# Regional Floodplain Database:

## Hydrologic and Hydraulic Modelling - Upper Pine River (UPR)

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**MORETON BAY REGIONAL COUNCIL**

# Regional Floodplain Database

## Hydrologic and Hydraulic Modelling Report: Upper Pine River (UPR)

301001-01156 – 00-EN-REP-0002

30 Jul 2012

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# SYNOPSIS

This flood study report has been prepared by WorleyParsons for Moreton Bay Regional Council for the purposes of documenting the methodology, approach and outcomes associated with the comprehensive flood assessment works undertaken for the Upper Pine River (UPR) minor basin as part of the MBRC Regional Floodplain Database (RFD) Stage 2 project. The study has included detailed hydrologic and hydraulic modelling to assess the flood behaviour of UPR for a range of design storm events from the 1 year Average Recurrence Interval (ARI) event to the Probable Maximum Flood (PMF).

Modelling software packages used in this flood study are the WBNM (Watershed Bounded Network Model) as the hydrologic modelling software and TUFLOW as the hydraulic modelling software.

The flood assessment undertaken for the UPR minor basin as documented in this report has been successful in addressing the overall objectives of the study. It is considered that the associated model outputs can be adopted by MBRC for the Regional Floodplain Database to deliver seamless information about flood behaviour across the entire Moreton Bay Regional Council area.

### Disclaimer



**PROJECT 301001-01156 - REGIONAL FLOODPLAIN DATABASE**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
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| 0 | Issue for use | L Cheung | K Hegerty | M Shaw | 30 Jul 2012 | | |
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# 1 INTRODUCTION

WorleyParsons Services Pty Ltd has been commissioned by Moreton Bay Regional Council (MBRC) to carry out detailed surface water flood modelling over six (6) regional minor basins located within the MBRC Local Government Area (LGA). The six minor basins are Upper Pine River (UPR), Sideling Creek (SID), Stanley River (STA), Neurum Creek (NEU), Mary River (MAR) and Byron Creek (BYR). This flood modelling study has been carried out as part of Stage 2 of the Regional Floodplain Database (RFD) Project. Stage 1 of the RFD Project involved a pilot study and various sub-projects that have provided the basis for the overall project methodology.

UPR and SID make up ‘Package 1’ and STA, NEU, MAR and BYR make up ‘Package 5’ of MBRC’s Stage 2 RFD Project.

This report details the project methodology, results and outcomes associated with the UPR minor basin investigation.

## 1.1 Scope

The scope of this flood modelling investigation was to carry out detailed hydrologic and hydraulic modelling over the UPR minor basin. The results from the detailed modelling of Upper Pine River will provide Council with an enhanced understanding of the flood behaviour in the minor basin for a large range of flood events from the 1 year Average Recurrence Interval (ARI) event to the Probable Maximum Flood (PMF).

## 1.2 Objectives

The objectives of this study are:

- Development of computer based hydrologic and hydraulic modelling suite for the Upper Pine River minor basin based on standardised modelling procedures and modelling input parameters specific for the RFD study minor basins.
- Use of the developed models to predict where and how flooding may occur in the Upper Pine River minor basin.

The associated model outputs are to be included in the RFD for delivering seamless information about flood behaviour across the entire MBRC LGA.

## 1.3 General Approach

The detailed hydrologic and hydraulic modelling undertaking for the UPR minor basin has involved the following tasks:

- Refine the broadscale WBNM2010 hydrologic model established for UPR minor basin in Stage 1 RFD project;
- Establish a detailed 1D/2D coupled TUFLOW model to investigate flood behaviour for the UPR minor basin utilising the topographic information, roughness values, inflow and other boundary condition information determined in previous sub-projects as detailed in Table 1-1;
- Undertake separate critical duration assessments for simulation of a range of storm durations for the 10 and 100 year ARI design events and the Probable Maximum Flood (PMF) event;
- Select three (3) critical durations for each design event from the above separate critical duration assessments as follows:
    - 1 to 10 year ARI events, determined by the 10 year ARI critical duration assessment;
    - 20 to 100 year ARI events, determined by the 100 year ARI critical duration assessment; and
    - 200 year ARI to PMF events, determined by the PMF critical duration assessment;
- Simulate 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI and PMF events for the three (3) selected critical durations for each design event;
- Simulate the 100 year ARI 15 minutes Burst in 270 minutes envelope Embedded Design Storm (EDS);
- Assess model sensitivity to Manning's 'n' and blockage of culverts;
- Assess climate change scenario by 20% increase of rainfall intensity over the UPR minor basin;
- Assess future landuse scenario by increased vegetation coverage and residential development on the floodplain; and
- Provide a concise report describing the adopted methodology, study data, model results and findings.

## 1.4 Related Sub-Projects (RFD Stage 1 & Stage 2 Pilot)

Table 1-1 summarises the previous related sub-projects (as part of the RFD Stage 1) for the purposes of providing input data and or methodologies to this RFD Stage 2 project:

**Table 1-1 Related Previous Sub-Projects**

| Sub-Project | Origin | Scope |
|---|---|---|
| 1D – Hydrologic and Hydraulic modelling (Broadscale) | BMT WBM (2010) | To define model naming conventions and model protocols to be used in the RFD project |
| 1E – Floodplain Topography (2009 LiDAR) | WorleyParsons (2010a) | To provide the topographic information, such as model z-pts layer and digital elevation models (DEM) utilising a DEM tool developed specifically for the RFD |
| 1G – Hydrography | MBRC | To supply the sub-catchment delineation of Burpengary minor basin including a stream line and junctions (used in the WBNM model) |
| 1H – Floodplain Landuse | SKM (2010a) | To deliver the current percentage impervious cover (utilised in the hydrologic model) and the roughness Manning's 'n' values (utilised in the hydraulic model) |
| 1I – Rainfall and Stream Gauges Information Summary | MBRC | To summarise available rainfall and stream gauge information for the study area |
| 2B – Detailed modelling of the Burpengary Creek minor basin | BMT WBM (2010) | The pilot study for the RFD Stage 2. One of the key outputs of this sub project was to develop a general modelling methodology and structure as an overall guideline for all detailed modelling being undertaken in Stage 2 of the RFD |
| 2C – Floodplain Structures (Culverts) | Aurecon (2010) | To supply a GIS layer of the culverts to be included in the hydraulic model for the RFD project |
| 2D - Floodplain Structures (Bridges) | Aurecon (2010) | To provide a GIS layer of the major road bridges and foot bridges to be included in the hydraulic model for the RFD project |
| 2F – Floodplain Structures (Trunk Underground Drainage) | Aurecon (2010) | To provide trunk underground drainage information for the RFD project |
| 2G - Floodplain Structures (Basins) | Aurecon (2010) | To consolidate and survey the existing basin information for the RFD project |

| Sub-Project | Origin | Scope |
|---|---|---|
| 2I - Floodplain Structures (Channels) | Aurecon (2010) | To identify channels within the minor basins |
| 2J – Floodplain Landuse (Historic and Future) | SKM (2010a) | To define the historic and future percentage impervious cover (utilised in the hydrologic model) and the roughness (Manning's 'n') values representing landuse for the February 1999 event (utilised in the hydraulic model) |
| 2K – Flood Information Historic Flooding | GHD (2010) | To locate and survey flood levels for the May 2009 and February 1999 historic flood events |
| 2L – Design Rainfall and Infiltration Loss | WorleyParsons (2010b) | To develop the hydrologic models for the Burpengary Creek minor basin and provide the design rainfall hydrographs for the TUFLOW models |
| 2M – Boundary Conditions, Joint Probability and Climate Risk Scenarios | SKM (2012b) | To define the boundary conditions and provide recommendations in regards to joint probability (i.e. occurrence of storm surge in combination with river flooding events, or river flooding in combination with local tributary flooding). This project also recommended certain sea level rise and rainfall intensity values to assess Climate Risk Scenarios |
| 2N – Floodplain Parameterisation | SKM (2012c) | To provide recommendations of the floodplain parameters, such as a range of values for various impervious percentages for various landuse types (i.e. residential or rural landuse, dense vegetation), a range of values for various roughness types (i.e. long grass, dense vegetation) and structure losses |

# 2 AVAILABLE DATA

The following list summarises the data available for the study:

- Floodplain Topography - DEM Tool to create 2.5m DEM and model Z-pts (model topography) The topography is based on LiDAR (Light Detection And Ranging) data collected in 2009 and data provided by Department of Environment and Resource Management (DERM) to MBRC;
- Hydrography - hydrography dataset (sub-minor basin delineation) supplied by MBRC;
- Floodplain Landuse – polygons for nine (9) different landuse categories provided by MBRC and developed by SKM (2010a) as part of RFD Stage 1;
- Floodplain Structures – DTMR and QT structures prepared by Aurecon (2010) and provided by MBRC in TUFLOW readable format. Other structure provided by MBRC in the form of as constructed drawings and detail survey;
- Design Rainfall – amendment of WBNM models, development of design simulations and provision of design rainfall hydrographs;
- Boundary Conditions, Joint Probability and Climate Risk Scenarios – report with recommendations for boundary conditions, joint probability and climate change scenarios; and
- Floodplain Parameterisation – recommendations for impervious percentages for various landuse types, roughness types and structure losses.

## 2.1 Qualification to Report Findings

It is important to appreciate that the accuracy of the information presented in this report is entirely dependent on the accuracy of these available data. Therefore, the interpretation of information presented in this report should be done so with an understanding of any limitations in their accuracy.

Factors for consideration:

- All data listed above have been provided by Moreton Bay Regional Council for the purpose of developing this model. WorleyParsons have assumed the accuracy of this data and suitability of use for this study, and have not critically reviewed this information. In particular, topographic information has been provided by MBRC, and the flood assessment predictions are based on the accuracy of this data;
- Recognition that no two floods behave in exactly the same manner and the data provided for use cannot represent conditions for all possible flood scenarios. Therefore, the results presented may not exactly replicate the flooding behaviour of an actual flood event;
- Design floods are considered a best estimate of an “average” flood for their probability of occurrence. It is assumed that these data provide the best estimate of the average;

- Over time further information may become available that could impact on the outcomes of the study as presented in this report. Council should be mindful of new information that may impact the outcomes as presented in this study and consider appropriate actions to address possible changes to findings;
- Flood study analysis relies on the requirement to have a freeboard between the predicted average recurrence interval flood event and land levels used for development purposes. The freeboard accounts for variation in modelling assumptions and impacts not accounted in the analysis such as wave action. Accordingly flood levels from this study will need to be used with freeboard allowances contained in the applicable MBRC Town Planning Scheme; and
- This analysis has been carried out using industry standard software and methods considered industry best practice at the time of the study.

