Regional Floodplain Database:

2014 Model Maintenance Report - Redcliffe (RED)

Moreton Bay
Regional Council

“Where will our knowledge take you?”

Regional Floodplain Database 2014 Model Maintenance Report

Redcliffe (RED)

June 2015

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Regional Floodplain Database 2014 Model Maintenance Report – Redcliffe (RED)

Prepared for:	Moreton Bay Regional Council
Prepared by:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Synopsis: This report summarises the maintenance of the Redcliffe catchment model, undertaken in 2014 / 2015, as part of the Regional Floodplain Database for Moreton Bay Regional Council.

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1 Introduction

BMT WBM has developed the Redcliffe Catchment (RED) hydrologic and hydraulic models as part of the Stage 2, Regional Floodplain Database Project (RFD) (BMT WBM, 2012).

Council identified some opportunities for improvement for these models and Hydrology and Water Management Consulting (HWMC) was subsequently engaged by Council to assist in testing and modifying the models, including:

- 2m grid versus 5m grid TUFLOW model;
- Additional underground drainage modelled in TUFLOW;
- Different methods for applying the inflow hydrographs to the model domain; and
- Identifying areas where RFD methods were not suited.

Recommendations from HWMC report (HWMC, 2013) were adopted and the models were rerun for all design events, sensitivity analysis and selected storm tide events. All modelling was undertaken by Council with support from HWMC, (MBRC, 2014).

In 2014, Council has also obtained additional information that could further enhance the model performance, including newly flown Light Detection and Ranging (LiDAR) elevation data and additional structure details. The hydraulic modelling software, TUFLOW, has had many advances made to it that improves modelling efficiencies. Finally, there has been improvement to modelling techniques that will provide a better representation of flood behaviour.

Due to these reasons, Council have decided to upgrade the existing RED model to incorporate the most recent data and improved modelling platform and techniques. The model has been re-run, incorporating these changes, for all events, including the sensitivity analysis. Model calibration or validation was not undertaken for this catchment.

This report highlights the changes to the 2013 model and results from the 2014 model for the simulated events.

2 2014 Model Maintenance Details

2.1 WBNM Model

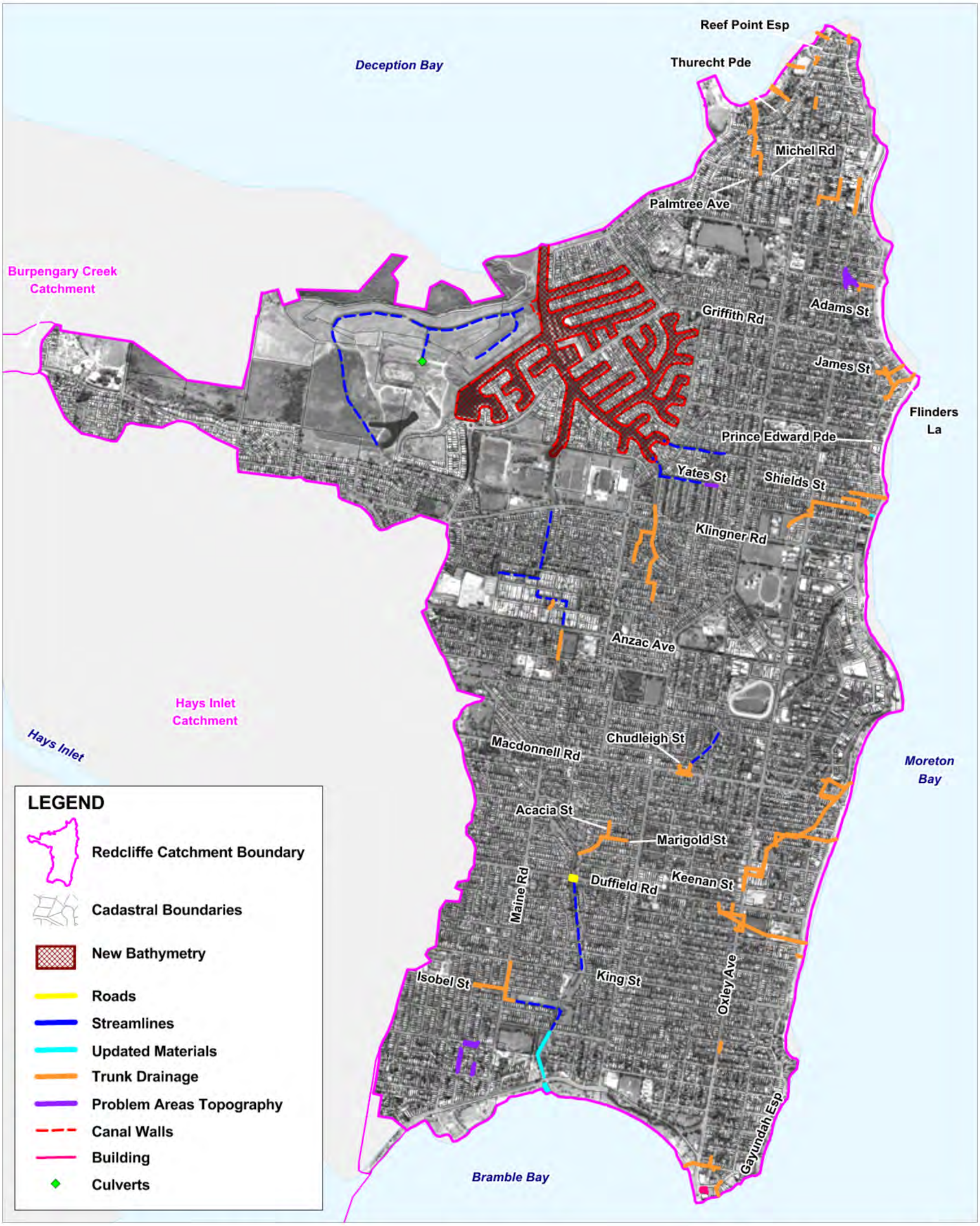
The WBNM minor catchments were reviewed against the 2014 LiDAR and no changes were deemed necessary. Furthermore, Council advised that the initial loss value for events up to and including the 5% AEP event be changed from 0mm to 15mm. Initial losses for events over the 5% AEP remain at 0mm.

2.2 TUFLOW Model

Council consolidated and provided data for the model maintenance in various formats. Figure 2-1 presents the locations of the additional data incorporated into the 2014 RED model. In summary, the following information was incorporated into the RED model:

- Updated topography data. This data has been read into the model as a DEM (rather than Z-points):
  - 2014 LiDAR data for the entire catchment; and
  - Bathymetry data, including:
    - Newport Canals.
- Inclusion of additional culverts:
  - 1 x 2.1m x 0.9m culvert under road in a future development area to the west of the canal system.
- Inclusion of additional trunk drainage:
  - Along Isobel Street and Maine Road;
  - In the southern most area of Woody Point (between Oxley Avenue and Gayndah Esplanade);
  - From Duffield Road, draining through Langdon Park then out to the ocean;
  - Along Marigold Street and Acacia Street to Margate Park;
  - In the area between Keenan Street, Oxley Ave, Greenup Street and the ocean;
  - Along MacDonnell Road and Chudleigh Street;
  - In the area between Aloomba Court, Lime Street and MacKenzie Street;
  - From Steven Street, along Oxley Avenue and Grant Street to Prince Edward Parade;
  - Along Shields Street;
  - Along Yates Street;
  - Along James Street, Prince Edward Parade and Flinders Lane;
  - Along Adams Street to the ocean;
  - From Michel Road, along Palmtree Avenue to Scarborough Boat Harbour;

    - From Thurecht Parade to Scarborough Boat Harbour; and
    - Draining Reef Point Esplanade, and Second Avenue to the ocean.
- Addition of other features:
    - A zshape has been applied to a building at the corner of Woodcliffe Cresent and Oxley Avenue. This was used to fill a local low point in the DEM;
    - The walls of the canals have been reinforced in the model; and
    - Additional topographic data have been included in three problem areas.
- Change in methodology of the application of hydrological flows. Where a subcatchment contains trunk drainage, the inflow (SA polygon) was changed to be read in as “Read MI SA Pits”. This directs the hydrological flows directly into the trunk drainage network.
  In some instances, it was found that the flows from large catchment were being applied directly to the trunk drainage network, causing the network to reach full capacity and increase flooding in some urban areas. This was as a result of model schematisation and not an accurate reflection of actual conditions. Where the hydrological subcatchment was significantly larger than the area of the catchment of the trunk drainage network, the SA inflows have been proportionally applied to both the trunk drainage network (“Read MI SA Pits”) and the rest of the 2D catchment not being drained by the trunk network (“Read MI SA”).
- Breaklines were incorporated along all stream centrelines, as per the methodology developed as part of the Lower Pine River Pilot Study (BMT WBM, 2014).
- Waterbody material layer has been updated to include a waterway materials layer along the streamlines.
- Inclusion of zlines to represent the crest elevation of key roads within the modelled area (to the west of Oxley Avenue, to the north of Anzac Avenue and at King Street).
- Plot output (PO) lines updated to include all locations of interest and to ensure all are located perpendicular to the general flow direction.



