Queensland Government
Department of Emergency Services

DOTARS
DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

Ipswich
City Council

Ipswich Rivers Improvement Trust

Ipswich Rivers Flood Study Rationalisation Project

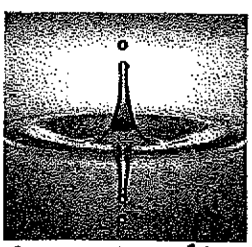
Phase 3

"Monte Carlo" Analysis of Design Flows

Final Report

January 2006

Job No 05002



Sargent Consulting

Sargent Consulting
ABN 74 424 370 508
11 Redwood Place
THE GAP
Queensland 4061
Tel 0419 311160
Fax 07 35110440
Email dms@sargentconsulting.com.au

Ipswich City Council and Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Study Rationalisation Project
Phase 3
"Monte Carlo" Analysis of Design Flows

Table of Contents

List of Tables

List of Figures

Executive Summary

Introduction

One objective of the Ipswich Rivers Flood Study Rationalisation Project (IRFSRP) is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC), in order to facilitate the preparation of new flood maps.

The IRFSRP is being conducted in parallel with the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

One of the outstanding issues that is being investigated as part of the IRFSRP is the catchment hydrology, in particular the definition of design flows as estimated using the RAFTS model which has previously been established for studies for both ICC and BCC. The provision of the most recent RAFTS model input files and data files by BCC is gratefully acknowledged.

The Independent Review Panel (Mein et al 2003) recommended that Monte Carlo methodology be used to simulate the possible combinations of storm temporal and spatial patterns and could also include variation of loss rates and reservoir drawdown.

A full Monte Carlo analysis would comprise running a large number of trials (typically in the order of tens of thousands) in order to adequately describe the distribution of the dependant variable, in this case flood peak magnitude.

Typically, applications of the Monte Carlo simulation process to rainfall – runoff modelling have used a simplified transfer function so that the sample trials could be automated and a large number of trials undertaken. However, due to the complexity of the RAFTS model and its data input requirements, it is not possible to automate the process in this case and manual editing of the data files is required for each model run. As significant time is required to conduct each model run, there are time and budget constraints on the number of trials which could be conducted.

As the current Brisbane/Bremer River RAFTS model has been developed at considerable expense and has been widely used by both ICC and BCC as the basis of flood event modelling for some time, there is no incentive to change the modelling platform at this time.

Taking these constraints into account, the Monte Carlo modelling undertaken for this study was limited to exploring the variation in estimation of peak 100 year ARI flows resulting from variations in a limited number of model inputs in order to provide further insight into this variability and to reduce the uncertainty in the Q_{100} flow estimates.

Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz) and for the rural areas in 2002 (Halliburton KBR), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

Resolution of these incompatibilities is required urgently by ICC so that:

- *The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and*
- *The current development of emergency response flood mapping is not compromised.*

Summary of Recent Estimates of Design Flows

The most recent estimates of design flows for the Lower Brisbane River are contained in the reports by SKM (2003) and Mein et al (2003) which are summarised below.

SKM (2003) presented a comprehensive investigation of flood frequency analyses for peak instantaneous flow in the Brisbane River at Savages crossing, under both natural (i.e. pre-dam construction) and current (post-dam construction) scenarios.

*Based on consideration of analysis of a number of datasets including a regional flood frequency analysis, SKM (2003) concluded that the "best" or "most plausible" estimate of the 100 year ARI (**Q_{100}**) peak flow at Savages Crossing for the pre-dam scenario was **12,000m³/s** within a likely range from 10,000m³/s to 14,000m³/s.*

*SKM (2003) also presented revised hydrologic modelling results using the RAFTS model (developed for both BCC and ICC flood studies) using the CRC-FORGE datasets and also allowing for possible variations on both temporal and spatial patterns of storm rainfalls. This analysis resulted in a median estimated peak **Q_{100}** flood flow at Savages Crossing for the pre-dam scenario of **9,600m³/s** within a likely range of 8,000m³/s to 11,500m³/s.*

*SKM (2003) also estimated peak flows in the post-dam scenario using the RAFTS model results combined with dam operations models for Somerset and Wivenhoe Dams (DNRM 2003), together with runs of the MIKE 11 model and estimated that the "best estimate" of **Q_{100}** peak flow in the Brisbane River at the Port Office is **6,500m³/s** within a likely range of 5,000m³/s to 8,000m³/s. The corresponding best estimate at Savages Crossing was **5,500m³/s**.*

*The Independent Review Panel commissioned by BCC (Mein et al 2003) endorsed SKM's "best estimate" of the pre-dam peak **Q_{100}** flood flows at Savages Crossing of **12,000m³/s** (within a likely range from 10,000m³/s to 14,000m³/s) based on flood frequency analysis. Mein et al (2003) considered that the RAFTS modelling estimates of about **10,000m³/s** (within a likely range of 8,000m³/s to 11,500m³/s) to be low.*

*Mein et al (2003) considered that the most plausible estimate of the post-dams Q_{100} peak flow in the Brisbane River at Savages Crossing to be **6,000m³/s** (within a likely range of 4,000m³/s to 8,000m³/s) and at the Port Office **6,000m³/s** (within a likely range of 5,000m³/s to 7,000m³/s).*

Mein et al (2003) made a number of recommendations including:

- *Using Monte Carlo methodology to simulate the possible combination of storm temporal and spatial patterns on peak flows together with rainfall losses and reservoir levels;*
- *The RAFTS model calibration be revisited with a view to reducing the variance between design flow estimates produced from the model and those obtained from flood frequency analysis; and*
- *Frequency analysis of flood volumes be carried out, and compared with runoff volumes predicted by the RAFTS model from design rainfalls of corresponding frequency.*

Scope of Monte Carlo Analysis

The Monte Carlo analysis component of the IRFSRP described in this report has comprised:

- *Reviewing the RAFTS hydrologic model with CRC-FORGE design rainfall inputs;*
- *Using the RAFTS model to undertake stochastic modelling (Monte Carlo simulation) to account for probability distributions of the model assumptions and combinations of spatial and temporal rainfall distributions to better define design flow hydrographs and to quantify the uncertainty therein;*
- *Comparison of hydrologic model design flows from the above with those from direct flood frequency analysis to determine the extent to which this resolves the inconsistency arising from SKM (2003);*
- *In the event that this inconsistency were not satisfactorily resolved by the above, undertake a frequency analysis of flood volumes as a further aid in this regard;*
- *Re-estimation of 100 year ARI design flows at key locations throughout the catchments on the basis of the new analysis; and*
- *Reporting on the work undertaken.*

Preliminary RAFTS Model Runs

Prior to undertaking the Monte Carlo analysis it was necessary to re-establish and review the RAFTS model.

Review of Existing RAFTS Model

BCC provided RAFTS input files and data files from the SKM (2003) study for use in the current study. However, these model and data files were incomplete for the 100 year ARI which is the focus of interest of the current study. A number of actions were taken to overcome these shortcomings, as outlined below:

i. The RAFTS input file for the whole catchment in its "pre-dams" configuration was copied from that provided from the Ipswich Rivers Flood Study Phase 2 (SKM 2000) and updated from RAFTS version 5.0 to the current version, viz. RAFTS 2000;

ii. The spatial rainfall distribution provided in spreadsheet form was checked for CRC-FORGE design rainfalls for 100 Year ARI for 24, 48 and 72 hours using the original values of CRC-FORGE rainfalls proved by DNRM (Ruffini J. 2004) and using thematic mapping in MapInfo to estimate mean rainfalls for each sub area in the RAFTS model. This check was satisfactory, confirming the validity of the rainfalls in the spreadsheet;

iii. The rainfall files for the RAFTS model were re-established on the basis of the sub-area rainfalls outlined above; and

iv. Initial check runs of the RAFTS model were then made for a range of storm durations based on the CRC-FORGE spatial variation, using temporal patterns from Australian Rainfall & Runoff (ARR), and with the same loss parameters used by SKM (2003) i.e. initial loss of 10mm and continuing loss of 1mm/hr.

However, these runs produced significantly different peak flows from those presented in SKM (2003) for all storm durations except 72 hours, with the highest differences at 30 and 36 hour durations (up to 56%). These values are shown in ***Table ES1****.*

It should also be noted that the RAFTS model peak flows in the current study are more consistent with the Independent Review Panel's best estimate of ***12,000**m^3/s* *within a likely range of 10,000 – 14,000m^3/s.*

The model runs for the current study also put the critical storm duration at 30 hours for all of the main Brisbane River locations, whereas in the previous analysis 72 hours was the critical duration at Moggill and the Port Office.

The reasons for these differences were briefly investigated and two reasons for the differences identified, namely:

- *Differences in sub area rainfalls; and*
- *Sensitivity to model conceptual storages.*

Although the 100 year ARI rainfall input files for RAFTS were not available from BCC, the output files were provided and these confirmed that the effective rainfalls on the sub areas (i.e. input rainfall minus losses) were consistently lower than those applied in the current study. It was also confirmed that the applied losses were identical, so it was concluded that the input rainfalls were less than those provided in the CRC-FORGE spreadsheet. This was confirmed by comparison of effective rainfalls on a small number of sub areas.

The rainfalls used in the current study were double checked and found to be correct, and the analysis continued on this basis.

Table ES1 Comparison of RAFTS Model Peak Flow Estimates

Location	Peak Flows (m^3/s) for Storm Durations of				
	24 Hrs	30 Hrs	36 Hrs	48 Hrs	72 Hrs
a) Values from SKM (2003) Table 4-2					
Savages Crossing	8,387	**9,607**	8,379	8,626	9,192
Moggill	7,607	9,015	7,588	8,004	**10,101**
Brisbane Port Office	7,608	9,015	7,589	8,005	**10,106**
b) Current Study					
Savages Crossing	9,700	**13,140**	11,400	9,700	9,100
Moggill	8,600	**12,600**	11,800	10,000	10,200
Brisbane Port Office	8,600	**12,600**	11,800	10,000	10,200
Difference between b) and a) %					
Savages Crossing	+16%	+37%	+36%	+12%	+9%
Moggill	+13%	+40%	+56%	+25%	+1%
Brisbane Port Office	+13%	+40%	+56%	+25%	+1%
NOTE: Critical duration values shown in bold type					

Basis of the Monte Carlo Analysis

The Independent Review Panel (Mein et al 2003) recommended that Monte Carlo methodology be used to simulate the possible combinations of storm temporal and spatial patterns and could also include variation of loss rates and reservoir drawdown.

A full Monte Carlo analysis would comprise running a large number of trials (typically in the order of tens of thousands) in order to adequately describe the distribution of the dependant variable, in this case flood peak magnitude.

Previous applications of the Monte Carlo simulation process to rainfall – runoff modelling have used simple models so that the sample trials could be automated and a large number of trials undertaken. However, due to the complexity of the RAFTS model and its data input requirements, it is not possible to automate the process in this case and manual editing of the data files is required for each model run. As significant time is required to conduct each model run, there are time and budget constraints on the number of trials which could be conducted.

In order to limit the model runs to a practical number a simplified procedure was adopted which required a number of assumptions, described in detail in the body of the report. Whilst limiting the overall generality of the model results, these assumptions were similar to those adopted in the most recent studies allowing a valid direct comparison of results to be made.

Monte Carlo Analysis Methodology

*Monte Carlo trials for each of the selected variables were undertaken using the risk analysis and simulation add-in program for MS Excel called **@RISK** (Version 4.5) (Palisade Corp. 2002).*

The simulation was set up to sample a sequence of trials of each of the selected variables, i.e. storm duration, storm spatial distribution, storm temporal pattern, initial loss, starting storage in Somerset Dam and starting storage in Wivenhoe Dam.

It was found that 100 trials were sufficient to define the mean outputs for the pre-dam scenario such that variations in the running means were no more than 0.3%. This was considered to be satisfactory. A further 60 trials were added for the post-dam scenarios.

For each trial for the pre-dam scenario a RAFTS model file was prepared, the model run, and the peak flows at a number of key points extracted from the model output.

For the post-dam scenarios, the Wivenhoe storage operation model (DNRM) was run with starting levels from the @RISK simulations and input hydrographs to Somerset and Wivenhoe Dams from the corresponding RAFTS model run. This produced the corresponding Wivenhoe Dam output hydrograph. The RAFTS generated hydrographs to Wivenhoe were then replaced with the Wivenhoe Dam output hydrograph for each trial from the dam operations program and the modified RAFTS model was re-run to produce the post-dams scenario flows.

*The results were subsequently analysed and compared with both the deterministic model runs undertaken for this study and with results from previous studies. These outcomes are summarised in **Table ES2 and ES3**, with more detailed results and discussion thereof being given in the body of the report.*

Comparison of Results

Lower Brisbane River

***Tables ES2** and **ES3** tabulate these results for the pre-dams and post-dams scenarios respectively.*

*In respect of the pre-dams scenario, the results from the Monte Carlo analysis are higher than those recommended in the Independent Review Panel (IRP) Report, with a "best" estimate of **14,000m³/s** at Savages Crossing compared to the IRP value of 12,000m³/s. This result is within the likely upper bound suggested by the IRP, so is consistent with those findings. The likely range is now estimated to be **12,500m³/s** to **15,000m³/s** compared to the previously estimated range of 10,000m³/s to 14,000m³/s.*

*The corresponding values at Moggill and Port Office are **13,000m³/s** from the Monte Carlo analysis compared to 12,000m³/s in the IRP report, within a range of **11,000m³/s** to **14,000m³/s** compared to the previously estimated range of 10,000m³/s to 14,000m³/s.*

The results from the deterministic RAFTS model runs of 13,000m³/s at Savages Crossing and 12,500m³/s at Moggill and Port Office are consistent with the IRP *comment that the RAFTS modelling estimates in SKM (2003) were considered to be about 20% low. The new results resolve this anomaly.*

In respect of the post-dams scenario, the results from the Monte Carlo analysis are about 10% lower than those recommended in the Independent Review Panel (IRP) Report, with a "best" estimate of **4,500m^3/s** *at Savages Crossing compared to 5,500m^3/s. The likely range of this estimate is considered to be* **2,500m^3/s** *to* **7,000m^3/s** *compared to the previously estimated range of 4,000m^3/s to 6,500m^3/s.*

The corresponding values at Moggill and Port Office are **4,500m^3/s** *from the Monte Carlo analysis compared to 5,000m^3/s in the IRP report, within a range of* **3,000m^3/s** *to* **6,000m^3/s** *compared to the previously estimated range of 4,000m^3/s to 6,000m^3/s.*

Given that the current analysis has explored a number of the uncertainties remaining from the previous studies noted in the IRP report, the current results should be given greater weight particularly in respect of the post-dams scenario, and should replace the previous estimates in design studies.

Bremer River

In respect of the Bremer River catchment, **Table ES4** *shows the comparison between the results from the current analysis and from previous studies. These results are not affected by the Brisbane River Dams.*

There is good agreement between the mean and median values of the Q_{100} peak flows from this study for the deterministic and stochastic (Monte Carlo) analyses.

For the Bremer River, the "best estimates" were **1,200m^3/s** *and* **2,600m^3/s** *for the Bremer River at Walloon and Ipswich respectively. The estimated likely ranges for the above were* **900m^3/s** *to* **1,500m^3/s** *and* **2,000m^3/s** *to* **3,100m^3/s** *respectively.*

Similarly, for Warrill Creek at Amberley, the "best estimate" was **1,800m^3/s** *with a likely range of* **1,300m^3/s** *to* **2,200m^3/s.**

SKM (2000) gave Q_{100} values of **2,600m^3/s** *for Warrill Creek at Amberley and* **3,200m^3/s** *for the Bremer River at Ipswich. These values are 30% and 20% higher respectively than the new estimates. This is consistent with the findings of Sargent Consulting (2003) and ICC's belief that the former estimates were too high.*

Table ES2 Comparison of Results Pre-Dam Construction

Source	Method	Location	Estimated Q_{100} Peak Flow m^3/s Best Estimate	Lower Bound	Upper Bound	Comment
Current Study	RAFTS Modelling ~Deterministic	Savages Crossing	13,000	N/A	N/A	Upper and lower bounds not applicable
		Moggill, Port Office	12,500	N/A	N/A	
	Monte Carlo Modelling with RAFTS	**Savages Crossing**	**14,000**	**12,500**	**15,000**	Lower and upper bound taken as 5% and 95% confidence limits
		Moggill, Port Office	**13,000**	**11,000**	**14,000**	
SKM (2003) and Independent Review Panel Report to BCC (2003)	Flood Frequency Analysis	Savages Crossing	12,000	10,000	14,000	
	RAFTS Modelling	Savages Crossing Moggill, Port Office	10,000	8,000	11,000	Estimates considered to be low by Independent Review Panel
SKM (2000) Ipswich Rivers Flood Study	RAFTS Modelling ~Deterministic	Moggill	13,700	N/A	N/A	

Table ES3 Comparison of Results Post-Dam Construction

Source	Method	Location	Estimated Q_{100} Peak Flow m^3/s Best Estimate	Lower Bound	Upper Bound	Comment
Current Study	RAFTS Modelling ~Deterministic	Savages Crossing	6,500	4,000	9,500	"Best" estimate based on 75% initial storage, and upper and lower bounds on 100% and 50% respectively
		Moggill, Port Office	5,000	4,000	7,500	
	Monte Carlo Modelling with RAFTS	**Savages Crossing**	**4,500**	**2,500**	**7,000**	Lower and upper bound taken as 5% and 95% confidence limits
		Moggill, Port Office	**4,500**	**3,000**	**6,000**	
SKM (2003) and Independent Review Panel Report to BCC (2003)	RAFTS Modelling	Savages Crossing	5,500	4,000	6,500	
		Moggill, Port Office	5,000	4,000	6,000	
SKM (2000) Ipswich Rivers Flood Study	RAFTS Modelling ~Deterministic	Moggill	8,100	N/A	N/A	

Conclusions

The analysis has shown that even with a relatively small number of trials, a Monte Carlo analysis was able to refine both the central estimates and likely range of key design values and to reduce the uncertainty in these estimates. It is considered unlikely that further trials will significantly influence the results obtained.

It is acknowledged that there were limitations to the analysis which were necessary due to time and budget constraints. These limited consideration to the range of outcomes from 100 year ARI catchment rainfalls, rather than from the entire distribution of rainfall events.

Nonetheless, this provided a direct comparison with results of previous studies which were also limited in this way.

The results from the Monte Carlo analysis were generally consistent with the recommendations in the Independent Review Panel Report (Mein et al 2003), and have refined both the central flood estimates and the confidence limits, or likely range of the flood estimates.

In respect of the Bremer River and Lockyer Creek catchments, the Monte Carlo analysis results were 20% - 30% lower than those in the Ipswich Rivers Flood Study (SKM 2000).

The review of the RAFTS model with deterministic inputs resolved the anomaly between the RAFTS modelling and flood frequency analysis from SKM (2003) noted in the IRP report, and hence it was considered unwarranted to undertake the frequency analysis of flood volumes.

Specific conclusions were as follows:

- *In respect of the pre-dams scenario, the "best" estimate of Q_{100} peak flow at Savages Crossing was **14,000m^3/s** within a range of **12,500m^3/s** to **15,000m^3/s** (compared to the IRP value of 12,000m^3/s, within a range of 10,000m^3/s to 14,000m^3/s);*

- *In respect of the pre-dams scenario, the "best" estimate of Q_{100} peak flow at Moggill and the Port Office was **13,000m^3/s** within a range of **11,000m^3/s** to **14,000m^3/s** (compared to the IRP value of 12,000m^3/s, within a range of 10,000m^3/s to 14,000m^3/s);*

- *In respect of the post-dams scenario, the "best" estimate of Q_{100} peak flow at Savages Crossing was **4,500m^3/s** compared to 5,500m^3/s, within a range of **2,500m^3/s** to **7,000m^3/s** compared to the IRP value of 5,000m^3/s within a range of 4,000m^3/s to 6,500m^3/s;*

- *The corresponding post-dam values at Moggill and Port Office are **4,500m^3/s** , within a range of **3,000m^3/s** to **6,000m^3/s** compared to the IRP value of 5,000m^3/s within a range of 4,000m^3/s to 6,000m^3/s;*

- *For the Bremer River at Walloon, the "best estimate" was **1,200m^3/s,** within a range of **900m^3/s** to **1,500m^3/s;***

Table ES4 Comparison of Results Bremer River Catchment

Source	Method	Location	Estimated Q_{100} Peak Flow m^3/s			Comment
			Best Estimate	Lower Bound	Upper Bound	
Current Study	*RAFTS Modelling ~Deterministic*	*Bremer River at Walloon*	*1,200*	*N/A*	*N/A*	*Upper and lower bounds not applicable*
		Warrill Creek at Amberley	*1,700*	*N/A*	*N/A*	
		Bremer River at Ipswich	*2,500*	*N/A*	*N/A*	
	Monte Carlo Modelling with RAFTS	***Bremer River at Walloon***	***1,200***	***900***	***1,500***	*Lower and upper bound taken as 5% and 95% confidence limits*
		Warrill Creek at Amberley	***1,800***	***1,300***	***2,200***	
		Bremer River at Ipswich	***2,600***	***2,000***	***3,100***	
SKM (2000) Ipswich Rivers Flood Study	*RAFTS Modelling ~Deterministic*	*Warrill Creek at Amberley*	*2,600*	*N/A*	*N/A*	*Upper and lower bounds not applicable*
		Bremer River at Ipswich	*3,200*	*N/A*	*N/A*	

- *For Warrill Creek at Amberley, the "best estimate" was **1,800m^3/s**, within a range of **1,300m^3/s** to **2,200m^3/s** compared to the previous estimate (SKM 2000) of **2,600m^3/s**; and*

- *For the Bremer River at Ipswich, the "best estimate" was **2,600m^3/s**, within a range of **2,000m^3/s** to **3,100m^3/s** compared to the previous estimate (SKM 2000) of **3,200m^3/s**.*

Recommendations

It is recommended that the estimates of Q_{100} design flows produced from the Monte Carlo analysis described in this report in respect of current catchment conditions be adopted as the basis for inputs to the hydraulic modelling component of this and the parallel BCC study to determine design flood levels and flood inundation mapping.

The following, which were beyond the scope of the current study, are recommended for consideration for further work:

- *Extension of the Monte Carlo analysis to the Q_{20} event which is still an important land use planning criterion for ICC;*

- *Refinement of the distribution of starting storage in Wivenhoe and Somerset Dams by an analysis of the historic distribution, and if this is significantly different from that assumed herein, consider repeating the Monte Carlo analysis; and*

- *Investigation of the sensitivity of RAFTS model results to the lumped conceptual storages in the model, particularly those at the Lockyer Creek/Brisbane River and Bremer River/Brisbane River confluences, and if found to be warranted, recalibration of the RAFTS model.*

1. Introduction

One objective of the *Ipswich Rivers Flood Study Rationalisation Project (IRFSRP)* is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC). The resolution of these anomalies will allow more reliable flood mapping to be prepared.

The IRFSRP is being conducted in parallel with the *Brisbane Valley Flood Damage Minimisation Study (BVFDMS)* which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

One of the outstanding issues that is being investigated as part of the IRFSRP is the catchment hydrology, in particular the definition of design flows as estimated using the RAFTS model which has previously been established for studies for both ICC and BCC. The provision of the most recent RAFTS model input files and data files by BCC is gratefully acknowledged.

The Independent Review Panel (Mein et al 2003) recommended that Monte Carlo methodology be used to simulate the possible combinations of storm temporal and spatial patterns and could also include variation of loss rates and reservoir drawdown.

A full Monte Carlo analysis would comprise running a large number of trials (typically in the order of tens of thousands) in order to adequately describe the distribution of the dependant variable, in this case flood peak magnitude.

Typically, applications of the Monte Carlo simulation process to rainfall – runoff modelling have used a simplified transfer function so that the sample trials could be automated and a large number of trials undertaken. However, due to the complexity of the RAFTS model and its data input requirements, it is not possible to automate the process in this case and manual editing of the data files is required for each model run. As significant time is required to conduct each model run, there are time and budget constraints on the number of trials which could be conducted.

As the current Brisbane/Bremer River RAFTS model has been developed at considerable expense and has been widely used by both ICC and BCC as the basis of flood event modelling for some time, there is no incentive to change the modelling platform at this time.

Taking these constraints into account, the Monte Carlo modelling undertaken for this study was limited to exploring the variation in peak 100 year ARI flows resulting from variations in a limited number of model inputs in order to provide further insight into this variability and to reduce the uncertainty in the Q_{100} flow estimates.

A map of the Brisbane River catchment showing key locations is given in **Appendix A**.

2. Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz) and for the rural areas in 2002 (Halliburton KBR), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

These include:

- Updating of flood hydrology for Wivenhoe Dam operations and the construction of *fuse plug* spillways;
- Availability of new rainfall design data (CRC-FORGE) and a new estimate of probable maximum flood (PMF);
- Revised flood modelling for Brisbane City Council; and
- Review of the latter by an Independent Review Panel which has led to the 100 *year design flood flow for the lower Brisbane River being reduced from 8,000* m^3/s to 6000 m^3/s.

In addition, in response to apparent anomalies with predicted 20 year ARI flood levels in particular, Council commissioned Sargent Consulting (SC) in 2002 to review the current flood models. That review (SC 2003) concluded that the current hydraulic model (MIKE 11) calibration is skewed towards the replication of major floods with the result that water levels for smaller floods are overestimated.

BCC recently commissioned DHI Water & Environment (DHIWE) to review the structure of the MIKE11 model, with the result that a number of recommendations were made to improve the model. The implementation of these recommendations is part of the current projects.

Also, in the period since the flood study results became available, a number of inconsistencies have been noted which require rectification.

As a consequence of the issues noted above, the current hydrologic and hydraulic models are known to have some inconsistencies, and the flood levels used by the two local government areas for town planning controls are no longer compatible.

Resolution of these matters is required urgently by ICC so that:

- The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and
- The current development of emergency response flood mapping is not compromised.

3. Summary of Recent Estimates of Design Flows

The most recent estimates of design flows for the Lower Brisbane River are contained in the reports by SKM (2003) and Mein et al (2003) which are summarised below.

SKM (2003) presented a comprehensive investigation of flood frequency analyses for peak instantaneous flow in the Brisbane River at Savages crossing, under both natural (i.e. pre-dam construction) and current (post-dam construction) scenarios.

Based on consideration of analysis of a number of datasets including a regional flood frequency analysis, SKM (2003) concluded that the "best" or "most plausible" estimate of the 100 year ARI (**Q_{100}**) peak flow at Savages Crossing for the pre-dam scenario was **12,000m^3/s** within a likely range from 10,000m^3/s to 14,000m^3/s.

SKM (2003) also presented revised hydrologic modelling results using the RAFTS model (developed for both BCC and ICC flood studies) using the CRC-FORGE datasets and also allowing for possible variations in both temporal and spatial patterns of storm rainfalls. This analysis resulted in a median estimated peak **Q_{100}** flood flow at Savages Crossing for the pre-dam scenario of **9,600m^3/s** within a likely range of 8,000m^3/s to 11,500m^3/s.

SKM (2003) also estimated peak flows in the post-dam scenario using the RAFTS model results combined with dam operations models for Somerset and Wivenhoe Dams (DNRM 2003), together with runs of the MIKE 11 model and estimated that the "best estimate" of **Q_{100}** peak flow in the Brisbane River at the Port Office is **6,500m^3/s** within a likely range of 5,000m^3/s to 8,000m^3/s. The corresponding best estimate at Savages Crossing was **5,500m^3/s.**

The Independent Review Panel commissioned by BCC (Mein et al 2003) endorsed SKM's "best estimate" of the pre-dam peak **Q_{100}** flood flows at Savages Crossing of **12,000m^3/s** (within a likely range from 10,000m^3/s to 14,000m^3/s) based on flood frequency analysis. Mein et al (2003) considered that the RAFTS modelling estimates of about **10,000m^3/s** (within a likely range of 8,000m^3/s to 11,500m^3/s) to be low.

Mein et al (2003) considered that the most plausible estimate of the post-dams **Q_{100}** peak flow in the Brisbane River at Savages Crossing to be **6,000m^3/s** (within a likely range of 4,000m^3/s to 8,000m^3/s) and at the Port Office **6,000m^3/s** (within a likely range of 5,000m^3/s to 7,000m^3/s).

Mein et al (2003) made a number of recommendations including:

- Using *Monte Carlo*[1] methodology to simulate the possible combination of storm temporal and spatial patterns on peak flows together with rainfall losses and reservoir levels;

[1] **Monte Carlo** methodology describes any method which solves a problem by generating large sets of estimated data using random number generation techniques and observing the relevant properties of the datasets. The method is useful for obtaining numerical solutions to problems which are too complicated to solve analytically. In this way, the probabilistic nature of variables in a system is taken into account by undertaking a large number of trials (simulations) in which the variables are allowed to vary within their known or assumed range. Overall system behaviour and its uncertainty is then predicted by the statistics of the trial results.

- The RAFTS model calibration be revisited with a view to reducing the variance between design flow estimates produced from the model and those obtained from flood frequency analysis; and

- Frequency analysis of flood volumes be carried out, and compared with runoff volumes predicted by the RAFTS model from design rainfalls of corresponding frequency.

4. Scope of Monte Carlo Analysis

The *Monte Carlo* analysis component of the IRFSRP described in this report has comprised:

- Reviewing the RAFTS hydrologic model with CRC-FORGE design rainfall inputs;

- Using the RAFTS model to undertake stochastic modelling (Monte Carlo simulation) to account for probability distributions of the model assumptions and combinations of spatial and temporal rainfall distributions to better define design flow hydrographs and to quantify the uncertainty therein;

- Comparison of hydrologic model design flows from the above with those from direct flood frequency analysis to determine the extent to which this resolves the inconsistency arising from SKM (2003);

- In the event that this inconsistency were not satisfactorily resolved by the above, undertake a frequency analysis of flood volumes as a further aid in this regard (this was subsequently found not to be warranted);

- Re-estimation of 100 year ARI design flows at key locations throughout the catchments on the basis of the new analysis; and

- Reporting on the work undertaken.

5. Preliminary RAFTS Model Runs

Prior to undertaking the Monte Carlo analysis it was necessary to re-establish and review the RAFTS model. This section outlines the procedure used to re-establish and review the existing RAFTS model and the use of the model to estimate peak flows at a number of points of interest for a range of storm durations. This deterministic modelling was undertaken as a preliminary task to the stochastic modelling using the Monte Carlo methodology as described in **Section 6** hereof.

5.1. Review of Existing RAFTS Model

BCC provided RAFTS input files and data files from the SKM (2003) study for use in the current study as acknowledged in **Section 1** hereof.

However, these model and data files were incomplete for the 100 year ARI which is the focus of interest of the current study. A summary of the missing files and the ways in which these were replaced is outlined below:

- BCC was not able to provide the RAFTS model files (.xp files) for the pre-dams case – this was overcome by using the model files from the Ipswich Rivers Flood Study Phase 2 (SKM 2000). The model components downstream of Wivenhoe dam were checked with those provided for the post-dams case and were found to be identical. As SKM (2003) stated that the model used was that developed for the Ipswich Rivers Study, it is reasonable to assume that the model upstream of Wivenhoe Dam was also the same; and

❖ BCC was not able to provide the RAFTS 100 year ARI rainfall input files – however, a spreadsheet containing the CRC-FORGE rainfalls for each model sub area and for a range of durations was provided; although the sub area naming scheme was different to that used in the earlier RAFTS modelling, it was possible to cross match these using the map of the sub areas provided.

In order to re-establish the RAFTS model, the following actions were taken:

i. The RAFTS input file for the whole catchment in its "pre-dams" configuration was copied from that provided from the *Ipswich Rivers Flood Study Phase 2* (SKM 2000) and updated from RAFTS version 5.0 to the current version, viz. RAFTS 2000.

ii. The spatial rainfall distribution provided in spreadsheet form was checked for CRC-FORGE design rainfalls for 100 Year ARI for 24, 48 and 72 hours using the original values of CRC-FORGE rainfalls proved by DNRM (Ruffini J. 2004) and using thematic mapping in MapInfo to estimate mean rainfalls for each sub area in the RAFTS model.

   CRC-FORGE design rainfalls are available for about 130 rainfall station locations within the Brisbane River catchment of 13,600km^2, a relatively dense network by Australian standards. There are over 260 sub areas in the RAFTS model, so the degree of interpolation to obtain the sub area mean rainfall is not great. The mean catchment rainfall was computed as the area-weighted mean for each of these durations and compared to that in the spreadsheet provided. Areal reduction factors, as estimated using the CRC-FORGE procedure were also checked. The results of this comparison are given in **Table 1**, and the distributions are mapped in **Figures 1** to **3**.

   As CRC-FORGE design rainfalls are only provided for durations of 1 to 5 days, the 30 and 36 hour values required interpolation. The interpolated values for these durations were included in the dataset provided by BCC and these were adopted for use herein.

   DNRM has recently released a computer program to estimate Intensity – Frequency – Duration (IFD) relationships using the CRC-FORGE dataset including interpolation for storm durations from 1 to 120 hours. However, this program was not available at the time of undertaking the analysis presented herein. No analysis of sub-daily rainfall durations was undertaken in the current study.

   It can be seen from **Table 1** that the check computations of mean catchment rainfalls are within 2% of those provided. Hence the spreadsheet values were adopted for these and other durations in this range.

   The critical storm duration in a number of the tributaries to the Brisbane and Bremer Rivers is less than 24 hours. Hence, in those tributaries, the results herein are unreliable. These have been noted in the results given in **Section 5.2** hereof (**Table 3**).

Table1
Estimated Brisbane River Catchment Rainfalls for 100 Year ARI Design Storms (CRC-FORGE)

Dataset	Mean 100 Year ARI Catchment Rainfall mm for Storm Durations below after applying Areal Reduction Factor (ARF)		
	24 Hours	48 Hours	72 Hours
CRC-FORGE Areal Reduction Factor (catchment area 13,600 km^2)	0.757	0.828	0.860
Spreadsheet provided by BCC	188	264	309
Independent check	191	268	315
Difference %	+1.6%	+1.5%	+1.9%

As can be seen from **Figures 1 to 3**, there is a marked variation in rainfall across the catchment, generally decreasing from east to west, with the greatest variation in the northern part of the catchment where, for example, 100 year ARI 24 hour rainfall ranges from 485mm on the northeast boundary of the Stanley River catchment to 177mm in the northwest of the upper Brisbane River Catchment. Across the southern sections of the catchment, the variations are less marked, from 395mm in the lower Brisbane River to 170mm in the Lockyer Creek catchment. Spatial variation follows a similar pattern for other durations.

iii. The rainfall files for the RAFTS model were re-established on the basis of the sub-area rainfalls outlined above, by cross-referencing the sub area names in the model to those in the spreadsheet.

iv. Initial check runs of the RAFTS model were then made for a range of storm durations based on the CRC-FORGE spatial variation, using temporal patterns from *Australian Rainfall & Runoff* (ARR), and with the same loss parameters used by SKM (2003) i.e. initial loss of 10mm and continuing loss of 1mm/hr.

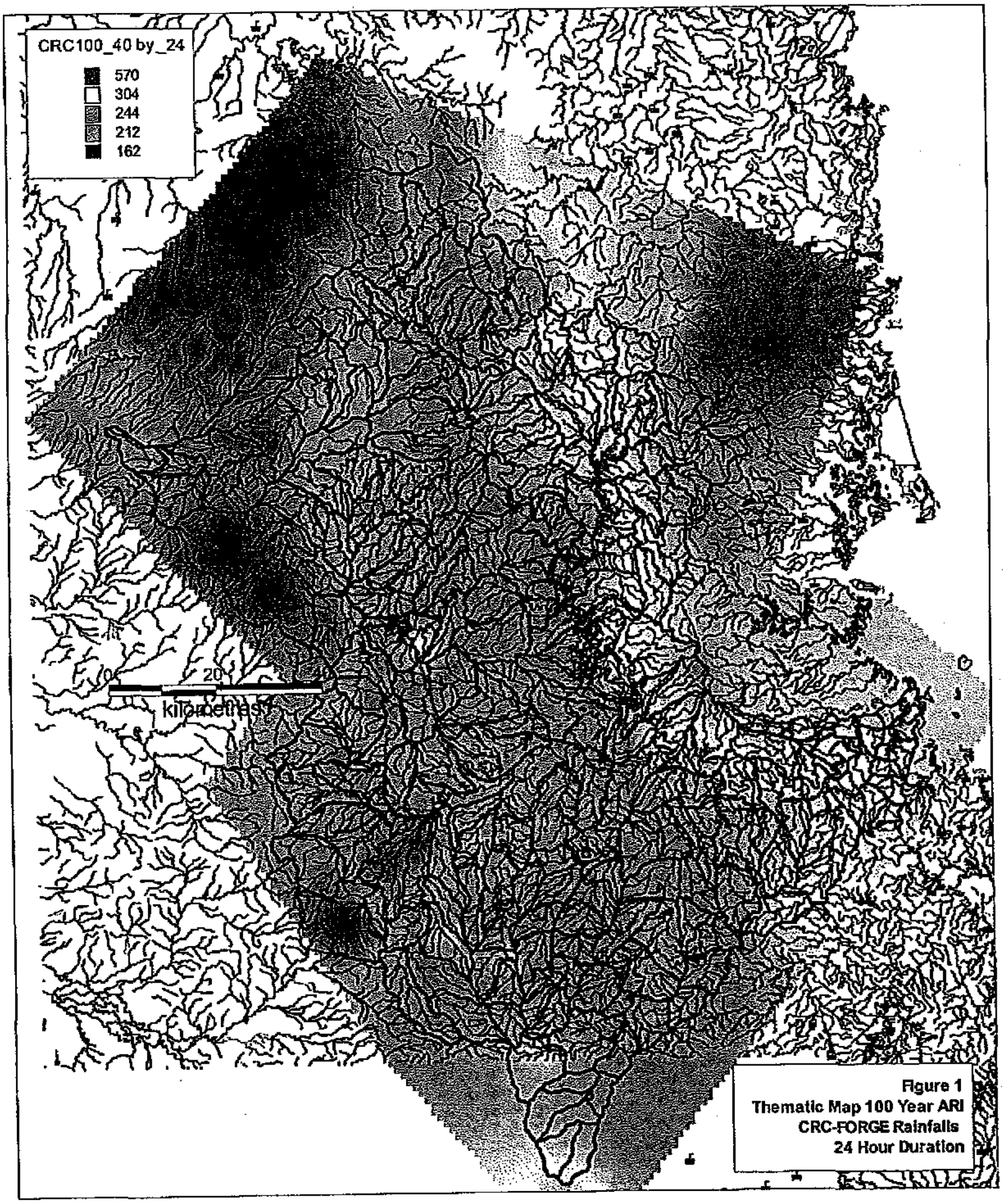


Figure 1
Thematic Map 100 Year ARI
CRC-FORGE Rainfalls
24 Hour Duration

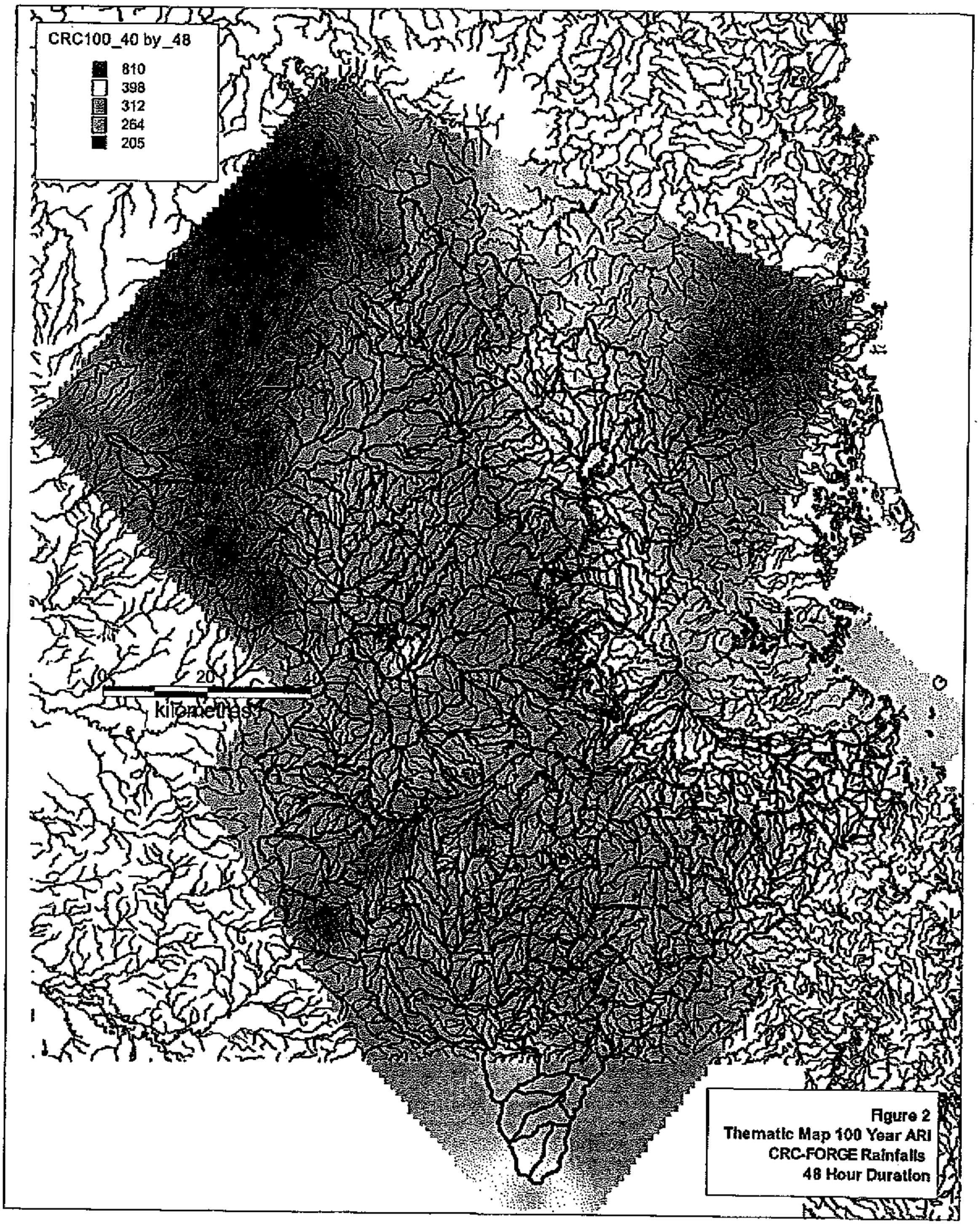


Figure 2
Thematic Map 100 Year ARI
CRC-FORGE Rainfalls
48 Hour Duration

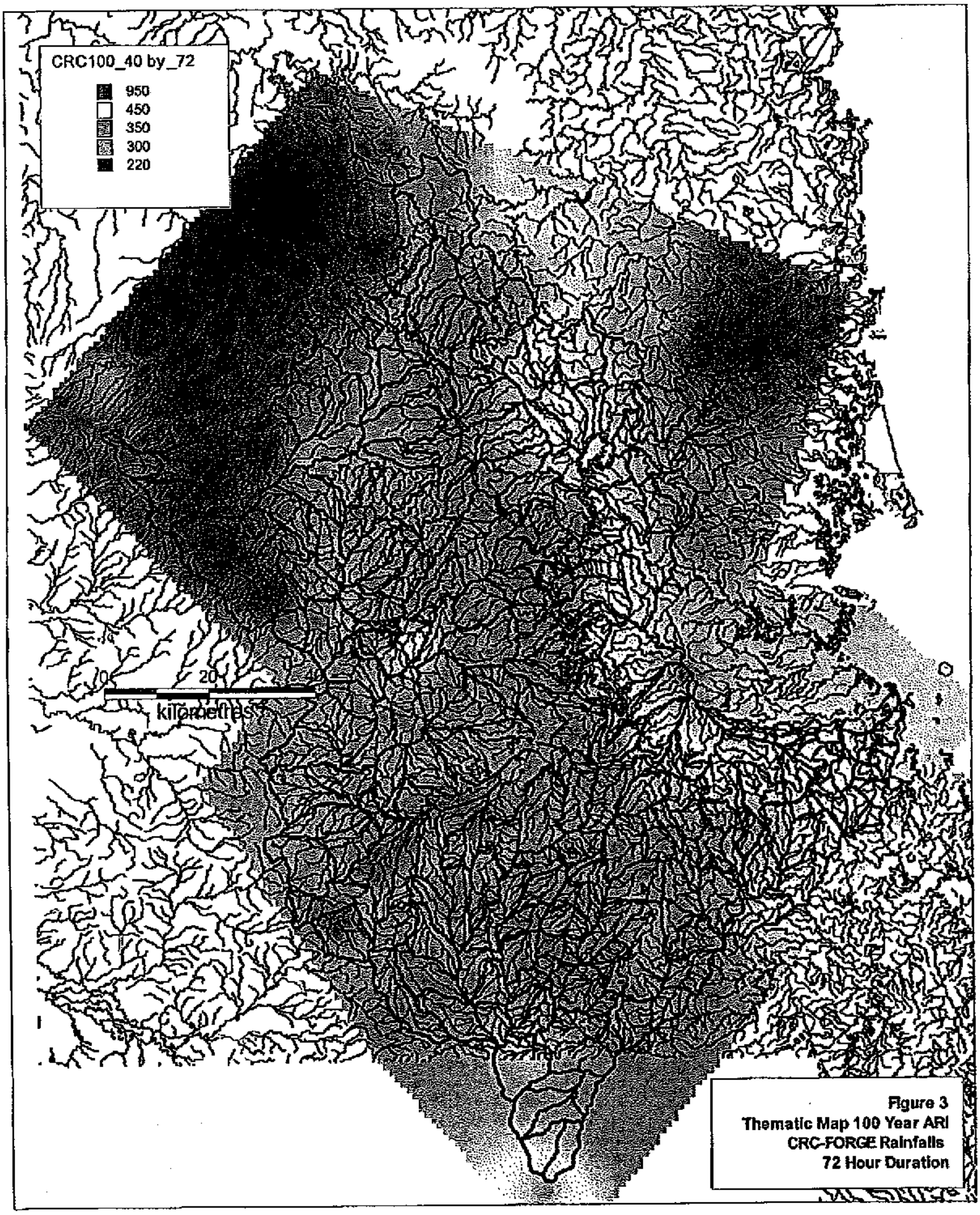


Figure 3
Thematic Map 100 Year ARI
CRC-FORGE Rainfalls
72 Hour Duration

However, these runs produced significantly different peak flows from those presented in SKM (2003) for all storm durations except 72 hours, with the highest differences at 30 and 36 hour durations (up to 56%). These values are shown in **Table 2.**

It should also be noted that the RAFTS model peak flows in the current study are more consistent with the Independent Review Panel's best estimate of **12,000**m^3/s within a likely range of 10,000 – 14,000m^3/s.

The model runs for the current study also put the critical storm duration at 30 hours for all of the main Brisbane River locations, whereas in the previous analysis 72 hours was the critical duration at Moggill and the Port Office.

Table 2 Comparison of Pre- Dam RAFTS Model Peak Flow Estimates

Location	Peak Flows (m^3/s) for Storm Durations of				
	24 Hrs	**30 Hrs**	**36 Hrs**	**48 Hrs**	**72 Hrs**
a) Values from SKM (2003) Table 4-2					
Savages Crossing	8,387	**9,607**	8,379	8,626	9,192
Moggill	7,607	9,015	7,588	8,004	**10,101**
Brisbane Port Office	7,608	9,015	7,589	8,005	**10,106**
b) Current Study					
Savages Crossing	9,700	**13,140**	11,400	9,700	9,100
Moggill	8,600	**12,600**	11,800	10,000	10,200
Brisbane Port Office	8,600	**12,600**	11,800	10,000	10,200
Difference between b) and a) %					
Savages Crossing	+16%	+37%	+36%	+12%	+9%
Moggill	+13%	+40%	+56%	+25%	+1%
Brisbane Port Office	+13%	+40%	+56%	+25%	+1%
NOTE: Critical duration values shown in bold type					

The reasons for these differences were briefly investigated and two reasons for the differences identified, namely:

- Differences in sub area rainfalls; and
- Sensitivity to model conceptual storages.

Although the 100 year ARI rainfall input files for RAFTS were not available from BCC, the output files were provided and these confirmed that the effective rainfalls on the sub areas (i.e. input rainfall minus losses) were consistently lower than those applied in the current study. It was also confirmed that the applied losses were identical, so it was concluded that the input rainfalls were less than those provided in the CRC-FORGE spreadsheet. This was confirmed by comparison of effective rainfalls on a small number of sub areas.

The rainfalls used in the current study were double checked and found to be correct, and the analysis continued on this basis.

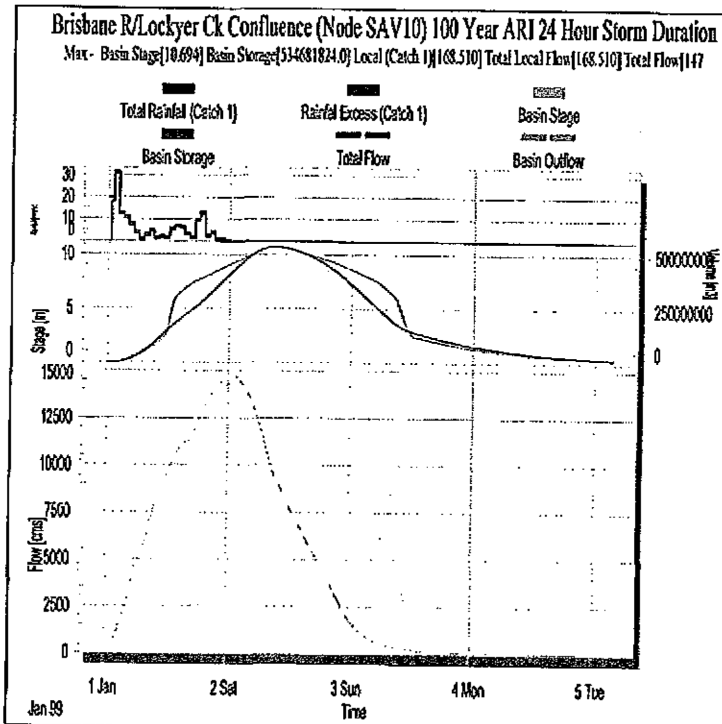
Flood flow attenuation in the RAFTS model may be undertaken using detailed flow routing using the Muskingum-Cunge method or by simple hydrograph lagging. In the Ipswich/Brisbane River model the latter approach was used. As simple hydrograph lagging does not take account of the attenuation effect of temporary storage of floodwaters on the floodplain, conceptual storages were added to the model at key points as part of the model calibration process. The largest of these storages are at the confluence of the Brisbane River and Lockyer Creek (model node SAV10) and at the confluence of the Brisbane River with the Bremer River (model node JIN#).

It was apparent from the RAFTS model results that the outflows from these storages, which directly determine the peak flows at Savages Crossing (node SAV-OUT) and Moggill (node JIN###), are sensitive to the differences in hydrograph shape for the different storm durations. **Figures 4** and **5** show the inflow and outflow hydrographs for the temporary storages at these confluences for 100 Year ARI storms of 24 and 30 hour durations. These figures show that there is significantly less peak flow attenuation in the 30 hour event even where the peak inflows are relatively similar in the 24 hour and 30 hour events.

It would be possible to estimate the physical storage at these locations from the mapping available, and compare this to the conceptual storages, but this is not necessarily helpful, as the conceptual storages are basically lumped storages representing all the temporary storage upstream.

This apparent sensitivity of downstream peak flows to these conceptual storages was not brought out by the previous analysis due to the lower flows modelled.

As a more detailed review of sensitivity of peak flows downstream of these conceptual storages to their depth-storage relationships would require re-calibration of the RAFTS model which was beyond the scope of the current study, it was decided to continue to the Monte Carlo analysis using the existing model.



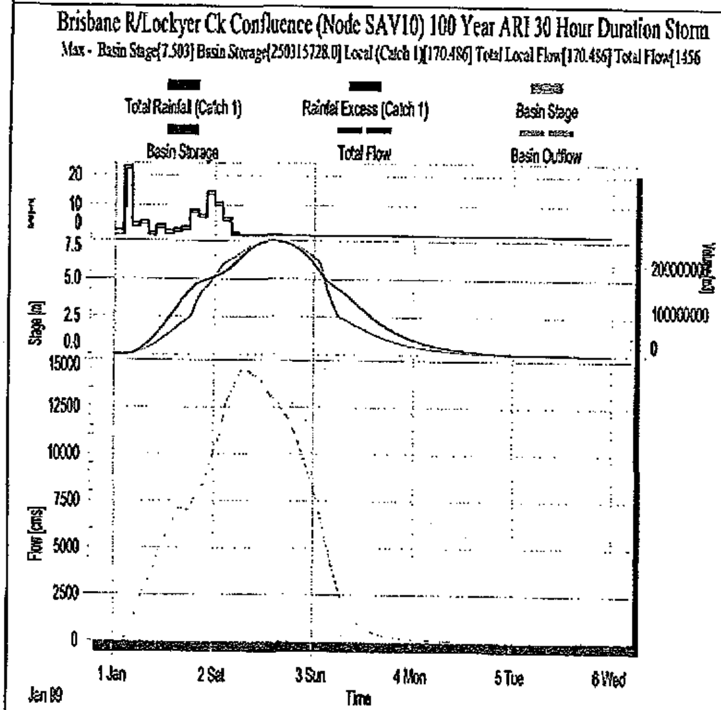
24 Hour Design Storm

I.L. 10mm
C.L. 1mm/hr

Peak Inflow to Storage
14,700 m^3/s

Peak Outflow from Storage
8,600 m^3/s

Peak Stage in Storage
10.64m AHD



30 Hour Design Storm

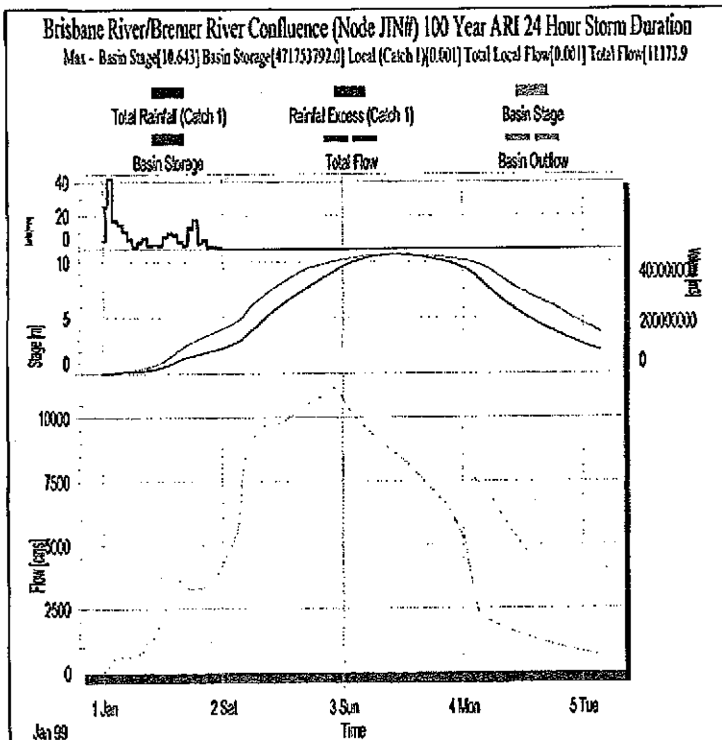
I.L. 10mm
C.L. 1mm/hr

Peak Inflow to Storage
14,560 m^3/s

Peak Outflow from Storage
13,130 m^3/s

Peak Stage in Storage
7.50m AHD

Figure 4 **Hydrographs for Brisbane R./Lockyer Ck. Confluence**



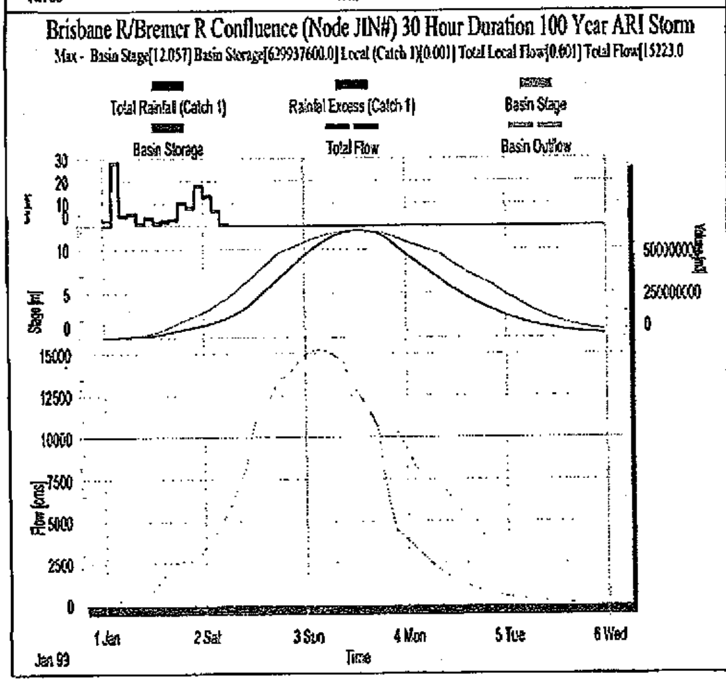
24 Hour Design Storm

I.L. 10mm
C.L. 1mm/hr

Peak Inflow to Storage
14,700 m^3/s

Peak Outflow from Storage
9,700 m^3/s

Peak Stage in Storage
10.69m AHD



30 Hour Design Storm

I.L. 10mm
C.L. 1mm/hr

Peak Inflow to Storage
15,200 m^3/s

Peak Outflow from Storage
12,600 m^3/s

Peak Stage in Storage
12.06m AHD

Figure 5 Hydrographs for Brisbane R./Bremer R. Confluence

5.2. Peak Flows at Key Locations

5.2.1. Pre Dam Conditions

The peak flows at key points obtained from these preliminary runs under pre-dam conditions are summarised in **Table 3**. These runs used the previously adopted rainfall loss rates (i.e. initial loss of 10mm, continuing loss of 1.0mm/hr) using spatially varied CRC-FORGE design rainfalls (as discussed in **Section 5.1** hereof) for storm durations of 24, 30, 36, 48 and 72 hours.

Table 3 shows that the critical storm duration is 30 hours for all locations on the Brisbane River and either 24 or 30 hours for all other stations.

Tributaries locations where the critical storm duration is known from previous studies to be less than 24 hours have been excluded from the results given, except for those in which the critical duration has previously been estimated as 18 hours. In those tributaries, Warrill Creek and Purga Creek the results herein based on 24 hour storm duration may not reliable.

Table 3 **Summary of Peak Flows at Key Locations (Pre-dams)**
(with previously assumed rainfalls and losses)

Spatial Distribution CRC-FORGE LOCATION	RAFTS NODE	CRC-FORGE Storm Duration Hours				
		24	30	36	48	72
Cooyar CK	COO-OUT	1320	1500	1350	1170	1210
Bris R at Linville	LIN-OUT	2990	3420	3070	2670	2780
Emu Ck at Boat Mtn	EMU-OUT	1320	1380	1250	1120	1220
Bris R at Gregors Ck	GRE-OUT	5360	6010	5390	4890	5060
Cressbrook Ck	CRE-OUT	660	690	680	590	670
Stanley R u/s Somerset Dam	SOM+++	2030	2230	2080	1950	2080
Bris R at Somerset Dam	SOM-OUT	3060	3620	3200	3130	3150
Bris R at Wivenhoe Dam	WIV-OUT	10700	11150	9790	9490	9490
Lockyer Ck at Helidon	HEL-OUT	820	880	840	740	800
Lockyer Ck at Gatton	GAT-OUT	2730	2970	2810	2330	2680
Laidley Ck at Laidley	SHO-OUT	690	670	660	590	630
Lockyer Ck at Lyons Br	LYO-OUT	3930	3720	3520	3070	3440
Inflow to temp Storage Lockyer/Bris jn	SAV10	14710	14560	12140	12290	11690
Bris R at Savages Crossing	SAV-OUT	9700	13140	11410	9680	9110
Bris R at Mt Crosby	MTC-OUT	9720	13170	11420	9710	9540
Bris R at Moggill	JIN###	8600	12590	11770	9990	10170
Bremer R at Walloon	WAL-OUT	1170	1130	1030	940	1030
Warrill Ck at Kalbar	KAL-OUT	1080	1020	1010	910	970
Warrill Ck at Amberley	AMB-OUT	1580	1700	1530	1520	1460
Purga Ck at Loamside	PUR-OUT	690	670	640	620	610
Bremer R at Ipswich	2C#	2390	2450	2200	2190	2180
Bris R at Jindalee	JIN-OUT	8600	12590	11770	9990	10180
Bris R at PO Gauge	POG-OUT	8610	12590	11770	9990	10180

☐ Critical Duration

5.2.2. Post Dam Conditions

In order to model post dam conditions, the following process was adopted:

- From the pre-dam model save the flow hydrographs at Wivenhoe Dam, Somerset Dam, Lockyer Creek outflow and Bremer River outflow;
- Convert the sampled starting storage volumes in Wivenhoe and Somerset Dams *for each individual trial* to the equivalent water levels, using the elevation storage levels for the dam;
- Convert the above into the data formats required by the SEQWater/DNRM Wivenhoe and Somerset Dams Operation Model and set up the model parameter file;
- Run the dam operations model to obtain the corresponding outflow hydrographs;
- Rerun the RAFTS model with the Wivenhoe dam output hydrograph from the operations model substituted fro the RAFTS dam inflow hydrograph and deletion of the catchment upstream of Wivenhoe; and
- Extraction of key outputs (eg peak flows, flood volumes at key points) – post dam conditions.

Results for the post dam runs are given in **Table 4**.

Table 4 Summary of Peak Flows at Key Locations (Post-dams) (with previously assumed rainfalls and losses) (other locations as in Table 3)

Spatial Distribution CRC-FORGE LOCATION	RAFTS NODE	CRC-FORGE Storm Duration Hours				
		24	30	36	48	72
Bris R at Wivenhoe Dam	WIV-OUT	3490	5080	6210	7410	6930
Inflow to temp Storage Lockyer/Bris jn	SAV10	5740	8420	9810	10060	9470
Bris R at Savages Crossing	SAV-OUT	5160	8120	9320	7000	7390
Bris R at Mt Crosby	MTC-OUT	5160	8130	9330	7010	7400
Bris R at Moggill	JIN###	4430	6010	6900	6540	7320
Bris R at Jindalee	JIN-OUT	4430	6010	6900	6540	7320
Bris R at PO Gauge	POG-OUT	4430	6010	6900	6540	7320

Critical Duration

It can be seen from **Table 4** that the critical duration at locations on the Brisbane River increased as a result of the presence of the dams in the catchment, which is to be expected, with the result that the critical duration for Wivenhoe Dam outflow was 48 hours, at Savages Crossing 36 hours, and at Moggill and further downstream of 72 hours.

The presence of the dams also results in significant attenuation of the 100 year ARI peak flow from **13,100** m^3/s to **9,300**m^3/s at Savages Crossing and from **12,600** m^3/s to **7,300**m^3/s at Moggill and further downstream.

6. Basis of the Monte Carlo Analysis

The Independent Review Panel (Mein et al 2003) recommended that Monte Carlo methodology be used to simulate the possible combinations of storm temporal and spatial patterns and could also include variation of loss rates and reservoir drawdown.

A full Monte Carlo analysis would comprise running a large number of trials (typically in the order of tens of thousands) in order to adequately describe the distribution of the dependant variable, in this case flood peak magnitude.

In the case of the rainfall runoff process, the full range of variables which could be sampled using the Monte Carlo approach is:

- Rainfall intensity;
- Rainfall duration;
- Rainfall temporal pattern;
- Rainfall spatial pattern;
- Rainfall areal reduction factor;
- Initial loss;
- Possibly continuing loss although this a soil characteristic and not a random variable; and
- Possibly rainfall to runoff transfer function variables, in this case RAFTS model parameters. Although these should be well defined by the calibration process, in reality there is uncertainty about key parameters which could be tested in this way.

Also in this case, the initial storage in Somerset Dam and Wivenhoe Dam could be added to this list.

Previous applications of the Monte Carlo simulation process to rainfall – runoff modelling have used a simplified transfer function so that the sample trials could be automated and a large number of trials undertaken. However, due to the complexity of the RAFTS model and its data input requirements, it is not possible to automate the process in this case and manual editing of the data files is required for each model run. As significant time is required to conduct each model run, there are time and budget constraints on the number of trials which could be conducted.

In this case, using the RAFTS model to estimate flows from a variety of model inputs, the data generation procedure comprised:

- Generation of sample parameter values selected from the above list;
- Estimation of sub area rainfalls from the CRC-FORGE design rainfalls and the appropriate areal reduction factor;
- Preparation of RAFTS input files to reflect the sampled parameters;

- Running the RAFTS model and extraction of key outputs (i.e. peak flows, at key points) for pre dam conditions;

- Using the Somerset Dam and Wivenhoe Dam input hydrographs from the above together with the sampled dam starting levels and running through the dam operations model to obtain the corresponding outflow hydrographs;

- Rerunning the RAFTS model with the Wivenhoe dam output hydrograph from the operations model substituted for the dam inflow hydrograph; and

- Extraction of key outputs (i.e. peak flows at key points) for post dam conditions.

All of the above then need to be repeated for each trial, then the results analysed to determine the flood frequency distributions at each of the key locations.

The process outlined above is time consuming, and in order to produce reasonably reliable results within the study budget, the number of trials had to be reduced to a very limited number, of the order of hundreds, not thousands, of trials.

In order to enable useful results to be obtained from this process with a relatively small number of trials, the following simplified sampling procedure was adopted:

- The analysis was based on the Q_{100} only – or more strictly on the 100 year ARI CRC-FORGE point rainfalls – this greatly reduces the sample size required as we are now concerned only with the distribution of estimates of Q_{100} and not that of the whole of the flood frequency distribution.

  It is recognised that this is a severe limitation to the analysis, as it assumes that 100 year ARI runoff is obtained from 100 year rainfall and excludes the possibility of 100 year ARI runoff resulting from, say, a more extreme rainfall on only part of the catchment, or a less extreme rainfall widely spread over a pre-saturated catchment. However, this process does test the uncertainty within the previous RAFTS results which were also based on 100 year ARI rainfalls only.

- Areal reduction factors were assumed not to be random variables but as estimated using the CRC-FORGE procedure.