# 3 METHODOLOGY

## 3.1 Data Review

### 3.1.1 Infrastructure Data Assessment

WorleyParsons completed a report entitled "*Infrastructure Data Assessment Report Package 1*" in October 2010. The purpose of the report was to review, identify and prioritise any additional floodplain infrastructures as well as the existing data for both Upper Pine River (UPR) and Sideling Creek (SID) minor basins that is necessary to complete the detailed modelling for the Stage 2 RFD project. The infrastructures assessed within the minor basins included:

- Structure junctions
- Hydraulic structures
- Basins and dams
- Buildings in the floodplains

A copy of the "*Infrastructure Data Assessment Report Package 1*" is included in Appendix A.

### 3.1.2 Calibration and Validation

WorleyParsons completed a report entitled "*Calibration and Validation Feasibility Report Package 1*" in November 2010. The purpose of the report was to assess the feasibility of carrying out historical event model calibration and validation for the Upper Pine River (UPR) and Sideling Creek (SID) minor basins as part of the Stage 2 RFD project. The report identified five (5) river gauges in the vicinity of UPR minor basin with potential historical data for the purpose of model calibration/validation.

A copy of the "*Calibration and Validation Feasibility Report Package 1*" is included in Appendix C.

Based on the recommendations from the feasibility study report, MBRC has decided to carry out model calibration to the January 2011 event and validation to the May 2009 event based on available data. Sections 3.4 and 4.1 provide a detailed description on the two calibration/validation modelling runs.

### 3.1.3 Hydrography

WorleyParsons completed a report entitled "*Hydrography Review Report Package 1*" in November 2010. The purpose of the report was to review the supplied hydrography data against other data provided for the Stage 2 RFD project including aerial imagery and a 2.5m grid aerial LiDAR digital elevation model and identify issues in the supplied data as well as make recommendations to improve the suitability of the hydrography for use in the Stage 2 RFD project. Most of the recommendations in the report have been adopted by MBRC and the sub-catchment delineation for UPR minor basin was updated and re-issued.

A copy of the "*Hydrography Review Report Package 1*" is included in Appendix B of this report.

## 3.2 Hydrologic Model

The WBNM (Watershed Bounded Network Model) software was nominated by MBRC as the hydrologic software package to be used for the RFD to calculate inflow hydrographs for the hydraulic model described in Section 3.3 of this report.

WBNM is an event based hydrologic model that was developed at the University of Woolongong and is widely used throughout Australia. The model calculates flood flow hydrographs from storm rainfall hyetographs and can simulate the behaviour of hydraulic structures including weirs, culverts and diversion works. The model routes runoff from upstream sub-areas through the current sub-area and adds the routed flow to the excess rainfall that is routed separately through the sub-area. The model can be used for natural, partly urban and fully urbanized minor basin using different lag factors for pervious and impervious areas.

Detailed hydrologic model parameters, such as adopted losses, design gauge locations and Intensity Frequency Duration (IFD) data are described in the Regional Floodplain Database Design Rainfall - Burpengary Pilot Project Report (WorleyParsons, 2010b). Other model input data, such as landuse and minor basin delineation, was provided through other sub-projects outlined in Section 1.4 of this report. Table 3-1 below summarises the ultimate rainfall loss and model lag parameters adopted for the current UPR WBNM model.

**Table 3-1 Rainfall Loss and Model Lag Parameters**

| Loss Parameters | | Sub-area Lag Parameter |
|---|---|---|
| Initial | Continuing | |
| 0mm | 2.5mm/hour | 1.6 |

## 3.3 Hydraulic Model

### 3.3.1 Model Selection

Because of the complex nature of floodplain flow patterns in urban and rural minor basins, MBRC has adopted TUFLOW, a dynamically-linked 2D/1D hydrodynamic numerical model, to predict the flood behaviour of a minor basin. TUFLOW has the ability to:

- Accurately represent overland flow paths, including flow diversion and breakouts (2D modelling);
- Model the waterway structures of the entire minor basin with a relatively high level of accuracy (1D or 2D modelling);
- Dynamically link components of the 1D models (i.e. culverts) to any point in the 2D model area; and
- Produce high quality flood map output (i.e. flood extent, flood levels, depths, velocities, hazard and stream power), which are fully compatible with Geographic Information Systems (GIS).

A brief description of TUFLOW is provided in the following sections.

### 3.3.2 Model Geometry

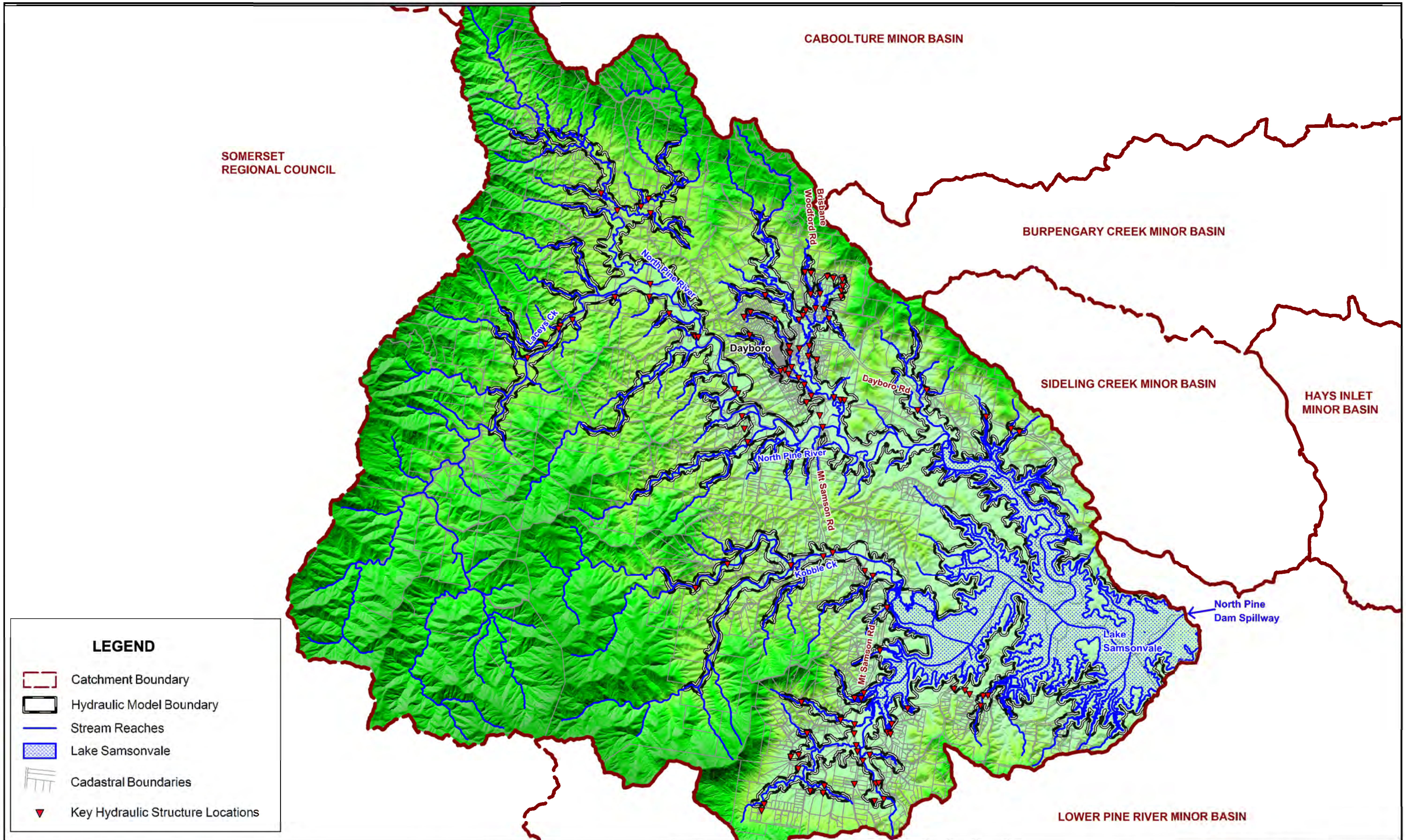
The North Pine River originates near Mount Pleasant (Elevation 522m AHD) drains generally in an easterly direction into North Pine Dam behind Lake Samsonvale. Laceys Creek, Terrors Creek and Kobble Creek are the major tributaries of North Pine River. Construction of the North Pine Dam was completed in 1976 with a capacity of approximately 200GL. The primary purpose of the dam is for water supply. The dam has limited storage available above full supply level (FSL) for flood mitigation. The total catchment area of UPR minor basin including Lake Samsonvale and North Pine Dam is approximately 348 $km^2$.

Due to the large catchment size of the UPR minor basin, the TUFLOW model has been constructed in two (2) chosen model cell sizes with a horizontal grid orientation (zero rotation). The horizontal grid orientation approach was selected as part of the development of the RFD to ensure consistency of model parameters across the entire RFD study area. The two chosen model cell sizes are detailed below:

- 5m cell to carry out all the selected critical duration runs for the 1 year to 100 year ARI design events to ensure highest resolution design event flood results can be achieved for the UPR minor basin. However, the 5m cell model requires extensive model run time to complete one flood event run.
- 10m cell to carry out all the other event model runs including very large and extreme events, calibration/validation and model sensitivity analysis runs. Other than the cell size, all model input parameters are identical to the 5m cell model. The chosen 10m cell size is considered to be sufficiently detailed to determine flood behaviour for the extreme events, calibration and sensitivity analysis runs without extensive model run times.

The model topography was derived from the DEM tool (WorleyParsons, 2010) including the DEM modifiers utilising the 2009 ALS data developed for the RFD project. During Stage 1 RFD studies, stream and road modifiers were used in the DEM tool to ‘carve out’ streams and define road embankments in the Z-pts layer. However, in the current RFD Stage 2 studies, the DEM tool has been updated so that roads are modified after the streams, avoiding the need to further modify the topography in TUFLOW.

