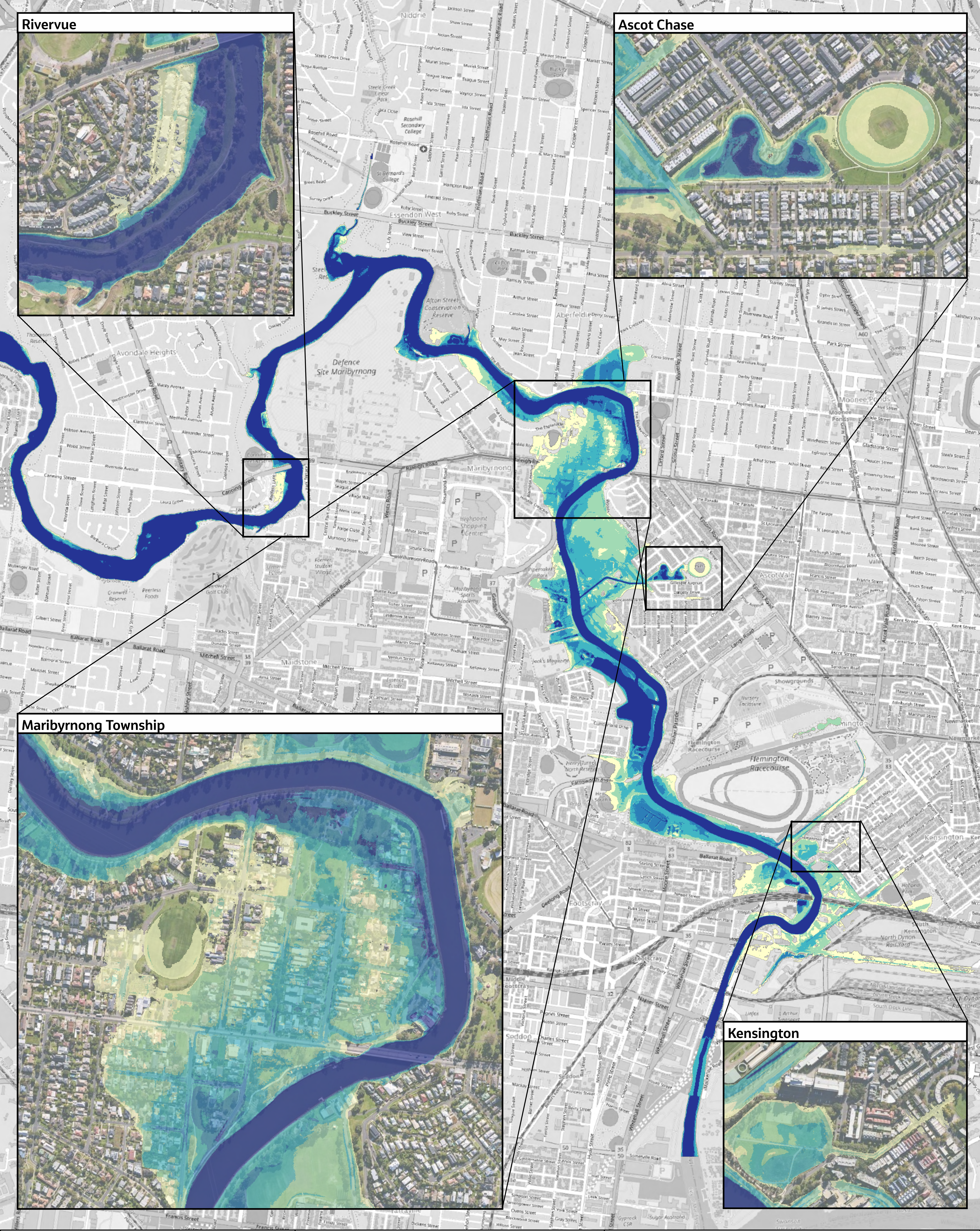
The only easily identifiable difference between flood extents of the two scenarios (Base Case and Scenario 1 on Figure 5-1 and Figure 5-2) is an area of inundation around Flemington Racecourse that is clearly present during Scenario 1 but is absent in the Base Case. This indicates that the VRC flood wall performed as intended during the modelled October 2022 event and Flemington Racecourse was not inundated.

Figure 5-3 presents a comparison of the peak flood extents between the Base Case and Scenario 1 for the October 2022 event. This figure highlights minor differences in inundation at the fringe of the flood extents (orange). Also, visible and expected is the inundation within Flemington Racecourse (magenta), indicating that the VRC flood wall is acting as intended. There is no change in flood extents at Rivervue, between Base Case and Scenario 1, under the October 2022 event. This was not unexpected due to the distance (upstream) of Rivervue from the VRC flood wall. Areas of difference in extent (orange) are visible in the Maribyrnong Township, Ascot Chase, and Kensington areas of interest. Closer inspection indicates that several of these areas are within public open/green spaces.

Figure 5-4 presents the difference in modelled flood depths between Base Case and Scenario 1 during the 2022 event. There are clear differences (green) where the Flemington Racecourse was inundated in Scenario 1 whereas it was dry during the Base Case. Figure 5-4 also indicates a general increase in water depth in proximity to the VRC flood wall, in the Base Case, when compared to Scenario 1. The highest difference in flood depths occurs in proximity to the VRC flood wall, downstream of Fisher Parade bridge. The largest differences, outside of the area in immediate proximity of the VRC flood wall, in flood depth (circa 80 mm) are contained to areas within either the banks of the Maribyrnong River or within areas that might be expected to inundate (public open spaces / green areas). As expected, the difference in flood depths between Base Case and Scenario 1 vary according to proximity with the VRC flood wall. The further away the area of interest is, the lower the difference in flood depths between Base Case and Scenario 1. Within Maribyrnong Township the difference in flood depths is limited to an increase of approximately 7-30mm. This difference in flood depth reduces to a negligible impact (less than 1mm – No Impact) further upstream, in the vicinity of the defence site.

Figure 5-5 presents several cross sections to contextualises the difference in flood depths along several roads within Maribyrnong Township. The cross sections show the topography (DEM) and modelled flood levels for both the Base Case and Scenario 1 during the October 2022 event. Three (3) cross sections within the Maribyrnong Township are presented, with the DEM/terrain level shown along with the flood levels of both the Base Case (with wall) and Scenario 1 (without wall). This figure indicates the difference in water levels along key roads in Maribyrnong Township varies from 7mm in the area furthest upstream from the VRC flood wall to less than 30mm on Rayleigh Road. These cross sections indicate the overall increase in flood levels are small in comparison to the total depth of water over the roads.

Figure 5-6 presents modelled flood levels for Base Case and Scenario 1, during the October 2022 event, at selected locations. This figure indicates, at several locations, a close match in water levels over time with a slightly different peak flow. While the peak levels are increased in proximity to the VRC flood wall the duration of the peak was not significantly altered by the presence of the VRC flood wall.



Legend

Flood depth: 2022 Base Case

- <= 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- > 2.0m

MGA Zone 55

0 0.5 1 km

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Figure 5-1: Flood Depth and Extent during the 2022 event - Base Case

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Satellite imagery from Metromap & map from openstreetmaps