Title:
Redcliffe Catchment Model Maintenance Features

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3 Model Simulations

3.1 Verification

Verification against recorded rainfall and flood marks was not undertaken for the RED model because of limited historical event data.

3.2 Design Flood Events

This section describes the design storm conditions used in the hydrodynamic modelling tasks. Design storm events are hypothetical events used to estimate design flood conditions. They are based on the probability of occurrence, usually specified as an Average Exceedance Probability (AEP).

3.2.1 River and Creek Critical Duration Assessment

An assessment of critical storm durations (storm duration/s that results in the highest peak flood level) was undertaken. The critical durations were selected based on the hydraulic results, rather than the hydrological model results. This means that the selected critical durations were selected based upon the maximum flood levels rather than flows. Separate assessments were undertaken for two representative flood events:

- 1% AEP event, to represent non-extreme events (1 Exceedance Year (EY) to 1% AEP events); and
- 0.1% AEP event, to represent extreme events (0.5% AEP to PMF events).

To determine the critical storm durations for the Redcliffe Catchment model, the following methodology was adopted:

(1) Hydrologic and hydraulic modelling for a range of storm durations for the 1% and 0.1% AEP events;

(2) Mapping of the peak flood level results for the 'maximum envelope' of all the storm durations for the two representative events;

(3) Mapping of the peak flood level results for the 'maximum envelope' of the selected storm durations for the two representative events;

(4) Difference comparison between the mapped peak flood levels for the selected critical durations and the results accounting for all the storm durations;

(5) Selection of the critical durations was undertaken in consultation with Council and was based on the storm durations generating the highest flood levels across the most widespread areas; and

(6) A summary of the selected critical storm durations for all events assessed is outlined in Table 3-1.

Table 3-1 Critical Storm Duration Selection

Assessment Event	Assessed Durations	Selected Critical Durations	Adopted Event
1% AEP	0.25, 0.5, 0.75,1, 1.5, 2, 3, 4.5, 6 and 12 hour storm	1 and 1.5 hour storm	1EY, 0.5EY, 20%, 10%, 5%, 2% and 1% AEP
0.1% AEP	0.25, 0.5, 0.75,1, 1.5, 2, 3, 5, 6 and 12 hour storm	0.5, 0.75 and 1.5 hour storm	0.5%, 0.2%, 0.1%, 0.05%, 0.02%, 0.01% AEP and PMF

Figure 3-1 and Figure 3-2 show which events generated the highest peak flood levels in different areas throughout the catchment. The following observations can be made:

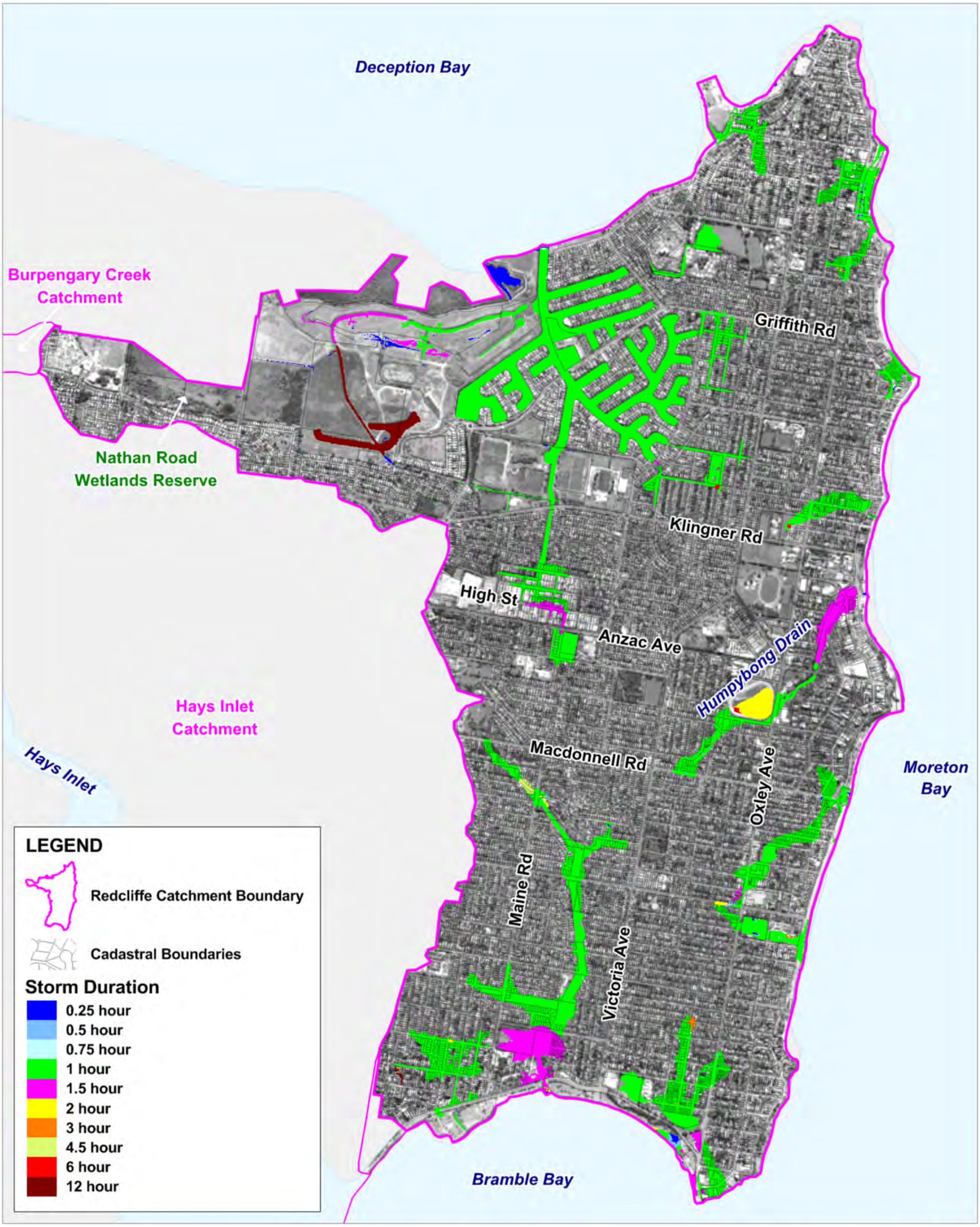
- For both events, the 1 hour duration is dominant in the canal system and some of the flow paths into the canals.
- For the 1% AEP event, the 1 hour duration is critical for most of the catchment:
  - The 1.5 hour duration is crucial along Humpybong Creek, between High Street and Anzac Avenue and from H.A. Dalton Park to the ocean;
  - The 12 hour duration is critical in the open channels to the east of Nathan Road Reserve; and
  - The 2 hour duration is critical within the Redcliffe Paceway.
- For the 0.1% AEP event:
  - The upper reaches of the catchments have a critical duration between 0.25 hours and 0.75 hours;
  - The 1 hour duration is critical in the middle reaches of most of the drainage paths, and the lower reaches of Humpybong Creek and along MacDonnell Road ;
  - The 1.5 hour duration is crucial from H.A. Dalton Park to the ocean and to the east of Victoria Avenue in Woody Point;
  - The 2 hour duration is critical in the open channels to the north of Nathan Road Reserve; and
  - The 3 hour duration is critical within the Redcliffe Paceway.

