Regional Floodplain Database:

2013 Model Maintenance Report - Redcliffe (RED)

Moreton Bay Regional Council

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Regional Floodplain Database
2013 Model Maintenance Report
Redcliffe (RED)

June 2014

Regional Floodplain Database 2013 Model Maintenance Report
Redcliffe (RED)

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Document History

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0	*New Flood information for RED*	*HvZ*	*SR*	*SR*	31/3/15
Revision	Purpose Description	Originated	Checked	Reviewed	Date

1. Introduction

BMT WBM developed the Redcliffe (RED) hydrologic and hydraulic models as part of Stage 2 of the Regional Floodplain Database (RFD) project in July 2012 (BMT WBM 2012). Some opportunities for improvement were identified for these models Hydrology and Water Management Consulting (HWMC) was subsequently engaged by Council to assist in making changes to both the hydrologic and hydraulic models for RED.

During 2013, HWMC tested various changes to the RED models including the following:

- 2m grid vs 5m grid TUFLOW model
- Additional underground drainage modeled in TUFLOW
- Different methods for applying the inflow hydrographs to the model domain
- Identifying areas where RFD methods were not suited

Recommendations from HWMC report (HWMC 2013) were adopted and the models were re-run for all design events, sensitivity analysis and selected storm tide events.

All modeling was undertaken by Council with support from HWMC. This report highlights the changes and results from the 2012 model for the simulated events.

2. 2014 Model Maintenance Details

2.1 WBNM model

An additional 51 minor catchments and flow paths were created to align with the additional underground drainage identified for inclusion in the TUFLOW model.

Each minor catchment's fraction impervious was re-calculated and provided to HWMC for inclusion in the WBNM model. The WBNM model was run with these updates and inflows for the TUFLOW returned to Council.

2.2 TUFLOW model

Several changes were made to the 2012 RED TUFLOW model as listed below and shown in Figure 2.1:

- The TUFLOW.2013-12-AA-w64 executable was used for the 2014 RED Maintenance model. This TUFLOW version includes Councils hazard categories as a default output.

  The default way of distributing inflows, for this version of TUFLOW, has changed from distributing across all wet cells within the 2d_sa polygon to proportioning the inflow according to the water depth of wet cells within the 2d_sa polygon. This is considered an improved approach for Councils regional RFD models.

Improvements to the executable have also increased the modelled capacity of pipe networks.

- All landuse layers were reviewed and changes made where appropriate.

- Approximately 11.3 km of additional existing underground drainage pipes were incorporated into the TUFLOW model. For minor catchments (2d_sa polygons) that include underground pipe drainage along their major flow paths, inflow hydrographs were incorporated into the RED TUFLOW using a separate GIS layer called '2d_sa_Pits'. The '2d_sa_Pits' polygon enclose those areas within the minor catchment that contained pits. The Inflow hydrographs for each minor catchment polygon within this GIS layer were distributed equally to all TUFLOW pits enclosed within each polygon. In this way, flow was initially directed to underground pipe networks and only entered the 2D domain once the drainage network capacity was exceeded (surcharging pit).

  An additional line was included in the TUFLOW boundary control file (*.tbc) to read-in the new '2d_sa Pits'layer as follows:

  Read MI SA PITS == ..\mi\Boundaries\RED_002a_E_2d_sa_Pits.mif

  This approach utilises the 'PITS' option of the TUFLOW 'Read GIS SA' command. The following is an excerpt from the TUFLOW Manual which describes this option:

  'The PITS option directs the inflow only to 2D cells that are connected to a 1D pit or node connected to the 2D domain using "SX" for the Conn_2D (previously Topo_ID) 1d_nwk attribute. The inflow is spread equally over the applicable 2D cells.'

- Adjustments were also made to 2d_sa polygons for minor catchments that do not include underground pipe drainage along their major flow paths. The 2d_sa polygons were modified to control where flows will be directed within the minor catchment. Modifications were only made to the 2d_sa polygons that would benefit from a modified polygon.

- The 1d_nwk stormwater drainage pits layer was updated across the entire model to ensure consistency of modelling and to ensure sufficient inlet capacities to the underground drainage network. The number of pits at a given location was increased based upon the number of pits in the upstream network draining to this point. For example, a TUFLOW pit located at a pipe junction that receives flow from an upstream pipe network with 7 additional pits was assigned these 7 extra pits. This is done by updating the 'Number_of' field in the 1d_nwk pit layer with the understanding that no more than 10 pits assigned in this way. Any 2d_bc_sa connections from the 2012 RED model was removed and replaced with the pit modeling approach from above.

- Several minor catchments included in the 2012 RED model were excluded from the 2014 Maintenance model by removing their catchment inflows. These minor catchments were excluded because they could not be adequately described using the RFD approach.