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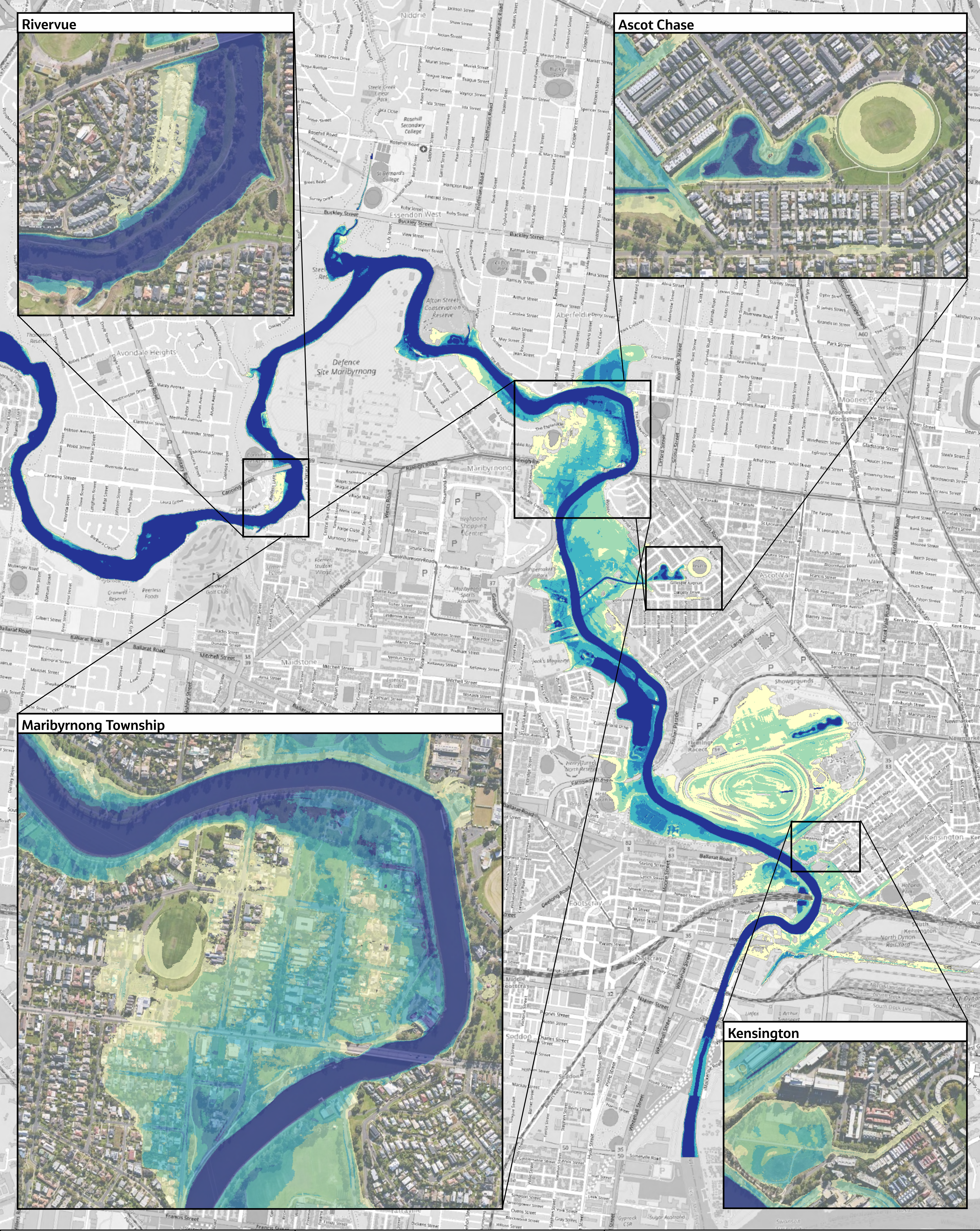

Legend

Flood Depth: 2022 Scenario 1

- <= 0.5m
- 0.5 - 1.0m
- 1.0 - 1.5m
- 1.5 - 2.0m
- > 2.0m

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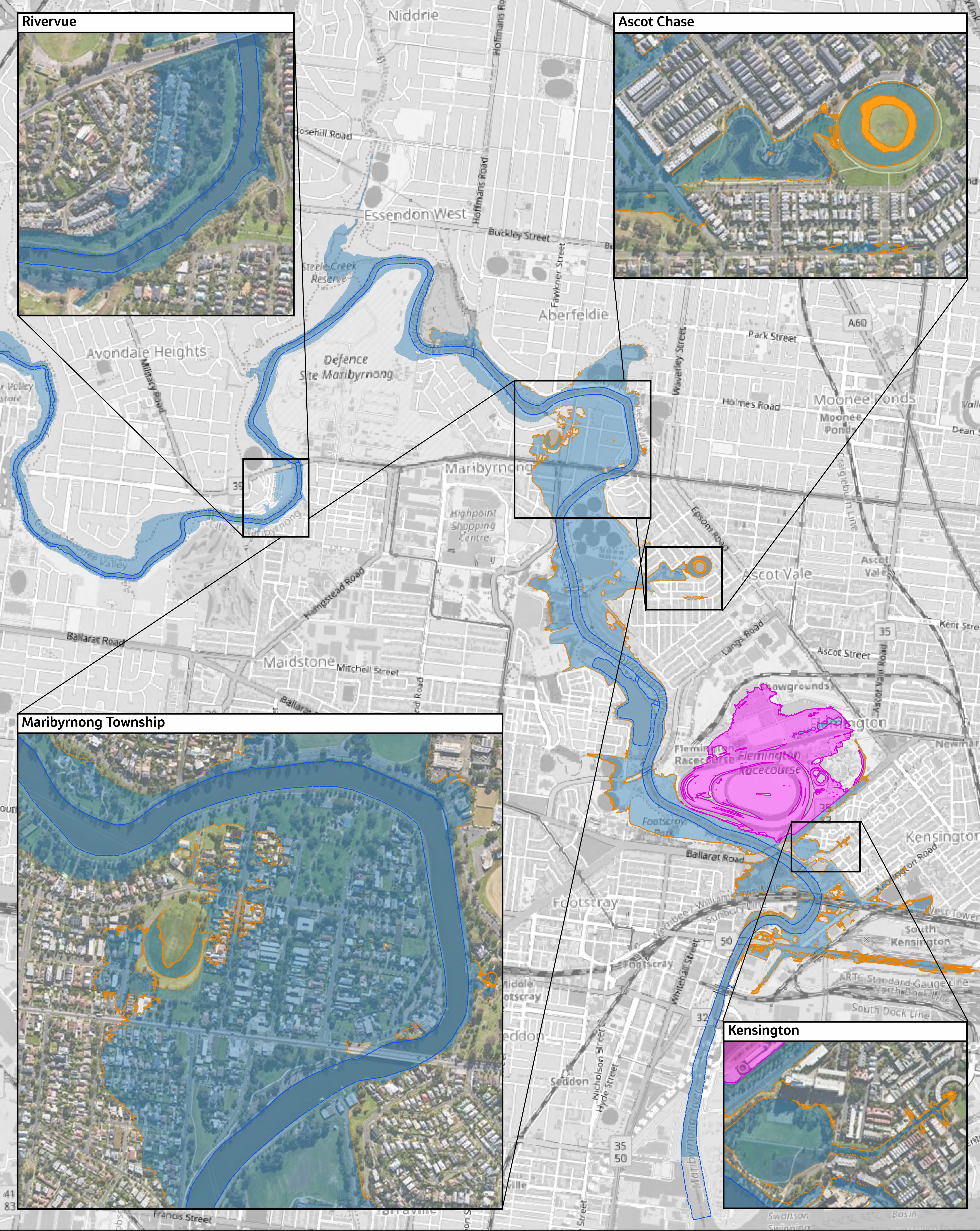
0 0.5 1 km

Figure 5-2: Flood Depth and Extent during the 2022 event - Scenario 1

Project Number: IA5000NN



Legend

- Waterway outline
- Flood extents common between base case & scenario 1
- Flooded locations in base case only
- Flooded locations in scenario 1 only