The combination of the above features has allowed for the development of catchment-wide flood models, providing detailed flood information across the entire UPR minor basin. Figure 3-1 illustrates the UPR model layout.



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**REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)**
**UPPER PINE RIVER**
**FIGURE 3.1 - HYDRAULIC MODEL LAYOUT**

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### 3.3.3 Model Structures

The majority of the UPR minor basin is established in the 2D domain in the TUFLOW model with the exception of Lake Samsonvale behind North Pine Dam. Lake Samsonvale and North Pine Dam are specifically established as a 1D element in the 1D domain. The 1D approach to represent the dam storage has adopted in order to significantly reduce the model run time.

To ensure the 1D approach for modelling Lake Samsonvale in the UPR model will produce the same result as in a full 2D model, a number of iteration runs of the UPR model have been undertaken to optimise a set of 1D modelling parameters to represent Lake Samsonvale and North Pine Dam that is able to produce good matching spillway outflow hydrographs against the full 2D modelling results.

A 1D network with a number of nodes from the top of Lake Samsonvale to North Pine Dam spillway has been constructed to represent the storage routing through the Dam. The supplied DEM for the UPR minor basin has been used to generate a level-nodal area relationship to represent the overall storage of Lake Samsonvale. Each node within the 1D network is distributed with a level-nodal area relationship to represent the proportional storage relative to the location of the node. This is to ensure the storage is distributed throughout the Lake and the level-storage relationship is preserved in the TUFLOW model.

The downstream boundary, located at the North Pine Dam spillway is specified in the 1D domain and the initial water level of the North Pine Dam has been assumed to be at Full Supply Level (FSL) at 39.60mAHD for all design event runs. The SEQWater spillway rating curve for the North Pine Dam is adopted and applied to the 1D downstream boundary. Details of the SEQWater spillway rating curve are discussed further in Section 3.3.5 of this report.

A total of some 121 culverts and 7 bridges have been included in the UPR TUFLOW model. Culvert crossings were typically modelled as 1D elements. Flow over structures was modelled within the 2D domain. Bridges and footbridges were also represented in the 2D domain. Structure details were provided by MBRC in the form of as constructed drawings and detail survey.

The adopted exit and entry loss coefficients, applied to the hydraulic structures, have been based on recommendations from Sub-project 2N (SKM, 2012c).

### 3.3.4 Landuse Mapping

Landuse mapping was used to define the spatially varying hydraulic roughness within the hydraulic model. In total, nine (9) different types of landuse based on recommendations from Sub-project 2N (SKM, 2012c) were mapped across UPR minor basin, together with associated Manning's 'n' values as presented in Table 3-2 and Figure 3-2.

**Table 3-2 Hydraulic Model Roughness and Landuse Categorisation**

| Landuse Type | Manning’s ‘n’ Roughness Coefficient |
|---|---|
| Dense vegetation | Depth varying Mannings ‘n’ |
| Medium dense vegetation | Depth varying Mannings ‘n’ |
| Low Grass/Grazing | Depth varying Mannings ‘n’ |
| Reeds | 0.080 |
| Crops | 0.040 |
| Roads/Footpaths | 0.015 |
| Buildings | 1.000 |
| Waterbodies | 0.030 |
| Urban block | 0.300 |

Footpaths within open space areas were excluded from the model, as these features are typically finer than the model grid resolution. In some locations where there were sudden changes in roughness across one or a few cells (e.g. narrow roads crossing dense vegetation), roughness was locally modified to resolve associated modelling instabilities.

In highly developed blocks larger than 2000m², the urban block category was used (Manning’s ‘n’ of 0.3). In addition, an individual buildings layer (building footprint) was used for areas outside the high residential development (Manning’s ‘n’ of 1.0 i.e. total blockage at buildings).

Based on  the results from the calibration and validation runs, MBRC has adopted a depth varying Manning's ‘n’ approach (Sub-project 2N, SKM 2012c) to globally represent the hydraulic roughness for the dense, medium dense and low grass grazing vegetation landuse profiles.

The change in roughness factors with increasing depth of water represents the increased obstruction to flow caused by branches and foliage of trees, compared to individual tree trunks at lower depths and the reduction in vegetation retardance due to flattening of grasses with increasing depth of flow.

The depth varying Manning’s ‘n’ relationships for the above vegetation profiles are summarised in

Table 3-3.

**Table 3-3 Depth Varying Manning’s ‘n’**

| Depth y(m) | Manning’s ‘n’ | | Depth y(m) | Manning’s ‘n’ |
|---|---|---|---|---|
| | Dense Vegetation | Medium Dense Vegetation | | Low Grass Grazing |
| 0 | 0.090 | 0.075 | 0 | 0.250 |
| 1.5 | 0.090 | 0.075 | 0.2 | 0.060 |
| 3.5 | 0.180 | 0.150 | 0.4 | 0.045 |
| 99.0 | 0.180 | 0.150 | 0.8 | 0.035 |
| | | | 2.0 | 0.025 |
| | | | 99.0 | 0.025 |

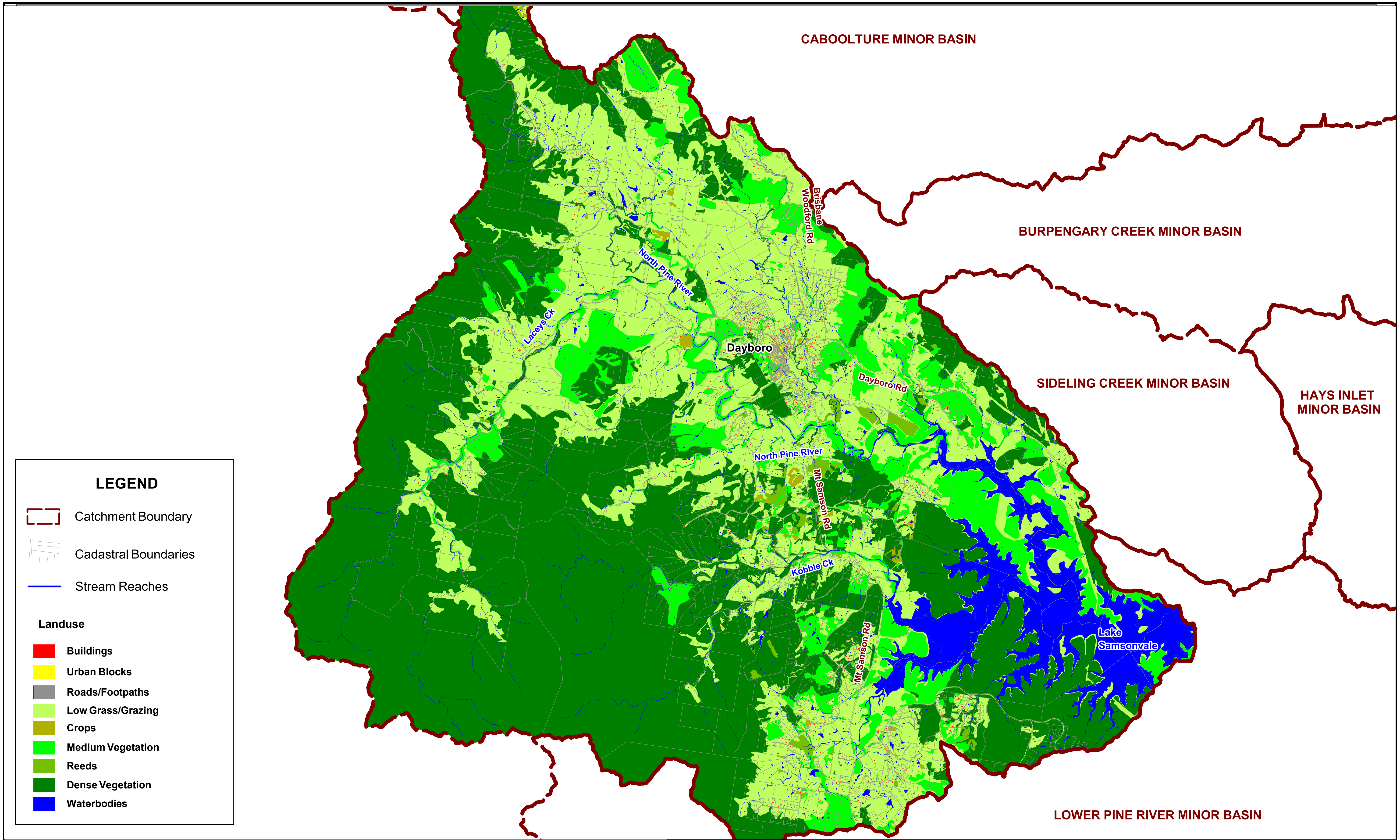




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**FIGURE 3.2 - LANDUSE MAPPING - EXISTING CONDITIONS**

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### 3.3.5 Model Boundaries

The results from the WBNM hydrologic model were used to generate inflow hydrographs for the hydraulic model for all design events, as discussed in Section 3.1. The inflows were applied to the 2D domain using a flow-time source boundary for each sub-catchment. This technique applies the inflow at the lowest grid cell in a sub-catchment initially and then subsequently to all wet cells in that sub-catchment. Inflows for the sub-catchments over Lake Samsonvale were applied to the 1D network specified for the Lake at appropriate nodes.

A revised SEQWater stage discharge relationship (H-Q) rating curve for North Pine Dam spillway has been adopted by MBRC as the downstream boundary condition of the UPR hydraulic model. This rating curve was revised by SEQWater following the January 2011 major flood event. The North Pine Dam spillway rating curve is outlined in Figure 3-3.