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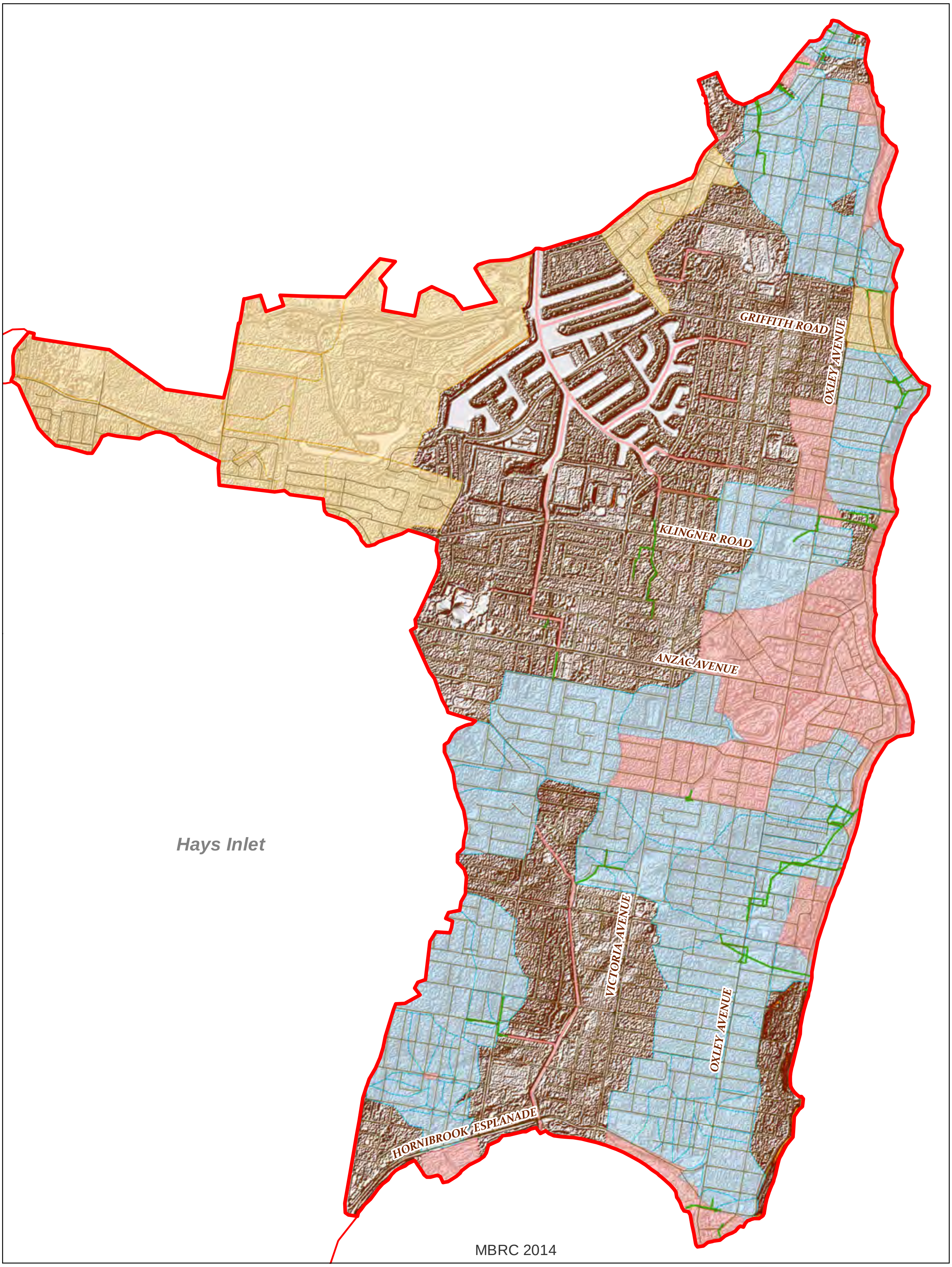

- Redcliffe Catchment Boundary
- Roads
- Additional underground drainage
- 2d_sa
- 2d_sa_Pits
- Areas excluded from model

Redcliffe Model Maintenance Features

FIGURE: 2-1

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N W E S

SCALE 1:35,000 (A4)

0 500 1,000

Metres

Projection: Map Grid of Australia, Zone 56
Horizontal Datum: Geocentric Datum of Australia 1994

PRODUCED BY:
ECM ENGINEERING

UNIT LOCATION:
Pine Rivers District Office
Stathpine QLD

COMPILED BY:
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Regional Floodplain Database

Path: Z:\AppData\RFD\L0\Admin\TUFLOW_model_upgrades\RED\RED_Report_figure_2_1.mxd

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3. Model Simulations

3.1 Verification

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

3.2 Design Flood Events

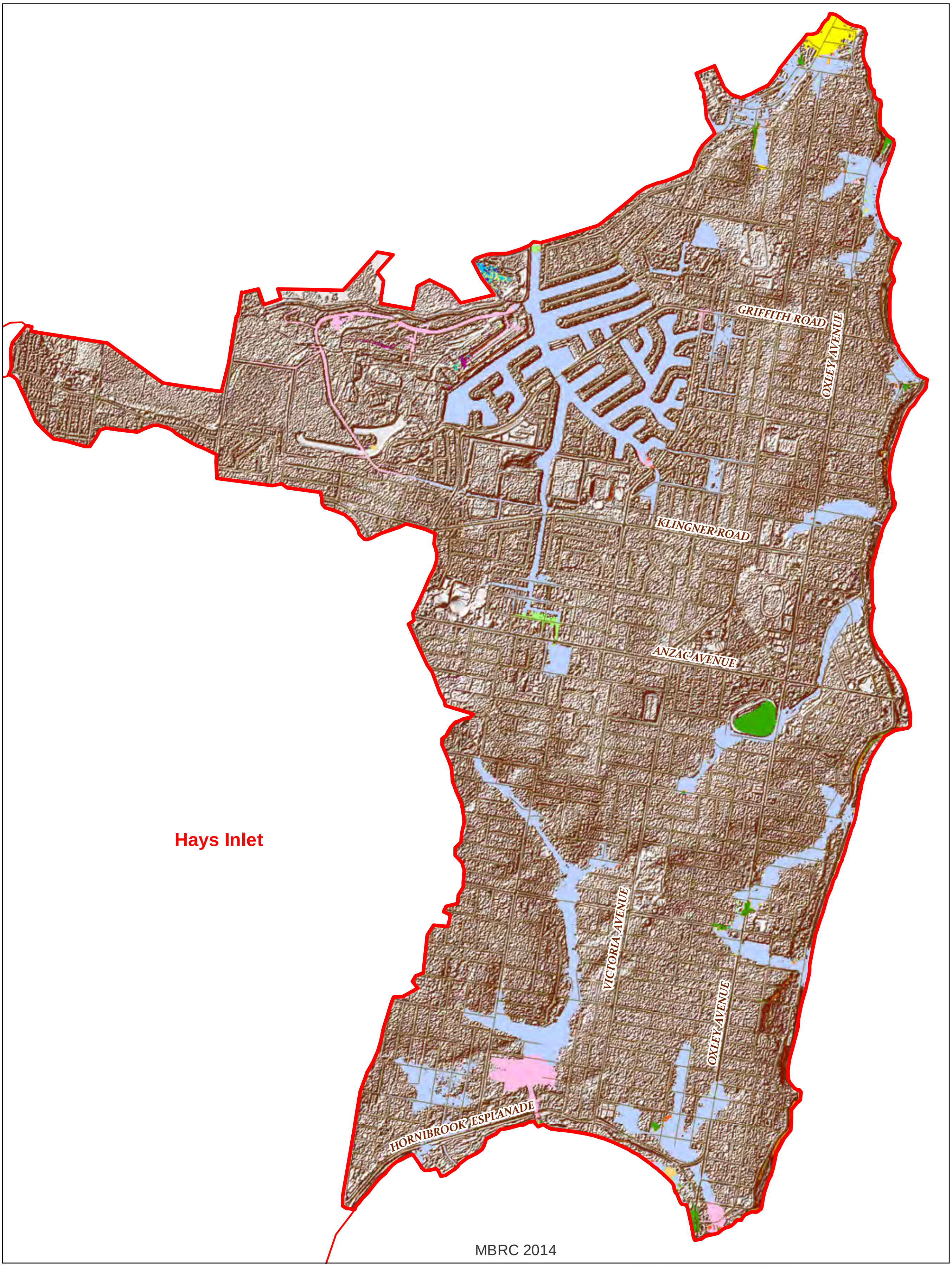
This section describes the design storm conditions used in the hydrodynamic modelling tasks. Design storm events are hypothetical events used to estimate design flood conditions. They are based on a probability of occurrence, usually specified as an Average Exceedance Probability (AEP). For events less than the 50% AEP, the terminology Exceedances per Year (EY) is used.

