

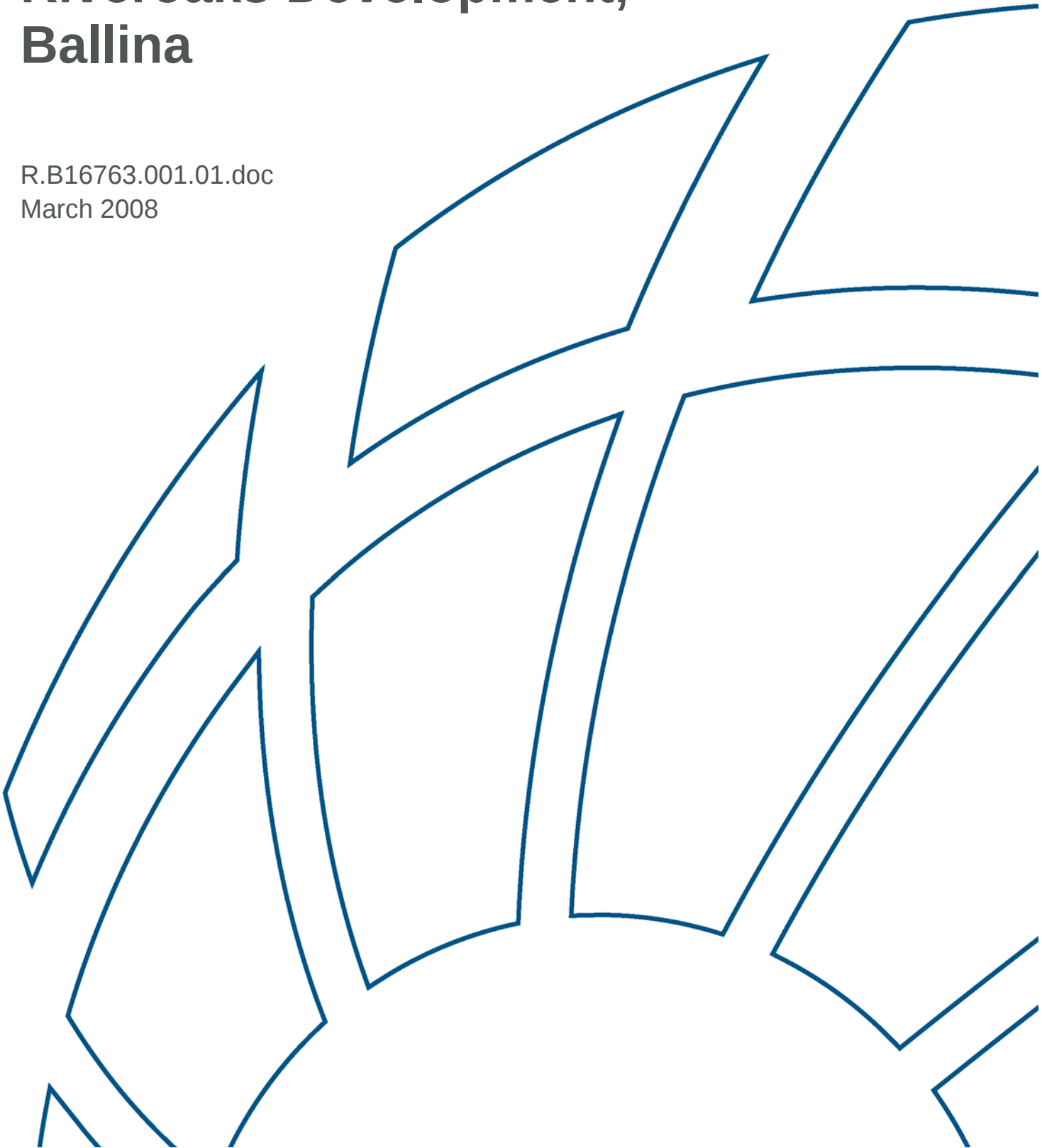
## Appendix 15

### Flood Study & Flood Evacuation Plan



# **Flood Impact Assessment for the Riveroaks Development, Ballina**

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March 2008





# Flood Impact Assessment for the Riveroaks Development, Ballina

Prepared For: Land Partners Pty Ltd

Prepared By: BMT WBM Pty Ltd (Member of the BMT group of companies)

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# 1 INTRODUCTION

Acting on behalf of Land Partners Pty Ltd, Ballina Shire Council has commissioned BMT WBM Pty Ltd to undertake a flood impact assessment for the Riveroaks development in Ballina. The purpose of the assessment is to determine the optimum size for the floodway proposed to be constructed as part of the flood mitigation scheme for the development.