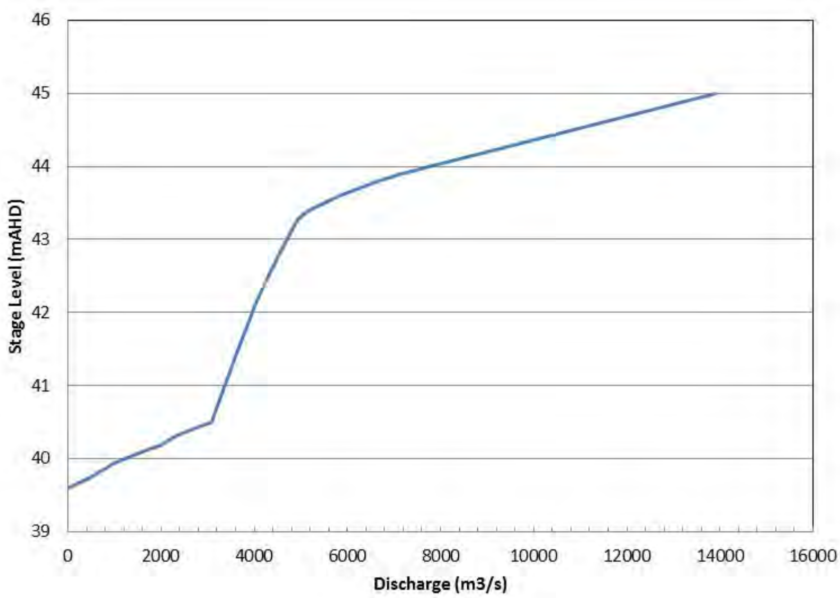



**Figure 3-3 North Pine Dam Spillway Stage-Discharge Rating Curve**

## 3.4 Model Calibration and Validation

The UPR TUFLOW model has been calibrated and verified against the following two historical events:

- January 2011 (calibration event); and
- May 2009 (validation event).

These events were chosen by MBRC due to the availability of rainfall, river stream gauge data and the availability of flood marks. Calibration and validation outcomes are provided and discussed in Section 4.1 of this report.

## 3.5 Design Flood Events

Design storm events are hypothetical events that are used to estimate design flood conditions. They are based on a probability of occurrence, frequently specified as an Average Recurrence Interval (ARI).

### 3.5.1 Critical Storm Duration Assessment

Critical storm durations were selected based on the hydraulic models results, rather than hydrologic model results. This means that the critical duration was selected based upon the maximum flood levels rather than flows. Separate assessments were undertaken for the minor events (1, 2, 5 and 10 year ARI event), moderate and major events (20, 50 and 100 year ARI), very large events (200, 500, 1000, 2000 year ARI and the probable maximum flood (PMF) event).

The following methodology was adopted to determine the critical storm durations for the UPR model:

- WBNM hydrologic modelling of a range of 10, 100 year ARI and PMF standard storm durations (from 30 minutes to 72 hours) to calculate inflow hydrographs for the TUFLOW hydraulic model.
- TUFLOW hydraulic modelling of 10, 100 year ARI and PMF to calculate peak flood levels for all the studied storm durations.
- Mapping of the peak flood level results for the ‘maximum envelope’ of all the 10, 100 year ARI and PMF standard storm durations.
- Selection of three critical durations for each ARI storm event based on the storm durations generating the highest flood levels across the most widespread and developed areas.
- Mapping of the peak flood level results for the ‘maximum envelope’ of the selected three storm durations for each storm event.
- Difference comparison between the mapped peak flood levels for the three selected critical durations and the results accounting for all storm durations for each of the storm event.
- The critical duration storms resulting in the least difference, compared with the mapping of the full envelope of durations, were then adopted throughout the studied storm events ranging from 1 year to PMF events.

A summary of the three selected critical storm durations for UPR model for all events assessed is outlined in Table 3-4. A comparison of the 10, 100 year ARI and PMF peak flood levels is illustrated in Figure 3-4 to Figure 3-6 respectively. The figures demonstrate that the three selected critical storm durations have dominated the 10, 100 year ARI and PMF peak flood levels across the study area.

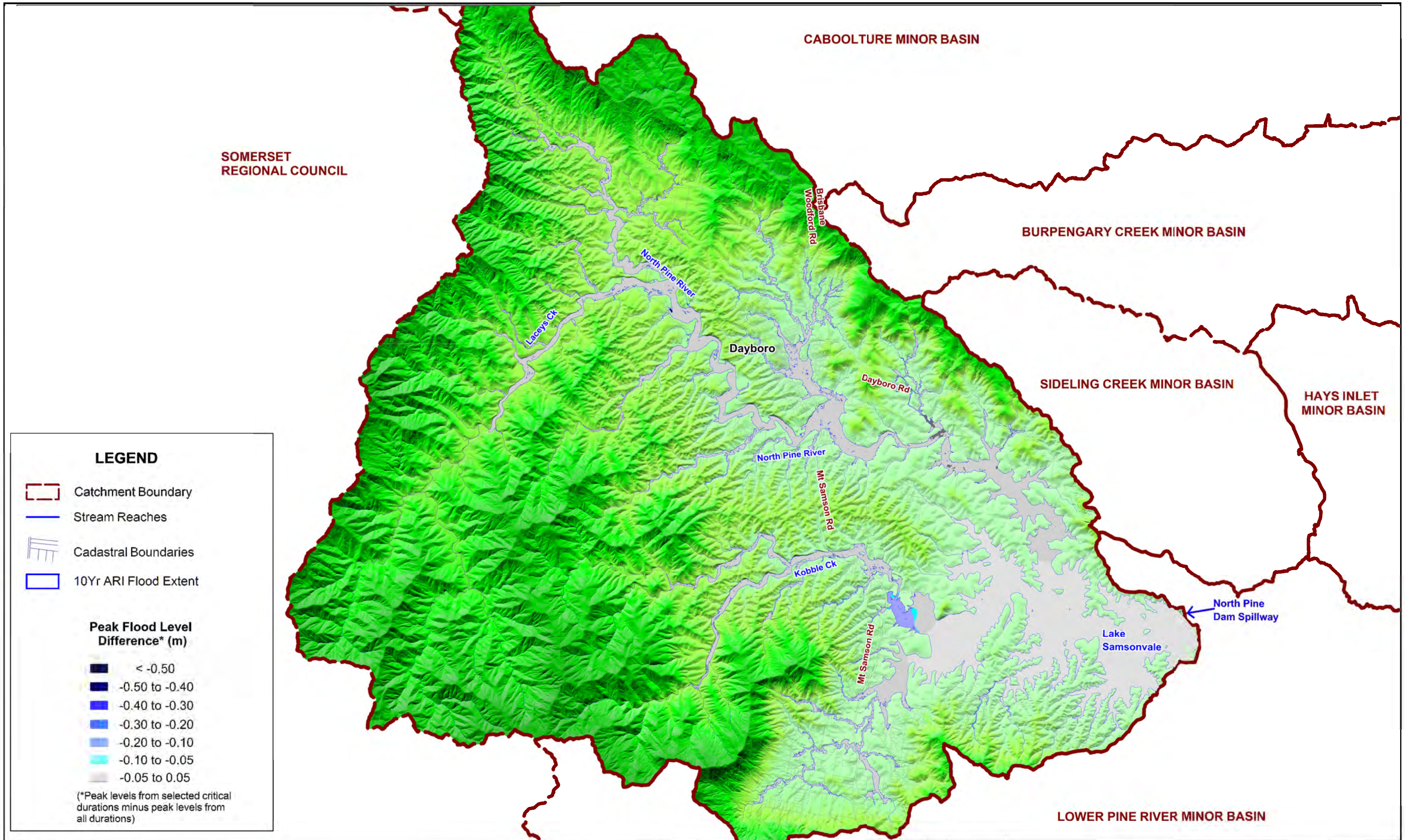
**Table 3-4 Critical Duration Selection**

| Assessment Event | Selected Critical Durations | Adopted Event |
|---|---|---|
| 10 year ARI | 2hr, 3hr and 24hr | 1, 2, 5 and 10 year ARI |
| 100 year ARI | 2hr, 3hr and 24hr | 20, 50 and 100 year ARI |
| PMF | 2hr, 3hr and 5hr | 200, 500, 1000, 2000 year ARI and PMF |

### 3.5.2 Design Event Simulations

As discussed in the previous section, the UPR model was simulated for a range of Average Recurrence Intervals (ARI) and storm durations which has included:

- Minor events – 1, 2, 5 and 10 year ARI events;
- Moderate and major events – 20, 50 and 100 year ARI events; and
- Very large and extreme events – 200, 500, 1000, 2000 year ARI and PMF events.



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**REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)**
**UPPER PINE RIVER**
**FIGURE 3.4 - CRITICAL DURATION ASSESSMENT**
**PEAK FLOOD LEVEL DIFFERENCE - 10 YEAR ARI**

| Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0067 | Rev: 0 |
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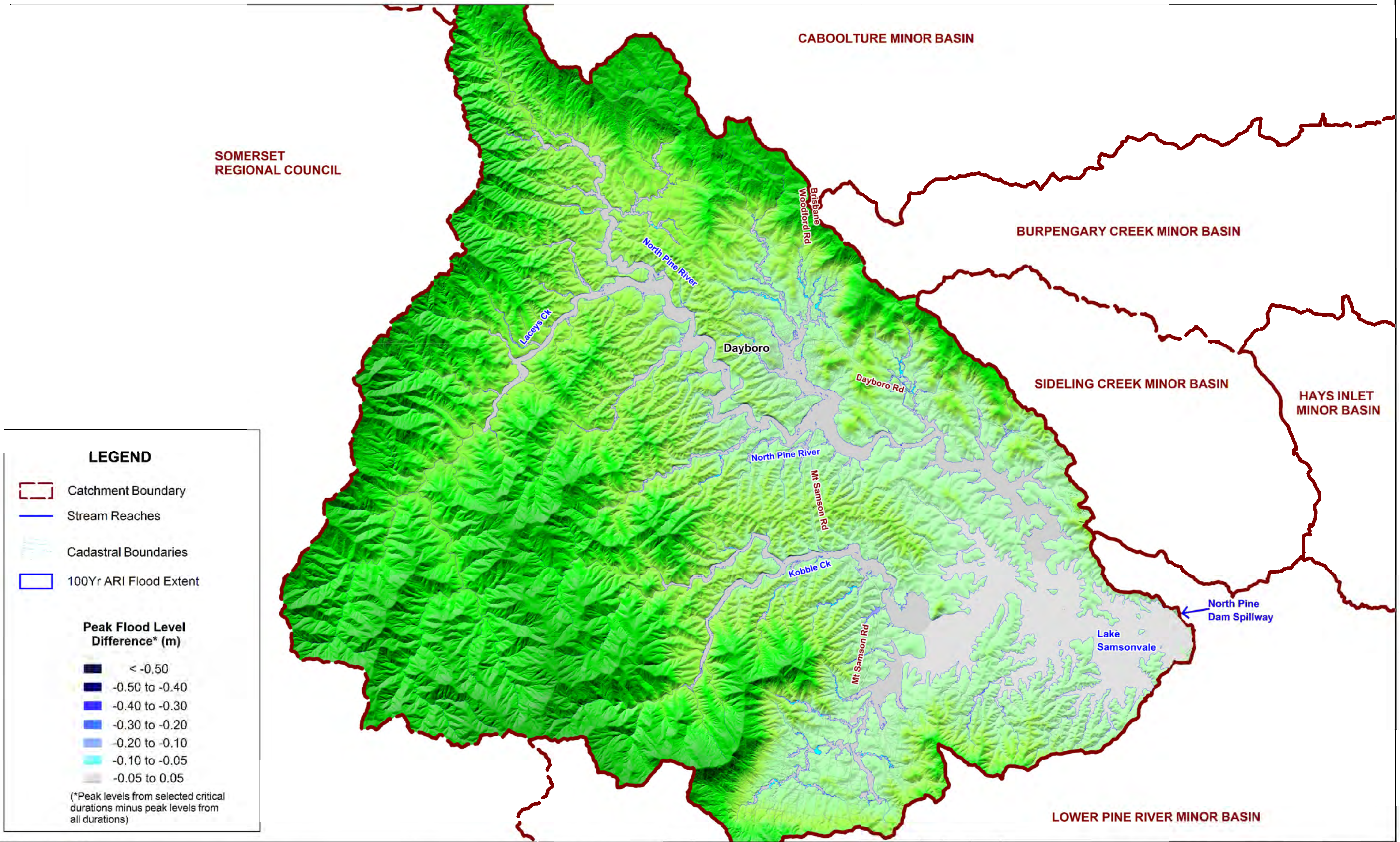




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**REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)**
**UPPER PINE RIVER**
**FIGURE 3.5 - CRITICAL DURATION ASSESSMENT**
**PEAK FLOOD LEVEL DIFFERENCE - 100 YEAR ARI**

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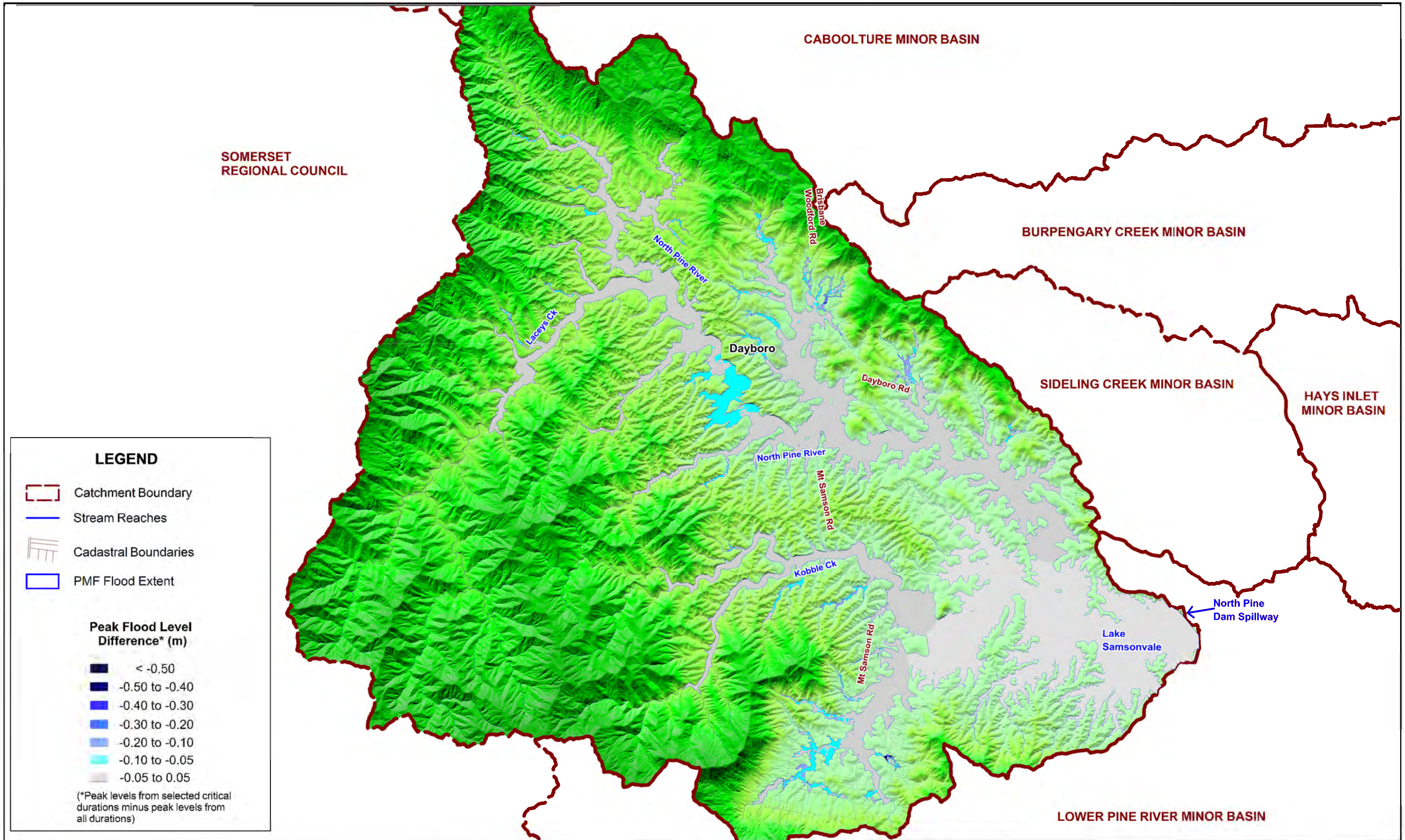




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**REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)**
**UPPER PINE RIVER**
**FIGURE 3.6 - CRITICAL DURATION ASSESSMENT**
**PEAK FLOOD LEVEL DIFFERENCE - PMF**

| Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0069 | Rev: 0 |
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## 3.6 Sensitivity Analysis

MBRC adopted the use of a single EDS which approximates the flood levels and behaviour of the 100 year ARI critical duration design events. The EDS is useful for initial investigations into changes in model parameters and catchment characteristics, as it reduces the number of model runs required.

The 15 minutes burst in a 270 minutes storm envelope duration provides the best representation across all minor basins within the MBRC LGA. Therefore, the 100 Year 15 minutes burst in a 270 minutes envelope EDS has been adopted for the UPR model.

The adopted EDS storm was utilised as a base case for the assessment of model sensitivity, climate change and future landuse scenarios as discussed in the following sections below.

### 3.6.1 Future Landuse Analysis

Three (3) future landuse scenario model runs utilising the 100 year EDS event have been undertaken to assess the potential impact of flooding as a result of future development in the Upper Pine River floodplains upstream of North Pine Dam. The three future landuse scenarios are:

- Assessment of the potential impact of increased vegetation in the Upper Pine River floodplains through the materials layer by
    - Changing medium dense vegetation to high density vegetation; and
    - Changing low grass/grazing to medium dense vegetation.
- Assessment of the potential impact of increased residential development in the Upper Pine River floodplains by raising the impervious percentage in the WBNM hydrologic model at future residential development areas determined by MBRC to calculate inflow hydrographs for the TUFLOW model. The TUFLOW model was then run with the increased inflow hydrographs to assess the impact of future landuse as a result of increased residential development.
- A combination of increased vegetation and residential development in the Upper Pine River floodplains.

The results of the above scenario model runs were then compared to the 100 year EDS base case results to assess the potential flood impact to the UPR minor basin as a result of future development on the floodplains.

### 3.6.2 Hydraulic Roughness Analysis

To check the sensitivity of the adopted model roughness values, all Manning's 'n' values were uniformly increased by 20% and applied to the 100 year EDS model. Results of the increased Manning's "n" values run were then compared to the base case run results to check how sensitive the model is to the initial selection of the roughness values.

### 3.6.3 Structure Blockage Analysis

A structure blockage scenario in the 100 year EDS event was run to simulate the effects of waterway crossings (culverts) becoming blocked during a flood event. This is a reasonably common occurrence and may be the result of debris being washed into the waterways during a flood. Recent storm event showed that the blockage is generally caused by accumulated 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 the water out of the channel, often increasing overland flooding.

The sub-project 2N report provided by SKM (SKM, 2012c) compared three potential debris risk categories to the culvert opening size, to determine culvert blockage factors.

Table 3-5 summarises the blockage factors as presented in of the SKM report (Table 8-3 SKM, 2012c).

Based on the SKM blockage factors, MBRC has adopted the moderate blockage category to assess the culvert blockage sensitivity scenario in the UPR model with the following updated blockage factors:

- 100% blockage for all culverts/pipes with culvert diameter/width less than 2.4m; and
- 15% blockage for culverts/pipes with culvert diameter/width larger than 2.4m.

**Table 3-5 Blockage Categories and Factors (SKM 2012c)**

| Blockage Category/ Debris Potential | Culvert Blockage Condition | |
|---|---|---|
| | Full Blockage | Partial Blockage |
| High | If culvert < 6.0m diagonal | If culvert > 6.0m diagonal, apply 25% |
| Moderate | If culvert < 2.4m diagonal | If culvert > 2.4m diagonal, apply 15% |
| Low | If culvert < 1.2m diagonal | If culvert > 1.2m diagonal, apply 10% |

### 3.6.4 Climate Change and Downstream Boundary Condition Analysis

As determined by MBRC, a climate change assessment to investigate the potential impact of projected increases in rainfall intensity on flooding has been undertaken for the UPR minor basin. Downstream boundary condition sensitivity analysis for the UPR model is not required for this study due to the North Pine Dam spillway controlling outflow from the model.

The rainfall intensity increase assessment used for this study is based on the project 2M reports (SKM, 2012b). A 20% increase of rainfall to the 100 year EDS event was applied to the WBNM hydrologic model to calculate inflow hydrographs for the TUFLOW model. The TUFLOW model was then run with the increased inflow hydrographs to assess the impact of climate change as a result of increased rainfall.