The difference comparison for the 1% and 0.1% AEP peak flood levels (as described in step 4 above) is shown in Figure 3-3 and Figure 3-4. For the 1% AEP event, the peak flood levels through the majority of the catchment are within ±0.01m from the chosen critical durations and all of the durations. The following areas have a decrease in flood levels between 0.01m and 0.05m:

- Redcliffe Paceway;
- Open channel to the east of Nathan Road Reserve; and
- A small section of channel between MacDonnell Road and Maine Road.

Similarly, the 0.1% AEP event typically shows minimal difference (of ±0.01m) in flood levels, except for in the following locations:

- A decrease in flood levels between 0.01m and 0.05m:
  - At the Redcliffe Paceway;
  - Along the open channel between H.A. Dalton Park and Duffield Road;
  - Along Thomas Street between Gerald Ave and Belvedere Street;
  - Along drain from McCulloch Avenue and Ella Street;
  - Between Sunnyside Road and Newport Drive; and
  - Along some open drains to the west of the canals.
- A decrease in levels between 0.05m and 0.1m:
  - Between Grant and Shields Street from the ocean for approximately 250m;
  - Approximately 150m upstream of Anzac Avenue along Humpybong Creek; and
  - A small portion along Anzac Avenue in Kippa Ring. There is also a localised decrease in flood levels between 0.1m and 0.2m in this area.



Title:
Critical Duration Assessment - 1% AEP

Figure: 3-1

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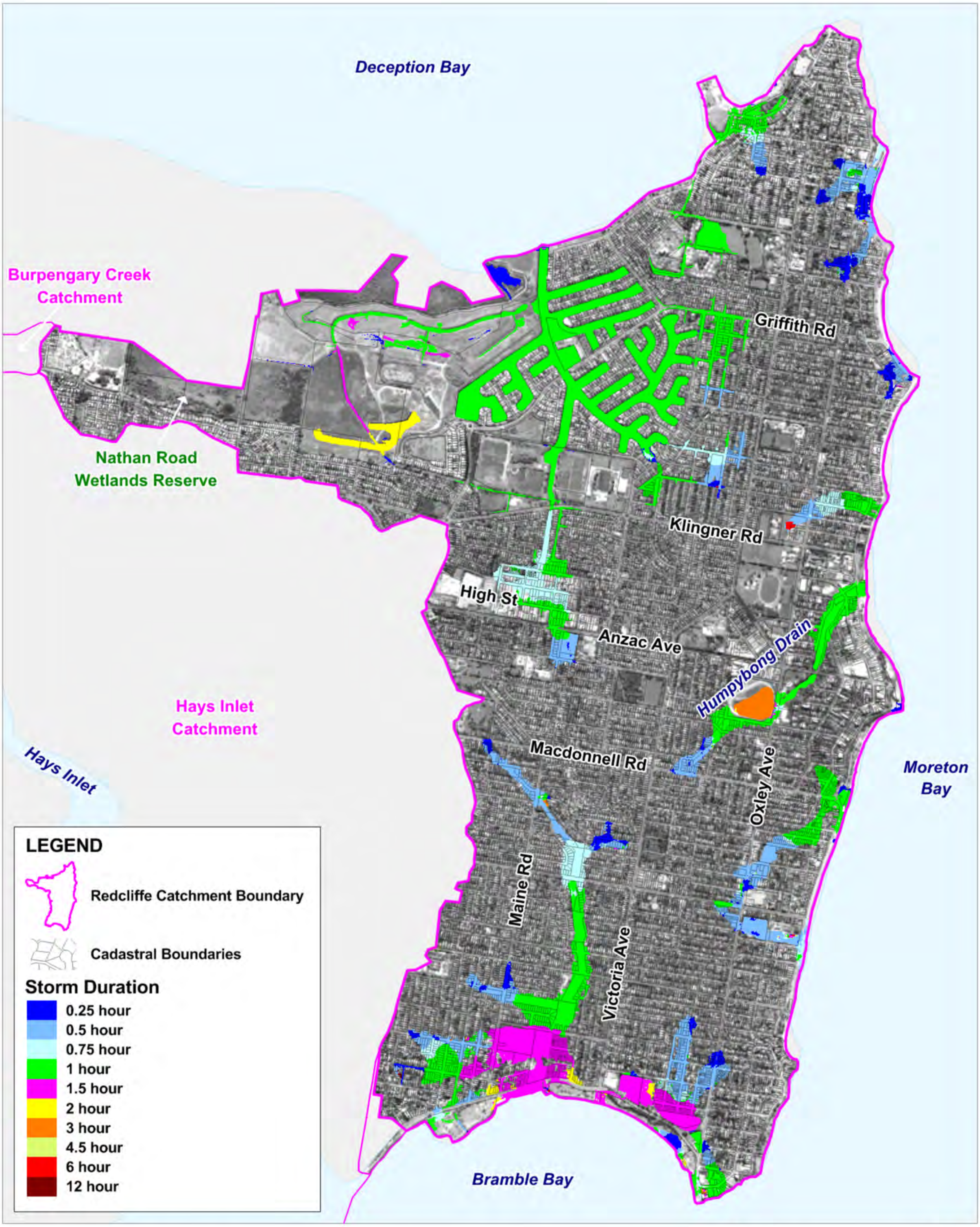

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Critical Duration Assessment - 0.1% AEP

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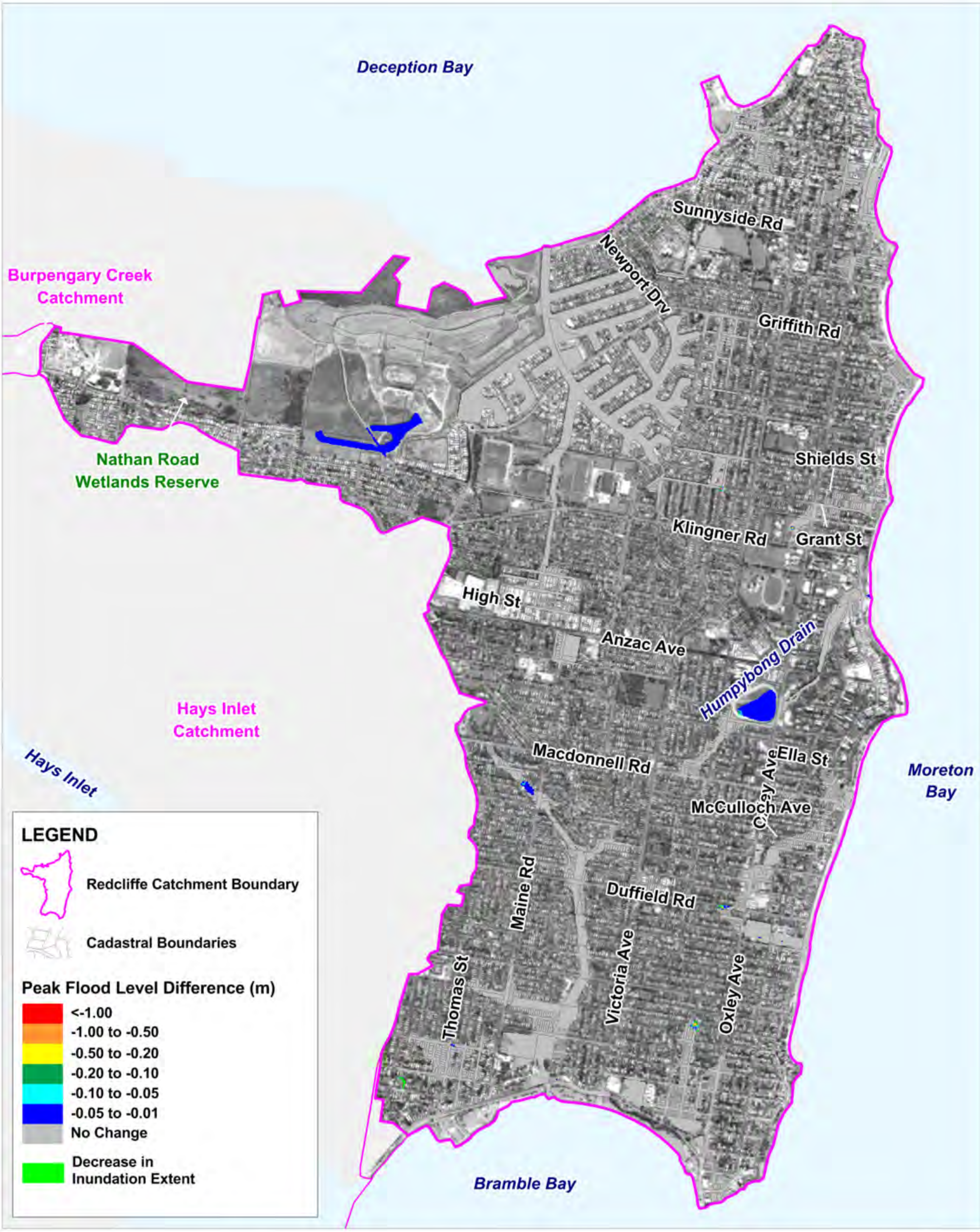