- The continuing loss rate was fixed and not varied from one event to another, which is reasonable as this is a function of soil infiltration capacity.

- The RAFTS parameters were also fixed. Whilst this will not test the uncertainty in the RAFTS parameters, these should be relatively small given the extensive model calibration which has been undertaken. Omission of the uncertainty in these values will still enable the objective comparison of the Q_{100} distribution with the previous RAFTS estimates.

On this basis, the parameters tested were:

- Storm duration;
- Storm spatial distribution;
- Storm temporal distribution;
- Initial loss; and
- Starting levels in Somerset and Wivenhoe Dams.

The following paragraphs outline the approach taken in respect of each of the above parameters.

6.1. Storm Duration

The initial RAFTS model runs had established that the critical storm duration for the main points of interest for the pre-dams scenario were either 24 hours or 30 hours.

For the pre-dams analysis, storm durations were limited to 24 and 30 hour events only, and it was assumed that these were equally likely to occur (i.e both have a 50% probability of occurrence).

For the post-dams analysis it was necessary to include events of 36, 48 and 72 hours.

Rahman et al (2001) determined, using pluviograph records from Victoria, that the duration of storm-cores (that part of the storm containing the most intense period of rain) was exponentially distributed. Hoang et al (1999) determined that a 3 parameter generalised Pareto Distribution best described the duration of complete storms in Victoria, whilst Carroll & Rahman (2004) recommended use of the exponential distribution for complete storms in south east Queensland.

In this analysis it was assumed that the storm durations were exponential and **Figure 6** shows the distribution used in this analysis.

6.2. Storm Spatial Distribution

The Brisbane River catchment has four major sub-catchments, namely:

- The upper Brisbane River catchment from its headwaters to Somerset Dam;
- The Stanley River catchment from its headwaters to Somerset Dam and the mid reaches of the Brisbane River to Wivenhoe Dam;
- Lockyer Creek; and
- The lower Brisbane River catchment downstream of Lockyer Creek and including the Bremer River catchment.

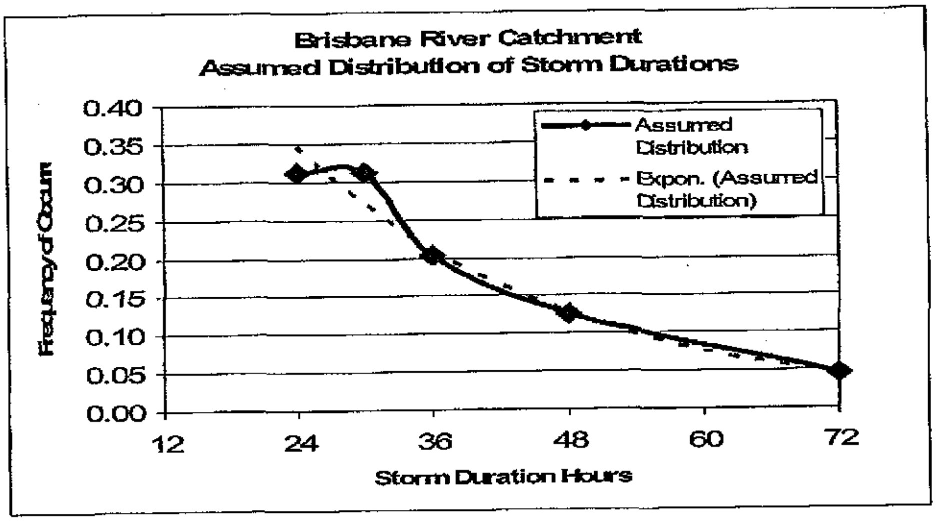


Figure 6 Assumed Distribution of Storm Durations

Approximately, these major sub-catchments comprise the northwest, northeast, southwest and southeast quadrants of the catchment as shown in **Figure 7**, and are of similar area. These sub-catchments were considered to be a reasonable basis on which to vary the spatial distribution of rainfall across the whole catchment.

In varying the spatial distribution of rainfall over the catchment, it was important to retain the overall mean catchment rainfall, and to not introduce distortions to the assumption of probability equality between rainfall and runoff.

The preferred means of doing this was to compute catchment rainfalls for each major sub-catchment in turn using the appropriate areal reduction factor, and then factorise rainfall over the other three sub-catchments to maintain the overall catchment rainfalls. However, this was found to produce only minor variations.

Instead, the method adopted was to increase the rainfall over the selected sub-catchment from 100 year to 200 year ARI, then reduce the rainfall depths over the remaining catchment so that the overall mean catchment rainfall remained at the 100 year ARI value. This resulted in increases of about 12% over the selected sub-catchment and reductions of about 4% over the remaining sub-catchments. This was applied to each sub-catchment in turn, resulting in a total of 5 spatial variants i.e. the original CRC-FORGE distribution over the whole catchment plus 4 variants in which the rainfall over one of the major sub-catchments was intensified.

Whilst the use of the 200 year intensity over individual sub-catchments with corresponding reduction elsewhere was arbitrary, this does maintain the overall integrity of the approach in having a neutral overall impact on rainfall probability and in not introducing undue bias.

It was assumed that the basic spatial distribution and one concentrated in one of the major sub-catchments were equally likely to occur (i.e. both have 50% probability of occurrence), with the latter group further divided into equal probabilities in each of the 4 sub-catchments (i.e. 12.5% in each). This was arbitrary but reasonable.

6.3. Storm Temporal Distribution

Two alternative storm temporal patterns were adopted, namely:

- Temporal patterns as given in ARR (I.E.Aust. 1987); and
- Temporal patterns derived using the Average Variability Method.

The ARR (1987) temporal patterns are those normally adopted for design rainfall-runoff modelling in Australia and were produced as a result of extensive research in the 1980's. The Brisbane River catchment is within Zone 3 for these temporal patterns and the appropriate values were adopted. These result in a bi-modal temporal distribution as shown in **Figure 8** with the heaviest rainfall early in the storm.

The Average Variability Method (AVM) was adopted by the Bureau of Meteorology in the development of its *Generalised Tropical Storm Method (GSTM)* for the estimation of probable maximum precipitation (BOM 2004). This was based on the analysis of a number of historic storms in each region and over a range of catchment sizes. The temporal patterns for a 10,000 km^2 coastal Queensland catchment for 24 and 36 hours were obtained from this publication, and the 30 hour duration pattern was estimated from the 36 hour pattern by dropping out the 2 smallest values at the ends (as based on 3 hour increments). The patterns are given in **Figure 9**, which show that this approach produces a distribution more weighted to the central part of the storm.

It was assumed that any given storm was equally likely to conform to either of these temporal patterns (i.e. both have 50% probability of occurrence).

6.4. Initial Loss

ARR (1987) gives median initial loss for Queensland of 25 – 35mm. The previous analysis adopted a value of 10mm which is relatively conservative.

In order to investigate the effect of the initial loss assumption on the design flows, a range of 0 to 50mm was considered with its mode (most likely value) being 10mm. A simple triangular distribution was assumed for this parameter, as shown in **Figure 10.**

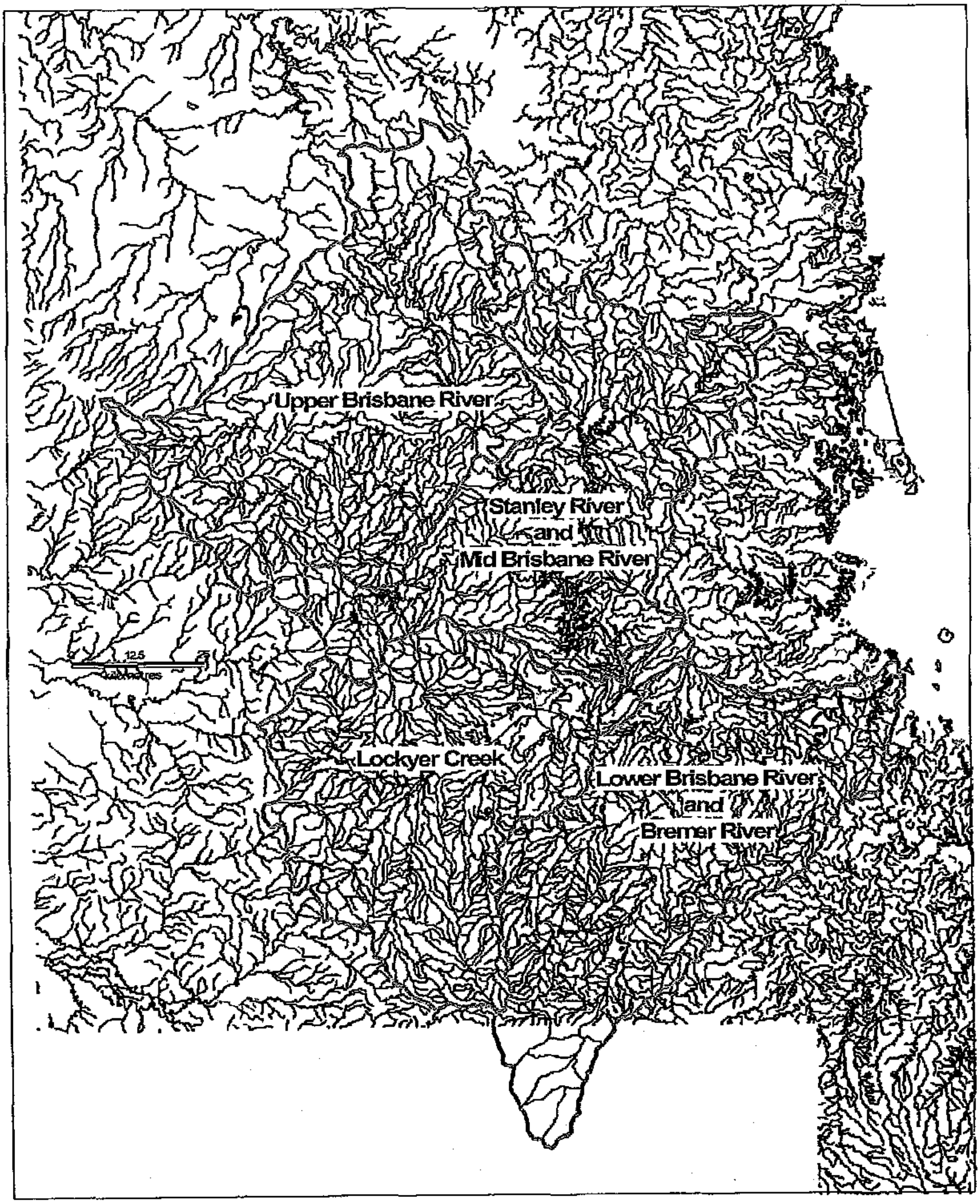


Figure 7 Brisbane River Catchment - Major Sub-Catchments

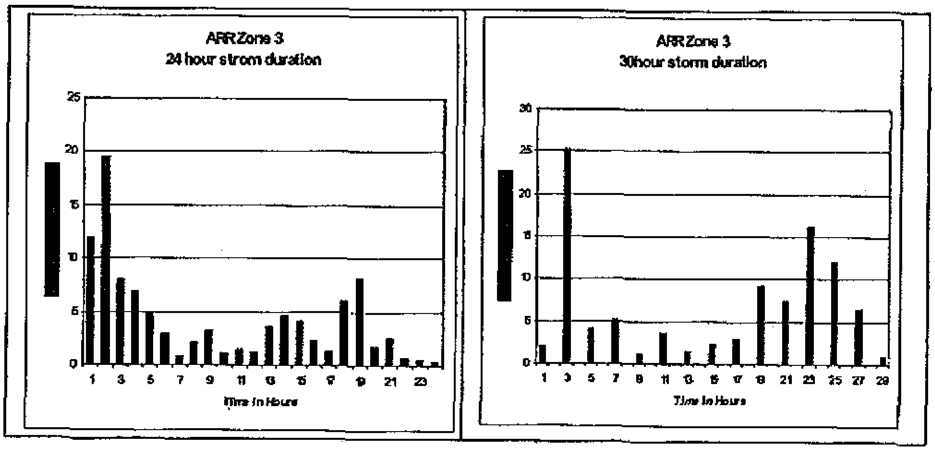


Figure 8 **ARR Temporal Patterns for 24 and 30 Hour Duration Storms**

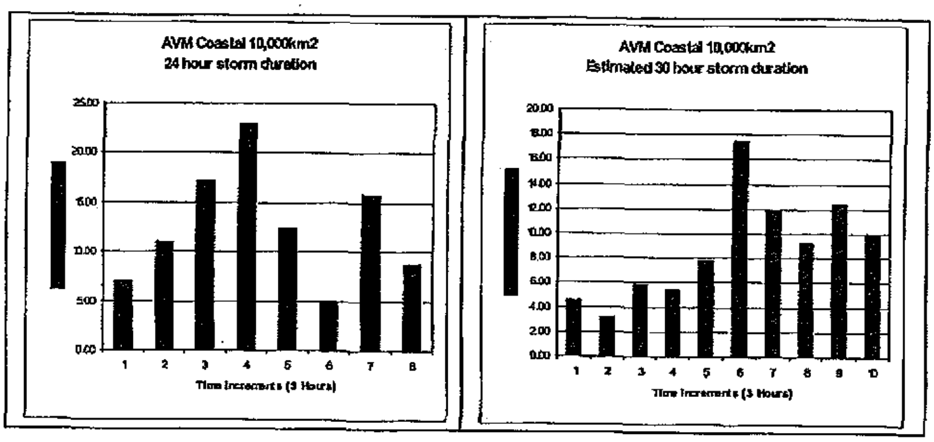


Figure 9 **AVM Temporal Patterns for 24 and 30 Hour Duration Storms**

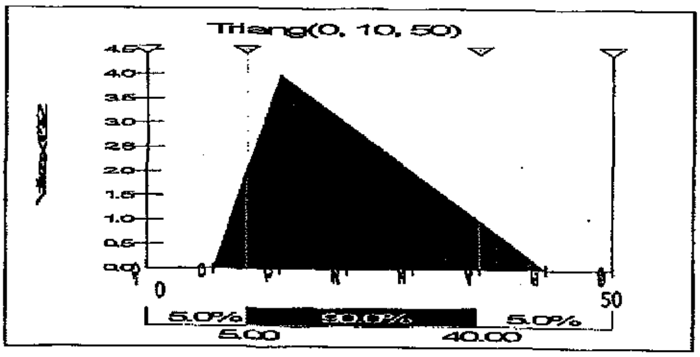


Figure 10 **Assumed Distribution of Initial Loss**

6.5. Dam Starting Levels

SKM (2003) used starting storage values of 50%, 75% and 100%.

We have assumed for this analysis that the storage levels in both Somerset Dam and Wivenhoe Dam are in the range of 50% to 100% with a rectangular distribution i.e. any value in this range is equally likely to occur. These distributions are shown in **Figure 11** for Somerset and Wivenhoe Dams respectively.

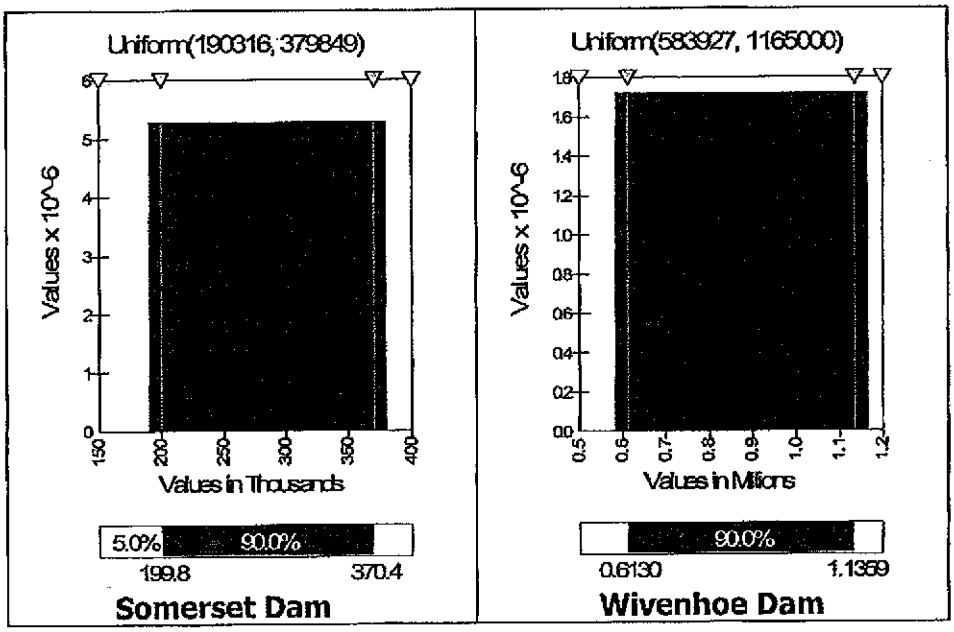


Figure 11
Assumed Distribution of Reservoir Storage at Start of Flood Event

Whilst storages in Somerset and Wivenhoe Dams will not be perfectly correlated, there should be a significant degree of correlation in dam inflows, which we have assumed to be 50%.

Although, in the current drought, dam storage levels are below 50%, the arbitrary limit of 50% for this analysis was thought to be reasonable.

7. Monte Carlo Analysis Results

7.1. Monte Carlo Simulation

Monte Carlo trials for each of the selected variables were undertaken using the risk analysis and simulation add-in program for MS Excel called **@RISK** (Version 4.5) (Palisade Corp. 2002).

The simulation was set up to sample a sequence of 500 trials of each of the variables as outlined above, i.e. storm duration, storm spatial distribution, storm temporal pattern, initial loss, starting storage in Somerset Dam and starting storage in Wivenhoe Dam. It was anticipated that satisfactory statistical outcomes would result from a smaller number of trials, and to track this the running mean (i.e. mean of all values included up to and including the current trial) value of key RAFTS outputs were computed and graphed.

It was found that 100 trials were sufficient to define the mean outputs for the pre-dam scenario such that variations in the running means were no more than 0.3%. This was considered to be satisfactory, given the main objective of the analysis is to reduce the uncertainty in output values. A further 60 trials were added for the post-dam scenarios (as outlined in **Section 7.3**).

Firstly, a RAFTS model file was prepared for each trial for the *pre-dam* scenario, the model run, and the peak flows at a number of key points extracted from the model output.

For the post-dam scenarios, the Wivenhoe storage operation model was run with starting levels from the @RISK simulations and input hydrographs to Somerset and Wivenhoe Dams from the corresponding RAFTS model run. This produced the corresponding Wivenhoe Dam output hydrograph. The RAFTS generated hydrographs to Wivenhoe were then replaced with Wivenhoe Dam output hydrograph for each trial from the dam operations program and the modified RAFTS model was re-run to produce the *post-dams* scenario flows.

Both the pre-dam and post-dam results were then analysed and are presented in **Sections 7.2** and **7.3** hereof. The outcomes of the analysis are summarised in **Section 7.4**, and subsequent sensitivity tests are outlined in **Section 7.5.** In **Section 7.6** the results are compared to those from previous analyses.

7.2. Results for Pre-Dam Scenario

Peak flows at key points in the Brisbane River and Bremer River catchments from the first 100 *Monte Carlo* trials under pre-dam conditions are given in **Table 5**.

Figure 12 shows that an acceptable convergence was achieved after about 70 trials, after which the variations in the running means of the key outputs were no more than 0.3%, showing that there is little to be gained from additional trials.

Table 5 Summary of Peak Flows at Key Locations from Initial Monte Carlo Simulations (Pre-Dam Scenario)

Location	RAFTS Node	NO DAMS SCENARIO Trials 1 -100 Peak Flows in Cumecs			
		Mean	5% CL	Median	95% CL
a) *Brisbane River*					
Bris R at Savages Crossing	SAV-OUT	11400	8200	11300	14700
Bris R at Moggill	JIN###	10300	7500	9400	13600
Bris R at PO Gauge	POG-OUT	10300	7500	9400	13600
b) Bremer River & Lockyer Ck					
Lockyer Ck at Lyons Br	LYO-OUT	3800	2500	3900	4600
Bremer R at Walloon	WAL-OUT	1200	920	1200	1500
Warrill Ck at Amberley	AMB-OUT	1800	1300	1750	2200
Bremer R at Ipswich	2C#	2600	2000	2550	3100

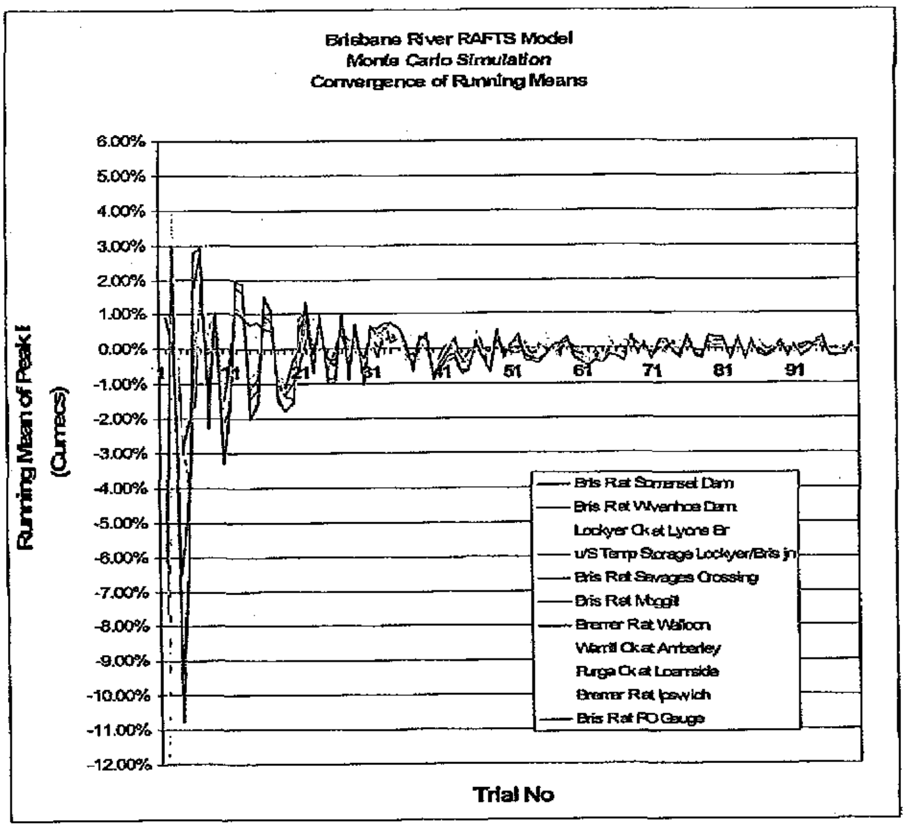


Figure 12 Convergence in Running Means (Pre- Dam Scenario)

Figure 13 shows the distributions of the peak flows at the locations in **Table 5** from the 100 trial values obtained. It is immediately apparent from these figures that whereas the values for locations in the Bremer River and Lockyer Creek are continuous across the value range, those on the lower Brisbane River are not. At the latter stations, there are clearly two populations within the samples, and this was found to relate to the two storm durations used (24 hours and 30 hours), with all of the values in the higher range being from the 30 hour duration events.

This shows that, for locations in the lower Brisbane River, the 24 hour storms do not produce critical conditions, whereas in the major tributaries, critical conditions can occur from either scenario.

This can also be seen in the scatter diagrams of peak flows in the Brisbane River at Savages Crossing, Moggill and Port Office and at Wivenhoe dam site, Lockyer Creek and Bremer River plotted against the corresponding peak inflow into the temporary storage at the Brisbane River/Lockyer Creek confluence shown in **Figures 14** and **15**. Only the Savages Crossing, Moggill and Port Office curves show this separation between results from the 24 hour and 30 hour storms (**Figure 14**).

For the tributaries and the Brisbane River at Wivenhoe, the curves for 24 hour and 30 hour overlap, albeit with the 30 hour storms giving the maximum flows overall (**Figure 15**).

Because of this dichotomy, it was decided that for the lower Brisbane River stations, the 24 hour storms should be excluded. The results for the 30 hour storms only (50 trials) are given in **Table 6** and the convergence is shown in **Figure 16**.

Table 6 Summary of Peak Flows at Key Locations from Monte Carlo Simulations of 30 Hour Storms only (Pre- Dams Scenario)

Location	RAFTS Node	NO DAMS SCENARIO 30 Hour Storms only Trials 1 - 50 Peak Flows in Cumecs			
		Mean	5% CL	Median	95% CL
a) Brisbane River					
Bris R at Savages Crossing	SAV-OUT	13800	12500	14000	14800
Bris R at Moggill	JIN###	12800	11300	13000	13700
Bris R at PO Gauge	POG-OUT	12800	11300	13000	13700
b) Bremer River & Lockyer Ck					
Lockyer Ck at Lyons Br	LYO-OUT	4000	3500	4100	4900
Bremer R at Walloon	WAL-OUT	1300	1050	1300	1550
Warrill Ck at Amberley	AMB-OUT	1900	1600	1900	2300
Bremer R at Ipswich	2C#	2700	2350	2800	3200

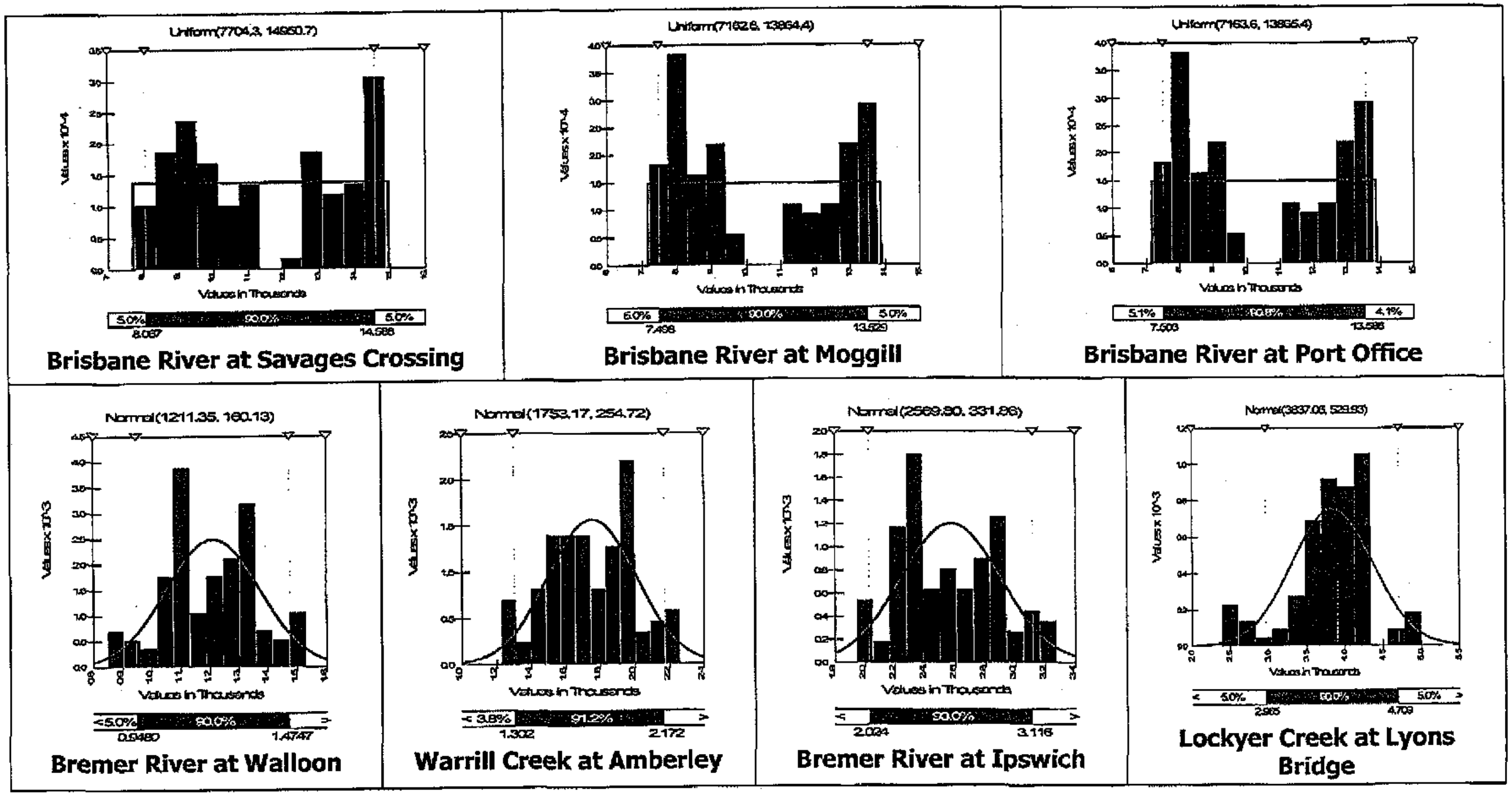


Figure 13 Distributions of Peak Flows at Key Locations from Monte Carlo Simulation (Pre- Dams)

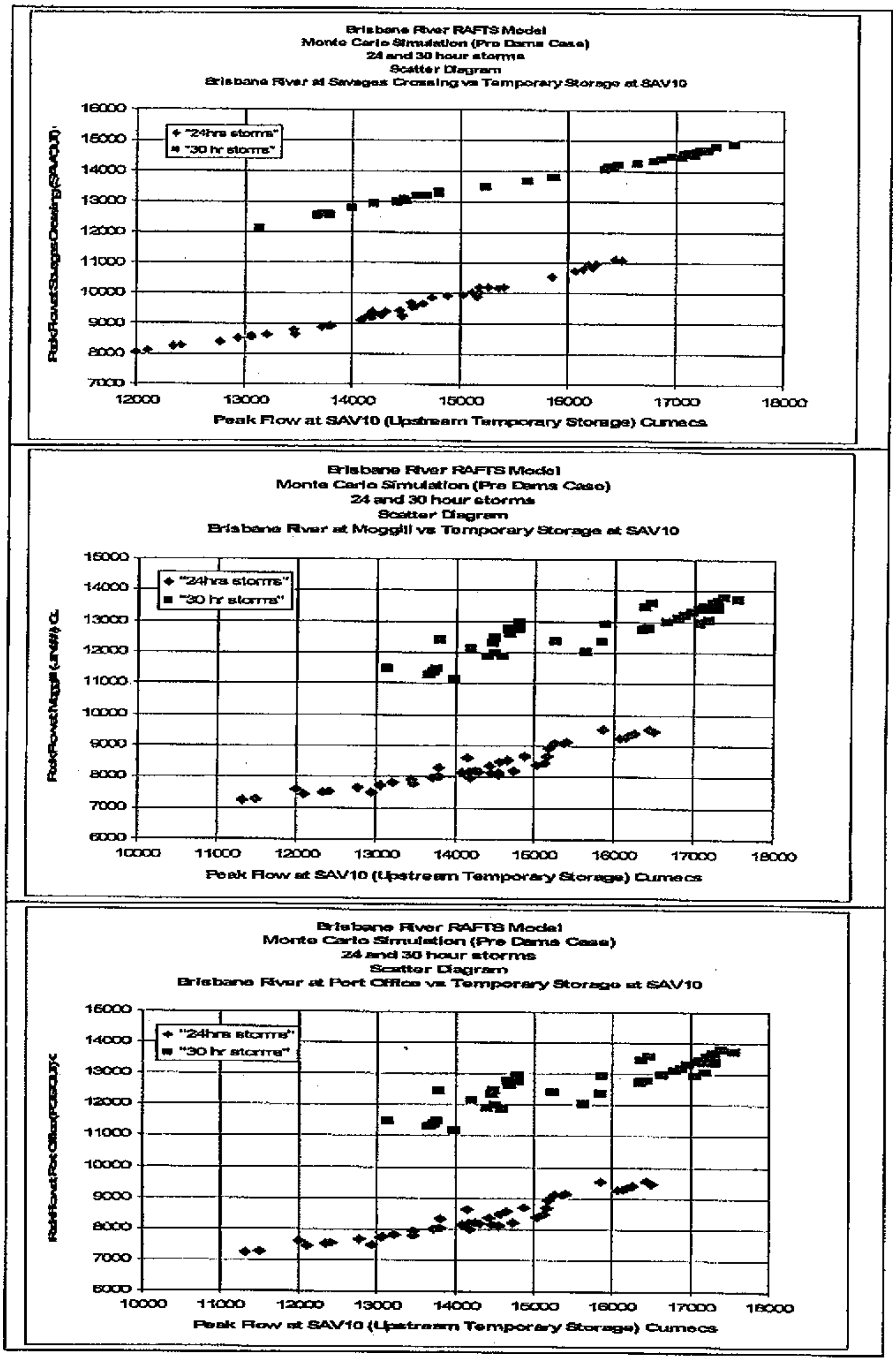


Figure 14 Scatter Diagrams - Brisbane River at Savages Crossing, Moggill and Port Office (Pre- Dams)

Sargent Consulting

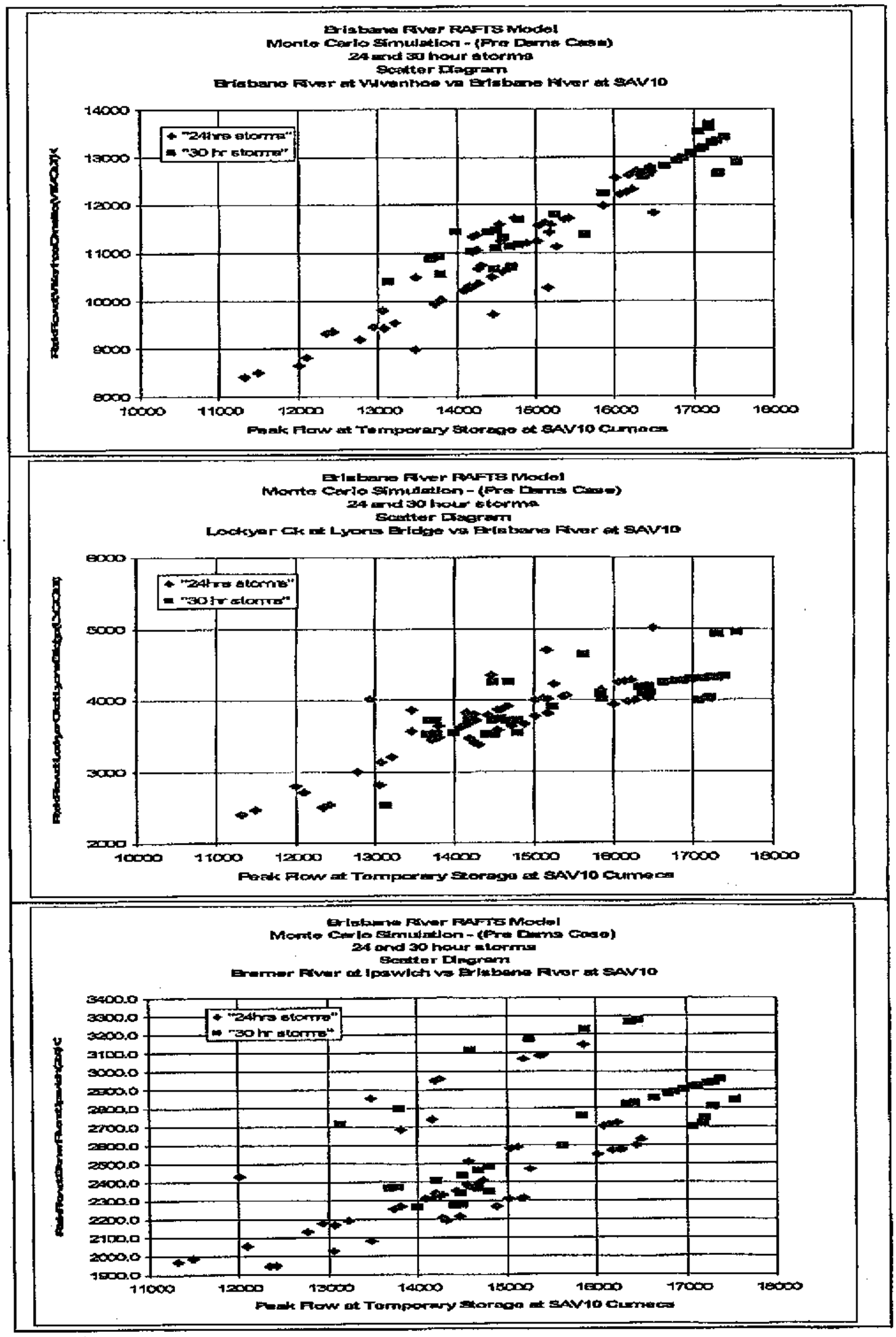


Figure 15 **Scatter Diagrams - Brisbane River at Wivenhoe, Lockyer Creek and Bremer River**

Comparing the results in **Tables 5** and **6**, it can be seen that there is a significant increase in the peak flow statistics for the lower Brisbane River locations (21% to 38%) when only the 30 hour duration storms are used, but a much smaller increase for the tributary stations (5% to 10%).

Distributions for the 30 hour only storms are given in **Figure 17**. Comparison of **Figures 13** and **17** shows that excluding the 24 hour storms from the analysis for the tributaries is detrimental to the spread of values obtained and that this should only be done for the lower Brisbane River locations.

Table 7 gives the final results using the 30 hour storms only for the latter and the combined 24 and 30 hour storms for the remaining locations.

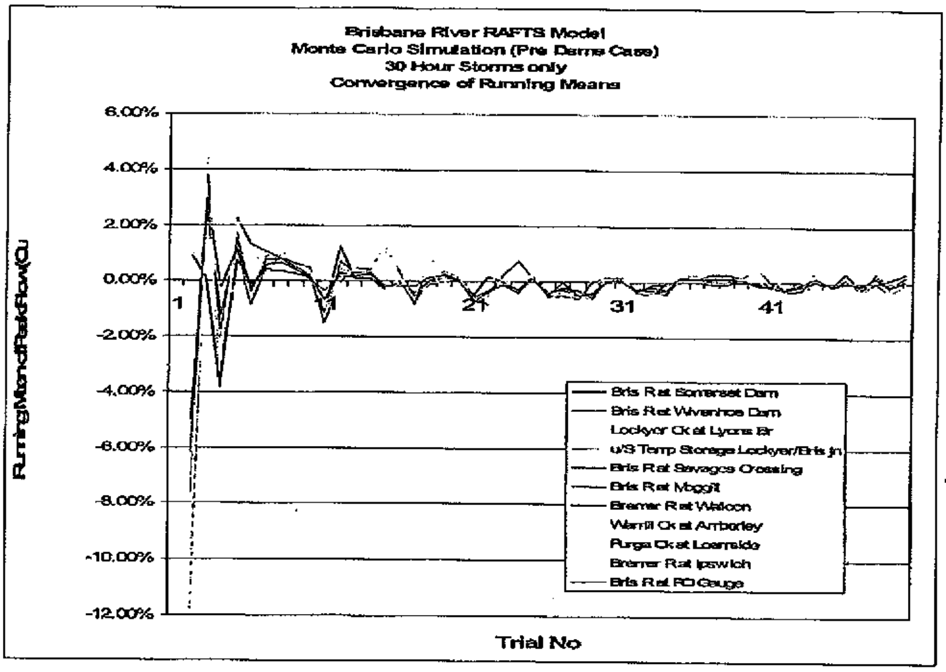


Figure 16 **Convergence in Running Means 30 Hour Storms only (Pre- Dam Scenario)**

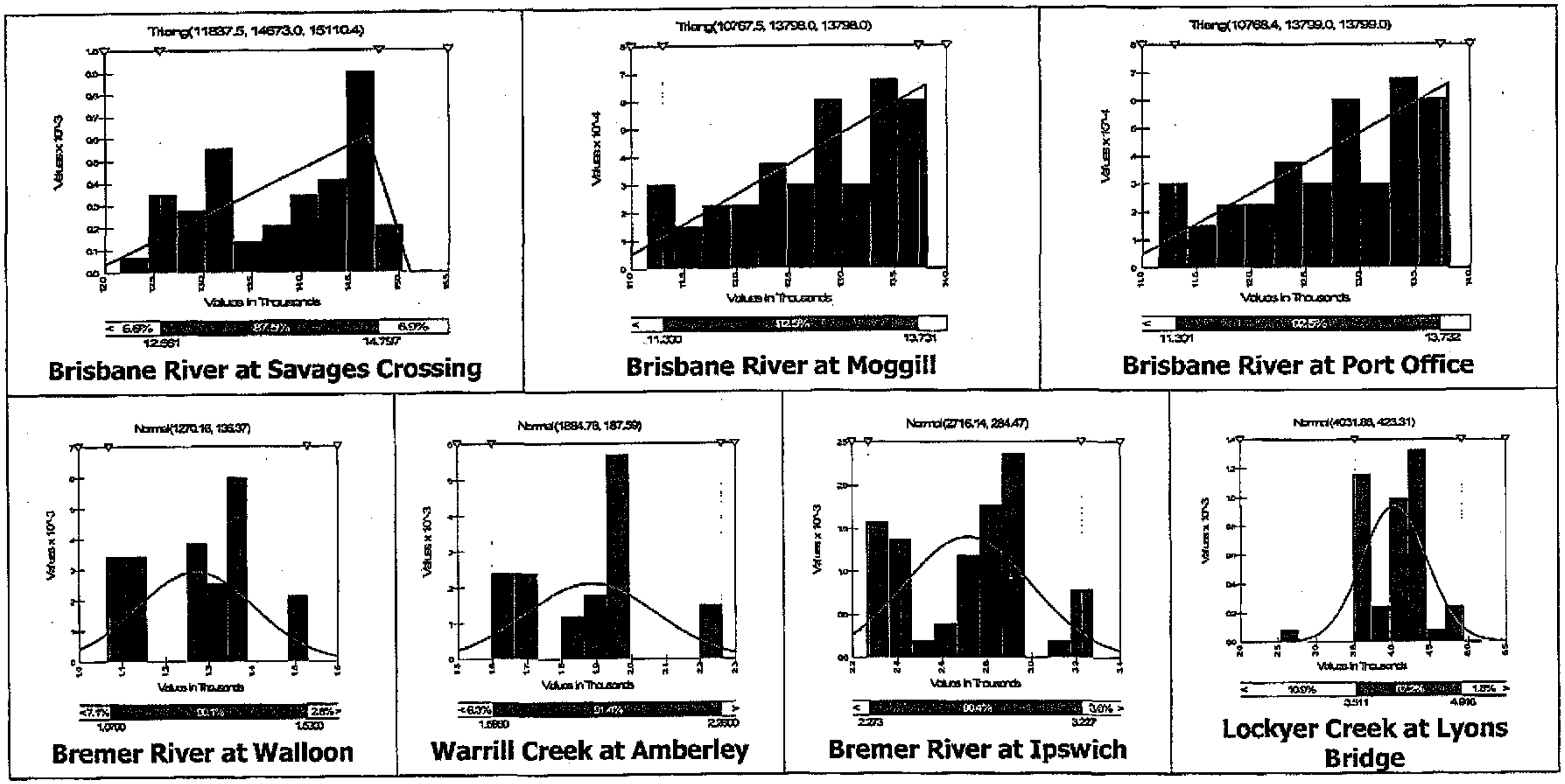


Figure 17 Distributions of Peak Flows at Key Locations from Monte Carlo Simulation (30 Hour Storms only)

Table 7 Adopted Peak Flows at Key Locations from Monte Carlo Simulations (Pre- Dams Scenario)

Location	RAFTS Node	NO DAMS SCENARIO Peak Flows in Cumecs			
		Mean	5% CL	Median	95% CL
a) Brisbane River (50 Trials 30 hour duration only)					
Bris R at Savages Crossing	SAV-OUT	13800	12500	14000	14800
Bris R at Moggill	JIN###	12800	11300	13000	13700
Bris R at PO Gauge	POG-OUT	12800	11300	13000	13700
b) Bremer River & Lockyer Ck (100 Trials 24 and 30 hour durations)					
Lockyer Ck at Lyons Br	LYO-OUT	3800	2500	3900	4600
Bremer R at Walloon	WAL-OUT	1200	920	1200	1500
Warrill Ck at Amberley	AMB-OUT	1800	1300	1750	2200
Bremer R at Ipswich	2C#	2600	2000	2550	3100

In respect of the other parameters varied in the Monte Carlo analysis, **Figure 18** shows the relationship between peak flow at Savages Crossing and the initial loss value used in the trial. This shows that, whilst peak flow decreases as initial loss increases as expected, the relationship is weak for the 30 hour storms in particular and has a greater impact in respect of the 24 hour duration storms.

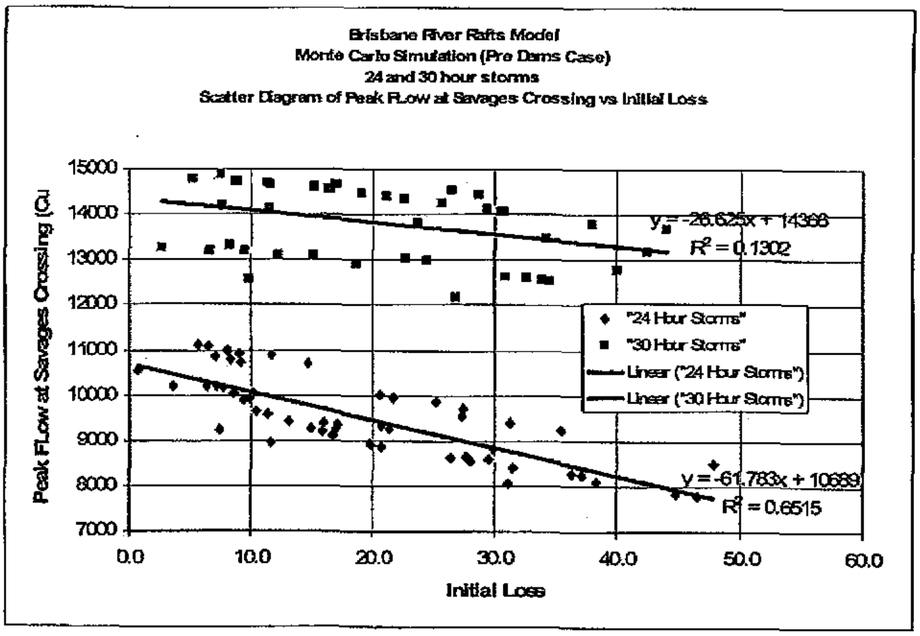


Figure 18 Peak Flow at Savages Crossing vs. Initial Loss (Pre-dams)

Figure 19 shows the effect on the peak flow at Savages Crossing of the assumed variations in storm spatial distribution as described in **Section 6.2** hereof. It can be seen from **Figure 19** that the modelled variations in storm spatial distribution resulted in changes in peak flow at Savages Crossing of +5% to -8% in mean and +15% to -12% in the median.

Figure 20 shows the effect on the peak flow at Savages Crossing of the assumed variations in storm temporal distribution as described in **Section 6.3** hereof. It can be seen from **Figure 20** that the modelled variations in storm temporal distribution resulted in changes in peak flow at Savages Crossing of +9% to -10% in mean and +21% to -17% in the median with higher flows using the AVM distribution and lower flows using the ARR distribution.

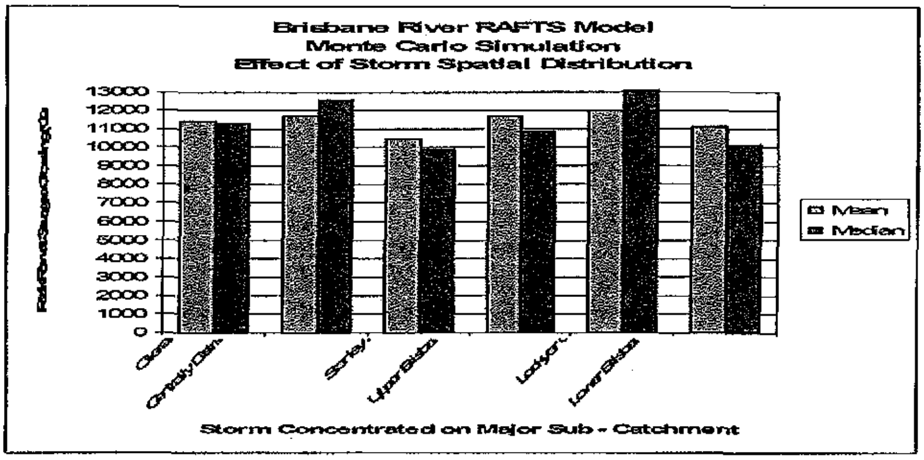


Figure 19 Effect of Variations in Spatial Distribution on Peak Flow at Savages Crossing (Pre-dams)

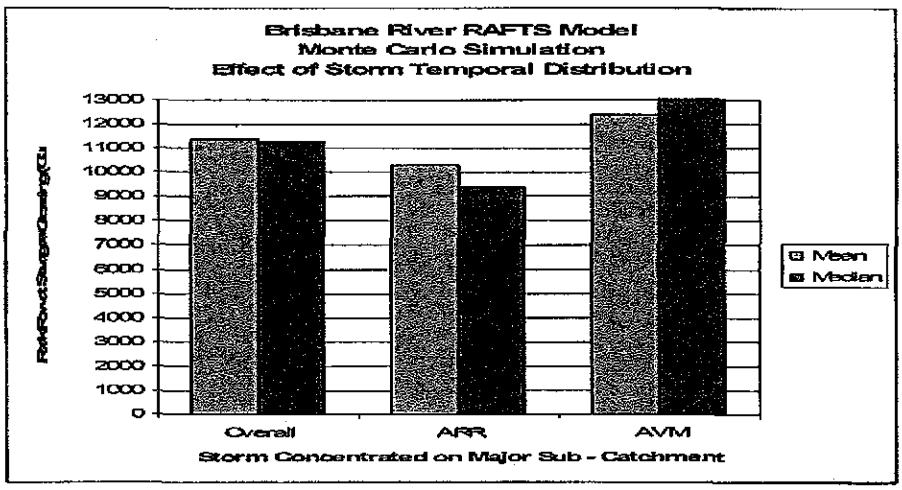


Figure 20 Effect of Variations in Temporal Distribution on Peak Flow at Savages Crossing (Pre-dams)

7.3. Results for Post-Dam Scenario

In order to model the post dam scenario, the model runs were undertaken as described in **Section 5.2.2** (for the deterministic case) but with this process being undertaken for each Monte Carlo trial. As noted in **Section 5.2.2**, the critical durations were increased by the presence of the dams, so it was necessary to undertake further trials to include longer durations.

The approximate exponential distribution of storm duration discussed in **Section 6.1** was used to determine the corresponding number of trials for each duration given that 50 trials had already been analysed for storm durations of 24 and 30 hours. This resulted in 30, 20 and 10 trials for durations of 36, 48 and 72 hours respectively.

Another 60 of the original 500 trials were used for this purpose with their durations changed as above. Whilst this does not strictly replicate the results from new samples for these durations, it was important to be able to retain the 100 trials already analysed and this approach facilitated this end.

Also, as the analysis to this point had shown that the *spatial and temporal variation* tested did not result in significant changes to downstream flows, it was assumed that the storm was centrally distributed and that the ARR temporal distribution applied in all the additional trials, thereby simplifying the file editing requirements for each RAFTS model run. Variations in initial loss and reservoir starting levels were retained.

Table 8 summarises the results of this analysis.

Table 8 Summary of Peak Flows at Key Locations from Monte Carlo Simulations (Post - Dams Scenario)

Location	RAFTS Node	WITH DAMS SCENARIO Trials 1 - 160 Peak Flows in m³/s			
		Mean	5% CL	Median	95% CL
Brisbane River					
Savages Crossing	SAV-OUT	4500	2400	4200	6900
Moggill	JIN###	4400	3200	4300	5800
Port Office Gauge	POG-OUT	4400	3200	4300	5800
Note: CL is Confidence Limit					

For the post-dams scenario, the means were found to converge after about 120 trials, the large number of trials in this case being due to the inclusion of the longer storm durations. This is shown in **Figure 21**.

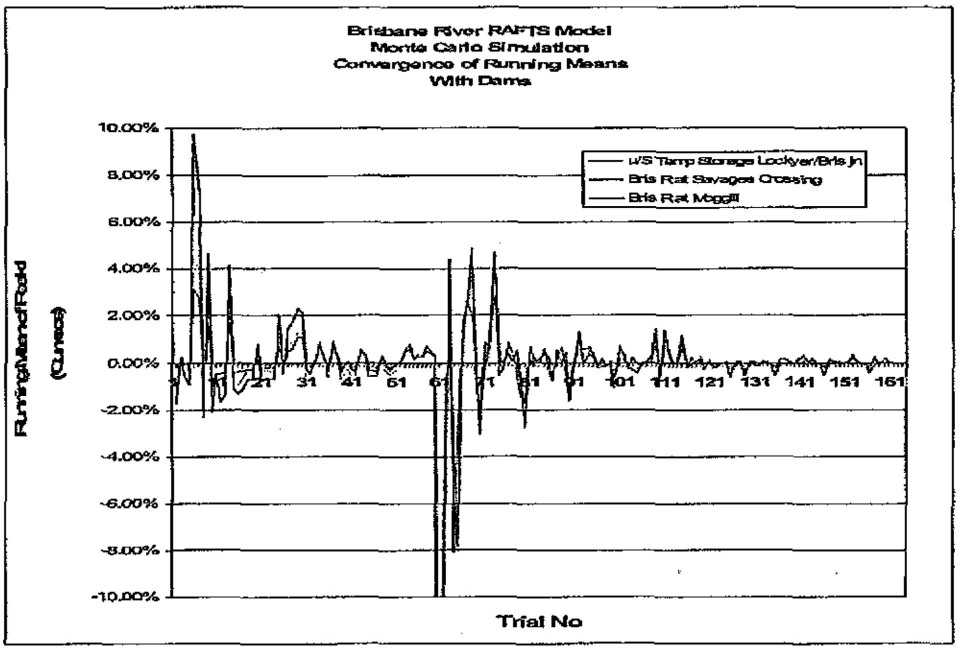


Figure 21 Convergence in Running Means (Post-dams Scenario)

Figure 22 shows the distribution of the peak flows at Savages Crossing, Moggill and the Port Office from the 160 trials.

Comparison of the distributions in **Figure 22** for the post-dams case with those in **Figures 12** and **16** for the pre-dams case shows a greater central tendency in respect of the post-dams scenario.

Figure 23 shows scatter diagrams of peak flows at Savages Crossing, Moggill and the Port Office against the corresponding peak inflow into the temporary flood storage at the Brisbane River/Lockyer Creek confluence and shows the storm duration of the individual trials. These show a reasonable spread across the range of storm durations.

Figure 24 shows the relationship between peak flows at Savages Crossing and the initial loss values used in each trial, from which it can be seen that there is no clear relationship in this regard.

Figure 25 shows the relationship between peak flows at Savages Crossing and the dam airspace at the start of each trial (combined airspace in Wivenhoe and Somerset Dams). It can be seen from **Figure 25** that there is a relationship between the initial airspace and the peak flow downstream, with the latter increasing as the former decreases as would be expected. This relationship is only significant for the longer duration events due to their larger volumes.

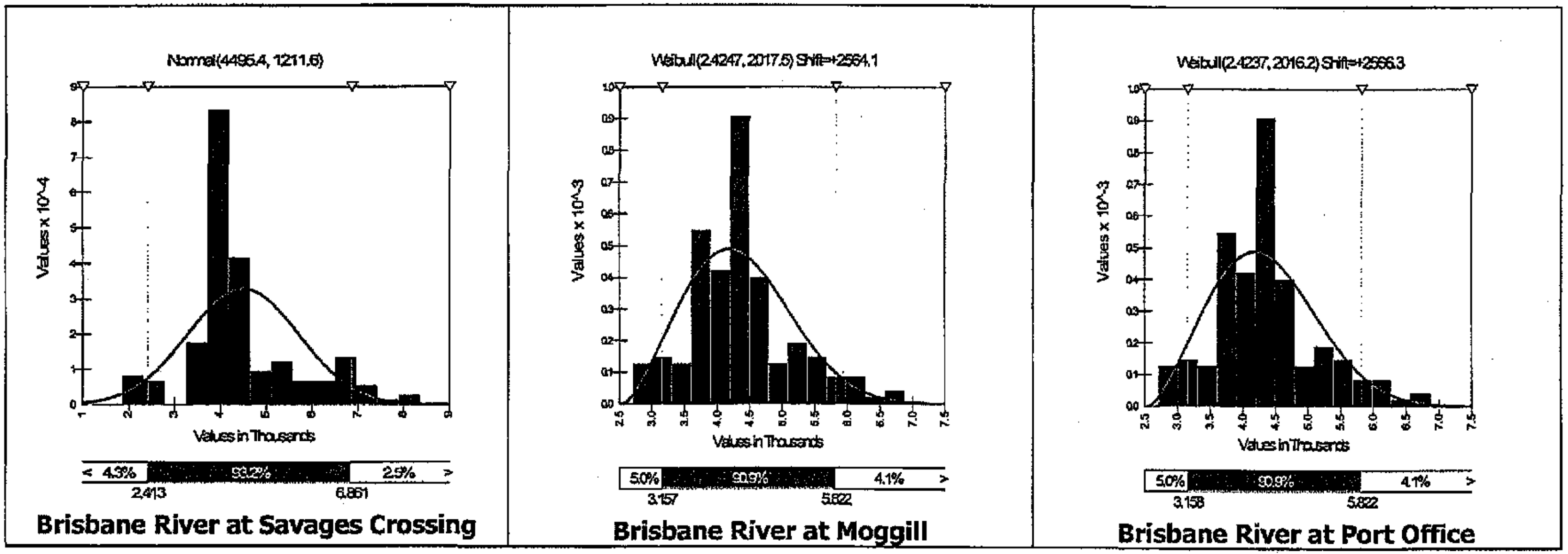


Figure 22 Distributions of Peak Flows at Key Locations from Monte Carlo Simulation (Post Dams)

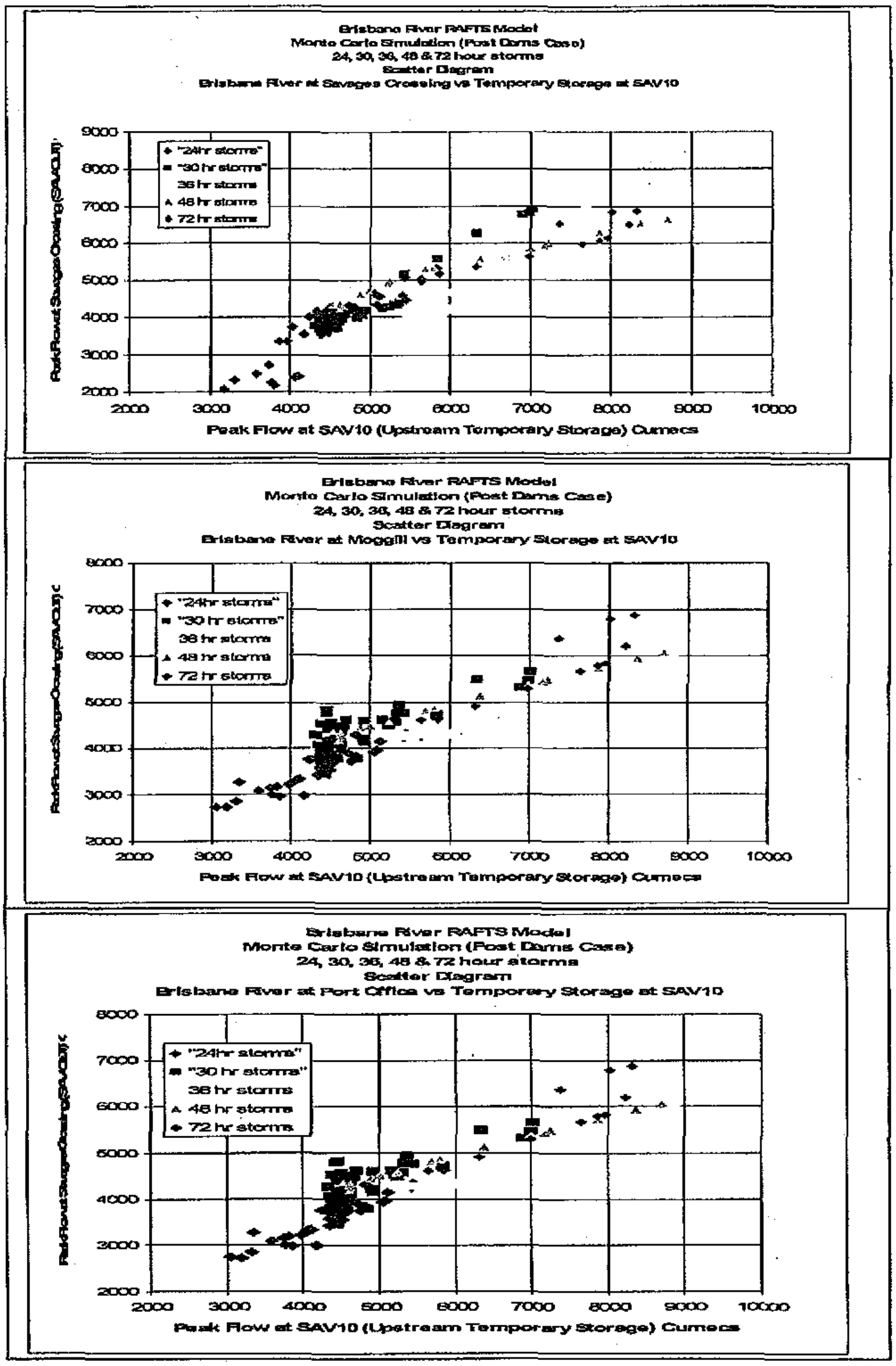


Figure 23 Scatter Diagrams - Brisbane River at Savages Crossing, Moggill and Port Office (Post- Dams)

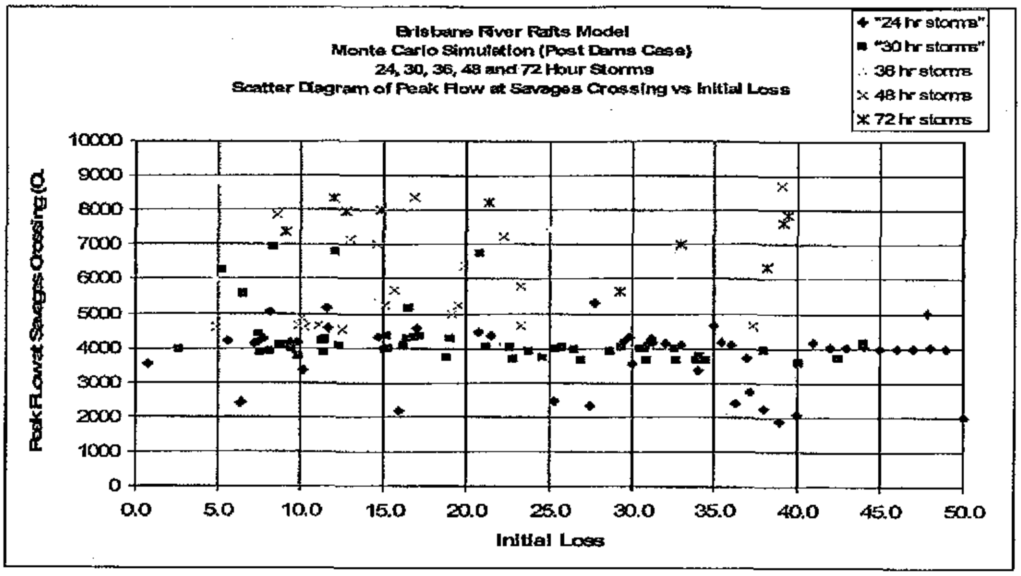


Figure 24 Peak Flow at Savages Crossing vs. Initial Loss (Post-dams)

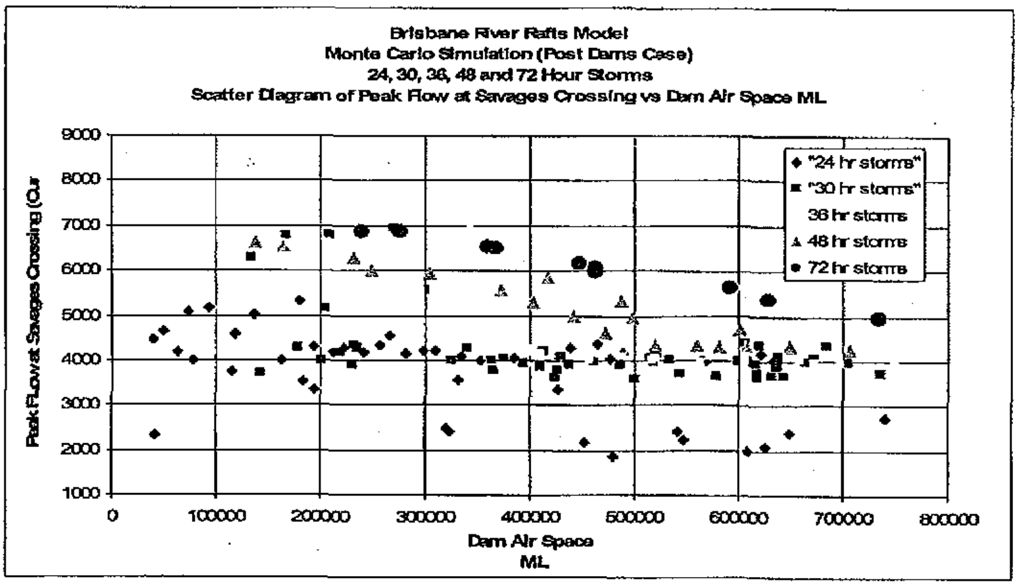


Figure 25 Peak Flow at Savages Crossing vs. Air Space (Post-dams)

7.4. Comparison with Results from Deterministic Analysis

7.4.1. Pre Dams Scenario

Table 9 summarises the primary peak flow statistics at the key locations on the Brisbane River and in the Bremer River catchment from both the deterministic analysis (i.e. RAFTS model with fixed parameter values) and from the Monte Carlo analysis described above, for the pre-dams case.

Figure 26 summarises the key statistics from **Table 9** in graphical form.

It can be seen from these results that the deterministic values are close to the mean and median of the Monte Carlo results.

7.4.2. Post Dams Scenario

Table 10 summarises the primary peak flow statistics at the key locations on the Brisbane River only (i.e. RAFTS model with fixed parameter values) and from the Monte Carlo analysis described above, for the post-dams case.

The Bremer River catchment locations are not included as they are not affected by the presence of the Brisbane River dams.

In addition to the original deterministic runs, the impact of the dam airspace has been estimated by also conducting runs with a starting storage of 50%, which is a reasonable lower limit assumption, and 75%. It can be seen from **Table 10** that this has a marked influence on the estimated downstream peak flows.