The project is being developed by Ray Shield Pty Ltd.

## 1.1 Base Case Flood Model

As part of the Ballina Flood Study Update (BMT WBM, Draft 2007) for Ballina Shire Council, BMT WBM has developed a hydrodynamic flood model of the floodplain around Ballina. The model enabled simulation of a range of design flood events to determine existing catchment flooding behaviour. The flood model was then used to simulate the effects of all approved development across the floodplain and subsequently develop a mitigation scheme to minimise adverse impacts. The product of the study was a 'Base Case' flood model to be used to assess the cumulative impacts of future development of the floodplain.

This flood impact assessment is the first project to use the base case flood model. Following completion of this project, Council will then use the updated model for further development assessments.

## 1.2 Design Standards

The design criterion for development works on the floodplain with respect to flooding is a maximum cumulative increase of 50mm during any assessed flood event, i.e. the 20 and 100 year ARI design events. Use of the base case flood model enables the cumulative impacts of all development to be assessed, rather than each development project considered in isolation.

## 1.3 Site Description

The Riveroaks development site is located on the Richmond River floodplain to the northwest of Ballina Island. Refer to Figure 1-1 for location of the site on the floodplain.

The Pacific Highway runs parallel to the northern boundary of the site. On the opposite side of the highway is the Southern Cross industrial estate. To the east is vacant land proposed for future urban development, herein referred to as 'Natuna'. Beyond the Natuna site is the North Creek Canal. To the south and west of the Riveroaks site is open paddock, used primarily for cattle grazing. Refer to Figure 1-2 and Figure 1-3 for locality.

During the Ballina Floodplain Management Study (BMT WBM 1997), it was identified that a floodway would be required between the Riveroaks site and the sewer treatment works to the south. The purpose of the floodway is to assist the draining of the floodplain to the east of the site into the North Creek Canal. The revised two-dimensional modelling undertaken for the Ballina Flood Study Update confirmed the requirement for the floodway.

The development of a design for the floodway is discussed further in Section 3 of this report. The results of the flood modelling undertaken are presented and discussed in Section 4. Recommendations for the implementation of the floodway are included in Section 5.

## 2 MODEL DEVELOPMENT

### 2.1 Overview

The overall flood model consists of a hydrological model and a hydraulic model. The hydrological model is first developed to estimate the flow rates within watercourses as a result of any particular rainfall event. Once the flow rates have been established, these can be directly input into the hydraulic model. The hydraulic model then simulates the passage of floodwaters through a floodplain. Each model is summarised below. Refer to the Ballina Flood Study Update (BMT WBM, Draft 2007) for further details on each model.

### 2.2 Hydrologic Model

The hydrological model was developed for the Ballina Floodplain Management Study (BMT WBM, 1997) using the XP-RAFTS software. This model was used during the Ballina Flood Study Update.

The model covers the entire Richmond River catchment downstream of Broadwater. Hydrographs for each sub-catchment were used as input into the hydraulic model.

### 2.3 Hydrodynamic Model

During the 1997 Ballina Floodplain Management Study, a one-dimensional (1D) ESTRY model was developed of the Richmond River downstream of Broadwater. As part of the Ballina Flood Study Update, the original 1D model was augmented with a two-dimensional (2D) representation of the Richmond River and floodplain downstream of Pimlico Island. The 1D representations of the creeks and watercourses from the 1997 study were retained and nested within the 2D domain. This produced an integrated 2D/1D coupled hydrodynamic model. The coupled 2D/1D model was developed using TUFLOW. Refer to Figure 2-1 for model layout.

### 2.4 Model Calibration

The flood model was calibrated during the Ballina Flood Study Update to the following three historical flood events:

- March 1974;
- February 1976; and
- June 2005.

Rainfall pluviograph records, stream flow gauges, and river and ocean level recordings were all used for the calibration. During the model calibration phase, a data collection exercise was undertaken to establish a range of data points across the catchment for calibration purposes.