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Peak Flood Levels for Critical Durations minus Peak Flood Levels for all duration - 1% AEP Event

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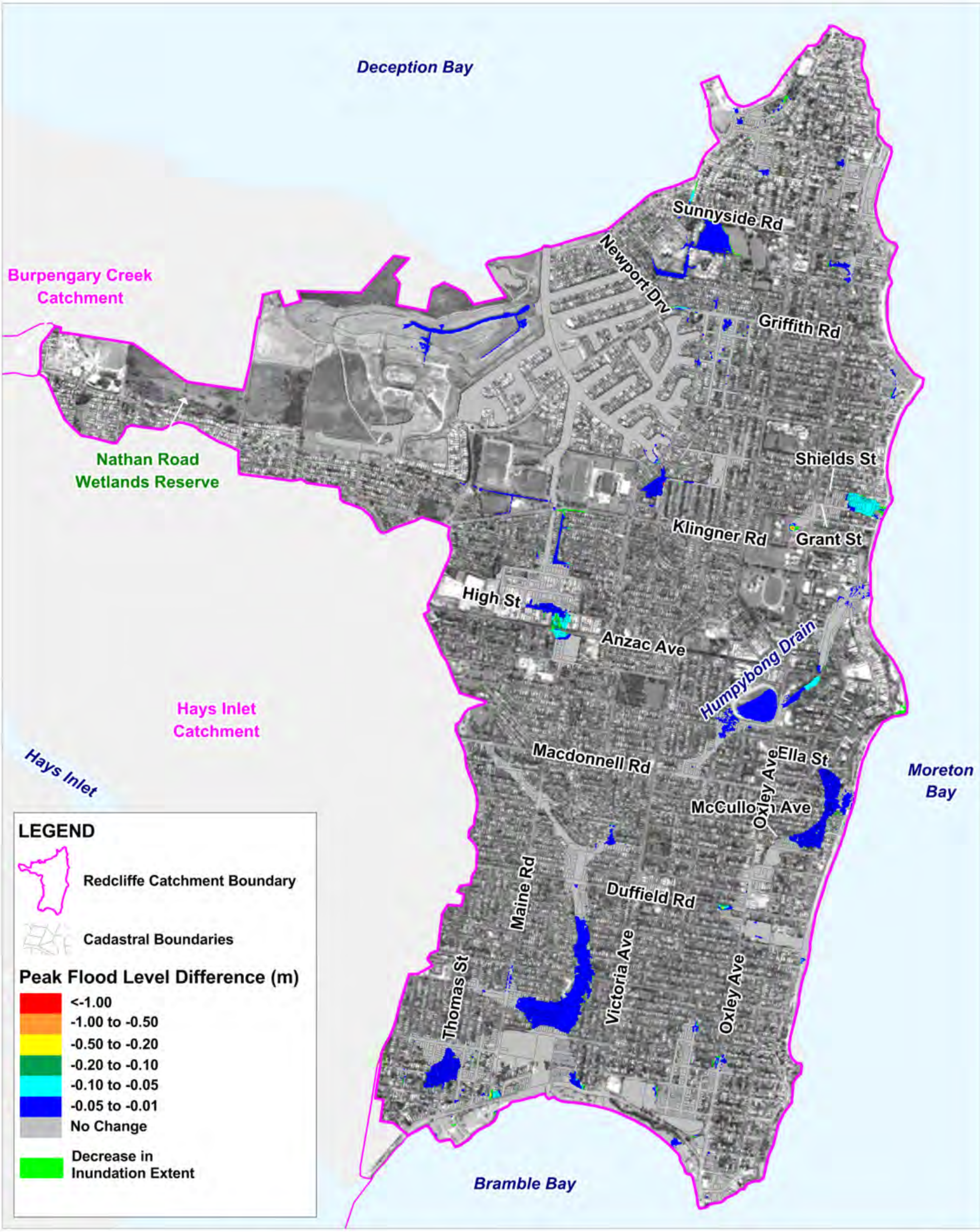

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Peak Flood Levels for Critical Durations minus Peak Flood Levels for all duration - 0.1% AEP Event

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3.2.2 River and Creek Design Event Simulations

The RED model was simulated for a range of AEP events and storm durations, as outlined in Section 3.2.1, as well as a Moreton Bay Design Storm (MDS). Councils adopted design storm is a 1% AEP 15 minute in 270 min embedded design storm. The MDS is useful for general investigations into changes in model parameters and catchment characteristics, as it reduces the number of model runs required (i.e. one run instead of multiple storm durations).

Council advised that the 1% AEP 15 minute in 270 minute EDS was to be adopted as the MBRC Design Storm (MDS). The adopted EDS was used as the base design storm for the sensitivity analyses.

In summary, the RED model was simulated for the following design events:

- The 1EY, 0.5EY, 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2%, 0.1%, 0.05%, 0.02%, 0.01% AEP events, and the PMF event for the three selected critical storm durations; and
- The Moreton Bay Design Storm – 1% AEP 15 minute in 270 minute embedded design storm.

3.2.3 Storm Tide Design Event Simulations

The RED model was simulated for a range of storm tide simulations. These simulations were based on a dynamic tide generated from the 'Storm Tide Hydrograph Tool' (Cardno Lawson Treloar, 2010). The following three storm tide reference points were used: MBC-093, MBC-106, and MBC-086.

Table 3-2 provides a summary of the Storm Tide design events that have been simulated.

Table 3-2 Storm Tide Design Event Simulations Summary

ID	Event	Description	Climate Change	Sea Level Rise (m)
S01	1% AEP	Current Climate	Excluded	0
S02	5% AEP	Current Climate	Excluded	0
S03	0.1% AEP	Current Climate	Excluded	0
S04	0.01% AEP	Current Climate	Excluded	0
S05	1% AEP	Future Climate	Included	0.8

The downstream boundary for the storm tide events needed to be modified, some of the major bends in the boundary needed to be smoothened. As a storm tide event has large volumes of water flowing into the model, the bends in the model were causing eddies along the boundary, causing instabilities. A straighter downstream boundary resulted in more stable storm tide models. This also required moving the boundary further off the shore to improve the stability. The Storm Tide boundary was modelled with a combination of a 2d_hx, 2d_cn_nodes, 1d_nwk_nodes and 1d_bnd_nodes (1d_HT). This allowed for the boundary to have sloping water levels along the boundary, together with the dynamic water level boundary from the 'Storm Tide Hydrograph Tool'.