3.2.1 River & Creek Critical Duration Assessment

For Stage 2 and 3 of the RFD project the Critical Duration Analysis (CDA) undertaken utilised the 1% AEP and 0.1% AEP events. Results from the CDA are shown in Figures 3.1 to 3.2.

For the RED 2013 maintenance study the 1% and 0.1% were utilised for the CDA. Critical durations selected from the 1% AEP event CDA were applied to all events ranging from the 1EY to the 1% AEP. Critical durations selected from the 0.1% AEP event CDA were applied to all events ranging from the 0.5% AEP to the PMF event.

The critical durations selected from the CDA is shown in Table 3-1.



Redcliffe Catchment Boundary
Roads

Durations

- 30 mins
- 45 mins
- 1 hr
- 1.5 hrs
- 2 hrs
- 3 hrs
- 6 hrs
- 9 hrs
- 12 hrs
- 24 hrs

Critical Duration Assesment

1% AEP Event

N W E S

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0 500 1,000
Metres

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FIGURE: 3-1

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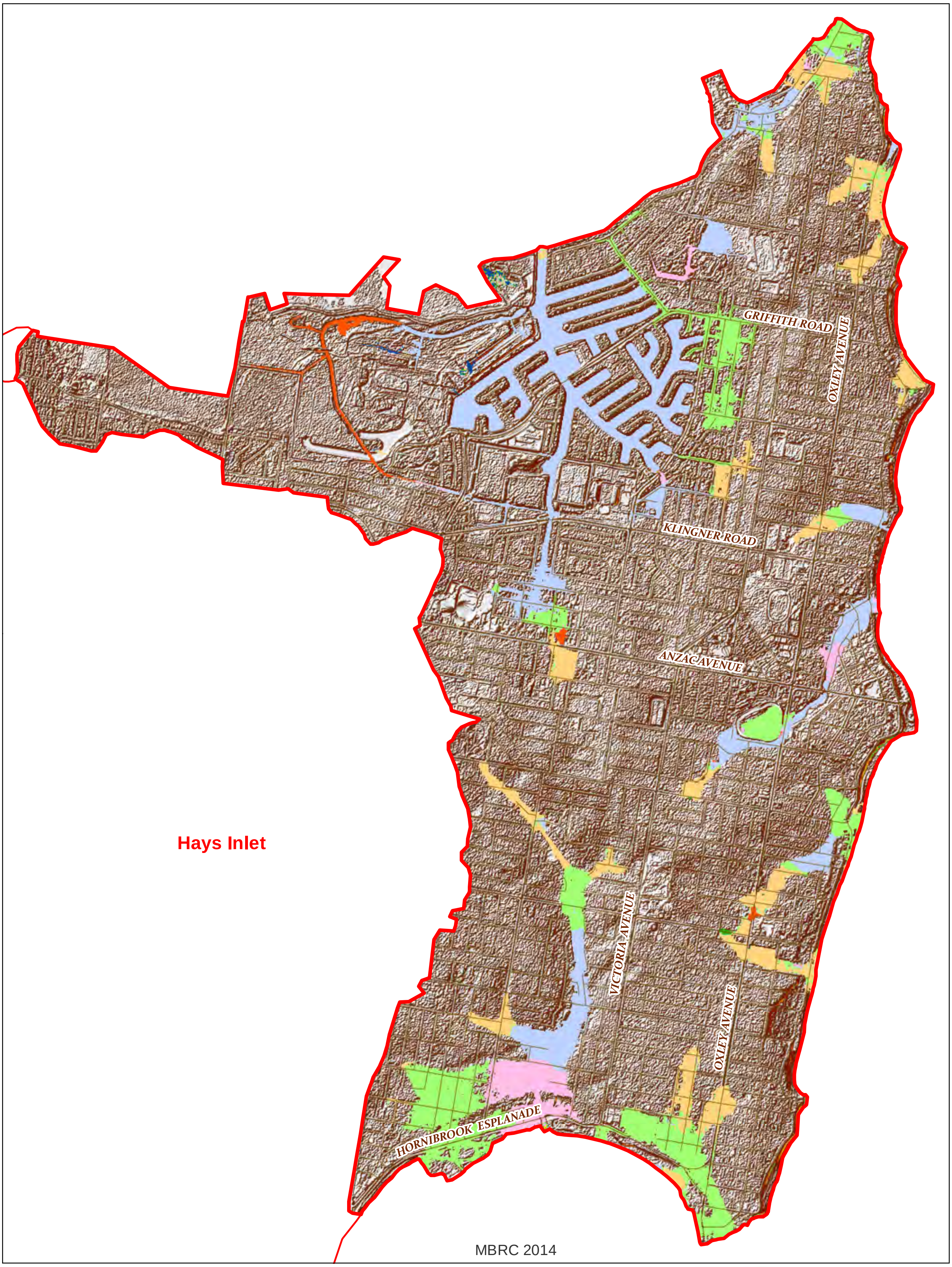