## 2.5 Design Boundary Conditions

### 2.5.1 Sources of Flooding

In accordance with the Ballina Flood Study Update (BMT WBM, Draft 2007), three sources of flooding have been identified for Ballina as listed below:

- Flooding of the Richmond River;
- Local catchment flooding caused by rainfall centred on Maguires, Emigrant and North Creeks; and
- Flooding due to elevated ocean levels, or storm surge.

The Ballina Flood Study Update includes a source dominance map indicating the areas of the floodplain that are dominated by floods from each of the three sources. That map is reproduced here as Figure 2-2.

The Riveroaks development site is in an area characterised by flooding from all three sources. Therefore, each of the three sources have been investigated as part of this study. The results from each event have been combined to form an envelope of peak flood levels. All results presented in this report are for the combined event.

For this flood impact assessment, the 20 and 100 year ARI events have been considered. The 5 and 10 year ARI events have also been modelled to assist with local drainage design. The combined sources of flooding used for each event are shown in Table 2-1.

**Table 2-1 Design Event Boundary Conditions**

|                 | Scenario | Richmond River Level | Local catchment storm | Ocean boundary                        |
|-----------------|----------|----------------------|-----------------------|---------------------------------------|
| <b>100y ARI</b> | A        | 100y                 | 100y 72h              | 10y surge + climate change allowance  |
|                 | B        | 10y                  | 100y 12h              | 10y surge + climate change allowance  |
|                 | C        | 10y                  | 10y 12h               | 100y surge + climate change allowance |
|                 |          |                      |                       |                                       |
| <b>20y ARI</b>  | A        | 20y                  | 20y 72h               | 10y surge + climate change allowance  |
|                 | B        | 10y                  | 20y 12h               | 10y surge + climate change allowance  |
|                 | C        | 10y                  | 10y 12h               | 20y surge + climate change allowance  |
|                 |          |                      |                       |                                       |
| <b>10y ARI</b>  | H        | 10y                  | 10y 12h               | 10y surge + climate change allowance  |
|                 |          |                      |                       |                                       |
| <b>5y ARI</b>   | D        | 5y                   | 5y 12h                | 5y surge + climate change allowance   |

### **2.5.2 Richmond River Levels**

A flood frequency analysis was undertaken for Broadwater to estimate the river levels during each design rainfall event. The flood frequency analysis is based upon 89 years of flood records. The flood frequency analysis is described in detail in the Ballina Flood Study Update.

### **2.5.3 Ocean Storm Surge Levels**

The downstream tide and storm surge levels used have been developed based upon the findings of a study of elevated ocean water levels for the Richmond River entrance by Lawson & Treloar (1994). During the Ballina Flood Study Update, an extensive literature review was undertaken to determine the likely impacts of climate change on ocean storm surge levels. As a results of the literature review, an increase in mean sea level equal to 200mm was adopted for a 50 year planning horizon. Thus, 200mm has been added to the ocean levels of all design flood events.

## 3 BASE CASE FLOOD MODELLING METHODOLOGY

### 3.1 Base Case Flood Model

The base case flood model is defined in the Ballina Flood Study Update (BMT WBM, Draft 2007) as:

*“the existing catchment conditions including all proposed public infrastructure works, currently zoned or approved urban development and mitigation measures designed to minimise adverse flooding impacts to acceptable levels”*

The base case flood model includes the following public infrastructure works:

- RTA's Ballina Bypass;
- Ballina Shire Council's Western Arterial and North Creek Road upgrade;
- North Creek revetment wall;
- Upgrade to the sewer treatment works; and
- Upgrade to the waster management centre.

Additionally, various parcels of land have been zoned for urban development. These are shown on Figure 3-1, together with the public infrastructure works listed above.

During the 1997 Ballina Floodplain Management Study and the Ballina Flood Study Update, a series of mitigation measures were developed to mitigate the impacts of the proposed development. These mitigation measures, mostly floodways and culverts, are also shown on Figure 3-1.

The floodway to the south of the Riveroaks development was originally proposed to be 30m wide with an approximate invert level equal to 0m AHD. The mitigation scheme developed for the Ballina Flood Study Update was conceptual. Therefore, actual site constraints such as existing structures, environmental issues and land ownership were not considered. Refer to Figure 3-2 for a schematic layout of the floodway as proposed in the Ballina Flood Study Update.