3.3 Sensitivity Analysis

The RED model was simulated for ten (10) sensitivity scenarios in total. A summary of the sensitivity scenarios, the model identifier (ID), description and purpose of the ten sensitivity scenarios are detailed in Table 3-3.

Table 3-3 Sensitivity Analysis Summary

ID	Description	Section
R01	Roughness	3.3.1
R02	Blockage	3.3.2
R03	Climate change – rainfall	3.3.3
R04	Climate change – sea level rise	3.3.3
R05	Climate change – rainfall and sea level rise	3.3.3
R06	Storm tide – current storm tide with current rainfall	3.3.3
R07	Storm tide – future storm tide with future rainfall and sea level rise	3.3.3
R08	Vegetated floodplain	3.3.4
R09	Future residential development	3.3.4
R10	Vegetated floodplain and future residential development	3.3.4

3.3.1 Hydraulic Roughness Analysis

The sensitivity of the model to landuse roughness (Manning's 'n') parameters was undertaken with the 1% AEP MDS event. All Manning's 'n' values within the 2D domain were increased by 20%.

3.3.2 Structure Blockage Scenario

A blockage scenario was run to simulate the effects of waterway crossing (culverts) becoming blocked during a flood event. This is a reasonably common occurrence and is the result of debris or sand/silt being washed into or moved within the waterways during a flood. Recent storm event showed that blockages are generally caused by debris, or larger items, such as tree stems, wood planks, shopping trolleys or even cars. Blockages reduce the capacity for water to flow through stormwater infrastructure and force water out of the channel, often increasing overland flooding.

A moderate blockage scenario was adopted from the SKM *Floodplain Parameterisation* report (2012b), and includes:

- A full blockage is applied if the culvert diagonal is less than 2.4m; and
- A 15% blockage is applied if the culvert diagonal is greater than 2.4m.

It should be noted that no blockage is applied for trunk drainage infrastructure.

3.3.3 Climate Change and Downstream Boundary Conditions

A climate change and storm tide assessment investigated the possible impact of a storm tide and projected increases in sea level rise and rainfall intensity of flooding in the catchment. In total, five (5) scenarios were assessed:

- **R03**: Investigated the impact of an increase in rainfall of 20%, as per *Boundary Conditions, Joint Probability and Climate Change* (SKM, 2012a).
- **R04**: Investigated the impact of an increased downstream boundary of MHWS + 0.8m due to predicted sea level rise.
- **R05:** Investigated the impact of an increase in rainfall intensity and an increased downstream boundary. This scenario combines R03 and R04.
- **R06:** Modelled a static storm tide to use as the reference for assessing the storm tide impacts. The downstream boundary was changed to a static storm tide level with a value of between 2.0 and 2.1mAHD (100 year Current) with the concurrent 1% AEP EDS rainfall event.
- **R07:** Investigated the impact of an increase in sea level (R04) and a static storm tide level of between 2.1 and 2.3mAHD (100 year GHG).

3.3.4 Future Landuse Analysis

Three future landuse scenarios were assessed to test the impact of future developments.

- **R08:** Investigated the impact of increased vegetation in floodplains.
  Landuse is defined in the hydraulic model through the materials layer. This information covers the entire hydraulic model extent and describes landuse and the Manning's 'n' roughness values associated with each type of landuse. The materials layer was updated to reflect the future landuse scenario (change in vegetation density). Any area with a landuse classification of Medium Dense Vegetation within the 1% AEP extent was changed to High Density Vegetation. Also, Low Grass / Grazing within the 1% AEP extent was changed to a Medium Dense Vegetation landuse classification.
- **R09:** Investigated the impact of increased residential development.
  The hydrologic model utilises a 'fraction impervious' parameter which described the proportion of each subcatchment where water is not able to infiltrate, i.e. there are no rainfall losses on paved surfaces. If the fraction impervious increases, there will be more rainfall runoff and quicker concentration of flows. The fraction impervious in each subcatchment of the WBNM model was updated to reflect the future landuse scenario provided by Council (R09).
- **R10:** Investigated the impact of the combination of increased vegetation in floodplains (R08) and increased residential development (R09).

4 Model Results and Outcomes

4.1 2014 Model Maintenance

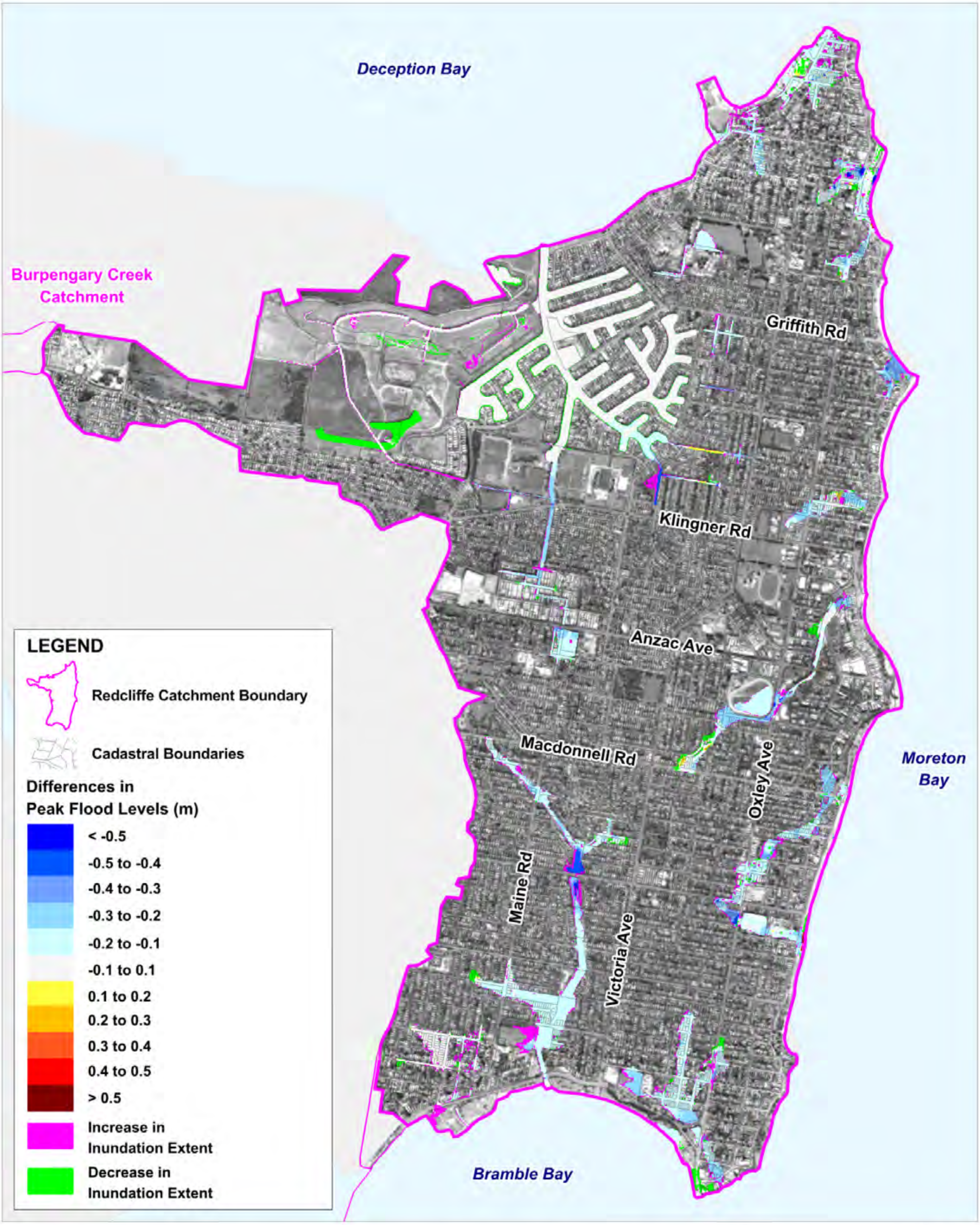
Figure 4-1 and Figure 4-2 shows the difference between the 2014 and 2013 Redcliffe Catchment models for the 5% and 1% AEP events, respectively. Both events are based on a comparison of the 1 hour storm duration.