Redcliffe Catchment Boundary
Roads

Duration
- 30 mins
- 45 mins
- 1 hr
- 1.5 hrs
- 2 hrs
- 3 hrs
- 4 hrs
- 5 hrs
- 6 hrs
- 12 hrs

Critical Duration Assessment

0.1% AEP Event

N W E S

SCALE 1:35,000 (A4)

0 500 1,000
Metres

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FIGURE: 3-2

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Table 3-1. Critical Duration Assessment

Assessment Event	Durations	Selected Durations	Adopted Event(s)
1% AEP	½, ¾, 1, 1½, 2, 3, 6, 9,12 and 24 hour storm	1, 1½, and 3 hour storm	1EY, 0.5EY, 20%, 10%, 5%, 2% and 1% AEP
0.1% AEP	½, ¾, 1, 1½, 2, 3, 4, 5, 6 and 12 hour storm	½, ¾ and 1 hour storm	0.5%, 0.2%, 0.1%, 0.05%, 0.02%, 0.01% AEP and PMF

To determine the critical storm durations, the following methodology was adopted:

i. Hydrologic and hydraulic modelling for the range of storm durations as listed in Table 3-1.

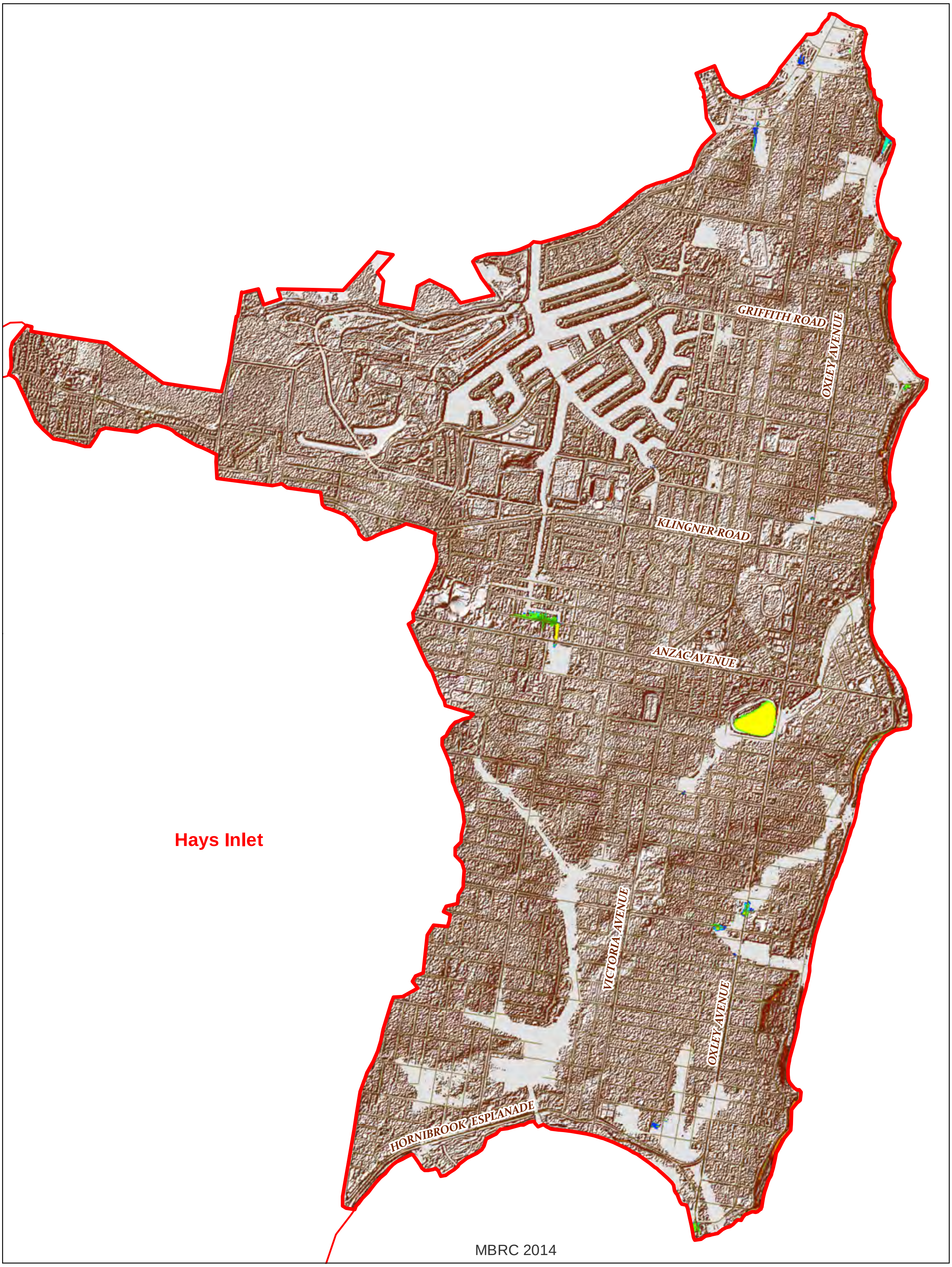
ii. Mapping of the peak flood levels for the "maximum envelope" of all the storm durations.

iii. Mapping of the peak flood levels for the "maximum envelope" of the selected storm durations as listed in Table 3-1.

iv. Difference comparison between the mapped peak flood levels for the selected storm durations (iii) and the mapped peak flood levels from all storm durations (ii).

v. Selection of the critical storm durations was based on the storm durations generating the highest flood levels across the most of the minor basin area.

The difference comparison for the 1% and 0.1% AEP peak flood levels determined from above methodology is shown in Figure 3-3 and Figure 3-4. These figures illustrate that the selected critical durations (see Table 3-1) generally represents the peak flood levels throughout the minor basin.