### 3.2 Proposed Development Scenario

As previously discussed, the purpose of this flood impact assessment is to develop a design for the Riveroaks floodway accounting for all local constraints. The key constraints are as follows:

- Land ownership;
- Acid sulphate soils and groundwater;
- Local drainage;
- Tidal intrusion; and
- Environmental implications associated with disturbance to the North Creek Canal.

Various iterations were investigated with the initial focus being land ownership and avoidance of groundwater and acid sulphate soil conditions. This resulted in the invert of the proposed floodway

being raised to 1.2m AHD and the alignment changed to accommodate the requirements of the landowner. Refer to the concept design drawing in Appendix A.

The proposed outlet into the North Creek Canal was also reviewed. It was decided to realign the floodway to discharge into the low-lying land between the sewer treatment works and the North Creek Canal. This realignment will eliminate any potential environmental complications arising from disturbing the North Creek Canal. Such complications could include tidal intrusion onto the farmland and/or impacts upon flora and fauna due to construction activities.

The realigned floodway is sympathetic to the local drainage design, enabling low flows to be directed into the existing drain around the northern boundary of the sewer treatment works.

### 3.3 Adjustments to the Base Case Flood Model

Detailed ground survey of the land to the south and west of the Riveroaks development site was provided by Land Partners Pty Ltd. Also supplied was a conceptual design surface for the development. The survey and design surface were added to the flood model.

The floodway is represented in the model as a 1D channel. The channel was realigned to suit design drawings provided by Land Partners.

Between the proposed realigned floodway and the sewer treatment works, rehabilitation of vegetation is proposed to be undertaken as part of this project. The increased roughness associated with the rehabilitated area was included in the model.

No further refinements to the model were undertaken.

## 4 MODELLING RESULTS

### 4.1 Ballina Flood Study Update Base Case Results

Peak flood level impacts for the Ballina Flood Study Update base case modelling are shown on Figure 4-1 for the 100 year ARI combined event. The impacts map shows that across most of the floodplain, peak flood level impacts are within the 50mm design criterion. There are three main areas where peak flood level impacts exceed 50mm:

- Upstream of the RTA's Ballina bypass at Cumbalum. This area is noted in the Ballina Flood Study Update as requiring further investigation. For this flood impact assessment, it is imperative that this area is not subject to further increases.
- Pacific Highway crossing of the north Creek Canal to the north of Ballina Island. Peak flood level increases in this isolated area are a result of ocean storm surge flooding. This area is addressed further in the following sections.
- The racecourse in north Ballina. The impacts shown are due to the absence of local drainage structures in the flood model. Hence, floodwaters overtop the perimeter levee surrounding the racecourse, and flood the low-lying land. Should local drainage structures have been modelled, this area would suitably drain and may not be shown to experience greater than 50mm increase.

### 4.2 Pre-Development Results

The first part of this flood impact assessment involved adapting the base case flood model to remove the Riveroaks development and the associated floodway. The peak flood levels impacts from this modelling exercise for the 100 year ARI combined event are shown on Figure 4-2.

When comparing Figure 4-1 and Figure 4-2 it can be seen that peak flood level impacts are lower in the pre-development scenario. Notable differences include:

- Decrease in peak flood levels across the floodplain to the west of the development site, extending to the RTA's Ballina bypass;
- Decrease in peak flood level impacts in the Cumbalum area, in particular the region upstream of the RTA's Ballina bypass. In this location, peak flood levels impacts are reduced below the 75mm contour band;
- Minor decrease in peak flood level impacts to the east of Gallans Road cycleway extending into the North Creek floodplain; and
- Reduced peak flood level impacts at the Pacific Highway crossing of the north Creek Canal as described in Section 4-1. Peak flood level impacts in this area are shown to be below 50mm in the pre-development scenario.

### 4.3 Unmitigated Scenario Results

Following the pre-development scenario, an unmitigated scenario was investigated. For this exercise, the Riveroaks development was retained in the base case flood model. However, the

associated floodway was removed. This simulation was undertaken to demonstrate the impact of flooding should the floodway not be implemented.