MGA Zone 55

Jacobs

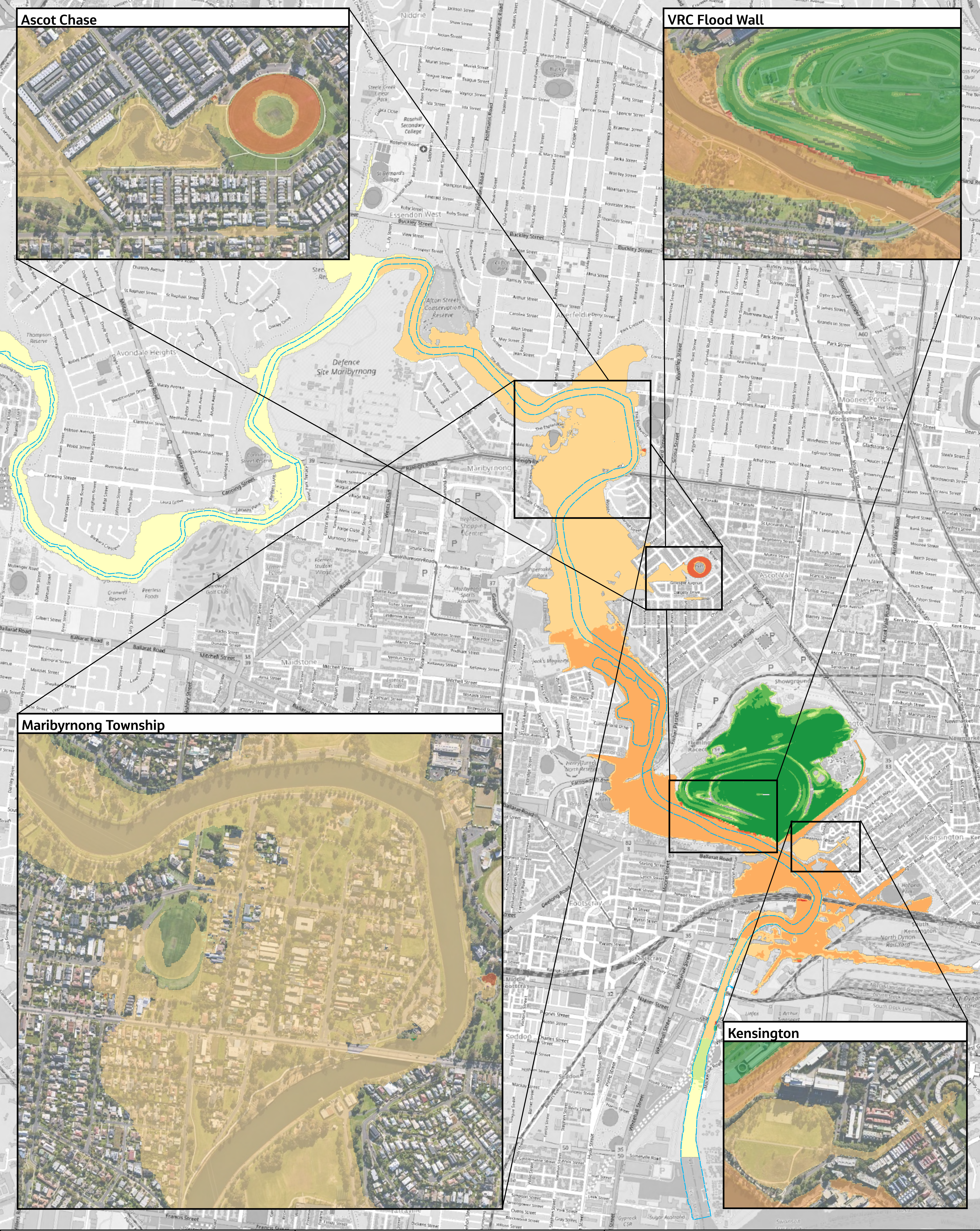
0 0.5 1 km

Figure 5-3: Flood Extent during the 2022 event - Base Case & Scenario 1

Disclaimer: Jacobs does not warrant that this document is definitive nor free of errors and does not accept liability for any loss caused or arising from reliance upon information provided herein
Satellite imagery from Metromap & map from openstreetmaps

Project Number: IA5000NN

DRAFT



Legend

Waterway outlines

Difference

>300mm lower	no change
100 - 300mm	1-50mm higher
50 - 100mm	50 - 100mm
1-50mm lower	100 - 300mm
	>300mm higher

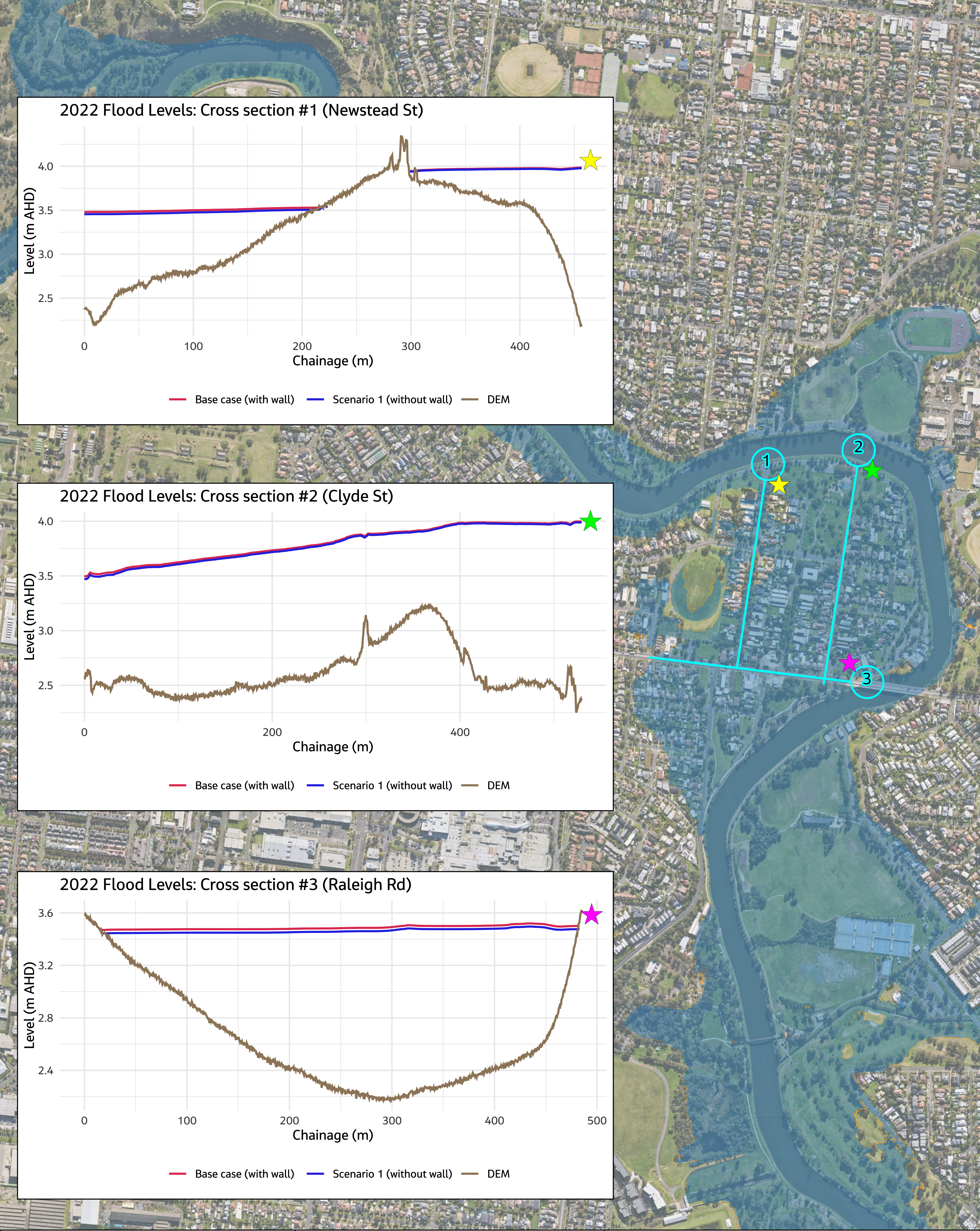
MGA Zone 55

Jacobs

0 0.5 1 km

Figure 5-4: Difference map of Flood Depth during the 2022 event - Base Case & Scenario 1

Project Number:
IA5000NN



Legend

- Cross sections
- Flooded locations in Base Case only
- Flood Extents common between Base Case and Scenario 1