Figure 27 summarises the key statistics from **Table 10** in graphical form.

In contrast to the pre-dams scenario, there is a significant difference between the deterministic value and the central statistics (mean, median) of the Monte Carlo results, with the former being at the extreme end (i.e. ~ 100%) of the distribution of the Monte Carlo results. The sensitivity of the peak flows downstream to the starting storage levels is shown by the 50% FSL deterministic values shown in **Table 10** and **Figure 27**.

7.5. Sensitivity Tests

As the Monte Carlo results are dependant on the assumptions made, a number of sensitivity tests were undertaken to gauge the sensitivity to the various assumptions.

The sensitivity of the Monte Carlo results to the variations in storm spatial distribution, temporal distribution and duration, and to initial loss, and starting storages in Wivenhoe and Somerset Dams have been presented in **Sections 7.2** and **7.3**.

These discussions have shown that, in respect of the pre-dam scenarios, the storm duration is the most critical variable, and that the sensitivity to the other parameters is relatively low. In respect of the post-dam scenario, the peak downstream flows are most sensitive to the starting storage levels particularly for the longer storm durations.

In this paragraph, the sensitivity of the results to the assumed underlying distribution of the key variables is investigated. This section also further considers the likely influence of the relatively small number of trials on the computed distributions.

Table 9 Comparison of Deterministic and Monte Carlo Results (Pre-dams case)

Deterministic Runs			
Location	RAFTS Node	NO DAMS SCENARIO Deterministic Base Runs	
		Peak Flows m³/s	Critical Duration hrs
a) Brisbane River			
Savages Crossing	SAV-OUT	13,100	30
Moggill	JIN###	12,600	30
Port Office Gauge	POG-OUT	12,600	30
b) Bremer River/Lockyer Ck			
Lockyer Ck at Lyons Bridge	LYO-OUT	3,900	24
Bremer R at Walloon	WAL-OUT	1,200	24
Warrill Ck at Amberley	AMB-OUT	1,700	30
Bremer R at Ipswich	2C#	2,500	30

Monte Carlo Runs					
Location	RAFTS Node	Trials 1 -100 Peak Flows in m³/s			
		Mean	5% CL	Median	95% CL
Savages Crossing	SAV-OUT	13,800	12,500	14,000	14,800
Moggill	JIN###	12,800	11,300	13,000	13,700
Port Office Gauge	POG-OUT	12,800	11,300	13,000	13,700
b) Bremer River/Lockyer Ck					
Lockyer Ck at Lyons Bridge	LYO-OUT	3,800	2,500	3,900	4,600
Bremer R at Walloon	WAL-OUT	1,200	900	1,200	1,500
Warrill Ck at Amberley	AMB-OUT	1,800	1,300	1,800	2,200
Bremer R at Ipswich	2C#	2,600	2,000	2,600	3,100

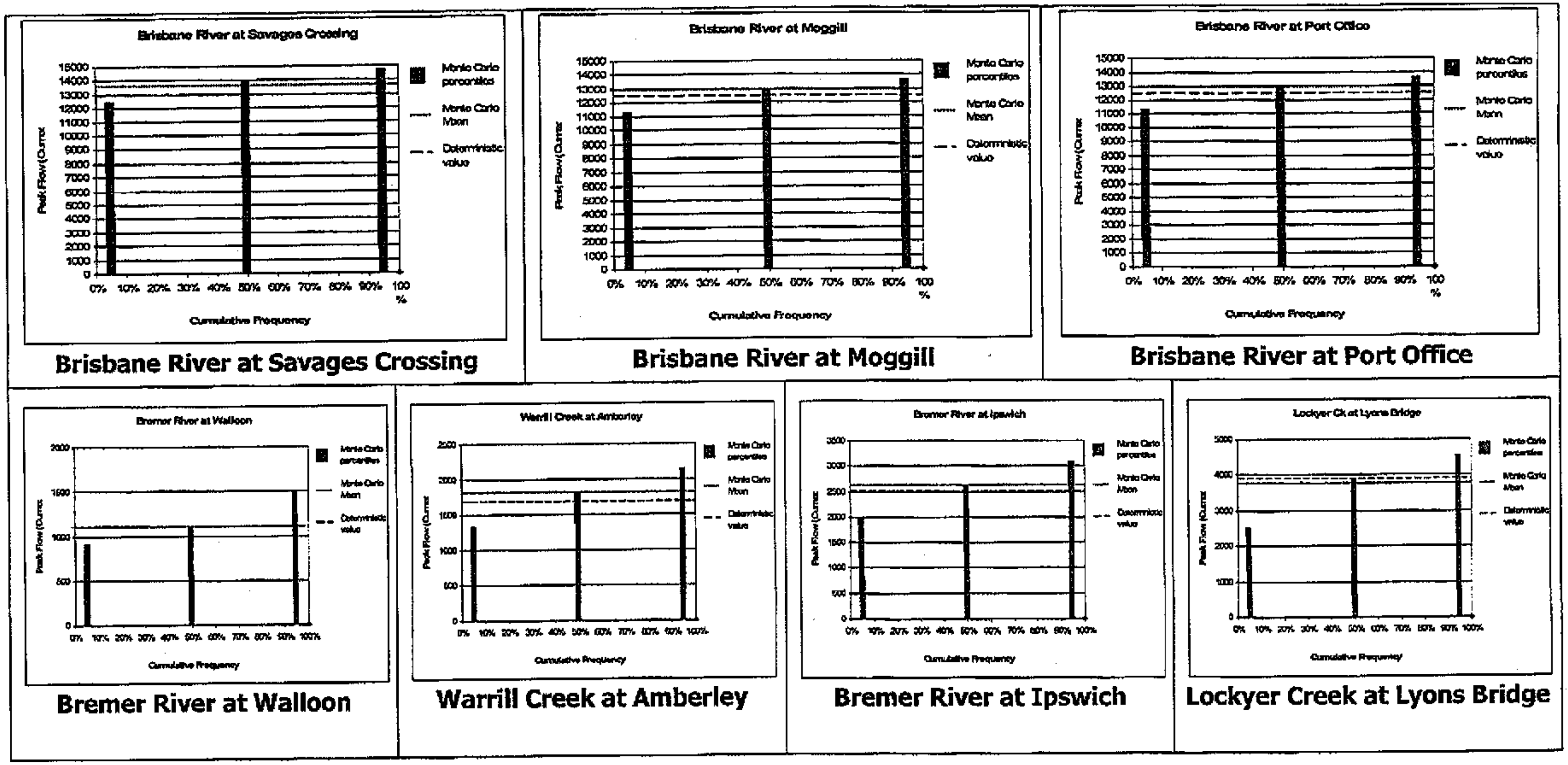
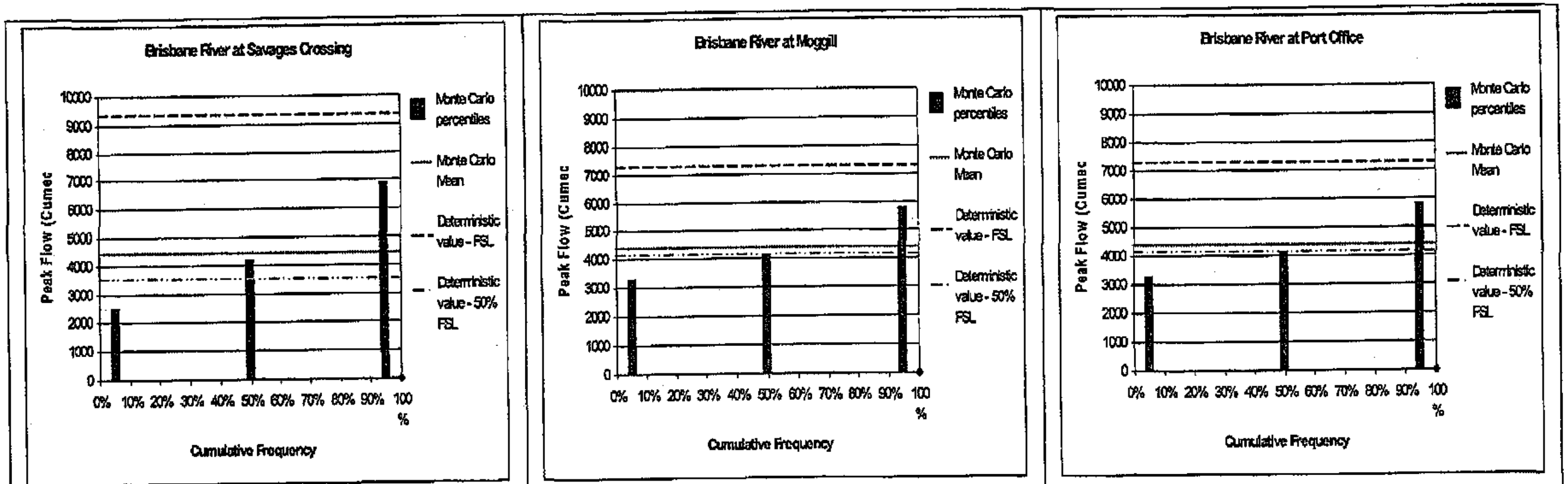


Figure 26 Key Statistics of Peak Flows at Key Locations (Pre-Dams)

Table 10 Comparison of Deterministic and Monte Carlo Results (Post-dams case)

Deterministic Runs				
Location	**RAFTS Node**	**WITH DAMS SCENARIO Deterministic Base Runs Peak Flows m³/s for starting storage of**		
		100% FSL	**75% FSL**	**50% FSL**
Savages Crossing	SAV-OUT	9,300	6,400	3,700
Moggill	JIN###	7,300	4,800	4,100
Port Office Gauge	POG-OUT	7,300	4,800	4,100

Monte Carlo Runs					
Location	**RAFTS Node**	**Trials 1 -160 Peak Flows in m³/s**			
		Mean	**5% CL**	**Median**	**95% CL**
Savages Crossing	SAV-OUT	4,500	2,400	4,200	6,900
Moggill	JIN###	4,400	3,200	4,300	5,800
Port Office Gauge	POG-OUT	4,400	3,200	4,300	5,800



Brisbane River at Savages Crossing | **Brisbane River at Moggill** | **Brisbane River at Port Office**

Figure 27 Key Statistics of Peak Flows at Key Locations (Post-Dams)

7.5.1. Distribution of Storm Duration

This analysis has shown that for the pre-dams scenario, the 30 hour storm duration is critical for peak flows in the Brisbane River downstream of Wivenhoe. However, for the post-dams case, 36 hour storm duration was found to be critical for Savages Crossing and 72 hours for Moggill and the Port Office.

In determining the relative number of trials for the various storm durations, an exponential distribution was assumed (see **Section 6.1**, **Figure 6**). The effect of this assumption was tested by assuming the mean values for each duration were the same as found from the various trials, but that the relative number of trials was varied.

Table 11 summarises, the mean peak flows from the Monte Carlo trials (post-dam) for Savages Crossing, Moggill and the Port Office for the range of storm durations tested.

For example, at Savages Crossing, these vary from 4,000m^3/s for 24 and 30 hour storms to 6,100m^3/s for 72 hour storms. The overall mean from the Monte Carlo analysis based on 160 trials was 4,500m^3/s.

Table 11 also shows that if the number of trials were the same for each duration, the overall mean for Savages Crossing would increase to 4,900m^3/s, an increase of 9%. This would be an extreme case, as it is generally accepted that there are fewer long duration events than short to medium duration events. Hence, it was considered that if the assumed distribution were in error, the magnitude of the impact would be a maximum underestimation of the mean of the order of 10%.

Table 11 Summary of Peak Flows for various Storm Durations (Post-dams case)

		Mean Peak Flow (cumecs) at		
Storm Duration Hours	No Samples	Bris R at Savages Crossing	Bris R at Moggill	Bris R at PO Gauge
Hours		SAV-OUT	JIN####	POG-OUT
24	50	4000	4000	4000
30	50	4000	4000	4000
36	30	5200	4700	4700
48	20	5100	4800	4800
72	10	6100	5800	5800
Overall Mean	160	4500	4400	4400
Weighted mean		4500	4300	4300
Mean if equal no of samples		4900	4700	4700

7.5.2. Distribution of Starting Storage

The storage levels in Somerset and Wivenhoe Dams at the beginning of each trial event were assumed to be rectangularly distributed between limits of 50% and 100% of the capacity at full supply level (FSL), and that there is a correlation between the two values of 50%.

Under this assumed distribution, every storage value is equally likely to occur as any other within the assumed range. Under the 50% correlation, there is a tendency (but not a strong tendency) for both dams to be relatively full or relatively low at the same time.

The deterministic runs with 100% and 50% starting storage represent extreme values (excluding for the moment the effect of the other variables). From **Table 10** and **Figure 26**, these gave peak flows at Savages Crossing of 9,300m^3/s and 3,700m^3/s respectively, with corresponding values at Moggill and the Port Office gauge of 7,300m^3/s and 4,100m^3/s respectively.

These values sit at percentiles of 100% and about 30% of the Monte Carlo distribution for Savages Crossing, and 100% and 50% for Moggill and the Port Office.

If a different distribution of starting storages had been assumed, the upper values would still be 100%, but the 50% full value would vary to some degree. If the starting storage distribution were biased towards the high end of the range, the Monte Carlo means would be higher and vice versa. Whilst further trials would be required to fully test this effect, it is considered unlikely that this would result in a significant change to the central statistics.

The lower limit of 50% storage is considered reasonable, and is conservative in light of the current operational conditions (below 40% as at September 2005). If a lower limit were used, this would reduce the overall mean values from the trials.

The actual historic distribution of storage levels at Wivenhoe was analysed to check the reasonableness of the assumed distribution. **Figure 28** shows the distribution of storages on the 1st December each year omitting the initial 2 years in which the reservoir was filling, the level at 1st December being a reasonable guide to that at the beginning of the flood season.

It can be seen from **Figure 28**, that the variation in storage on 1st December over the period 1988 – 2003 was from 49.3% to 100% of capacity at FSL, with a mean of 80% and median of 82%. These are in good agreement wit hthe assumed range of 50% to 100% with 75% mean.

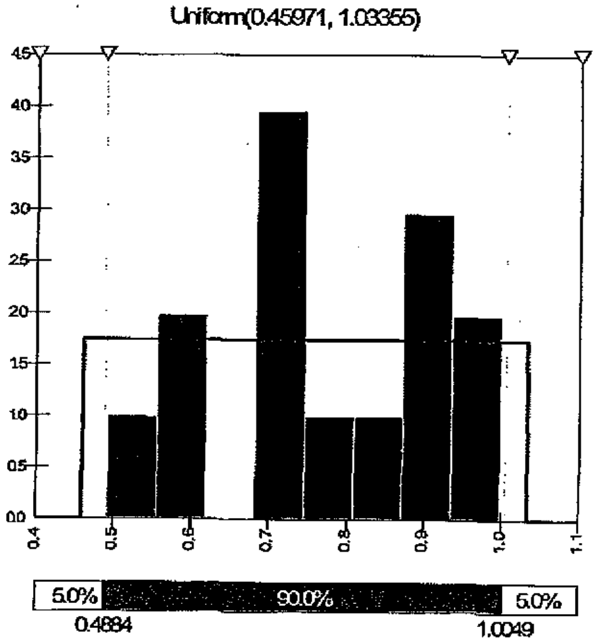


Figure 28 **Historic Records of Wivenhoe Storage on 1st December for 1988 - 2003**

7.5.3. Number of Trials

As discussed in **Sections 6** and **7.1**, time and budget constraints on this study dictated that only a relatively small number of Monte Carlo trials could be undertaken due to the time required to edit the RAFTS data files for each trial.

It was demonstrated in **Sections 7.2** and **7.3** that satisfactory convergence of the distribution mean peak flows at various key locations was achieved within 70 trials for the pre-dam scenario and 120 trials for the post-dams scenario (due to inclusion of longer durations) with only about 0.3% variation in the means occurring with subsequent trials. It was concluded from this that the use of 100 trials and 160 trials for the pre-dam and post-dam scenarios respectively should be satisfactory in this regard.

7.6. Comparison with Results from Recent Studies

The most recent design flow estimates from other studies were summarised in **Section 3** hereof. In this section, those flow estimates are compared with the results from this study.

7.6.1 Lower Brisbane River

Tables 12 and **13** tabulate these results for the pre-dams and post-dams scenarios respectively.

In respect of the pre-dams scenario, the results from the Monte Carlo analysis are higher than those recommended in the Independent Review Panel (IRP) Report, with a "best" estimate of **14,000m^3/s** at Savages Crossing compared to the IRP value of 12,000m^3/s. This result is within the likely upper bound suggested by the IRP, so is consistent with those findings.

The likely range is now estimated to be **12,500m^3/s** to **15,000m^3/s** compared to the previously estimated range of 10,000m^3/s to 14,000m^3/s.

The corresponding values at Moggill and Port Office are **13,000m^3/s** from the Monte Carlo analysis compared to 12,000m^3/s in the IRP report, within a range of **11,000m^3/s** to **14,000m^3/s** compared to the previously estimated range of 10,000m^3/s to 14,000m^3/s.

The results from the deterministic model runs of 13,000m^3/s at Savages Crossing and 12,500m^3/s at Moggill and Port Office are consistent with the IRP comment that the RAFTS modelling estimates in SKM (2003) were considered to be about 20% low. The new results resolve this anomaly.

In respect of the post-dams scenario, the results from the Monte Carlo analysis are about 10% lower than those recommended in the Independent Review Panel (IRP) Report, with a "best" estimate of **4,500m^3/s** at Savages Crossing compared to 5,500m^3/s. The likely range of this estimate is considered to be **2,500m^3/s** to **7,000m^3/s** compared to the previously estimated range of 4,000m^3/s to 6,500m^3/s.

The corresponding values at Moggill and Port Office are **4,500m^3/s** from the Monte Carlo analysis compared to 5,000m^3/s in the IRP report, within a range of **3,000m^3/s** to **6,000m^3/s** compared to the previously estimated range of 4,000m^3/s to 6,000m^3/s.

Given that the current analysis has explored a number of the uncertainties remaining from the previous studies noted in the IRP report, the current results should be given greater weight particularly in respect of the post-dams scenario, and should replace the previous estimates in design studies.

Table 12 Comparison of Results Pre-Dam Construction

Source	Method	Location	Estimated Q_{100} Peak Flow m³/s			Comment
			Best Estimate	Lower Bound	Upper Bound	
Current Study	RAFTS Modelling –Deterministic	Savages Crossing	13,000	N/A	N/A	Upper and lower bounds not applicable
		Moggill, Port Office	12,500	N/A	N/A	
	Monte Carlo Modelling with RAFTS	**Savages Crossing**	**14,000**	**12,500**	**15,000**	Lower and upper bound taken as 5% and 95% confidence limits
		Moggill, Port Office	**13,000**	**11,000**	**14,000**	
SKM (2003) and Independent Review Panel Report to BCC (2003)	Flood Frequency Analysis	Savages Crossing	12,000	10,000	14,000	
	RAFTS Modelling	Savages Crossing Moggill, Port Office	10,000	8,000	11,000	Estimates considered to be low by Independent Review Panel
SKM (2000) Ipswich Rivers Flood Study	RAFTS Modelling –Deterministic	Moggill	13,700	N/A	N/A	

Table 13 Comparison of Results Post-Dam Construction

Source	Method	Location	Estimated Q_{100} Peak Flow m³/s			Comment
			Best Estimate	Lower Bound	Upper Bound	
Current Study	RAFTS Modelling –Deterministic	Savages Crossing	6,500	4,000	9,500	"Best" estimate based on 75% initial storage, and upper and lower bounds on 100% and 50% respectively
		Moggill, Port Office	5,000	4,000	7,500	
	Monte Carlo Modelling with RAFTS	**Savages Crossing**	**4,500**	**2,500**	**7,000**	Lower and upper bound taken as 5% and 95% confidence limits
		Moggill, Port Office	**4,500**	**3,000**	**6,000**	
SKM (2003) and Independent Review Panel Report to BCC (2003)	RAFTS Modelling	Savages Crossing	5,500	4,000	6,500	
		Moggill, Port Office	5,000	4,000	6,000	
SKM (2000) Ipswich Rivers Flood Study	RAFTS Modelling –Deterministic	Moggill	8,100	N/A	N/A	

7.6.2. Bremer River

In respect of the Bremer River catchment, **Table 14** shows the comparison between the results from the current analysis and from previous studies. These results are not affected by the Brisbane River Dams.

As mentioned in **Section 5.2.1** hereof, the results from this study are applicable only to those locations in which the critical duration is 24 hours or greater.

There is good agreement between the mean and median values of the Q_{100} peak flows from this study for the deterministic and stochastic (Monte Carlo) analyses.

For the Bremer River, the "best estimates" were **1,200m^3/s** and **2,600m^3/s** for the Bremer River at Walloon and Ipswich respectively. The estimated likely ranges for the above were **900m^3/s** to **1,500m^3/s** and **2,000m^3/s** to **3,100m^3/s** respectively.

Similarly, for Warrill Creek at Amberley, the "best estimate" was **1,800m^3/s** with a likely range of **1,300m^3/s** to **2,200m^3/s.**

SKM (2000) gave Q_{100} values of **2,600m^3/s** for Warrill Creek at Amberley and **3,200m^3/s** for the Bremer River at Ipswich. These values are 30% and 20% higher respectively than the new estimates. This is consistent with the findings of Sargent Consulting (2003) and ICC's belief that the former estimates were too high.

8. Conclusions

The analysis has shown that even with a relatively small number of trials, a Monte Carlo analysis was able to refine both the central estimates and likely range of key design values and to reduce the uncertainty in these estimates. It is considered unlikely that further trials will significantly influence the results obtained.

It is acknowledged that there were limitations to the analysis which were necessary due to time and budget constraints. These limited consideration to the range of outcomes from 100 year ARI catchment rainfalls, rather than from the entire distribution of rainfall events.

Nonetheless, this provided a direct comparison with results of previous studies which were also limited in this way.

The results from the Monte Carlo analysis were generally consistent with the recommendations in the Independent Review Panel Report (Mein et al 2003), and have refined both the central flood estimates and the confidence limits, or likely range of the flood estimates.

In respect of the Bremer River and Lockyer Creek catchments, the Monte Carlo analysis results were 20% - 30% lower than those in the Ipswich Rivers Flood Study (SKM 2000).

The review of the RAFTS model with deterministic inputs resolved the anomaly between the RAFTS modelling and flood frequency analysis from SKM (2003) noted in the IRP report, and hence it was considered unwarranted to undertake the frequency analysis of flood volumes listed in **Section 4** hereof.

Specific conclusions were as follows:

- In respect of the pre-dams scenario, the "best" estimate of Q_{100} peak flow at Savages Crossing was **14,000m^3/s** within a range of **12,500m^3/s** to **15,000m^3/s** (compared to the IRP value of 12,000m^3/s, within a range of 10,000m^3/s to 14,000m^3/s);

- In respect of the pre-dams scenario, the "best" estimate of Q_{100} peak flow at Moggill and the Port Office was **13,000m^3/s** within a range of **11,000m^3/s** to **14,000m^3/s** (compared to the IRP value of 12,000m^3/s, within a range of 10,000m^3/s to 14,000m^3/s);

- In respect of the post-dams scenario, the "best" estimate of Q_{100} peak flow at Savages Crossing was **4,500m^3/s** compared to 5,500m^3/s, within a range of **2,500m^3/s** to **7,000m^3/s** compared to the IRP value of 5,000m^3/s within a range of 4,000m^3/s to 6,500m^3/s;

- The corresponding post-dam values at Moggill and Port Office are **4,500m^3/s** , within a range of **3,000m^3/s** to **6,000m^3/s** compared to the IRP value of 5,000m^3/s within a range of 4,000m^3/s to 6,000m^3/s;

- For the Bremer River at Walloon, the "best estimate" was **1,200m^3/s,** within a range of **900m^3/s** to **1,500m^3/s;**

- For Warrill Creek at Amberley, the "best estimate" was **1,800m^3/s,** within a range of **1,300m^3/s** to **2,200m^3/s** compared to the previous estimate (SKM 2000) of **2,600m^3/s**; and

- For the Bremer River at Ipswich, the "best estimate" was **2,600m^3/s,** within a range of **2,000m^3/s** to **3,100m^3/s** compared to the previous estimate (SKM 2000) of **3,200m^3/s.**

9. Recommendations

It is recommended that the estimates of Q_{100} design flows produced from the Monte Carlo analysis described in this report in respect of current catchment conditions be adopted as the basis for inputs to the hydraulic modelling component of this and the parallel BCC study to determine design flood levels and flood inundation mapping.

The following, which were beyond the scope of the current study, are recommended for consideration for further work:

- Extension of the Monte Carlo analysis to the Q_{20} event which is still an important land use planning criterion for ICC; and

- Investigation of the sensitivity of RAFTS model results to the lumped conceptual storages in the model, particularly those at the Lockyer Creek/Brisbane River and Bremer River/Brisbane River confluences, and if found to be warranted, recalibration of the RAFTS model.

Table 14 Comparison of Results Bremer River Catchment

Source	Method	Location	Estimated Q_{100} Peak Flow m^3/s			Comment
			Best Estimate	Lower Bound	Upper Bound	
Current Study	RAFTS Modelling –Deterministic	Bremer River at Walloon	1,200	N/A	N/A	Upper and lower bounds not applicable
		Warrill Creek at Amberley	1,700	N/A	N/A	
		Bremer River at Ipswich	2,500	N/A	N/A	
	Monte Carlo Modelling with RAFTS	**Bremer River at Walloon**	**1,200**	**900**	**1,500**	Lower and upper bound taken as 5% and 95% confidence limits
		Warrill Creek at Amberley	**1,800**	**1,300**	**2,200**	
		Bremer River at Ipswich	**2,600**	**2,000**	**3,100**	
SKM (2000) Ipswich Rivers Flood Study	RAFTS Modelling –Deterministic	Warrill Creek at Amberley	2,600	N/A	N/A	Upper and lower bounds not applicable
		Bremer River at Ipswich	3,200	N/A	N/A	

10. References

BUREAU OF METEOROLOGY (2004) *Generalised Tropical Storm Method – Guide to the Estimation of Probable Maximum Precipitation*

CARROLL D, RAHMAN A (2004) *Investigation of sub-tropical rainfall characteristics for use in the joint probability approach to design flood estimation* paper presented to AOGS 1st Annual Meeting/2nd APHW Conference, Singapore

HALLIBURTON KBR (2002a) *Local Storm Flood Mapping - Final Report* prepared for Ipswich City Council

HALLIBURTON KBR (2002b) *Ipswich Rivers Flood Study Phase 3 - Final Report* prepared for Ipswich City Council

HOANG T, RAHMAN A, WEINMANN E, LAURENSON E, NATHAN R (1999) *Joint Probability Descriptions of Design Rainfalls* International Hydrology and Water Resources Symposium, IEAust, Brisbane

INSTITUTION OF ENGINEERS AUSTRALIA (1987 and updates) *Australian Rainfall and Runoff – A Guide to Flood Estimation*

MEIN R, APELT C, MACINTOSH J, WEINMANN E (2003) *Review of Brisbane River Flood Study – Independent Review Panel Report* prepared for Brisbane City Council

PALISADE CORPORATION (2002) *Guide to Using @RISK - Risk Analysis and Simulation Add-In for Microsoft Excel*, Newfield NY

RAHMAN A, WEINMANN E, HOANG T, LAURENSON E, NATHAN R (2001) *Monte Carlo Simulation of Flood Frequency Curves from Rainfall* Cooperative Research Centre for Catchment Hydrology Technical Report 01/4

RUFFINI J (2004) *CRC-FORGE Rainfalls for Queensland*, Dept. of Natural Resources & Mines pers. comm.

SARGENT CONSULTING (2003) *Brief Review of Flood Frequency Analysis and Discharge Rating Curve for Brisbane River at Moggill Gauge* prepared for Ipswich City Council

SINCLAIR KNIGHT MERZ (2000) *Ipswich Rivers Flood Study Phase 1 & Phase 2 - Final Report* prepared for Ipswich Rivers Improvement Trust in association with Ipswich City Council

SINCLAIR KNIGHT MERZ (2003) *Brisbane River Flood Study – Further Estimates of Flood Frequency incorporating Dam Operations and CRC-FORGE Rainfall Estimates – Brisbane River* prepared for Brisbane City Council

Appendices

Appendix A Catchment Map

Appendix B Summary Output from Monte Carlo Trials

Note:

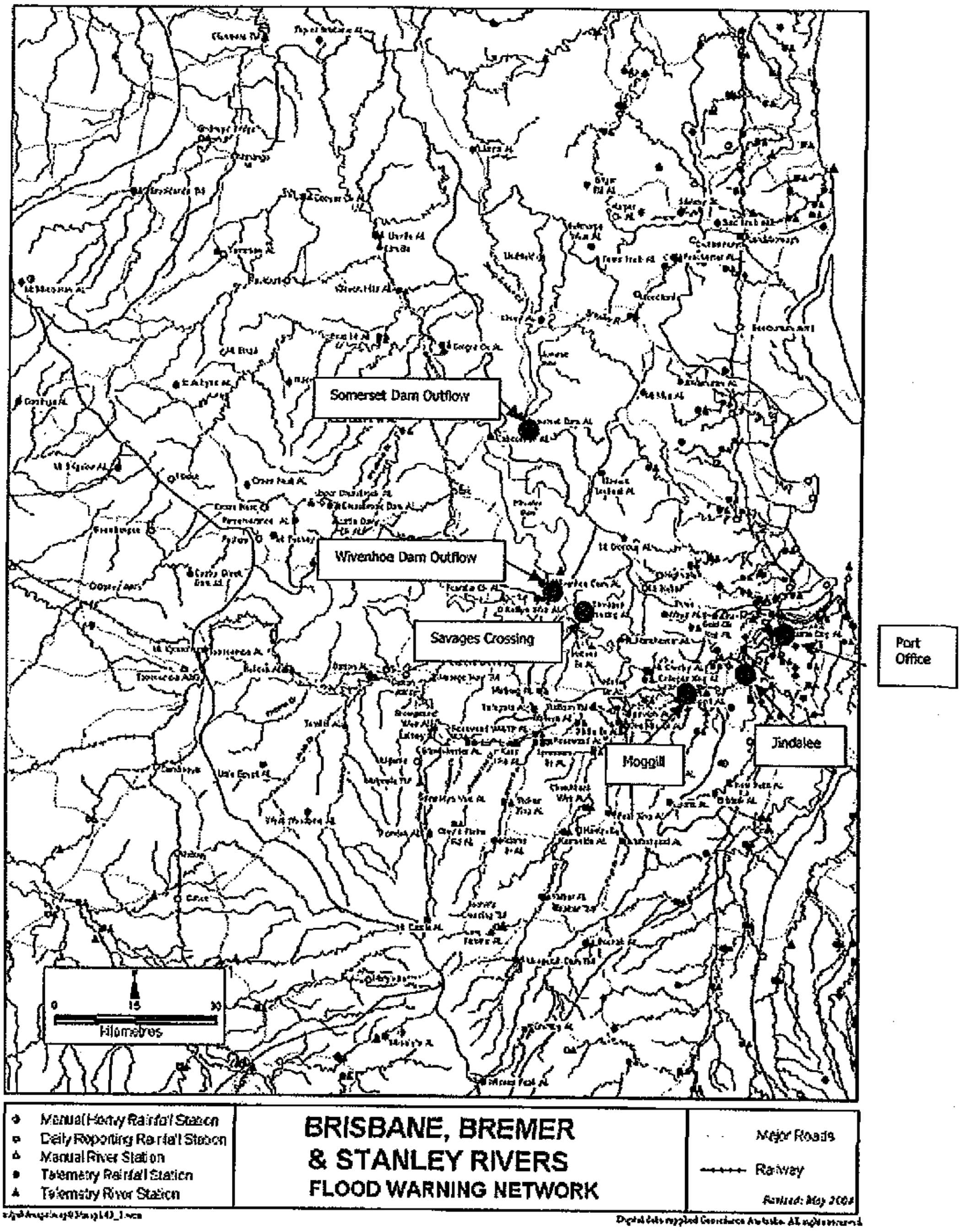
The following notes apply to the tabulated results in Appendix B

- The tables have been sorted into blocks of storms of the same duration
- The order of the original samples is given by the trial number
- The spatial distribution is shown as:
  - Central – storm centrally located over whole catchment
  - SS - storm centrally located over Stanley River/Somerset Dam sub-catchment
  - UB - storm centrally located over Upper Brisbane River sub-catchment
  - LY - storm centrally located over Lockyer Creek sub-catchment
  - LB - storm centrally located over Bremer River/Lower Brisbane River sub-catchment
- The temporal distribution is shown as:
  - ARR – as given in Australian Rainfall and Runoff (Zone 3)
  - AVM – Average Variability Method as per the Bureau of Meteorology's *Generalised Tropical Storm Method (GSTM)*

Appendix A

MAP 143.1

Australian Government
Bureau of Meteorology



ICC.005.2820

Appendix B Monte Carlo Analysis Results
a) Pre- Dams Analysis

Trial No	Storm Duration Hrs	Spatial Dist	Temporal Pattern	Initial Loss mm	RAFTS Results "No Dams" Peak Flows at									
					Bris R at Somerset Dam	Bris R at Wivenhoe Dam	Lockyer Ck at Lyons Br	u/S Temp Storage Lockyer/Bris Jn	Bris R at Savages Crossing	Bris R at Mt Crosby	Bris R at Moggill	Bremer R at Ipswich	Bris R at Jindalee	Bris R at PO Gauge
					SOM-OUT	WIV-OUT	LYO-OUT	SAV10	SAV-OUT	MTC-OUT	JIN###	2C#	JIN-OUT	POG-OUT
87	24	Central	ARR	13.1	3030	10490	3794	14440	9438	9453	8356	2353.0	8357	8357
63	24	Central	ARR	15.9	3003	10281	3668	14180	9198	9213	8161	2319.0	8162	8162
5	24	Central	ARR	19.8	2961	10004	3482	13803	8920	8933	8022	2269	8023	8023
62	24	Central	ARR	44.8	2761	8512	2464	11496	7847	7857	7274	1986.0	7274	7274
47	24	Central	ARR	3.6	3157	11130	4227	15265	10209	10226	9098	2472	9099	9099
41	24	Central	ARR	10.5	3064	10667	3908	14663	9653	9668	8559	2385	8560	8560
25	24	Central	ARR	14.9	3013	10361	3714	14277	9287	9301	8199	2331	8200	8200
96	24	Central	ARR	16.7	2994	10225	3624	14096	9124	9138	8131	2310.0	8132	8132
61	24	Central	ARR	20.0	2959	9991	3472	13785	8910	8923	8015	2266.0	8016	8016
82	24	Central	ARR	26.4	2891	9549	3203	13213	8625	8637	7813	2189.0	7814	7814
64	24	Central	ARR	31.4	2840	9193	2995	12775	8405	8417	7658	2132.0	7658	7658
40	24	Central	ARR	46.6	2752	8415	2393	11321	7776	7787	7229	1968	7230	7230
37	24	Central	ARR	11.4	3047	10606	3867	14584	9579	9594	8490	2374	8491	8491
97	24	Central	ARR	16.8	2993	10218	3617	14084	9114	9128	8127	2308.0	8128	8128
71	24	Central	ARR	20.7	2952	9944	3441	13719	8878	8891	7992	2256.0	7992	7992
10	24	Central	ARR	28.0	2876	9441	3135	13070	8554	8567	7763	2170	7764	7764
19	24	Central	ARR	38.4	2790	8828	2709	12102	8104	8116	7446	2053	7447	7447
42	24	Central	AVM	7.1	3469	12327	4275	16231	10865	10878	9379	2724	9379	9379
68	24	Central	AVM	8.3	3459	12275	4257	16144	10798	10810	9303	2714.0	9304	9304
50	24	Central	AVM	9.2	3451	12236	4245	16077	10749	10761	9249	2706	9250	9250
77	24	Central	AVM	20.6	3348	11642	4023	15117	10018	10029	8466	2592.0	8466	8466
100	24	Central	AVM	21.7	3338	11580	4001	15033	9943	9953	8384	2580.0	8384	8384
78	24	Central	AVM	27.3	3289	11244	3865	14561	9542	9553	8090	2515.0	8090	8090
15	24	LB	ARR	7.4	2935	10309	3824	14157	9255	9271	8617	2741	8618	8618
14	24	LB	ARR	11.6	2893	10030	3641	13804	8946	8961	8313	2685	8314	8314
48	24	LB	ARR	31.2	2693	8652	2792	12004	8059	8071	7609	2432	7610	7610
56	24	LB	AVM	0.7	3496	11987	4131	15857	10555	10567	9534	3144.0	9535	9535
23	24	LB	AVM	7.2	3429	11733	4057	15415	10212	10224	9136	3092	9136	9136
65	24	LB	AVM	7.8	3422	11708	4047	15370	10176	10188	9096	3087.0	9096	9096
86	24	LB	AVM	10.2	3394	11604	4012	15189	10040	10052	8944	3066.0	8944	8944
90	24	LB	AVM	20.8	3266	11050	3800	14254	9327	9338	8204	2959.0	8205	8205
75	24	LB	AVM	21.5	3259	11012	3785	14195	9280	9290	8180	2952.0	8181	8181
67	24	LB	AVM	29.9	3158	10489	3565	13466	8803	8813	7928	2856.0	7928	7928
54	24	LY	ARR	9.4	2942	10267	4698	15158	9890	9905	8680	2308	8681	8681
18	24	LY	ARR	17.0	2865	9718	4350	14471	9262	9276	8136	2214	8136	8136
84	24	LY	ARR	27.7	2755	8981	3859	13472	8659	8670	7783	2083.0	7783	7783
8	24	LY	AVM	6.4	3341	11830	5003	16499	11072	11084	9486	2634	9486	9487
44	24	LY	AVM	47.9	2948	9445	4012	12941	8506	8516	7489	2179	7490	7490
60	24	SS	ARR	6.4	3611	11422	3811	15183	10204	10221	8948	2312.0	8949	8949
66	24	SS	ARR	9.8	3543	11198	3662	14883	9928	9944	8683	2269.0	8684	8684
26	24	SS	ARR	16.0	3474	10748	3377	14312	9398	9413	8186	2192	8186	8186
45	24	SS	ARR	29.5	3333	9811	2806	13061	8586	8599	7735	2029	7736	7736
20	24	SS	ARR	36.4	3263	9363	2528	12417	8279	8290	7525	1952	7526	7526
30	24	SS	ARR	37.1	3255	9329	2502	12352	8249	8260	7505	1945	7506	7506
43	24	SS	AVM	5.6	4003	12780	4020	16447	11114	11127	9558	2599	9558	9558
74	24	SS	AVM	8.1	3978	12669	3985	16260	10978	10990	9405	2578.0	9405	9405
93	24	SS	AVM	9.0	3970	12628	3973	16189	10929	10941	9351	2571.0	9351	9351
28	24	SS	AVM	25.3	3803	11733	3635	14738	9854	9865	8198	2408	8198	8198
55	24	SS	AVM	27.4	3787	11596	3578	14552	9698	9709	8125	2386	8126	8126
92	24	SS	AVM	31.3	3750	11338	3468	14196	9395	9404	7992	2341.0	7993	7993

Pre- Dams Analysis (Contd)

Trial No	Storm Duration Hrs	Spatial Dist	Temporal Pattern	Initial Loss mm	RAFTS Results "No Dams" Peak Flows at									
					Bris R at Somerset Dam	Bris R at Wivenhoe Dam	Lockyer Ck at Lyons Br	u/S Temp Storage Lockyer/Bris Jn	Bris R at Savages Crossing	Bris R at Mt Crosby	Bris R at Moggill	Bremer R at Ipswich	Bris R at Jindalee	Bris R at PO Gauge
					SOM-OUT	WIV-OUT	LYO-OUT	SAV10	SAV-OUT	MTC-OUT	JIN###	2C#	JIN-OUT	POG-OUT
11	24	UB	ARR	8.6	2935	11236	3780	15026	10061	10076	8791	2310	8792	8792
98	24	UB	ARR	17.1	2850	10665	3395	14277	9377	9391	8156	2205.0	8157	8157
69	24	UB	AVM	11.7	3272	12717	3999	16277	10878	10890	9208	2578.0	9208	9208
53	24	UB	AVM	14.7	3246	12567	3944	16013	10692	10703	9001	2548	9001	9001
4	24	UB	AVM	35.4	3060	11374	3422	14252	9236	9246	7876	2324	7877	7877
94	30	Central	ARR	12.3	3612	11090	3717	14497	13090	13111	12464	2437.0	12465	12465
99	30	Central	ARR	18.8	3600	11044	3717	14206	12929	12949	12121	2410.0	12122	12122
51	30	Central	ARR	32.7	3568	10898	3716	13724	12593	12609	11373	2371	11374	11374
91	30	Central	ARR	34.0	3565	10881	3716	13689	12561	12577	11300	2368.0	11301	11301
52	30	Central	ARR	2.6	3628	11170	3717	14799	13244	13269	12959	2482	12960	12960
32	30	Central	ARR	6.6	3622	11126	3717	14678	13189	13213	12764	2464	12765	12765
70	30	Central	ARR	30.9	3573	10918	3716	13772	12637	12653	11472	2375.0	11473	11473
36	30	Central	ARR	34.5	3563	10875	3516	13674	12549	12565	11273	2367	11274	11274
35	30	Central	AVM	19.1	4031	13061	4280	16972	14474	14490	13295	2898	13296	13296
13	30	Central	AVM	5.2	4063	13396	4319	17383	14797	14814	13798	2953	13798	13799
12	30	Central	AVM	16.3	4041	13158	4296	17088	14560	14576	13413	2913	13414	13414
31	30	Central	AVM	29.4	3974	12650	4192	16436	14113	14128	12809	2829	12810	12810
39	30	Central	AVM	30.5	3967	12598	4179	16370	14072	14087	12755	2821	12755	12755
59	30	Central	AVM	30.8	3964	12584	4175	16350	14060	14075	12738	2818.0	12739	12739
7	30	Central	AVM	11.3	4054	13287	4311	17242	14676	14692	13587	2932	13588	13588
16	30	Central	AVM	11.5	4053	13284	4311	17238	14672	14688	13581	2931	13582	13582
83	30	Central	AVM	15.2	4044	13192	4300	17130	14590	14607	13457	2917.0	13457	13457
17	30	Central	AVM	21.2	4022	12984	4266	16879	14407	14423	13201	2886	13202	13202
1	30	Central	AVM	22.7	4013	12925	4256	16806	14355	14371	13131	2877	13132	13132
9	30	Central	AVM	38.0	3909	12240	4072	15853	13795	13810	12357	2758	12358	12358
27	30	Central	AVM	8.7	4058	13334	4315	17302	14726	14744	13674	2941	13675	13675
3	30	Central	AVM	8.9	4058	13330	4315	17296	14722	14739	13666	2941	13667	13667
24	30	Central	AVM	16.4	4041	13156	4296	17085	14557	14574	13409	2912	13410	13410
49	30	Central	AVM	16.5	4040	13153	4295	17081	14554	14571	13405	2912	13406	13406
68	30	Central	AVM	25.7	3997	12807	4232	16650	14251	14267	12990	2856.0	12991	12991
73	30	LB	ARR	9.9	3449	10555	3525	13792	12570	12594	12420	2801.0	12421	12421
58	30	LB	ARR	26.9	3414	10410	2524	13135	12157	12176	11460	2714.0	11461	11461
95	30	LB	AVM	7.6	3884	12740	4094	16471	14203	14221	13591	3278.0	13592	13592
33	30	LB	AVM	11.4	3877	12670	4087	16388	14133	14151	13463	3268	13464	13464
29	30	LB	AVM	23.8	3828	12255	4018	15880	13806	13823	12935	3227	12936	12936
85	30	LB	AVM	34.1	3757	11797	3895	15249	13482	13499	12392	3178.0	12393	12393
46	30	LB	AVM	42.5	3693	11314	3742	14593	13189	13206	11871	3113	11871	11871
21	30	LY	ARR	9.5	3488	10704	4246	14690	13190	13213	12622	2364	12623	12623
72	30	LY	ARR	15.1	3478	10666	4246	14484	13093	13114	12330	2340.0	12331	12331
34	30	LY	AVM	7.5	3930	12883	4939	17549	14879	14895	13731	2844	13732	13732
76	30	LY	AVM	16.9	3908	12659	4918	17305	14673	14689	13408	2809.0	13409	13409
79	30	LY	AVM	17.2	3906	12649	4916	17294	14665	14681	13396	2807.0	13397	13397
89	30	LY	AVM	44.0	3721	11381	4636	15630	13682	13697	12044	2595.0	12045	12045
6	30	UB	ARR	8.2	3453	11698	3544	14799	13331	13348	12774	2350	12775	12775
38	30	SS	ARR	22.8	4089	11459	3512	14508	13041	13062	11973	2277	11974	11974
2	30	SS	ARR	24.6	4086	11423	3511	14416	12989	13010	11880	2273	11881	11881
57	30	UB	ARR	40.1	3374	11439	3541	13996	12787	12801	11150	2263.0	11151	11151
22	30	SS	AVM	15.3	4516	13679	4025	17202	14634	14651	13406	2744	13407	13407
81	30	UB	AVM	26.5	3781	13611	4015	17190	14525	14541	13056	2716.0	13057	13057
80	30	UB	AVM	28.7	3770	13512	3990	17070	14445	14460	12952	2699.0	12952	12952

b) Post - Dams Analysis

Trial No	Storm Duration Hrs	Spatial Dist	Temporal Pattern	Initial Loss mm	Somerset Start		Wivenhoe Start		RAFTS Results "With Dams" Peak Flows at						
					ML	m AHD	ML	m AHD	Bris R at Wivenhoe Dam	u/S Temp Storage Lockyer/Bris In	Bris R at Savages Crossing	Bris R at Mt Crosby	Bris R at Moggill	Bris R at Jindalee	Bris R at PO Gauge
									WIV-OUT	SAV10	SAV-OUT	MTC-OUT	JIN###	JIN-OUT	POG-OUT
42	24	Central	AVM	7.1	347053	98.2	1080115	66.2	3020	5408	4588	4692	4287	4288	4288
87	24	Central	ARR	13.1	279771	96.3	1008159	66.2	2477	4732	4329	4334	3892	3893	3893
63	24	Central	ARR	15.9	376063	98.9	956717	64.9	2452	4560	4176	4180	3731	3731	3731
5	24	Central	ARR	19.8	211448	94.1	792792	62.9	0	4111	2420	2429	3336	3337	3337
62	24	Central	ARR	44.8	367808	98.7	1113758	66.5	2452	4560	4176	4180	3731	3731	3731
47	24	Central	ARR	3.6	209484	94.0	1070190	66.1	3019	5122	4561	4565	4146	4146	4146
88	24	Central	AVM	8.3	235752	94.8	1129449	66.7	3773	5837	5311	5316	4675	4676	4676
41	24	Central	ARR	10.5	264945	95.8	1143827	66.8	3483	5647	5025	5030	4261	4262	4262
25	24	Central	ARR	14.9	281021	96.4	955046	64.9	2519	4571	4203	4207	3765	3765	3765
61	24	Central	ARR	20.0	316957	97.4	903134	64.3	1897	4102	2413	2421	3330	3332	3332
77	24	Central	AVM	20.6	310865	97.2	1160801	67.0	3369	5433	5068	5073	4240	4241	4241
78	24	Central	AVM	27.3	317805	97.4	985717	65.2	2390	4454	4180	4184	3648	3648	3648
82	24	Central	ARR	26.4	289331	96.6	803718	63.1	0	3813	2172	2178	3180	3182	3182
64	24	Central	ARR	31.4	191687	93.3	1034088	65.7	1897	3590	2484	2488	3078	3080	3080
40	24	Central	ARR	46.6	352616	98.3	1151083	66.9	1897	3311	2314	2318	2855	2857	2857
50	24	Central	AVM	9.2	340544	98.0	906660	64.3	2463	4622	4200	4204	3966	3967	3967
37	24	Central	ARR	11.4	321499	97.6	733788	62.2	2496	4545	4156	4161	3801	3802	3802
71	24	Central	ARR	20.7	237049	94.9	658644	61.2	0	4068	2389	2397	3312	3314	3314
10	24	Central	ARR	28.0	211875	94.1	592948	60.2	1861	3738	2726	2732	3143	3144	3144
19	24	Central	ARR	38.4	212098	94.1	1150067	66.9	1897	4169	3539	3543	2990	2991	2991
11	24	UB	ARR	8.6	283219	96.4	802982	63.1	2469	4479	4119	4124	3733	3734	3734
69	24	UB	AVM	11.7	334105	98.1	690437	61.6	2468	4353	4153	4158	3804	3805	3805
53	24	UB	AVM	14.7	285459	96.5	1035836	65.7	2597	4821	4281	4286	3846	3846	3846
4	24	UB	AVM	35.4	336497	97.9	1014762	65.6	1897	3864	3362	3366	2969	2970	2970
8	24	LY	AVM	6.4	378686	98.9	1072652	66.2	2764	5865	5176	5188	4626	4626	4626
54	24	LY	ARR	9.4	379519	99.0	1125227	66.7	2847	5456	4468	4488	4331	4332	4332
18	24	LY	ARR	17.0	264315	96.4	796207	63.0	2434	5092	4358	4363	3973	3974	3974
84	24	LY	ARR	27.7	230561	94.7	1120594	66.6	2249	4760	4304	4309	3745	3745	3745
44	24	LY	AVM	47.9	316349	97.3	790896	62.9	2415	4501	4274	4278	3547	3547	3547
43	24	SS	AVM	5.6	289845	96.6	924929	64.6	668	4383	3553	3562	3670	3671	3671
60	24	SS	ARR	6.4	331017	97.8	694917	61.7	2530	4452	4142	4147	3751	3751	3751
74	24	SS	AVM	8.1	302763	97.0	620823	60.6	2538	4342	4147	4151	3812	3813	3813
66	24	SS	ARR	9.8	193098	93.4	831491	63.5	2545	4522	4114	4119	3678	3878	3878
26	24	SS	ARR	16.0	195478	93.4	922743	64.5	1897	3973	3345	3349	3217	3219	3219
28	24	SS	AVM	25.3	357791	98.4	1137348	66.7	3177	5058	4650	465	3933	3934	3934
55	24	SS	AVM	27.4	374413	98.9	837180	63.6	2563	4348	4081	4085	3423	3424	3424
45	24	SS	ARR	29.5	282496	96.4	1147069	66.8	2307	4031	3743	3748	3266	3266	3266
92	24	SS	AVM	31.3	219813	94.4	777180	62.8	1896	3769	2241	2247	2995	2996	2996
20	24	SS	ARR	36.4	201972	93.7	863627	63.9	1897	3054	1872	1876	2740	2742	2742
30	24	SS	ARR	37.1	219214	94.3	699511	61.7	1896	3190	2070	2074	2723	2726	2725
56	24	LB	AVM	0.7	210832	94.0	1052061	65.9	2355	4822	4160	4165	4302	4303	4303
23	24	LB	AVM	7.2	218203	94.3	850363	63.7	2462	4421	4029	4033	4003	4003	4003
15	24	LB	ARR	7.4	312384	97.3	664058	61.2	2429	4442	4009	4014	3878	3880	3880
65.	24	LB	AVM	7.8	251408	95.4	908958	64.4	2499	4409	4044	4049	3994	3995	3995
86	24	LB	AVM	10.2	199168	93.7	735030	62.2	2374	4370	3990	3994	3943	3944	3944
14	24	LB	ARR	11.6	271660	95.1	639720	60.9	2443	4397	4000	4004	3790	3791	3791
90	24	LB	AVM	20.8	318608	97.4	873679	63.9	2478	4233	4000	4004	3764	3765	3765
75	24	LB	AVM	21.5	372339	98.9	1094402	65.4	2448	4255	4004	4008	3750	3751	3751
67	24	LB	AVM	29.9	333196	97.9	1048941	65.8	2440	4357	3989	3994	3571	3572	3572
48	24	LB	ARR	31.2	217932	94.3	717286	61.9	0	3351	1977	1983	3267	3269	3269
94	30	Central	ARR	12.3	239622	95.0	929720	64.6	2595	4912	4057	4061	4208	4209	4209
99	30	Central	ARR	18.8	210506	94.0	599063	60.2	2483	4396	3719	3722	4044	4045	4045
35	30	Central	AVM	19.1	376147	98.9	989942	65.3	3374	5246	4277	4281	4479	4480	4480
51	30	Central	ARR	32.7	257624	95.7	654613	61.1	2350	4383	3645	3648	3802	3803	3803
91	30	Central	ARR	34.0	258400	95.7	668582	61.3	2353	4385	3640	3644	3781	3782	3782
52	30	Central	ARR	2.6	267638	95.9	816132	63.3	2450	4652	3955	3958	4465	4467	4467
13	30	Central	AVM	5.2	367019	98.6	1044930	65.8	4359	6348	6272	6277	5471	5472	5472
32	30	Central	ARR	6.6	266519	95.9	978262	65.2	4004	5863	5572	5575	4713	4714	4714
12	30	Central	AVM	16.3	240944	95.1	631341	60.7	2465	4674	4059	4063	4479	4481	4481
31	30	Central	AVM	29.4	310754	97.2	909527	64.3	2478	4515	4008	4012	4164	4165	4165
39	30	Central	AVM	30.5	238832	95.0	601144	60.3	2451	4498	3977	3981	4138	4138	4138
59	30	Central	AVM	30.8	242374	95.2	701974	61.8	2464	4493	3987	3991	4129	4130	4130
7	30	Central	AVM	11.3	225415	94.6	907490	64.3	2630	4930	4205	4209	4587	4588	4588
16	30	Central	AVM	11.5	375076	98.9	933886	64.7	3214	5175	4261	4265	4605	4606	4606
83	30	Central	AVM	15.2	332990	97.8	979457	65.2	3122	5318	4344	4348	4568	4568	4568
17	30	Central	AVM	21.2	192341	93.3	836891	63.6	2496	4628	4061	4065	4369	4370	4370
1	30	Central	AVM	22.7	318213	97.4	588387	60.1	2470	4609	4028	4032	4332	4333	4333
9	30	Central	AVM	38.0	323735	97.6	826941	63.4	2518	4481	3939	3943	3997	3998	3998
27	30	Central	AVM	8.7	330080	97.8	786019	62.9	2528	4706	4104	4109	4611	4612	4612
3	30	Central	AVM	8.9	255377	95.6	650799	61.0	2444	4705	4086	4090	4607	4608	4608
24	30	Central	AVM	16.4	241479	95.2	963221	65.0	2841	5233	4275	4279	4526	4527	4527
49	30	Central	AVM	16.5	308479	97.2	1032039	65.6	3369	6442	5161	5165	4763	4764	4764
68	30	Central	AVM	25.7	229043	94.7	781752	62.8	2536	4571	4024	4028	4258	4259	4259
70	30	Central	ARR	30.9	233128	94.8	668362	61.3	2368	4393	3660	3663	3832	3833	3833
36	30	Central	ARR	34.5	206294	93.9	761085	62.6	2411	4410	3659	3662	3768	3769	3769
6	30	UB	ARR	8.2	234182	94.9	825407	63.4	2583	4631	3893	3896	4093	4094	4094
480	30	UB	AVM	8.3	206108	93.9	1067787	66.1	4972	7030	6929	6929	5643	5643	5643
81	30	UB	AVM	28.5	247393	95.3	680611	61.4	2549	4445	3937	3941	4013	4014	4014
80	30	UB	AVM	28.7	228194	94.7	879791	64.1	2557	4409	3912	3916	3979	3980	3980
57	30	UB	ARR	40.1	332558	97.8	712258	62.1	2504	4441	3592	3595	3436	3438	3438

Post – Dams Analysis (Contd)

Trial No	Storm Duration Hrs	Spatial Dist	Temporal Pattern	Initial Loss mm	Somerset Start		Wivenhoe Start		RAFTS Results "With Dams" Peak Flows at						
					ML	m AHD	ML	m AHD	Bris R at Wivenhoe Dam	U/S Temp Storage Lockyer/Bris in	Bris R at Savages Crossing	Bris R at Mt Crosby	Bris R at Moggill	Bris R at Jindalee	Bris R at PO Gauge
									WIV-OUT	SAV10	SAV-OUT	MTC-OUT	JIN###	JIN-OUT	POG-OUT
34	30	LY	AVM	7.5	213185	94.0	726390	62.1	2422	5379	4406	4410	4933	4934	4934
21	30	LY	ARR	9.5	206921	93.8	771016	62.7	2330	4508	3999	4003	4555	4556	4556
470	30	LY	ARR	12.1	267381	96.8	1068831	66.2	4180	6998	6799	6804	5448	5448	5448
72	30	LY	ARR	15.1	232526	94.8	647722	60.9	2178	4475	3952	3956	4400	4400	4400
76	30	LY	AVM	16.9	211792	94.1	648125	60.9	2451	5350	4331	4335	4769	4770	4770
79	30	LY	AVM	17.2	218667	94.3	706935	61.9	2386	5348	4341	4345	4763	4764	4764
69	30	LY	AVM	44.0	352343	98.3	972797	65.1	2454	4944	4170	4174	4138	4139	4139
22	30	SS	AVM	15.3	295992	96.6	730990	62.2	2563	4476	3977	3981	4168	4159	4169
500	30	SS	AVM	20.8	288347	96.6	1089677	66.3	4602	6916	6764	6769	5309	5309	5309
38	30	SS	ARR	22.8	247008	95.3	679820	61.4	2551	4558	3705	3708	3802	3803	3803
2	30	SS	ARR	24.6	244260	95.2	758280	62.6	2600	4588	3711	3715	3767	3769	3769
490	30	SS	ARR	25.4	207980	93.9	974500	65.1	2600	4845	3993	3996	3780	3780	3780
460	30	SS	AVM	32.6	315616	97.4	1026320	65.7	2963	4511	3987	3990	3881	3881	3881
95	30	LB	AVM	7.6	224588	94.6	683188	61.5	2379	4464	3874	3878	4830	4830	4830
73	30	LB	ARR	9.9	279258	96.3	901964	64.3	2438	4520	3781	3785	4458	4460	4460
33	30	LB	AVM	11.4	302879	97.0	833308	63.6	2458	4453	3879	3883	4769	4770	4770
29	30	LB	AVM	23.8	351916	98.3	961905	64.9	2547	4390	3916	3920	4523	4524	4524
58	30	LB	ARR	26.9	259181	95.7	863388	63.8	2465	4467	3640	3644	4019	4021	4021
85	30	LB	AVM	34.1	194659	93.4	924312	64.7	2449	4327	3777	3781	4275	4276	4276
46	30	LB	AVM	42.5	371386	98.8	1031043	65.4	2518	4365	3730	3734	4065	4066	4066
111	36	Central	ARR	4.9	317538	97.4	854502	63.7	2772	6034	4681	4686	4337	4339	4339
130	36	Central	ARR	5.1	363490	98.7	1047354	65.9	5310	8842	8372	8379	6092	6092	6092
105	36	Central	ARR	8.3	225069	94.6	714496	61.9	2527	5767	4005	4009	4303	4305	4305
112	36	Central	ARR	9.4	336043	97.9	646179	60.9	2497	5529	3967	3971	4295	4296	4296
126	36	Central	ARR	10.3	242766	95.2	846813	63.7	2626	5957	4257	4262	4332	4334	4334
117	36	Central	ARR	10.8	214943	94.2	658568	61.2	2499	5586	3957	3961	4296	4298	4298
123	36	Central	ARR	11.0	192099	93.4	694393	61.7	2525	5709	4016	4020	4305	4307	4307
101	36	Central	ARR	11.8	300860	96.9	842982	63.6	2728	5951	4285	4250	4325	4326	4326
104	36	Central	ARR	12.1	310003	97.2	780547	62.8	2506	5884	4128	4133	4306	4308	4308
129	36	Central	ARR	12.6	245486	95.2	1037113	65.8	5253	8785	8307	8314	6039	6040	6040
128	36	Central	ARR	13.9	357704	98.4	965877	65.0	4405	7826	7225	7230	5330	5331	5331
124	36	Central	ARR	14.5	216403	94.2	632526	60.7	2536	5461	3949	3953	4291	4293	4293
107	36	Central	ARR	16.8	325641	97.6	982637	65.2	4354	7886	7153	7159	5334	5334	5334
120	36	Central	ARR	17.4	358085	98.4	891231	64.2	3382	6889	5567	5572	4669	4669	4669
102	36	Central	ARR	18.4	365231	98.7	770080	62.7	2729	5888	4139	4144	4306	4308	4308
118	36	Central	ARR	18.8	201825	93.7	593333	60.2	2461	5386	3924	3928	4284	4286	4286
125	36	Central	ARR	19.4	325838	97.7	975645	65.2	4354	7886	7153	7159	5334	5334	5334
109	36	Central	ARR	20.8	244859	95.2	957575	64.8	4296	7674	6986	6991	5176	5176	5176
113	36	Central	ARR	23.4	299580	96.9	728681	62.1	2485	5801	4019	4023	4307	4309	4309
119	36	Central	ARR	24.1	283916	96.4	797541	63.0	2717	5870	4145	4150	4305	4307	4307
127	36	Central	ARR	25.1	338672	98.0	952074	64.8	4001	7478	6704	6710	5088	5088	5088
106	36	Central	ARR	25.4	356383	98.4	944954	64.8	4118	7595	6861	6867	5155	5156	5156
121	36	Central	ARR	26.3	215176	94.2	756952	62.5	2553	5793	4094	4099	4304	4306	4306
114	36	Central	ARR	28.8	243736	95.1	993005	65.3	4624	8301	7708	7714	5607	5607	5607
108	36	Central	ARR	29.4	256957	95.6	768239	62.7	2442	5820	4069	4074	4305	4307	4307
103	36	Central	ARR	32.6	287303	96.6	860762	63.8	2683	5954	4241	4245	4341	4343	4343
110	36	Central	ARR	36.1	354998	98.3	733456	62.2	2530	5676	4041	4045	4306	4308	4308
115	36	Central	ARR	40.6	341010	98.1	803174	63.1	2725	5940	4193	4198	4305	4307	4307
116	36	Central	ARR	42.8	312779	97.3	841598	63.6	2644	5954	4251	4256	4329	4330	4330
122	36	Central	ARR	43.5	264417	95.8	791975	62.9	2422	5806	4103	4108	4305	4307	4307
147	48	Central	ARR	5.0	200642	93.7	636695	60.8	2494	4618	4232	4243	4181	4182	4182
143	48	Central	ARR	8.6	337000	97.9	975108	65.1	5995	7865	6289	6296	5718	5719	5719
145	48	Central	ARR	9.9	279498	96.3	684740	61.5	2891	4633	4317	4329	4290	4291	4291
136	48	Central	ARR	10.0	305624	97.1	767573	62.6	3420	4883	4623	4629	4438	4439	4439
142	48	Central	ARR	10.2	270102	96.1	715732	61.9	2845	4630	4343	4355	4335	4336	4336
139	48	Central	ARR	11.2	197756	93.5	698815	61.7	2623	4631	4325	4337	4308	4309	4309
132	48	Central	ARR	12.6	281439	96.4	744406	62.3	3324	4534	4329	4341	4359	4360	4360
148	48	Central	ARR	13.0	305430	97.1	934552	64.6	5428	7176	5928	5934	5420	5420	5420
138	48	Central	ARR	14.7	222781	94.5	905030	64.3	5373	7005	5862	5868	5361	5361	5361
131	48	Central	ARR	15.1	249701	95.4	796276	63.1	3715	5233	4940	4947	4568	4569	4569
140	48	Central	ARR	15.7	323753	97.6	817543	63.3	4287	5699	5289	5294	4803	4803	4803
134	48	Central	ARR	16.9	364896	98.7	1015422	65.5	6266	8368	6535	6541	5928	5928	5928
141	48	Central	ARR	19.1	190545	93.3	753735	62.4	3478	4996	4718	4724	4493	4493	4493
149	48	Central	ARR	19.5	309189	97.2	793696	63.0	3884	5240	4970	4975	4578	4579	4579
135	48	Central	ARR	19.9	308165	97.1	866487	63.9	4872	6390	5564	5570	5116	5116	5116
144	48	Central	ARR	22.3	376748	98.9	919197	64.5	5551	7239	5994	5999	5472	5473	5473
150	48	Central	ARR	23.3	243967	95.2	652571	61.1	2623	4652	4290	4301	4238	4239	4239
133	48	Central	ARR	23.3	227665	94.8	830052	63.4	4293	5811	5323	5330	4848	4848	4848
146	48	Central	ARR	37.4	247984	95.3	689170	61.6	2751	4635	4322	4334	4296	4297	4297
137	48	Central	ARR	39.0	377729	98.9	1028223	65.7	6469	8699	6630	6637	6058	6058	6058
159	72	Central	ARR	9.2	258632	95.6	926417	64.6	5538	7367	6527	6534	6359	6360	6360
154	72	Central	ARR	12.0	244941	95.2	1022694	65.6	6434	8326	6860	6871	6876	6877	6877
160	72	Central	ARR	12.7	294310	96.8	803549	63.1	6264	7968	6150	6165	5822	5822	5822
158	72	Central	ARR	14.8	313922	97.6	991697	65.3	6294	8017	6854	6862	6797	6798	6798
153	72	Central	ARR	21.3	321440	97.5	855489	63.8	6593	8223	6507	6514	6197	6198	6198
151	72	Central	ARR	29.2	194319	93.4	616823	60.5	3816	5644	4953	4960	4605	4608	4608
155	72	Central	ARR	33.0	249999	95.3	702147	61.8	5200	6993	5628	5634	5283	5283	5283
152	72	Central	ARR	38.2	270865	96.1	845252	60.9	4501	6332	5359	5366	4899	4899	4899
157	72	Central	ARR	39.2	361795	98.6	719893	62.0	5944	7648	5976	5982	5660	5661	5661
156	72	Central	ARR	39.4	273031	96.1	808923	63.2	6200	7866	6079	6086	5787	5788	5788

Ipswich River MIKE11 Model Upgrade
Ipswich City Council

Ipswich City Council

Final Report
May 2006

Ipswich River MIKE11 Model Upgrade

Final Report

Post Office Box 1508
Nerang, QLD, 4211
Australia

Tel: +61 7 5570 4205
Fax: +61 7 5570 4206
e-mail: dhi@dhiwae.com
Web: www.dhiwae.com

Client	Client's representative
Ipswich City Council	[redacted]

Project	Project No
MIKE11 Model Upgrade Ipswich Rivers	AU50342
Authors	**Date**
David Kane Stefan Szylkarski	19 May 2006
	Approved by
	Stefan Szylkarski

Revision	Description	By	Checked	Approved	Date
03	Final Report – Appendices Added to TOC	SPS	DHK	SPS	19/05/06
02	Final Report	SPS	MFB	SPS	17/05/06
01	Draft Report	SPS	MFB	SPS	6/03/06

Key words	Classification
Ipswich Rivers MIKE11 Model Upgrade	☐ Open ☐ Internal ☒ Proprietary

Distribution		No of copies
DHI	Office Copy	1 Copy
Ipswich City Council	Ravi Raveenthiran	1 Copy

CONTENTS

1 INTRODUCTION

Ipswich City Council (ICC) commissioned DHI Water and Environment (DHI) to carry out a review of their MIKE11 model covering the Ipswich Rivers and associated tributaries (The Model). The review was carried out for the separate upper and lower models which encompass the Ipswich Rivers area. The upper model encompasses the major tributaries of the Bremer River upstream of Amberly Airbase whilst the lower model includes the Bremer River and a number of creek systems that drain directly to the Brisbane River

The review was completed in May 2005 with a number of recommendations made for updating and improving the model stability and accuracy. Upon review of the recommendations, ICC subsequently commissioned DHI to undertake the model update.