The peak flood level impacts of this scenario for the 100year ARI combined event are shown on Figure 4-3. Comparing Figure 4-3 with Figure 4-2 shows the increase in peak flood levels attributable to the Riveroaks development. Additionally, comparing Figure 4-3 with Figure 4-1 shows the value of the proposed floodway in reducing peak flood level impacts across the floodplain.

## 4.4 Mitigated Scenario Results

The mitigated scenario flood modelling was undertaken as an iterative process. The focus of this stage of the investigation was to develop a design scheme for the floodway that was sympathetic to the surrounding area, whilst having maximum flood mitigation benefit.

The ultimate alignment for the floodway is shown on Figure 4-4. The realignment of the floodway is discussed in Section 3-3. Refer also to the concept design drawing included in Appendix A. As discussed in Section 3-3, the invert of the floodway was raised to 1.2m AHD.

Peak flood levels for the 20 year and 100 year ARI combined events are shown on Figure 4-4 and Figure 4-6 respectively. The peak flood levels on these figures are only indicative, since the figures do not show the flow within the floodway. It should be noted that the results are also the combined results of the three different flood events analysed and do not necessarily represent the flood surface at any particular time during any particular event.

Peak flood level impacts for the 20 year and 100 year ARI combined events are shown on Figure 4-5 and Figure 4-7 respectively.

### 4.4.1 20 Year ARI Modelling Results

Peak flood level impacts for the 20 year ARI combined event exceed the 50mm criterion in four locations as summarised below.

The farmland on the eastern floodplain of North Creek is shown to have increased peak flood levels of greater than 75mm. This area was investigated as part of the Ballina Flood Study Update. It was concluded that this area is separated from North Creek by a series of levees. The absence of minor drainage structures from the flood model results in this area not being shown to drain efficiently as it would under existing site conditions.

Peak flood level impacts at the racecourse are as discussed in Section 4-1.

The localised area at the eastern end of Fishery Creek is due to the elevated peak flood levels in the North Creek canal. This is discussed below.

The prominent region experiencing increased peak flood levels above 50mm is at the Pacific Highway crossing of the north Creek Canal. This area was identified in the Ballina Flood Study Update modelling.

During this flood impact assessment, the cause of this increase was investigated. Since this area is dominated by flooding from ocean storm surge, this event was considered in isolation. During that

event under pre-development conditions, floodwaters would overtop the northern bank of the North Creek Canal into the low-lying area described as the Natuna site. Refer to Figure 3-2 for topography. This low-lying land extends north westwards through the Riveroaks site to the upstream end of Fishery Creek. Once overtopping of the North Creek Canal occurs, floodwaters flow upstream to fill the floodplain as a flood storage zone. The development of the Riveroaks and Natuna sites will block this flowpath. Therefore, floodwaters in the North Creek Canal emanating from North Creek, are forced further westwards to overtop into the low-lying land to the east of the sewer treatment works. At this point flows enter the proposed floodway from the eastern end flowing in an upstream direction.

The increased flooding is therefore attributable to the proposed development due to:

- Decreased flood storage across the Riveroaks and Natuna development sites;
- Obstruction of the natural flowpath; and
- Increased distance for floodwater to travel to utilise the floodplain. This is exacerbated by the short and steep peaks resulting from tidal flooding.

#### **4.4.2 100 Year ARI Modelling Results**

During the 100 year ARI combined event, peak flood level impacts exceed the 50mm criterion in two locations as described below.

As noted in Section 4-1, peak flood level impacts exceed 50mm in the Cumbalum area. These impacts are not a direct result of this development as discussed above and in the Ballina Flood Study Update. The adverse impacts in this area are not worsened by the proposed development and floodway.

The second location is as described in Section 4.4.1 for the Pacific Highway crossing of the north Creek Canal. The mean increase over the region subject to greater than 50mm impact is 63mm.

#### **4.4.3 Acceptability of Impacts**

During the meeting between Council, Ray Shield, Land Partners, the NSW Department of Environment and Climate Change, Ardill Payne and Partners and BMT WBM on the 14<sup>th</sup> February 2008, the adverse flooding impacts were discussed. A key focus of the meeting was the area to the east of the development site, since both residential and industrial properties were affected. The meeting concluded that since the peak 100 year ARI flood levels in that area did not exceed Council's standard for minimum floor levels, that the impacts would be accepted. This decision was supported by the fact that the design of the floodway had been optimised with respect to key performance criteria.