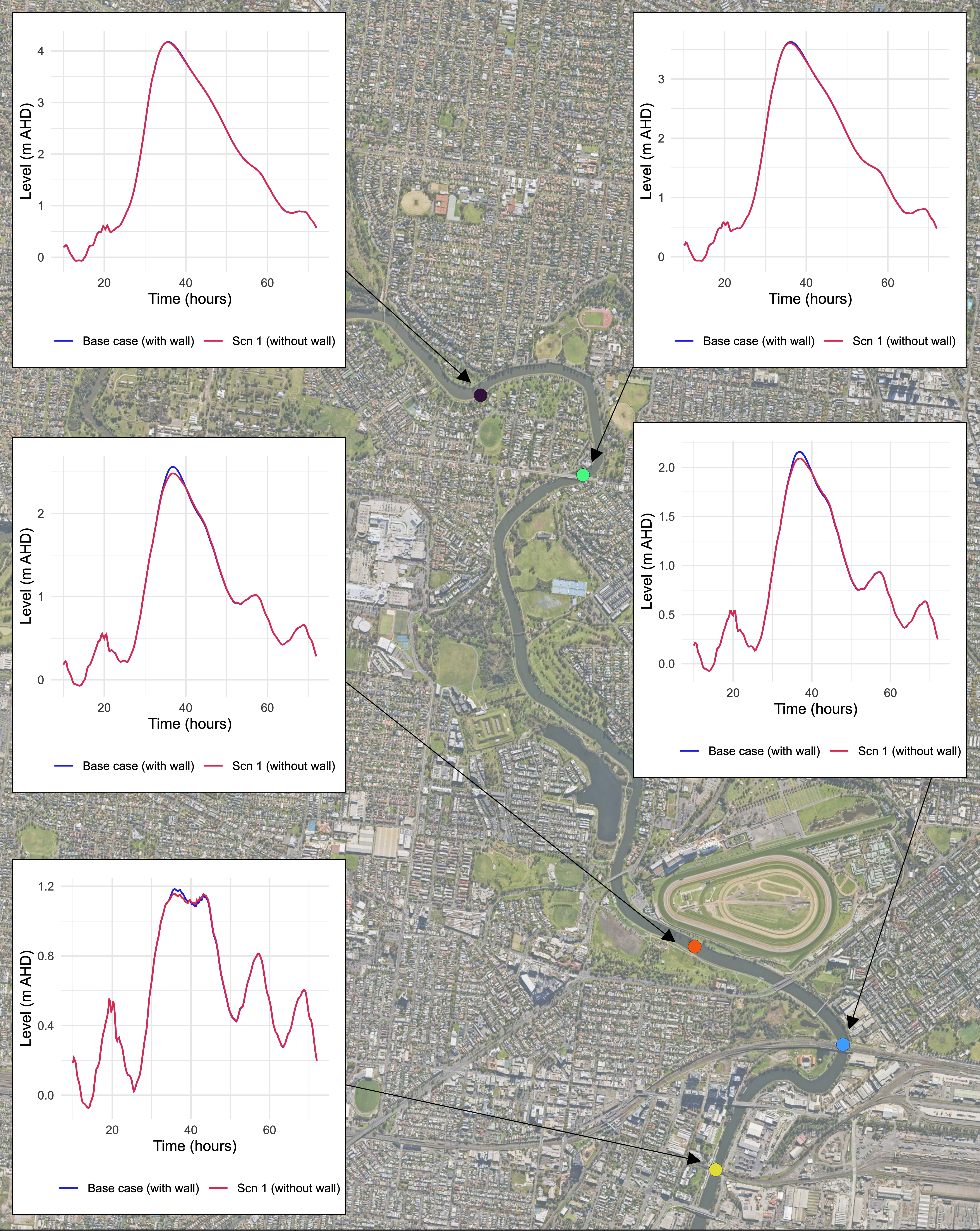
MGA Zone 55

Jacobs

0 100 200 300 m

Figure 5-5: Flood Levels as cross sections in Maribyrnong Township during the 2022 event – Base Case & Scenario 1

Project Number:
IA5000NN



Legend

2022 Flood Event: modelled levels at select gauges, Base Case & Scenario 1

- Chifley Street gauge
- Footscray rail bridge
- U/S Raleigh Road bridge
- U/S Footscray Road bridge
- Victorian Racing Club (VRC)

MGA Zone 55

Jacobs

0 250 500 750 m

Figure 5-6: Flood Levels as timeseries at selected locations during 2022 event - Base Case and Scenario 1

Project Number:
IA5000NN

6. Analysis & Discussion

When using the 2024 Maribyrnong River Flood Model to compare a Base Case and Scenario 1 the calculated impact of the VRC flood wall and the associated downstream mitigation measures is a general increase in flood depths.

Flood Extents

The difference in flood extents between Base Case and Scenario 1 is highlighted on Figure 5-3. Minor differences at the edge of the model extents, where the Base Case extents exceed those of Scenario 1 (orange), are visible throughout the model domain. While Figure 5-3 generally indicates that modelled results of flood extents of the Base Case are larger than those of Scenario 1 (orange), there are various model and data nuances that influence the ability to make conclusions at the lot-level about variations in extents in a catchment scale model. These include:

- Model cell size, sub-grid sampling, results smoothing and edge effects. These are captured in detail in Jacobs 2024a.
- Input LiDAR survey has a Root Mean Square Error (RMSE) of 0.027m in the vertical. This is consistent with a generally accepted vertical accuracy of Global Positioning System (GPS) land survey.
- Small scale infrastructure or subtle variations in ground conditions such as kerbs, steps, fences, and other obstructions may not be represented in the model.

As a result, an expected limitation of the 2024 Maribyrnong River Flood Model is the ability to draw conclusions at the lot scale at the edge of the model. Nevertheless, the modelled flood extents do indicate that the Base Case has a larger model extent than Scenario 1. Table 6-1 presents the total area of flood extent for both scenarios. This difference is largely a result of small amounts of water spilling into neighbouring model cells based on the topographic survey. The total area would likely be revised in post-processing of the results after lot-level considerations, but this is outside the scope of this report and would provide limited benefit as the event being considered in this report is the October 2022 event rather than a design AEP event which could be used for planning purposes.

Table 6-1: Estimated areas of flood extents

Flood Extent	Area (m^2)
Total Flood Extent[4] (Base Case)	3,074,000
Total Flood Extent[4] (Scenario 1)	3,034,000
Difference in Flood Extents	39,500

Table 6-1 indicates a little over a 1% increase in flood extents as a result of the VRC flood wall. Of this 1% it is estimated that approximately 4% is over residential land use.

[4] Extents are limited to depth changes which are greater than 1mm so comparisons with the flood extents and flood depths can be made. i.e., it is assumed that depth changes of less than 1mm do not result in a change in model extents.

Flood Depth Increases

The difference in flood depth between Base Case and Scenario 1 is shown on Figure 5-4. A summary of observations of increases in flood depths, in key areas, in order of highest difference in flood depths is:

- The greatest increase in flood depths is in immediate proximity to the VRC flood wall and is greater than 300mm on the edge of the wall. This is localised and expected, as is a result of the topographic modifications near the wall in Scenario 1. This area is a grassed land use with access roads on private land (assumed to be in the control of VRC) and does not affect any residential properties.
- Downstream of the Footscray Rail culverts the increase in flood depths is greater than 300mm, but this is on to the access track as expected. This localised change is a result of the change in elevation of the road (by up to 400mm) between Base Case and Scenario 1. The flood depth increase reduces to 60-80mm on either side of the access track. This area is local parks and gardens land use with an access track.
- Ascot Vale Oval, adjacent to Ascot Vale wetland, is a large, depressed area of public open space that acts as a storage zone during both the Base Case and Scenario 1. The increase in flood depth in this location is 180mm. This is localised, expected and is a result of the topography. This does not affect any residential properties.
- Near the VRC flood wall but closer to the Maribyrnong River, itself, the increase in flood depth ranges from approximately 70mm to 80mm. This is the greatest increase in flood depths as a result of Base Case compared to Scenario 1 (when excluding localised effects) and is as expected in the area closest to the VRC flood wall. These larger increases are generally confined to the Base Case flood extent and do not affect residential property.
- The difference in flood depths in the Kensington area ranges from approximately 30-70mm, excluding localised effects. Hobsons Road has an increase in flood depths of approximately 65mm and Kensington Road south of the railway has an increase in flood depths of approximately 60mm.
- Maribyrnong Township has an increase inf flood depths that ranges from 7-10mm at the north end of the township to approximately 25-30mm south of Raleigh Road.

Land Use Considerations

Whilst there are varying differences in flood depths between Base Case and Scenario 1, it is important to contextualise where the increases in water depth are located. For the purposes of further consideration in this section of the report, increases in flood depths have been characterised by land use.

Within any catchment, there are various land uses that may be considered to be more vulnerable, or where an increase in flood depths would have a comparatively higher consequence. For the purpose of further consideration in this report, the following are identified:

- Industrial/commercial.
- Residential.

There are a variety of other land uses within the catchment, that might be expected to be inundated on a regular or semi-regular basis (e.g., wetlands, waterways etc) or where an increase in water depth might be assumed to have a lesser consequence (e.g., public open spaces, road easements, paved surfaces like carparks etc.) than the industrial/commercial or residential land uses identified above. For the purposes of examining the increases in flood depths between Base Case and Scenario 1 the areas identified as having a limited consequence of being inundated (i.e., open grassed areas, carparks etc) have been mapped in grey on Figure 6-1. These areas are subsequently noted as “Less Impacted Land Uses” but it is important to note that while these land uses have been excluded for the purposes of considering implications in Table 6-2 and Table 6-3 this is not an indication of the absence of impact or flood risk in these areas.

The remaining areas (Industrial/commercial and Residential) can be seen on Figure 6-1 as orange and yellow and are also presented in Figure 6-2. The area noted as Kensington in the inset on Figure 6-2 is primarily commercial and heavy industrial land uses, while the area noted as Maribyrnong Township is primarily residential.

Table 6-2 presents the areas with an increase in flood depth, when comparing Base Case and Scenario 1, by different land uses.

Table 6-2: Estimated areas with an increase in flood depths based on land use.