# 4 RESULTS AND OUTCOMES

## 4.1 Calibration and Validation

### 4.1.1 Overview

Calibration and validation of the TUFLOW model was based on recorded flood level data collected in Sub-project 2K for the January 2011 and May 2009 historical events, respectively. Surveyed levels were provided for 33 flood marks for the January 2011 calibration event. The flood marks had been assigned reliability ratings, with 18 marks rated 'high' and the remaining 15 rated 'medium'. No surveyed flood levels were available for the May 2009 validation event.

In addition, stage hydrographs were obtained for the Baxter's Creek (May 2009 and January 2011 events) and Kobble Creek (January 2011 event) ALERT flood warning stations. The Baxter's Creek gauge is located on the middle reaches of the upper North Pine River, approximately 16 km upstream of Lake Samsonvale. The Kobble Creek gauge is located on the major southern tributary of the North Pine River, approximately 4 km upstream of Lake Samsonvale.

Stage hydrographs for Lake Samsonvale at North Pine Dam were obtained from SEQWater for both the January 2011 and May 2009 events.

As stated in Section 3.3.3 above, the entry and exit loss coefficients at hydraulic structures adopted for the TUFLOW model have been based on recommendations from Sub-project 2N (SKM, 2012c). Initial runs for the May 2009 and January 2011 events were undertaken using the parameters for the Burpengary Pilot Project. Following a calibration and validation exercise for this and the adjacent minor basins, MBRC selected the final hydraulic roughness parameters as stated in Section 3.3.4. Therefore, the calibration and validation of the TUFLOW model was undertaken primarily to validate the adopted model parameters, as no refinement of parameters was required by Council. The results using the final adopted parameters are discussed below.

### 4.1.2 January 2011 Results

The modelled peak flood levels were compared to the recorded flood levels and stage hydrographs.

The modelled peak flood levels were generally underestimated slightly with the median difference being -132mm and the range extending from -733mm to 949mm. The distributions of modelled differences are summarised in Table 4-1. The differences distributions show that approximately 40% of modelled levels are within ±200mm and 75% of modelled levels are within ±300mm for the event. A histogram showing the difference in flood levels versus the number of flood marks is presented in Figure 4-1. The spatial results of the January 2011 calibration are presented on Figure 4-2.

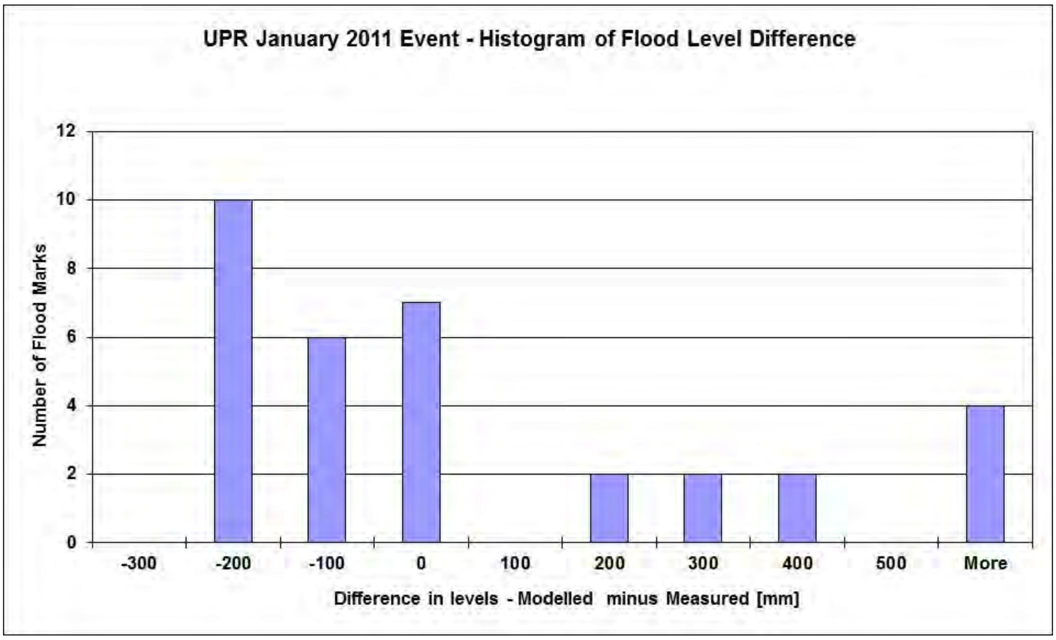
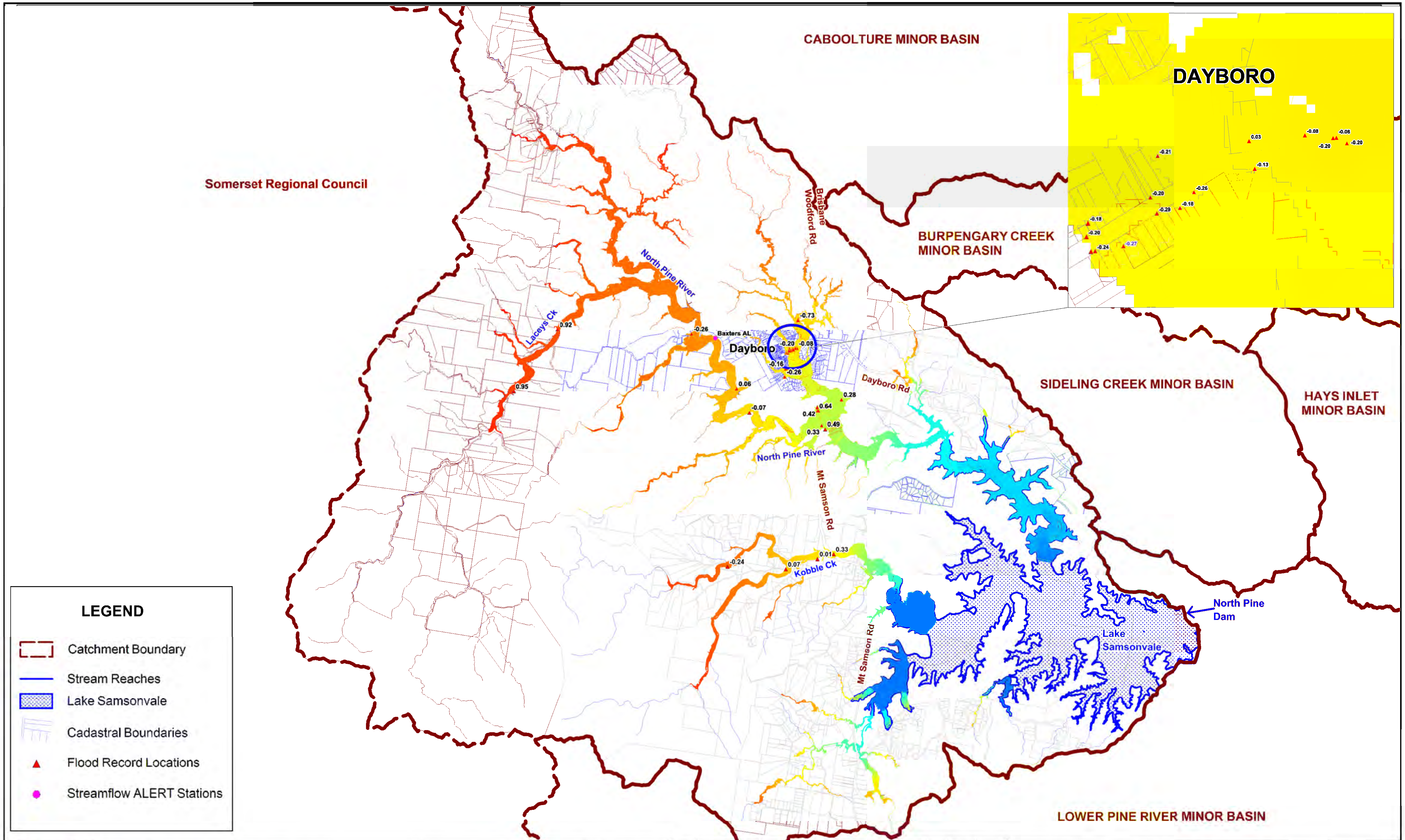



**Figure 4-1 Flood Level Comparison Histogram**

**Table 4-1 Summary of Modelled Differences in Peak Flood Levels**

| Parameter | January 2011 |
|---|---|
| Average (mm) | 8.5 |
| Median (mm) | -131.7 |
| Maximum (mm) | 949.3 |
| Minimum (mm) | -732.8 |
| No. within Range >1.0m | 0 |
| No. within Range 0.5m, 1.0m | 3 |
| No. within Range 0.4m, 0.5m | 2 |
| No. within Range 0.3m, 0.4m | 2 |
| No. within Range 0.2m, 0.3m | 2 |
| No. within Range 0.1m, 0.2m | 0 |
| No. within Range 0.0m, 0.1m | 4 |

| Parameter | January 2011 |
|---|---|
| No. within Range -0.1m, 0.0m | 3 |
| No. within Range -0.2m, -0.1m | 6 |
| No. within Range -0.3m, -0.2m | 10 |
| No. within Range -0.4m, -0.3m | 0 |
| No. within Range -0.5m, -0.4m | 0 |
| No. within Range -1.0m, -0.5m | 1 |



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**REGIONAL FLOODPLAIN DATABASE PROJECT (STAGE 2)**
**UPPER PINE RIVER**
**FIGURE 4.2 - FLOOD LEVEL COMPARISON**
**(MODELLED - MEASURED)**
**JANUARY 2011 EVENT**

Project No: 301001-01156 | Figure:301001-01156-EN-DAL-0070 | Rev: 0

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Comparisons of modelled and recorded stage hydrographs to the North Pine Dam, Baxters and Kobble gauges for the January 2011 event are presented on Figure 4-3 to Figure 4-5 respectively. As stated in Section 4.1.1, the TUFLOW model has been initially run using the hydraulic roughness parameters for the Burpengary pilot project and then run by the final adopted hydraulic roughness parameters.

It can be seen from Figure 4-3 that the modelled stage hydrograph for North Pine Dam showed good correlation with the recorded lake levels for the January 2011 flood event with respect to timing and peak level. The modelled peak lake level is some 100mm lower than the recorded level based on the final adopted hydraulic roughness parameter set.