The aim of the model update is to implement necessary improvements and modifications required to improve stability and improve the model performance. A major task of the update process was the merging of the upper and lower models into a single model. The lower model consists of the Brisbane River flood model from Wivenhoe Dam to the Port of Brisbane combined with the Ipswich Rivers model of the lower Bremer River. Brisbane City Council have previously carried out some minor updating of the Brisbane River components of this model and it was necessary to incorporate these into the combined model to ensure that the most up to date information available, was included in the model.

A range of modifications were proposed in order to update the model to a standard sufficient for future flood and forecasting studies. The specific recommendations from the model review undertaken included the following:

1. Positional Accuracy
   - Include accurate aerial photographic background image to ensure positional accuracy of the model branches and cross sections.
2. Model Schematisation:
   - Remove closely spaced grid points.
   - Include Link Channels in place of artificial slots in connecting cross sections.
   - Check model chainages against registered photographic images.
   - Update branch layouts where possible and cross section extents in areas of cross section overlap in order to eliminate storage duplication.
   - Divide channel and floodplain flows into separate branches for excessively wide floodplain sections.
3. Cross Sections
   - Remove all artificial slots in cross sections.
   - Increase the number of processed data points in some cross sections to between 20 and 40.
4. Numerical Parameters
   - Centre the numerical scheme using a delta value of 0.55.

- Define a stable static initial condition to allow the model to cold start correctly.

5. Simulation Time step
   - Update model time step to between 30 seconds and 1 minute depending on model sensitivity testing.

2 AVAILABLE INFORMATION AND MODELS

The updating of the model was based on the following MIKE11 models:

- Existing Brisbane River MIKE11 model incorporating lower Ipswich Rivers,
- Upper Bremer River MIKE11 model,
- Brisbane River MIKE11 model updates completed by Brisbane City Council.

The Brisbane River MIKE11 model which incorporated the lower Ipswich Rivers model was provided by Brisbane City Council (BCC). This model was originally developed by Sinclair Knight Merz (SKM) as part of the Brisbane River Flood Study (*Ref-1*). This "SKM model" has recently been updated by the Wivenhoe Alliance (*Ref-4*) to incorporate a range of link channels and floodplain modification to accommodate high levels flows which occur during the Probable Maximum Flood (PMF). The model files supplied include:

▪ Simulation File	Fuse_01-1a.sim11
▪ Network File	TotalRiver4.nwk11
▪ Cross Sections File	TotalRiver3.xns11
▪ HD Parameter	Design_01.hd11
▪ Hotstart File	Phase3-HS.res11
▪ Timestep	15 secs
▪ Simulation Start	05/01/1999 00:00
▪ Simulation Stop	23/01/1999 10:00
▪ Result File	Fuse_01-1a.res11

The upper model which incorporated the upper Bremer River and tributaries was provided by ICC. This model was originally developed by Halliburton KBR as part of the Ipswich Rivers Flood Studies (*Ref 2*). The model files supplied and adopted as the basis for this study include:

▪ Simulation File	Ipswich_100y24h.sim11
▪ Network File	Ipswich18.nwk11
▪ Cross Sections File	Ipswich7.xns11
▪ HD Parameter	Ipswich2.hd11
▪ Hotstart File	HOTSTART_11SEPTEMBER2002.RES11
▪ Timestep	2 secs
▪ Simulation Start	01/01/2001 00:00
▪ Simulation Stop	03/01/2001 00:00
▪ Result File	100y24h.res11

The following additional information was supplied by BCC and ICC:

- Aerial photographs provided for the purpose of importing into the MIKE11 model as background information.
- MapInfo line feature detailing survey cross section extents.
- MapInfo Line features detailing river AMTD lines.
- Digital Elevation Model (DEM) provided in XYZ txt format.
- Ipswich Rivers Flood Studies, Lower Bremer River Flooding Report (*Ref-3*)
- MIKE11 model results files for the SKM flood study (*Ref-1*) calibration events including 1974, 1983 and 1989 flood events.

3 MODEL SCHEMATISATION

The updating of the model schematisation included the following elements:

- Positional Accuracy;
- Remove closely spaced grid points;
- Include Link Channels in place of artificial slots in connecting cross-sections;
- Check model chainages against registered photographic images;
- Update branch layouts and cross-section extents in areas of cross-section overlap in order to eliminate storage duplication; and
- Divide channel and floodplain flows into separate branches for excessively wide floodplain sections.

3.1 Positional accuracy

To ensure that the positional alignment of the model is accurate the MIKE11 models were digitally layered over aerial photographs imported into MIKE11. The extent of the lower model (major river branches only) is shown in Figure 3-1.

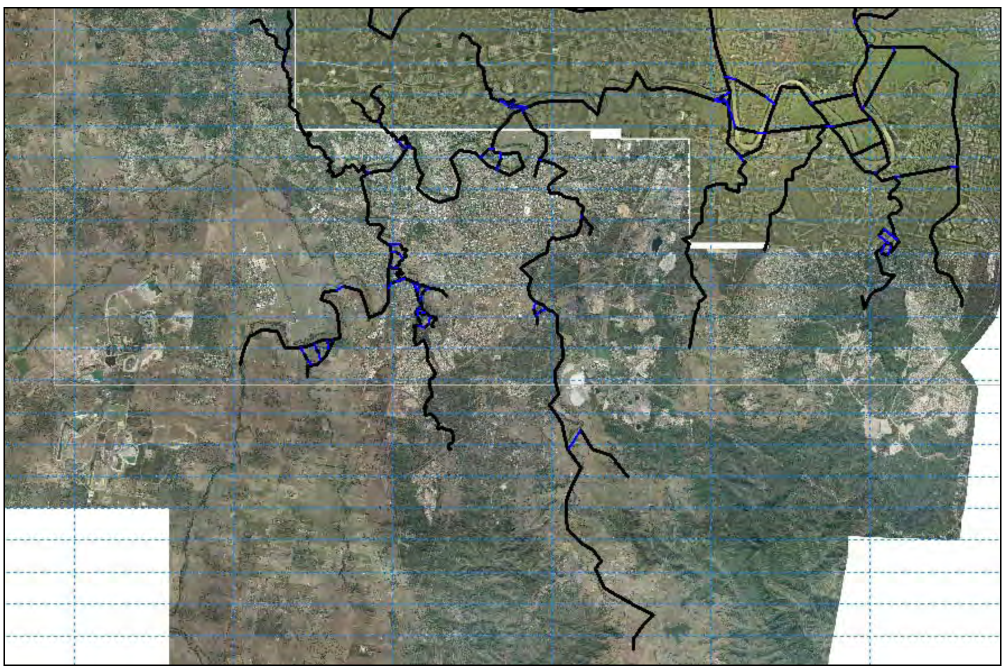


Figure 3-1: Mike 11 model for lower reaches of the Bremer River catchment.

The AMTD and cross section survey line features were imported from the MapInfo GIS to MIKE11 and were used to confirm the river branch alignments and cross sectional locations within the model.

A typical example of the layers within MIKE11 for the Warill Creek branch is presented in Figure 3-2. The overlay clearly demonstrates the simplification and dislocation of the model branch from the GIS data layers. The dislocation is partly due to a translation of the MIKE11 model coordinates from AMG56 projection to the recently adopted MGA56 project system. The branch alignment was manually reconfigured to match the aerial photography and survey data. Figure 3-3 shows the Warill Creek branch with the new alignment to MGA 56 earth projections.

When updating the branch alignments only the positional locations have been modified. All cross-section chainage have been maintained where possible in order to maintain the original model grid points. In MIKE11, cross section chainage are used to set model grid points and the chainage have been maintained in order to maintain compatibility between the updated model results and previous studies, and mapping that is based in the old models.

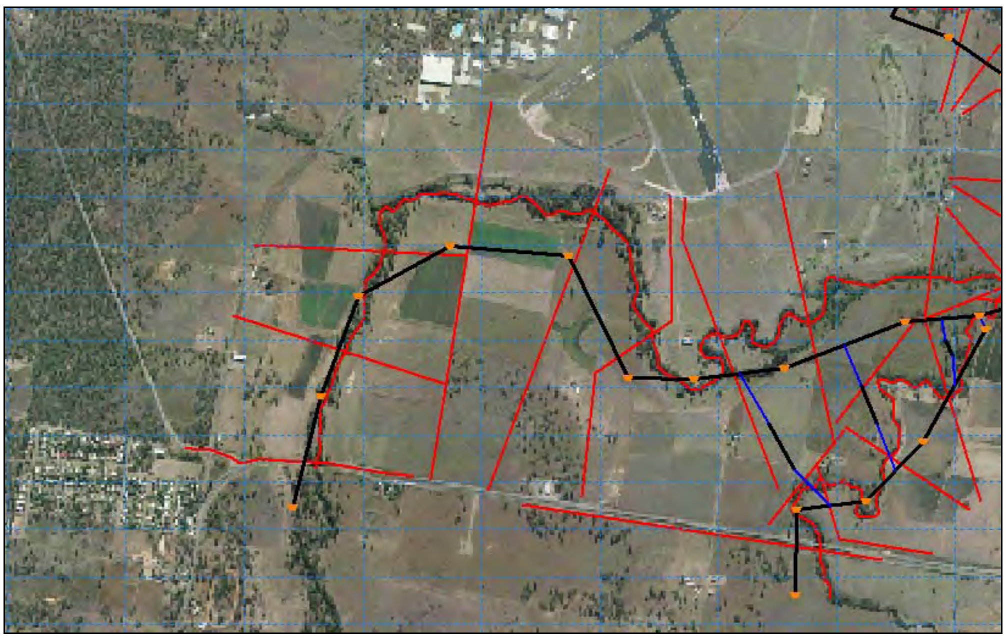


Figure 3-2: Warill Creek Branch, original Mike 11 Model. The red lines indicate the branch AMDT and cross section survey data and black the existing model alignment.

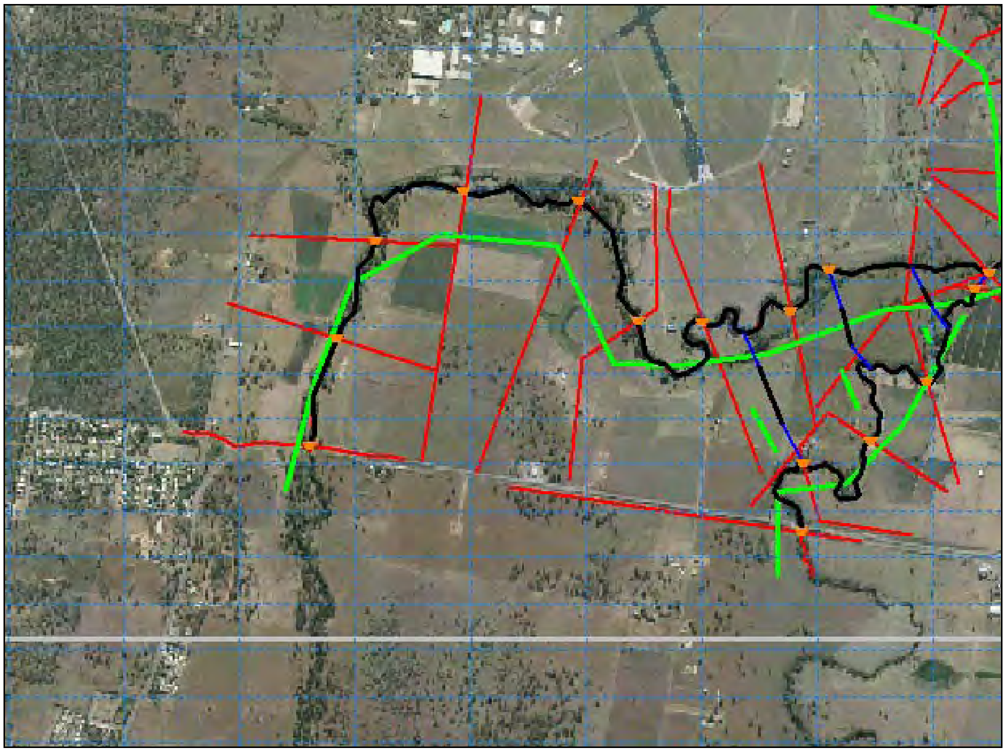


Figure 3-3: Warill Creek Branch, updated model. The green line indicates the original ICC model, respectively black and orange the updated model alignment and cross-section locations.

A summary of the branches within the lower model where alignments have been modified is presented in Table 3-1. In all instances, the model alignment has been altered to match the survey AMTD lines. An analysis of the model chainages suggests that all cross section chainages have been based on the AMTD line. The model branch and chainage layouts are discussed further in Section 3.5.

Table 3-1: Summary of branches that have been realigned.

Branch ID	Upstream Chainage (m)	Downstream Chainage (m)	Branch Type
BUND	10615	41030	Regular
BUND#	0	90	Link Channel
DEEB	10000	19912	Regular
DEEB_LK1	0	30	Link Channel
DEEB_LK2	0	30	Link Channel
DEEB_LK3	0	30	Link Channel
DEEB_LK4	0	30	Link Channel
DEEB_LK5	0	30	Link Channel
DEEB_LK6	0	30	Link Channel
DEEB_LK7	0	30	Link Channel
GOOD	10000	16725	Regular
HWAY LEFT	0	390	Regular
IRON	10000	18584	Regular
IRON_BR1	1000	2491	Regular
LOW BRANCH1	0	480	Regular
LOW BRANCH2	0	740	Regular
PURGA	100000	102502	Regular
PWLINK1	0	1	Link Channel
PWLINK2	0	1	Link Channel
PWLINK3	0	1	Link Channel
SCH	10000	13972	Regular
SIX	9530	20235	Regular
UP BRANCH1	0	2290	Regular
WAR	100000	108140	Regular
WOOG	10000	19075	Regular
WOOG_LK2	0	30	Link Channel

3.2 Grid Spacing

There are a number of branches within the model where grid points were extremely closely spaced. In some cases the distance between grid points was less than 5m.

This spacing is consistent with local storm drainage modelling but is not recommended for broad scale flood models. The close spacing of the grid points significantly restricts the model time step. Model grid points were analysed with cross-sections closer than 50m being removed from the model. The exception to this was when cross-sections were located up stream or downstream of a structure and where cross-sections were significantly different. In these instances, the cross-sections were not removed from the model.

An example where branch spacing has been addressed and cross-sections removed is presented in Figure 3-4 and Figure 3-5. Cross sections were removed from the model at chainages 13550 and 14930m.

A summary of the lower model cross-sections that were removed is provided in Table 3-2. A full summary of all changes made to the model with accompanying figures detailing the original model layout and new model configuration is provided in Appendix A.

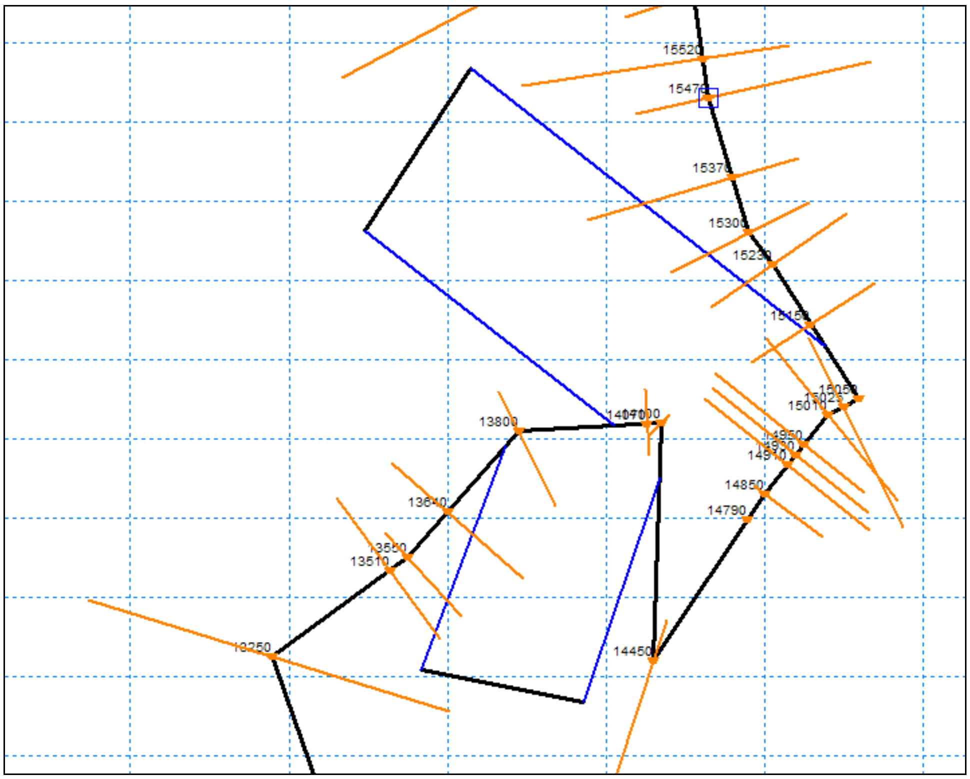


Figure 3-4: "WOOG" Branch original model (cross-sections shown in orange).

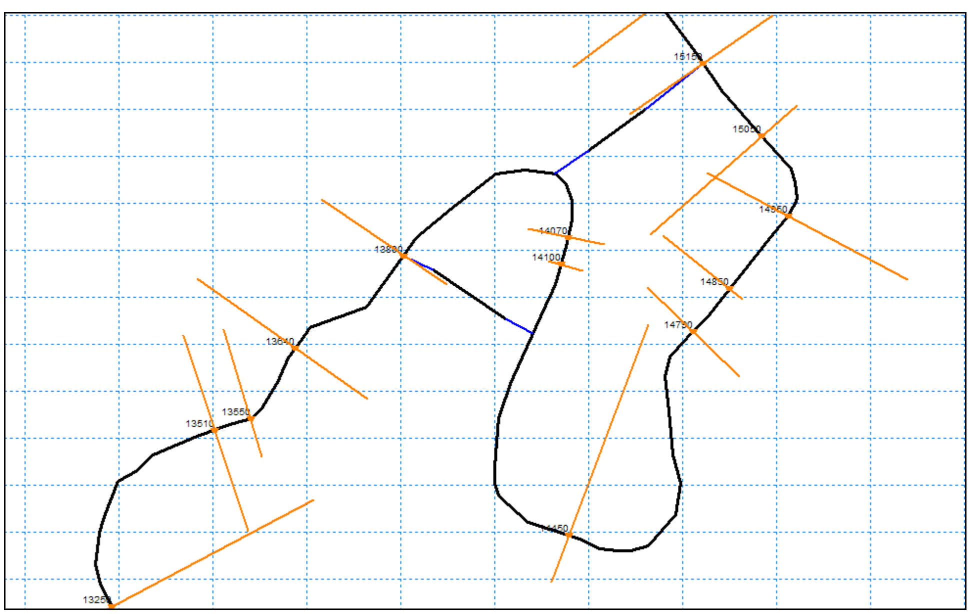


Figure 3-5: "WOOG" Branch realigned model with enhanced spacing between cross-sections.

Table 3-2: Summary of cross-sections removed from model.

Branch	Cross-Section Chainage (m)
IRON	11765
IRON_BR1	2463
DEEB	16215
DEEB	16303
DEEB	16635
GOOD	14555
GOOD	14635
GOOD	14895
GOOD	14930
WOOG	13550
WOOG	14930
WOOG	15025
WOOG	15990
WOOG	16150

3.3 Link Channels

The link channels contained within the model have been reviewed with respect to:

- location and alignment of the link channel;
- connection of the link channel to the main branches; and
- removing artificial slots used in connecting cross sections and replace with link channels.

To assist with the location of the link channels, ICC provided surface elevation data in the form of a XYZ file. The XYZ data was converted into a Digital Elevation Model (DEM) using Mike Zero's bathymetry editor. The DEM and aerial photography where used as the basis for accessing and redefining the locations of the link channels. Figure 3-6 and Figure 3-7 provide an example of the original and new link channel configurations for the "DEEB" branch.

In some instances, the hydraulic connections of link channels to the main branches required redefining after the model branch alignment had been updated.

A summary of all the link channels where modifications to the hydraulic connections have been made is given in Table 3-3 and Table 3-4 below. A complete list of changes made to the model, including detailed figures comparing the original model, configuration to the updated configuration, is provided in Appendix A.

Table 3-3: Summary of link channels that have been realigned.

Branch ID	Upstream Chainage	Downstream Chainage
BUND#	0	90
DEEB_LK1	0	30
DEEB_LK2	0	30
DEEB_LK3	0	30
DEEB_LK4	0	30
DEEB_LK5	0	30
DEEB_LK6	0	30
DEEB_LK7	0	30
PWLINK1	0	1
PWLINK2	0	1
PWLINK3	0	1
WOOG_LK2	0	30

Table 3-4: Summary of link channel hydraulic connections.

	ICC Original Model				Updated Model			
Branch Name	Upstream Connection		Downstream Connection		Upstream Connection		Downstream Connection	
	Branch	Chainage	Branch	Chainage	Branch	Chainage	Branch	Chainage
BREMBRIS 2	BREM	1028190	BNE	1005870	BREM	1028190	BNE	1005325
BUND#	HWAY LEFT	200	BUND	28200	HWAY LEFT	170	BUND	28350
DEEB_LK1	BREM	1004320	DEEB	19157	BREM	1004320	DEEB	19247
DEEB_LK2	BREM	1003840	DEEB	18593	BREM	1003840	DEEB	18670
DEEB_LK3	BREM	1003130	DEEB	17629	BREM	1003200	DEEB	17697
DEEB_LK5	DEEB	16643	SMALL	1624	DEEB	16635	SMALL	1670
DEEB_LK6	DEEB	16035	REEDY	1948	DEEB	16035	REEDY	1995
DEEB_LK7	DEEB	15692	REEDY	1529	DEEB	15682	REEDY	1542
MIHI_LINK1	MIHI	12135	BREM	1009585	MIHI	12094	BREM	1009675
PWLINK1	PURGA	100773	WAR	103831	PURGA	100432	WAR	103831
PWLINK2	PURGA	101479	WAR	104287	PURGA	101546	WAR	104444
SCH_LK1	SCH	13750	BREM	1020440	SCH	13757.6	BREM	1020450
SCH_LK2	SCH	13050	BREM	1020440	SCH	13060	BREM	1020000
WOOG_LK1	WOOG	14000	WOOG	15120	WOOG	13995	WOOG	15150
WOOG_LK2	WOOG	13770	WOOG	14180	WOOG	13800	WOOG	14180

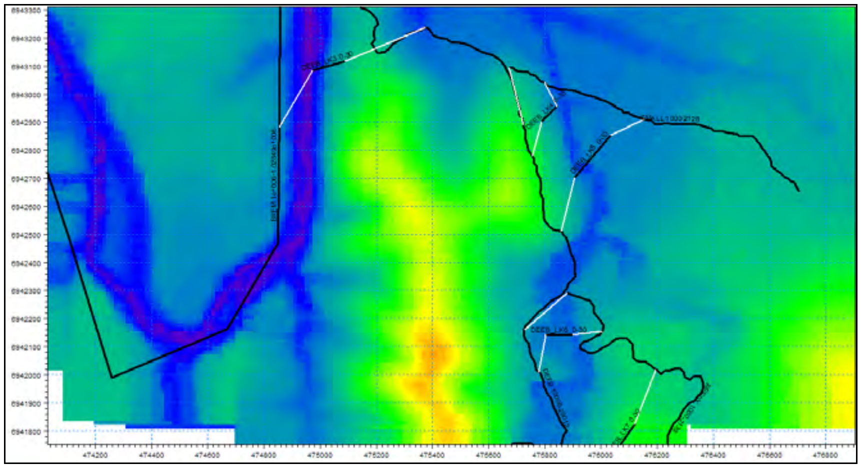


Figure 3-6: Link channel configuration for ICC original model.

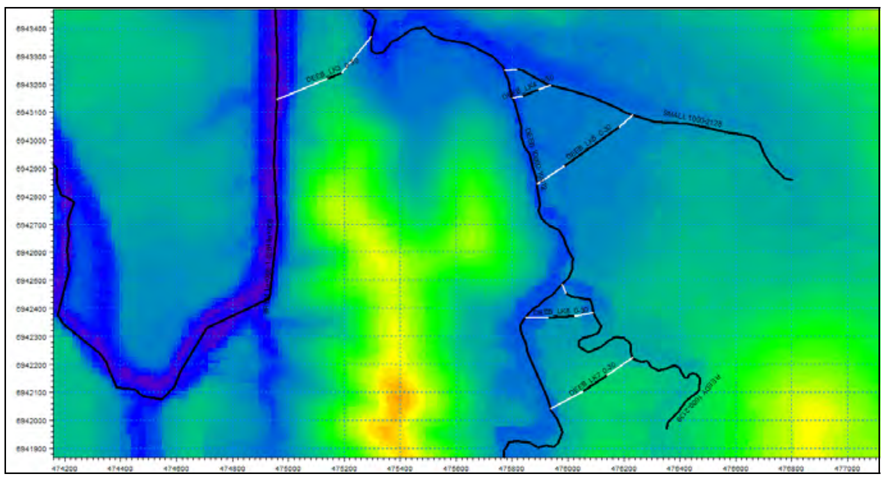


Figure 3-7: Link channel configuration for updated model.

3.4 Model Storage Volumes and Storage Duplication

The upper and lower Ipswich Rivers models have generally been developed using single branches which combine river channel and floodplain flows together at a single cross section. This technique is suitable for the purposes of investigating large over bank floods where the chainage length reflects the floodplain length. The MIKE-11 terminology for this schematisation is referred to as FP1 (*Ref 5*).

In the Ipswich Rivers models (upper and lower) the chainage length is generally based on the AMTD or low flow channel length which is significantly longer than the floodplain length. However the model is generally based on the FP1 schematisation technique. Consequently the MIKE11 model will almost certainly overestimate the storage within the floodplain due to the increased length of the floodplain.

There is also general duplication of storage volumes in the floodplain due to the occurrence of overlapping cross sections. The volume in a MIKE11 model is represented by the surface area between consecutive cross-sections multiplied by the depth of flow. When cross-sections overlap the surface area is duplicated and consequently the volume in the overlapping areas is represented twice.

A typical example of overlapping cross sections and storage duplication is presented in Figure 3-8. The example is located at the downstream end of Franklinvale model branch.

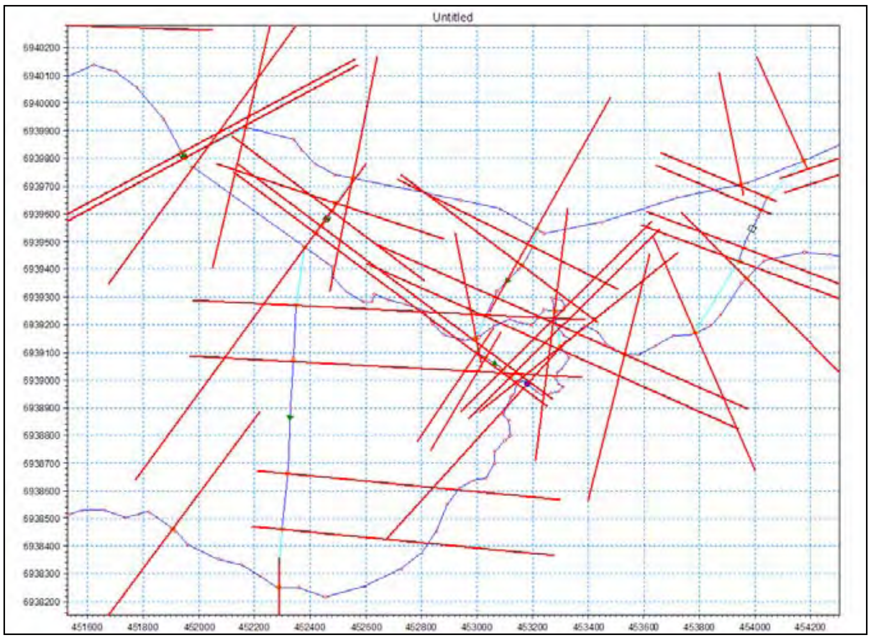


Figure 3-8 Typical example of storage duplication where cross-sections overlap.

An alternative schematisation technique (referred to as FP4) is to divide the floodplain and channel into separate model branches which are connected by link channels to represent the exchange of flows between the channel and the floodplain. The floodplain branch represents the floodplain storage and conveyance whilst the channel branch represents the conveyance and storage of the main channel. The FP4 schematisation (*Ref 5*) enables the model to differentiate between floodplain and channel levels and velocities which is important for flood mapping.

3.5 Model Chainages

The model chainages within the Ipswich Rivers area have been checked to ensure that the model branch lengths accurately represent the physical branch lengths as assessed against aerial photographic background features.

A summary of the chainage lengths is presented in Table 3-5.

Table 3-5: Comparison of model branch chainages against physical branch length.

Branch	Original Model Branch Length		Physical Branch Length (AMTD)		
	Upstream Chainage	Downstream Chainage	Upstream Chainage	Downstream Chainage	Chainage Difference
	(m)	(m)	(m)	(m)	(m)
WAR	100000	108140	100000	108220	80
BREM	1000000	1028490	1000000	1028519	29
PURGA	100000	102502	100000	102411.8	-90.2
DEEB	10000	19912	10000	19906	-6
SMALL	1000	2128	1000	2103	-25
REEDY	1000	2139	1000	2107	-32
BUND	10615	41030	10615	41397	367
UP BRANCH1	0	2290	0	2663	373
HWAY LEFT	0	390	0	216	-174
LOW BRANCH2	0	740	0	1169	429
LOW BRANCH1	0	480	0	631	151
SIX	9530	20235	9530	20262	27
GOOD	10000	16725	10000	16626	-99
WOOG	10000	19075	10000	19232	157
SAND	10000	23900	10000	Outside Study Area	-
IRON_BR1	1000	2491	1000	2488	-3
IRON	10000	18584	10000	18408	-176
MIHI_BR1	1292	2700	1292	2660	-40
MIHI	10000	13121	10000	12909	-212
SCH	10000	13972	10000	13878	-94

3.6 Structures

A number of changes to the model were made to the structures within the model in order to improve stability. The primary change was the updating of the structure schematisation for the bridges crossing the Bremer River in the lower model area.

All model structures schematised as culverts and weirs were reprocessed to ensure that the stored tabular flow relationships were based on the updated cross section parameters. The re-processing of the cross-section is carried out automatically by MIKE11. The modern version of MIKE11 includes an automatic error checking facility to ensure that each structure has monotonically increasing level and flow relationships. A number of the relationships contained errors and were corrected by making small modifications to the structure geometry to ensure a smooth transition in the level/area relationships for the structure.

The culvert and weir structure that represented the Walter Taylor Bridge at Indooroopilly was particularly unstable and the schematisation adopted in the model was considered inappropriate. This bridge is located outside the study area; however it was limiting the stability of the model. The bridge structure was therefore removed from the model. This structure should be replaced with a MIKE11 bridge structure if results are to be used locally but will not have a significant impact on the model results at Ipswich.

3.6.1 Bridge Structures

The modern version of MIKE11 (version 2004 and above) includes a "Bridge Structure" option within the structures routine. The Bridge Structure option is specifically design to represent bridges which consist of abutments and piers with simply supported bridge decks. The method replaces the traditional method of representing a bridge using an irregular culvert and weir combination. A summary of the bridge structures updated to the bridge option is presented in Table 3-6, and their locations shown in Figure 3-9.

Table 3-6: Summary of new bridge structures.

Branch	Structure Chainage (m)	Description
BREM	1008400	Hancock St
BREM	1004600	One Mile Bridge
BREM	1006500	WULKARAKA RAIL
BREM	1012060	David Trumpy
BREM	1023500	Wareggo H'Way
BREM	1011800	Railway Workshop

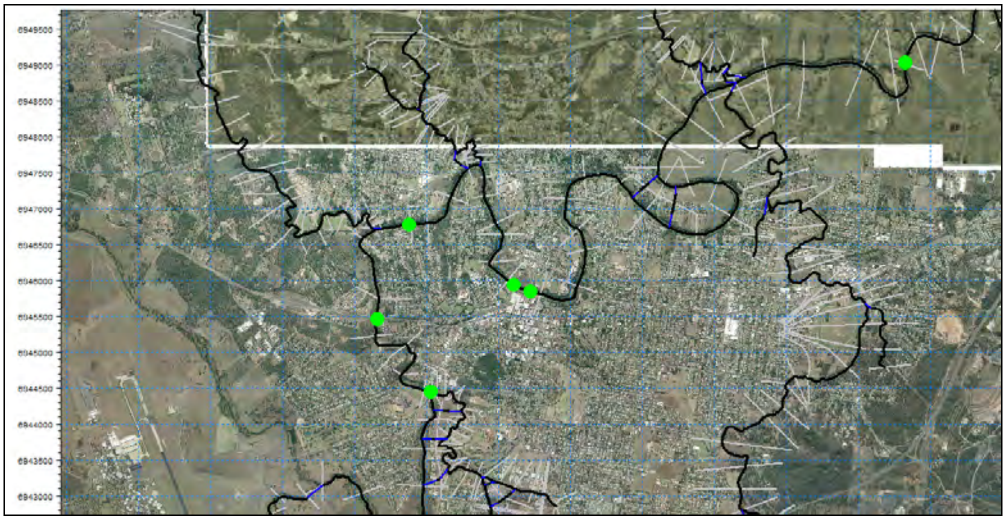


Figure 3-9: Location of new bridge structures (shown in green) on the Bremer River.

The bridge structure has a range of alternative solution schemes for determining hydraulic characteristics. The Energy Equation method for bridge structures was adopted and is consistent with the HEC-RAS modelling of the bridge structures that has been used previously to assess head losses at bridges.

The Energy Method will improve the modelling and stability of bridges where there is little or no contraction and expansion losses under the bridge. The typical bridge setup that has been adopted in the updated model is presented in Figure 3-10.

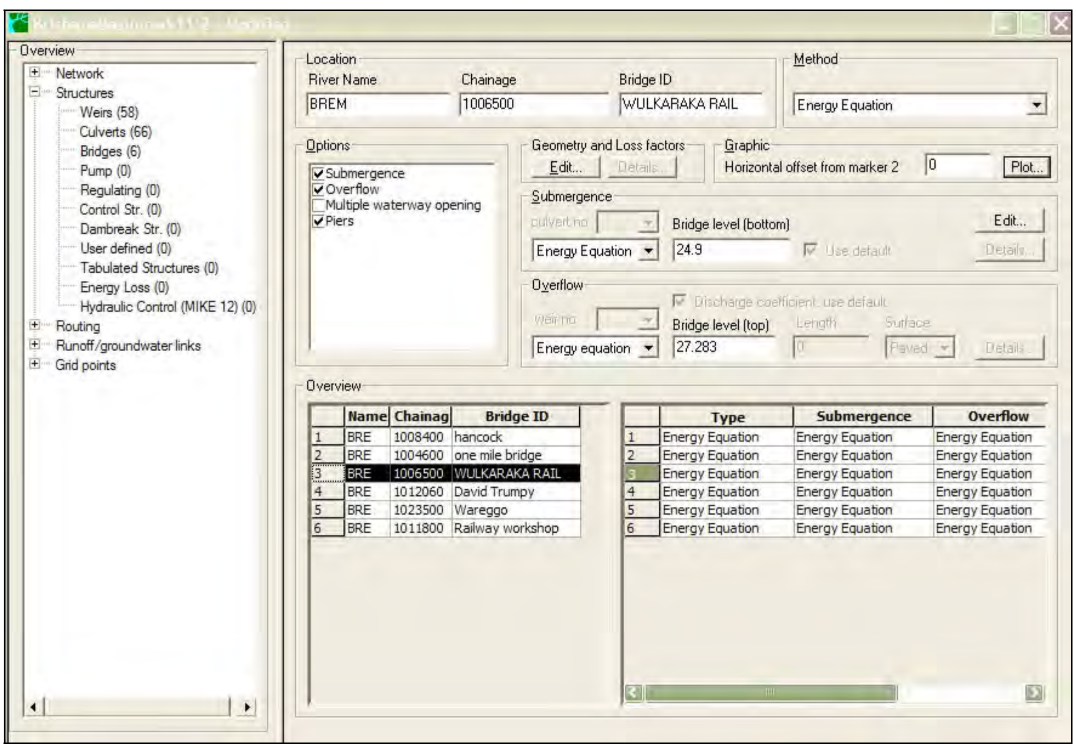


Figure 3-10: Typical bridge structure setup in MIKE11.

3.6.2 *Western Creek Branch*

The schematisation of the structures in the RailNorth and RailSouth branches within the Western Creek area were a major source of instability in the upper model areas, and it was necessary to make significant adjustments to the model in this area. The following adjustments were made:

- Cross-sections in all link branches were reduced from 4 sections to 2 section per branch.
- Cross-sections on link branches were schematised as trapezoidal sections (In the existing model, these sections were copied from the main branches and were considered inappropriate).
- Inverts of cross-sections on link branches were matched to inverts of the main branch connection points.

The following link branches in the Western Creek area were adjusted:

- RailBridge1
- RailBridge2
- RailBridge3
- RailBridge4
- RailBridge5
- RailWeir1
- RailWeir2
- RailBridge6
- RailWeir3
- RailWeir4
- RailWeir5
- RailWeir6
- WestBrem1
- WestBrem2
- WestBrem3

3.6.3 *Upper Bremer River Branch*

A number of the link branches connecting the Franklinvale branches have been adjusted with the following changes:

- Cross-section in link branches were reduced from 4 sections to 2 sections per branch.
- Cross-sections on link branches were schematised as trapezoidal sections (In the existing model, these sections were copied from the main branches and were considered inappropriate.
- Inverts of cross-sections on link branches were matched to inverts of the main branch connection points.

The following link branches were adjusted:

- Frank_West_Weir 1
- Frank_West_Weir 2
- WarPurWeir3
- WarPurWeir2
- WarPurWeir1

4 CROSS-SECTIONS

Cross-sectional data has been reviewed and updated taking into account the following elements:

- Cross-section alignment and orientation;
- Use of “slots” for low flow stability;
- Hydraulic Radius methodology;
- Specification of low flow bank markers; and
- Processed data conveyance curves.

Each of the elements and changes to the updated model are discussed in the following sections.

4.1 Cross-Section Alignment

The cross-section alignment convention in MIKE11 is based on the surveyed profile input to the data-base from left to right looking downstream. In most cases this convention was reversed in the existing models (upper and lower model) and has been updated in this project to reflect the MIKE11 convention.

The reversal of cross-section survey profiles will have no impact on the model storage characteristics or water level predictions because the model only utilises the cross-section processed data and not the spatial locations of the survey. However, if the model is to be utilised for flood mapping then it is critical that water levels are assigned to the correct spatial locations.

The cross-section information was exported in raw text format from MIKE11 and the cross section X, Z survey information was reversed by recalculating the chainage lengths from the left to right banks. This process was automated using a utility program developed internally at DHI. The reversed survey profiles were imported back into the cross-section data base and reprocessed.

An example of the cross-section reversal and branch re-alignment results for Six Mile Creek is presented in Figure 4-1 and Figure 4-2 These figures show the model cross-sections layer over the GIS line features detailing the cross section survey locations. A list of model branches where the cross-sections have been reversed and updated is provided in Table 4-1.

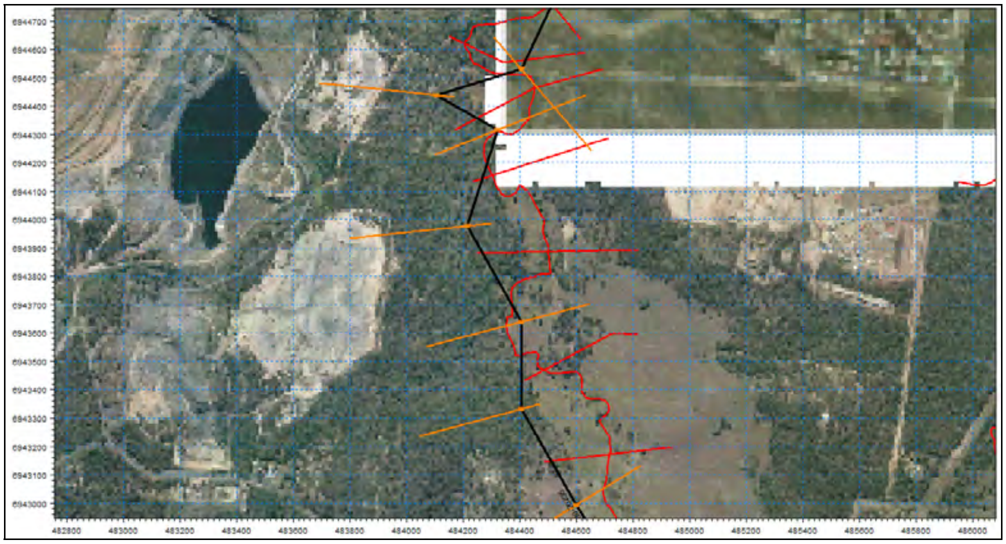


Figure 4-1: Six Mile Creek from the original ICC model prior to reversal (model shown in orange and survey data in red).

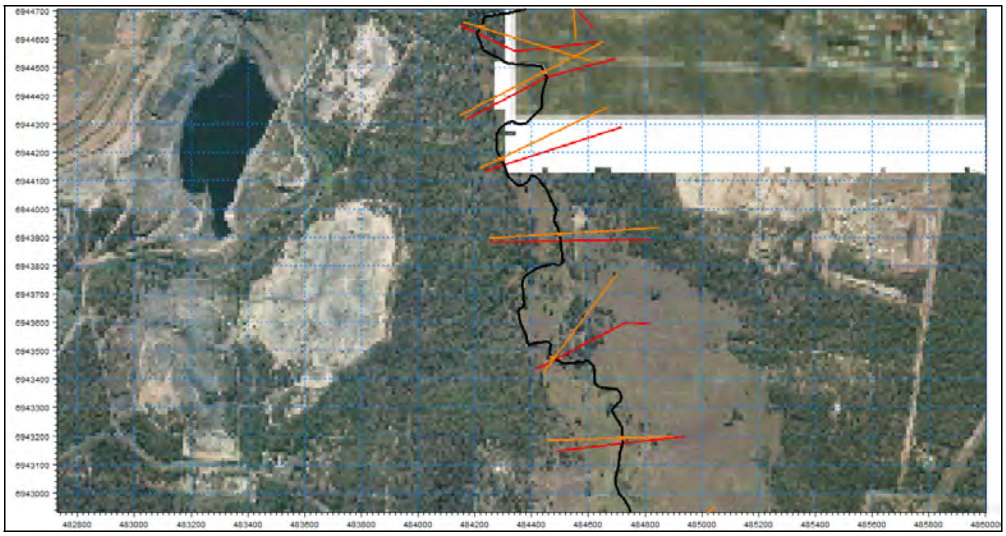


Figure 4-2: Six Mile Creek from the updated model after reversal (model shown in orange and survey data in red).

Table 4-1: Summary of cross-sections that have been reversed.

Branch ID	Topo ID	Upstream Chainage	Downstream Chainage
BREM	TOPO-1995	1000000	1028490
DEEB	Topo-1998	10000	19912
GOOD	TOPO-1998	10000	16725
IRON	TOPO-1998	10000	18584
IRON_BR1	TOPO-1998	1000	2491
MIHI	Topo-1998	10000	13121
MIHI_BR1	Topo-1998	1292	2700
PURGA	EXIST	0	22343.56
REEDY	Topo-1998	1000	2139
SAND	2003	10000	23900
SCH	TOPO-1998	10000	13972
SIX	TOPO-1998	9530	20235
SMALL	Topo-1998	1000	2128
WARRILL	EXIST	0	33860.35
WOOG	TOPO-1998	10000	19075

4.2 Low Flow Slots

A number of cross-sections throughout the upper model had been modified with the introduction of an artificial slot. A typical example of a slot on the Warrill branch is presented in Figure 4-3. These slots were adopted as a common technique in the 1990's for maintaining model stability during low flow simulations. This technique is not recommended and often creates more stability issues than are solved.

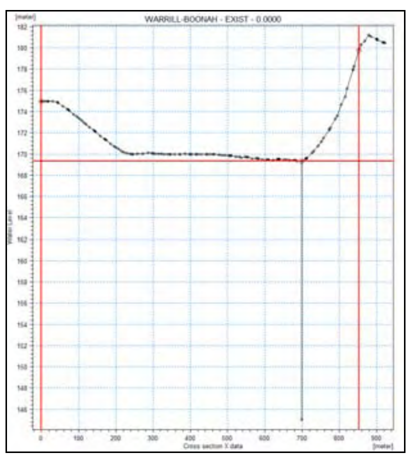


Figure 4-3: Example of a cross-section "slot".

4.3 Hydraulic Radius

The hydraulic radius method selected within MIKE11 is critical for the correct computation of conveyance in cross-sections. MIKE11 offers three alternative methodologies for computing hydraulic radius including:

1. Resistance Radius;
2. Hydraulic Radius , Effective Area; and
3. Hydraulic Radius, Total Area.

The Resistance Radius method has previously been adopted in both the upper and lower models. The Resistance Radius method will overestimate conveyance for flow conditions within bank or marginally over bank because it does not adequately account for the channel side wall friction. In large overbank floods the Resistance Radius is an acceptable solution because the channel conveyance is relatively smaller compared to the over bank floodplain conveyance.

The alternative Hydraulic Radius using the Total Area method is recommended for a general purpose flood model where the full range of flooding conditions are being investigated. In the model update process the cross-section radius types have been updated to the Hydraulic Radius, Total Area method and all processed data recalculated. The update process included an individual review of every model cross-section to ensure that bank markers No 4 (left low flow bank) and No 5 (right low flow bank) were set appropriately.

4.4 Processed Data

The raw cross-section profile data for each cross-section in the model is individually processed to compute a range of depth and width averaged storage and conveyance characteristics in tabular format. These processed data tables form the basis of all numerical computations within the model. It is essential for stability of the model that each conveyance curve is smooth and monotonically increasing in conveyance with increasing flow depth.

Each of the conveyance curves in the processed data tables have been visually reviewed to ensure they are smoothly and monotonically increasing in conveyance. Where the conveyance curves were non-monotonically increasing, the cross-section bank markers in the raw data (Section 4.3) have been updated to ensure a smooth curve is achieved. An example of a non-monotonically increasing conveyance curves without bank markers set is presented in Figure 4-4 and the updated cross section and conveyance curve is presented in Figure 4-5.

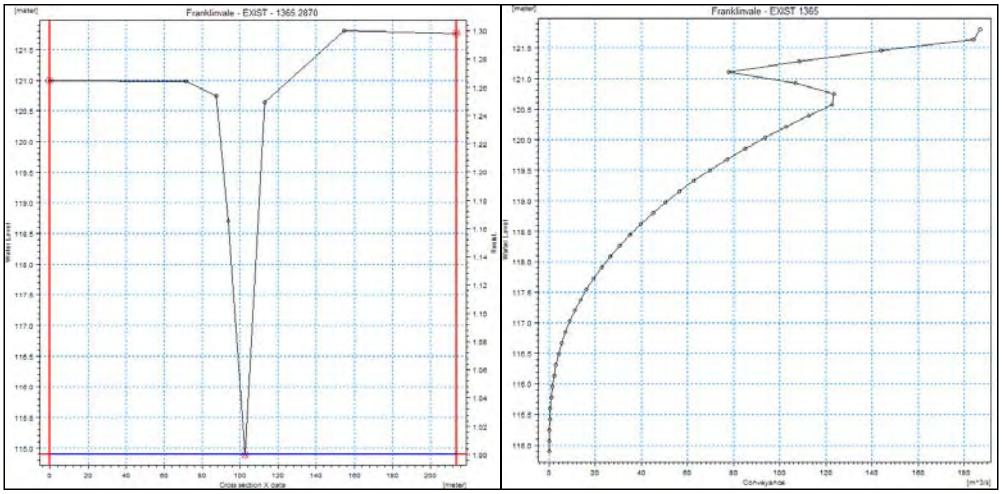


Figure 4-4: Example of a non-monotonically increasing conveyance curve and cross section.

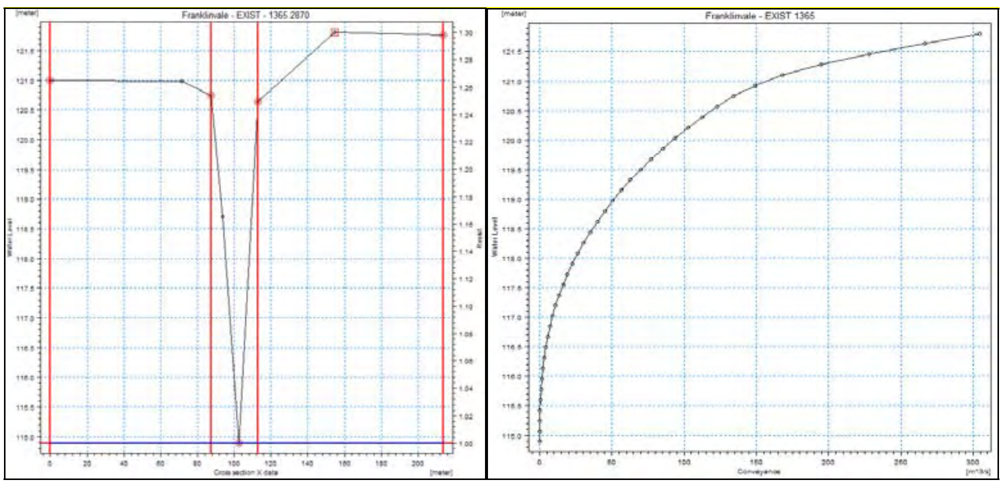


Figure 4-5: Example of an updated monotonically increasing conveyance curve using bank markers.

The default number of processed data values in MIKE11 is 20 points over a reasonable range in water level (5 to 10 meters). The number of processed data points is a user defined setting that should be adjusted to ensure that the conveyance characteristics of the curve are represented smoothly and accurately.

The number of processed data points was reviewed and in some cases there were excessively large numbers of processed data points (up to 100 points). The large number of points is not necessary for developing an accurate and stable model. However they will significantly increase the data-base size and memory requirements for the model during simulation. The number of processed data points have therefore been adjusted to achieve a more reasonable representation of the conveyance curves with a vertical spacing of approximately 0.5m between points.

5 MODEL MERGE

The merging of the three MIKE11 model described in Section 2 was completed using the "pfsmerge.exe" utility program that is provided with every MIKE11 installation.

The merging of the models was completed by combining the network layouts and the cross-section data bases into a single set of model files. The combined upper and lower model branch layout in MIKE11 is presented in Figure 5-1. All model roughness values stored in the parameter file were also combined.

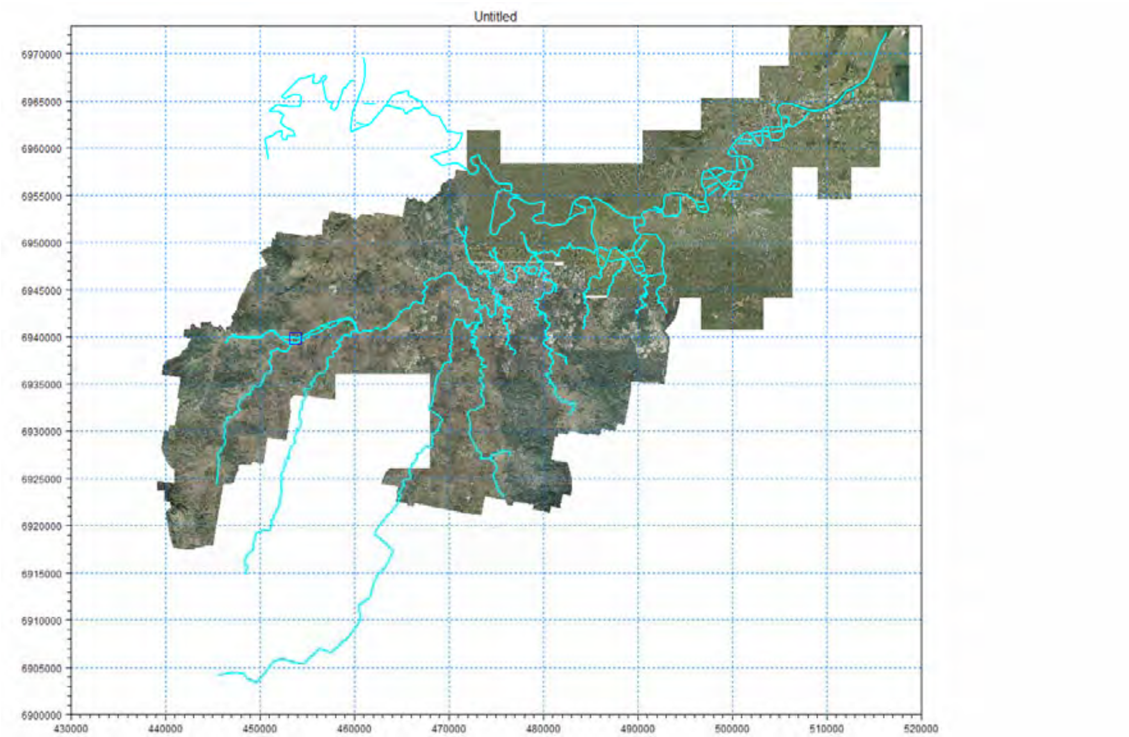


Figure 5-1 Combined upper and Lower Ipswich Rivers MIKE Models

The merging of the three models was complicated by the overlap of the upper and lower models in the areas around the Amberly Airbase as shown in Figure 5-2 and Figure 5-3. The lower model overlapped with the upper model for the part of the Bremer River, Warrill Creek and Purga Creek branches. The upper model in the areas of overlap was more detailed and was therefore adopted in these areas. The duplicated branch sections in the lower model areas were deleted from the merged model.

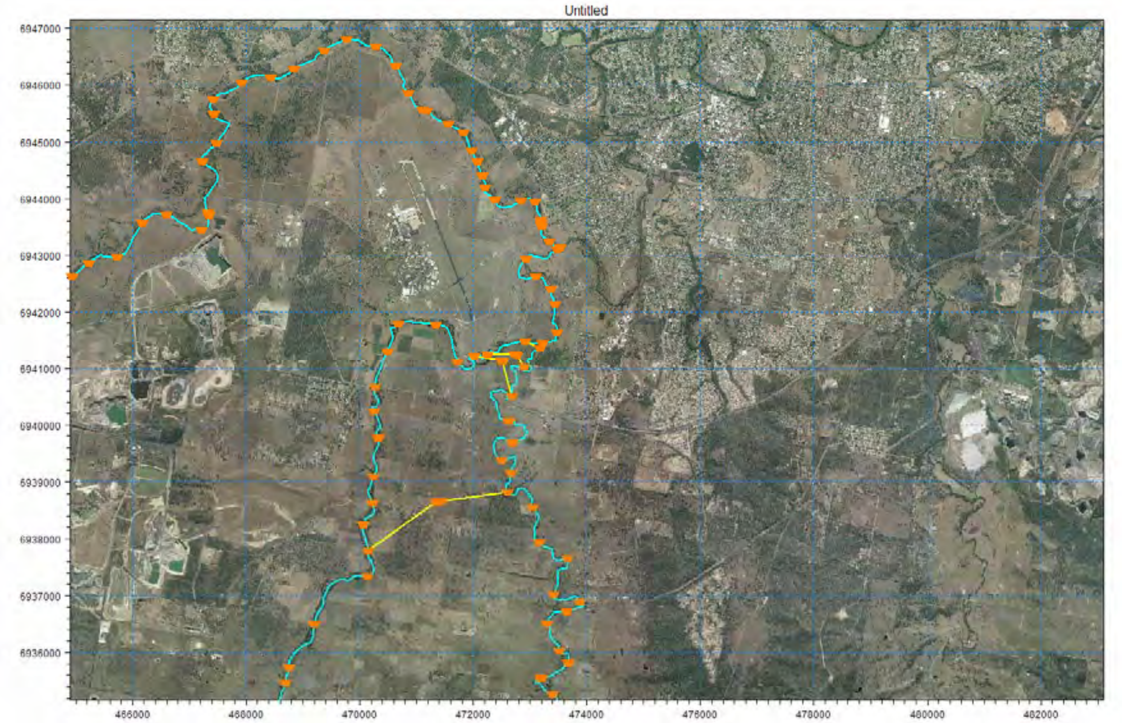


Figure 5-2 Upper model branch layout - Amberly Airbase.

Figure 5-3 Lower model branch layout - Amberly Airbase.

5.1 Boundary Conditions

The development of a common set of model boundary conditions for the merged model was required to allow the model to run effectively.

The upper model provided by ICC included a number of alternative boundary condition files. The boundaries included a range of durations from 3 hours up to 48 hours for the 100 year ARI design event.

The lower model provided by BCC from the Wivenhoe Alliance contained only one set of boundary conditions for an event of unknown magnitude. An analysis of the flow hydrographs indicates that the event is likely to be much larger than the 100 year ARI event. It was therefore not appropriate to apply this event in conjunction with the upper model flows.

An alternative set of boundary conditions for the lower model were developed as part of the original SKM flood study for the Brisbane River (*Ref 1*). These boundary conditions were adopted for the merged model in order to provide the basis for a comparison of results between the original calibrated model and the updated merged model.

The boundary conditions for the merged model were adopted for the 1974, 1983 and 1989 calibration flood events. These boundary conditions included large inflows for the Bremer and Brisbane Rivers which were represented as open boundaries in the SKM flood study. These flows were converted to local source points at the equivalent chainage in the merged model.

A number of the boundary conditions in the SKM flood study were small "baseflow" conditions which were applied to the open ended model branches to allow the model to run at low flows. These baseflow conditions were removed and replaced with the following "Constant" flow conditions listed in Table 5-1.

Table 5-1: Constant base flow boundary conditions for merged model.

Branch Boundary	Chainage (m)	Discharge (m^3/s)
BNE	928920	1.0
Bremer-BoonahNew	9869	1.0
Franklinvale	0	1.0
GOOD	10000	1.0
HWAY LEFT	0	0.2
LOCKYER	0	1.0
MIHI	11310	1.0
Purga	0	1.0
Purga_2	42	1.0
SAND	10000	1.0
SCH	10000	0.1
SIX	9530	0.2
Warrill-Boonah	0	1.0
Western	0	1.0

6 NUMERICAL PARAMETERS

The following numerical parameters were reviewed:

- Default Values
- Initial Conditions
- Roughness Values

6.1 Default Values

The default values were unchanged with the exception of the "Delta" parameter and the "NoIter" (Number of Iterations). The "Delta" value controls the centring of the numerical scheme and can be varied in the range of 0.5 for a "fully centred" scheme to 1.0 for a "fully forward" scheme. The "Delta" value has a varying level of influence on the model simulation that reduces as the model time step is decreased.

The upper and lower models had been previously run with a "Delta" of 0.7 which is partially forward and was probably set at this level in order to improve the model stability. In contrast the "NoIter" parameter was increased from the default value of 1 to a value of 2 which produces an additional iteration producing the opposite affect of centring the scheme.

An increase to the "Delta" value introduces a dissipative influence on the model results and can help to stabilise a model. The setting is particularly important if tidal waves are to be correctly propagated within the model. A dissipative influence in the numerical scheme will dampen the tidal waves and adversely affect the model results in tidal areas and where the flow depths become significant.

The "Delta" setting was returned to a more neutral setting of 0.55.

The "NoIter" value was set to a value of 1 representing a single iteration of the model scheme. The previous setting of 2 would introduce a second iteration to the model and double the model simulation times. A value of 2 is not considered necessary for a standard flood model application.

6.2 Initial Conditions

The model previously operated from a hot-start file that was used to generate an initial stable water surface profile. The hot-start initial conditions have been replaced by a set of detailed initial conditions in the parameter file for the updated model.

This will improve the flexibility of applying the model in future applications as it will allow the model to be modified without the need to update the hot-start file in each case.

The initial conditions consist of a small depth of water specified in the main model branches where initial stability was not well maintained. These small depths will contribute to an initial flushing flow out of the system over several hours. The flows are small however care must be taken when interpreting results to ensure that the initial flushing flow does not adversely influence the model results

6.3 Roughness Conditions

A range of model roughness conditions have been previously developed for the lower Bremer and Brisbane River MIKE11 model. The SKM (*Ref-1*) calibration utilised one set of roughness values for the 1974 event and an alternative set for the smaller flood events of 1983, 89, 91 and 96 events.

The model roughness conditions for the original SKM calibration model of the lower Bremer have been previously adjusted by KBR in a recalibration study for the lower Bremer system (*Ref 3*). This adjustment was a general reduction in the roughness values for the Bremer River channel in conjunction with a change in the hydraulic radius type used in the model.

An alternative set of model roughness conditions, for the Brisbane and lower Bremer River model, were contained in the MIKE11 model setup obtained from the Wivenhoe Alliance MIKE11 model (*Ref 4*).

The roughness values for the lower Bremer and Brisbane River model branches were adopted by merging the SKM model roughness values (*Ref 1*) for the various calibration events with the KBR (*Ref 2*) adjusted values. These roughness conditions were then applied to the various calibration events in accordance with the SKM model.

A summary of the roughness conditions applied for each of the model studies *(Ref 1-4)* is provided in Appendix C.

7 SIMULATION TIME STEP

The model simulation time step was previously set at 2 seconds for the upper model and 15 seconds for the Brisbane River and lower Ipswich Rivers model. This is unreasonably low for the typical flow conditions that occur within the model. Such low time steps are typically set to ensure stability in areas of steep channel slopes or in areas where the schematisation is not well defined.

The majority of model schematisation issues which may have previously limited the model time step were improved as part of the work carried out in this study. A small number of channel reaches within the model contained particularly steep channel slopes which were still limiting the model time step. These steep branches were generally in the upper reaches of the local creek systems in Ipswich and the upper reaches of upper model.

The steep reaches were removed from the model with the aim of improving the overall performance of the model run time. If it is necessary to provide models for these areas then it would be more appropriate to build separate small models for these specific areas and run them at low time steps.

The following model branches were changed as described:

- The upper 10km of the branch BremerBoonahNew has been cut from the model. The boundary condition at chainage 0 m has been moved to chainage 9869 m.
- The branch IRON_BR1 was removed from the model
- The upper 1.3 km of the branch MIHI was cut from the model. The upper boundary conditions previously applied at chainage 10000 m were moved to chainage 11310 m.

The model time step has been increased to 30 seconds which provides a reasonable compromise between model stability and simulation time. A model time step of 1 minute can be used if a greater initial water depth is applied as initial conditions. These greater depths are not appropriate for the simulation of small floods, which limits the models versatility. Consequently a model time step of 30 seconds is recommended for general applications.

8 COMPARISON OF MODEL RESULTS

A comparison of the model results for the three calibration events (1974, 1983 and 1989) was completed. The comparison of model results was based on model results files provided by ICC for the original SKM flood study (*Ref 1*) and the boundary conditions from this study applied to the current model as described in Section 5.

The comparison of results was based on maximum water levels for each of the main branches in the lower Ipswich and Brisbane River model. The results are presented in Appendix A.

The model comparison shows a general increase in water levels for the smaller flow events of 1983 and 1989. These events are dominated by in channel conveyance which has been modified in this study through the adoption of the Hydraulic Radius, Total Area method. The levels in the Bremer River have increased significantly for these smaller events. This contrasts with flood levels in the larger 1974 event which have been lowered substantially in the Bremer River.

In some cases there are significant changes in water levels in the Bremer River. These differences arise from changes in the model which have removed instabilities and errors in flow calculations associated with the schematisation.

The model comparison in this study has not considered the accuracy of the original model calibration but simply compared the updated model to the adopted study results.

9 RECOMMENDATIONS

The Brisbane Basin Model developed in this study, through the merging of the upper Ipswich Rivers model with the lower Brisbane River model, is consistent with the model schematisation that was originally adopted. The intention of this study was to update and upgrade the previous models into a single model that could be more efficiently used in hydraulic studies with greater model stability. This updating has required substantial modification in many areas of the basin model in order to improve stability and correct errors and inconsistencies in model inputs.

The model updating has resulted in some significant changes in calibration water level predictions when compared against previous model calibration results from the SKM study *(Ref-1)*. We have not attempted to review the accuracy of the previous calibrations but have simply compared the relative changes from the previous model results. These water level changes are significant (over 1 meter change) in some areas and introduce a high degree of uncertainty to the model results.

We also note that the previous model calibrations were based on alternative roughness parameter sets for the various calibration events which vary significantly for small and large flood events. It is unlikely that the channel roughness would vary substantially within large river systems such as the Brisbane and Bremer Rivers. We believe that there is an underlying problem with the model schematisation of the flood plain storage and has required the development of alternative roughness parameter sets in order to achieve calibration.

The schematisation of both the upper Ipswich Rivers model and the lower Brisbane River model do not adequately account for floodplain storage within the Ipswich Rivers areas and to a lesser degree within the Brisbane River area. There is likely to be an overestimation of floodplain storage in the model which will affect the models ability to accurately predict larger flood events.

We recommend that the model be re-developed with an alternative schematisation technique which incorporates separate floodplain model branches for all flood plain flows within the system.

We recommend that the model be recalibrated to the historical flood events. The calibration should be based upon one unique set of roughness values that are suitable for both large and small flood events.