Model Extents	Area (m^2)	Percentage of total area	Average Increase in flood depth (mm)
Area with an increase in flood depth as a result of Base Case compared to Scenario 1	3,074,000	100%	36
Increased flood depths within "Less Impacted Land Use" zones (e.g., wetlands, public open spaces, roads etc)	2,697,000	88%	37
Increase in flood depths within "Impacted Land Use" zones (e.g., residential etc)	377,000	12%	32
Increase in flood depths within Industrial/Commercial land use	**179,000**	**6%**	**51**
Increase in flood depths within Residential land use	**198,000**	**6%**	**17**

To contextualise Figure 6-2 and Table 6-2 the average increase in water depth over residential areas is 17mm and is limited to 6% of the total impacted area between Base Case and Scenario 1.

Table 6-3: Estimated areas of with an increase in flood depths based on land use in proximity to Maribyrnong Township.

Maribyrnong Township	Area (m^2)	Percentage of total area	Average Increase in flood depth (mm)
Area with an increase in flood depth as a result of Base Case compared to Scenario 1	1,695,000	100%	19
Increased flood depths within "Less Impacted Land Use" zones (e.g., wetlands, public open spaces, roads etc)	1,493,000	88%	19
Increase in flood depths within "Impacted Land Use" zones (e.g., residential etc)	202,000	12%	17
Increase in flood depths within Industrial/Commercial land use	**11,000**	**0.6%**	**22**
Increase in flood depths within Residential land use	**191,000**	**11%**	**17**

Table 6-3 focusses on Maribyrnong Township which is primarily a residential area and is represents the majority of the residential area impacted by an increase in flood depth when comparing Base Case to Scenario 1. Table 6-3 presents the areas with an increase in flood depth by different land uses within a subsection of the model around Maribyrnong Township and it can again be seen that the average water depth over residential land uses is 17mm.

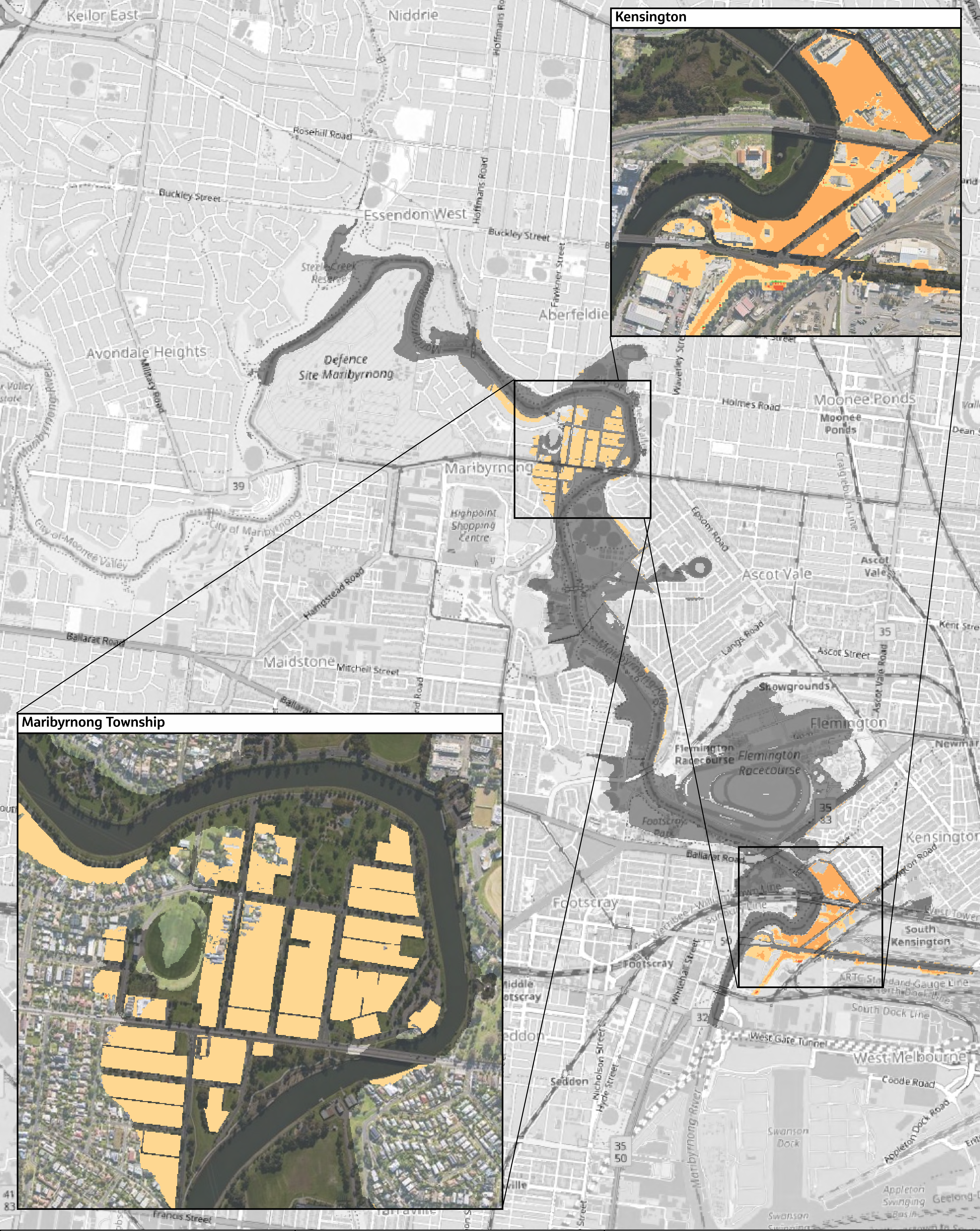
As noted above, based on a variety of modelling characteristics it is difficult to draw conclusions about impacts to individual properties without detailed, localised, land parcel analysis of the results, which was not the purpose of this report. Detailed validation and post-processing of flood extents on land parcels will be undertaken within future deliverables using design events and the 2024 Maribyrnong River Flood Model (Jacobs, 2024a). However, based on the Base Case and Scenario 1 model runs in the 2024 Maribyrnong River Flood Model indicate that:

- Increases in flood depths are identifiable in various locations, including:
  - Greater than 300mm immediately adjacent to the VRC flood wall. This is expected, is contained to a localised area, and does not extend to the wider floodplain. This does not affect any residential areas.
  - Greater than 300mm immediately adjacent to where the access track has been lowered as a mitigation measure (by approximately 300 to 400mm). This is expected, is contained to a localised area, and does not extend to the wider floodplain.
  - Approximately 80mm in the Maribyrnong River near the VRC flood wall. This does not affect any residential areas.
  - An average of approximately 51mm impacting industrial and commercial properties in Kensington.
  - An average of approximately 17mm afflux impacting residential properties in Maribyrnong Township which varies from 7mm to 30mm within the locality.

When using the 2024 Maribyrnong River Flood Model to compare a Base Case and Scenario 1 the calculated impact of the VRC flood wall and the associated downstream mitigation measures there an increase in flood extents and depths. The largest increases in flood depth are localised and do not extend to the wider floodplain. The flood level impacts generally decrease with distance from the VRC flood wall, and mitigation works, particularly in the upstream direction.

As previously noted in Section 1.3 and Table 1-1 there are various differences between modelling that was undertaken in 2003, using a 1D HEC-RAS Model, and the 2024 Maribyrnong River Flood Model that uses a 1D/2D TUFLOW model. These differences include: the survey data, model representations of channel and floodplains and the representation of hydraulic losses at bridge structures. These differences are expected to cause a difference in results if the 2003 1D HEC-RAS Model and the 2024 Maribyrnong River Flood Model results were compared. The purpose of the modelling and results presented in this report was not to compare differences between the models.

The use of the most up-to-date data and developments in modelling methodology in the 2024 Maribyrnong River Flood Model is suitable for the scenario modelling within this report.