Negative values mean that the 2014 RED model results are lower than the 2013 model results and vice versa (positive values mean that the 2014 RED model results are higher than the 2013 model results).

Peak levels are generally lower in 2014 and differences between 2014 and the 2013 model generally remain with a +/- 0.15m range.

For the 5% AEP event, the decrease in initial loss results in smaller volume of flood water entering the system. The flood wave also propagates more rapidly in the 2014 model, however, due to the smaller volume of flood waters, the peak flow remains smaller than in the 2014 model.

For the 1% AEP event, the flood wave propagates more rapidly in the 2014 model. This is due to a better definition of gullies and canals. Although the peak flow in the 2014 model occurs earlier and is slightly greater than in the 2013 model, peak flood levels remain lower in the 2014 model, due to the 2014 LiDAR surveyed elevations being generally lower than those from the 2009 LiDAR elevations.



Title:
2014 Redcliffe Catchment Model versus 2012 Redcliffe Model Peak Flood Level Difference - 5% AEP

Figure: 4-1

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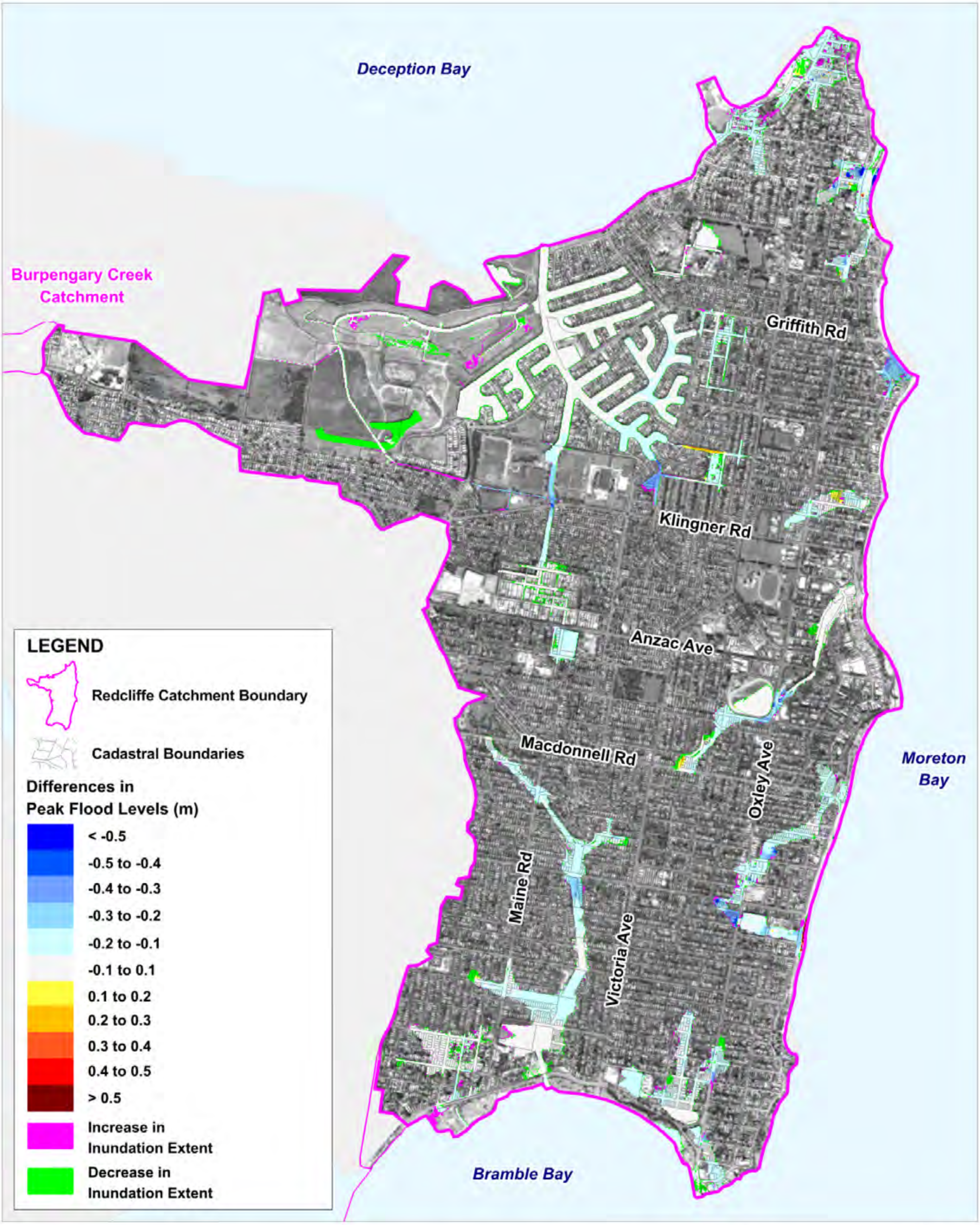

Title:
2014 Redcliffe Catchment Model versus 2012 Redcliffe Model
Peak Flood Level Difference - 1% AEP

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4.2 Verification

Verification against recorded rainfall and flood marks was not undertaken for the RED model because of limited historical event data.

4.3 Design Flood Behaviour

The following data were output by the model at 30 minute intervals as well as the peak values recorded during each simulation:

(1) Flood Levels (h flag);

(2) Flood Depth (d flag);

(3) Flood Velocity (v flag);

(4) Depth Velocity Product (Z0 flag);

(5) Hazard Categories adopted by Council (ZMBRC flag);

(6) Hazard Categories developed by the Queensland Reconstruction Authority (ZQRA flag);

(7) Steam Power (SP flag); and

(8) Inundation Times (no flag required).

The maximum velocity was used in combination with a 'Maximum Velocity Cutoff Depth' of 0.1m. Consequently, the model result files plot the maximum velocity for depths greater than 0.1m; for depths of less than 0.1m the velocity at the peak level is recorded in the TUFLOW output file. This approach is recommended so as to exclude any high velocities that can occur as an artefact of the modelling during the wetting and drying process.

TUFLOW can provide output relevant to the timing of inundation. In particular:

- The time that a cell first experiences a depth greater than the depth(s) specified; and
- The duration of time that a cell is inundated above the depth(s) specified.

A 'Time Output Cutoff Depth' of 0.1m, 0.3m and 1m was selected. This selection provides further flood information in the catchment, e.g.

- Establishing when areas are inundated with shallow depths of 0.1m;
- Considering pedestrian and vehicle safety (flood depth between 0.1m and 0.3m); and
- The duration and/or time of inundation for significant flood depths of 1m and more throughout the catchment.

This information can assist in emergency planning by highlighting which areas of the catchment are inundated early in the flood event and also highlighting which regions may be isolated for long durations.

Flood maps have not been provided in this report because the focus of this project is on digital data, rather than the provision of flood maps.

4.3.1 River and Creek

General patterns of flood behaviour that can be observed from the RED TUFLOW design event modelling include:

- Flooding along the canals is fairly confined to the canals and open drains up to the 10% AEP event;
- In Scarborough, there is flooding from Michel Road to the boat harbour and from Turner Street to the ocean in the 1EY;
- There is flooding along Prince Edward Parade and Flinders Parade in the 1EY;
- In the 1EY there is flooding along the drainage path from Steven Street to the Esplanade in Redcliffe;
- The Humpybong Creek (downstream of the Redcliffe Paceway) is fairly contained within the channel up to the 10% AEP event. In the 10% AEP event, there is a breakout to the east of Sutton Street. By the 1% AEP event, most of the drain downstream of Anzac Avenue is overtopping and inundates parts of Humpybong Esplanade and some properties along Humpybong Esplanade;
- In the 1EY, there is flooding between MacDonnell Road, Chudleigh Street and Redbank Road;
- In the 0.5 EY event, the open drain upstream of the Redcliffe Paceway is overtopping in some locations;
- The drainage path between Cox Street and Margate Parade is shown to be flooding in the 1EY event, impacting on property;
- In Woody Point, properties along the main drainage paths are shown to be impacted in the 1EY event;
- The main open drain in Clontarf / Margate is fairly contained in the drain until the 5% AEP event. There are some areas that are shown to be impacting on properties in the 1EY event, including:
  - Marigold Street;
  - Along Maine Road and Isobel Street; and
  - Between Wendy Crescent and Thomas Street.