The modelled stage hydrograph plots for Baxters and Kobble gauges also showed good correlation to timing. However, the model has overestimated the peak flood levels of the Baxters Creek gauge by about 1m and Kobble Creek Gauge by almost 2.5m as a result of the model being run with the final adopted hydraulic roughness parameter set.

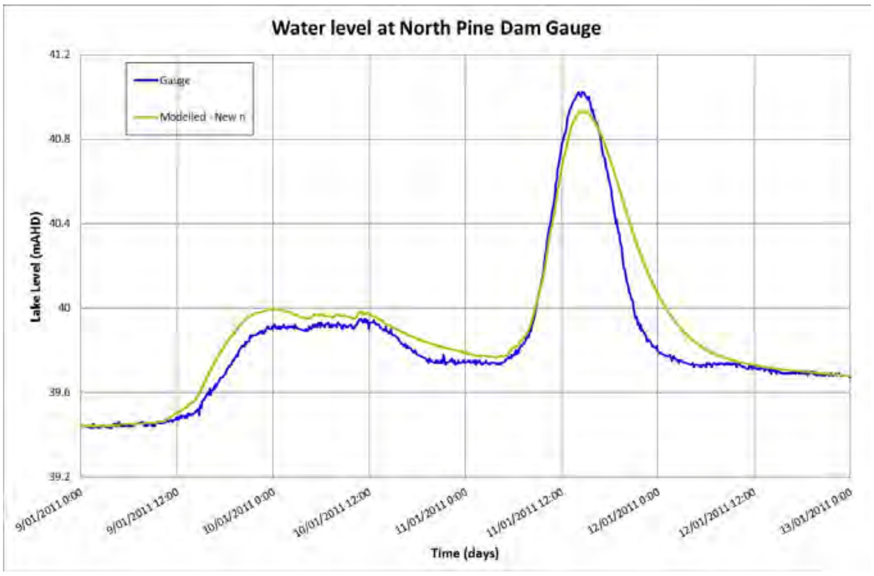


**Figure 4-3 Comparison of Stage Hydrographs – North Pine Dam 2011 Event**

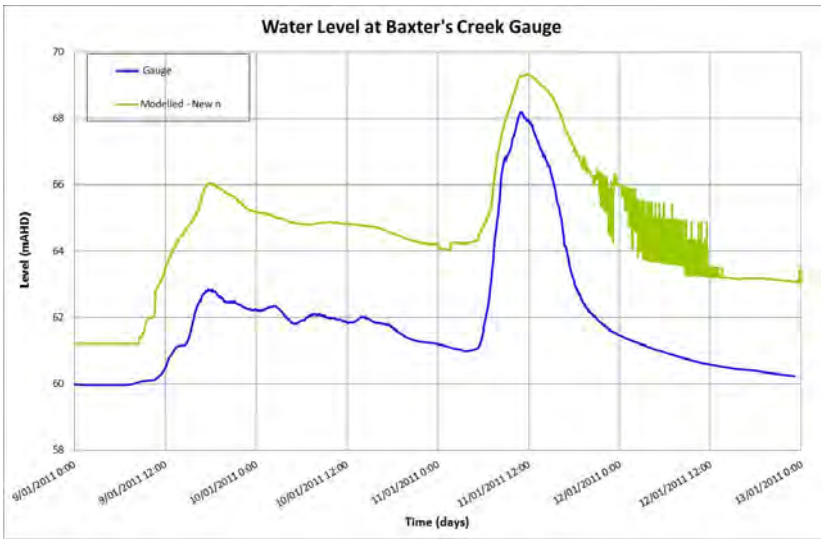


**Figure 4-4 Comparison of Stage Hydrographs – Baxters Creek Gauge 2011 Event**

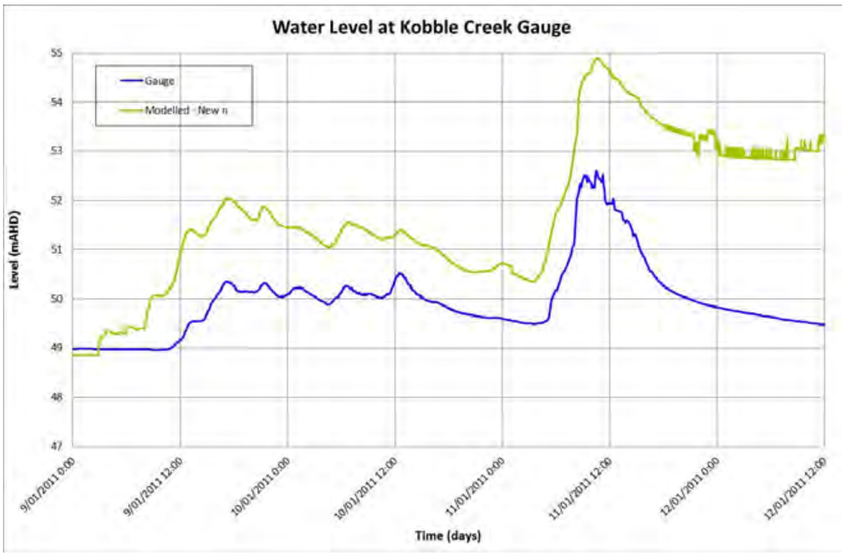


**Figure 4-5 Comparison of Stage Hydrographs – Kobble Creek Gauge 2011 Event**

### 4.1.3 May 2009 Results

A comparison of the modelled and gauged stage hydrographs at Baxters Creek and North Pine Dam for the May 2009 validation event is illustrated on Figure 4-7 and Figure 4-7 respectively. Both hydrograph plots show the rising limbs of the modelled stage hydrographs for the May 2009 event are approximately 12 hours in advance of the recorded lake level hydrograph. It is considered that the variation between modelled and recorded hydrographs is due to the WBNM hydrologic modelling of inflows.

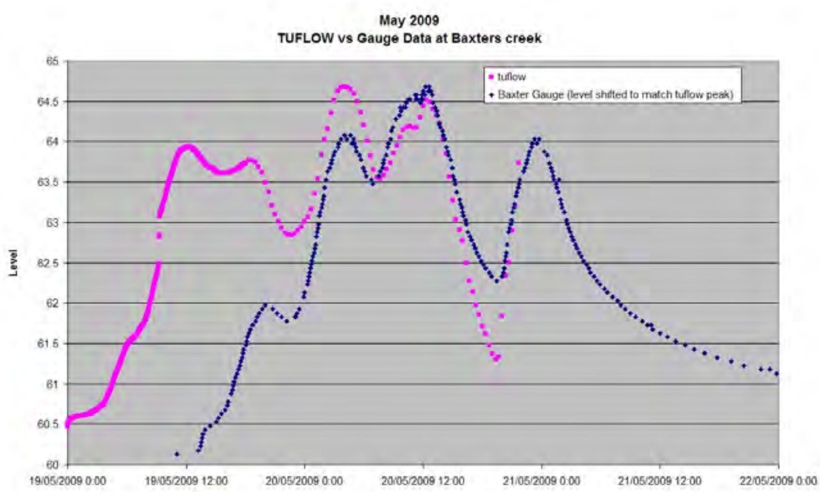


**Figure 4-6 Comparison of Stage Hydrographs – Baxters Creek Gauge 2009 Event**

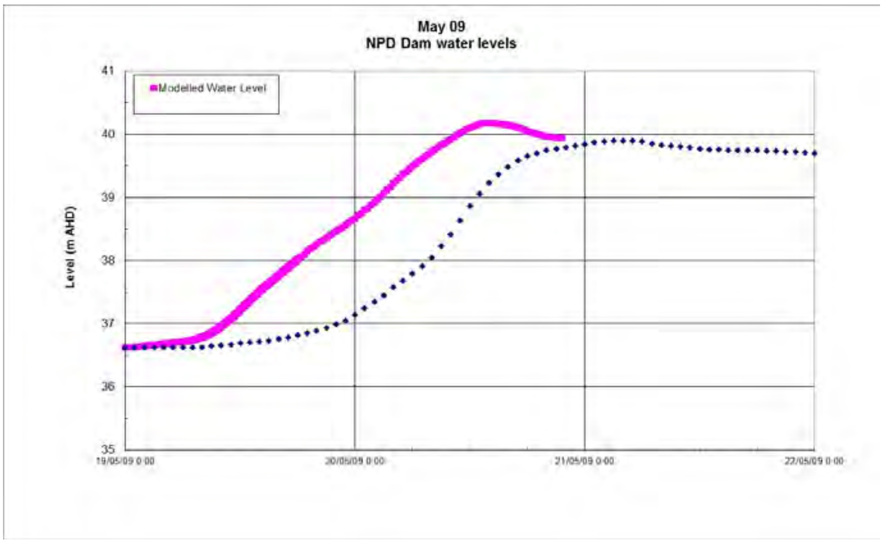


**Figure 4-7 Comparison of Stage Hydrographs – North Pine Dam 2009 Event**

### 4.1.4 Conclusion

Localised model adjustments may have resulted in better "fit" between the measured and modelled results. However such a course of action would be counter to Council's objective for a regionally consistent model library. Localised model adjustments may also mask underlying modelling uncertainties and input data limitations. The adopted parameter set was therefore considered on-balance to be appropriate to this model. It is also noted that this decision was reached by Council having regard to similar calibration and validation exercises in adjoining catchments. These results therefore need to be considered in the context of a regional calibration approach across multiple model domains.

## 4.2 Design Flood Behaviour

Design flood event modelling of minor basin runoff events was undertaken using the UPR TUFLOW model for the 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000 year ARI design events and the Probable Maximum Flood (PMF) event. For each design flood magnitude, the model was run for the three nominated storm durations (refer to Section 3.5.1).

The performance of the model was monitored throughout the simulation. Careful attention was to ensure that flows through the 1D elements in the model as well as flows over the floodplain in the 2D domain were stable. Overland flow hydrographs were checked at key locations in the floodplain and the North Pine Dam to ensure the simulation extended well beyond the peak throughout the study area. A modelling quality report of the UPR model has been included in Appendix D of this report.