Redcliffe Catchment Boundary
Roads

Difference in Peak Flood Levels (m)

- < -1
- -1.0 to -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- No Change
- Decrease in Inundation Extent

Peak Flood Levels for critical durations minus Peak Flood Levels for all durations

1% AEP Event

N E S W

SCALE 1:35,000 (A4)

0 500 1,000
Metres

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FIGURE: 3-3

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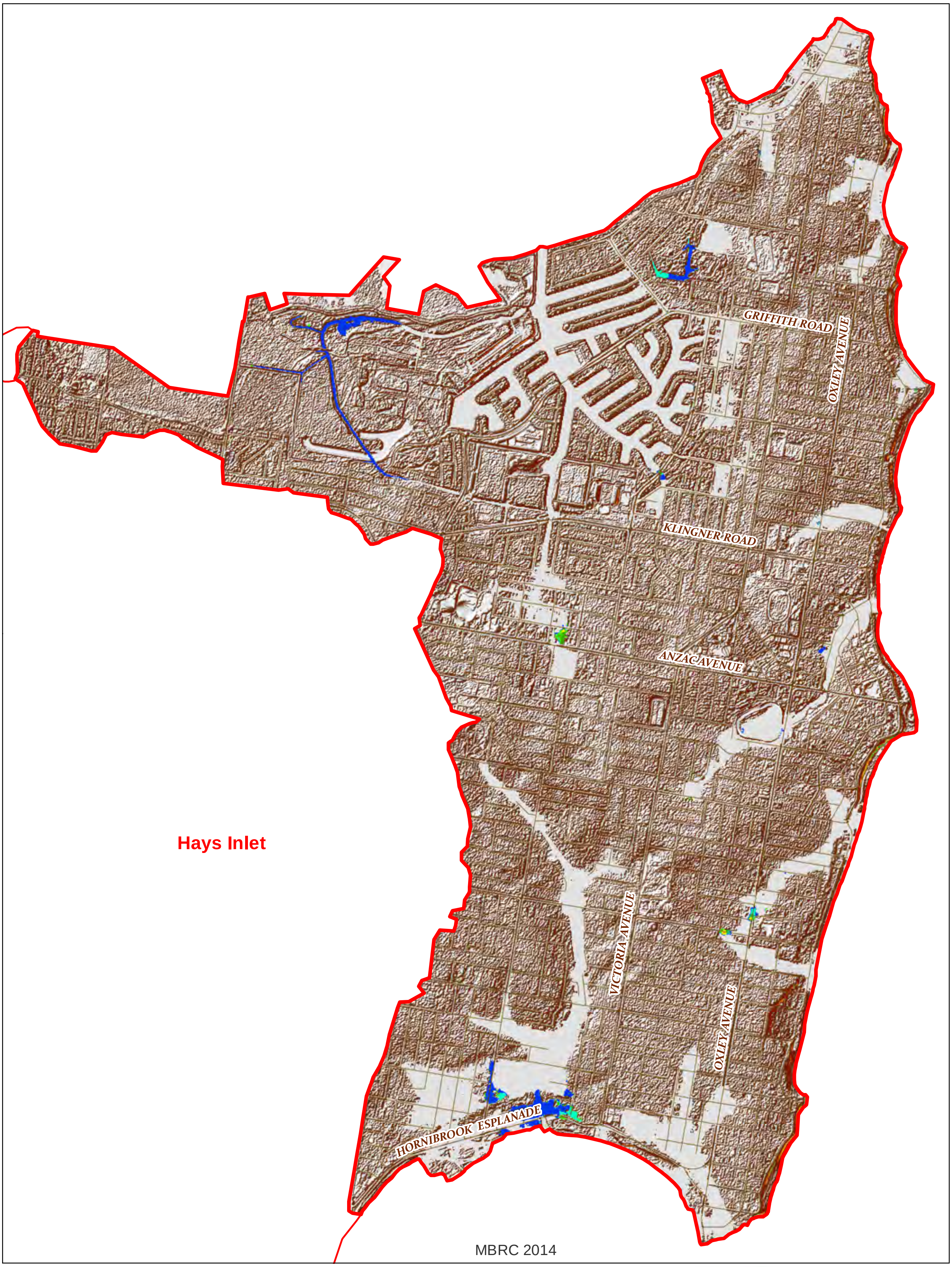

Redcliffe Catchment Boundary

Roads

Difference in Peak Flood Levels (m)

- < -1
- -1.0 to -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- No Change
- Decrease in Inundation Extent

Peak Flood Levels for critical durations minus Peak Flood Levels for all durations

0.1% AEP Event

N W E S

SCALE 1:35,000 (A4)

0 500 1,000

Metres

Projection: Map Grid of Australia, Zone 56
Horizontal Datum: Geocentric Datum of Australia 1994

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FIGURE: 3-4

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3.2.2 River & Creek Design Event Simulations

The Redcliffe model was simulated for a range of AEPs and storm durations as detailed in Section 3.2.1 and 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).

The Redcliffe 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 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 downstream boundaries of the RED TUFLOW model were modified to include the entire coastline. No rainfall was applied and a dynamic storm tide boundary for three events (see Table 3-2) was applied. The dynamic storm tide boundaries were generated using the Storm Tide Hydrograph Calculator developed for Council by Cardno Lawson Treloar in 2010 as part of the Storm Tide Hazard Study. The following three storm tide reference points were used: MBC-093, MBC-106 and MBC-086.

Table 3-2. Summary of Storm Tide events.

ID	Description
RED_S_002b_E_00100Y	No rainfall, dynamic Storm Tide (1% AEP current)
RED_S_002b_E_01000Y	No rainfall, dynamic Storm Tide (0.1% AEP current)
RED_S_002b_F_00100Y	No rainfall, dynamic Storm Tide (1% AEP future (0.8m sea level rise and increased cyclonic activity))

3.3 Sensitivity Analysis

The 2012 RED model was simulated for a total twelve scenarios of which one was a dynamic storm tide with no rainfall. The 2014 RED maintenance model was simulated for a total eleven scenarios. The 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 and R14	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 MDS event. All Manning's 'n' values in the 2D domain were increased by 20%.