We also recommend that a sensitivity analysis be carried out as part of the recalibration in order to test the level of uncertainty that exists within the model parameter sets adopted.

A number of specific recommendations have been made in relation to issues that were found in the upper Ipswich Rivers model areas and the lower Brisbane River model. These recommendations are detailed in the following sections.

9.1 Lower Ipswich Rivers Area

The following specific recommendations are made in relation to the Lower Ipswich Rivers area:

- The WOOG branch is very poorly schematised and should be re-modelled and calibrated.
- The lower part or Sandy Creek Branch from Chainage 15620 to 23900 is not fully developed and should be re-modelled and calibrated. This branch actually falls outside the ICC local government area and may not be necessary for ICC purposes.
- A general smoothing of a number of culvert Depth Width tables was required to ensure stability was maintained. These tables contained non-monotonically increasing conveyance curves and are actually bridge structures. We recommend that they be replaced by MIKE11 Bridge structures if any future calibration of the model is carried out. The following structures were smoothed:

    - BNE 1037110
    - BNE 979510
    - BNE 1052626
    - BNE 944135
    - BUND 31990
    - DEEB 17072
    - WOOG 17340

9.2 Upper Ipswich Rivers Area

The schematisation of the *Rail North* and *Rail South* and *Western* branches is inappropriate particularly for the smaller events. The model should be completely re-built in this area and will require additional cross-section information of survey. The schematisation has been improved as part of the model updating but we recommend that the model be revised if specific focus on flooding in this area is required.

10 REFERENCES

/1/ Sinclair Knight Merz, 2003 Final (18-Dec-2003) *Brisbane River Flood Study: Recalibration of the MIKE11 hydraulic model and determination of the 1 in 100 AEP flood levels.* Brisbane City Council.

/2/ Halliburton KBR Pty Ltd, (27th September 2002); *Ipswich Rivers Flood Studies; Phase 3 Final Report*, Ipswich City Council.

/3/ Halliburton KBR Pty Ltd, (8 May 2002); *Ipswich Rivers Flood Studies; Lower Bremer River Flooding Report*, Ipswich City Council.

/4/ Wivenhoe Alliance, (1 December 2005), Dam Failure Analysis of Wivenhoe Dam, Q1091

/5/ DHI Water and Environment, (August 2004); *MIKE11 A Modelling System for Rivers Channels, Reference Manual.*

APPENDIX A

Comparison with Calibration Model Results.

Comparison of Updated Basin Model to SKM Flood Study Results (2000) Diffference in Maximum Water Levels (m)			
Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
BNE 964170	0.50	0.40	0.60
BNE 966610	0.51	0.55	0.77
BNE 967410	0.52	0.55	0.77
BNE 969790	0.77	0.60	0.81
BNE 971160	0.84	0.62	0.83
BNE 972260	0.87	0.62	0.82
BNE 973260	0.84	0.58	0.78
BNE 973260	0.84	0.58	0.78
BNE 974580	0.88	0.59	0.79
BNE 976020	0.32	0.27	0.50
BNE 976750	0.18	0.20	0.41
BNE 978280	-0.08	0.08	0.26
BNE 979507	0.04	0.11	0.28
BNE 979513	0.11	0.13	0.30
BNE 979530	0.03	0.13	0.30
BNE 980330	0.03	0.16	0.36
BNE 981660	0.02	0.18	0.37
BNE 982460	0.00	0.19	0.38
BNE 984160	-0.06	0.17	0.34
BNE 985260	-0.07	0.19	0.36
BNE 985260	-0.07	0.19	0.36
BNE 986480	-0.01	0.22	0.38
BNE 987960	-0.09	0.25	0.40
BNE 988160	-0.07	0.21	0.34
BNE 988170	-0.05	0.23	0.37
BNE 988360	-0.11	0.22	0.36
BNE 989700	-0.19	0.21	0.36
BNE 990700	-0.22	0.19	0.33
BNE 990760	-0.22	0.19	0.33
BNE 991710	-0.30	0.14	0.28
BNE 992420	-0.30	0.14	0.28
BNE 992450	-0.25	0.16	0.29
BNE 992470	-0.22	0.15	0.30
BNE 992670	-0.24	0.16	0.31
BNE 993760	-0.21	0.19	0.33
BNE 994760	-0.29	0.23	0.38
BNE 994760	-0.29	0.23	0.38
BNE 995690	-0.28	0.27	0.42
BNE 996980	-0.31	0.34	0.46
BNE 996980	-0.31	0.34	0.46
BNE 998460	-0.41	0.27	0.38
BNE 998460	-0.41	0.27	0.38
BNE 999160	-0.55	0.15	0.27
BNE 1000000	-0.55	0.05	0.18
BNE 1000285	-0.55	-0.01	0.18
BNE 1000285	-0.55	-0.01	0.18
BNE 1000775	-0.48	-0.09	0.18
BNE 1001315	-0.51	-0.19	0.20
BNE 1001315	-0.51	-0.19	0.20
BNE 1001865	-0.48	-0.25	0.20
BNE 1002350	-0.51	-0.23	0.21
BNE 1002785	-0.60	-0.23	0.20
BNE 1003275	-0.51	-0.22	0.20
BNE 1003775	-0.46	-0.20	0.20
BNE 1004300	-0.34	-0.19	0.20
BNE 1004810	-0.46	-0.19	0.11
BNE 1005325	-0.44	-0.18	-0.01
BNE 1005325	-0.44	-0.18	-0.01
BNE 1005870	-0.34	-0.17	-0.12
BNE 1005870	-0.34	-0.17	-0.12
BNE 1006300	-0.48	-0.18	-0.13
BNE 1006300	-0.48	-0.18	-0.13
BNE 1006910	-0.46	-0.17	-0.11
BNE 1007410	-0.52	-0.17	-0.10
BNE 1007920	-0.46	-0.15	-0.07
BNE 1008195	--	--	--
BNE 1008195	--	--	--
BNE 1008445	-0.51	-0.16	-0.07
BNE 1008925	-0.52	-0.15	-0.06
BNE 1008925	-0.52	-0.15	-0.06
BNE 1009400	-0.49	-0.15	-0.06
BNE 1009720	-0.50	-0.15	-0.05
BNE 1009720	-0.50	-0.15	-0.05
BNE 1010490	-0.46	-0.14	-0.03
BNE 1010725	-0.51	-0.15	-0.03
BNE 1010980	-0.44	-0.14	-0.03
BNE 1011510	-0.47	-0.14	-0.02
BNE 1011510	-0.47	-0.14	-0.02
BNE 1011980	-0.47	-0.14	-0.01
BNE 1012475	-0.50	-0.13	0.00
BNE 1012475	-0.50	-0.13	0.00
BNE 1012935	-0.49	-0.14	0.00
BNE 1013445	-0.51	-0.14	0.01
BNE 1013680	-0.50	-0.11	0.03
BNE 1013680	-0.50	-0.11	0.03
BNE 1013910	-0.50	-0.10	0.05
BNE 1014310	-0.51	-0.10	0.05
BNE 1014610	-0.50	-0.10	0.06
BNE 1014610	-0.50	-0.10	0.06
BNE 1015090	-0.52	-0.14	0.04
BNE 1015560	-0.51	-0.14	0.04
BNE 1015850	-0.48	-0.14	0.05
BNE 1015850	-0.48	-0.14	0.05
BNE 1016140	-0.46	-0.14	0.05
BNE 1016640	-0.46	-0.12	0.08
BNE 1016640	-0.46	-0.12	0.08
BNE 1017130	-0.39	-0.11	0.11
BNE 1017130	-0.39	-0.11	0.11
BNE 1017610	-0.47	-0.14	0.11
BNE 1017610	-0.47	-0.14	0.11
BNE 1017920	-0.44	-0.14	0.12
BNE 1018200	-0.47	-0.15	0.12
BNE 1018725	-0.46	-0.14	0.12
BNE 1019095	-0.43	-0.14	0.12
BNE 1019490	-0.42	-0.13	0.12
BNE 1019490	-0.42	-0.13	0.12
BNE 1019865	-0.35	-0.14	0.11
BNE 1020115	-0.48	-0.14	0.11
BNE 1020525	-0.54	-0.15	0.11
BNE 1020525	-0.54	-0.15	0.11
BNE 1020830	-0.50	-0.15	0.11
BNE 1021095	-0.48	-0.14	0.11
BNE 1021539	-0.39	-0.14	0.11
BNE 1021715	-0.47	-0.15	0.10
BNE 1021895	-0.49	-0.15	0.10

Comparison of Updated Basin Model to SKM Flood Study Results (2000) Diffference in Maximum Water Levels (m)			
Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
BREM 1000000	-1.27	0.76	0.88
BREM 1000700	-1.06	0.78	0.79
BREM 1001120	-1.01	0.79	0.80
BREM 1001700	-0.92	0.76	0.86
BREM 1002300	-0.63	0.76	0.86
BREM 1002700	-0.39	0.77	0.88
BREM 1003200	-0.18	0.79	0.90
BREM 1003200	-0.18	0.79	0.90
BREM 1003700	-0.08	0.82	0.94
BREM 1003840	-0.05	0.84	0.97
BREM 1003840	-0.05	0.84	0.97
BREM 1004150	-0.03	0.86	1.01
BREM 1004320	0.00	0.91	1.06
BREM 1004320	0.00	0.91	1.06
BREM 1004590	0.05	0.99	1.13
BREM 1004590	0.05	0.99	1.13
BREM 1004610	-1.83	0.56	0.77
BREM 1004700	-1.77	0.55	0.80
BREM 1005140	-1.72	0.60	0.77
BREM 1005520	-1.56	0.67	0.82
BREM 1005740	-1.58	0.66	0.82
BREM 1006090	-1.47	0.70	0.82
BREM 1006250	-1.50	0.59	0.76
BREM 1006490	-1.46	0.67	0.82
BREM 1006510	-1.43	0.69	0.82
BREM 1006780	-1.46	0.68	0.84
BREM 1007440	-1.30	0.95	1.07
BREM 1007700	-1.35	0.92	1.04
BREM 1008000	-1.18	0.99	1.09
BREM 1008000	-1.18	0.99	1.09
BREM 1008390	-1.13	0.98	1.14
BREM 1008410	-1.09	0.95	1.11
BREM 1008420	-1.05	0.98	1.12
BREM 1008660	-0.96	1.05	1.15
BREM 1009210	-0.75	1.07	1.12
BREM 1009675	-0.63	1.07	1.11
BREM 1009675	-0.63	1.07	1.11
BREM 1009856	--	--	--
BREM 1009856	--	--	--
BREM 1010020	-0.52	1.17	1.15
BREM 1010280	-0.47	1.14	1.09
BREM 1010700	-0.41	1.15	1.10
BREM 1010890	-0.36	1.19	1.11
BREM 1011320	-0.32	1.21	1.12
BREM 1011700	-0.27	1.29	1.14
BREM 1011790	-0.27	1.27	1.14
BREM 1011810	-0.19	1.26	1.11
BREM 1012050	-0.18	1.21	1.08
BREM 1012070	-0.19	1.31	1.15
BREM 1012200	-0.18	1.37	1.18
BREM 1012870	-0.19	1.35	1.18
BREM 1013380	-0.19	1.41	1.22
BREM 1013700	-0.18	1.43	1.24
BREM 1014220	-0.18	1.51	1.28
BREM 1014640	-0.17	1.53	1.30
BREM 1015180	-0.18	1.59	1.33
BREM 1015445	-0.18	1.59	1.34
BREM 1015445	-0.18	1.59	1.34
BREM 1015710	-0.18	1.59	1.35
BREM 1016110	-0.18	1.62	1.36
BREM 1016110	-0.18	1.62	1.36
BREM 1016510	-0.18	1.66	1.38
BREM 1017080	-0.18	1.69	1.40
BREM 1017750	-0.18	1.73	1.42
BREM 1018140	-0.18	1.78	1.46
BREM 1018320	-0.18	1.78	1.45
BREM 1018320	-0.18	1.78	1.45
BREM 1018500	-0.18	1.78	1.45
BREM 1018630	-0.18	1.81	1.46
BREM 1018630	-0.18	1.81	1.46
BREM 1018760	-0.18	1.83	1.47
BREM 1019150	-0.18	1.81	1.48
BREM 1019580	-0.18	1.87	1.50
BREM 1020000	-0.18	1.86	1.48
BREM 1020000	-0.18	1.86	1.48
BREM 1020450	-0.17	1.77	1.43
BREM 1020450	-0.17	1.77	1.43
BREM 1020600	--	--	--
BREM 1020600	--	--	--
BREM 1020920	-0.16	1.83	1.46
BREM 1021460	-0.16	1.78	1.37
BREM 1022300	-0.15	1.71	1.27
BREM 1022950	-0.14	1.58	1.15
BREM 1023490	-0.14	1.52	1.06
BREM 1023510	-0.37	1.70	1.17
BREM 1023870	-0.37	1.62	1.11
BREM 1024220	-0.36	1.59	1.06
BREM 1024520	-0.36	1.52	0.99
BREM 1024750	-0.35	1.47	0.94
BREM 1025300	-0.35	1.38	0.85
BREM 1025670	-0.34	1.33	0.77
BREM 1025920	-0.33	1.24	0.68
BREM 1026150	-0.33	1.16	0.62
BREM 1026560	-0.32	1.02	0.52
BREM 1027100	-0.32	0.78	0.35
BREM 1027640	-0.30	0.51	0.17
BREM 1027840	-0.30	0.40	0.10
BREM 1028190	-0.29	0.12	-0.08
BREM 1028190	-0.29	0.12	-0.08
BREM 1028490	-0.29	-0.17	-0.12
BUND 10000	0.07	0.05	0.05
BUND 10307.5	0.20	0.21	0.19
BUND 10615	-0.11	0.73	0.56
BUND 11107.5	-0.66	0.06	-0.01
BUND 11600	-0.08	0.07	0.06
BUND 11968.33	-0.21	-0.18	-0.21
BUND 12336.67	-0.25	-0.36	-0.50
BUND 12705	0.25	-0.06	-0.05
BUND 13165	0.32	0.15	0.18
BUND 13552.5	0.39	0.33	0.36
BUND 13940	0.10	0.13	0.14
BUND 14217.5	-0.47	-0.16	-0.13
BUND 14495	0.77	0.38	0.45
BUND 14775	0.16	-0.08	0.01

Comparison of Updated Basin Model to SKM Flood Study Results (2000)
Diffference in Maximum Water Levels (m)

Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
BNE 1022105	-0.50	-0.15	0.10
BNE 1022575	-0.43	-0.14	0.10
BNE 1022575	-0.43	-0.14	0.10
BNE 1023040	-0.41	-0.14	0.09
BNE 1023570	-0.47	-0.14	0.09
BNE 1024080	-0.39	-0.15	0.08
BNE 1024080	-0.39	-0.15	0.08
BNE 1024563	-0.48	-0.15	0.08
BNE 1024563	-0.48	-0.15	0.08
BNE 1025070	-0.42	-0.14	0.08
BNE 1025360	-0.44	-0.14	0.08
BNE 1025590	-0.23	-0.14	0.08
BNE 1025590	-0.23	-0.14	0.08
BNE 1026170	-0.25	-0.14	0.08
BNE 1026680	-0.36	-0.14	0.07
BNE 1026900	-0.32	-0.14	0.07
BNE 1027160	-0.28	-0.14	0.07
BNE 1027680	-0.33	-0.14	0.07
BNE 1028180	-0.41	-0.14	0.07
BNE 1028680	-0.29	-0.14	0.07
BNE 1028680	-0.29	-0.14	0.07
BNE 1028760	-0.63	-0.18	0.08
BNE 1029200	-0.57	-0.17	0.08
BNE 1029680	-0.60	-0.18	0.07
BNE 1030220	-0.60	-0.18	0.07
BNE 1030220	-0.60	-0.18	0.07
BNE 1030870	-0.62	-0.18	0.06
BNE 1030870	-0.62	-0.18	0.06
BNE 1031260	-0.59	-0.17	0.06
BNE 1031700	-0.53	-0.17	0.06
BNE 1031995	-0.58	-0.17	0.06
BNE 1032230	-0.61	-0.17	0.05
BNE 1032585	-0.57	-0.17	0.05
BNE 1033080	-0.54	-0.18	0.05
BNE 1033080	-0.54	-0.18	0.05
BNE 1033370	-0.49	-0.17	0.05
BNE 1033370	-0.49	-0.17	0.05
BNE 1033900	-0.41	-0.17	0.05
BNE 1033900	-0.41	-0.17	0.05
BNE 1034370	-0.43	-0.17	0.04
BNE 1034890	-0.39	-0.17	0.04
BNE 1034890	-0.39	-0.17	0.04
BNE 1035414	-0.50	-0.17	0.04
BNE 1035900	-0.48	-0.17	0.04
BNE 1035900	-0.48	-0.17	0.04
BNE 1036460	-0.51	-0.17	0.03
BNE 1036770	-0.53	-0.17	0.03
BNE 1036915	-0.49	-0.17	0.03
BNE 1037090	-0.52	-0.17	0.03
BNE 1037175	-0.19	-0.08	0.05
BNE 1037175	-0.19	-0.08	0.05
BNE 1037285	-0.19	-0.07	0.05
BNE 1037625	-0.10	-0.07	0.05
BNE 1038085	-0.22	-0.08	0.05
BNE 1038085	-0.22	-0.08	0.05
BNE 1038600	-0.20	-0.08	0.05
BNE 1038600	-0.20	-0.08	0.05
BNE 1039100	-0.20	-0.07	0.05
BNE 1039100	-0.20	-0.07	0.05
BNE 1039200	-0.20	-0.06	0.05
BNE 1039200	-0.20	-0.06	0.05
BNE 1039565	-0.21	-0.07	0.04
BNE 1039670	-0.20	-0.07	0.05
BNE 1039670	-0.20	-0.07	0.05
BNE 1040090	-0.18	-0.07	0.04
BNE 1040090	-0.18	-0.07	0.04
BNE 1040250	-0.15	-0.07	0.04
BNE 1040250	-0.15	-0.07	0.04
BNE 1040490	-0.12	-0.06	0.04
BNE 1041010	-0.23	-0.06	0.04
BNE 1041230	-0.22	-0.06	0.04
BNE 1041460	-0.19	-0.06	0.04
BNE 1041700	-0.23	-0.07	0.04
BNE 1041700	-0.23	-0.07	0.04
BNE 1041960	-0.20	-0.06	0.04
BNE 1042235	-0.21	-0.06	0.04
BNE 1042500	-0.22	-0.07	0.04
BNE 1042500	-0.22	-0.07	0.04
BNE 1042515	-0.22	-0.07	0.04
BNE 1042910	-0.26	-0.07	0.04
BNE 1043010	-0.26	-0.07	0.04
BNE 1043010	-0.26	-0.07	0.04
BNE 1043080	-0.25	-0.06	0.04
BNE 1043110	-0.26	-0.06	0.04
BNE 1043110	-0.26	-0.06	0.04
BNE 1043725	-0.27	-0.05	0.04
BNE 1044060	-0.20	-0.05	0.04
BNE 1044060	-0.20	-0.05	0.04
BNE 1044340	-0.16	-0.05	0.04
BNE 1044340	-0.16	-0.05	0.04
BNE 1044605	-0.17	-0.05	0.04
BNE 1044860	-0.19	-0.05	0.04
BNE 1045400	-0.15	-0.05	0.04
BNE 1045400	-0.15	-0.05	0.04
BNE 1045885	-0.11	-0.04	0.03
BNE 1046180	-0.17	-0.05	0.03
BNE 1046340	-0.19	-0.05	0.03
BNE 1046580	-0.16	-0.05	0.03
BNE 1046900	-0.15	-0.04	0.03
BNE 1047350	-0.10	-0.03	0.03
BNE 1047915	-0.06	-0.03	0.02
BNE 1047915	-0.06	-0.03	0.02
BNE 1048375	-0.13	-0.04	0.03
BNE 1048375	-0.13	-0.04	0.03
BNE 1048890	-0.13	-0.03	0.02
BNE 1049120	-0.12	-0.03	0.02
BNE 1049370	-0.05	-0.03	0.01
BNE 1049590	-0.07	-0.03	0.01
BNE 1049870	-0.10	-0.03	0.01
BNE 1050430	-0.05	-0.03	0.01
BNE 1050430	-0.05	-0.03	0.01
BNE 1050860	-0.09	-0.03	0.01
BNE 1050860	-0.09	-0.03	0.01
BNE 1051360	-0.01	-0.04	0.01
BNE 1051360	-0.01	-0.04	0.01

Comparison of Updated Basin Model to SKM Flood Study Results (2000)
Diffference in Maximum Water Levels (m)

Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
BUND 15055	0.15	0.08	0.11
BUND 15377.5	0.17	0.12	0.12
BUND 15700	0.14	0.15	0.11
BUND 16047.5	0.25	0.26	0.25
BUND 16395	0.25	0.19	0.22
BUND 16647.5	0.23	0.17	0.19
BUND 16900	0.33	0.16	0.18
BUND 17215	0.28	0.17	0.19
BUND 17530	0.23	0.28	0.27
BUND 17885	0.24	0.05	0.01
BUND 18307.5	0.14	-0.18	-0.43
BUND 18730	-0.03	-0.33	-0.36
BUND 18750	0.03	0.39	0.09
BUND 19015	-0.06	0.19	0.14
BUND 19280	0.13	0.34	0.35
BUND 19540	0.19	0.21	0.20
BUND 19800	0.11	0.19	0.18
BUND 20120	0.11	0.12	0.11
BUND 20440	0.08	0.02	0.03
BUND 20905	-0.01	0.02	-0.02
BUND 21370	-0.01	0.17	0.13
BUND 21745	--	--	--
BUND 22120	-0.24	-0.02	-0.05
BUND 22120	-0.24	-0.02	-0.05
BUND 22452.5	-0.23	-0.16	-0.13
BUND 22785	-0.26	-0.13	-0.13
BUND 23150	-0.27	-0.11	-0.15
BUND 23515	-0.19	-0.13	-0.16
BUND 23822.5	0.01	0.00	-0.01
BUND 24130	0.05	0.10	0.08
BUND 24445	0.11	0.21	0.19
BUND 24760	0.12	0.09	0.07
BUND 25075	-0.05	-0.06	-0.08
BUND 25327.5	-0.08	-0.02	-0.04
BUND 25580	-0.09	0.03	0.02
BUND 25600	-0.09	0.02	0.00
BUND 26070	-0.25	-0.34	-0.36
BUND 26540	0.06	0.24	0.22
BUND 26780	0.06	0.06	0.04
BUND 27280	0.07	0.00	-0.01
BUND 27380	0.07	-0.02	-0.02
BUND 27400	0.12	0.16	0.14
BUND 27655	0.14	0.14	0.13
BUND 27675	0.15	0.15	0.13
BUND 28010	0.19	-0.01	-0.03
BUND 28350	--	--	--
BUND 28350	--	--	--
BUND 28480	0.23	-0.01	-0.04
BUND 28530	-0.38	-0.25	-0.25
BUND 28560	-0.54	-0.39	-0.39
BUND 28630	--	--	--
BUND 28630	--	--	--
BUND 28935	--	--	--
BUND 29240	0.06	0.01	-0.04
BUND 29550	0.07	0.13	0.09
BUND 29910	0.19	0.45	0.41
BUND 30215	0.25	0.25	0.14
BUND 30520	0.21	0.21	0.12
BUND 30940	0.18	0.19	0.13
BUND 31360	0.19	0.16	0.12
BUND 31630	0.18	0.16	0.15
BUND 31980	0.15	0.12	0.15
BUND 32000	0.21	0.19	0.13
BUND 32150	0.19	0.21	0.15
BUND 32350	0.08	0.17	0.12
BUND 32370	0.14	0.18	0.12
BUND 32675	0.13	0.17	0.11
BUND 32980	0.01	0.18	0.11
BUND 33320	-0.17	0.26	0.19
BUND 33660	-0.17	0.13	0.08
BUND 34000	-0.17	0.15	0.11
BUND 34000	-0.17	0.15	0.11
BUND 34260	-0.17	0.17	0.10
BUND 34305	-0.17	0.16	0.08
BUND 34345	-0.17	0.24	0.17
BUND 34395	-0.17	0.25	0.19
BUND 34760	-0.17	0.25	0.16
BUND 35050	-0.17	0.21	0.08
BUND 35100	-0.17	0.16	-0.09
BUND 35120	-0.17	0.21	-0.07
BUND 35520	-0.17	0.35	0.12
BUND 35540	-0.17	0.36	0.41
BUND 35730	-0.17	0.42	0.41
BUND 36005	-0.17	0.36	0.26
BUND 36025	-0.17	0.40	0.28
BUND 36297.5	-0.17	0.48	0.35
BUND 36570	-0.17	0.53	0.34
BUND 36840	-0.17	0.72	0.10
BUND 37110	-0.17	0.84	-0.10
BUND 37510	--	--	--
BUND 37910	-0.17	1.48	0.39
BUND 37910	-0.17	1.48	0.39
BUND 38280	-0.17	1.59	0.39
BUND 38722.5	-0.17	1.66	0.67
BUND 39165	-0.17	1.71	1.09
BUND 39546.67	-0.17	1.72	1.27
BUND 39928.33	-0.17	1.73	1.33
BUND 40310	-0.17	1.74	1.35
BUND 40670	-0.17	1.75	1.37
BUND 41030	-0.17	1.76	1.41
BUND 41049.04	--	--	--
DEEB 10000	0.51	0.72	0.65
DEEB 10315	0.60	1.02	0.96
DEEB 10588.5	1.04	1.41	1.36
DEEB 10862	0.54	0.97	0.91
DEEB 11141	0.69	1.03	0.97
DEEB 11453	1.17	1.38	1.34
DEEB 11837	1.85	2.42	2.33
DEEB 12111	0.99	1.78	1.66
DEEB 12377	1.27	1.97	1.86
DEEB 12643	1.91	2.59	2.50
DEEB 12927	1.39	1.99	1.90
DEEB 12947	1.44	2.15	2.02
DEEB 13165	1.56	2.27	2.16

Comparison of Updated Basin Model to SKM Flood Study Results (2000) Diffference in Maximum Water Levels (m)			
Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
BNE 1051895	0.04	-0.04	0.01
BNE 1052310	-0.12	-0.06	0.01
BNE 1052390	-0.12	-0.07	0.00
BNE 1052595	-0.16	-0.07	0.00
BNE 1052640	0.05	-0.10	-0.01
BNE 1052865	0.13	-0.10	-0.01
BNE 1052865	0.13	-0.10	-0.01
BNE 1053320	0.13	-0.10	-0.01
BNE 1053385	0.11	-0.09	-0.01
BNE 1053385	0.11	-0.09	-0.01
BNE 1053900	0.12	-0.09	-0.02
BNE 1053900	0.12	-0.09	-0.02
BNE 1054640	0.03	-0.09	-0.01
BNE 1054680	0.04	-0.09	-0.02
BNE 1054970	0.09	-0.08	-0.02
BNE 1055280	0.09	-0.07	-0.02
BNE 1055420	0.10	-0.07	-0.02
BNE 1055960	0.07	-0.06	-0.02
BNE 1055960	0.07	-0.06	-0.02
BNE 1056400	0.10	-0.05	-0.02
BNE 1056400	0.10	-0.05	-0.02
BNE 1056695	0.08	-0.05	-0.02
BNE 1056865	0.01	-0.06	-0.02
BNE 1056950	0.06	-0.06	-0.02
BNE 1057090	0.09	-0.06	-0.02
BNE 1057090	0.09	-0.06	-0.02
BNE 1057530	0.08	-0.06	-0.02
BNE 1057530	0.08	-0.06	-0.02
BNE 1058040	0.10	-0.07	-0.02
BNE 1058040	0.10	-0.07	-0.02
BNE 1058230	0.11	-0.08	-0.02
BNE 1058530	0.22	-0.09	-0.02
BNE 1058735	0.11	-0.10	-0.01
BNE 1059035	0.17	-0.12	-0.01
BNE 1059540	0.09	-0.13	-0.01
BNE 1059990	0.11	-0.13	-0.01
BNE 1060535	0.21	-0.12	-0.01
BNE 1060535	0.21	-0.12	-0.01
BNE 1060845	--	--	--
BNE 1060845	--	--	--
BNE 1061015	0.16	-0.12	-0.01
BNE 1061530	0.11	-0.12	-0.01
BNE 1062020	0.11	-0.12	-0.01
BNE 1062020	0.11	-0.12	-0.01
BNE 1062535	0.09	-0.12	-0.01
BNE 1062940	0.10	-0.12	-0.01
BNE 1063125	0.21	-0.11	-0.01
BNE 1063125	0.21	-0.11	-0.01
BNE 1063310	0.15	-0.11	-0.01
BNE 1063645	0.19	-0.11	-0.01
BNE 1064000	0.17	-0.11	0.00
BNE 1064490	0.16	-0.11	0.00
BNE 1065010	0.14	-0.12	0.00
BNE 1065503	0.13	-0.12	0.00
BNE 1065990	0.11	-0.13	0.00
BNE 1066505	0.14	-0.13	0.00
BNE 1067020	0.12	-0.14	0.00
BNE 1067020	0.12	-0.14	0.00
BNE 1067485	0.12	-0.15	0.00
BNE 1067965	0.12	-0.15	0.01
BNE 1068660	0.07	0.03	0.01
BNE 1069045	0.05	0.07	0.01
BNE 1069535	0.04	-0.03	0.01
BNE 1070025	0.01	-0.10	0.01
BNE 1070530	0.00	-0.09	0.01
BNE 1071040	0.01	-0.09	0.01
BNE 1071520	0.01	-0.10	0.01
BNE 1072015	0.01	-0.10	0.01
BNE 1072020	0.01	-0.10	0.01
BNE 1072020	0.01	-0.10	0.01
BNE 1072515	0.01	-0.13	0.00
BNE 1072995	0.01	-0.14	0.00
BNE 1073485	0.01	-0.15	0.00
BNE 1074000	0.01	-0.16	-0.01
BNE 1074460	0.00	-0.16	-0.02
BNE 1074985	0.00	-0.14	-0.02
BNE 1075480	-0.01	-0.15	-0.02
BNE 1076000	-0.01	-0.15	-0.02
BNE 1076495	-0.01	-0.14	-0.02
BNE 1077010	0.00	-0.14	-0.01
BNE 1077510	0.00	-0.14	0.00
BNE 1078040	0.00	-0.14	0.00
BNE 1078525	0.01	-0.13	0.00
BNE 1078660	0.01	-0.13	0.00
GOOD 10000	0.19	0.18	0.19
GOOD 10275	0.08	0.06	0.04
GOOD 10475	0.16	0.04	0.04
GOOD 10705	0.03	0.08	0.12
GOOD 10925	-0.38	0.36	0.28
GOOD 11335	-0.50	0.00	0.03
GOOD 11625	-0.50	0.01	0.09
GOOD 11945	-0.50	-0.05	0.13
GOOD 12020	-0.50	-0.20	0.08
GOOD 12044	-0.50	0.09	0.10
GOOD 12155	-0.50	0.02	0.08
GOOD 12425	-0.50	0.08	0.09
GOOD 12680	-0.50	0.13	0.18
GOOD 12935	-0.50	0.02	-0.03
GOOD 13275	-0.50	0.02	0.01
GOOD 13475	-0.50	-0.02	-0.03
GOOD 13675	-0.50	0.01	0.13
GOOD 14155	-0.50	0.21	0.20
GOOD 14195	-0.50	0.05	0.06
GOOD 14265	-0.50	0.05	0.09
GOOD 14375	-0.50	0.04	0.08
GOOD 14555	-0.50	0.02	0.03
GOOD 14575	-0.50	0.01	0.01
GOOD 14615	-0.50	0.17	0.16
GOOD 14635	-0.50	0.18	0.26
GOOD 14735	-0.50	0.07	0.35
GOOD 14895	-0.50	0.07	0.07
GOOD 14905	-0.50	0.06	0.06
GOOD 14920	-0.50	0.15	0.07
GOOD 14930	-0.50	0.16	0.07

Comparison of Updated Basin Model to SKM Flood Study Results (2000) Diffference in Maximum Water Levels (m)			
Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Even
DEEB 13295	1.62	2.52	2.39
DEEB 13587	1.40	2.33	2.20
DEEB 13888	1.45	2.56	2.40
DEEB 13922	0.79	1.40	1.30
DEEB 14201	0.09	1.34	1.27
DEEB 14486	-0.03	1.54	1.50
DEEB 14771	-0.03	1.68	1.61
DEEB 14979	-0.03	1.58	1.43
DEEB 15159	-0.03	1.87	1.73
DEEB 15336	-0.03	1.52	1.37
DEEB 15682	-0.03	1.21	1.06
DEEB 15682	-0.03	1.21	1.06
DEEB 15904	-0.03	1.27	1.13
DEEB 16035	-0.03	1.33	1.19
DEEB 16035	-0.03	1.33	1.19
DEEB 16120	--	--	--
DEEB 16215	-0.03	1.41	1.27
DEEB 16215	-0.03	1.41	1.27
DEEB 16303	-0.03	1.39	1.25
DEEB 16340	-0.03	1.45	1.30
DEEB 16609	-0.03	1.54	1.40
DEEB 16635	-0.03	1.51	1.37
DEEB 16635	-0.03	1.51	1.37
DEEB 16854	-0.03	1.08	1.01
DEEB 16960	-0.03	1.04	0.94
DEEB 16960	-0.03	1.04	0.94
DEEB 17064	-0.03	1.06	0.93
DEEB 17064	-0.03	1.06	0.93
DEEB 17080	-0.03	1.09	0.95
DEEB 17317	-0.03	1.22	0.91
DEEB 17609	-0.03	1.32	0.94
DEEB 17697	-0.02	1.34	0.81
DEEB 17697	-0.02	1.34	0.81
DEEB 17717	-0.02	1.35	1.07
DEEB 17902	-0.02	1.36	0.93
DEEB 17927	-0.02	1.37	0.99
DEEB 18337	-0.02	1.38	0.91
DEEB 18357	-0.02	1.38	0.93
DEEB 18478	-0.02	1.38	0.85
DEEB 18502	-0.02	1.39	0.98
DEEB 18670	-0.02	1.39	0.97
DEEB 18670	-0.02	1.39	0.97
DEEB 18795	-0.02	1.39	1.08
DEEB 18936	-0.01	1.39	1.19
DEEB 19112	0.00	1.39	1.19
DEEB 19132	0.00	1.40	1.20
DEEB 19247	0.06	1.40	1.21
DEEB 19247	0.06	1.40	1.21
DEEB 19401	0.04	1.39	1.21
DEEB 19537	0.04	1.39	1.21
DEEB 19607	0.03	1.39	1.21
DEEB 19702	0.03	1.39	1.21
DEEB 19827	0.03	1.39	1.21
DEEB 19847	0.04	1.39	1.21
DEEB 19912	0.04	1.39	1.21
IRON 10000	-0.12	-0.13	-0.12
IRON 10274	-0.09	-0.09	-0.07
IRON 10563	-0.08	-0.06	-0.05
IRON 10725	-0.05	-0.06	-0.06
IRON 11001	0.16	0.04	-0.04
IRON 11422	-0.10	-0.12	-0.13
IRON 11765	-0.01	-0.02	-0.04
IRON 11794	0.00	-0.02	-0.02
IRON 12052	0.03	0.00	0.01
IRON 12335	-0.17	-0.12	-0.11
IRON 12618	0.15	0.13	0.10
IRON 12658	0.14	0.13	0.10
IRON 12962.5	-0.02	-0.04	-0.05
IRON 13267	0.03	0.03	0.02
IRON 13766	0.05	0.05	0.03
IRON 14107	0.03	0.04	0.03
IRON 14456	-0.41	-0.26	-0.26
IRON 14805	-0.24	0.40	0.37
IRON 15139	-1.18	-0.01	-0.01
IRON 15407	-1.18	-0.08	-0.04
IRON 15700	-1.18	0.29	0.45
IRON 15887	-1.18	1.16	0.97
IRON 16198.5	-1.18	0.76	0.60
IRON 16510	-1.18	0.96	0.15
IRON 16827	-1.18	0.98	0.35
IRON 17093	-1.18	0.99	0.19
IRON 17336	-1.18	0.99	0.53
IRON 17628	-1.18	0.98	1.08
IRON 17884	-1.18	0.98	1.08
IRON 18031	-1.18	0.98	1.08
IRON 18156	-1.18	0.98	1.08
IRON 18263	-1.18	0.98	1.08
IRON 18363	-1.18	0.98	1.09
IRON 18384	-1.18	0.99	1.09
IRON 18584	-1.18	0.99	1.09
MIHI 11310	-0.64	0.34	0.12
MIHI 11468	-0.64	1.06	0.05
MIHI 11708	-0.64	1.07	-0.04
MIHI 11968	-0.64	1.07	0.10
MIHI 12094	--	--	--
MIHI 12094	--	--	--
MIHI 12230	-0.64	1.07	0.86
MIHI 12485	-0.64	1.07	1.10
MIHI 12630	-0.64	1.07	1.10
MIHI 12764	-0.64	1.07	1.10
MIHI 12921	-0.64	1.07	1.10
MIHI 13121	--	--	--
SAND 10000	0.05	0.09	0.14
SAND 10320	0.13	0.11	0.13
SAND 10520	0.14	0.20	0.14
SAND 10920	0.08	0.08	0.14
SAND 11040	0.19	0.06	0.07
SAND 11062	0.11	0.08	0.16
SAND 11240	0.07	0.23	0.55
SAND 11518	-0.09	0.02	0.37
SAND 11540	0.13	0.10	0.41
SAND 11760	-0.03	0.02	0.22

Comparison of Updated Basin Model to SKM Flood Study Results (2000)
Diffference in Maximum Water Levels (m)

Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Event
GOOD 14975	-0.50	0.14	0.05
GOOD 15350	-0.50	-0.09	0.05
GOOD 15845	-0.50	-0.13	0.14
GOOD 16175	-0.50	-0.13	-0.01
GOOD 16355	-0.50	-0.13	0.00
GOOD 16525	-0.50	-0.13	0.00
GOOD 16725	-0.50	-0.13	0.00
WOOG 10000	0.55	0.33	0.14
WOOG 10450	0.76	0.48	0.19
WOOG 10930	0.50	0.32	0.19
WOOG 11150	0.25	0.14	0.15
WOOG 11530	0.48	0.42	0.33
WOOG 12030	0.13	0.10	0.12
WOOG 12130	0.08	0.08	0.09
WOOG 12620	0.19	0.17	0.22
WOOG 12930	0.27	0.11	0.15
WOOG 13070	0.06	0.15	0.16
WOOG 13250	-0.15	0.16	0.13
WOOG 13510	-0.32	0.26	0.22
WOOG 13550	-0.42	0.27	0.26
WOOG 13640	-0.48	0.35	0.36
WOOG 13800	-0.50	0.34	0.39
WOOG 13800	-0.50	0.34	0.39
WOOG 13995	--	--	--
WOOG 13995	--	--	--
WOOG 14070	-0.50	0.21	0.26
WOOG 14100	-0.50	0.25	0.25
WOOG 14180	-0.50	0.28	0.26
WOOG 14180	-0.50	0.28	0.26
WOOG 14450	-0.50	0.36	0.30
WOOG 14790	-0.50	0.61	0.75
WOOG 14850	-0.50	0.76	0.91
WOOG 14950	-0.50	0.62	0.98
WOOG 15050	-0.50	0.53	1.00
WOOG 15150	-0.50	0.54	1.29
WOOG 15150	-0.50	0.54	1.29
WOOG 15230	-0.50	0.59	1.41
WOOG 15300	-0.50	0.48	1.18
WOOG 15370	-0.50	0.42	0.30
WOOG 15470	-0.50	0.45	0.34
WOOG 15520	-0.50	0.53	0.38
WOOG 15600	-0.50	0.67	0.41
WOOG 15720	-0.50	0.57	0.43
WOOG 15800	-0.50	0.50	0.36
WOOG 15840	-0.50	0.32	0.37
WOOG 15860	-0.50	0.54	0.31
WOOG 15960	-0.50	0.66	0.39
WOOG 15990	-0.50	0.61	0.38
WOOG 16010	-0.50	0.57	0.41
WOOG 16125	-0.50	0.55	0.51
WOOG 16150	-0.50	0.44	0.47
WOOG 16275	-0.50	0.41	0.44
WOOG 16440	-0.50	0.42	0.35
WOOG 16600	-0.50	0.39	0.28
WOOG 16700	-0.50	0.38	0.28
WOOG 16850	-0.50	0.37	0.27
WOOG 16900	-0.50	0.37	0.26
WOOG 17050	-0.50	0.23	0.15
WOOG 17125	-0.50	0.12	0.12
WOOG 17275	-0.50	0.08	0.03
WOOG 17310	-0.50	0.05	0.01
WOOG 17370	-0.50	0.15	0.08
WOOG 17440	-0.50	0.17	0.19
WOOG 17460	-0.50	0.07	-0.02
WOOG 17500	-0.50	0.09	0.10
WOOG 17550	-0.50	0.09	0.12
WOOG 17580	-0.50	0.09	0.10
WOOG 17600	-0.50	0.08	0.05
WOOG 17615	-0.50	0.06	0.05
WOOG 17750	-0.50	0.03	0.01
WOOG 17760	-0.50	0.07	0.04
WOOG 17780	-0.50	0.13	0.11
WOOG 17950	-0.50	0.23	0.25
WOOG 17960	-0.50	0.23	0.25
WOOG 18250	-0.50	0.14	0.20
WOOG 18250	-0.50	0.14	0.20
WOOG 18500	-0.50	-0.10	0.06
WOOG 18750	-0.50	-0.10	0.06
WOOG 18900	-0.50	-0.10	0.06
WOOG 19075	-0.50	-0.10	0.06

Comparison of Updated Basin Model to SKM Flood Study Results (2000)
Diffference in Maximum Water Levels (m)

Model Reference	1974 Calibration Event	1983 Calibration Event	1989 Calibration Event
SAND 11998	-0.02	0.01	0.10
SAND 12020	0.11	0.11	0.36
SAND 12120	0.03	0.01	0.39
SAND 12440	0.14	0.12	0.31
SAND 12690	0.09	0.12	0.71
SAND 13020	0.38	0.25	0.28
SAND 13320	-0.02	0.01	0.32
SAND 13820	0.12	0.30	0.48
SAND 14220	-0.04	0.37	0.59
SAND 14620	0.17	0.40	0.80
SAND 14700	0.14	0.30	0.71
SAND 14740	0.14	0.29	0.71
SAND 14820	-0.06	0.12	0.49
SAND 15220	--	--	--
SAND 15620	--	--	--
SAND 15620	--	--	--
SAND 15992	--	--	--
SAND 16364	--	--	--
SAND 16721	--	--	--
SAND 17078	--	--	--
SAND 17435	--	--	--
SAND 17873.33	--	--	--
SAND 18311.67	--	--	--
SAND 18750	--	--	--
SAND 19195.71	--	--	--
SAND 19641.43	--	--	--
SAND 20087.14	--	--	--
SAND 20532.86	--	--	--
SAND 20978.57	--	--	--
SAND 21424.29	--	--	--
SAND 21870	--	--	--
SAND 22270	--	--	--
SAND 22670	--	--	--
SAND 23070	--	--	--
SAND 23070	--	--	--
SAND 23340	--	--	--
SAND 23610	--	--	--
SAND 23900	--	--	--
SCH 10000	5.36	1.15	0.70
SCH 10340	3.91	2.85	1.17
SCH 10800	-0.17	1.38	1.17
SCH 10810	-0.17	1.73	1.74
SCH 11110	-0.17	0.73	0.70
SCH 11382.8	-0.17	0.79	0.50
SCH 11610	-0.17	1.02	0.90
SCH 11887	-0.17	1.60	1.36
SCH 11927	-0.17	1.25	1.02
SCH 12167	-0.17	1.21	0.76
SCH 12287	-0.17	1.55	0.82
SCH 12435	-0.17	1.84	0.75
SCH 12462.8	-0.17	1.80	0.67
SCH 12805.6	-0.17	1.77	0.64
SCH 13060	-0.17	1.76	1.05
SCH 13060	-0.17	1.76	1.05
SCH 13209	-0.17	1.76	1.14
SCH 13598.5	-0.17	1.76	1.42
SCH 13757	-0.17	1.76	1.42
SCH 13757.61	--	--	--
SCH 13757.61	--	--	--
SCH 13972	-0.17	1.76	1.42
SIX 9530	0.08	0.03	0.02
SIX 10060	0.45	0.76	0.98
SIX 10310	0.12	0.02	0.14
SIX 10365	0.12	-0.05	-0.02
SIX 10380	0.13	0.09	0.10
SIX 10460	0.13	0.07	0.08
SIX 10920	0.09	0.05	0.08
SIX 11355	0.42	0.34	0.17
SIX 11570	0.01	0.24	0.31
SIX 11670	-0.10	0.00	0.31
SIX 11770	-0.30	-0.12	0.25
SIX 11800	0.22	0.24	0.32
SIX 11870	0.13	0.13	0.20
SIX 12010	-0.01	0.20	0.20
SIX 12470	0.17	0.07	0.05
SIX 12970	0.08	0.09	0.09
SIX 13620	0.05	-0.02	0.14
SIX 14045	0.25	0.14	0.11
SIX 14470	0.42	0.56	0.55
SIX 14800	0.45	0.59	0.62
SIX 15170	0.48	0.39	0.24
SIX 15570	0.52	0.44	0.28
SIX 15910	0.55	0.46	0.30
SIX 16270	0.60	0.14	-0.06
SIX 16470	0.37	0.16	-0.01
SIX 16720	-0.72	0.09	0.02
SIX 17140	-0.72	0.21	0.06
SIX 17270	-0.72	0.22	0.08
SIX 17530	-0.72	0.27	0.15
SIX 17930	-0.72	0.09	-0.02
SIX 18270	-0.72	0.21	0.13
SIX 18720	-0.72	0.42	0.19
SIX 18970	-0.72	0.45	0.28
SIX 19170	-0.72	-0.19	0.23
SIX 19370	-0.72	-0.19	0.16
SIX 19650	-0.72	-0.19	-0.11
SIX 19790	-0.72	-0.19	-0.11
SIX 19870	-0.72	-0.19	-0.11
SIX 20000	-0.72	-0.19	-0.11
SIX 20140	-0.72	-0.19	-0.11
SIX 20160	-0.72	-0.19	-0.10
SIX 20235	-0.72	-0.19	-0.10

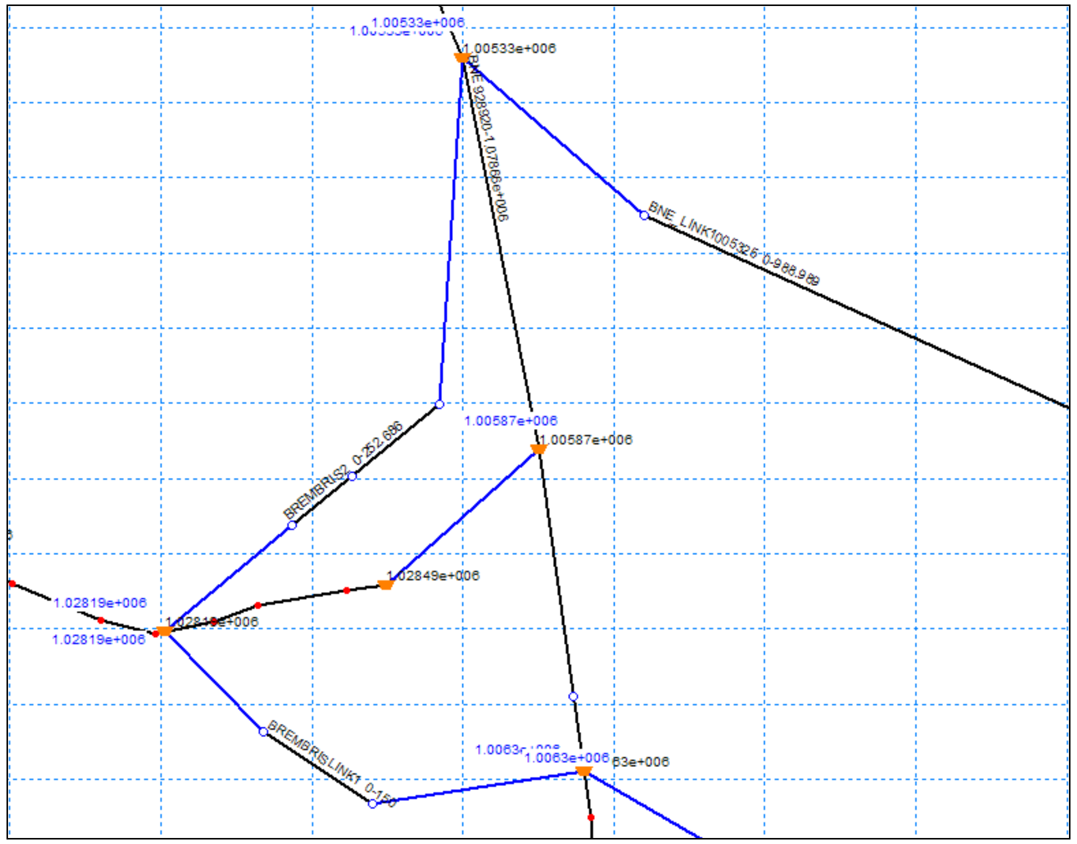
APPENDIX B

Summary of Model Grid Changes.

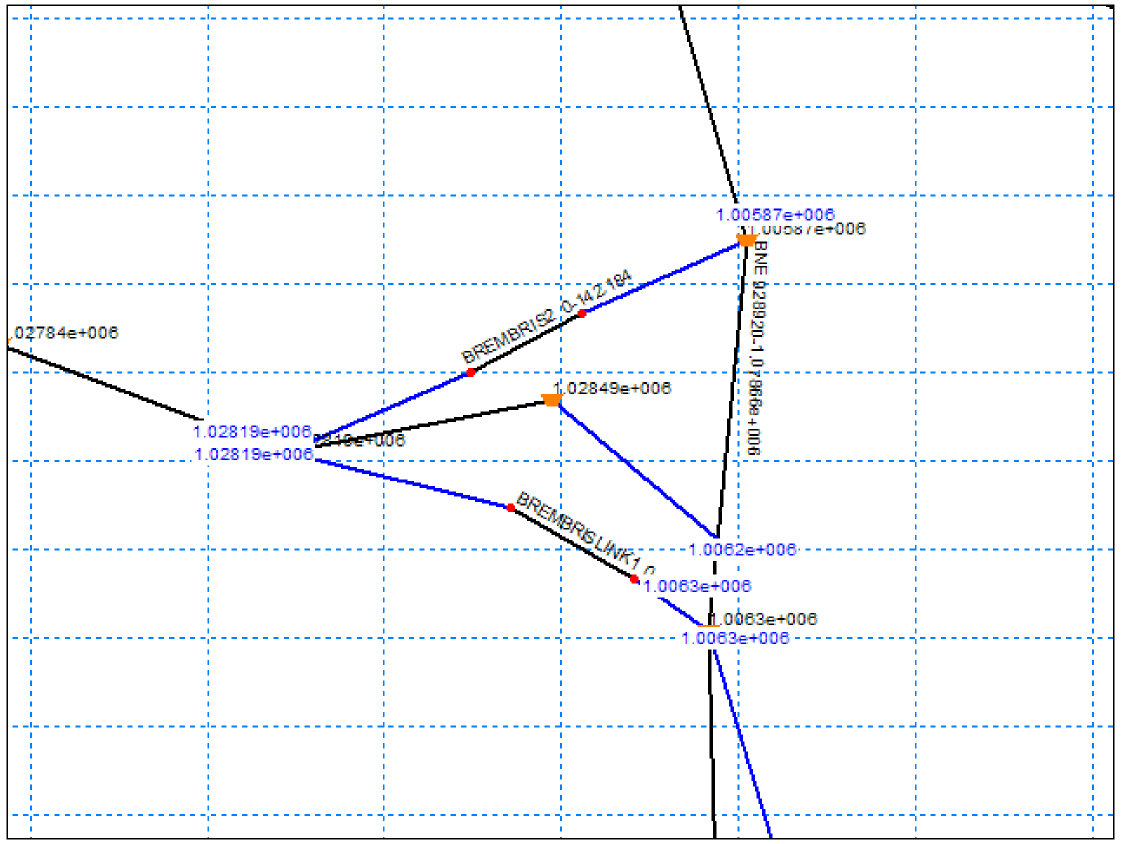
Branchl	Ch (m)	Ch (m)	Figure	Comment
BNE	928920	928920		
BNE	929270	929270		
BNE	929670	929670		
BNE	930070	930070		
BNE	931020	931020		
BNE	931020	931020		
BNE	931570	931570		
BNE	933670	933670		
BNE	933670	933670		
BNE	934270	934270		
BNE	934620	934620		
BNE	934870	934870		
BNE	936070	936070		
BNE	936070	936070		
BNE	936820	936820		
BNE	939770	939770		
BNE	939770	939770		
BNE	942320	942320		
BNE	942320	942320		
BNE	943570	943570		
BNE	944130	944130		
BNE	944150	944150		
BNE	945570	945570		
BNE	946170	946170		
BNE	947170	947170		
BNE	947570	947570		
BNE	948120	948120		
BNE	948120	948120		
BNE	949370	949370		
BNE	950270	950270		
BNE	952320	952320		
BNE	953870	953870		
BNE	954920	954920		
BNE	955970	955970		
BNE	958770	958770		
BNE	960170	960170		
BNE	962070	962070		
BNE	964170	964170		
BNE	966610	966610		
BNE	967410	967410		
BNE	969790	969790		
BNE	971160	971160		
BNE	972260	972260		
BNE	973260	973260		
BNE	973260	973260		
BNE	974580	974580		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	976020	976020		
BNE	976750	976750		
BNE	978280	978280		
BNE	979507	979507		
BNE	979513	979513		
BNE	979530	979530		
BNE	980330	980330		
BNE	981660	981660		
BNE	982460	982460		
BNE	984160	984160		
BNE	985260	985260		
BNE	985260	985260		
BNE	986480	986480		
BNE	987960	987960		
BNE	988160	988160		
BNE	988170	988170		
BNE	988360	988360		
BNE	989700	989700		
BNE	990700	990700		
BNE	990760	990760		
BNE	991710	991710		
BNE	992420	992420		
BNE	992450	992450		
BNE	992470	992470		
BNE	992670	992670		
BNE	993760	993760		
BNE	994760	994760		
BNE	994760	994760		
BNE	995690	995690		
BNE	996980	996980		
BNE	996980	996980		
BNE	998460	998460		
BNE	998460	998460		
BNE	999160	999160		
BNE	1000000	1000000		
BNE	1000285	1000285		
BNE	1000285	1000285		
BNE	1000775	1000775		
BNE	1001315	1001315		
BNE	1001315	1001315		
BNE	1001865	1001865		
BNE	1002350	1002350		
BNE	1002785	1002785		
BNE	1003275	1003275		
BNE	1003775	1003775		
BNE	1004300	1004300		
BNE	1004810	1004810		
BNE	1005325	1005325		
BNE	1005325	1005325		
BNE	1005870	1005870		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1005870	1005870		
BNE	**1006200**		New_BNE_1006300	Hydraulic Connection redefined from 1006200 to 1005870
BNE	**1006200**		Old_BNE_1006200	
BNE	1006300	1006300		
BNE	1006300	1006300		

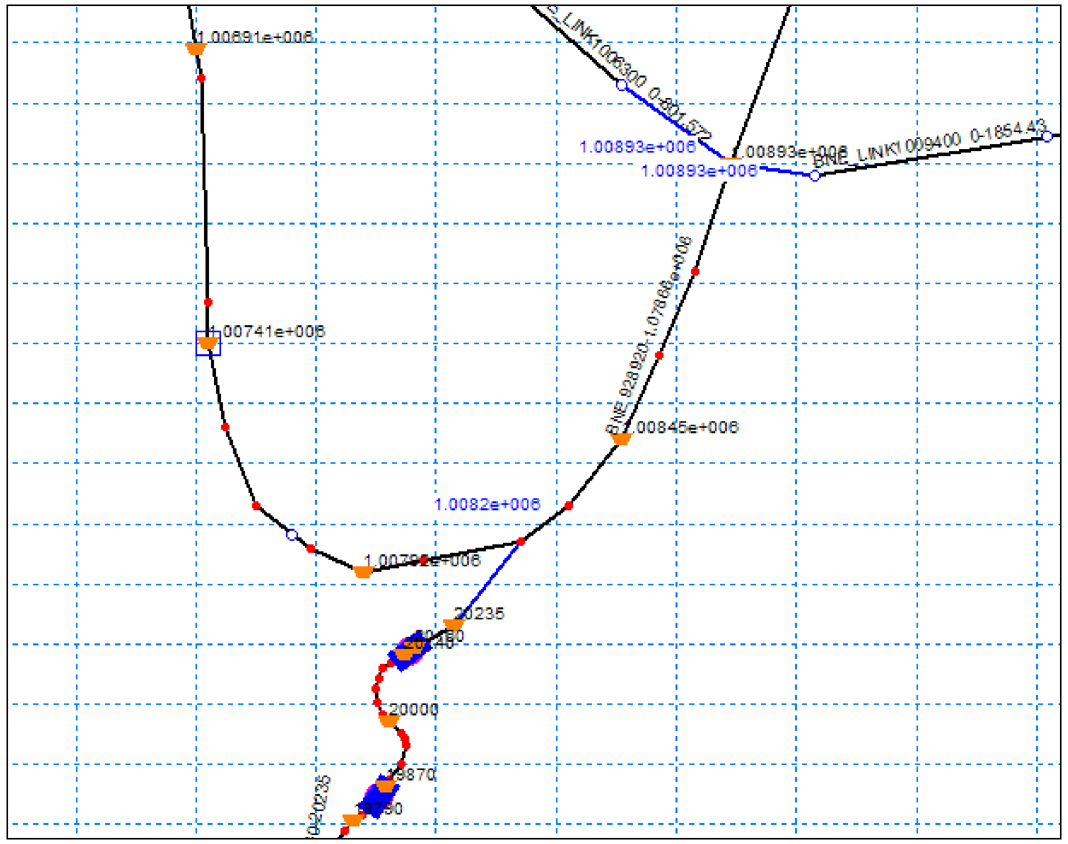


New_BNE_1006300

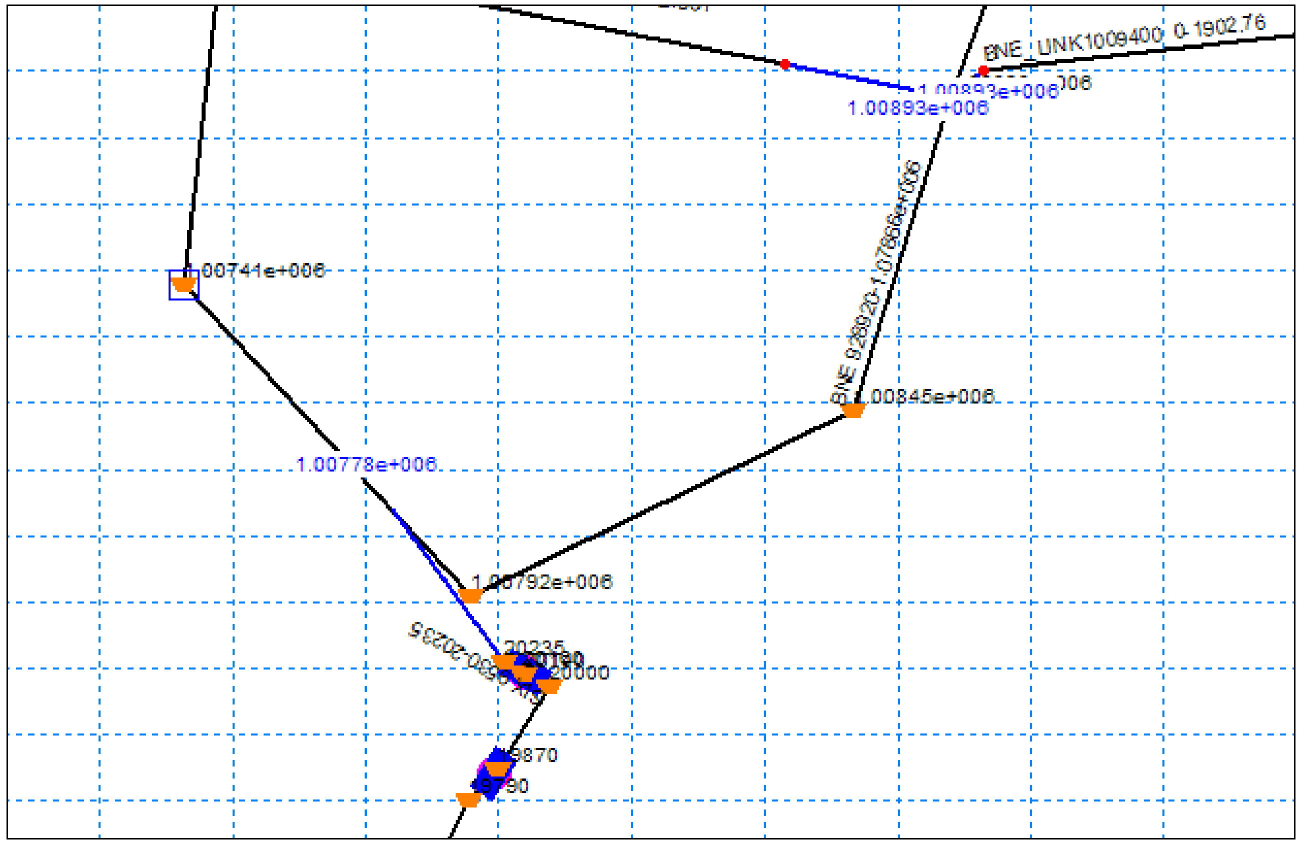


Old_BNE_1006200

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1006910	1006910		
BNE	1007410	1007410		
BNE	**1007780**		New_BNE_1008195	
BNE	**1007780**		Old_BNE_1007780	Hydraulic Connection redefined from 1007780 to 1008195
BNE	1007920	1007920		
BNE		**1008195**		
BNE		**1008195**		



New_BNE_1008195



Old_BNE_1007780

Branch	Ch (m)	Ch (m)	Figure	Comment
BNE	1008445	1008445		
BNE	1008925	1008925		
BNE	1008925	1008925		
BNE	1009400	1009400		
BNE	1009720	1009720		
BNE	1009720	1009720		
BNE	1010490	1010490		
BNE	1010725	1010725		
BNE	1010980	1010980		
BNE	1011510	1011510		
BNE	1011510	1011510		
BNE	1011980	1011980		
BNE	1012475	1012475		
BNE	1012475	1012475		
BNE	1012935	1012935		
BNE	1013445	1013445		
BNE	1013680	1013680		
BNE	1013680	1013680		
BNE	1013910	1013910		
BNE	1014310	1014310		
BNE	1014610	1014610		
BNE	1014610	1014610		
BNE	1015090	1015090		
BNE	1015560	1015560		
BNE	1015850	1015850		
BNE	1015850	1015850		
BNE	1016140	1016140		
BNE	1016640	1016640		
BNE	1016640	1016640		
BNE	1017130	1017130		
BNE	1017130	1017130		
BNE	1017610	1017610		
BNE	1017610	1017610		
BNE	1017920	1017920		
BNE	1018200	1018200		
BNE	1018725	1018725		
BNE	1019095	1019095		
BNE	1019490	1019490		
BNE	1019490	1019490		
BNE	1019865	1019865		
BNE	1020115	1020115		
BNE	1020525	1020525		
BNE	1020525	1020525		
BNE	1020830	1020830		
BNE	1021095	1021095		
BNE	1021539	1021539		
BNE	1021715	1021715		

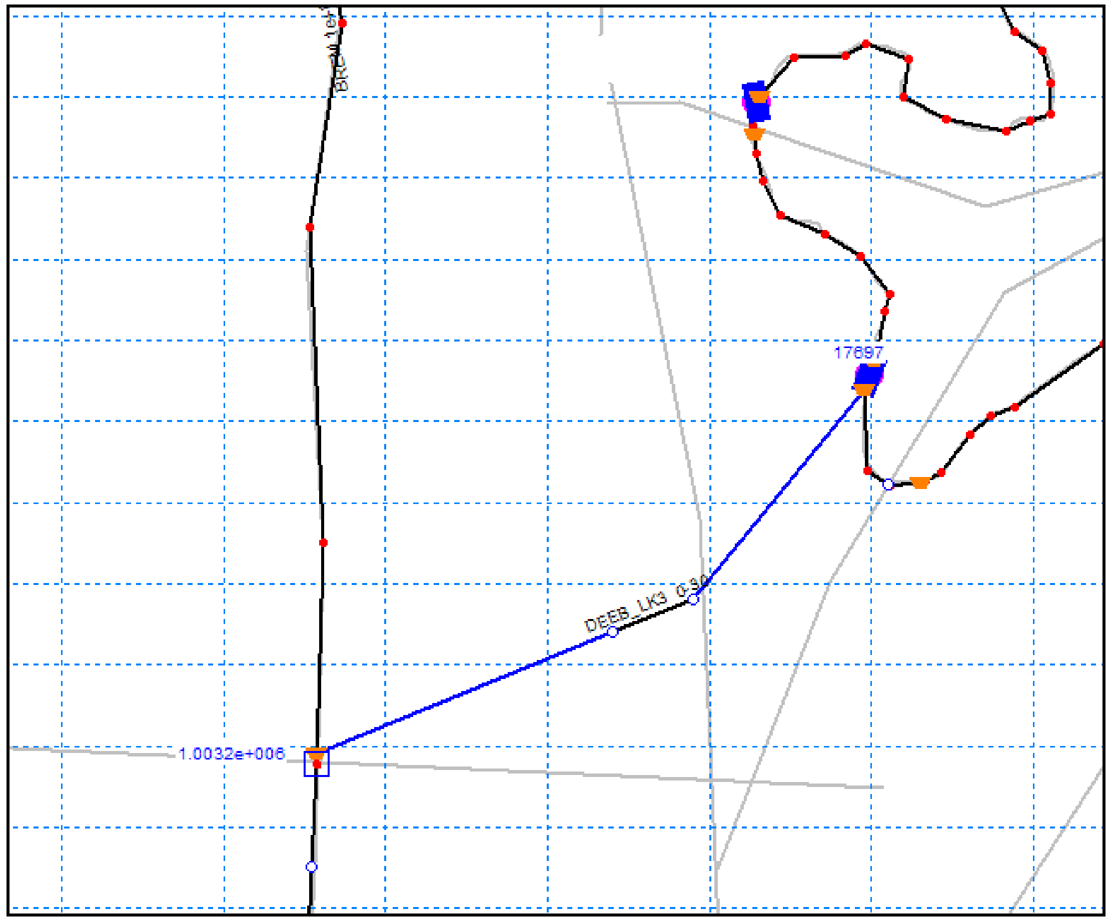
Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1021895	1021895		
BNE	1022105	1022105		
BNE	1022575	1022575		
BNE	1022575	1022575		
BNE	1023040	1023040		
BNE	1023570	1023570		
BNE	1024080	1024080		
BNE	1024080	1024080		
BNE	1024563	1024563		
BNE	1024563	1024563		
BNE	1025070	1025070		
BNE	1025360	1025360		
BNE	1025590	1025590		
BNE	1025590	1025590		
BNE	1026170	1026170		
BNE	1026680	1026680		
BNE	1026900	1026900		
BNE	1027160	1027160		
BNE	1027680	1027680		
BNE	1028180	1028180		
BNE	1028680	1028680		
BNE	1028680	1028680		
BNE	1028760	1028760		
BNE	1029200	1029200		
BNE	1029680	1029680		
BNE	1030220	1030220		
BNE	1030220	1030220		
BNE	1030870	1030870		
BNE	1030870	1030870		
BNE	1031260	1031260		
BNE	1031700	1031700		
BNE	1031995	1031995		
BNE	1032230	1032230		
BNE	1032585	1032585		
BNE	1033080	1033080		
BNE	1033080	1033080		
BNE	1033370	1033370		
BNE	1033370	1033370		
BNE	1033900	1033900		
BNE	1033900	1033900		
BNE	1034370	1034370		
BNE	1034890	1034890		
BNE	1034890	1034890		
BNE	1035414	1035414		
BNE	1035900	1035900		
BNE	1035900	1035900		
BNE	1036460	1036460		
BNE	1036770	1036770		
BNE	1036915	1036915		
BNE	1037090	1037090		