A maximum ASCII grid was derived using the envelope of all critical storms (section 4.3.2) for each event and all the TUFLOW outputs listed in Section 4.3 above. Results for the 5%, 1% and 0.1% AEP events are available on Council's website (www.moretonbay.qld.gov.au/floodcheck) as PDF suburb maps or in the Flood Explorer interactive mapping tool.

4.3.2 Storm Tide

Table 4-1 summarises the general patterns of flood behaviour that can be observed from the RED TUFLOW storm tide modelling.

Table 4-1 Storm Tide Flood Behaviour Descriptions

Event	Flood Behaviour
1% AEP	Flooding along drain from Hornibrook Esplanade to Duffield Road. Two properties (Lot 19 RP91678 and Lot 20 RP91678) flood affected at the end of Conley Street. Flooding of the canal system; Walkers Creek Canal along the drain to Anzac Avenue; Spoonbill Canal until Klinger Road and Scarborough Road; Gannet Canal until Grace Street; Osprey Canal until Grace Street; Sandpiper Canal until the Ballycara Nursing Home. Flooding of the land to the west of the Canals. Flooding along Reef Point Esplanade and Second, Third and Fourth avenues. Flooding at the park at the corner of Grant Street and Prince Edward Parade. Flooding at the south eastern corner of the sports fields on Sunnyside Road. Flooding at the northern end of Endeavour Esplanade. Flooding at Oyster Point Esplanade. Flooding at the parkland between Bird Opassage Parade and Thurecht Parade. Flooding between Lilla Street and Woodcliffe Crescent
5% AEP	Similar to 1% AEP, but with a lesser extent. The two properties at the end of Conley Street were not affected by flooding
0.1% AEP	Similar to 1% AEP, but with a greater extent in the following areas: The drainage systems around the canals. Along Reef Point Esplanade. Along drain from Hornibrook Esplanade to Duffield Road. Flooding along Thomas, Cornelius and Yacht streets. Breakout from the canal at Inglis and Bell Streets. Between Lilla Street and Woodcliffe Crescent. Breakout from the channels along Benson Street
0.01% AEP	Similar to 0.1% AEP, but with a greater extent in the following areas: The drainage systems around the canals. Breakout from the channels along Lime, Benson, Roma and Walsh streets. Bellevue Terrace flooded to Scarborough Road and into the parkland of Sportsgrounds Street. Along Reef Point Esplanade and Endeavour Esplanade. Along drain from Hornibrook Esplanade to Duffield Road. In Clontarf, in particular along Thomas and Cornelius Streets.
Future 1% AEP	Similar to 0.1% AEP, but with a greater extent the following areas: The drainage system around the canals. Breakout from the channels along Lime, Benson, Roma and Walsh Streets now flooding properties. Bellevue Terrace flooded to Scarborough Road and into the parkland of Sportsgrounds Street. Breakouts from the canal crossing Klingner Road through to Anzac Avenue. The area along the coast at Clontarf and Woody Point. Flooding to the properties between Grant and Shield Streets at the Prince Edward Parade end. Flooding to the corner of Fernlea Avenue and Jeays Street.

4.4 Sensitivity Analysis Results

The 1% AEP MDS (defined in Section 3.2.2) was used as a base case for the sensitivity analysis. The following sections provide a discussion of the impacts as a result of the sensitivity analysis. Maps of the impacts have not been provided as the focus of this project is on digital data, rather than the provision of flood maps.

A comparison of the MDS event with the 1% AEP design event (envelope of all durations) indicates that in the majority of the catchment, the MDS results in very similar peak flood levels (within 0.1m) to the envelope of the 1% AEP design event. There is only one location between Anzac Avenue and High Street where the MDS under predicts peak flood levels by up to 0.3m.

4.4.1 Hydraulic Roughness Analysis

Increasing the Manning's 'n' by 20% has resulted in an increase of peak flood levels between ±0.1m throughout most of the catchment. There are two localised increases in levels throughout the catchment:

- An increase of up to approximately 0.12m along the drain near Duchess Street; and
- An increase of up to approximately 0.13m near Shields Street.

4.4.2 Structure Blockage Analysis

Blocking culverts on a catchment wide scale has impacts of between ±0.1m. There are localised impacts (greater than ±0.1m) surrounding the following culverts:

- Southern Cross Catholic College in Scarborough (south west): the assumed culverts under the internal road cause an increase in peak flood levels of up to approximately 0.42m upstream of the culvert, which is contained within the sports field. There is a decrease in peak flood levels of approximately 0.35m downstream of the culvert, along the open channel.
- A decrease in peak flood levels of up to 0.36m between Boardman Road and the open channel between Boardman Road and Klingner Road.
- An increase in peak flood levels along the culvert system from Anzac Avenue, through the commercial precinct in Kippa Ring:
    - Localised peak flood level increase of up to 0.38m upstream of culvert under Anzac Avenue;
    - An increase in peak flood levels of up to 0.29m between the culverts under Anzac Avenue and the culverts under High Street; and
    - Increases in levels of up to 0.12m throughout the commercial buildings.
- Prince Edward Parade and Grant Street: localised increase in peak flood levels of up to approximately 0.12m directly upstream of the culverts.
- An increase in peak flood levels of up to 0.12m upstream of Anzac Avenue, along Humpybong Creek.
- The culverts under Duffield Road produce a significant impact if they become blocked. There is an increase in levels both upstream (up to 0.32m) and downstream (up to 0.75m) of this culvert.

The increase in peak flood levels downstream is due to the flood waters being forced over the road, rather than through the culverts, changing the timing and height of the flood wave.

4.4.3 Climate Change and Downstream Boundary Conditions

R03 – Increase in rainfall intensity of 20%

A 20% increase in rainfall increases peak flood levels throughout the catchment, typically up to 0.2m. There are areas where there are larger increases in peak flood levels in the following locations:

- Between Anzac Avenue and High streets:
  - An increase of up to 0.45m approximately 25m upstream of the culvert across Anzac Avenue;
  - An increase of up to approximately 0.25m along Anzac Avenue, upstream of the culvert;
  - An increase of up to approximately 0.37m along the open channel between Anzac Avenue and High Street; and
  - An increase of up to 0.26m to the north of High Street.
- Up to 0.6m at the entrance to the underground drainage network to the west of Herschell Court.
- Up to approximately 0.27m to the west of Prince Edward Parade and north of Grant Street.
- Along Humpybong Creek: an increase ranging from 0.3m to approximately 0.1m, from the south of Anzac Avenue to Redcliffe Parade.
- Localised increases of up to approximately 0.45m downstream of the culvert crossing Duffield Road.
- Increases of up to 0.28m between Thompson Crescent and Hornibrook Esplanade.
- An increase of up to 0.21m to the south of Cornelius Street, near Thomas Street.

R04- Increased downstream boundary of 0.8m due to predicted sea level rise

Increasing the downstream boundary by 0.8m, to take into account predicted sea level rise, results in an increase in peak flood levels of up to approximately 0.93m. The greatest increase in peak flood levels is seen in the following locations:

- In the canal system;
- The open drainage network to the west of the canals;
- In the open channel draining through Pelican Park, to the south of Hornibrook Esplanade;
- In the open channel to the east of Bramble Bay Caravan Park, to the south of Hornibrook Esplanade; and
- Along the beaches at all other outlet/wet locations.