Legend

'Less impacted' land use

Difference

- >300mm lower
- 100 - 300mm
- 50 - 100mm
- <50mm lower
- no change
- <50mm higher
- 50 - 100mm
- 100 - 300mm
- >300mm higher

MGA Zone 55

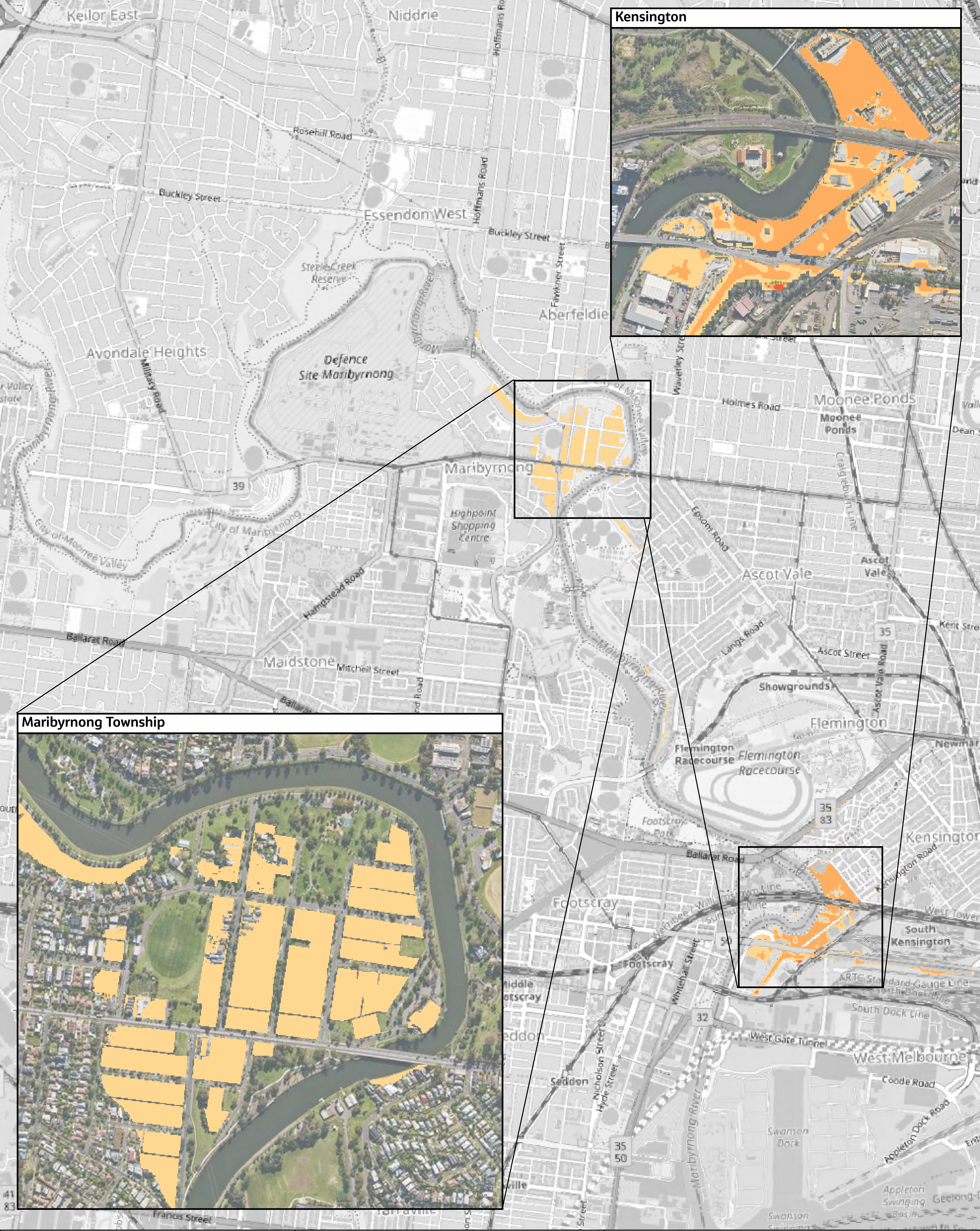
Jacobs

0 0.5 1 km

Figure 6-1: Difference map of Flood Depth during the 2022 event (impacted land uses only) - Base Case & Scenario 1

Disclaimer: Jacobs does not warrant that this document is definitive nor free of errors and does not accept liability for any loss caused or arising from reliance upon information provided herein
Satellite imagery from Metromap & map from openstreetmaps

Project Number:
IA5000NN



Legend

Difference due to wall

>300mm lower	no change
100 - 300mm	<50mm higher
50 - 100mm	50 - 100mm
<50mm lower	100 - 300mm
	>300mm higher

MGA Zone 55

Jacobs

0 0.5 1 km

Figure 6-2: Difference map of Flood Depth during the 2022 event (impacted land uses only) - Base Case & Scenario 1

Disclaimer: Jacobs does not warrant that this document is definitive nor free of errors and does not accept liability for any loss caused or arising from reliance upon information provided herein
Satellite imagery from Metromap & map from openstreetmaps

Project Number:
IA5000NN

7. Limitations and Exclusions

The sole purpose of the modelling presented in this report and associated services performed by Jacobs was to investigate the impact of the Victoria Racing Club (VRC) flood wall on the extent, depth, and duration of flooding of the October 2022 event, in the vicinity of the Maribyrnong River, in accordance with the scope of services set out in the contract between Jacobs and Melbourne Water ("MW"; the Client).

This report has been prepared on behalf of, and for the exclusive use of, Melbourne Water, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and Melbourne Water. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by Melbourne Water and/or from other sources. Except as otherwise stated in the report and other associated Jacobs reports, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate, or incomplete, then it is possible that our observations and conclusions, as expressed in this report, may change.

Jacobs derived the data in this report from information sourced from Melbourne Water, third parties, and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations, and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures, and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full, in conjunction with the final reporting of the 2024 Maribyrnong River Flood Model. and no excerpts are to be taken as representative of the final findings. Jacobs accepts no responsibility for using any part of this report in any other context.

A work-in-progress TUFLOW model, the 2024 Maribyrnong River Flood Model, being developed as part of the Lower Maribyrnong Flood Mapping Project has been used as the basis for the modelling presented in this report, as it is considered the best available information at the time of this request. The model(s) currently being developed have not been finalised nor documented but are due to be produced as deliverables as part of the Lower Maribyrnong Flood Mapping project (Jacobs 2024a). Noting that the Lower Maribyrnong Flood Mapping project is still a work-in-progress the results presented as part of this report will be superseded by (and may differ from) results that will be reported when the project is completed in April 2024.

The sole purpose of the flood modelling undertaken for this report is to define flood behaviour in the vicinity of the project sites. Flood extents and flood behaviour around the boundary of the TUFLOW hydraulic model domain should be interpreted with caution. The model should be reviewed in detail prior to being used for any other purpose.

8. References

Bradley, J (1978), Hydraulics of Bridge Waterways. Hydraulics Branch Bridge Division, Office of Engineering, U.S. Department of Transportation/Federal Highway Administration. March 1978.

GHD (2003a) Maribyrnong River Hydraulic Model: Final Report. Report for Melbourne Water Corporation. February 2003.

GHD (2003b) Flemington Racecourse Flood Protection: Investigation of Maribyrnong River Flood Protection. Report for Victoria Racing Club. May 2003.

Jacobs (2023a) Maribyrnong Flood Event October 2022- Post Event Analysis. Final. IA5000LI. March 2023.

Jacobs (2023b) Lower Maribyrnong Hec Ras Model Verification. Rev C. IA5000LI. 18 May 2023.

Jacobs (2023c) Mid Maribyrnong HEC-RAS Model Verification. Rev B. IA5000LI. 4 July 2023.

Jacobs (2023d) Maribyrnong River Changes. IA5000NN_MEM_001_Bath_Comparison_001. July 2023.

Jacobs (2023e) Model Schematisation Report, Lower Maribyrnong Flood Mapping. IA5000NN_MEM_002_Schematisation_001. August 2023.

Jacobs (2023f) Comparison of Flood Frequency Analysis Software Flike and Best-Fit IA5000NN_MEM_004_Comp_Flike_Best_Fit_001. September 2023.

Jacobs (2023g) Maribyrnong River Hec-Ras Model Updates: Mid and Lower Maribyrnong IA5000NN_MEM_005_Hec-Ras_Model_Update_Mid_and_Lower_Maribyrnong_002. September 2023. IA5000NN_MEM_003_Hec-Ras_Model_Update_005. August 2023.

Jacobs (2023h) Survey Report - Maribyrnong River Flood Modelling IA5000NN_REP_001_Survey_Report_Maribyrnong_River_Flood_Modelling_001_C. 13 November 2023

Jacobs (2023i) Draft Hydraulics & Hydrology Model Calibration Report. IA5000NN_RPT_002_Final_Report_002_DRAFT. November 2023.

Jacobs (2024a) Lower Maribyrnong Flood Mapping project WORK-IN-PROGRESS for Melbourne Water Corporation (Unpublished).

Melbourne Water (2023) AM STA 6200 Flood Mapping Project Specifications, Version 13, Melbourne

Appendix A. 2024 Maribyrnong River Flood Model

A brief summary of the 2024 Maribyrnong River Flood Model calibration to the October 2022 event has been provided below for context. This information is correct as of February 2024 and final details will be presented in Jacobs (2024a). Key features with respect to this assessment are:

Upstream Inflow Boundary

The 2022 recorded hydrograph at Maribyrnong River at Keilor (230105A) was applied as the upstream boundary (taken from Bureau of Meteorology Water Data Online [5]).