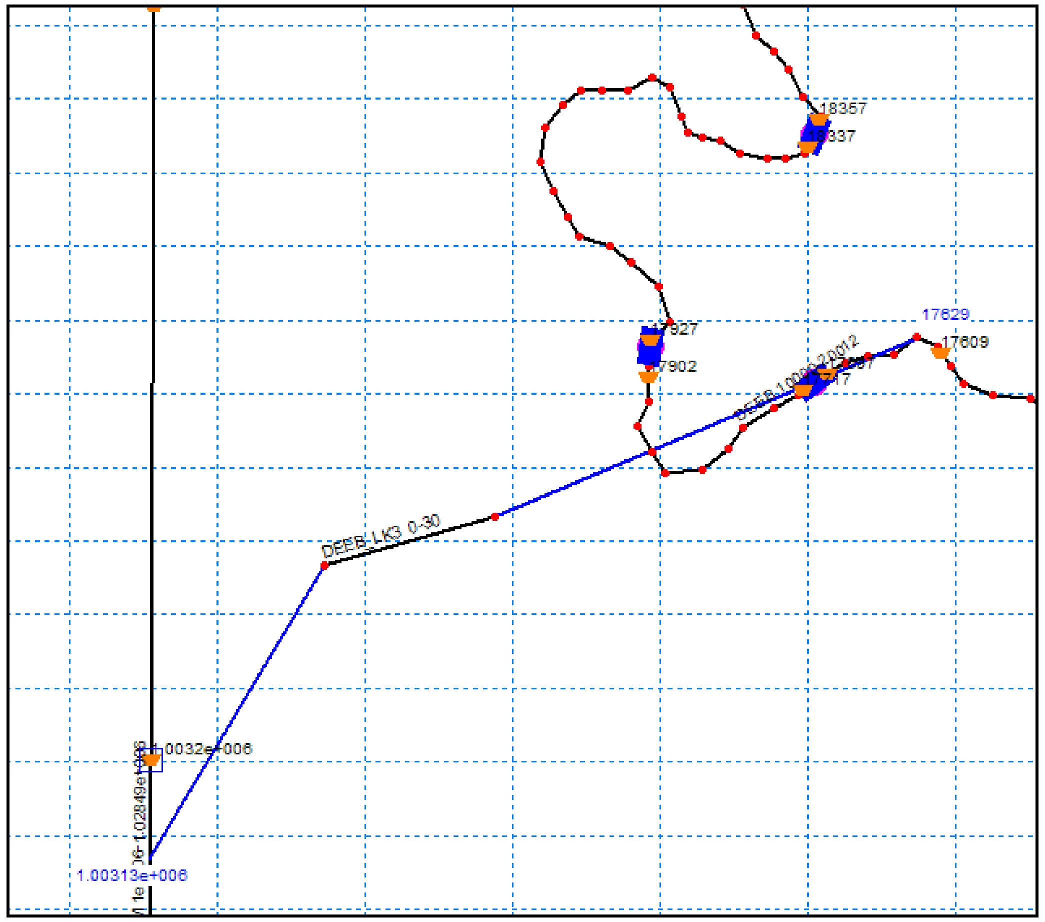
Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1037175	1037175		
BNE	1037175	1037175		
BNE	1037285	1037285		
BNE	1037625	1037625		
BNE	1038085	1038085		
BNE	1038085	1038085		
BNE	1038600	1038600		
BNE	1038600	1038600		
BNE	1039100	1039100		
BNE	1039100	1039100		
BNE	1039200	1039200		
BNE	1039200	1039200		
BNE	1039565	1039565		
BNE	1039670	1039670		
BNE	1039670	1039670		
BNE	1040090	1040090		
BNE	1040090	1040090		
BNE	1040250	1040250		
BNE	1040250	1040250		
BNE	1040490	1040490		
BNE	1041010	1041010		
BNE	1041230	1041230		
BNE	1041460	1041460		
BNE	1041700	1041700		
BNE	1041700	1041700		
BNE	1041960	1041960		
BNE	1042235	1042235		
BNE	1042500	1042500		
BNE	1042500	1042500		
BNE	1042515	1042515		
BNE	1042910	1042910		
BNE	1043010	1043010		
BNE	1043010	1043010		
BNE	1043080	1043080		
BNE	1043110	1043110		
BNE	1043110	1043110		
BNE	1043725	1043725		
BNE	1044060	1044060		
BNE	1044060	1044060		
BNE	1044340	1044340		
BNE	1044340	1044340		
BNE	1044605	1044605		
BNE	1044860	1044860		
BNE	1045400	1045400		
BNE	1045400	1045400		
BNE	1045885	1045885		
BNE	1046180	1046180		
BNE	1046340	1046340		
BNE	1046580	1046580		
BNE	1046900	1046900		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1047350	1047350		
BNE	1047915	1047915		
BNE	1047915	1047915		
BNE	1048375	1048375		
BNE	1048375	1048375		
BNE	1048890	1048890		
BNE	1049120	1049120		
BNE	1049370	1049370		
BNE	1049590	1049590		
BNE	1049870	1049870		
BNE	1050430	1050430		
BNE	1050430	1050430		
BNE	1050860	1050860		
BNE	1050860	1050860		
BNE	1051360	1051360		
BNE	1051360	1051360		
BNE	1051895	1051895		
BNE	1052310	1052310		
BNE	1052390	1052390		
BNE	1052595	1052595		
BNE	1052640	1052640		
BNE	1052865	1052865		
BNE	1052865	1052865		
BNE	1053320	1053320		
BNE	1053385	1053385		
BNE	1053385	1053385		
BNE	1053900	1053900		
BNE	1053900	1053900		
BNE	1054640	1054640		
BNE	1054680	1054680		
BNE	1054970	1054970		
BNE	1055280	1055280		
BNE	1055420	1055420		
BNE	1055960	1055960		
BNE	1055960	1055960		
BNE	1056400	1056400		
BNE	1056400	1056400		
BNE	1056695	1056695		
BNE	1056865	1056865		
BNE	1056950	1056950		
BNE	1057090	1057090		
BNE	1057090	1057090		
BNE	1057530	1057530		
BNE	1057530	1057530		
BNE	1058040	1058040		
BNE	1058040	1058040		
BNE	1058230	1058230		
BNE	1058530	1058530		
BNE	1058735	1058735		
BNE	1059035	1059035		
BNE	1059540	1059540		

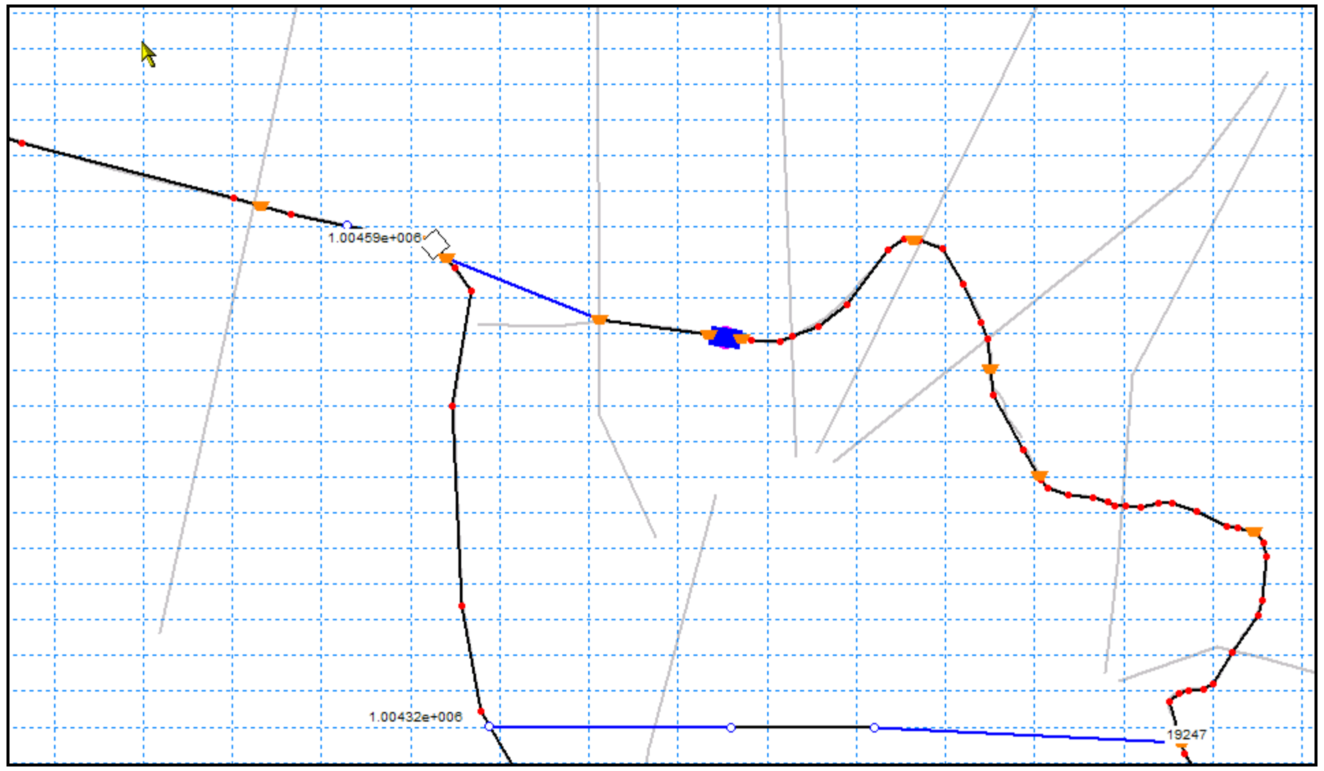
Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BNE	1059990	1059990		
BNE	1060535	1060535		
BNE	1060535	1060535		
BNE	1060845	1060845		
BNE	1060845	1060845		
BNE	1061015	1061015		
BNE	1061530	1061530		
BNE	1062020	1062020		
BNE	1062020	1062020		
BNE	1062535	1062535		
BNE	1062940	1062940		
BNE	1063125	1063125		
BNE	1063125	1063125		
BNE	1063310	1063310		
BNE	1063645	1063645		
BNE	1064000	1064000		
BNE	1064490	1064490		
BNE	1065010	1065010		
BNE	1065503	1065503		
BNE	1065990	1065990		
BNE	1066505	1066505		
BNE	1067020	1067020		
BNE	1067020	1067020		
BNE	1067485	1067485		
BNE	1067965	1067965		
BNE	1068660	1068660		
BNE	1069045	1069045		
BNE	1069535	1069535		
BNE	1070025	1070025		
BNE	1070530	1070530		
BNE	1071040	1071040		
BNE	1071520	1071520		
BNE	1072015	1072015		
BNE	1072020	1072020		
BNE	1072020	1072020		
BNE	1072515	1072515		
BNE	1072995	1072995		
BNE	1073485	1073485		
BNE	1074000	1074000		
BNE	1074460	1074460		
BNE	1074985	1074985		
BNE	1075480	1075480		
BNE	1076000	1076000		
BNE	1076495	1076495		
BNE	1077010	1077010		
BNE	1077510	1077510		
BNE	1078040	1078040		
BNE	1078525	1078525		
BNE	1078660	1078660		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1000000	1000000		
BREM	1000700	1000700		
BREM	1001120	1001120		
BREM	1001700	1001700		
BREM	1002300	1002300		
BREM	1002700	1002700		
BREM	**1003130**			Hydraulic Connection redefined from 1003130 to 1003200
BREM	**1003130**			
BREM	1003200	1003200		
		1003200		

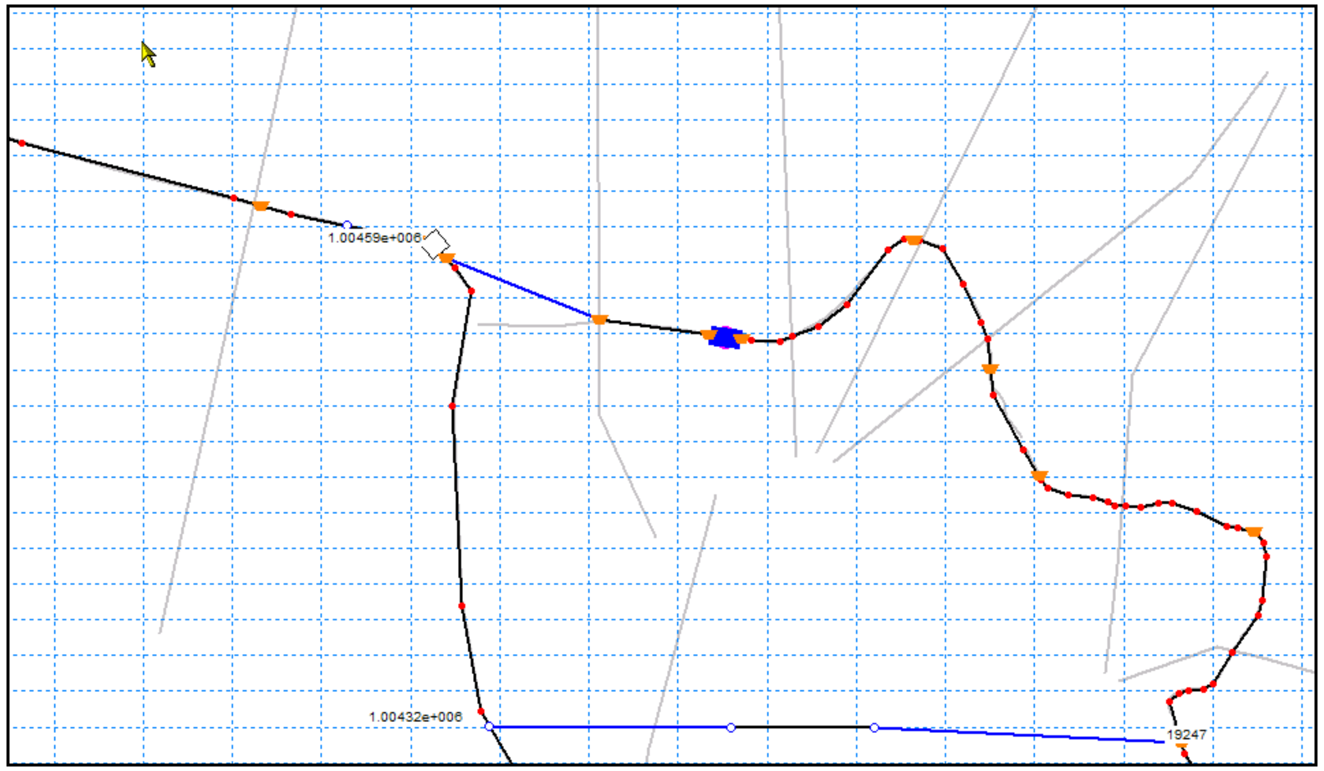




Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1003700	1003700		
BREM	1003840	1003840		
BREM	1003840	1003840		
BREM	1004150	1004150		
BREM	1004320	1004320		
BREM	1004320	1004320		
BREM	1004590	1004590	Old_BREM_1004650	Hydraulic Connection redefined from 1004650 to 1004590
		1004590	New_BREM_1004590	
BREM	1004610	1004610		
BREM	**1004650**			
BREM	**1004650**			

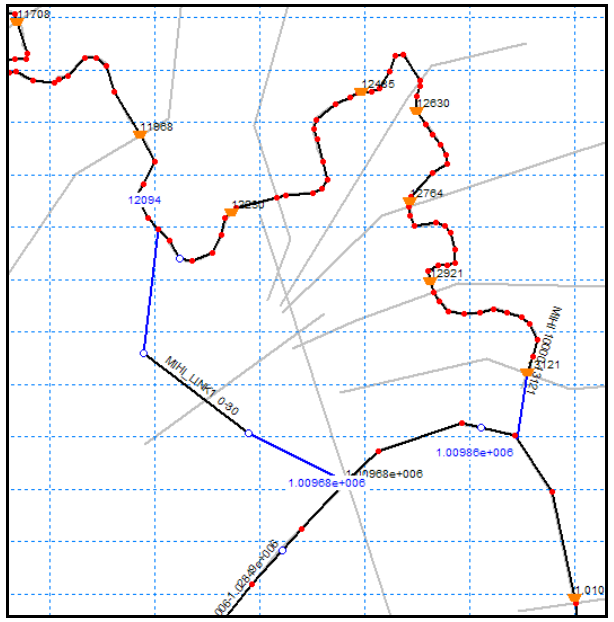


New_BREM_1004590

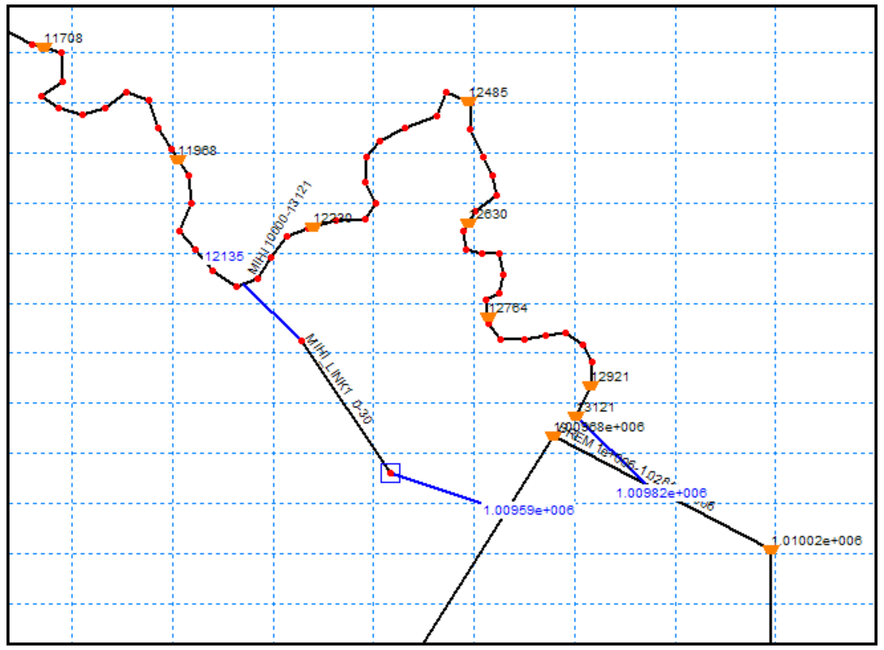


Old_BREM_1004650

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1004700	1004700		
BREM	1005140	1005140		
BREM	1005520	1005520		
BREM	1005740	1005740		
BREM	1006090	1006090		
BREM	1006250	1006250		
BREM	1006490	1006490		
BREM	1006510	1006510		
BREM	1006780	1006780		
BREM	1007440	1007440		
BREM	1007700	1007700		
BREM	1008000	1008000		
BREM	1008000	1008000		
BREM	1008390	1008390		
BREM	1008410	1008410		
BREM	1008420	1008420		
BREM	1008660	1008660		
BREM	1009210	1009210		
BREM	**1009585**		Old_BREM_1009585	Hydraulic Connection redefined from 1009585 to 1009680
BREM	**1009585**		New_BREM_1009675	
BREM	1009675	1009675		
BREM		**1009675**		
BREM	**1009820**			Hydraulic Connection amended from Pt 1009820 to 1009856
BREM	**1009820**			
BREM		**1009856.2**		
BREM		**1009856.2**		



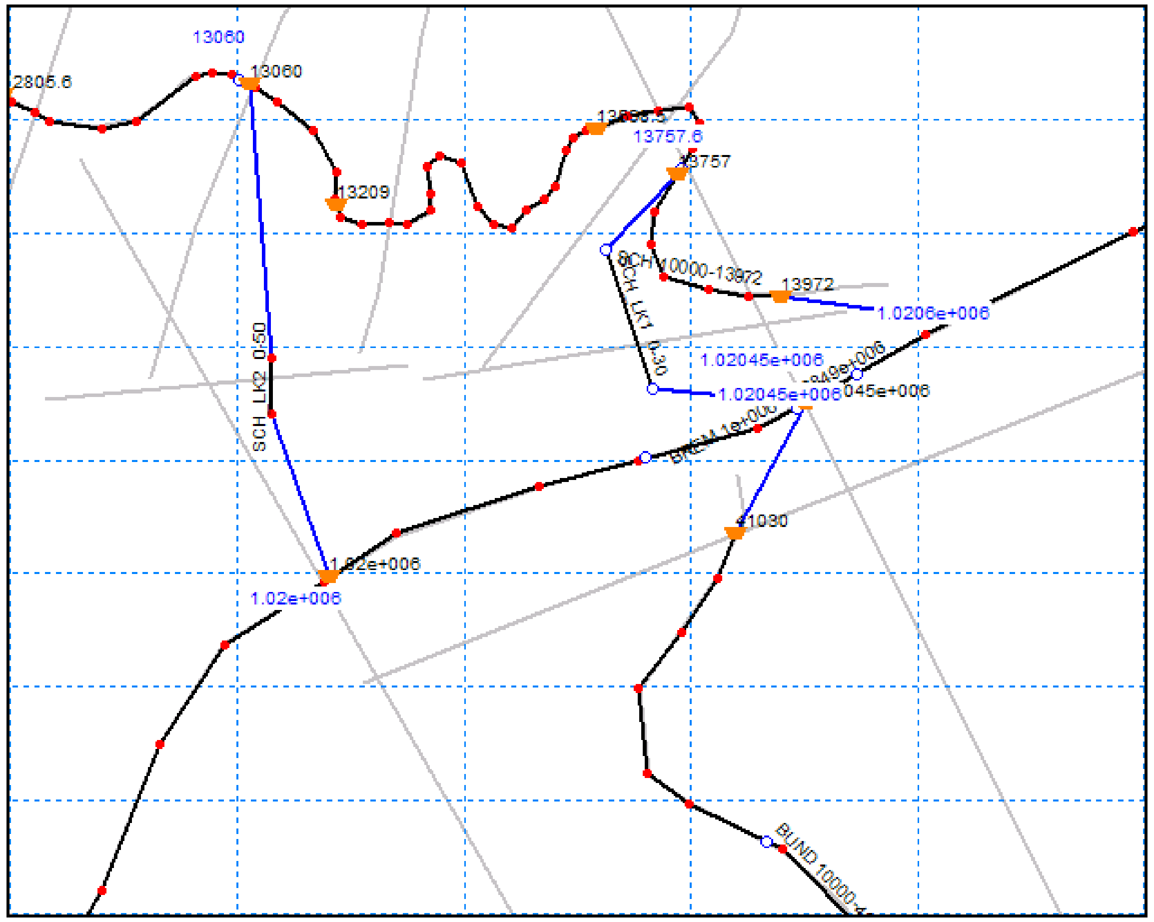
New_BREM_1009675



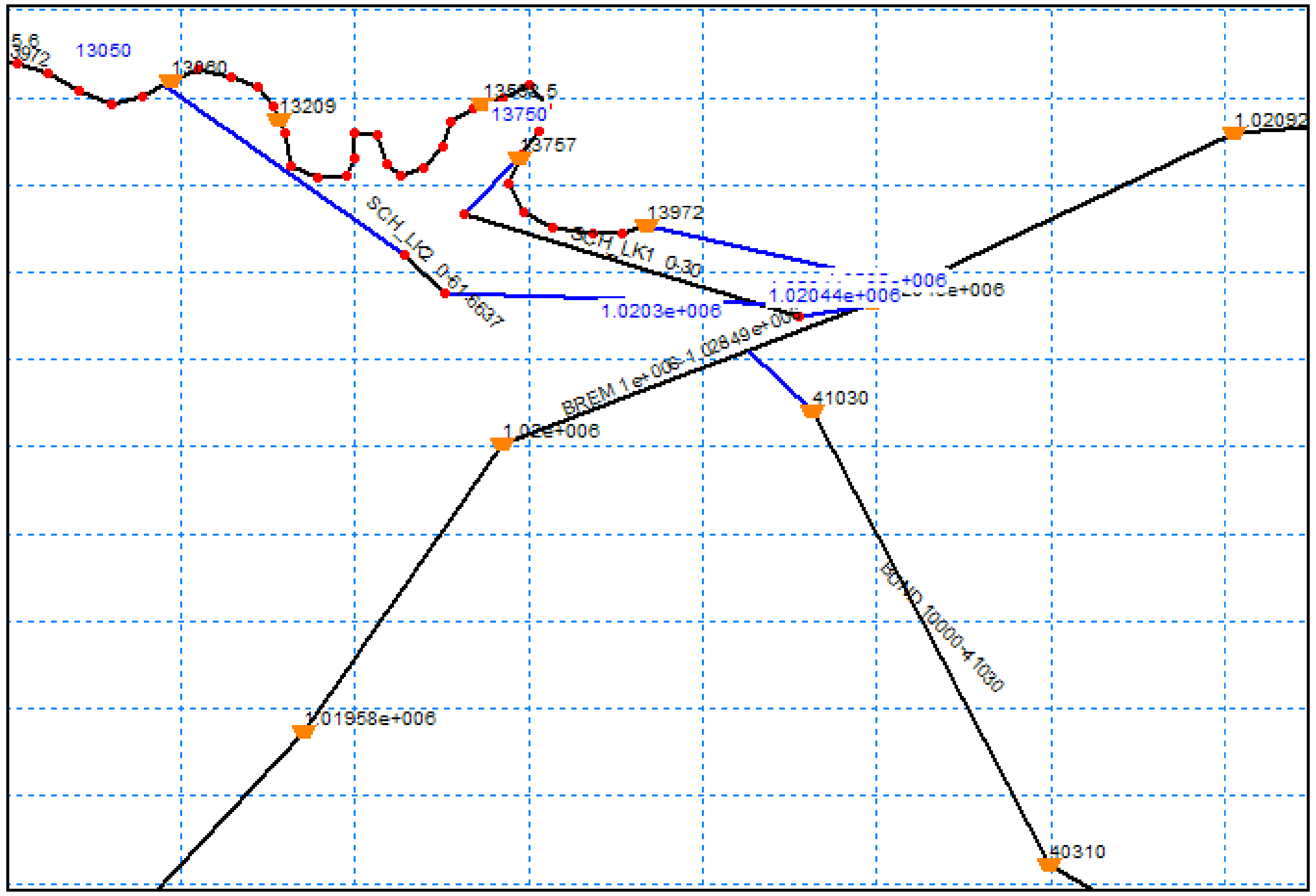
Old_BREM_1009585

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1010020	1010020		
BREM	1010280	1010280		
BREM	1010700	1010700		
BREM	1010890	1010890		
BREM	1011320	1011320		
BREM	1011700	1011700		
BREM	1011790	1011790		
BREM	1011810	1011810		
BREM	1012050	1012050		
BREM	1012070	1012070		
BREM	1012200	1012200		
BREM	1012870	1012870		
BREM	1013380	1013380		
BREM	1013700	1013700		
BREM	1014220	1014220		
BREM	1014640	1014640		
BREM	1015180	1015180		
BREM	1015445	1015445		
BREM	1015445	1015445		
BREM	1015710	1015710		
BREM	1016110	1016110		
BREM	1016110	1016110		
BREM	1016510	1016510		
BREM	1017080	1017080		
BREM	1017750	1017750		
BREM	1018140	1018140		
BREM	1018320	1018320		
BREM	1018320	1018320		
BREM	1018500	1018500		
BREM	1018630	1018630		
BREM	1018630	1018630		
BREM	1018760	1018760		
BREM	1019150	1019150		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1019580	1019580		
BREM	1020000	1020000	New_Brem_1020000	Hydraulic connection redefined from 1020450 to 1020000
		1020000	New_Brem_1020000	refer figure for 1020450
BREM	1020300			Hydraulic connection redefined from 1020300 to 1020450
BREM	1020300			refer figure for 1020450
BREM	1020440			
BREM	1020440			
BREM	1020450	1020450		
		1020450		
BREM	1020500			
BREM	1020500			
		1020600		Hydraulic connection redefined from 1020450 to 1020600
		1020600		



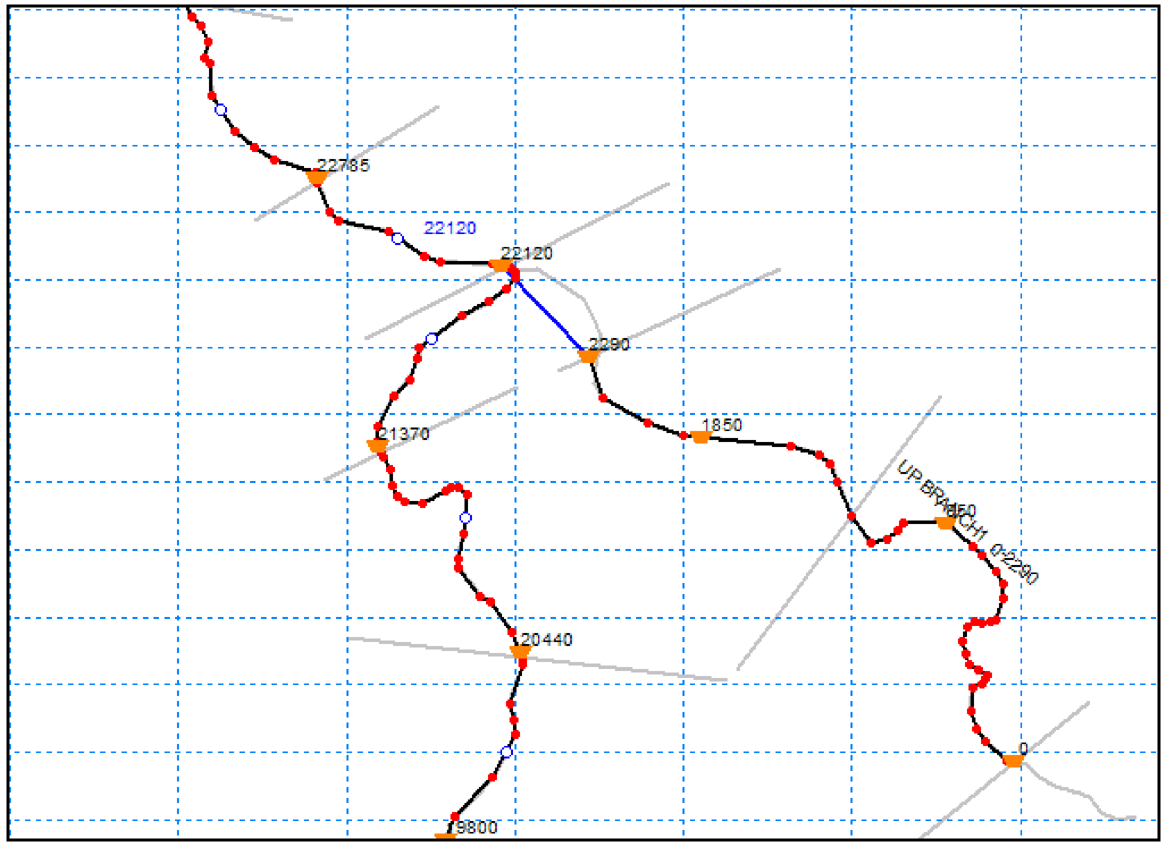
New_Brem_1020000



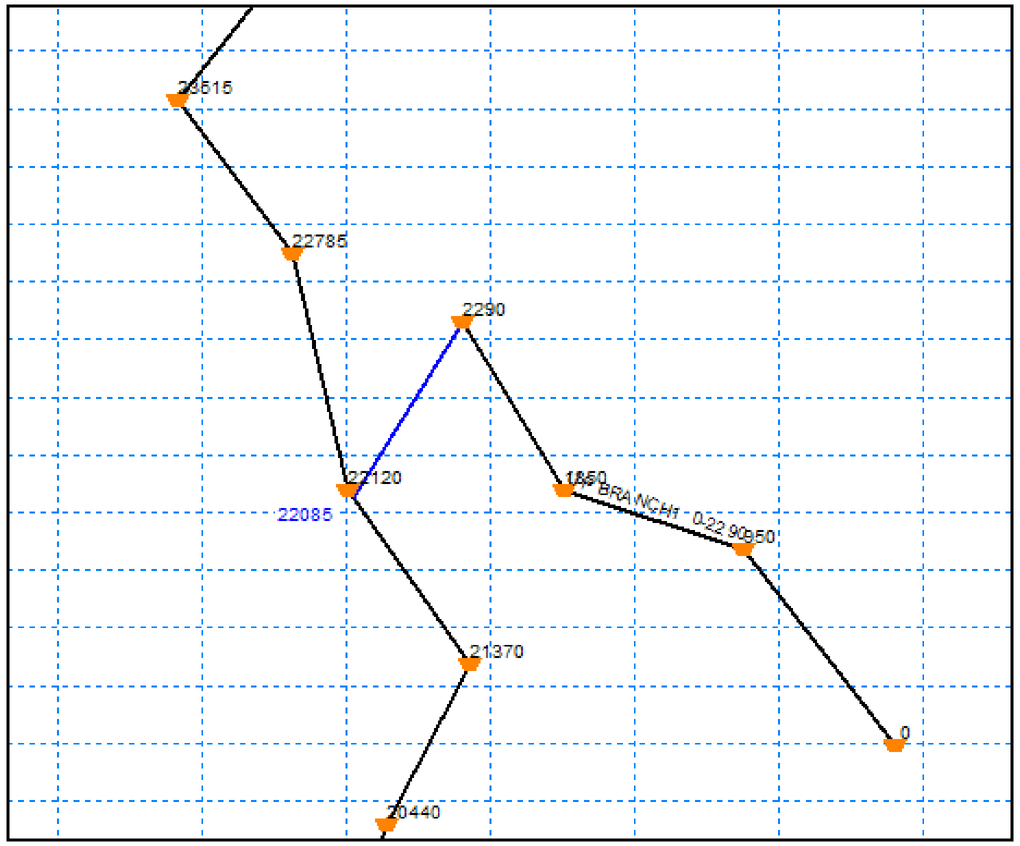
New_Brem_1020000

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BREM	1020920	1020920		
BREM	1021460	1021460		
BREM	1022300	1022300		
BREM	1022950	1022950		
BREM	1023490	1023490		
BREM	1023510	1023510		
BREM	1023870	1023870		
BREM	1024220	1024220		
BREM	1024520	1024520		
BREM	1024750	1024750		
BREM	1025300	1025300		
BREM	1025670	1025670		
BREM	1025920	1025920		
BREM	1026150	1026150		
BREM	1026560	1026560		
BREM	1027100	1027100		
BREM	1027640	1027640		
BREM	1027840	1027840		
BREM	1028190	1028190		
BREM	1028190	1028190		
BREM	1028490	1028490		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BUND	10000	10000		
BUND	10307.5	10307.5		
BUND	10615	10615		
BUND	11107.5	11107.5		
BUND	11600	11600		
BUND	11968.33	11968.33		
BUND	12336.67	12336.67		
BUND	12705	12705		
BUND	13165	13165		
BUND	13552.5	13552.5		
BUND	13940	13940		
BUND	14217.5	14217.5		
BUND	14495	14495		
BUND	14775	14775		
BUND	15055	15055		
BUND	15377.5	15377.5		
BUND	15700	15700		
BUND	16047.5	16047.5		
BUND	16395	16395		
BUND	16647.5	16647.5		
BUND	16900	16900		
BUND	17215	17215		
BUND	17530	17530		
BUND	17885	17885		
BUND	18307.5	18307.5		
BUND	18730	18730		
BUND	18750	18750		
BUND	19015	19015		
BUND	19280	19280		
BUND	19540	19540		
BUND	19800	19800		
BUND	20120	20120		
BUND	20440	20440		
BUND	20905	20905		
BUND	21370	21370		
BUND	**21727.5**			Grid pt redefined
BUND		**21745**		
BUND	**22085**		New_Bund_22120	Hydraulic Connection redefined from 22085 to 22120
BUND	**22085**		Old_Bund_28085	
BUND	22120	22120		
BUND		**22120**		



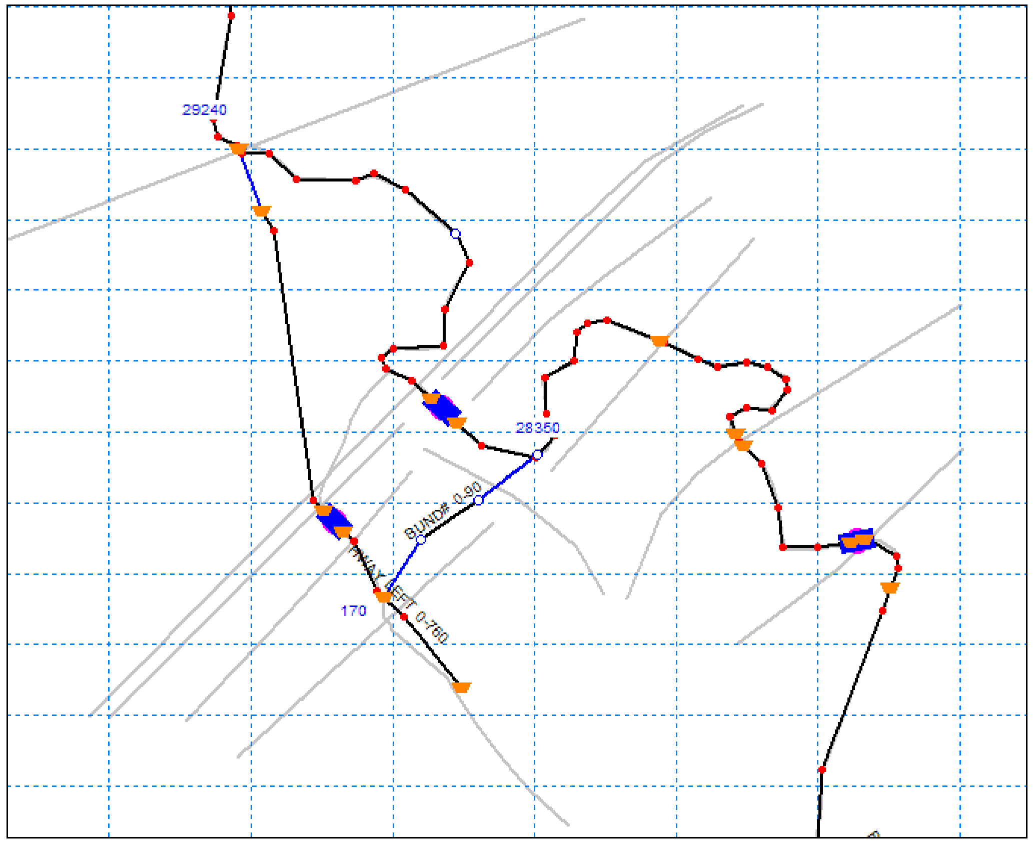
New_Bund_22120



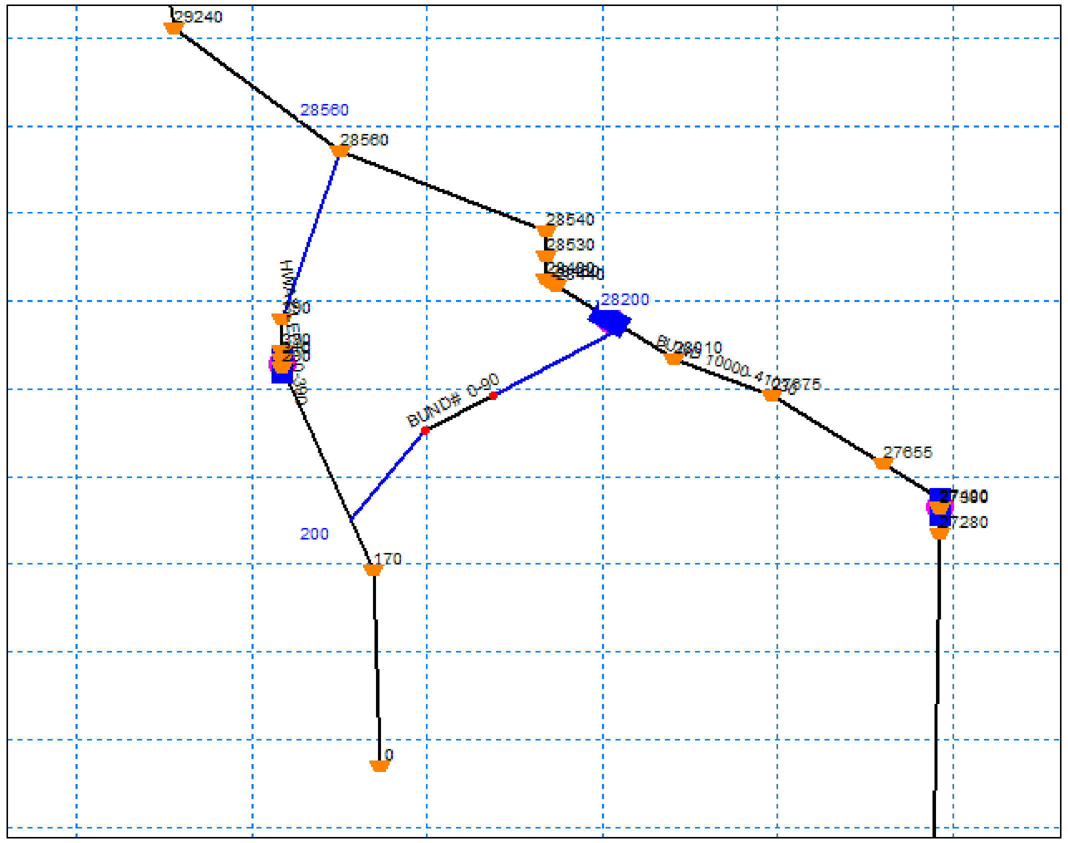
Old_Bund_28085

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BUND	22452.5	22452.5		
BUND	22785	22785		
BUND	23150	23150		
BUND	23515	23515		
BUND	23822.5	23822.5		
BUND	24130	24130		
BUND	24445	24445		
BUND	24760	24760		
BUND	25075	25075		
BUND	25327.5	25327.5		
BUND	25580	25580		
BUND	25600	25600		
BUND	26070	26070		
BUND	26540	26540		
BUND	26780	26780		
BUND	27280	27280		
BUND	27380	27380		
BUND	27400	27400		
BUND	27655	27655		
BUND	27675	27675		
Branch/Link Channel	**Ch (m)**	**Ch (m)**	**Figure**	**Comment**
BUND	28010	28010		

BUND	28200		New_Bund_28350	Hydraulic connection redefined from 28200 to 28350
BUND	28200		Old_Bund_28200	
		28350		Hydraulic Connection redefined from 28010 to 28350
		28350		
BUND	28440			Cross Section Removed
BUND	28460			Cross Section Removed
BUND	28480	28480		
BUND	28530	28530		
BUND	28540			Cross Section Removed & Hydraulic Connection redefined to 29240
BUND	28560			Hydraulic Connection redefined from 28560 to 29240
BUND	28560			
		28885		Additional Grid Pt introduced
BUND	28900			
BUND	29240	29240		
		29240		

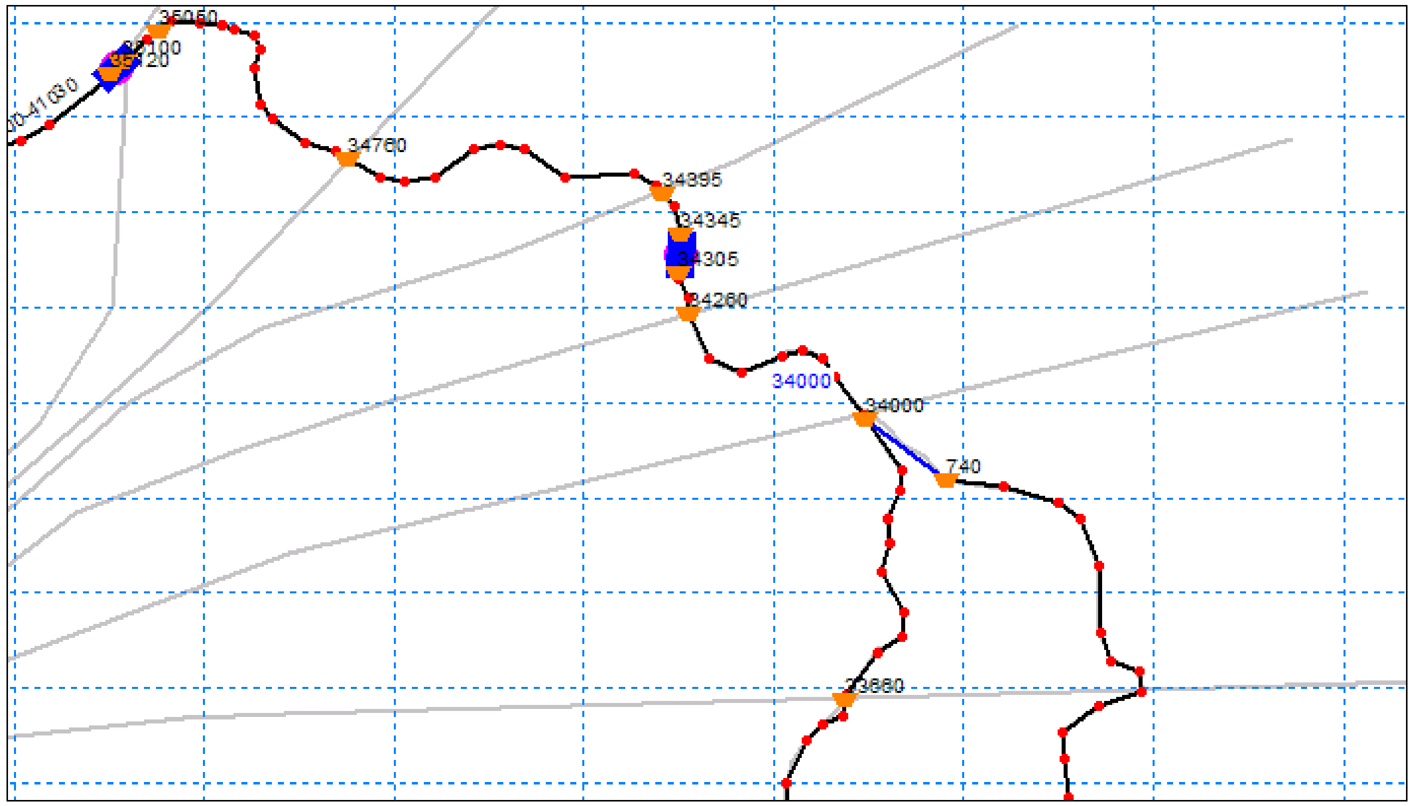


New_Bund_28350

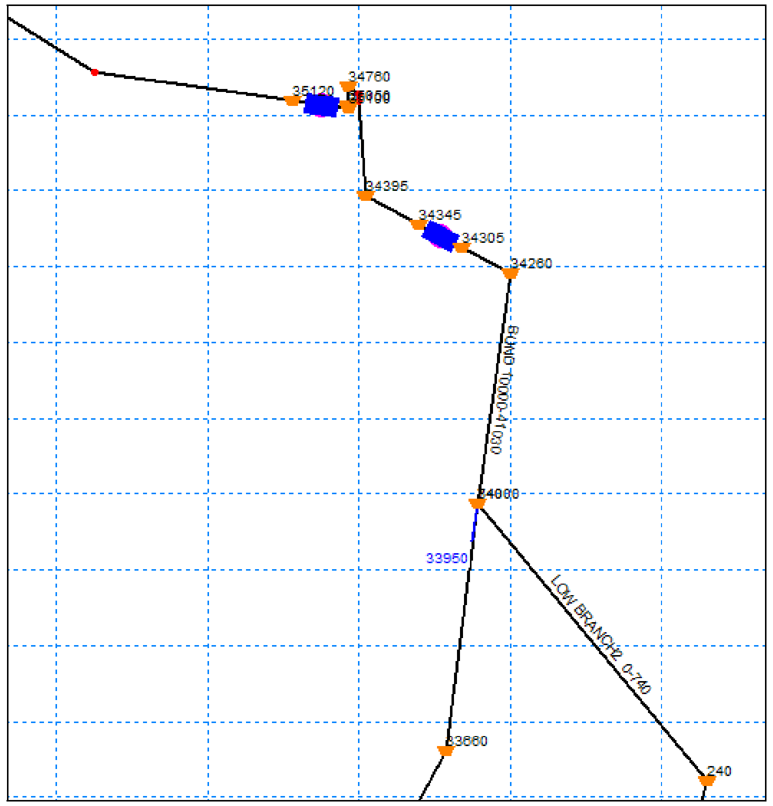


Old_Bund_28200

Branch/Link Channel	Ch (m)	Ch (m)	Comment
BUND	29550	29550	
BUND	29910	29910	
BUND	30215	30215	
BUND	30520	30520	
BUND	30940	30940	
BUND	31360	31360	
BUND	31630	31630	
BUND	31980	31980	
BUND	32000	32000	
BUND	32150	32150	
BUND	32350	32350	
BUND	32370	32370	
BUND	32675	32675	
BUND	32980	32980	
BUND	33320	33320	
BUND	33660	33660	
BUND	**33950**		Hydraulic Connection redefined from 33950 to 34000
BUND	**33950**		
BUND	34000	34000	
		34000	

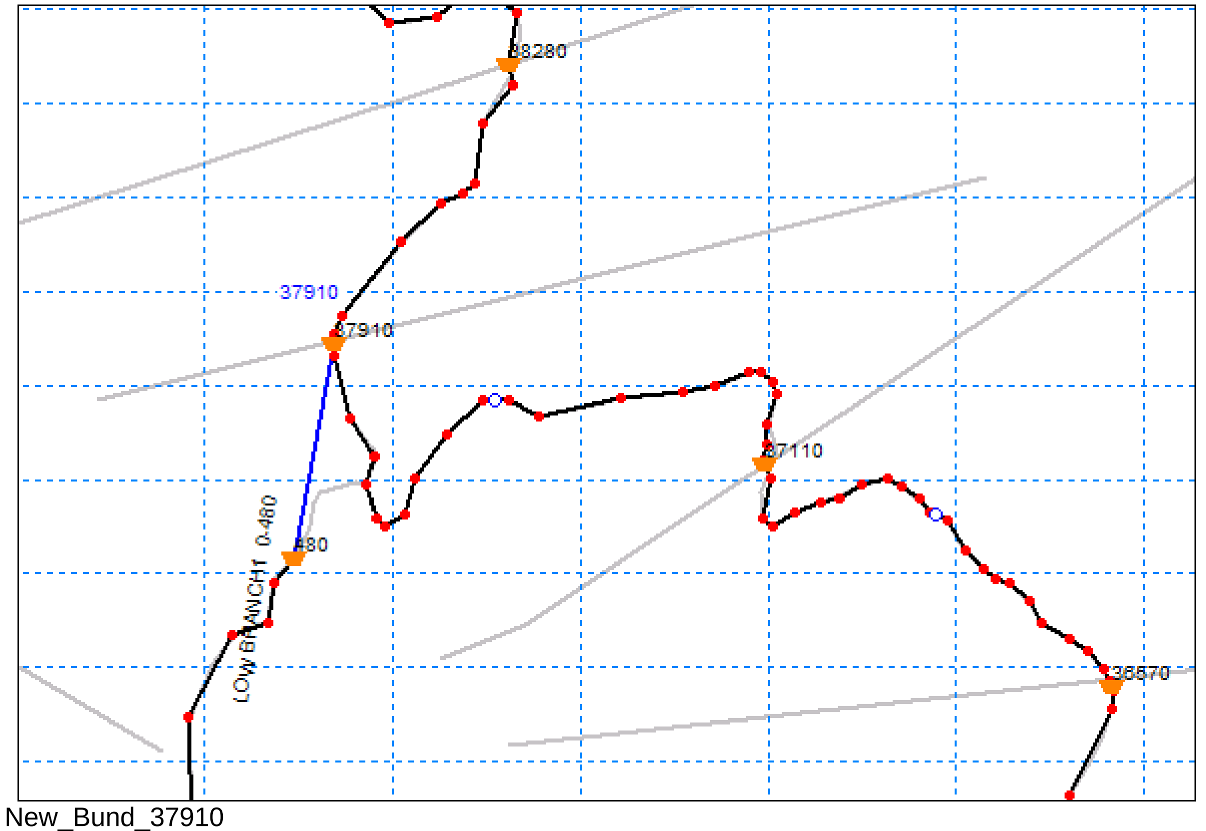


New_Bund_34000

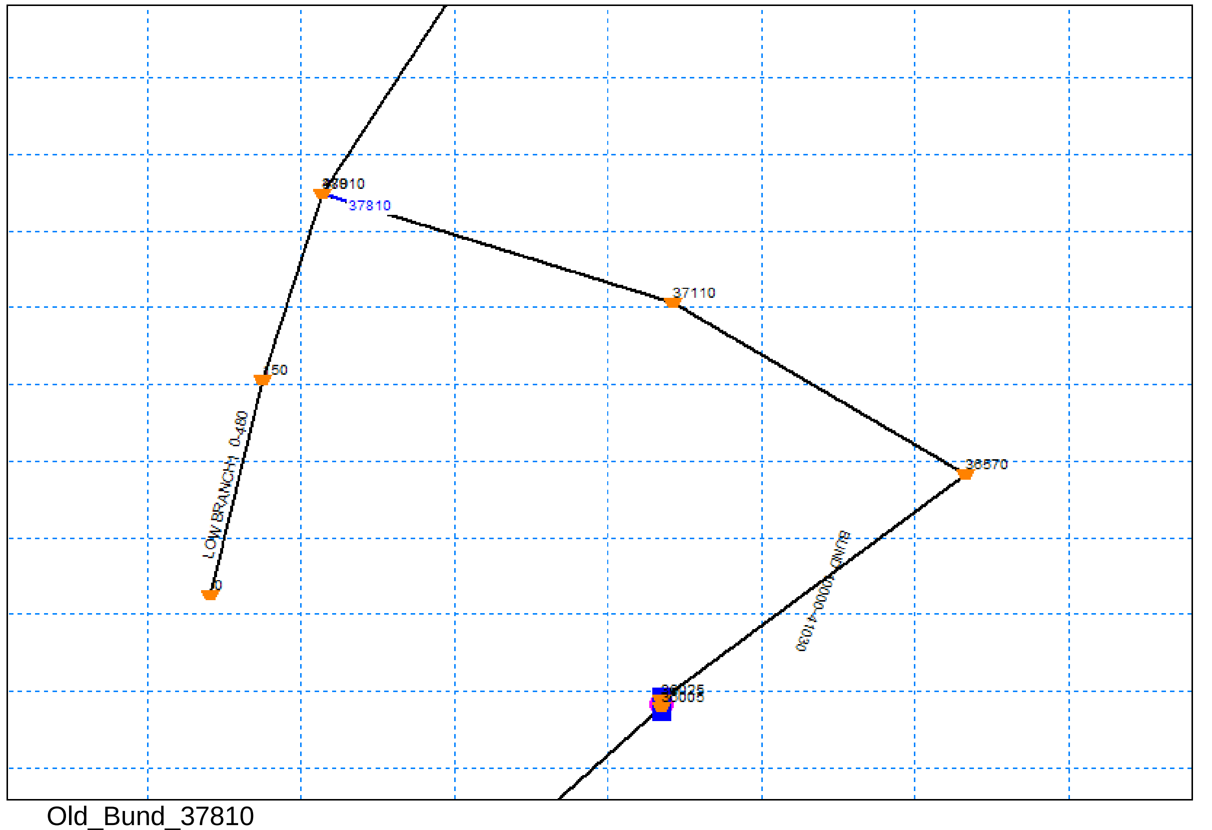


Old_Bund_33950

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BUND	34260	34260		
BUND	34305	34305		
BUND	34345	34345		
BUND	34395	34395		
BUND	34760	34760		
BUND	35050	35050		
BUND	35100	35100		
BUND	35120	35120		
BUND	35520	35520		
BUND	35540	35540		
BUND	35730	35730		
BUND	36005	36005		
BUND	36025	36025		
BUND	36297.5	36297.5		
BUND	36570	36570		
BUND	36840	36840		
BUND	37110	37110		
BUND	**37460**			Grid Pt relocated
		37510		
BUND	**37810**		New_Bund_37910	Hydraulic Connection redefined from 37810 to 37910
BUND	**37810**		Old_Bund_37810	
BUND	37910	37910		
		37910		



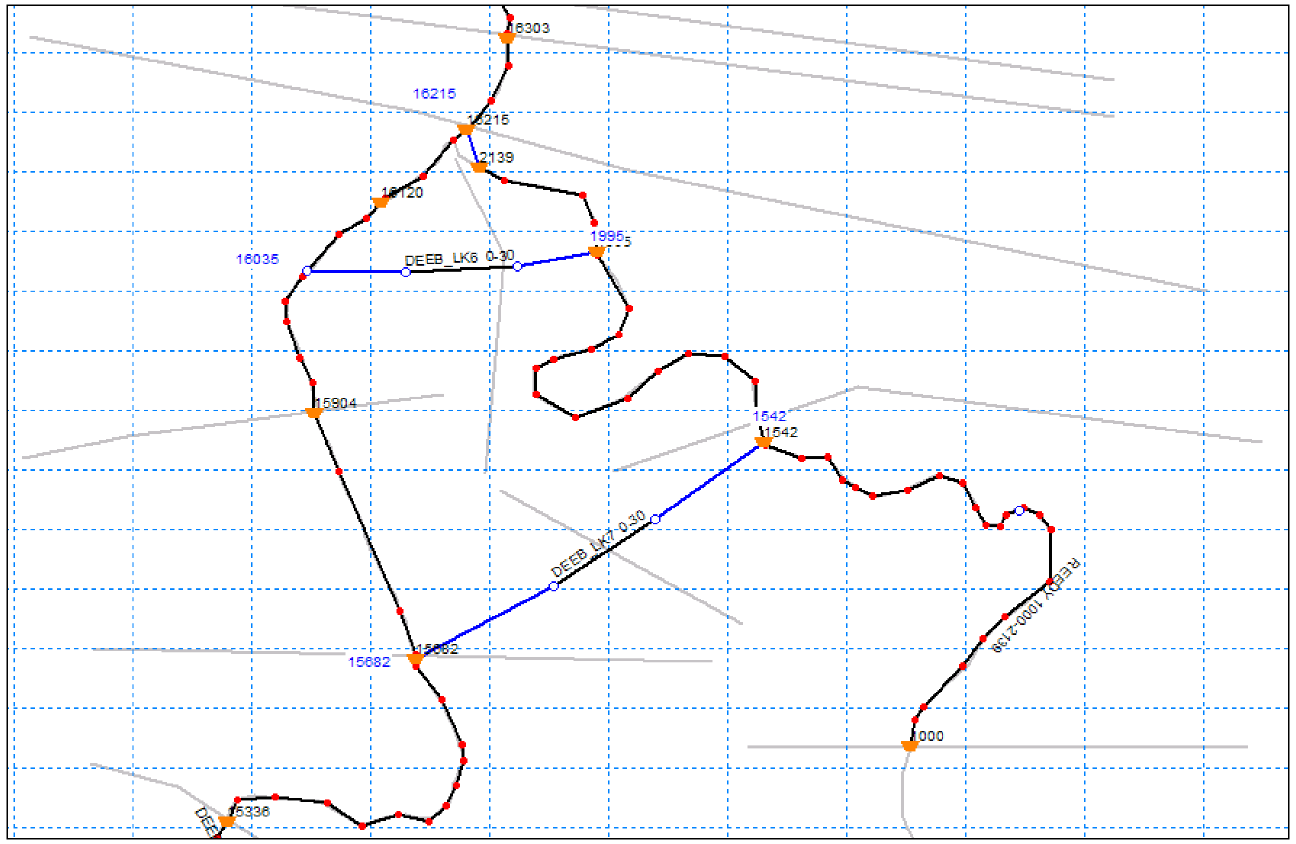
New_Bund_37910



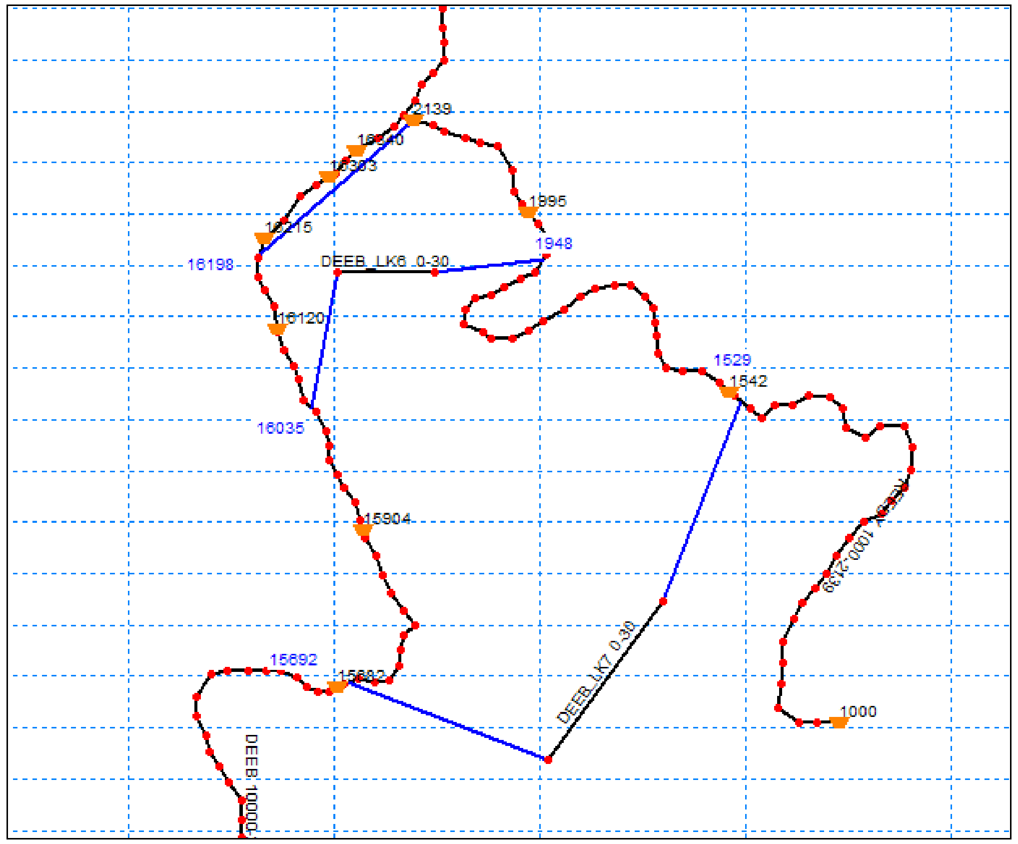
Old_Bund_37810

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
BUND	38280	38280		
BUND	38722.5	38722.5		
BUND	39165	39165		
BUND	39546.67	39546.67		
BUND	39928.33	39928.33		
BUND	40310	40310		
BUND	40670	40670		
BUND	41030	41030		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
DEEB	10000	10000		
DEEB	10315	10315		
DEEB	10588.5	10588.5		
DEEB	10862	10862		
DEEB	11141	11141		
DEEB	11453	11453		
DEEB	11837	11837		
DEEB	12111	12111		
DEEB	12377	12377		
DEEB	12643	12643		
DEEB	12927	12927		
DEEB	12947	12947		
DEEB	13165	13165		
DEEB	13295	13295		
DEEB	13587	13587		
DEEB	13888	13888		
DEEB	13922	13922		
DEEB	14201	14201		
DEEB	14486	14486		
DEEB	14771	14771		
DEEB	14979	14979		
DEEB	15159	15159		
DEEB	15336	15336		
DEEB	15682	15682	New_Deeb _15682	Hydraulic Connection redefined from 15692 to 15682
		15682	Old_Deeb_ 15692	
DEEB	**15692**			
DEEB	**15692**			
DEEB	15904	15904		
DEEB	16035	16035		
DEEB	16035	16035		
DEEB	16120	16120		
DEEB	**16198**			Hydraulic connection redefined from 16198 to 16215
DEEB	**16198**			
DEEB	16215	16215		
		16215		