There are lesser peak flood levels increases radiating along the open drainage upstream of the canals:

- The open channel draining from Southern Cross Catholic College: peak flood levels increases between approximately 0.13m and 0.26m for approximately 700m;
- Increases in peak flood levels between approximately 0.1m and 0.42m in the open channel between Grace Street and Benson Street;
- Increases in peak flood levels between approximately 0.09m and 0.5m along the open channel off Bellevue Terrace;
- Increases in peak flood levels between approximately 0.1m and 0.49m along the open channel along Yates Street (from Ashmole Road to between Ettie and O'connell Streets), and in the undeveloped land to the west of Walsh Street;
- Increases in peak flood levels between approximately 0.095m and 0.5m along the open channel from Klinger Road to around Dalton Street; and
- Increases in peak flood levels between approximately 0.11m and 0.33m in the open channel between High Street and Anzac Avenue.

R05- Increase in rainfall intensity and 0.8m increase in downstream boundary

A 20% increase in rainfall combined with a predicted sea level rise of 0.8m, compared to the 1% AEP MDS, results in:

- There is an increase of up to 0.28m at the following locations:
  - To the west of Oxley Avenue (along the open channel through the Redcliffe Paceway);
  - Along the drainage path between Bank Street and Ella Street;
  - Along open drain between Hornibrook Esplanade and Robina Street; and
  - Along Cornelius Street.
- There is an increase in levels of up to approximately 0.93m along:
  - The canal system;
  - The open drainage network to the west of the canals;
  - In the open channel draining through Pelican Park, to the south of Hornibrook Esplanade;
  - In the open channel to the east of Bramble Bay Caravan Park, to the south of Hornibrook Esplanade; and
  - Along the beaches at all other outlet/wet locations.
- There are increases in flood levels at the following locations:
  - An increase of up to approximately 0.3m between Oxley Avenue and View Street;
  - An increase of up to approximately 0.29m along Humpybong Creek from the outlet to around McNaughton Street;
  - An increase of up to approximately 0.5m along some channels draining into the Canals; and

    - An increase in levels between approximately 0.2m to 0.4m along the open channel draining from Southern Cross Catholic College.

R06 – 1% AEP current static storm tide with a current 1% AEP MDS rainfall event

This scenario investigates the impact of a static storm tide compared to the 1% AEP MDS.

Results indicate that throughout most of the catchment there are no flood level impacts with the exception of the lower portion of the catchment where the downstream boundary conditions impact on the flood levels:

- The canal system had increases of approximately 1.13m throughout;
- Increases of up to approximately 0.2m along Humpybong Creek from the outlet to around Anzac Avenue; and
- An increase of up to 0.28m around Cornelius and Thomas Streets.

R07- Increase in rainfall intensity (20%) combined with a static storm tide level (1% APE GHG) + 0.8m sea level rise

This scenario investigates the impact of a 20% increase in rainfall intensity and an increased sea level (0.8m) when used together with a future static storm tide, compared to the 1% AEP MDS.

Results indicate that there are peak flood level increases between 2.0m to 2.3m at the downstream boundaries with 2.0m in the north and 2.3m in the south of the catchment. The following locations indicate the following peak flood level changes greater than ±0.1m:

- An increases of approximately 2.0m throughout the canal system ;
- The open channel between Klinger Road and Dalton Street shows an increase of up to 2.0m at Klinger Road and 0.5m at Dalton Street;
- The open channel through the Bally Cara Retirement Village has an increase of approximately 0.5m;
- An increase of up to 0.55m along the open channel between Grace Street and Ashmole Road;
- An increase of up to 0.47m along the open channel between Anzac Avenue and High Street;
- Increases up to 0.8m around Oak Avenue, North Quay and Jeays Street;
- An increase of up to 0.17m between Philip Street and Kennedy Esplanade along Hanlon Street;
- An increase up to 0.9m between Oxley Avenue (0.1m) and Prince Edward Parade (0.9m) along Grant Street;
- The peak flood levels in the open channel near Doanld Street north of Hornibrook Esplanade increase:
    - by up to approximately 0.7m near Hornibrook Esplanade,
    - by up to approximately 0.5m at Bell Street,
    - up to approximately 0.3m increase at King Street, and

  - up to approximately 0.15m at Duffield Road; and
- Increases of up to approximately 0.35m at View Street, Woody Point.

4.4.4 Future Landuse Analysis

R08 – Increased vegetation in floodplain

Increasing the vegetation in floodplains typically changes level throughout the catchment by ±0.1m. Areas where peak flood levels differ (from ±0.1m) include:

- Increases up to 0.2m:
  - Along the open channel to the west of Yates Street;
  - Along Longland Street and Bellevue Terrace;
  - In A.J. Kelly Park;
  - Along Plume Street and the open channel to the south of Plume Street;
  - Along the open drain between Maine Street and Duffield Road;
  - Along the open drain to the east of Duchess Street and Lavelle Court;
  - Along the open drain from King Street to the east of Tainton Street;
- Increases of up to 0.3m upstream of the culverts underneath High Street and Anzac Avenue, in Redcliffe.
- An increase of up to 0.4m along the open channel between Anzac Avenue and Klingner Road.

These areas are typically located where there is a change in landuse to Medium Dense Vegetation.

R09 – Increased residential development

Increasing the residential development within the catchment typically results in impacts between ±0.1m. There are some localised increases in levels at the entrance of some of the pipe networks due to the higher flow in these areas.

R10 – Increased vegetation in the floodplain and increased residential development

Combining R08 and R09 produces similar results to R08. The following areas have a greater increases in peak flood levels than R08:

- An increase in levels of up to 0.11m on the park near Southern Cross Catholic College (off Sunnyside Road); and
- An increase in levels of up to 0.15m upstream of the Redcliffe Paceway (from around Mary Street to Sydney Street).

4.5 Model Limitations and Quality

Watercourses within the Redcliffe Catchment were represented in the 2D domain, for which the grid resolution is 5m. This may not allow adequate representation of the channel conveyance, particularly for smaller, more frequent flood events. in some instances, this limitation may lead to the model over or under estimating conveyance in the watercourses. The extent of this over or under estimation will vary according to local topographic features.

4.6 Model Specification and Run Times

The RED River TUFLOW model is the smallest model within the MBRC area. It has run times below 2 hours for the design events, but run times of approximately 12 hours for the MDS. The RED model requires approximately 2GB of memory (RAM). Details for various design events, the validation event and the 1% AEP MDS are shown in Table 4-2. The 1.5 hour storm duration was chosen, as it is the longest critical duration storm modelled. It should be noted that the model run time is partially dependent upon the machine's specifications and the other demands on the machine's CPU's (e.g. other models running simultaneously).

Table 4-2 Model Specification and Run Time Summary

Event	Model Run Time	Model RAM/Memory
1 EY 1.5 hr	1 hour	2.08GB
10% AEP 1.5 hr	1 hour	2.08GB
1% AEP 1.5 hr	1.5 hours	2.08GB
0.2% AEP 1.5 hr	1.1 hours	2.08GB
0.05% AEP 1.5 hr	1.2 hours	2.08GB
1% AEP MDS	13 hours	2.28GB

5 Conclusion

As part of the Regional Floodplain Database 2014 Model Maintenance project, Council are updating all of the existing hydrologic and hydraulic models, due to the availability of additional and more accurate data.

As a result, the hydrologic subcatchments within the Redcliffe (RED) catchment were reviewed and found to be fit-for purpose. The initial losses within WBNM (hydrologic modelling software) for events up to and including the 5% AEP were changed from 0mm to 15mm.

The existing 5m TUFLOW model of RED were updated with LiDAR elevation data (collected in 2014), additional structures including the trunk drainage network, improved representation of streams and roads, and additional bathymetry data for the Newport Canals.

The model was set up in a manner prescribed by Council specifically for the RFD project to ensure a consistent approach across the whole Local Government Area (LGA) and to enable the model and model outputs to be integrated into Council's RFD. Minimal flood maps have been provided within the report, as requested by Council. The model and model outputs for all events have been provided in digital format. The outcomes of this work will be included into Council's Flood Explorer, used in the automated provision of Council's flood reports provided to the community and used by Council to analyse and assist with managing flood risk in the Redcliffe catchment.

6 References

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