3.3.2 Structure Blockage Analysis

The 2012 RED model had a blockage factor applied to both culverts and trunk drainage, which was resulting in increased flood levels. For the blockage scenario as part of the 2014 Model Maintenance study for Redcliffe, a blockage factor was only applied to culverts (i.e. trunk drainage is unblocked).

For culverts 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.

3.3.3 Climate Change and Downstream Boundary Conditions Analysis

The effect of changes in climate such as increases in rainfall and sea level rise were assessed as its combined impact with a storm tide event. The following 6 scenarios were assessed:

- **R03:** Investigated the impact of an increase in rainfall intensity of 20% (as per SKM (2012a) *Boundary Conditions, Joint Probability and Climate Change* Report).

- **R04:** Investigated the impact of an increased downstream boundary of 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 scenarios R03 and R04.

- **R06:** Investigated the impact of a 1% AEP current static storm tide level with concurrent 1% AEP MDS rainfall event.

- **R07:** Investigated the impact of an increase in rainfall and an increase in sea level rise. An increase in rainfall of 20% was applied combined with a static storm tide level (1% AEP GHG) + 0.8m.

- **R14:** Investigated the impact of an increase in rainfall and an increase in sea level rise. An increase in rainfall of 20% was applied combined with a static storm tide level (1% AEP GHG) + 0.4m.

3.3.4 Future Landuse Analysis

Three future landuse scenarios were assessed using the 1% AEP MDS. These scenarios did not include a change in rainfall intensities or sea level rise due to climate change.

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 future landuse.

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).

The following 3 scenarios were assessed:

- **R08:** Investigated the impact of increased vegetation in the floodplain. This involved changing the 'medium dense vegetation' material class to a 'high dense vegetation' class and changing the 'low grass/grazing' material class to a 'medium dense vegetation' class.

- **R09:** Investigated the impact of increased residential development. The hydrology model was updated with future development (changing the fraction impervious) to estimate future inflows for the TUFLOW model.

- **R10:** Investigated the impact of increased residential development and increased vegetation in the floodplain. This scenario combines scenario R08 and R09.

4. Model Results and outcomes

4.1 Comparison against previous results

Figures 4-1 and Figure 4-2 shows the difference between the 2012 RED model and the 2013 RED Maintenance model for the 1 hour duration, 5% and 1% AEP events respectively. The storm durations used in creating a combined envelope for the two models and events are shown in Table 4-1.

Table 4-1. Storm duration comparison for 5% and 1% AEP events.

Event	Storm durations for 2012 model	Storm durations for 2013 Maintenance model
5% AEP	1 and 3 hour	1, 1½, and 3 hour
1% AEP	½, 1, 3, 6, 12,24 and 48 hour	½, ¾, 1, 1½, 2, 3, 6, 9,12 and 24 hour

Significant reductions in the extent of flooding and flood levels were achieved when compared with the 2012 RFD model. Negative values in the Figures mean that the 2014 RED maintenance model results are lower than the 2012 RED model results and vice versa.