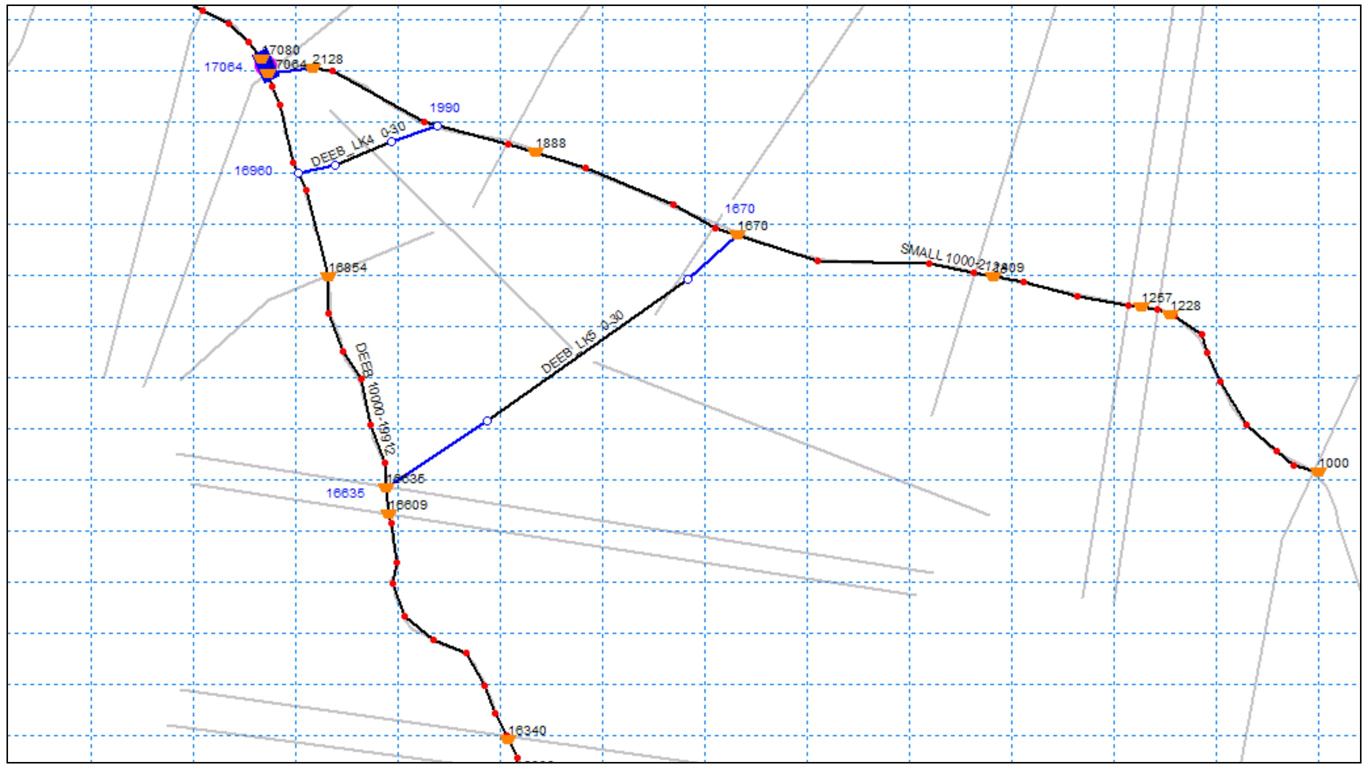


New_Deeb_15682

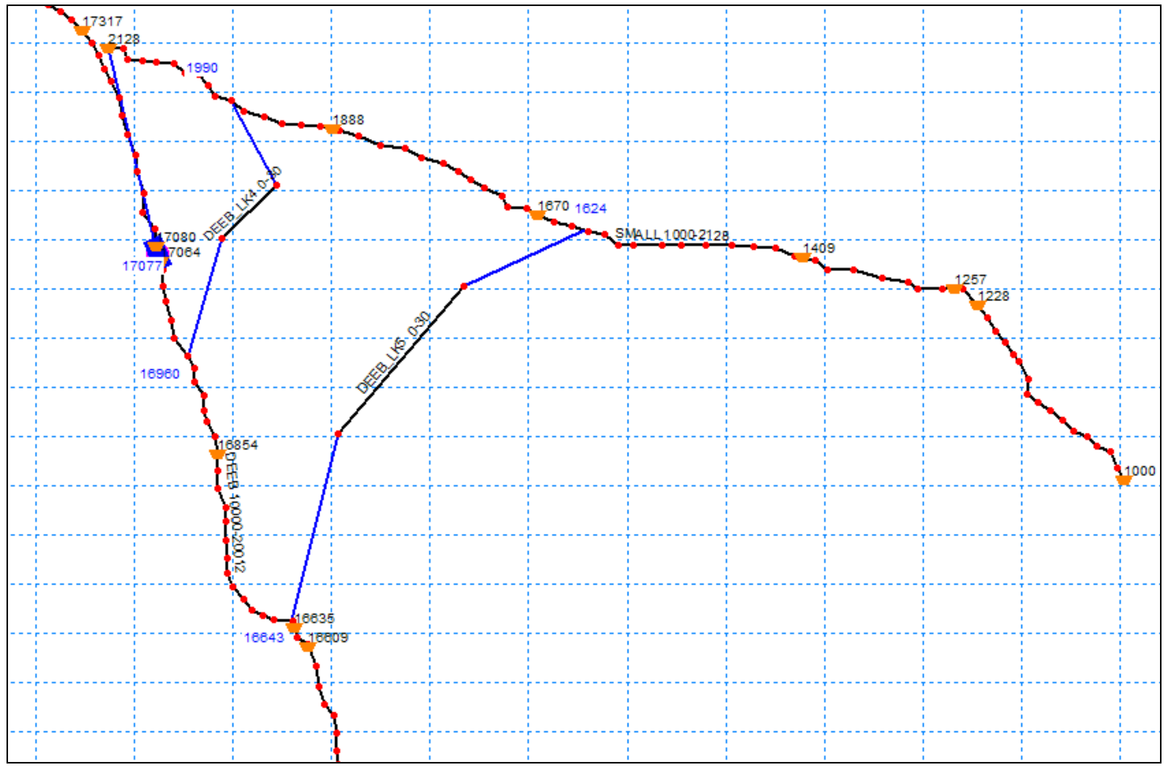


Old_Deeb_15692

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
DEEB	16303	16303		
DEEB	16340	16340		
DEEB	16609	16609		
DEEB	16635	16635	New_Deeb_16635	Hydraulic connection redefined from 16643 to 16635
		16635	Old_Deeb_16643	
DEEB	**16643**			
DEEB	**16643**			
DEEB	16854	16854		
DEEB	16960	16960		
DEEB	16960	16960		
DEEB	17064	17064		Hydraulic Connection redefined from 17077 to 17064
DEEB	**17077**	**17064**		
DEEB	**17077**			

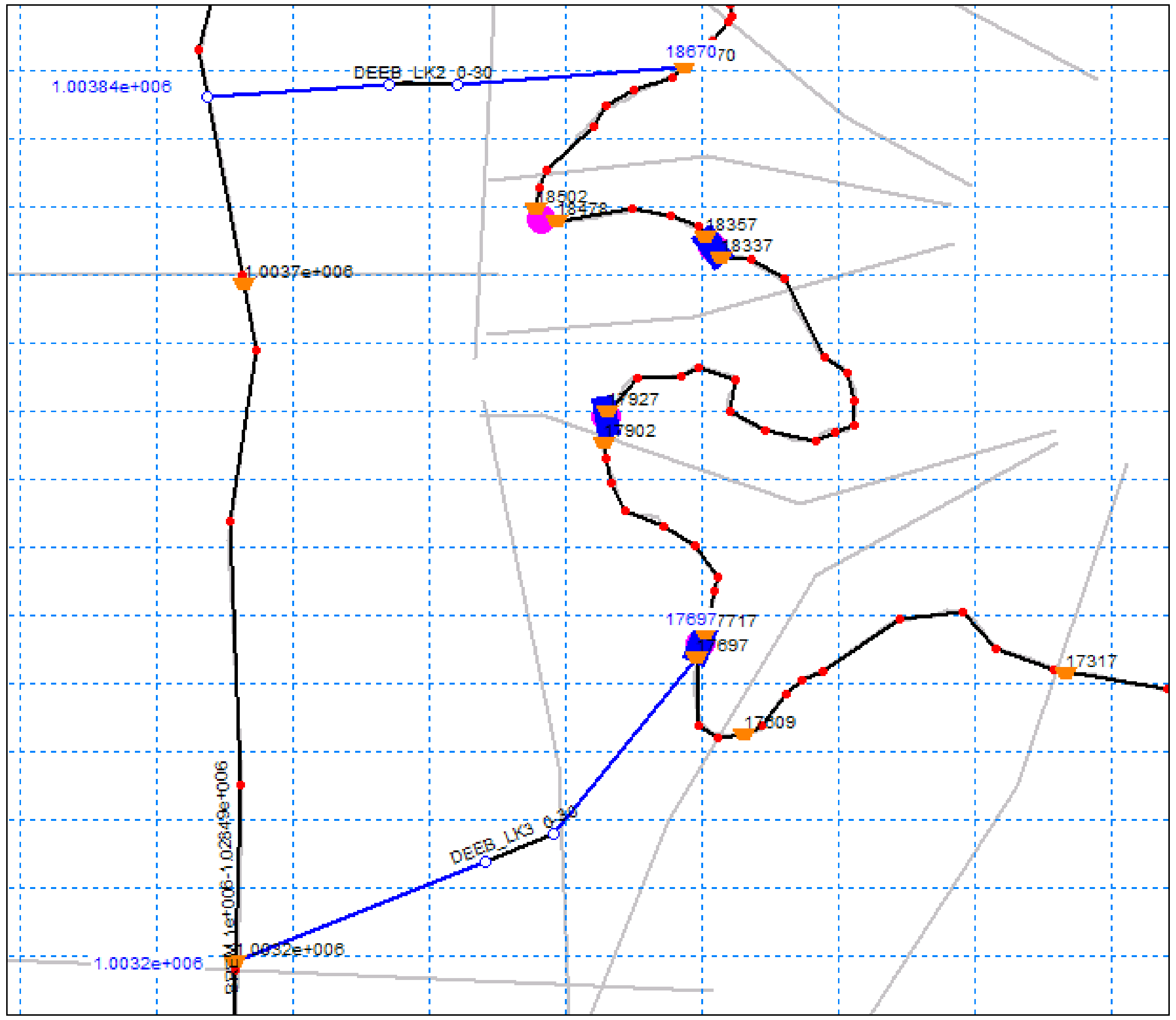


New_Deeb_16635

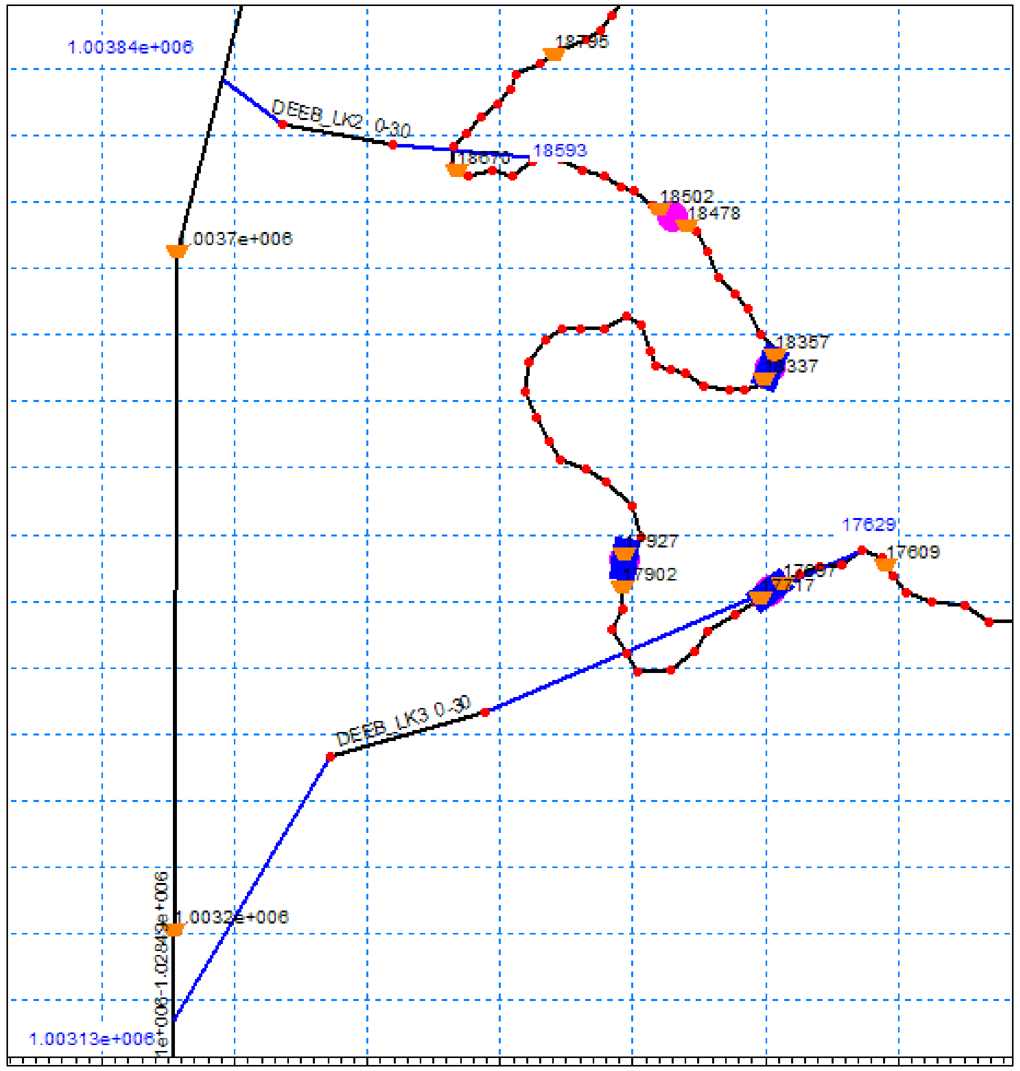


Old_Deeb_16643

Branch/Link Channel	Ch (m)	Ch (m)	Comment
DEEB	17080	17080	
DEEB	17317	17317	
DEEB	17609	17609	
DEEB	**17629**		Hydraulic connection redefined from 17629 to 17697
DEEB	**17629**		
DEEB	17697	17697	
		17697	
DEEB	17717	17717	
DEEB	17902	17902	
DEEB	17927	17927	
DEEB	18337	18337	
DEEB	18357	18357	
DEEB	18478	18478	
DEEB	18502	18502	
DEEB	**18593**		Hydraulic connection redefined from 18593to 18670
DEEB	**18593**		
DEEB	18670	18670	
		18670	



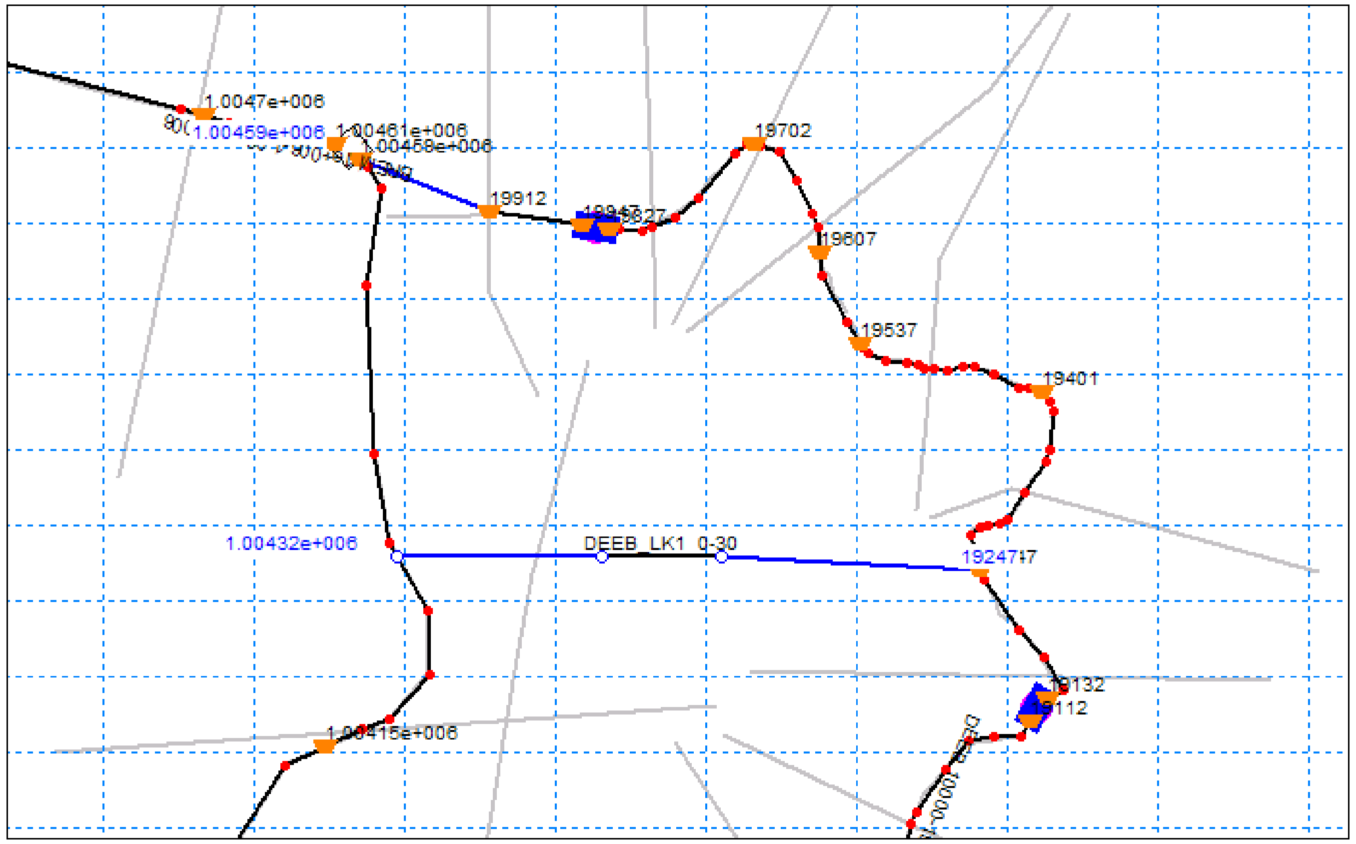
New_Deeb_17697



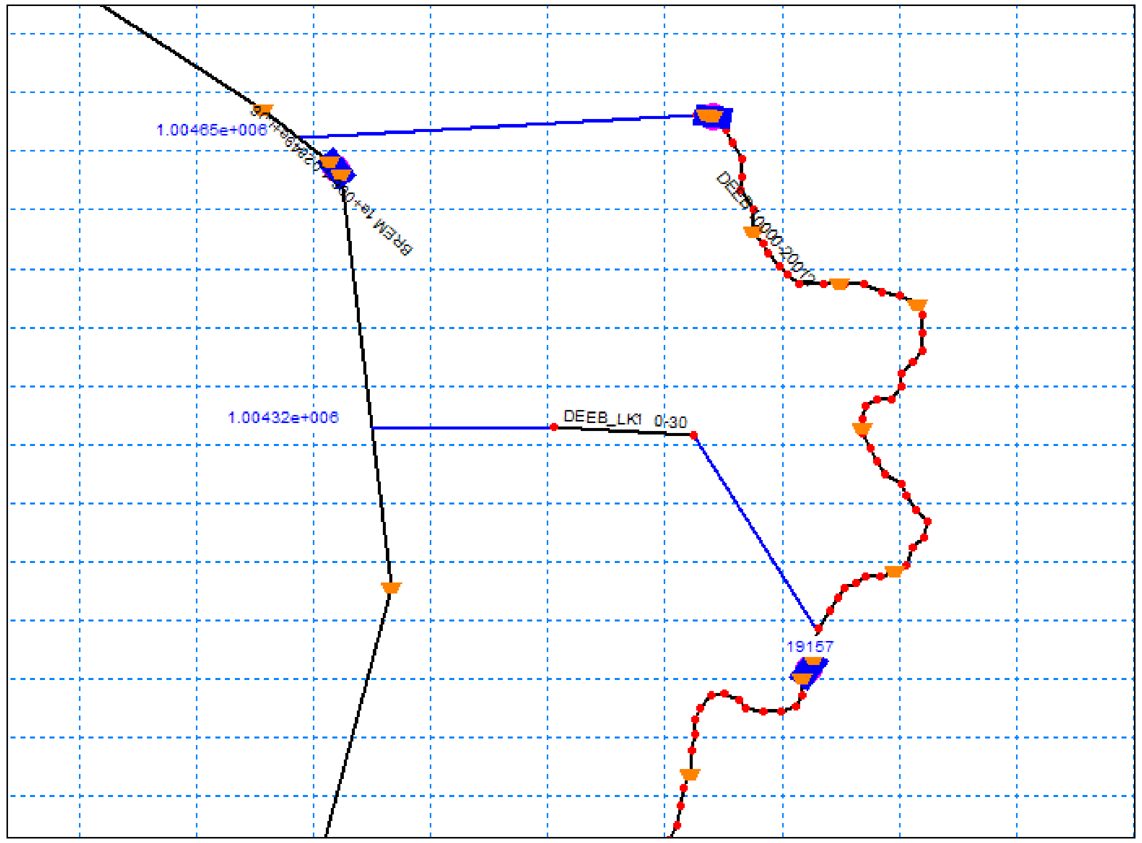
Old_Deeb_17629

Branch/Link Channel	**Ch (m)**	**Ch (m)**	**Figure**	**Comment**
DEEB	18795	18795		
DEEB	18936	18936		
DEEB	19112	19112		
DEEB	19132	19132		
DEEB	**19157**		New_Deeb_19247	Hydraulic connection redefined from 19157 to 19247
DEEB	**19157**		Old_Deeb_19157	
DEEB	19247	19247	19247	
		19247		
DEEB	19401	19401		
DEEB	19537	19537		
DEEB	19607	19607		
DEEB	19702	19702		
DEEB	19827	19827		
Branch/Lin	Ch (m)	Ch (m)	Figure	Comment

k Channel				
DEEB	19847	19847		
DEEB	19912	19912		
DEEB	**20012**			End of Branch relocated to last Cross section at 19912



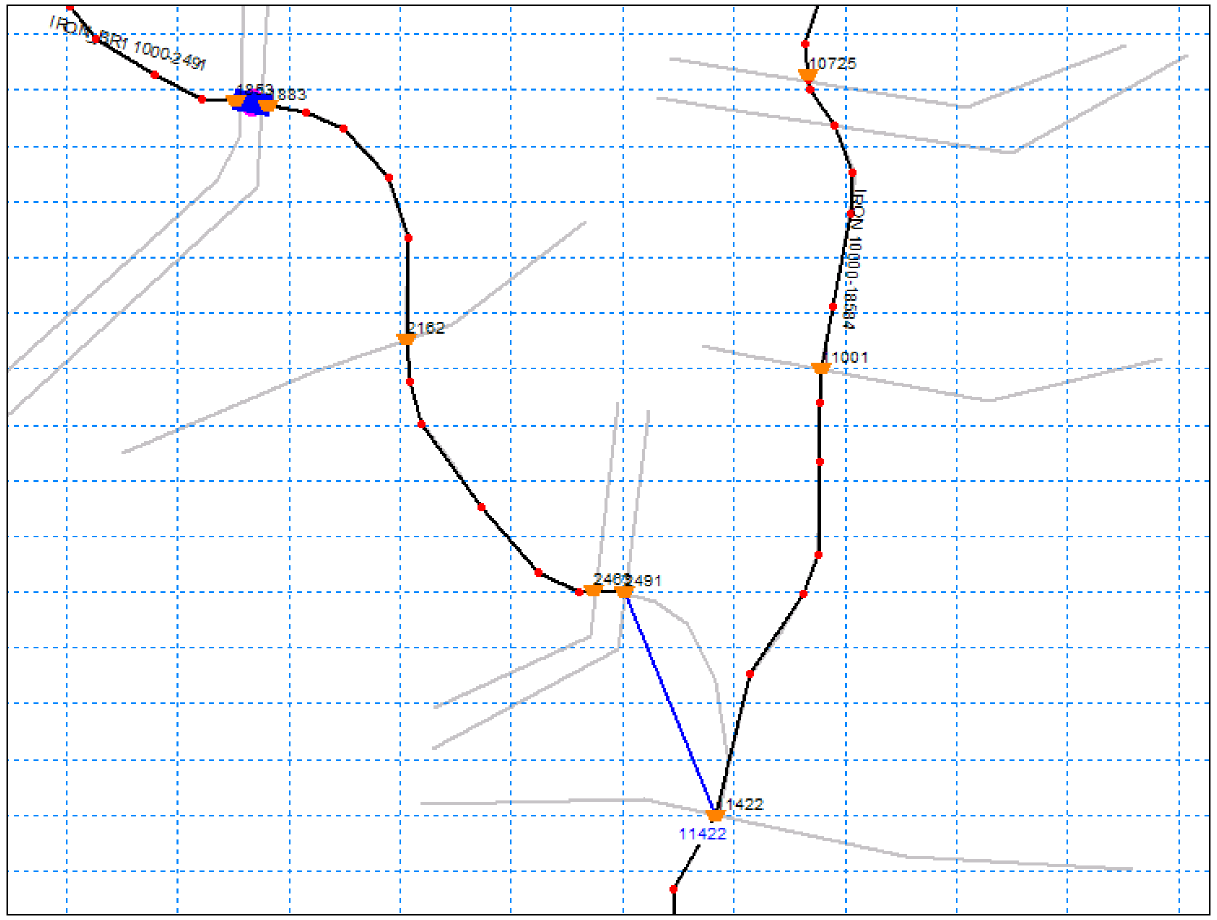
New_Deeb_19247



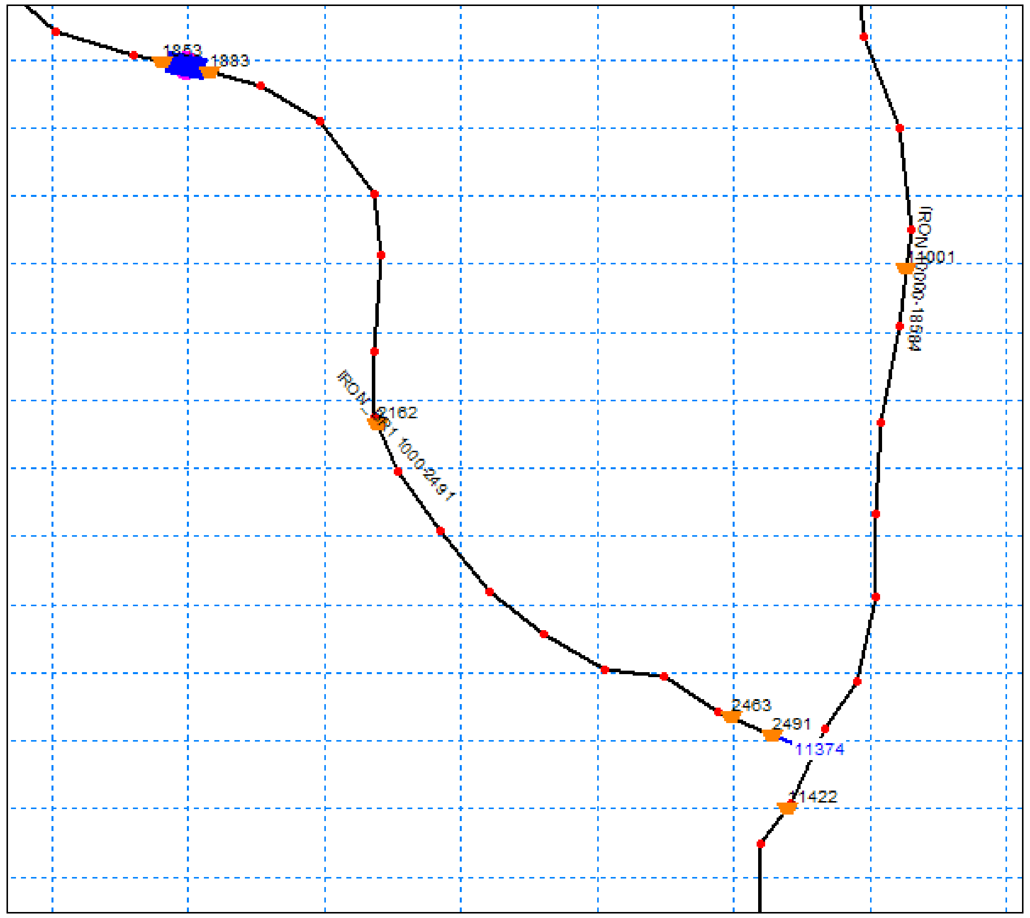
Old_Deeb_19157

Branch/Link Channel	Ch (m)	Ch (m)	\Figure	Comment
GOOD	10000	10000		
GOOD	10275	10275		
GOOD	10475	10475		
GOOD	10705	10705		
GOOD	10925	10925		
GOOD	11335	11335		
GOOD	11625	11625		
GOOD	11945	11945		
GOOD	12020	12020		
GOOD	12044	12044		
GOOD	12155	12155		
GOOD	12425	12425		
GOOD	12680	12680		
GOOD	12935	12935		
GOOD	13275	13275		
GOOD	13475	13475		
GOOD	13675	13675		
GOOD	14155	14155		
GOOD	14195	14195		
GOOD	14265	14265		
GOOD	14375	14375		
GOOD	14555	14555		
GOOD	14575	14575		
GOOD	14615	14615		
GOOD	14635	14635		
GOOD	14735	14735		
GOOD	14895	14895		
GOOD	14905	14905		
GOOD	14920	14920		
GOOD	14930	14930		
GOOD	14975	14975		
GOOD	15350	15350		
GOOD	15845	15845		
GOOD	16175	16175		
GOOD	16355	16355		
GOOD	16525	16525		
GOOD	16725	16725		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
IRON	10000	10000		
IRON	10274	10274		
IRON	10563	10563		
IRON	10725	10725		
IRON	11001	11001		
IRON	**11374**		New_Iron_11422	Hydraulic Connection redefined from 11374 to 11422
IRON	**11374**		Old_Iron_11374	
IRON	11422	11422		
		11422		



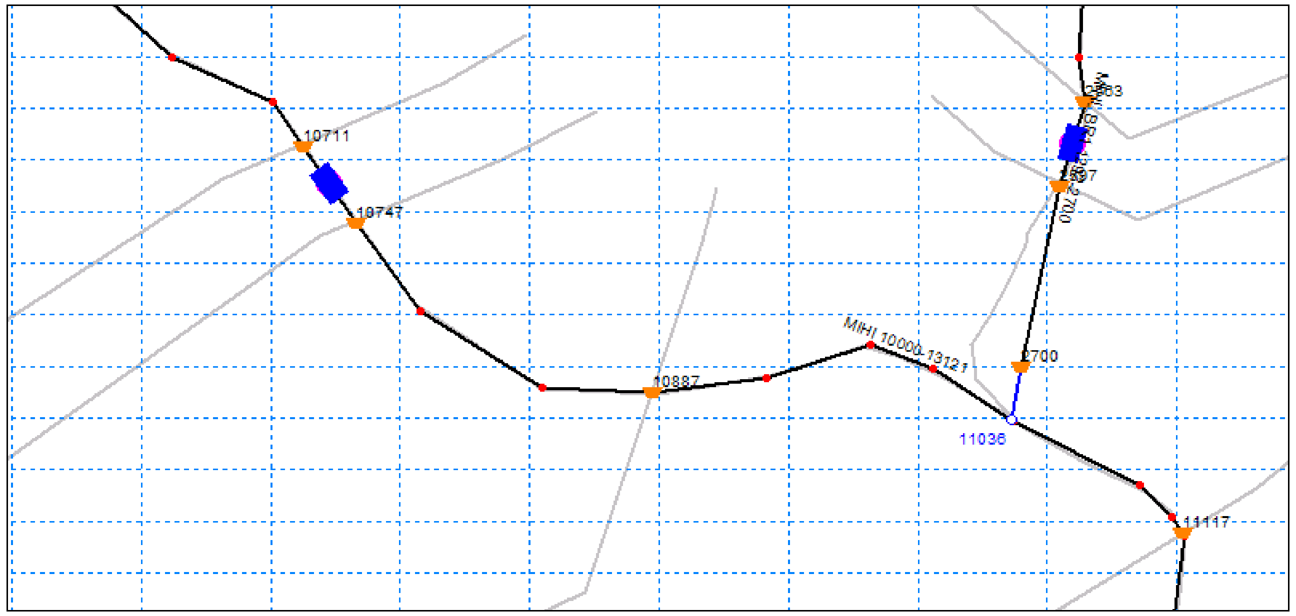
New_Iron_11422



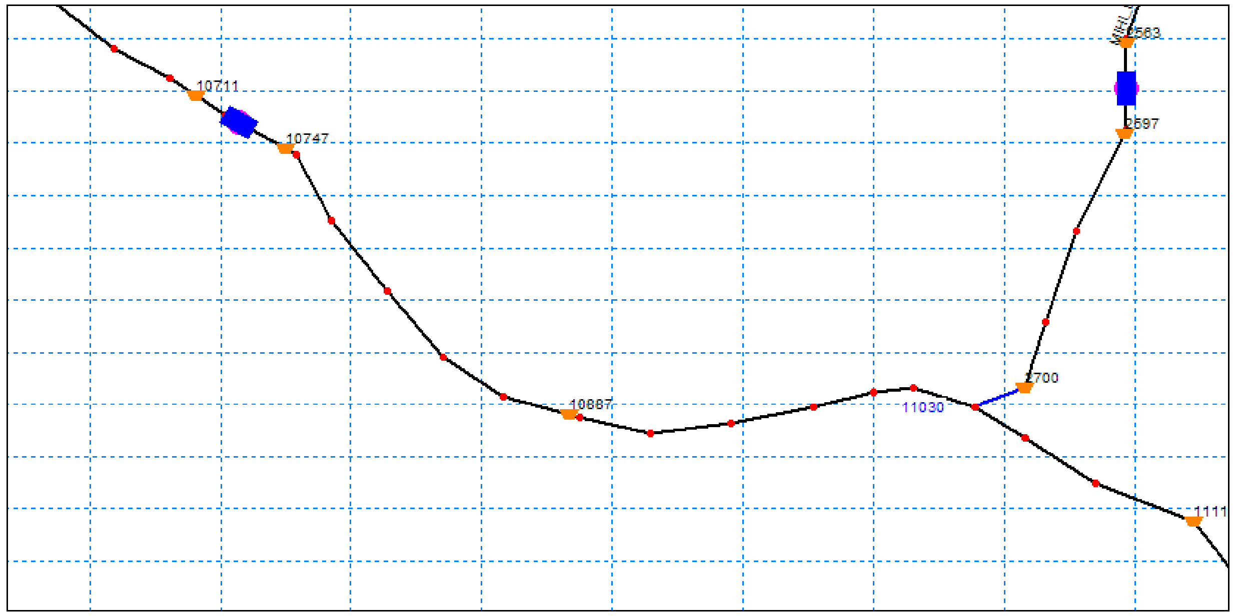
Old_Iron_11374

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
IRON	11765	11765		
IRON	11794	11794		
IRON	12052	12052		
IRON	12335	12335		
IRON	12618	12618		
IRON	12658	12658		
IRON	12962.5	12962.5		
IRON	13267	13267		
IRON	13766	13766		
IRON	14107	14107		
IRON	14456	14456		
IRON	14805	14805		
IRON	15139	15139		
IRON	15407	15407		
IRON	15700	15700		
IRON	15887	15887		
IRON	16198.5	16198.5		
IRON	16510	16510		
IRON	16827	16827		
IRON	17093	17093		
IRON	17336	17336		
IRON	17628	17628		
IRON	17884	17884		
IRON	18031	18031		
IRON	18156	18156		
IRON	18263	18263		
IRON	18363	18363		
IRON	18384	18384		
IRON	18584	18584		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
MIHI	10000	10000		
MIHI	10192	10192		
MIHI	10513	10513		
MIHI	10711	10711		
MIHI	10747	10747		
MIHI	10887	10887		
MIHI	**11030**		New_MIHI_11036	Hydraulic connection redefined from 11030 to 11036
MIHI	**11030**		Old_MIHI_11030	
		11036		
		11036		

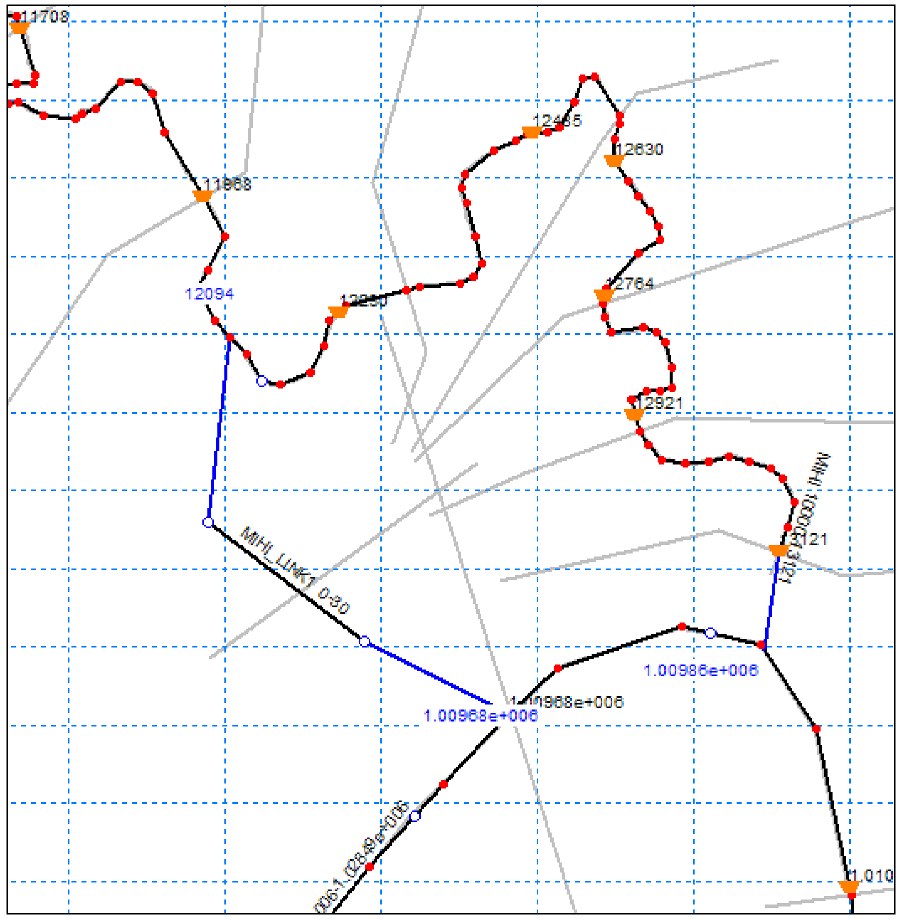


New_MIHI_11036

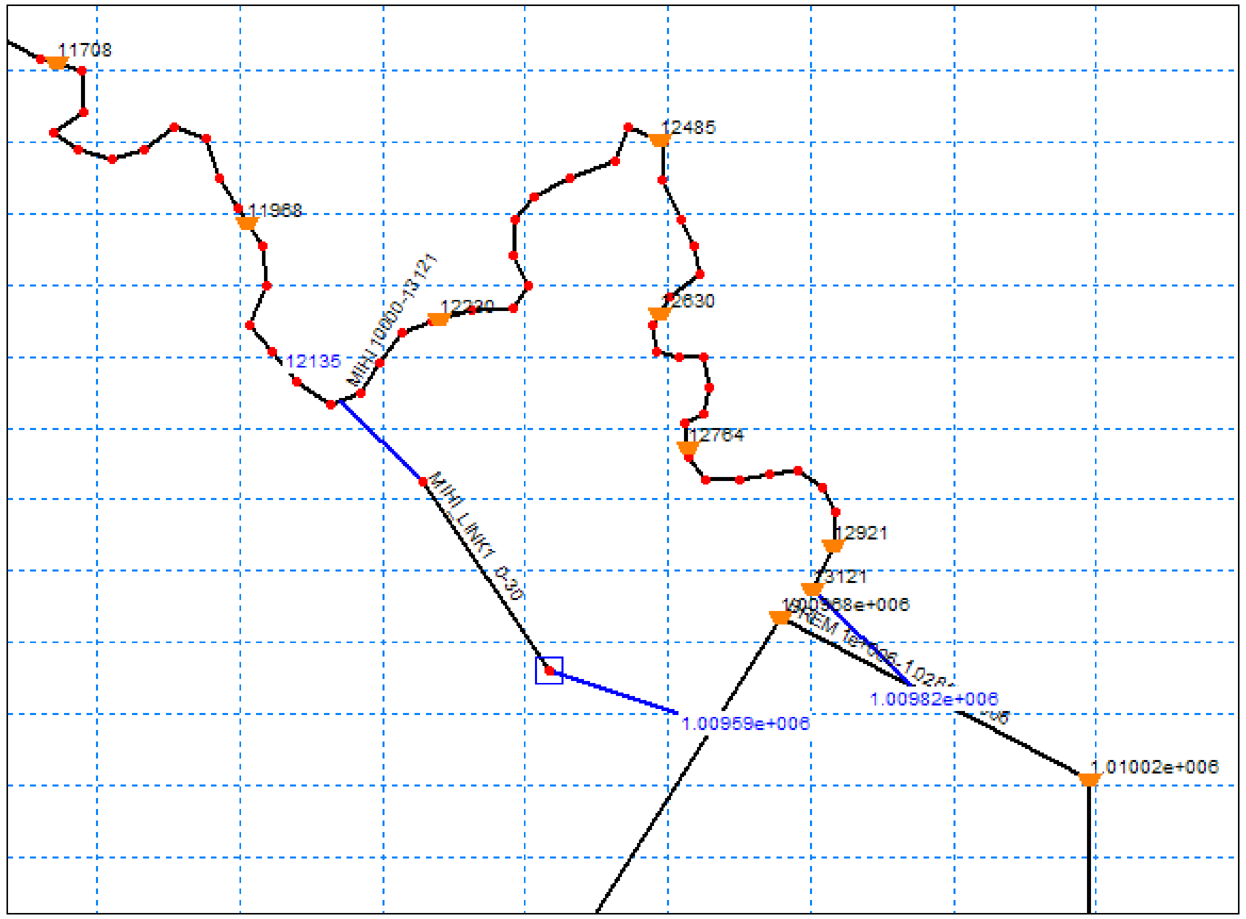


Old_MIHI_11030

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
MIHI	11117	11117		
MIHI	11277	11277		
MIHI	11310	11310		
MIHI	11468	11468		
MIHI	11708	11708		
MIHI	11968	11968		
		12094	New_Brem_10096775	Hydraulic connection redefined from 12135 to 12094
		12094	Old_Brem_1009585	
MIHI	**12135**			
MIHI	**12135**			



New_Brem_10096775



Old_Brem_1009585

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
MIHI	12230	12230		
MIHI	12485	12485		
MIHI	12630	12630		
MIHI	12764	12764		
MIHI	12921	12921		
MIHI	13121	13121		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
MIHI_BR1	1292	1292		
MIHI_BR1	1352	1352		
MIHI_BR1	1412	1412		
MIHI_BR1	1471	1471		
MIHI_BR1	1827	1827		
MIHI_BR1	2072	2072		
MIHI_BR1	2346	2346		
MIHI_BR1	2563	2563		
MIHI_BR1	2597	2597		
MIHI_BR1	2700	2700		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
MIHI_BR1	1292	1292		
MIHI_BR1	1352	1352		
MIHI_BR1	1412	1412		
MIHI_BR1	1471	1471		
MIHI_BR1	1827	1827		
MIHI_BR1	2072	2072		
MIHI_BR1	2346	2346		
MIHI_BR1	2563	2563		
MIHI_BR1	2597	2597		
MIHI_BR1	2700	2700		

Branch/Link Channel	Ch (m)	Ch (m)	Figure	Comment
PURGA	100000	100000		
PURGA	100432	100432	New_WAR_104444	Hydraulic Connection redefined from 100773 to 100432
		100432	Old_WAR_104287	
		100772.5		
PURGA	**100773**			
PURGA	**100773**			
PURGA	101113	101113		
PURGA	**101479**			Hydraulic connection redefined from 101479 to 101546
PURGA	**101479**			
		101546		
		101546		
PURGA	101845	101845		
PURGA	102174	102174		
PURGA	102174	102174		
PURGA	102502	102502		

APPENDIX C

Roughness Conditions Applied in Previous Studies.

Branch	Chainage	Roughness Mannings 'n				
		SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)*	Wivenhoe Alliance Model *(Ref-4)*	KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)*	KBR Upper Bremer River Model *(Ref-2)*
BNE	964170	0.085	0.080	0.085	-	-
BNE	966610	0.085	0.080	0.085	-	-
BNE	967410	0.085	0.080	0.085	-	-
BNE	969790	0.085	0.080	0.085	-	-
BNE	971160	0.085	0.080	0.085	-	-
BNE	972260	0.085	0.080	0.085	-	-
BNE	972600	0.085	0.080	0.085	-	-
BNE	973260	0.030	0.025	0.03	-	-
BNE	974580	0.030	0.025	0.03	-	-
BNE	976020	0.130	0.125	0.03	-	-
BNE	976750	0.130	0.125	0.13	-	-
BNE	976750	0.130	0.125	0.13	-	-
BNE	978280	0.130	0.125	0.13	-	-
BNE	979507	0.130	0.125	0.13	-	-
BNE	979513	0.130	0.125	0.13	-	-
BNE	979530	0.082	0.077	0.082	-	-
BNE	980330	0.082	0.077	0.082	-	-
BNE	981660	0.082	0.077	0.082	-	-
BNE	981960	0.082	0.077	0.082	-	-
BNE	982460	0.082	0.077	0.082	-	-
BNE	984160	0.082	0.077	0.082	-	-
BNE	985260	0.082	0.077	0.082	-	-
BNE	986480	0.082	0.077	0.082	-	-
BNE	987960	0.120	0.115	0.12	-	-
BNE	988160	0.120	0.115	0.12	-	-
BNE	988360	0.120	0.115	0.12	-	-
BNE	989700	0.085	0.080	0.085	-	-
BNE	990700	0.085	0.080	0.085	-	-
BNE	990760	0.090	0.085	0.09	-	-
BNE	991710	0.090	0.085	0.09	-	-
BNE	992420	0.090	0.085	0.09	-	-
BNE	992450	0.090	0.085	0.09	-	-
BNE	992470	0.090	0.085	0.09	-	-
BNE	992670	0.085	0.080	0.085	-	-
BNE	993760	0.090	0.085	0.09	-	-
BNE	994760	0.090	0.085	0.09	-	-
BNE	995690	0.090	0.085	0.09	-	-
BNE	996980	0.090	0.085	0.09	-	-
BNE	998460	0.080	0.075	0.08	-	-
BNE	999160	0.090	0.085	0.09	-	-
BNE	1000000	0.080	0.065	0.08	-	-
BNE	1000285	0.080	0.065	0.08	-	-
BNE	1000775	0.080	0.065	0.08	-	-
BNE	1001315	0.070	0.065	0.07	-	-
BNE	1001865	0.070	0.065	0.07	-	-
BNE	1002350	0.065	0.065	0.065	-	-
BNE	1002785	0.065	0.065	0.065	-	-
BNE	1003275	0.075	0.065	0.075	-	-
BNE	1003775	0.075	0.065	0.075	-	-
BNE	1004300	0.065	0.065	0.065	-	-
BNE	1004810	0.065	0.065	0.065	-	-
BNE	1005325	0.065	0.055	0.065	-	-
BNE	1005870	0.065	0.035	0.065	-	-
BNE	1006300	0.070	0.035	0.074	-	-
BNE	1006910	0.070	0.035	0.074	-	-
BNE	1007410	0.050	0.035	0.053	-	-
BNE	1007920	0.065	0.035	0.068	-	-
BNE	1008445	0.055	0.035	0.058	-	-
BNE	1008925	0.040	0.035	0.042	-	-
BNE	1009400	0.040	0.035	0.042	-	-
BNE	1009820	0.040	0.035	0.042	-	-
BNE	1010490	0.040	0.035	0.042	-	-
BNE	1010725	0.040	0.035	0.042	-	-
BNE	1010980	0.040	0.035	0.042	-	-
BNE	1011510	0.040	0.035	0.042	-	-
BNE	1011980	0.055	0.035	0.058	-	-
BNE	1012475	0.053	0.035	0.056	-	-
BNE	1012935	0.058	0.035	0.061	-	-
BNE	1013445	0.063	0.035	0.066	-	-
BNE	1013920	0.065	0.035	0.068	-	-
BNE	1014110	0.065	0.035	0.068	-	-
BNE	1014610	0.065	0.035	0.068	-	-
BNE	1015090	0.065	0.035	0.068	-	-
BNE	1015560	0.065	0.040	0.068	-	-
BNE	1016140	0.065	0.040	0.068	-	-
BNE	1016640	0.065	0.040	0.068	-	-
BNE	1017130	0.068	0.040	0.071	-	-
BNE	1017610	0.068	0.040	0.071	-	-
BNE	1017920	0.068	0.040	0.071	-	-
BNE	1018200	0.073	0.040	0.077	-	-
BNE	1018725	0.073	0.040	0.077	-	-
BNE	1019095	0.073	0.040	0.077	-	-
BNE	1019490	0.073	0.040	0.077	-	-
BNE	1019865	0.073	0.040	0.077	-	-
BNE	1020115	0.073	0.040	0.077	-	-
BNE	1020525	0.073	0.040	0.077	-	-
BNE	1020830	0.073	0.040	0.077	-	-
BNE	1021095	0.073	0.040	0.077	-	-
BNE	1021539	0.068	0.040	0.071	-	-
BNE	1021715	0.068	0.040	0.071	-	-
BNE	1021895	0.068	0.040	0.071	-	-
BNE	1022105	0.068	0.040	0.071	-	-
BNE	1022575	0.043	0.040	0.045	-	-
BNE	1023040	0.043	0.040	0.045	-	-
BNE	1023570	0.043	0.040	0.045	-	-
BNE	1024080	0.043	0.040	0.045	-	-
BNE	1024563	0.053	0.040	0.056	-	-
BNE	1025070	0.053	0.040	0.056	-	-
BNE	1025360	0.053	0.040	0.056	-	-
BNE	1025590	0.053	0.040	0.056	-	-
BNE	1026170	0.053	0.040	0.056	-	-
BNE	1026680	0.053	0.040	0.056	-	-
BNE	1026900	0.053	0.040	0.056	-	-
BNE	1027160	0.053	0.040	0.056	-	-
BNE	1027680	0.028	0.040	0.029	-	-
BNE	1028180	0.028	0.040	0.029	-	-
BNE	1028680	0.028	0.040	0.029	-	-
BNE	1028760	0.033	0.040	0.035	-	-
BNE	1029200	0.033	0.040	0.035	-	-
BNE	1029680	0.028	0.040	0.029	-	-

		Roughness Mannings 'n				
Branch	**Chainage**	**SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)***	**SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)***	**Wivenhoe Alliance Model *(Ref-4)***	**KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)***	**KBR Upper Bremer River Model *(Ref-2)***
BNE	1030220	0.028	0.040	0.029	-	-
BNE	1030870	0.028	0.040	0.029	-	-
BNE	1031260	0.048	0.045	0.05	-	-
BNE	1031700	0.073	0.045	0.077	-	-
BNE	1031995	0.073	0.045	0.077	-	-
BNE	1032230	0.063	0.045	0.066	-	-
BNE	1032585	0.073	0.045	0.077	-	-
BNE	1033080	0.053	0.045	0.056	-	-
BNE	1033370	0.053	0.045	0.056	-	-
BNE	1033900	0.048	0.045	0.05	-	-
BNE	1034370	0.048	0.045	0.05	-	-
BNE	1034414	0.063	0.045	0.066	-	-
BNE	1034890	0.058	0.045	0.061	-	-
BNE	1035900	0.063	0.045	0.066	-	-
BNE	1036460	0.063	0.045	0.066	-	-
BNE	1036770	0.063	0.045	0.066	-	-
BNE	1036915	0.063	0.045	0.066	-	-
BNE	1037090	0.063	0.045	0.066	-	-
BNE	1037175	0.053	0.045	0.056	-	-
BNE	1037285	0.053	0.045	0.056	-	-
BNE	1037625	0.053	0.045	0.056	-	-
BNE	1038085	0.028	0.045	0.029	-	-
BNE	1038600	0.028	0.040	0.029	-	-
BNE	1039100	0.028	0.040	0.029	-	-
BNE	1039565	0.028	0.040	0.029	-	-
BNE	1040090	0.028	0.040	0.029	-	-
BNE	1040490	0.028	0.040	0.029	-	-
BNE	1041010	0.058	0.045	0.061	-	-
BNE	1041230	0.058	0.045	0.061	-	-
BNE	1041460	0.058	0.055	0.061	-	-
BNE	1041700	0.058	0.055	0.061	-	-
BNE	1041960	0.058	0.055	0.061	-	-
BNE	1042235	0.058	0.055	0.061	-	-
BNE	1042515	0.058	0.055	0.061	-	-
BNE	1042910	0.058	0.055	0.061	-	-
BNE	1043725	0.058	0.055	0.061	-	-
BNE	1044060	0.068	0.055	0.071	-	-
BNE	1044340	0.068	0.055	0.071	-	-
BNE	1044605	0.068	0.055	0.071	-	-
BNE	1044860	0.068	0.055	0.071	-	-
BNE	1045400	0.068	0.055	0.071	-	-
BNE	1045885	0.068	0.055	0.071	-	-
BNE	1046180	0.068	0.045	0.071	-	-
BNE	1046340	0.068	0.045	0.071	-	-
BNE	1046580	0.068	0.045	0.071	-	-
BNE	1046900	0.068	0.045	0.071	-	-
BNE	1047350	0.068	0.045	0.071	-	-
BNE	1047915	0.048	0.045	0.05	-	-
BNE	1048375	0.048	0.045	0.05	-	-
BNE	1048890	0.048	0.045	0.05	-	-
BNE	1049120	0.048	0.045	0.05	-	-
BNE	1049370	0.048	0.045	0.05	-	-
BNE	1049590	0.043	0.035	0.045	-	-
BNE	1049870	0.043	0.028	0.045	-	-
BNE	1050430	0.028	0.028	0.029	-	-
BNE	1050860	0.028	0.028	0.029	-	-
BNE	1051360	0.028	0.028	0.029	-	-
BNE	1051895	0.028	0.030	0.029	-	-
BNE	1052310	0.028	0.025	0.029	-	-
BNE	1052390	0.028	0.025	0.029	-	-
BNE	1052595	0.028	0.025	0.029	-	-
BNE	1052640	0.043	0.025	0.045	-	-
BNE	1052865	0.048	0.025	0.05	-	-
BNE	1053320	0.058	0.025	0.061	-	-
BNE	1053385	0.058	0.025	0.061	-	-
BNE	1053900	0.058	0.040	0.061	-	-
BNE	1054490	0.058	0.040	0.061	-	-
BNE	1054640	0.058	0.040	0.061	-	-
BNE	1054680	0.058	0.040	0.061	-	-
BNE	1054760	0.048	0.040	0.05	-	-
BNE	1054970	0.033	0.035	0.035	-	-
BNE	1055280	0.033	0.035	0.035	-	-
BNE	1055420	0.033	0.035	0.035	-	-
BNE	1055960	0.033	0.035	0.035	-	-
BNE	1056400	0.033	0.035	0.035	-	-
BNE	1056695	0.048	0.040	0.05	-	-
BNE	1056865	0.038	0.005	0.04	-	-
BNE	1056950	0.038	0.005	0.04	-	-
BNE	1057090	0.038	0.045	0.04	-	-
BNE	1057530	0.038	0.045	0.04	-	-
BNE	1058040	0.038	0.045	0.04	-	-
BNE	1058230	0.038	0.045	0.04	-	-
BNE	1058530	0.038	0.045	0.04	-	-
BNE	1058735	0.048	0.045	0.05	-	-
BNE	1059035	0.048	0.045	0.05	-	-
BNE	1059540	0.048	0.045	0.05	-	-
BNE	1059990	0.048	0.040	0.05	-	-
BNE	1060535	0.043	0.030	0.045	-	-
BNE	1060845	0.033	0.030	0.035	-	-
BNE	1061015	0.033	0.030	0.035	-	-
BNE	1061530	0.033	0.031	0.035	-	-
BNE	1062020	0.033	0.031	0.035	-	-
BNE	1062535	0.033	0.031	0.035	-	-
BNE	1062940	0.033	0.031	0.035	-	-
BNE	1063310	0.048	0.040	0.05	-	-
BNE	1063645	0.029	0.040	0.03	-	-
BNE	1064000	0.029	0.023	0.03	-	-
BNE	1064490	0.029	0.023	0.03	-	-
BNE	1065010	0.029	0.023	0.03	-	-
BNE	1065503	0.029	0.023	0.03	-	-
BNE	1065990	0.029	0.023	0.03	-	-
BNE	1066505	0.029	0.023	0.03	-	-
BNE	1067020	0.029	0.023	0.03	-	-
BNE	1067485	0.029	0.023	0.03	-	-
BNE	1067965	0.029	0.023	0.03	-	-
BNE	1068660	0.029	0.024	0.03	-	-
BNE	1069045	0.029	0.024	0.03	-	-
BNE	1069535	0.029	0.024	0.03	-	-
BNE	1070025	0.029	0.024	0.03	-	-
BNE	1070530	0.029	0.024	0.03	-	-

Branch	Chainage	Roughness Mannings 'n SKM Lower Ipswich Rivers Model 1974 Event (Ref-1)	SKM Lower Ipswich Rivers Model 1989 Event (Ref-1)	Wivenhoe Alliance Model (Ref-4)	KBR Adjustments to SKM Lower Ipswich Model (Ref-3)	KBR Upper Bremer River Model (Ref-2)
BNE	1071040	0.029	0.024	0.03	-	-
BNE	1071520	0.029	0.024	0.03	-	-
BNE	1072015	0.029	0.024	0.03	-	-
BNE	1072515	0.029	0.024	0.03	-	-
BNE	1072995	0.029	0.024	0.03	-	-
BNE	1073485	0.029	0.024	0.03	-	-
BNE	1074000	0.029	0.024	0.03	-	-
BNE	1074460	0.029	0.024	0.03	-	-
BNE	1074985	0.029	0.024	0.03	-	-
BNE	1075480	0.029	0.024	0.03	-	-
BNE	1076000	0.029	0.024	0.03	-	-
BNE	1076495	0.029	0.024	0.03	-	-
BNE	1077010	0.029	0.024	0.03	-	-
BNE	1077510	0.029	0.024	0.03	-	-
BNE	1078040	0.029	0.024	0.03	-	-
BNE	1078525	0.029	0.024	0.03	-	-
BNE	1078660	0.029	0.024	0.03	-	-
BREAKFAST	599400	0.06	0.07	0.06	-	-
BREAKFAST	600000	0.06	0.07	0.06	-	-
BREM	1000000	0.13	0.07	0.13	0.08	-
BREM	1000700	0.13	0.07	0.13	0.08	-
BREM	1001120	0.13	0.07	0.13	0.08	-
BREM	1001700	0.14	0.07	0.14	0.08	-
BREM	1002300	0.14	0.07	0.14	0.08	-
BREM	1002700	0.14	0.07	0.14	0.08	-
BREM	1003200	0.12	0.07	0.12	0.08	-
BREM	1003700	0.12	0.07	0.12	0.08	-
BREM	1004150	0.12	0.07	0.12	0.08	-
BREM	1004590	0.12	0.07	0.12	0.08	-
BREM	1004610	0.1	0.07	0.1	0.08	-
BREM	1004700	0.1	0.07	0.1	0.08	-
BREM	1005140	0.1	0.07	0.1	0.08	-
BREM	1005520	0.1	0.07	0.1	0.08	-
BREM	1005740	0.1	0.07	0.1	0.08	-
BREM	1006090	0.1	0.07	0.1	0.08	-
BREM	1006250	0.1	0.07	0.1	0.08	-
BREM	1006490	0.085	0.07	0.085	0.08	-
BREM	1006510	0.085	0.07	0.085	0.08	-
BREM	1006780	0.085	0.07	0.085	0.08	-
BREM	1007440	0.085	0.07	0.085	0.08	-
BREM	1007700	0.11	0.07	0.11	0.08	-
BREM	1008000	0.11	0.07	0.11	0.08	-
BREM	1008390	0.11	0.07	0.11	0.08	-
BREM	1008410	0.11	0.07	0.11	0.08	-
BREM	1008420	0.11	0.07	0.11	0.08	-
BREM	1008660	0.11	0.07	0.11	0.08	-
BREM	1009210	0.13	0.07	0.13	0.08	-
BREM	1009675	0.13	0.07	0.13	0.08	-
BREM	1010020	0.13	0.07	0.13	0.08	-
BREM	1010280	0.11	0.07	0.11	0.08	-
BREM	1010700	0.11	0.07	0.11	0.08	-
BREM	1010890	0.11	0.07	0.11	0.08	-
BREM	1011320	0.11	0.07	0.11	0.08	-
BREM	1011700	0.11	0.07	0.11	0.08	-
BREM	1011790	0.11	0.07	0.11	0.08	-
BREM	1011810	0.11	0.07	0.11	0.08	-
BREM	1012050	0.05	0.04	0.05	-	-
BREM	1012070	0.05	0.04	0.05	-	-
BREM	1012200	0.05	0.04	0.05	-	-
BREM	1012870	0.05	0.04	0.05	-	-
BREM	1013380	0.05	0.04	0.05	-	-
BREM	1013700	0.05	0.04	0.05	-	-
BREM	1014220	0.05	0.04	0.05	-	-
BREM	1014640	0.05	0.04	0.05	-	-
BREM	1015180	0.05	0.04	0.05	-	-
BREM	1015445	0.05	0.04	0.05	-	-
BREM	1015445	0.05	0.04	0.05	-	-
BREM	1015710	0.05	0.04	0.05	-	-
BREM	1016110	0.05	0.04	0.05	-	-
BREM	1016110	0.05	0.04	0.05	-	-
BREM	1016510	0.05	0.04	0.05	-	-
BREM	1017080	0.05	0.04	0.05	-	-
BREM	1017750	0.05	0.04	0.05	-	-
BREM	1018140	0.05	0.04	0.05	-	-
BREM	1018320	0.05	0.04	0.05	-	-
BREM	1018320	0.05	0.04	0.05	-	-
BREM	1018500	0.05	0.04	0.05	-	-
BREM	1018630	0.05	0.04	0.05	-	-
BREM	1018630	0.05	0.04	0.05	-	-
BREM	1018760	0.05	0.04	0.05	-	-
BREM	1019150	0.05	0.04	0.05	-	-
BREM	1019580	0.05	0.04	0.05	-	-
BREM	1020000	0.09	0.055	0.09	0.08	-
BREM	1020300	0.09	0.055	0.09	0.08	-
BREM	1020300	0.09	0.055	0.09	0.08	-
BREM	1020450	0.09	0.055	0.09	0.08	-
BREM	1020920	0.09	0.055	0.09	0.08	-
BREM	1021460	0.09	0.055	0.09	0.08	-
BREM	1022300	0.09	0.055	0.09	0.08	-
BREM	1022950	0.09	0.055	0.09	0.08	-
BREM	1023490	0.09	0.055	0.09	0.08	-
BREM	1023510	0.09	0.055	0.09	0.08	-
BREM	1023870	0.09	0.055	0.09	0.08	-
BREM	1024220	0.09	0.055	0.09	0.08	-
BREM	1024520	0.09	0.055	0.09	0.08	-
BREM	1024750	0.09	0.055	0.09	0.08	-
BREM	1025300	0.09	0.055	0.09	0.08	-
BREM	1025670	0.09	0.055	0.09	0.08	-
BREM	1025920	0.09	0.055	0.09	0.08	-
BREM	1026150	0.09	0.055	0.09	0.08	-
BREM	1026560	0.09	0.055	0.09	0.08	-
BREM	1027100	0.09	0.055	0.09	0.08	-
BREM	1027640	0.09	0.055	0.09	0.08	-
BREM	1027840	0.09	0.055	0.09	0.08	-
BREM	1028190	0.09	0.055	0.09	0.08	-
BREM	1028190	0.09	0.055	0.09	0.08	-
BREM	1028490	0.09	0.055	0.09	0.08	-
BREMBRISLINK1	0	0.06	0.07	0.06	-	-
BREMBRISLINK1	150	0.06	0.07	0.06	-	-
Bremer	0	-	-	-	-	0.045