### **4.5 Minor Event Modelling Results**

To assist with the local drainage design of the development, Land Partners requested that model simulations for the 5 and 10 year ARI events be undertaken.

#### **4.5.1 5 Year ARI Event**

The peak flood levels for the 5 year ARI event are shown on Figure 4-8. As noted for the less frequent events, these results are only indicative since flood levels in the floodway are not shown. The peak flow rates within the proposed floodway and the existing drain along the northern boundary of the sewer treatment works are shown in Appendix B.

#### **4.5.2 10 Year ARI Event**

The peak flood levels for the 10 year ARI event are shown on Figure 4-9. Again, as noted for the less frequent events, these results are only indicative since flood levels in the floodway are not shown. The peak flow rates within the proposed floodway and the existing drain along the northern boundary of the sewer treatment works are also shown in Appendix B.

#### **4.5.3 Minor Event Summary**

Due to the Riveroaks development site being located in the coarse 40m grid section of the flood model, the 5 and 10 year ARI results should only be used to apply tailwater levels for the local drainage design process. Flows and other hydraulic design parameters should be calculated using alternative methods.

## 5 RECOMMENDATIONS

It is proposed in the Ballina Flood Study Update (BMT WBM, Draft 2007) that a floodway is constructed as part of the Riveroaks development. The floodway is required to minimise the adverse impacts of the development on peak flood levels.

Ballina Shire Council's base case flood model has been adapted for this flood impact assessment. The assessment has been undertaken to determine the flooding impacts of the proposed Riveroaks development and determine the optimum design for the proposed floodway.

A range of design options for the proposed floodway have been considered during this assessment and an ultimate design option developed. The design presented in this report is considered to result in minimal impact to peak flood levels whilst minimising adverse environmental and land ownership conflicts.

BMT WBM recommend that should the design for the development and associated floodway be amended, then due consideration to impacts on flooding should be given. If the amendments are considered to affect the local flooding behaviour, then further flood modelling should be undertaken to assess the impacts of the changes.

## 6 REFERENCES

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BMT WBM Pty Ltd *Ballina Floodplain Management Study*, Prepared for Ballina Shire Council (December 1997)

BMT WBM Pty Ltd *Draft Working Paper: Flooding for Ballina Bypass Improved Concept Design* (May 2007)

BMT WBM Pty Ltd *Ballina Flood Study Update Draft Public Exhibition Version* (November, 2007)