Downstream Tidal Boundary Condition

Tidal level data for the Yarra River at Crown Casino Spencer Street Southbank gauge (229663A), was applied as a dynamic water level at the downstream boundary (provided by Melbourne Water). Tidal data from the Southbank gauge was adopted as it is the closest gauge with a complete dataset for the October 2022 event.

Calibration Results

Figure 8-1 is a comparison between recorded and modelled flood levels at the Maribyrnong River at Chiefly Drive gauge (230106A) from the draft calibration report. This figure demonstrates a close agreement between recorded and modelled water level with a difference in peak levels of 41mm. There are noticeably larger differences in the recorded versus modelled depths on Figure 8-1 starting at approximately 50 hours. This indicates that the peak flow in the model is taking longer to subside than the recorded levels indicated actually occurred. At levels lower than approximately 2.0m AHD at Chifley Drive gauge there is limited inundation across the Lower Maribyrnong catchment, flows are constrained to within the banks of the Maribyrnong River and in the context of the work within this report the key metric of interest is peak water levels (and resulting inundation in the wider floodplain).

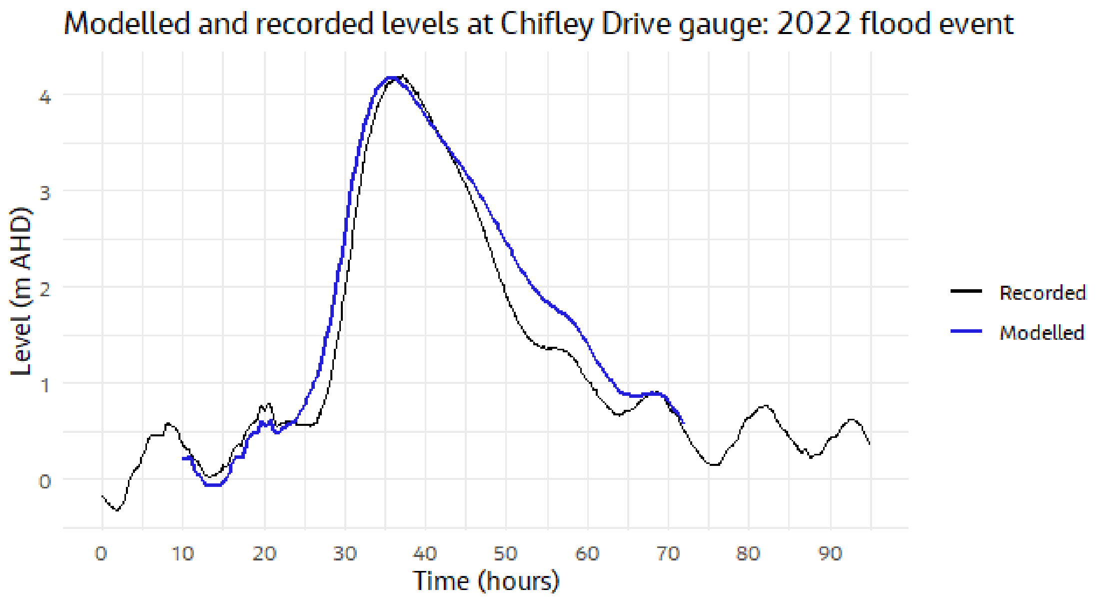


Figure 8-1: 2022 flood event comparison of recorded and draft calibration modelled water levels at the Chifley Drive gauge.

[5] http://www.bom.gov.au/waterdata/

Figure 8-2 shows a long section of the draft calibration modelled peak water level compared to the observed flood marks. This figure demonstrates that the model was able to reproduce observed flood levels throughout the Lower Maribyrnong River with few exceptions. One area where the model overpredicts flood levels is around chainage 12,350m (Tea Gardens Reserve). These flood marks were determined from photographs that were not taken at the peak and hence may underpredict the actual peak and these flood marks could be considered at the minimum flood level that occurred at this location.

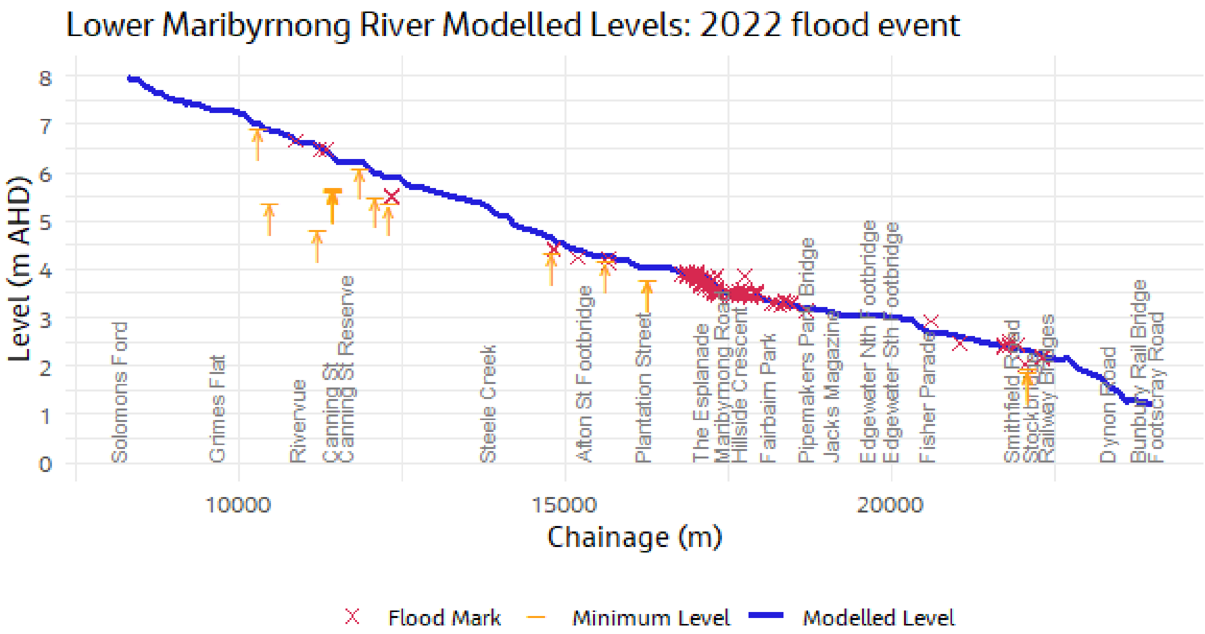


Figure 8-2: Longitudinal section of Lower Maribyrnong River draft calibration modelled levels during 2022 flood event compared to known flood marks.

Flood marks are data collected by 3rd parties and are assumed to represent high level water marks. 'Minimum Level' are extra flood marks included by Jacobs which represent a combination of information such as drone footage, road staining, and photos. The Minimum Level data does not necessarily represent the peak of the event, but it is assumed that the flood peak reached at least to this level.

Table 8-1 shows a histogram of calibration points and Table 8-2 presents some goodness-of-fit statistics with the root mean square error (RMSE) calculated as 0.09.

Table 8-1: Histogram of calibration points - recorded versus modelled levels.

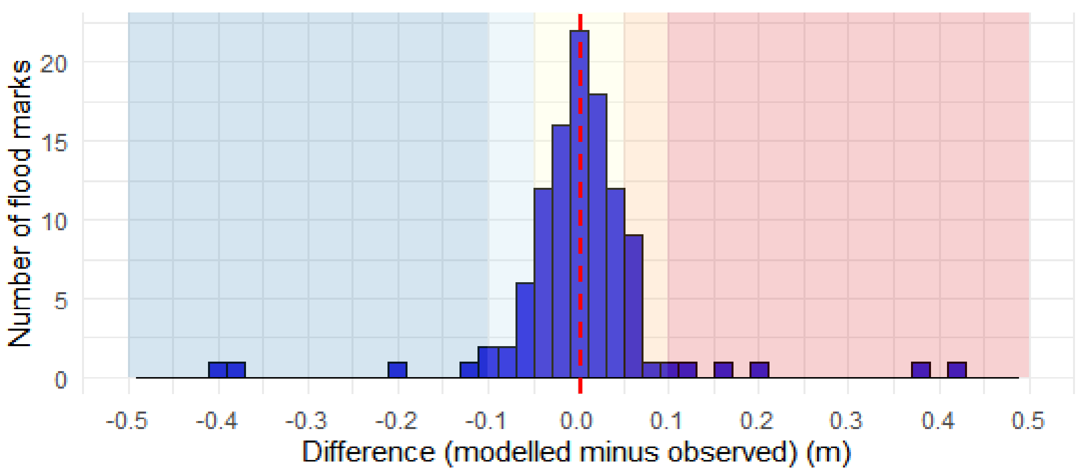
Run	Histogram of calibration points – recorded versus modelled levels
Calibration	

Table 8-2: Goodness-of-fit Statistics for the 2024 Maribyrnong River Flood Model

Statistic	Calibration
PBIAS	0.1%
NSE	0.99
mNSE	0.89
rPearson	0.99
RMSE	0.09
nRMSE	11.6

The sample size of calibration points used in this calibration was 110 points.