4.2 Verification

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

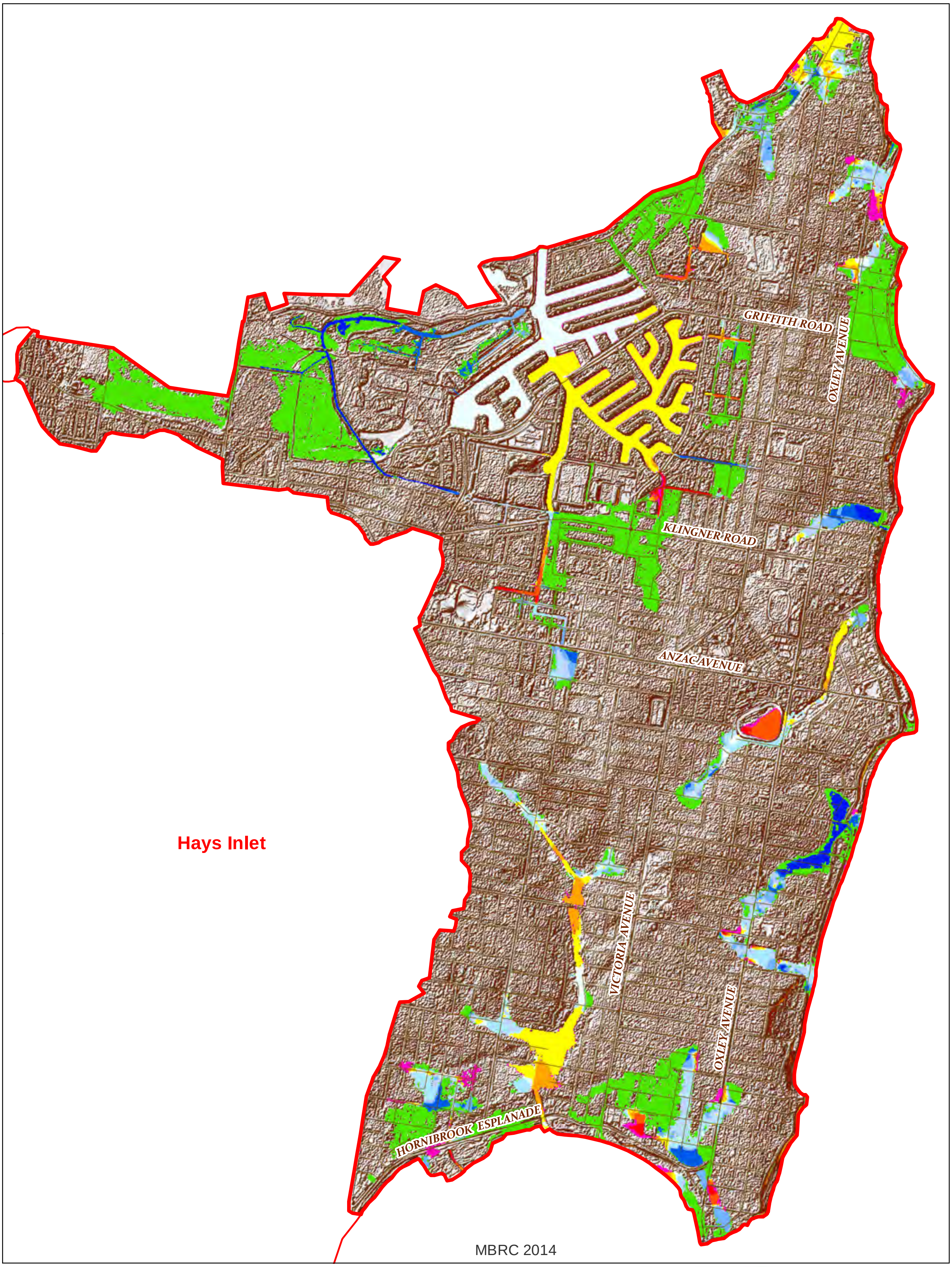
4.3 Design Flood Behavior

The following TUFLOW outputs were generated at 5 minute intervals as well as the peak values for each simulation:

i. Flood levels (H)
ii. Flood Depth (D)
iii. Flood velocity (V)
iv. Depth Velocity product (Z0)
v. Hazard categories (ZMBRC)
vi. Stream Power (SP)

4.3.1 River & Creek

A maximum ASCII grid was derived using the envelope of all critical storms (section 3.2.1) durations 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.



Redcliffe Catchment Boundary

Roads

Difference in Peak Flood Levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5

Decrease in Inundation Extent

Increase in Inundation Extent

2014 RED Maintenance Model Flood Levels minus 2012 RED Model Flood Levels

5% AEP Event

N W E S

SCALE 1:35,000 (A4)

0 500 1,000

Metres

Projection: Map Grid of Australia, Zone 56
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FIGURE: 4-1

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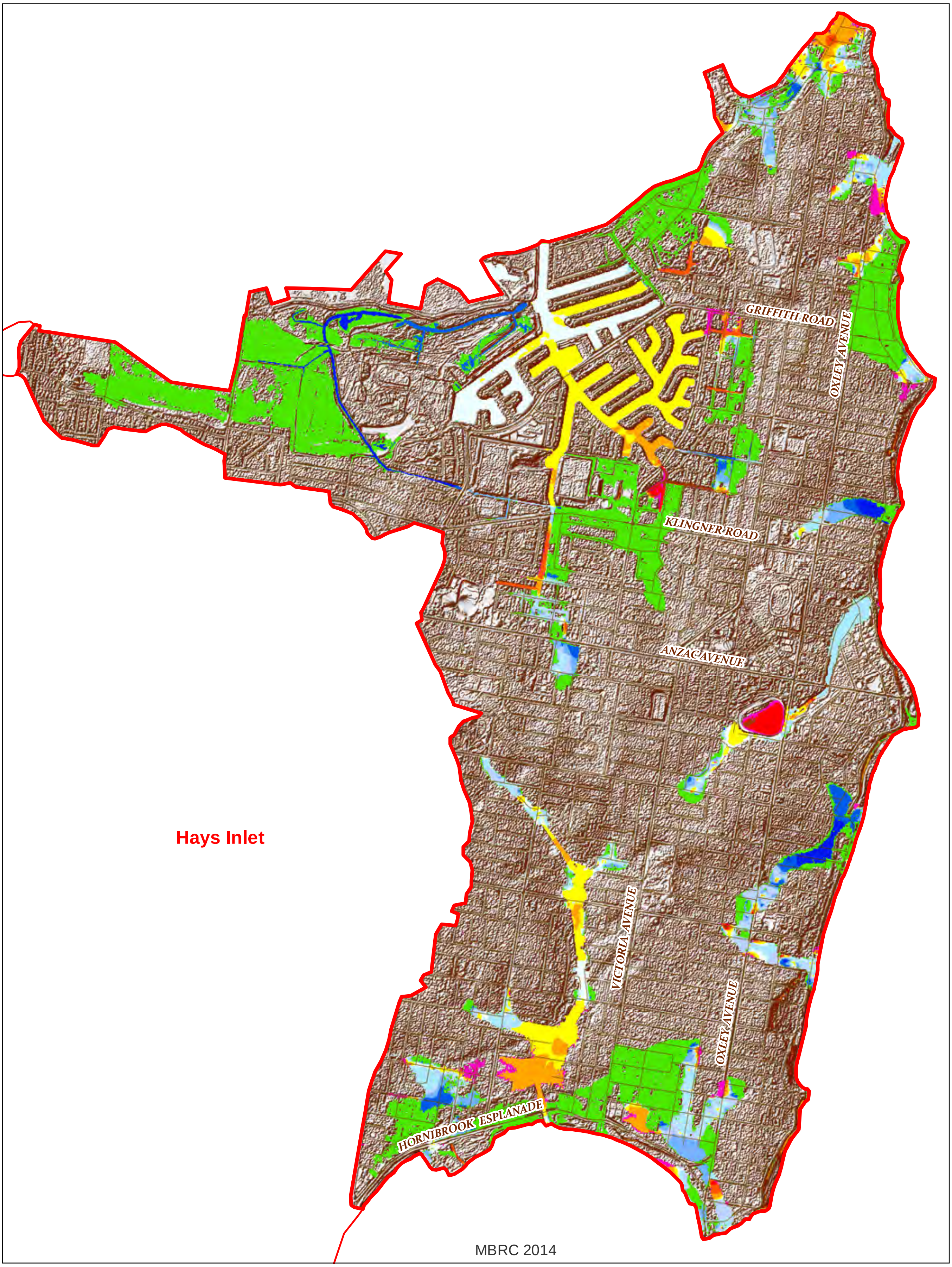

Redcliffe Catchment Boundary

Roads

Difference in Peak Flood Levels (m)

< -0.5	0.01 to 0.05
-0.5 to -0.2	0.05 to 0.1
-0.2 to -0.1	0.1 to 0.2
-0.1 to -0.05	0.2 to 0.5
-0.05 to -0.01	> 0.5
-0.01 to 0.01	

Decrease in Inundation Extent

Decrease in Inundation Extent

2014 RED Maintenance Model Flood Levels minus 2012 RED Model Flood Levels

1% AEP Event

N W E S

SCALE 1:35,000 (A4)

0 500 1,000

Metres

Projection: Map Grid of Australia, Zone 56
Horizontal Datum: Geocentric Datum of Australia 1994

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FIGURE: 4-2

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4.3.2 Storm Tide

ASCII grids were generated for each event (section 3.2.3) and all the TUFLOW outputs listed in section 4.3 above. The Storm Tide modeling undertaken was not incorporated into Council's public flood products. Using TUFLOW for modeling the impacts of Storm Tide will be included in a future regional model maintenance update.