## **APPENDIX A: CONCEPT DESIGN DRAWING**

## **APPENDIX B: MODELLING RESULTS FOR MINOR EVENTS**

Figure B-1 - 5 Year ARI Flow along Existing Sewer Treatment Works Drain

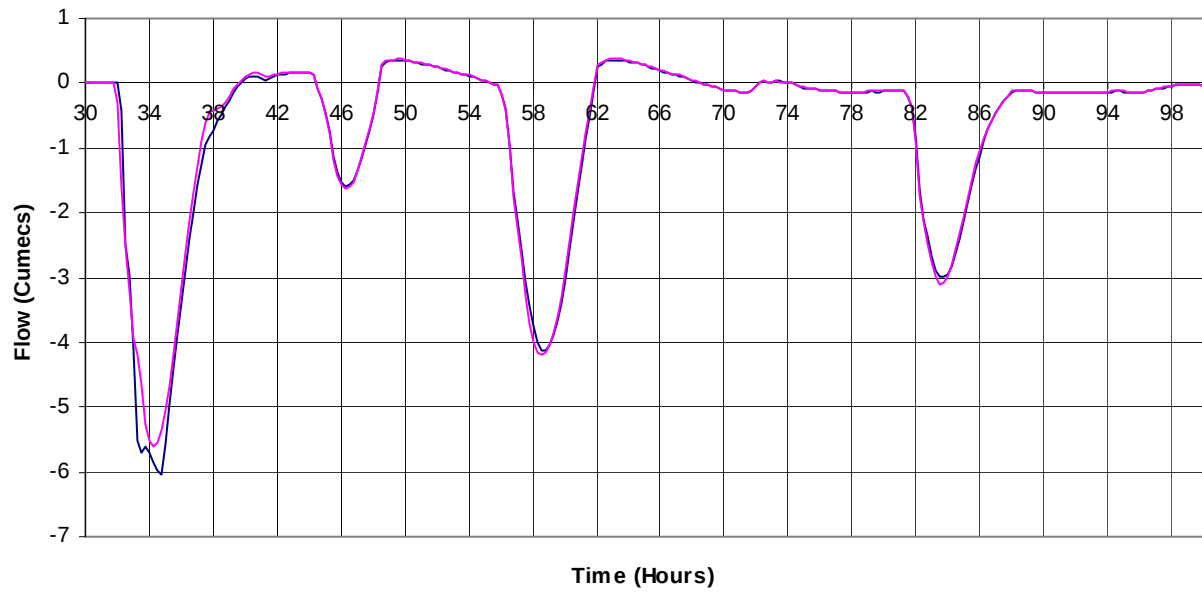


Figure B-2 - 5 Year ARI Flow along Riveroaks Floodway

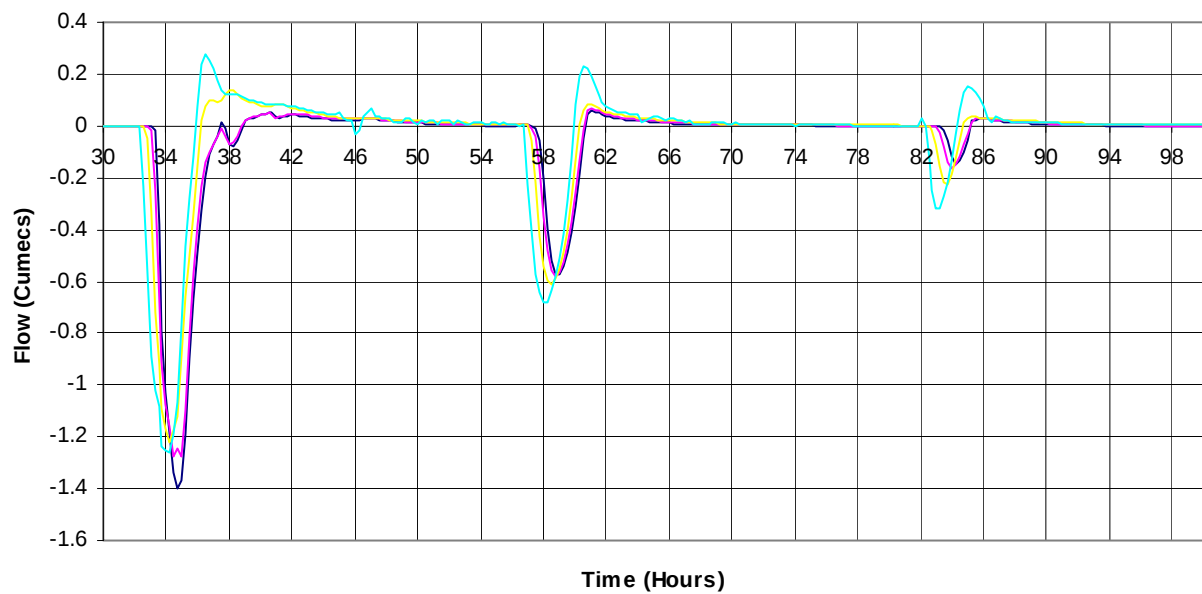


Figure B-3 - 10 Year ARI Flow along Existing Sewer Treatment Works Drain

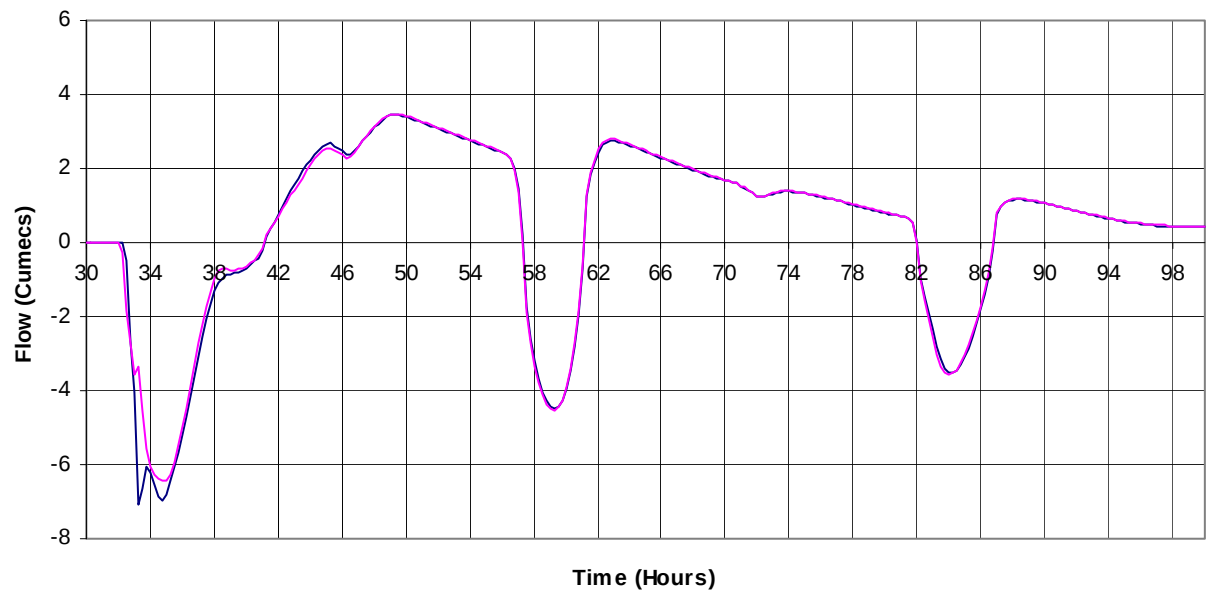