The draft calibration (and the summary of results presented in Figure 8-1, Figure 8-2, Table 8-1 and Table 8-2) demonstrate that the 2024 Maribyrnong River Flood Model is suitable for the scenario modelling within this report.

Appendix B. Supporting Reports

Maribyrnong Flood Event October 2022- Post Event Analysis (Jacobs, 2023a)

- This report was commissioned to prepare a post-flood analysis in the Maribyrnong River catchment soon after the event. The initial version was made available in November 2022, with subsequent versions incorporating new and emerging data, updates, and revision to live data and analysis to assist Melbourne Water provide answers to enquiries. This memo documented rainfall and river conditions prior to and during the October 2022 flood event using publicly available information.

  The analysis focused on Deep Creek at Darraweit Guim and the Lower Maribyrnong River, in and around Maribyrnong Township.

Lower Maribyrnong Hec Ras Model Verification (Jacobs, 2023b)

- The purpose of this memorandum was to compare flood levels and extents calculated with the GHD (2003) HEC-RAS Lower Maribyrnong Flood model to observations from the October 2022 flood event and the May 1974 flood event. This analysis found that the model was able to reproduce observed flood levels from the 1974 with the average difference between the observations and modelled levels being 30mm and the model slightly underpredicting once spurious data was removed. For the 2022 event the model on average overpredicted flood level by 55mm once spurious data was removed. It was concluded that this model was still a useful tool for floodplain management in the Lower Maribyrnong.

Mid Maribyrnong HEC-RAS Model Verification (Jacobs, 2023c)

- The purpose of this memorandum was to compare flood levels and extents calculated with the GHD (2003) HEC-RAS Mid Maribyrnong Flood model to observations from the October 2022 flood event and the May 1974 flood event. This memo found that for both the 1974 and 2022 flood events the model underpredicted flood levels at Canning Street and over predicted flood levels at Maribyrnong Township. It was concluded that this model should not be used for floodplain management in the Lower Maribyrnong and should be calibrated to the available data.

Bathymetric Comparison Memorandum (Jacobs, 2023d)

- This memorandum compared bathymetric dataset over time for the Lower Maribyrnong River to the bathymetric survey obtained in May 2023 as part of this study. This memo found that there were changes in bathymetry but overall, the differences between older datasets and the newly commissioned bathymetry were within expected ranges.

Schematisation Memorandum (Jacobs, 2023e)

- A Schematisation document (Jacobs 2023) was produced for this study that details the proposed approach and methodology for the hydrology (RORB) and hydraulic (TUFLOW) modelling used to inform the outcomes of the study. This was reviewed by Melbourne Water and external reviewers and discussed in a workshop. Some key changes have occurred to this methodology:
  - The approach in the schematisation report stated that event calibration would inform the choice of routing parameters for the RORB model. The approach for determining routing parameters is now based on fitting Monte Carlo results to the FFA quantiles.

Best Fit memorandum (Jacobs, 2023f)

- This memo compared the results of the Flood Frequency Analysis presented in this report using the software TUFLOW Flike to results using the software Best-Fit to ensure the correct application of historic information. The results in this confirmed that the TUFLOW Flike results were correct.

Hec-Ras Update - Model and Report (mid and lower) (Jacobs, 2023g)

- The purpose of this work was to update the Mid and Lower- Maribyrnong Hec Ras models to provide flood information for the area. This involved calibration to the 2022 flood event, verification to the 1974 event and modelling of the 1% Annual Exceedance Probability (AEP) event. Flood mapping products were also developed as part of this work.

Survey Report - Maribyrnong River Flood Modelling (Jacobs, 2023h)

- This work delivered a high-quality homogenous dataset across the Lower Maribyrnong River hydraulic model extent to support flood modelling and mapping. It involved a variety of surveying tasks and flowing best survey practices, Jacobs were able to independently validate all data incoming to the model and detail is completeness and accuracy. The report (Jacobs, 2023h) detailed the methodology and accuracy of the analysis.

Draft Hydraulics & Hydrology Model Calibration Report Jacobs (2023i)

- This draft report was the culmination of all data collection, survey, model construction, calibration, and validation of hydrologic (ROBR) and hydraulic (TUFLOW) model activities for the Lower Maribyrnong Flood Mapping Project and detailed the 2024 Maribyrnong River Flood Model at a point in time (calibration). This work was reviewed by independent peer reviewers.

Lower Maribyrnong Flood Mapping Project Final Report Jacobs (2024a) WORK-IN-PROGRESS

- The final report remains a work-in-progress and is due for completion in April 2024. This report will detail the final 2024 Maribyrnong River Flood Model including design scenarios for various annual exceedance probability (AEP) events.

Appendix C. LiDAR Survey

Jacobs engaged a suitable qualified supplier (Aerometrex) to undertake an airborne LiDAR project across the study area. The survey was carried out on the 25/07/2023). A 0.5m DEM was supplied as the main output for use. A summary of the validation exercises and main findings are as follows:

- Jacobs first reviewed the supplied metadata report and found the result of the adjustment to the supplied Ground Control Points had good agreement in the vertical component across 65 different observations. This provided Jacobs with confidence that the data was of a high quality.
- Jacobs then conducted an independent assessment using alternative measured points not supplied to Aerometrex for processing. Across 453 observations, the data indicated a RMSE of 0.027m (Figure 8-3).

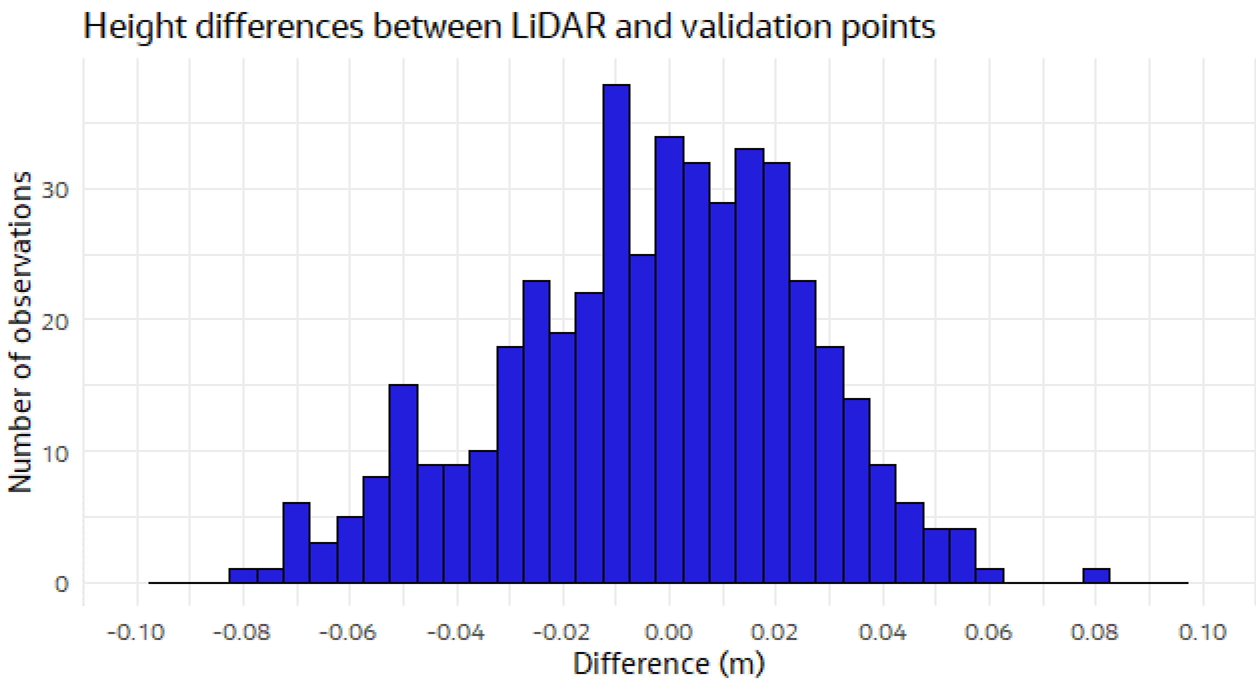


Figure 8-3: Distribution of vertical height differences between the LiDAR and independent validation points