4.4 Sensitivity Analysis Results

The Moreton Bay Design Storm (MDS) was used as the base case for the sensitivity analysis. The results of the sensitivity analysis are summarised in Sections 4.4.1 to 4.4.4.

A comparison of the MDS event with the 1% AEP design event (envelope of all durations) indicates that the MDS is under predicting flood levels in less that 10% of the floodplain in non-urban areas.

4.4.1 Hydraulic Roughness Analysis

Increasing Manning's 'n' by 20% resulted in a few localised increases of up to 200mm. Overall the impact of this increase in Manning's 'n' was negligible.

4.4.2 Structure Blockage Analysis

The structure blockage analysis shows that peak flood levels increase by more than 500mm upstream of blocked structures and the extent of flooding also increases. Decreases in peak flood levels of up to 300mm are observed downstream of some of the blocked structures.

4.4.3 Climate Change and Downstream Boundary Conditions Analysis

Climate change has a significant impact on flood levels especially in the lower catchment.

Increase in rainfall intensity of 20%

An increase in rainfall throughout the catchment increased flood levels by between 100-200mm in most parts of the catchment and in the Newport canals an increase of more than 500mm is observed but still contained within the canals. Some small increases in the extent of flooding are also observed in the downstream areas of the catchment.

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

An increase in the downstream boundary to simulate the effects of sea level rise increases the flood levels in the Newport canals by 600-900mm but the extent of flooding is still contained within the canals. Increases of up to 400mm are observed in areas directly upstream of the canals while the remaining catchment is mostly unaffected. Some small increases in the extent of flooding are also observed in the downstream areas of the catchment.

Increase in rainfall intensity and 0.8m increase in downstream boundary

Combining the above two scenarios affects the entire catchment with increases in flood levels of between 100-200mm in the upper catchment, 200-400mm in the middle catchment and 600-900mm in the Newport canals and lower catchment. Although flood levels in the canals increase the extent of flooding is still contained within the canals. Some small increases in the extent of flooding are also observed in the middle and downstream areas of the catchment.

1% AEP current static storm tide with concurrent 1% AEP MDS rainfall event

The impact of a 1% Storm tide is mostly confined to the Newport canals and the downstream areas of the catchment. Flood levels in the canals increase by more than 800mm, increased between 100-500mm in areas upstream of the canals and increased between 100-200mm in the Clontarf area. Some small increases in the extent of flooding are also observed in the areas upstream of the canals and downstream areas of the catchment.

Increase in rainfall of 20% combined with a static storm tide level (1% AEP GHG) + 0.8m sea level rise

The impact of a 1% future Storm tide combined with an increase in rainfall intensity and 0.8m sea level rise has a significant impact on flood levels and extents in the catchment. Flood levels increase by 600-900mm in the Newport canals and most of the downstream areas of the catchment. Increased flood levels of up to 400mm are observed in the middle catchment and significant increases in the extent of flooding occurs in Newport, Scarborough, Clontarf and Woody Point.

Increase in rainfall of 20% combined with a static storm tide level (1% AEP GHG) + 0.4m sea level rise

The impact of a 1% future Storm tide combined with an increase in rainfall intensity and 0.4m sea level rise was similar to the scenario above except that the increase in the flood extent was less.

The above scenario results show that the Newport canals and the downstream areas of the catchment is sensitive to climate change and Storm Tide.

4.4.4 Future Landuse Analysis

Increased vegetation in the floodplain

Increasing the vegetation in the floodplain only increases flood levels in a few areas along Bells Creek by 100-200mm.

Increased residential development

Increased residential development has no significant impact on peak flood levels in the catchment.

Increased vegetation in the floodplain and increased residential development

Combining the 2 scenarios above does not have an additional impact over and above the individual scenarios.

4.5 Model Limitations and Quality

Watercourses and open drains within the Redcliffe minor basin were represented in the 2D domain for which the grid resolution is 5m. Although various modelling techniques were used to make the representation of the watercourses and open drains as accurately as possible on a 5m grid channel conveyance may not be adequately represented. This would have the biggest impact on smaller, more frequent events. In some instances this limitation may lead to the model over or underestimating conveyance in the watercourses. The extent of this over or underestimation will vary according to local topographic factors.

4.6 Model Specification and Run Times

The Redcliffe TUFLOW model is a relatively small model with relatively short runtimes and low demand on memory (RAM). Table 4-1 provides details on runtimes and memory requirements for various design events and the MDS.

Table 4-1. Model Specification and Run Times

Event	Model Grid Size	Model duration [hours]	Model run time [CPU hours]	Model memory (RAM) [Gb]
1 EY (3hrs)	5m	8	6.3	1.2
10% AEP (3hrs)	5m	8	6.6	1.2
1% AEP (3hrs)	5m	10	7.8	1.2
0.1 % AEP (1hr)	5m	8	6.9	1.2
0.01 % AEP (1hr)	5m	8	7.0	1.2
PMF (3hrs)	5m	8	14.9	1.2
MDS	5m	15	12.2	1.2
1 % AEP Storm Tide	5m	50	39.7	1.2
0.1 % AEP Storm Tide	5m	50	43.3	1.2

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5. Conclusion

The TUFLOW model for the Redcliffe catchment was updated with additional underground drainage and some new methodologies for modelling the underground drainage were also incorporated and the latest TUFLOW version used. These changes significantly reduced the extent of flooding in the catchment.

The Storm Tide modelling undertaken showed a good correlation with the results from the Storm Tide Hazard study (Cardno 2009) and will be incorporated in future regional model maintenance.

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