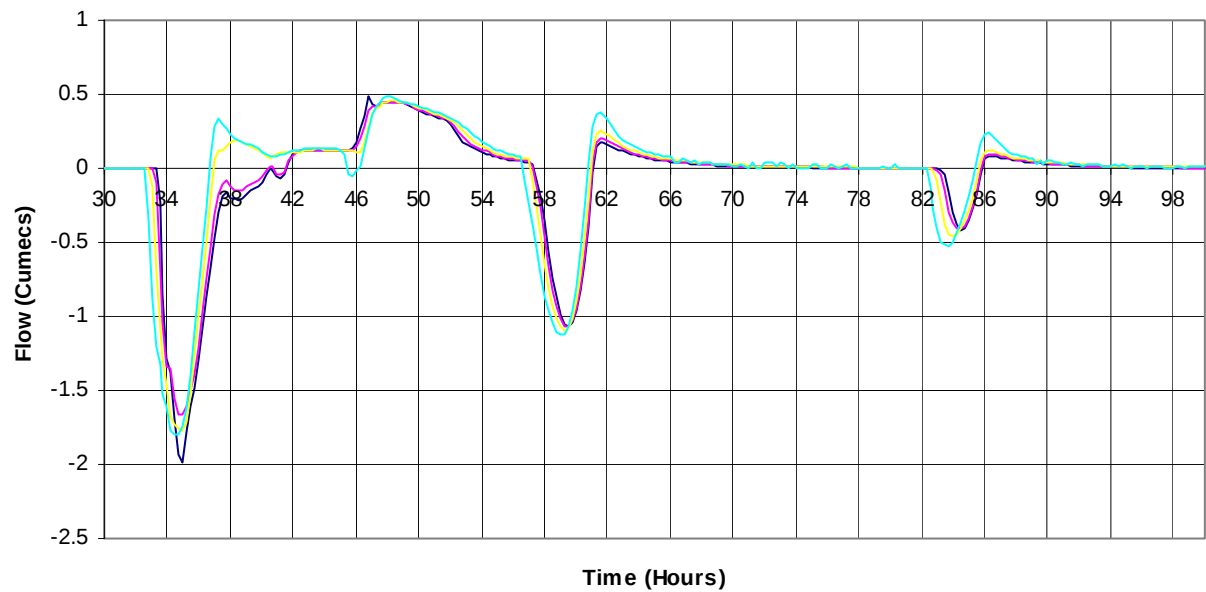


Figure B-4 - 10 Year ARI Flow along Riveroaks Floodway





|                   |                                                                                                                                                                                                                                                                                |
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