General patterns of flood behaviour that can be observed from the UPR minor basin design run results include:

- Inundation is generally confined to a corridor less than 300m wide along each of the major tributary streams discharging into Lake Samsonvale.
- Extensive shallow flooding is predicted to occur where Kobble Creek and the nearby gullies enter the southern branch of Lake Samsonvale.
- Flooding in Terrors Creek, downstream of Dayboro is predicted to extend to approximately 500m in width.
- Channel velocities are generally in the range of 2 - 5m/s with overbank velocities being generally less than 1m/s.

### 4.2.1 Model Results

The following output types were used in the model to produce modelling results:

- Flood Levels (H flag);
- Flood Depth (D flag);
- Flood Velocity (V flag);
- Flood Velocity x Depth (Z0 flag);
- Flood Hazard based on NSW Floodplain Development Manual (DIPNR, 2005) (Z1 flag);
- Stream Power (SP flag);
- Unit Flow (q flag); and
- Inundation times (Times flag).

The model results were used to prepare a set of design flood map database, including inundation, peak flow velocity, hazard and stream power. The flood conditions for these flood map database were derived using the envelope (maximum) of the three selected critical storm durations for all studied events. Typical flood maps presented in Appendix E are the 100 year ARI design event as the focus of this project is on digital data, rather than provision of hardcopy flood maps. A description of the digital data provided to MBRC for incorporation into their RFD is summarised in Section 4.2.2.

### 4.2.2 Digital Data Provision

The Regional Floodplain Database is focused on structuring model input and output data in a GIS database held by MBRC. Therefore, all model input and output data in digital format will be provided to MBRC at the completion of the study. The digital data includes all model files and result files for all the design events, sensitivity analysis, climate change assessment and future landuse scenarios.

## 4.3 Sensitivity Analysis

The 100 Year Embedded Design Storm (EDS) with a 15 minutes burst and a 270 minutes envelope storm duration was simulated to form the base case for model sensitivity runs as described previously. The sensitivity runs undertaken for the UPR minor basin have included future landuse, hydraulic roughness, structure blockage and climate change scenarios.

A plot for comparing flood levels of the 100 year EDS base case run against the 100 year ARI design storm is provided in Figure F1 of Appendix F. The plot demonstrates that the predicted EDS flood levels at the upper reaches of the tributaries are generally +/- 100mm while at the middle reaches of the major tributary streams and the lower floodplains, the EDS flood levels are at the range of 100 to 200mm lower than the ARI design storms. Flood level at Lake Samsonvale is also some 50mm lower than the ARI design storms. This is due to EDS is a 15minute burst in a 270 minute duration storm whereas the majority of the UPR minor basin are dominated by the 24 hour critical storm. Therefore, the flood volume of the EDS is lesser than the ARI design storms resulting a lower flood level over the lower floodplains including Lake Samsonvale. It is recommended that future sensitivity analysis undertaken during model upgrades use the selected critical duration events rather than the EDS event in order to eliminate the under prediction of flooding for the UPR minor basin.

### 4.3.1 Future Landuse Analysis

The predicted difference in peak flood levels for the three (3) future landuse scenarios as described in Section 3.6.1 compared to the EDS Base Case are as follows:

*Increase of vegetation scenario*

A general increase in flood level by more than 500mm of flood levels along Laceys Creek and the upper reach of North Pine River upstream the confluence of Terrors Creek is observed due to significant change of vegetation profiles at these areas. At a section of the watercourse of Upper Pine River downstream Laceys Creek confluence, a maximum increase of some 2m of floodwaters is predicted.

The model has also predicted that flood levels along North Pine River downstream of Terrors Creek have been lowered by some 200mm due to the retardation of flood flow by the increased vegetation upstream. Figure F10 in Appendix F shows the difference in peak flood levels between existing and the future landuse (increase vegetation) conditions.

*Increase of residential development scenario*

The areas with potential increase of residential development are illustrated on Figure F11 of Appendix F (refer to Section 3.6.1). The model has predicted that there is no significant impact on flood level as a result of increased residential development to the catchment. This is due to most of the increased flow being attenuated during routing through the river channels.

*Combination of Increase Vegetation and Residential Development*

The modelling results showed that the flood profile for this scenario is mainly affected by increase of vegetation. Figure F12 in Appendix F shows the difference in peak flood levels between existing and a combination of increase vegetation and residential development conditions.

### 4.3.2 Hydraulic Roughness Analysis

A hydraulic roughness sensitivity scenario has been simulated to assess an increase in roughness coefficients. Figures F2 in Appendix F illustrates the difference in peak flood levels between the sensitivity run and the Base Case utilising the 100 year EDS.

Model results indicate that an increase in Manning's 'n' roughness coefficients by 20% generally results in an increase of peak levels about 200-300mm at the upper reach waterways. Flood level differences at the lower reach waterways upstream of Lake Samsonvale are generally within the range of ±100mm.

### 4.3.3 Structure Blockage Analysis

A structure blockage analysis has been simulated utilising the 100 year EDS model as described in Section 3.6.3 to assess impact to the UPR minor basin as a result of blockage of culverts. The difference in peak flood levels for the structure blockage modelling compared to the EDS Base Case is generally within the range of ±50mm. This is due to all the culvert crossings within the study area already being overtopped during the flood event in the base case scenario. As such, blockage of the culverts will only have minimal impact to the flood levels across the UPR minor basin. Figures F3 in Appendix F illustrates the difference in peak flood levels between the Structure Blockage run and the Base Case utilising the 100 year EDS.

### 4.3.4 Climate Change Assessment and Downstream Boundary Condition Analysis

The climate change scenario assessed an increase of 20% of the 100 year EDS rainfall intensity as described in Section 3.6.4. A 20% increase rainfall results in higher flood levels throughout the UPR minor basin. Figure F4 in Appendix F indicates the difference in peak flood levels for the increased rainfall scenario compared to the EDS Base Case is generally an increase within the range of 200 to 500mm of flood levels over the tributary streams within the UPR minor basin and an increase of 500 to 1000mm in flood levels along Laceys Creek and Upper Pine River upstream of Lake Samsonvale. The flood level at Lake Samsonvale is generally increased by some 150mm.

A downstream boundary sensitivity run was not undertaken for the UPR model because the North Pine River Dam behind Lake Samsonvale is the downstream boundary for the UPR minor basin model. The spillway of the North Pine Dam will control water levels in the lake and the outflow of the UPR model.

## 4.4 Model Limitations

The topography of creeks in the UPR minor basin is defined using LiDAR data due to the absence of surveyed cross-sections or bathymetry. LiDAR data are unable to pick up ground levels below the water surface, and therefore the bed levels of creeks are not precisely represented in detail. This approach means that the flood levels, particularly for small flood events where a greater proportion of the flow is typically conveyed within bank (e.g. the 1 to 10 year ARI), may be overestimated. The extent of this over-estimation will vary according to local topographic factors.

Watercourses have also been represented in the 2D domain, for which the grid resolution is limited to 5m up to the 100 year ARI major design event runs and 10m for the very large and extreme event runs. In addition, for the narrower upstream reaches, a waterway landuse layer has not been incorporated. This may not allow adequate representation of the channel conveyance, particularly for the narrower upper reaches. In some instances this limitation may lead to the model over or underestimating conveyance in the watercourses for small flood events.

As discussed in Section 3.3.2 about the structure of the TUFLOW model, Lake Samsonvale and North Pine Dam have been established in the 1D domain for the purpose of minimising model run times. Due to the limitation of 1D modelling, the design flood results provided in this study for Lake Samsonvale and North Pine Dam are only limited to water levels and flood flow hydrographs.

# 5 CONCLUSIONS AND RECOMMENDATIONS

The hydrologic modelling works undertaken in this study have utilised the WBNM (Watershed Bounded Network Model) software to calculate flood flow hydrographs for a range of design storm events to be used as inflows to the hydraulic model developed for the UPR minor basin.

The hydraulic assessment under this project has included the development of a detailed 5m grid TUFLOW hydraulic model, a dynamically-linked 2D/1D hydrodynamic numerical model for the UPR minor basin to run all the selected critical durations for the 1, 2, 5, 10, 20, 50 and 100 ARI design events to achieve the highest resolution design event flood results for the UPR minor basin.

A detailed 10m grid TUFLOW hydraulic model has also been developed for the UPR minor basin to run the very large and extreme flood events including the 200, 500, 1000, 2000 year ARI and the PMF events as well as the calibration/ validation and model sensitivity analysis runs. The chosen 10m cell size is considered to be sufficiently detailed to determine flood behaviour for the extreme large events, calibration/validation and sensitivity analysis runs without extensive model run times.

Separate critical storm duration assessments have been undertaken for the minor events (1, 2, 5 and 10 year ARI event), moderate and major events (20, 50 and 100 year ARI), very large and extreme events (200, 500, 1000, 2000 year ARI and the probable maximum flood (PMF) event) to determine three (3) critical storm durations for each design flood event for the purpose of predicting the peak flood behaviour of the UPR minor basin including Lake Samsonvale and North Pine Dam.

Based on the critical duration assessments, the UPR TUFLOW model has been utilised to run for the following three (3) nominated storm durations for each design flood event:

- Minor events (1, 2, 5 and 10 year ARI) - 2hr, 3hr and 24hr;
- Moderate and major events (20, 50 and 100 year ARI) - 2hr, 3hr and 24hr; and
- Very large and extreme events - 2hr, 3hr and 5hr.

The 15 minutes burst in a 270 minutes 100 year Embedded Design Storm (EDS) has been adopted and applied to the TUFLOW model. The EDS is useful for initial investigations into changes in model parameters and minor basin characteristics, as it reduces the number of model runs required. The adopted EDS storm was utilised as a base case for the comparison to model sensitivity, climate change and future landuse scenarios.

The Regional Floodplain Database is focused on structuring model input and output data in a GIS database held by MBRC. Therefore, all model input and output data in digital format will be provided to MBRC at the completion of the study. The data includes all model files for all the design events, sensitivity analysis, climate change assessment and future landuse scenarios.

The flood assessment undertaken for the UPR minor basin as documented in this report has been successful in addressing the overall objectives of the study. It is recommended that this study report be accepted by MBRC and the associated model outputs be included in RFD for delivering seamless information about flood behaviour across the entire Moreton Bay Regional Council area.

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