		Roughness Mannings 'n				
Branch	**Chainage**	**SKM Lower Ipswich Rivers Model 1974 Event** ***(Ref-1)***	**SKM Lower Ipswich Rivers Model 1989 Event** ***(Ref-1)***	**Wivenhoe Alliance Model** ***(Ref-4)***	**KBR Adjustments to SKM Lower Ipswich Model** ***(Ref-3)***	**KBR Upper Bremer River Model** ***(Ref-2)***
Bremer	30791	-	-	-	-	0.045
Bremer-BoonahNew	9869	-	-	-	-	0.045
Bremer-BoonahNew	29213	-	-	-	-	0.045
BREMLINKBRANCH1	0	0.06	0.055	0.06	-	-
BREMLINKBRANCH1	10	0.06	0.055	0.06	-	-
BREMLINKBRANCH2	0	0.06	0.055	0.06	-	-
BREMLINKBRANCH2	50	0.06	0.055	0.06	-	-
BULIMBA	599400	0.06	0.06	0.06	-	-
BULIMBA	600000	0.06	0.06	0.06	-	-
BUND	10000	0.08	0.05	0.08	-	-
BUND	10307	0.08	0.05	0.08	-	-
BUND	10615	0.08	0.05	0.08	-	-
BUND	11108	0.08	0.05	0.08	-	-
BUND	11600	0.08	0.05	0.08	-	-
BUND	11968	0.08	0.05	0.08	-	-
BUND	12337	0.08	0.05	0.08	-	-
BUND	12705	0.08	0.05	0.08	-	-
BUND	13165	0.08	0.05	0.08	-	-
BUND	13553	0.08	0.05	0.08	-	-
BUND	13940	0.08	0.05	0.08	-	-
BUND	14217	0.08	0.05	0.08	-	-
BUND	14495	0.08	0.05	0.08	-	-
BUND	14775	0.08	0.05	0.08	-	-
BUND	15055	0.08	0.05	0.08	-	-
BUND	15378	0.08	0.05	0.08	-	-
BUND	15700	0.08	0.05	0.08	-	-
BUND	16047	0.08	0.05	0.08	-	-
BUND	16395	0.08	0.05	0.08	-	-
BUND	16648	0.08	0.05	0.08	-	-
BUND	16900	0.08	0.05	0.08	-	-
BUND	17215	0.08	0.05	0.08	-	-
BUND	17530	0.08	0.05	0.08	-	-
BUND	17885	0.08	0.05	0.08	-	-
BUND	18308	0.08	0.05	0.08	-	-
BUND	18730	0.08	0.05	0.08	-	-
BUND	18750	0.08	0.05	0.08	-	-
BUND	19015	0.08	0.05	0.08	-	-
BUND	19280	0.08	0.05	0.08	-	-
BUND	19540	0.08	0.05	0.08	-	-
BUND	19800	0.08	0.05	0.08	-	-
BUND	20120	0.08	0.05	0.08	-	-
BUND	20440	0.08	0.05	0.08	-	-
BUND	20905	0.08	0.05	0.08	-	-
BUND	21370	0.08	0.05	0.08	-	-
BUND	21727	0.08	0.05	0.08	-	-
BUND	22085	0.08	0.05	0.08	-	-
BUND	22085	0.08	0.05	0.08	-	-
BUND	22120	0.08	0.05	0.08	-	-
BUND	22453	0.08	0.05	0.08	-	-
BUND	22785	0.08	0.05	0.08	-	-
BUND	23150	0.08	0.05	0.08	-	-
BUND	23515	0.08	0.05	0.08	-	-
BUND	23823	0.08	0.05	0.08	-	-
BUND	24130	0.08	0.05	0.08	-	-
BUND	24445	0.08	0.05	0.08	-	-
BUND	24760	0.08	0.05	0.08	-	-
BUND	25075	0.08	0.05	0.08	-	-
BUND	25328	0.08	0.05	0.08	-	-
BUND	25580	0.08	0.05	0.08	-	-
BUND	25600	0.08	0.05	0.08	-	-
BUND	26070	0.08	0.05	0.08	-	-
BUND	26540	0.08	0.05	0.08	-	-
BUND	26780	0.08	0.05	0.08	-	-
BUND	27280	0.08	0.05	0.08	-	-
BUND	27380	0.08	0.05	0.08	-	-
BUND	27400	0.08	0.05	0.08	-	-
BUND	27655	0.08	0.05	0.08	-	-
BUND	27675	0.08	0.05	0.08	-	-
BUND	28010	0.08	0.05	0.08	-	-
BUND	28200	0.08	0.05	0.08	-	-
BUND	28200	0.08	0.05	0.08	-	-
BUND	28440	0.08	0.05	0.08	-	-
BUND	28460	0.08	0.05	0.08	-	-
BUND	28480	0.08	0.05	0.08	-	-
BUND	28540	0.08	0.05	0.08	-	-
BUND	28560	0.08	0.05	0.08	-	-
BUND	28900	0.08	0.05	0.08	-	-
BUND	29240	0.06	0.05	0.06	-	-
BUND	29550	0.06	0.05	0.06	-	-
BUND	29910	0.06	0.05	0.06	-	-
BUND	30215	0.06	0.045	0.06	-	-
BUND	30520	0.06	0.045	0.06	-	-
BUND	30940	0.06	0.045	0.06	-	-
BUND	31360	0.06	0.045	0.06	-	-
BUND	31630	0.06	0.045	0.06	-	-
BUND	31980	0.06	0.045	0.06	-	-
BUND	32000	0.06	0.045	0.06	-	-
BUND	32150	0.06	0.045	0.06	-	-
BUND	32350	0.06	0.045	0.06	-	-
BUND	32370	0.06	0.045	0.06	-	-
BUND	32675	0.06	0.045	0.06	-	-
BUND	32980	0.06	0.045	0.06	-	-
BUND	33320	0.06	0.045	0.06	-	-
BUND	33660	0.06	0.045	0.06	-	-
BUND	33950	0.06	0.045	0.06	-	-
BUND	33950	0.06	0.045	0.06	-	-
BUND	34000	0.04	0.045	0.04	-	-
BUND	34260	0.04	0.045	0.04	-	-
BUND	34305	0.04	0.045	0.04	-	-
BUND	34345	0.04	0.045	0.04	-	-
BUND	34395	0.04	0.045	0.04	-	-
BUND	34760	0.04	0.045	0.04	-	-
BUND	35050	0.04	0.045	0.04	-	-
BUND	35100	0.04	0.045	0.04	-	-
BUND	35120	0.04	0.045	0.04	-	-
BUND	35520	0.04	0.045	0.04	-	-
BUND	35540	0.04	0.045	0.04	-	-
BUND	35730	0.04	0.045	0.04	-	-
BUND	36005	0.04	0.045	0.04	-	-
BUND	36025	0.04	0.045	0.04	-	-

Branch	Chainage	Roughness Mannings 'n				
		SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	**SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)***	**Wivenhoe Alliance Model *(Ref-4)***	**KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)***	**KBR Upper Bremer River Model *(Ref-2)***
BUND	36297	0.04	0.045	0.04	-	-
BUND	36570	0.04	0.045	0.04	-	-
BUND	36840	0.04	0.045	0.04	-	-
BUND	37110	0.04	0.045	0.04	-	-
BUND	37460	0.04	0.045	0.04	-	-
BUND	37810	0.04	0.045	0.04	-	-
BUND	37810	0.04	0.045	0.04	-	-
BUND	37910	0.04	0.045	0.04	-	-
BUND	38280	0.04	0.045	0.04	-	-
BUND	38722	0.04	0.045	0.04	-	-
BUND	39165	0.04	0.045	0.04	-	-
BUND	39547	0.04	0.045	0.04	-	-
BUND	39928	0.04	0.045	0.04	-	-
BUND	40310	0.04	0.045	0.04	-	-
BUND	40670	0.04	0.045	0.04	-	-
BUND	41030	0.04	0.045	0.04	-	-
BUND#	0	0.06	0.06	0.06	-	-
BUND#	90	0.06	0.06	0.06	-	-
DEEB	10000	0.05	0.05	0.05	-	-
DEEB	10315	0.05	0.05	0.05	-	-
DEEB	10572	0.05	0.05	0.05	-	-
DEEB	10862	0.05	0.05	0.05	-	-
DEEB	11080	0.05	0.05	0.05	-	-
DEEB	11141	0.05	0.05	0.05	-	-
DEEB	11453	0.05	0.05	0.05	-	-
DEEB	11837	0.05	0.05	0.05	-	-
DEEB	12080	0.05	0.05	0.05	-	-
DEEB	12111	0.05	0.05	0.05	-	-
DEEB	12407	0.05	0.05	0.05	-	-
DEEB	12643	0.05	0.05	0.05	-	-
DEEB	12887	0.05	0.05	0.05	-	-
DEEB	12971	0.05	0.05	0.05	-	-
DEEB	13165	0.05	0.05	0.05	-	-
DEEB	13295	0.05	0.05	0.05	-	-
DEEB	13587	0.05	0.05	0.05	-	-
DEEB	13881	0.05	0.05	0.05	-	-
DEEB	13929	0.05	0.05	0.05	-	-
DEEB	14201	0.05	0.05	0.05	-	-
DEEB	14446	0.05	0.05	0.05	-	-
DEEB	14771	0.05	0.05	0.05	-	-
DEEB	14979	0.05	0.05	0.05	-	-
DEEB	15159	0.05	0.05	0.05	-	-
DEEB	15336	0.05	0.05	0.05	-	-
DEEB	15682	0.05	0.05	0.05	-	-
DEEB	15904	0.05	0.05	0.05	-	-
DEEB	16215	0.05	0.05	0.05	-	-
DEEB	16303	0.05	0.05	0.05	-	-
DEEB	16340	0.05	0.05	0.05	-	-
DEEB	16609	0.05	0.05	0.05	-	-
DEEB	16635	0.05	0.05	0.05	-	-
DEEB	16854	0.05	0.05	0.05	-	-
DEEB	17064	0.05	0.05	0.05	-	-
DEEB	17157	0.05	0.05	0.05	-	-
DEEB	17317	0.05	0.05	0.05	-	-
DEEB	17609	0.05	0.05	0.05	-	-
DEEB	17880	0.05	0.05	0.05	-	-
DEEB	18252	0.05	0.05	0.05	-	-
DEEB	18493	0.05	0.05	0.05	-	-
DEEB	18670	0.05	0.05	0.05	-	-
DEEB	18795	0.05	0.05	0.05	-	-
DEEB	18936	0.05	0.05	0.05	-	-
DEEB	19087	0.05	0.05	0.05	-	-
DEEB	19247	0.05	0.05	0.05	-	-
DEEB	19401	0.05	0.05	0.05	-	-
DEEB	19537	0.05	0.05	0.05	-	-
DEEB	19607	0.05	0.05	0.05	-	-
DEEB	19702	0.05	0.05	0.05	-	-
DEEB	19912	0.05	0.05	0.05	-	-
Frank_West_Weir1	0	-	-	-	-	0.045
Frank_West_Weir1	20	-	-	-	-	0.045
Frank_West_Weir2	0	-	-	-	-	0.045
Frank_West_Weir2	20	-	-	-	-	0.045
Franklinvale	0	-	-	-	-	0.045
Franklinvale	20087	-	-	-	-	0.045
GOOD	10000	0.06	0.06	0.06	-	-
GOOD	10092	0.06	0.06	0.06	-	-
GOOD	10183	0.06	0.06	0.06	-	-
GOOD	10275	0.06	0.06	0.06	-	-
GOOD	10375	0.06	0.06	0.06	-	-
GOOD	10475	0.06	0.06	0.06	-	-
GOOD	10552	0.06	0.06	0.06	-	-
GOOD	10628	0.06	0.06	0.06	-	-
GOOD	10705	0.06	0.06	0.06	-	-
GOOD	10778	0.06	0.06	0.06	-	-
GOOD	10852	0.06	0.06	0.06	-	-
GOOD	10925	0.06	0.06	0.06	-	-
GOOD	11007	0.06	0.06	0.06	-	-
GOOD	11089	0.06	0.06	0.06	-	-
GOOD	11171	0.06	0.06	0.06	-	-
GOOD	11253	0.06	0.06	0.06	-	-
GOOD	11335	0.06	0.06	0.06	-	-
GOOD	11432	0.06	0.06	0.06	-	-
GOOD	11528	0.06	0.06	0.06	-	-
GOOD	11625	0.06	0.06	0.06	-	-
GOOD	11705	0.06	0.06	0.06	-	-
GOOD	11785	0.06	0.06	0.06	-	-
GOOD	11865	0.06	0.06	0.06	-	-
GOOD	11945	0.06	0.06	0.06	-	-
GOOD	12020	0.06	0.06	0.06	-	-
GOOD	12044	0.06	0.06	0.06	-	-
GOOD	12100	0.06	0.06	0.06	-	-
GOOD	12155	0.06	0.06	0.06	-	-
GOOD	12245	0.06	0.06	0.06	-	-
GOOD	12335	0.06	0.06	0.06	-	-
GOOD	12425	0.06	0.06	0.06	-	-
GOOD	12510	0.06	0.06	0.06	-	-
GOOD	12595	0.06	0.06	0.06	-	-
GOOD	12680	0.06	0.06	0.06	-	-
GOOD	12765	0.06	0.06	0.06	-	-
GOOD	12850	0.06	0.06	0.06	-	-

Branch	Chainage	Roughness Mannings 'n				
		SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)*	Wivenhoe Alliance Model *(Ref-4)*	KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)*	KBR Upper Bremer River Model *(Ref-2)*
GOOD	12935	0.06	0.06	0.06	-	-
GOOD	13020	0.06	0.06	0.06	-	-
GOOD	13105	0.06	0.06	0.06	-	-
GOOD	13190	0.06	0.06	0.06	-	-
GOOD	13275	0.06	0.06	0.06	-	-
GOOD	13375	0.06	0.06	0.06	-	-
GOOD	13475	0.06	0.06	0.06	-	-
GOOD	13575	0.06	0.06	0.06	-	-
GOOD	13675	0.06	0.06	0.06	-	-
GOOD	13771	0.06	0.06	0.06	-	-
GOOD	13867	0.06	0.06	0.06	-	-
GOOD	13963	0.06	0.06	0.06	-	-
GOOD	14059	0.06	0.06	0.06	-	-
GOOD	14155	0.06	0.06	0.06	-	-
GOOD	14195	0.06	0.06	0.06	-	-
GOOD	14265	0.06	0.06	0.06	-	-
GOOD	14320	0.06	0.06	0.06	-	-
GOOD	14375	0.06	0.06	0.06	-	-
GOOD	14465	0.06	0.06	0.06	-	-
GOOD	14555	0.06	0.06	0.06	-	-
GOOD	14575	0.06	0.06	0.06	-	-
GOOD	14615	0.06	0.06	0.06	-	-
GOOD	14635	0.06	0.06	0.06	-	-
GOOD	14735	0.06	0.06	0.06	-	-
GOOD	14815	0.06	0.06	0.06	-	-
GOOD	14895	0.06	0.06	0.06	-	-
GOOD	14905	0.06	0.06	0.06	-	-
GOOD	14920	0.06	0.06	0.06	-	-
GOOD	14930	0.06	0.06	0.06	-	-
GOOD	14975	0.06	0.06	0.06	-	-
GOOD	15069	0.06	0.06	0.06	-	-
GOOD	15163	0.06	0.06	0.06	-	-
GOOD	15256	0.06	0.06	0.06	-	-
GOOD	15350	0.06	0.06	0.06	-	-
GOOD	15449	0.06	0.06	0.06	-	-
GOOD	15548	0.06	0.06	0.06	-	-
GOOD	15647	0.06	0.06	0.06	-	-
GOOD	15746	0.06	0.06	0.06	-	-
GOOD	15845	0.06	0.06	0.06	-	-
GOOD	15928	0.06	0.06	0.06	-	-
GOOD	16010	0.06	0.06	0.06	-	-
GOOD	16093	0.06	0.06	0.06	-	-
GOOD	16175	0.06	0.06	0.06	-	-
GOOD	16265	0.06	0.06	0.06	-	-
GOOD	16355	0.06	0.06	0.06	-	-
GOOD	16440	0.06	0.06	0.06	-	-
GOOD	16525	0.06	0.06	0.06	-	-
GOOD	16625	0.06	0.06	0.06	-	-
GOOD	16725	0.06	0.06	0.06	-	-
GOODNALINK1	0	0.06	0.06	0.06	-	-
GOODNALINK1	1000	0.06	0.06	0.06	-	-
GOODNALINK2	0	0.06	0.06	0.06	-	-
GOODNALINK2	1070	0.06	0.06	0.06	-	-
HWAY LEFT	0	0.06	0.06	0.06	-	-
HWAY LEFT	170	0.06	0.06	0.06	-	-
HWAY LEFT	200	0.06	0.06	0.06	-	-
HWAY LEFT	200	0.06	0.06	0.06	-	-
HWAY LEFT	290	0.06	0.06	0.06	-	-
HWAY LEFT	310	0.06	0.06	0.06	-	-
HWAY LEFT	330	0.06	0.06	0.06	-	-
HWAY LEFT	390	0.06	0.06	0.06	-	-
IRON	10000	0.05	0.05	0.05	-	-
IRON	10274	0.05	0.05	0.05	-	-
IRON	10563	0.05	0.05	0.05	-	-
IRON	10729	0.05	0.05	0.05	-	-
IRON	10775	0.05	0.05	0.05	-	-
IRON	11001	0.05	0.05	0.05	-	-
IRON	11374	0.05	0.05	0.05	-	-
IRON	11422	0.05	0.05	0.05	-	-
IRON	11765	0.05	0.05	0.05	-	-
IRON	11794	0.05	0.05	0.05	-	-
IRON	12052	0.05	0.05	0.05	-	-
IRON	12305	0.05	0.05	0.05	-	-
IRON	12558	0.05	0.05	0.05	-	-
IRON	12718	0.05	0.05	0.05	-	-
IRON	12923	0.05	0.05	0.05	-	-
IRON	13267	0.05	0.05	0.05	-	-
IRON	13766	0.05	0.05	0.05	-	-
IRON	14107	0.05	0.05	0.05	-	-
IRON	14456	0.05	0.05	0.05	-	-
IRON	14805	0.05	0.05	0.05	-	-
IRON	15139	0.05	0.05	0.05	-	-
IRON	15407	0.05	0.05	0.05	-	-
IRON	15700	0.05	0.05	0.05	-	-
IRON	15887	0.05	0.05	0.05	-	-
IRON	16199	0.05	0.05	0.05	-	-
IRON	16510	0.05	0.05	0.05	-	-
IRON	16827	0.05	0.05	0.05	-	-
IRON	17093	0.05	0.05	0.05	-	-
IRON	17336	0.05	0.05	0.05	-	-
IRON	17628	0.05	0.05	0.05	-	-
IRON	17884	0.05	0.05	0.05	-	-
IRON	18031	0.05	0.05	0.05	-	-
IRON	18156	0.05	0.05	0.05	-	-
IRON	18263	0.05	0.05	0.05	-	-
IRON	18363	0.05	0.05	0.05	-	-
IRON	18384	0.05	0.05	0.05	-	-
IRON	18584	0.05	0.05	0.05	-	-
LOW BRANCH1	0	0.06	0.06	0.06	-	-
LOW BRANCH1	150	0.06	0.06	0.06	-	-
LOW BRANCH1	480	0.06	0.06	0.06	-	-
LOW BRANCH2	0	0.06	0.06	0.06	-	-
LOW BRANCH2	240	0.06	0.06	0.06	-	-
LOW BRANCH2	740	0.06	0.06	0.06	-	-
MIHI	11310	0.05	0.05	0.05	-	-
MIHI	11468	0.05	0.05	0.05	-	-
MIHI	11708	0.05	0.05	0.05	-	-
MIHI	11968	0.05	0.05	0.05	-	-
MIHI	12230	0.05	0.05	0.05	-	-
MIHI	12485	0.05	0.05	0.05	-	-

Branch	Chainage	Roughness Mannings 'n				
		SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	**SKM Lower Ipswich Rivers Model 1989 Event** *(Ref-1)*	**Wivenhoe Alliance Model** *(Ref-4)*	**KBR Adjustments to SKM Lower Ipswich Model** *(Ref-3)*	**KBR Upper Bremer River Model** *(Ref-2)*
MIHI	12630	0.05	0.05	0.05	-	-
MIHI	12764	0.05	0.05	0.05	-	-
MIHI	12921	0.05	0.05	0.05	-	-
MIHI	13121	0.05	0.05	0.05	-	-
OXLEY	599400	0.06	0.06	0.06	-	-
OXLEY	600000	0.06	0.06	0.06	-	-
Purga	0	-	-	-	-	0.045
Purga	22344	-	-	-	-	0.045
Purga_2	42	-	-	-	-	0.045
Purga_2	4652	-	-	-	-	0.045
RailBridge1	0	-	-	-	-	0.045
RailBridge1	20	-	-	-	-	0.045
RailBridge2	0	-	-	-	-	0.045
RailBridge2	20	-	-	-	-	0.045
RailBridge3	0	-	-	-	-	0.045
RailBridge3	20	-	-	-	-	0.045
RailBridge4	0	-	-	-	-	0.045
RailBridge4	20	-	-	-	-	0.045
RailBridge5	0	-	-	-	-	0.045
RailBridge5	20	-	-	-	-	0.045
RailBridge6	0	-	-	-	-	0.045
RailBridge6	20	-	-	-	-	0.045
RailBridge7	0	-	-	-	-	0.045
RailBridge7	20	-	-	-	-	0.045
RailBridge8	0	-	-	-	-	0.045
RailBridge8	20	-	-	-	-	0.045
RailBridge9	0	-	-	-	-	0.045
RailBridge9	20	-	-	-	-	0.045
RailNorth	869	-	-	-	-	0.045
RailNorth	5082	-	-	-	-	0.045
RailNorth	6909	-	-	-	-	0.045
RailNorth	16228	-	-	-	-	0.045
RailSouth	869	-	-	-	-	0.045
RailSouth	4558	-	-	-	-	0.045
RailSouth	6909	-	-	-	-	0.045
RailSouth	16228	-	-	-	-	0.045
RailWeir1	0	-	-	-	-	0.045
RailWeir1	20	-	-	-	-	0.045
RailWeir2	0	-	-	-	-	0.045
RailWeir2	20	-	-	-	-	0.045
RailWeir3	0	-	-	-	-	0.045
RailWeir3	20	-	-	-	-	0.045
RailWeir4	0	-	-	-	-	0.045
RailWeir4	20	-	-	-	-	0.045
RailWeir5	0	-	-	-	-	0.045
RailWeir5	20	-	-	-	-	0.045
RailWeir6	0	-	-	-	-	0.045
RailWeir6	20	-	-	-	-	0.045
REEDY	1000	0.05	0.05	0.05	-	-
REEDY	1271	0.05	0.05	0.05	-	-
SAND	10000	0.06	0.06	0.06	-	-
SAND	10080	0.06	0.06	0.06	-	-
SAND	10160	0.06	0.06	0.06	-	-
SAND	10240	0.06	0.06	0.06	-	-
SAND	10320	0.06	0.06	0.06	-	-
SAND	10420	0.06	0.06	0.06	-	-
SAND	10520	0.06	0.06	0.06	-	-
SAND	10620	0.06	0.06	0.06	-	-
SAND	10720	0.06	0.06	0.06	-	-
SAND	10820	0.06	0.06	0.06	-	-
SAND	10920	0.06	0.06	0.06	-	-
SAND	10980	0.06	0.06	0.06	-	-
SAND	11040	0.06	0.06	0.06	-	-
SAND	11062	0.06	0.06	0.06	-	-
SAND	11151	0.06	0.06	0.06	-	-
SAND	11240	0.06	0.06	0.06	-	-
SAND	11333	0.06	0.06	0.06	-	-
SAND	11425	0.06	0.06	0.06	-	-
SAND	11518	0.06	0.06	0.06	-	-
SAND	11540	0.06	0.06	0.06	-	-
SAND	11613	0.06	0.06	0.06	-	-
SAND	11687	0.06	0.06	0.06	-	-
SAND	11760	0.06	0.06	0.06	-	-
SAND	11839	0.06	0.06	0.06	-	-
SAND	11919	0.06	0.06	0.06	-	-
SAND	11998	0.06	0.06	0.06	-	-
SAND	12020	0.06	0.06	0.06	-	-
SAND	12120	0.06	0.06	0.06	-	-
SAND	12200	0.06	0.06	0.06	-	-
SAND	12280	0.06	0.06	0.06	-	-
SAND	12360	0.06	0.06	0.06	-	-
SAND	12440	0.06	0.06	0.06	-	-
SAND	12523	0.06	0.06	0.06	-	-
SAND	12607	0.06	0.06	0.06	-	-
SAND	12690	0.06	0.06	0.06	-	-
SAND	12773	0.06	0.06	0.06	-	-
SAND	12855	0.06	0.06	0.06	-	-
SAND	12938	0.06	0.06	0.06	-	-
SAND	13020	0.06	0.06	0.06	-	-
SAND	13120	0.06	0.06	0.06	-	-
SAND	13220	0.06	0.06	0.06	-	-
SAND	13320	0.06	0.06	0.06	-	-
SAND	13420	0.06	0.06	0.06	-	-
SAND	13520	0.06	0.06	0.06	-	-
SAND	13620	0.06	0.06	0.06	-	-
SAND	13720	0.06	0.06	0.06	-	-
SAND	13820	0.06	0.06	0.06	-	-
SAND	13920	0.06	0.06	0.06	-	-
SAND	14020	0.06	0.06	0.06	-	-
SAND	14120	0.06	0.06	0.06	-	-
SAND	14220	0.06	0.06	0.06	-	-
SAND	14320	0.06	0.06	0.06	-	-
SAND	14420	0.06	0.06	0.06	-	-
SAND	14520	0.06	0.06	0.06	-	-
SAND	14620	0.06	0.06	0.06	-	-
SAND	14700	0.06	0.06	0.06	-	-
SAND	14740	0.06	0.06	0.06	-	-
SAND	14820	0.06	0.06	0.06	-	-
SAND	14920	0.06	0.06	0.06	-	-
SAND	15019	0.06	0.06	0.06	-	-

Branch	Chainage	Roughness Mannings 'n SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)*	Wivenhoe Alliance Model *(Ref-4)*	KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)*	KBR Upper Bremer River Model *(Ref-2)*
SAND	15119	0.06	0.06	0.06	-	-
SAND	15218	0.06	0.06	0.06	-	-
SAND	15318	0.06	0.06	0.06	-	-
SAND	15417	0.06	0.06	0.06	-	-
SAND	15517	0.06	0.06	0.06	-	-
SAND	15616	0.06	0.06	0.06	-	-
SAND	15716	0.06	0.06	0.06	-	-
SAND	15816	0.06	0.06	0.06	-	-
SAND	15915	0.06	0.06	0.06	-	-
SAND	16015	0.06	0.06	0.06	-	-
SAND	16114	0.06	0.06	0.06	-	-
SAND	16214	0.06	0.06	0.06	-	-
SAND	16313	0.06	0.06	0.06	-	-
SAND	16413	0.06	0.06	0.06	-	-
SAND	16512	0.06	0.06	0.06	-	-
SAND	16612	0.06	0.06	0.06	-	-
SAND	16712	0.06	0.06	0.06	-	-
SAND	16811	0.06	0.06	0.06	-	-
SAND	16911	0.06	0.06	0.06	-	-
SAND	17010	0.06	0.06	0.06	-	-
SAND	17110	0.06	0.06	0.06	-	-
SAND	17209	0.06	0.06	0.06	-	-
SAND	17309	0.06	0.06	0.06	-	-
SAND	17408	0.06	0.06	0.06	-	-
SAND	17508	0.06	0.06	0.06	-	-
SAND	17608	0.06	0.06	0.06	-	-
SAND	17707	0.06	0.06	0.06	-	-
SAND	17807	0.06	0.06	0.06	-	-
SAND	17906	0.06	0.06	0.06	-	-
SAND	18006	0.06	0.06	0.06	-	-
SAND	18105	0.06	0.06	0.06	-	-
SAND	18205	0.06	0.06	0.06	-	-
SAND	18304	0.06	0.06	0.06	-	-
SAND	18404	0.06	0.06	0.06	-	-
SAND	18504	0.06	0.06	0.06	-	-
SAND	18603	0.06	0.06	0.06	-	-
SAND	18703	0.06	0.06	0.06	-	-
SAND	18802	0.06	0.06	0.06	-	-
SAND	18902	0.06	0.06	0.06	-	-
SAND	19001	0.06	0.06	0.06	-	-
SAND	19101	0.06	0.06	0.06	-	-
SAND	19200	0.06	0.06	0.06	-	-
SAND	19300	0.06	0.06	0.06	-	-
SCH	10000	0.05	0.05	0.05	-	-
SCH	10384	0.05	0.05	0.05	-	-
SCH	10756	0.05	0.05	0.05	-	-
SCH	10847	0.05	0.05	0.05	-	-
SCH	11101	0.05	0.05	0.05	-	-
SCH	11354	0.05	0.05	0.05	-	-
SCH	11382	0.05	0.05	0.05	-	-
SCH	11789	0.05	0.05	0.05	-	-
SCH	11950	0.05	0.05	0.05	-	-
SCH	12167	0.05	0.05	0.05	-	-
SCH	12435	0.05	0.05	0.05	-	-
SCH	12462	0.05	0.05	0.05	-	-
SCH	12805	0.05	0.05	0.05	-	-
SCH	13018	0.05	0.05	0.05	-	-
SCH	13209	0.05	0.05	0.05	-	-
SCH	13598	0.05	0.05	0.05	-	-
SIX	10920	0.06	0.06	0.06	-	-
SIX	11007	0.06	0.06	0.06	-	-
SIX	11094	0.06	0.06	0.06	-	-
SIX	11181	0.06	0.06	0.06	-	-
SIX	11268	0.06	0.06	0.06	-	-
SIX	11355	0.06	0.06	0.06	-	-
SIX	11427	0.06	0.06	0.06	-	-
SIX	11498	0.06	0.06	0.06	-	-
SIX	11570	0.06	0.06	0.06	-	-
SIX	11670	0.06	0.06	0.06	-	-
SIX	11770	0.06	0.06	0.06	-	-
SIX	11800	0.06	0.06	0.06	-	-
SIX	11870	0.06	0.06	0.06	-	-
SIX	11940	0.06	0.06	0.06	-	-
SIX	12010	0.06	0.06	0.06	-	-
SIX	12102	0.06	0.06	0.06	-	-
SIX	12194	0.06	0.06	0.06	-	-
SIX	12286	0.06	0.06	0.06	-	-
SIX	12378	0.06	0.06	0.06	-	-
SIX	12470	0.06	0.06	0.06	-	-
SIX	12570	0.06	0.06	0.06	-	-
SIX	12670	0.06	0.06	0.06	-	-
SIX	12770	0.06	0.06	0.06	-	-
SIX	12870	0.06	0.06	0.06	-	-
SIX	12970	0.06	0.06	0.06	-	-
SIX	13063	0.06	0.06	0.06	-	-
SIX	13156	0.06	0.06	0.06	-	-
SIX	13249	0.06	0.06	0.06	-	-
SIX	13341	0.06	0.06	0.06	-	-
SIX	13434	0.06	0.06	0.06	-	-
SIX	13527	0.06	0.06	0.06	-	-
SIX	13620	0.06	0.06	0.06	-	-
SIX	13705	0.06	0.06	0.06	-	-
SIX	13790	0.06	0.06	0.06	-	-
SIX	13875	0.06	0.06	0.06	-	-
SIX	13960	0.06	0.06	0.06	-	-
SIX	14045	0.06	0.06	0.06	-	-
SIX	14130	0.06	0.06	0.06	-	-
SIX	14215	0.06	0.06	0.06	-	-
SIX	14300	0.06	0.06	0.06	-	-
SIX	14385	0.06	0.06	0.06	-	-
SIX	14470	0.06	0.06	0.06	-	-
SIX	14553	0.06	0.06	0.06	-	-
SIX	14635	0.06	0.06	0.06	-	-
SIX	14717	0.06	0.06	0.06	-	-
SIX	14800	0.06	0.06	0.06	-	-
SIX	14893	0.06	0.06	0.06	-	-
SIX	14985	0.06	0.06	0.06	-	-
SIX	15078	0.06	0.06	0.06	-	-
SIX	15170	0.06	0.06	0.06	-	-
SIX	15270	0.06	0.06	0.06	-	-

Branch	Chainage	Roughness Mannings 'n SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)*	Wivenhoe Alliance Model *(Ref-4)*	KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)*	KBR Upper Bremer River Model *(Ref-2)*
SIX	15370	0.06	0.06	0.06	-	-
SIX	15470	0.06	0.06	0.06	-	-
SIX	15570	0.06	0.06	0.06	-	-
SIX	15655	0.06	0.06	0.06	-	-
SIX	15740	0.06	0.06	0.06	-	-
SIX	15825	0.06	0.06	0.06	-	-
SIX	15910	0.06	0.06	0.06	-	-
SIX	16000	0.06	0.06	0.06	-	-
SIX	16090	0.06	0.06	0.06	-	-
SIX	16180	0.06	0.06	0.06	-	-
SIX	16270	0.06	0.06	0.06	-	-
SIX	16370	0.06	0.06	0.06	-	-
SIX	16470	0.06	0.06	0.06	-	-
SIX	16553	0.06	0.06	0.06	-	-
SIX	16637	0.06	0.06	0.06	-	-
SIX	16720	0.06	0.06	0.06	-	-
SIX	16804	0.06	0.06	0.06	-	-
SIX	16888	0.06	0.06	0.06	-	-
SIX	16972	0.06	0.06	0.06	-	-
SIX	17056	0.06	0.06	0.06	-	-
SIX	17140	0.06	0.06	0.06	-	-
SIX	17205	0.06	0.06	0.06	-	-
SIX	17270	0.06	0.06	0.06	-	-
SIX	17357	0.06	0.06	0.06	-	-
SIX	17443	0.06	0.06	0.06	-	-
SIX	17530	0.06	0.06	0.06	-	-
SIX	17630	0.06	0.06	0.06	-	-
SIX	17730	0.06	0.06	0.06	-	-
SIX	17830	0.06	0.06	0.06	-	-
SIX	17930	0.06	0.06	0.06	-	-
SIX	18015	0.06	0.06	0.06	-	-
SIX	18100	0.06	0.06	0.06	-	-
SIX	18185	0.06	0.06	0.06	-	-
SIX	18270	0.06	0.06	0.06	-	-
SIX	18360	0.06	0.06	0.06	-	-
SIX	18450	0.06	0.06	0.06	-	-
SIX	18540	0.06	0.06	0.06	-	-
SIX	18630	0.06	0.06	0.06	-	-
SIX	18720	0.06	0.06	0.06	-	-
SIX	18803	0.06	0.06	0.06	-	-
SIX	18887	0.06	0.06	0.06	-	-
SIX	18970	0.06	0.06	0.06	-	-
SIX	19070	0.06	0.06	0.06	-	-
SIX	19170	0.06	0.06	0.06	-	-
SIX	19270	0.06	0.06	0.06	-	-
SIX	19370	0.06	0.06	0.06	-	-
SIX	19463	0.06	0.06	0.06	-	-
SIX	19557	0.06	0.06	0.06	-	-
SIX	19650	0.06	0.06	0.06	-	-
SIX	19720	0.06	0.06	0.06	-	-
SIX	19790	0.06	0.06	0.06	-	-
SIX	19870	0.06	0.06	0.06	-	-
SIX	19935	0.06	0.06	0.06	-	-
SIX	20000	0.06	0.06	0.06	-	-
SIX	20070	0.06	0.06	0.06	-	-
SIX	20140	0.06	0.06	0.06	-	-
SIX	20160	0.06	0.06	0.06	-	-
SIX	20235	0.06	0.06	0.06	-	-
SMALL	1000	0.05	0.05	0.05	-	-
SMALL	1228	0.05	0.05	0.05	-	-
SMALL	1257	0.05	0.05	0.05	-	-
SMALL	1409	0.05	0.05	0.05	-	-
SMALL	1670	0.05	0.05	0.05	-	-
SMALL	1888	0.05	0.05	0.05	-	-
STLUCIALINK1	0	0.06	0.06	0.06	-	-
STLUCIALINK1	1050	0.06	0.06	0.06	-	-
STLUCIALINK2	0	0.06	0.06	0.06	-	-
STLUCIALINK2	1050	0.06	0.06	0.06	-	-
STLUCIALINK3	0	0.06	0.06	0.06	-	-
STLUCIALINK3	850	0.06	0.06	0.06	-	-
UP BRANCH1	0	0.06	0.06	0.06	-	-
UP BRANCH1	475	0.06	0.06	0.06	-	-
UP BRANCH1	950	0.06	0.06	0.06	-	-
UP BRANCH1	1400	0.06	0.06	0.06	-	-
UP BRANCH1	1850	0.06	0.06	0.06	-	-
UP BRANCH1	2290	0.06	0.06	0.06	-	-
WarPurWeir1	0	-	-	-	-	0.045
WarPurWeir1	20	-	-	-	-	0.045
WarPurWeir2	0	-	-	-	-	0.045
WarPurWeir2	20	-	-	-	-	0.045
WarPurWeir3	0	-	-	-	-	0.045
WarPurWeir3	20	-	-	-	-	0.045
Warrill	0	-	-	-	-	0.045
Warrill	33860	-	-	-	-	0.045
Warrill-Boonah	0	-	-	-	-	0.045
Warrill-Boonah	30815	-	-	-	-	0.045
WestBrem1	0	-	-	-	-	0.045
WestBrem1	20	-	-	-	-	0.045
WestBrem2	0	-	-	-	-	0.045
WestBrem2	20	-	-	-	-	0.045
WestBrem3	0	-	-	-	-	0.045
WestBrem3	20	-	-	-	-	0.045
Western	0	-	-	-	-	0.045
Western	869	-	-	-	-	0.045
Western	5082	-	-	-	-	0.045
Western	6909	-	-	-	-	0.045
WOOG	10000	0.06	0.065	0.06	-	-
WOOG	10090	0.06	0.065	0.06	-	-
WOOG	10180	0.06	0.065	0.06	-	-
WOOG	10270	0.06	0.065	0.06	-	-
WOOG	10360	0.06	0.065	0.06	-	-
WOOG	10450	0.06	0.065	0.06	-	-
WOOG	10546	0.06	0.065	0.06	-	-
WOOG	10642	0.06	0.065	0.06	-	-
WOOG	10738	0.06	0.065	0.06	-	-
WOOG	10834	0.06	0.065	0.06	-	-
WOOG	10930	0.06	0.065	0.06	-	-
WOOG	11003	0.06	0.065	0.06	-	-
WOOG	11077	0.06	0.065	0.06	-	-
WOOG	11150	0.06	0.065	0.06	-	-

Branch	Chainage	Roughness Mannings 'n SKM Lower Ipswich Rivers Model 1974 Event *(Ref-1)*	SKM Lower Ipswich Rivers Model 1989 Event *(Ref-1)*	Wivenhoe Alliance Model *(Ref-4)*	KBR Adjustments to SKM Lower Ipswich Model *(Ref-3)*	KBR Upper Bremer River Model *(Ref-2)*
WOOG	11245	0.06	0.065	0.06	-	-
WOOG	11340	0.06	0.065	0.06	-	-
WOOG	11435	0.06	0.065	0.06	-	-
WOOG	11530	0.06	0.065	0.06	-	-
WOOG	11630	0.06	0.065	0.06	-	-
WOOG	11730	0.06	0.065	0.06	-	-
WOOG	11830	0.06	0.065	0.06	-	-
WOOG	11930	0.06	0.065	0.06	-	-
WOOG	12030	0.06	0.065	0.06	-	-
WOOG	12128	0.06	0.065	0.06	-	-
WOOG	12227	0.06	0.065	0.06	-	-
WOOG	12325	0.06	0.065	0.06	-	-
WOOG	12423	0.06	0.065	0.06	-	-
WOOG	12522	0.06	0.065	0.06	-	-
WOOG	12620	0.06	0.065	0.06	-	-
WOOG	12698	0.06	0.065	0.06	-	-
WOOG	12775	0.06	0.065	0.06	-	-
WOOG	12852	0.06	0.065	0.06	-	-
WOOG	12930	0.06	0.065	0.06	-	-
WOOG	13000	0.06	0.065	0.06	-	-
WOOG	13070	0.06	0.065	0.06	-	-
WOOG	13160	0.06	0.065	0.06	-	-
WOOG	13250	0.06	0.065	0.06	-	-
WOOG	13350	0.06	0.065	0.06	-	-
WOOG	13450	0.06	0.065	0.06	-	-
WOOG	13550	0.06	0.065	0.06	-	-
WOOG	13633	0.06	0.065	0.06	-	-
WOOG	13717	0.06	0.065	0.06	-	-
WOOG	13800	0.06	0.065	0.06	-	-
WOOG	13900	0.06	0.065	0.06	-	-
WOOG	14000	0.06	0.065	0.06	-	-
WOOG	14100	0.06	0.065	0.06	-	-
WOOG	14188	0.06	0.065	0.06	-	-
WOOG	14275	0.06	0.065	0.06	-	-
WOOG	14363	0.06	0.065	0.06	-	-
WOOG	14450	0.06	0.065	0.06	-	-
WOOG	14550	0.06	0.065	0.06	-	-
WOOG	14650	0.06	0.065	0.06	-	-
WOOG	14750	0.06	0.065	0.06	-	-
WOOG	14850	0.06	0.065	0.06	-	-
WOOG	14930	0.06	0.065	0.06	-	-
WOOG	15010	0.06	0.065	0.06	-	-
WOOG	15025	0.06	0.065	0.06	-	-
WOOG	15050	0.06	0.065	0.06	-	-
WOOG	15140	0.06	0.065	0.06	-	-
WOOG	15230	0.06	0.065	0.06	-	-
WOOG	15300	0.06	0.065	0.06	-	-
WOOG	15385	0.06	0.065	0.06	-	-
WOOG	15470	0.06	0.065	0.06	-	-
WOOG	15535	0.06	0.065	0.06	-	-
WOOG	15600	0.06	0.065	0.06	-	-
WOOG	15700	0.06	0.065	0.06	-	-
WOOG	15800	0.06	0.065	0.06	-	-
WOOG	15880	0.06	0.065	0.06	-	-
WOOG	15960	0.06	0.065	0.06	-	-
WOOG	15990	0.06	0.065	0.06	-	-
WOOG	16058	0.06	0.065	0.06	-	-
WOOG	16125	0.06	0.065	0.06	-	-
WOOG	16200	0.06	0.065	0.06	-	-
WOOG	16275	0.06	0.065	0.06	-	-
WOOG	16356	0.06	0.065	0.06	-	-
WOOG	16438	0.06	0.065	0.06	-	-
WOOG	16519	0.06	0.065	0.06	-	-
WOOG	16600	0.06	0.065	0.06	-	-
WOOG	16683	0.06	0.06	0.06	-	-
WOOG	16767	0.06	0.06	0.06	-	-
WOOG	16850	0.06	0.06	0.06	-	-
WOOG	16950	0.06	0.06	0.06	-	-
WOOG	17050	0.06	0.06	0.06	-	-
WOOG	17125	0.06	0.06	0.06	-	-
WOOG	17200	0.06	0.06	0.06	-	-
WOOG	17275	0.06	0.06	0.06	-	-
WOOG	17350	0.06	0.06	0.06	-	-
WOOG	17425	0.06	0.06	0.06	-	-
WOOG	17500	0.06	0.06	0.06	-	-
WOOG	17550	0.06	0.06	0.06	-	-
WOOG	17600	0.06	0.06	0.06	-	-
WOOG	17615	0.06	0.06	0.06	-	-
WOOG	17683	0.06	0.06	0.06	-	-
WOOG	17750	0.06	0.06	0.06	-	-
WOOG	17850	0.06	0.06	0.06	-	-
WOOG	17950	0.06	0.06	0.06	-	-
WOOG	17960	0.06	0.06	0.06	-	-
WOOG	18057	0.06	0.06	0.06	-	-
WOOG	18153	0.06	0.06	0.06	-	-
WOOG	18250	0.06	0.06	0.06	-	-
WOOG	18333	0.06	0.06	0.06	-	-
WOOG	18417	0.06	0.06	0.06	-	-
WOOG	18500	0.06	0.06	0.06	-	-
WOOG	18583	0.06	0.06	0.06	-	-
WOOG	18667	0.06	0.06	0.06	-	-
WOOG	18750	0.06	0.06	0.06	-	-
WOOG	18825	0.06	0.06	0.06	-	-
WOOG	18900	0.06	0.06	0.06	-	-
WOOG	18988	0.06	0.06	0.06	-	-
WOOG	19075	0.06	0.06	0.06	-	-

Queensland Government
Department of Emergency Services

DOTAR
DEPARTMENT OF TRANSPORT AND REGIONAL SEF

Ipswich Rivers
Improvement Trust

Natural Disaster Risk Management Studies Program

Ipswich Rivers Improvement Trust

Ipswich Rivers Flood Study Rationalisation Project

Phase 3

Re-estimation of Design Flows

Final Report

September 2006

Sargent Consulting

Sargent Consulting
ABN 74 424 370 508
11 Redwood Place
THE GAP
Queensland 4061
Tel 0419 311160
Fax 07 35110440
Email dms@sargentconsulting.com.au
Job No 06003

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Study Rationalisation Project
Phase 3

Re-estimation of Design Flows
Final Report

Table of Contents

List of Tables

List of Figures

Executive Summary

Introduction

The objective of the Ipswich Rivers Flood Study Rationalisation Project (IRFSRP) is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC), in order to facilitate the preparation of new flood maps.

The IRFSRP is being conducted in parallel with the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

One of the outstanding issues that is being investigated as part of the IRFSRP is the catchment hydrology, in particular the definition of design flows as estimated using the RAFTS model which has previously been established for studies for both ICC and BCC.

Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz) and for the rural areas in 2002 (Halliburton KBR), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

In addition, in response to apparent anomalies with predicted 20 year ARI flood levels in particular, Council commissioned Sargent Consulting (SC) in 2002 to review the current flood models. That review (SC 2003) concluded that the current hydraulic model (MIKE 11) calibration is skewed towards the replication of major floods with the result that water levels for smaller floods are overestimated, and that the design flows estimated using the RAFTS model (SKM 2000) may be overly conservative.

As a consequence of the issues noted above, the current hydrologic and hydraulic models are known to have some inconsistencies, and the flood levels used by the two local government areas for town planning controls are no longer compatible.

Resolution of these matters is required urgently by ICC so that:

- *The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and*
- *The current development of emergency response flood mapping is not compromised.*

Scope of Work
The current report describes a re-estimation of design flows, using the RAFTS model, for those parts of the Bremer and Brisbane River catchments within Ipswich. A map of the RAFTS model sub areas is given in ***Appendix A****.*

The 100 year Average Recurrence Interval (ARI) design flow for the Brisbane River at Savages Crossing, post-construction of Wivenhoe Dam was estimated by the Independent Review Panel (Mein et al 2003) to be 6,000m^3/s, and in the interest of consistency, this value has been adopted herein. In view of the above, this study has concentrated on the re-estimation of design flows for the Bremer River catchment and those tributaries of the Brisbane River within Ipswich.

This has comprised:

- *Re-estimation of design rainfalls over the study catchments using the new CRC-FORGE rainfall data and intensity-frequency-duration estimation procedure (DNRM 2005);*
- *Partial re-calibration of the RAFTS model using the above design rainfalls;*
- *The re-estimation of design flows for the Bremer River catchment and those tributaries of the Brisbane River within Ipswich;*
- *Derivation of design flow hydrographs for the Brisbane River at Savages Crossing consistent with the recommendations of the Independent Review Panel (Mein et al 2003); and*
- *Comparison of the new design flow estimates with previous estimates.*

Design Rainfall Analysis
The new FORGE design rainfall dataset and methodology were used to extract rainfall intensity – duration – frequency (IFD curves) for each sub area in the RAFTS model in the Bremer River catchment and the Brisbane River catchment between Savages Crossing and Galles and for the complete catchments.

As well as defining IFD curves based on the new FORGE rainfall dataset, this process also computes and accounts for areal reduction factors (ARFs) which are dependant on catchment area and storm duration. These ARFs are used in determining the IFD curve for a given location/catchment size.

The IFD curves give design rainfall intensities (or totals) for storm durations from 15 minutes to 120 hours and for ARIs from 5 years to 500 years.

Adjustment of Rainfall Losses
In order to utilise the new design rainfall data with the RAFTS model, it was appropriate to reconsider the appropriate rainfall losses to use in the design runs of the model. It was beyond the scope of work of this commission to re-calibrate the RAFTS model parameters.

In order to provide a basis for comparison and to maximise consistency between the modelled flows and recorded flow series within the Bremer River catchment, new flood frequency analyses were undertaken and compared to those available from the previous studies.

The following conclusions were drawn in this regard:

- *There are apparent anomalies in the direct flood frequency curves for Bremer River at Walloon and Purga Creek at Loamside but it was outside the scope of work of this commission to undertake a detailed data review in order to resolve these anomalies;*
- *The use of a regional flood frequency analysis using the index flood methodology improved the ability to match predicted design flood flows from flood frequency analysis and from RAFTS modelling;*
- *In order to reasonably match flows modelled in RAFTS using the FORGE design rainfalls, the values of initial loss used in the model must reduce as the ARI increases;*
- *Given that the initial loss obtained from RAFTS modelling reduced to zero for ARIs of 100 years and greater it was not possible to match the flood frequency curve figures for higher ARIs. However, as the fitted flood frequency distributions are tentative in respect of the more extreme floods, and that rainfall based estimates are more reliable in this regard due to their longer record length, this may be reasonable; and*
- *Given the uncertainties apparent from this process to better define design initial losses, it was appropriate to consider the possible accuracy of the estimates by undertaking a sensitivity analysis.*

RAFTS Modelling of Design Flows

*The design peak flood flows for the Bremer River catchment, for the Brisbane River downstream of Savages Crossing to the Ipswich/Brisbane local government boundary at Gailes, and for the Brisbane River tributaries within Ipswich were obtained using the RAFTS model with initial loss computed as discussed in **Section 3** hereof, together with assumed design input hydrographs at Savages Crossing consistent with the 6,000 m^3/s design flow for 100 year ARI as recommended by the Independent Review Panel (Mein et al 2003).*

Input Hydrographs at Savages Crossing

In order for this study to be consistent with the adoption of a Q_{100} *at Savages Crossing of 6,000 m^3/s, as recommended by the Brisbane River Flood Study Independent Review Panel (Mein et al 2003), it was desirous to use input hydrographs at that location which reflected this assumption. It was also necessary to estimate hydrographs for the other flood event ARIs which were being considered.*

This was done using flood frequency relationships (for post-dam flows) fitted by SKM (2003) to define the peak flows for each ARI and then scaling the hydrograph with the nearest peak flow from the Monte Carlo analysis (Sargent Consulting 2006) to define the corresponding hydrograph shape. These were then input into the RAFTS model.

*Design flows were then estimated using the RAFTS model for a range of storm durations from 1 hour to 72 hours for ARIs of 2, 5, 10, 20, 50, 100, 200 and 500 years. A summary table of the maximum estimated peak flows across the range of durations at key locations for the range ARIs used is given in **Table ES1**.*

Table ES1 Summary of Peak Flow Estimates

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for ARI Years							
			2	5	10	20	50	100	200	500
Brisbane R	Savages Crossing	SAV-OUT	360	910	1900	2900	4200	6000	7200	8000
	Mt Crosby	MTC-OUT	360	910	1900	2900	4200	6000	7200	8000
Warrill Ck	Kalbar	KAL-OUT	130	440	600	730	990	1400	1610	1900
	Amberley	AMB-OUT	170	560	840	1050	1710	2220	2300	2900
Purga Ck	Loamside	PUR-OUT	90	360	460	560	880	1250	1400	1700
Bremer R	Walloon	WAL-OUT	180	540	700	850	1260	1590	1800	2100
Deebing Ck	U/s Bremer R	DB-OUT	21	50	63	76	120	170	200	230
Ironpot Ck	U/s Bremer R	IP-OUT	14	40	46	55	110	150	180	200
Mihi Ck	U/s Bremer R	MH-OUT	13	18	20	24	56	83	95	110
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	7	20	26	33	76	120	130	160
Bremer R	David Trumpy Br	2C#	370	1200	1580	1770	2410	3060	3200	3600
Bundamba Ck	U/s Bremer R	BUND15	40	140	190	220	310	430	500	580
Bremer R	D/s Bundamba Ck	IPS-OUT	370	1200	1600	1800	2430	3070	3300	3600
Six Mile Ck	u/s Brisbane R	JINAO	24	60	80	94	180	250	280	330
Goodna Ck	u/s Brisbane R	JINCG	11	30	36	44	86	120	140	160
Woogaroo Ck	u/s Brisbane R	JIN3M	40	130	160	190	320	460	520	620
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	26	80	105	120	190	270	310	360

Sensitivity Analysis

In order to test the impact of the adopted initial loss and continuing loss on the results, the effect on peak flow estimates of an extreme initial loss of 10mm for all ARIs up to 100 years was tested.

These results show that the estimated peak flood flows are sensitive to the assumed initial loss particularly at low ARI, with this sensitivity reducing as the ARI increases. This is because of the increased difference between the adopted and sensitivity value of the initial loss as the ARI reduces.

Comparison with Previous Results

The results from the current analysis were compared with those from the sensitivity testing and from previous analyses, and recommendations made in respect of the adopted design values.

Previous estimates were obtained from SKM (2000), SKM (2003), KBR (2002) and Sargent Consulting (2006). The latter contained estimates for 100 year ARI only for Bremer River and Warrill Creek only based on a Monte Carlo analysis undertaken as a separate component of the current project.

The results from the new modelling were all lower than those from SKM (2000) and KBR (2002) with the exception of Bremer River at Walloon for ARIs up to 100 years, for Warrill Creek at Amberley for ARIs of 10 years and under, and for Purga Creek at Loamside also for 5 year ARI only.

The new curves are consistent with the Monte Carlo *estimates for 100 year ARI for Amberley, Walloon and Ipswich.*

As none of the streamflow records are of sufficient length to estimate flood flows at higher ARIs with reasonable accuracy, rainfall based estimates are preferable for ARIs of about 50 years and above.

Taking these factors into account, it was considered that the results from the new modelling are the best estimates available because these are based on the most recent rainfall data (CRC-FORGE data and methodology) and reasonable assumptions of initial losses.

Hence, it is recommended that the detailed results from the new modelling be used in the new design runs to be undertaken using the recently updated MIKE 11 hydraulic model under a separate component of this project.

It is also recommended that the flood frequency curves be revised using the MIKE 11 model results, as the latter takes full account of temporary flood plain storage whereas this is only approximated in the RAFTS model.

Boundary Conditions for MIKE 11 Model

The principal use of the flows from the RAFTS modelling is the derivation of the input flows to the MIKE 11 model. To this end, the RAFTS hydrographs for each combination of ARI and storm duration have been converted to MIKE 11 time series format so that they can be used for this purpose.

1. Introduction

The objective of the *Ipswich Rivers Flood Study Rationalisation Project (IRFSRP)* is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC). The resolution of these anomalies will allow more reliable flood mapping to be prepared.

The IRFSRP is being conducted in parallel with the *Brisbane Valley Flood Damage Minimisation Study (BVFDMS)* which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

One of the outstanding issues that is being investigated as part of the IRFSRP is the catchment hydrology, in particular the definition of design flows as estimated using the RAFTS model which has previously been established for studies for both ICC and BCC.

As the current Brisbane/Bremer River RAFTS model has been developed at considerable expense and has been widely used by both ICC and BCC as the basis of flood event modelling for some time, there is no incentive to change the modelling platform at this time.

Figure 1 is a map of the Brisbane River catchment showing key locations whilst **Figure 2** shows the Bremer River catchment in more detail.

1.1. Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz) and for the rural areas in 2002 (Halliburton KBR), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

These include:

- Updating of flood hydrology for Wivenhoe Dam operations and the construction of *fuse plug* spillways;
- Availability of new rainfall design data (CRC-FORGE) and a new estimate of probable maximum flood (PMF);
- Revised flood modelling for Brisbane City Council; and

- Review of the latter by an Independent Review Panel which has led to the 100 year design flood flow for the lower Brisbane River being reduced from 8,000 $m^{3/}s$ to 6,000 $m^{3/}s$.

In addition, in response to apparent anomalies with predicted 20 year ARI flood levels in particular, Council commissioned Sargent Consulting (SC) in 2002 to review the current flood models. That review (SC 2003) concluded that the current hydraulic model (MIKE 11) calibration is skewed towards the replication of major floods with the result that water levels for smaller floods are overestimated, and that the design flows estimated using the RAFTS model (SKM 2000) may be overly conservative.

As a consequence of the issues noted above, the current hydrologic and hydraulic models are known to have some inconsistencies, and the flood levels used by the two local government areas for town planning controls are no longer compatible.

Resolution of these matters is required urgently by ICC so that:

- The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and

- The current development of emergency response flood mapping is not compromised.

1.2. Scope of Work

The current report describes a re-estimation of design flows, using the RAFTS model, for those parts of the Bremer and Brisbane River catchments within Ipswich. A map of the RAFTS model sub areas is given in **Appendix A**.

The 100 year Average Recurrence Interval (ARI) design flow for the Brisbane River at Savages Crossing, post-construction of Wivenhoe Dam was estimated by the Independent Review Panel (Mein et al 2003) to be 6,000m^3/s, and in the interest of consistency, this value has been adopted herein. In view of the above, this study has concentrated on the re-estimation of design flows for the Bremer River catchment and those tributaries of the Brisbane River within Ipswich.

This has comprised:

- Re-estimation of design rainfalls over the study catchments using the new CRC-FORGE rainfall data and intensity-frequency-duration estimation procedure (DNRM 2005);

- Partial re-calibration of the RAFTS model using the above design rainfalls;

- The re-estimation of design flows for the Bremer River catchment and those tributaries of the Brisbane River within Ipswich;

- Derivation of design flow hydrographs for the Brisbane River at Savages Crossing consistent with the recommendations of the Independent Review Panel (Mein et al 2003); and

- Comparison of the new design flow estimates with previous estimates.

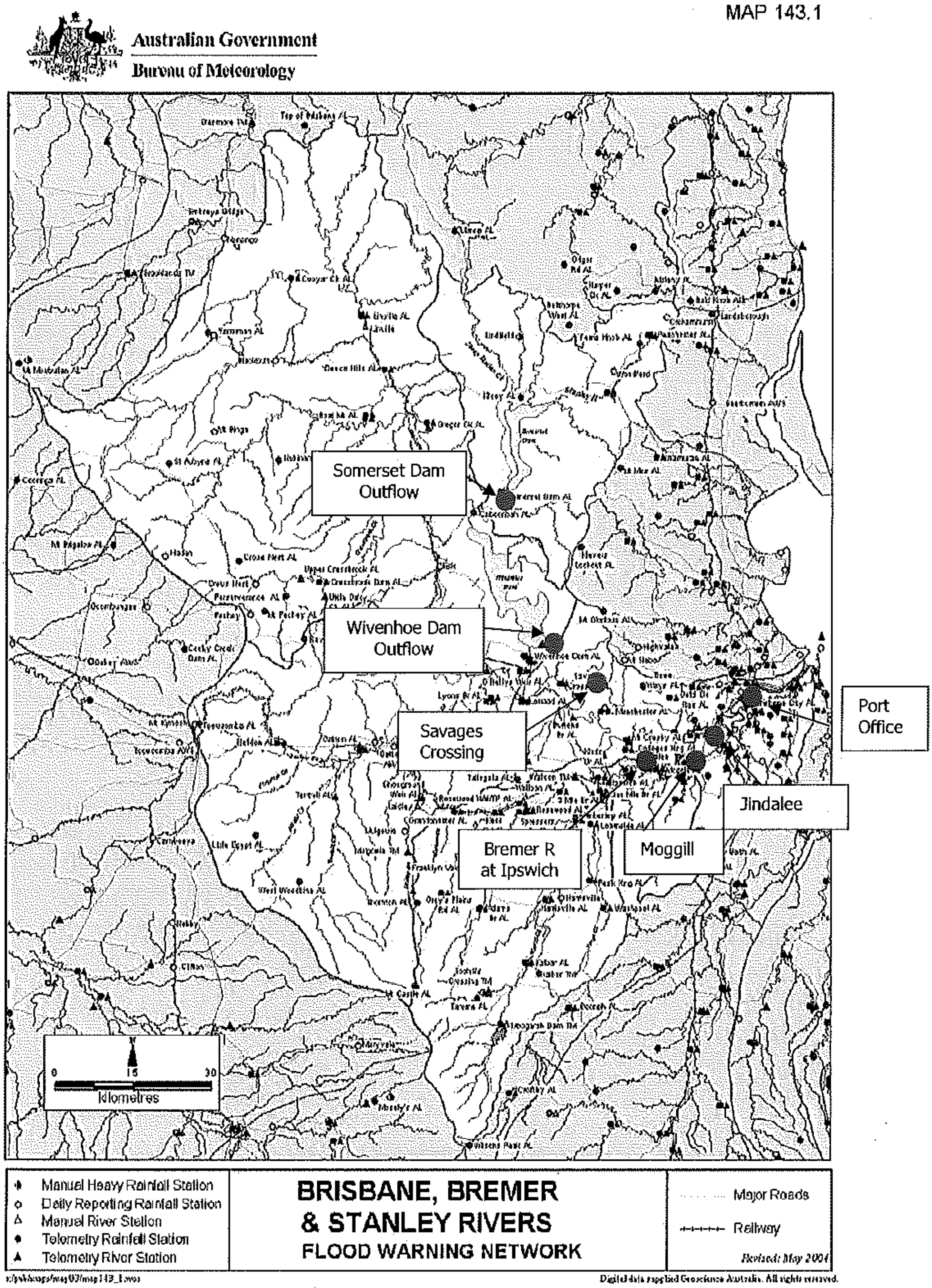


Figure 1 Brisbane River Catchment Map

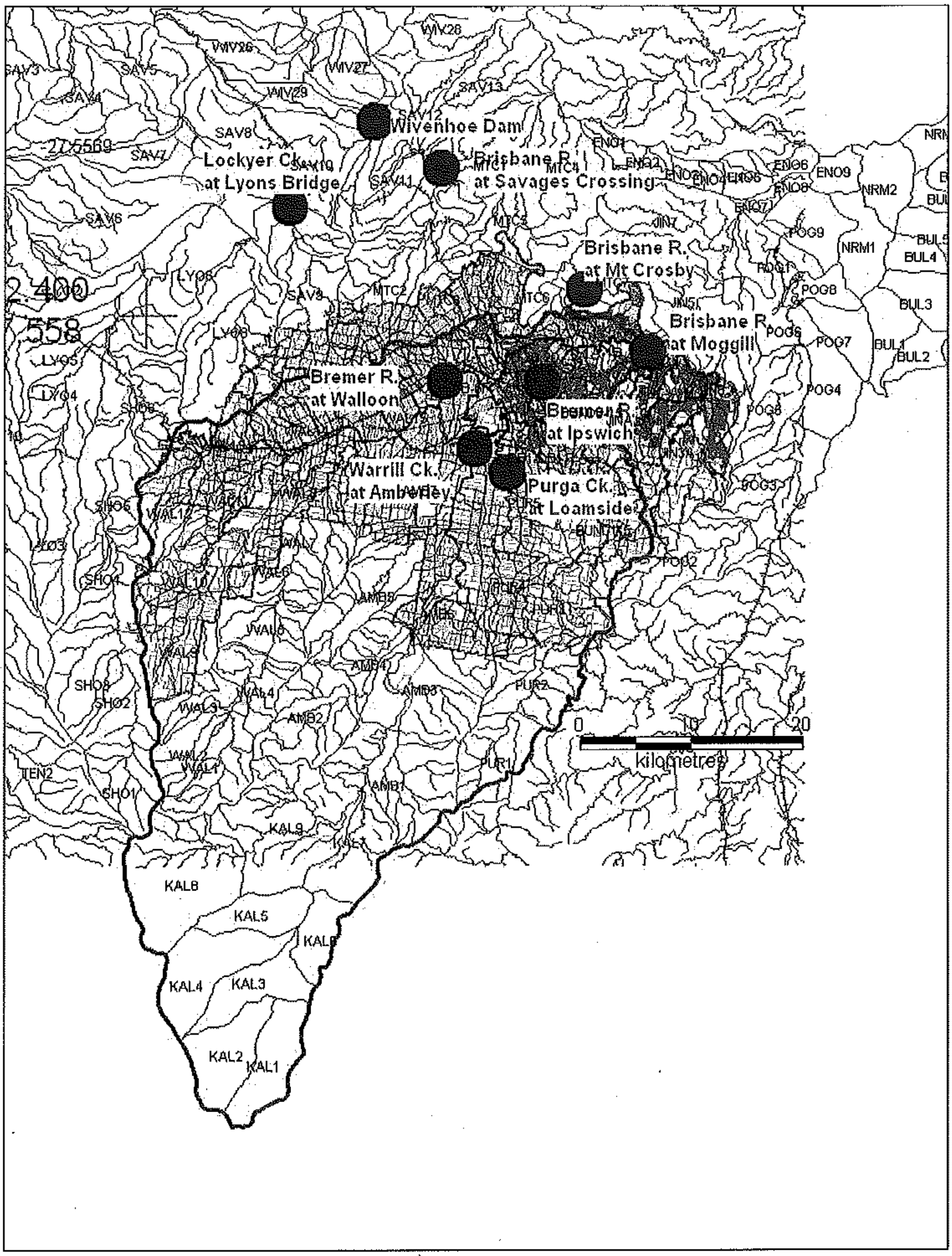


Figure 2 Bremer River Catchment showing RAFTS Sub-areas and Key Locations

2. Design Rainfall Analysis

Using the FORGE design rainfall intensity – duration – frequency (IFD) analysis procedure, design rainfalls were extracted for:

- Each sub area in the RAFTS model in the Bremer River catchment and the Brisbane River catchment between Savages Crossing and Gailes;
- For the catchments above the gauging stations at:
  - Warrill Creek at Amberley;
  - Bremer River at Walloon; and
  - Purga Creek at Loamside;
- For the whole Bremer River catchment to its confluence with the Brisbane River; and
- Brisbane River between Savages Crossing and Gailes (including Ipswich tributaries).

As well as defining IFD curves based on the new FORGE rainfall dataset, this process also computes and accounts for areal reduction factors (ARFs) which are dependant on catchment area and storm duration. These ARFs are used in determining the IFD curve for a given location/catchment size.

The IFD curves give design rainfall intensities (or totals) for storm durations from 15 minutes to 120 hours and for ARIs from 5 years to 2,000 years.

Table 1 shows IFD curves for the whole of the Bremer River catchment and for Warrill Creek to Amberley as examples, from which it can be seen that there is a small reduction in design intensity for the larger catchment.

Figure 3 shows the Bremer River catchment IFD curves in graphical form.

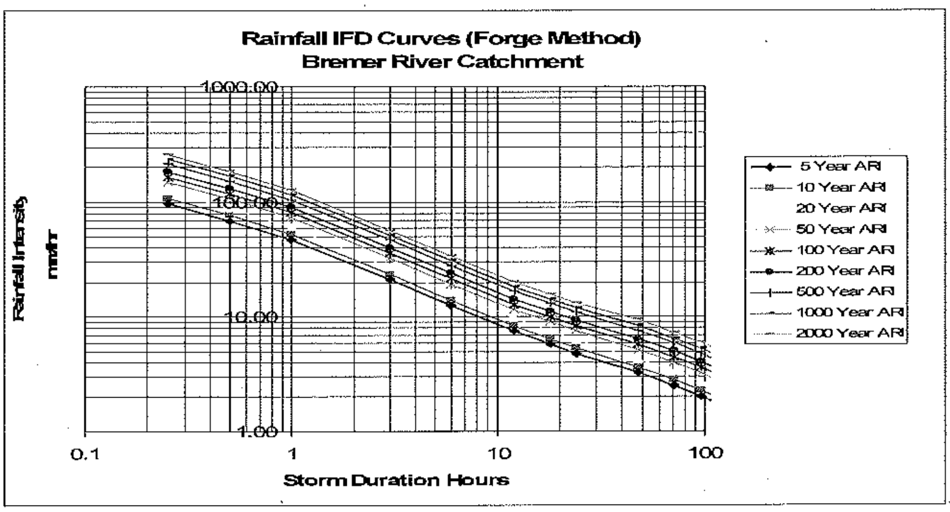


Figure 3 **FORGE IFD Curve for Bremer River Catchment**

The spatial variation for the 100 year ARI 18 hour storm duration rainfall is shown in **Figure 4** as an example.

The temporal patterns from ARR (1987 & updates) were used with the IFD curves to define the rainfall inputs to the RAFTS model runs (see **Sections 3.2** and **4**).

Table 1 FORGE IFD Tables

a) Bremer River Catchment

Storm Duration Hours	Rainfall Intensity mm/hr for ARI (Years)								
	5	10	20	50	100	200	500	1000	2000
0.25	96.36	108.30	124.80	147.10	165.70	185.20	212.50	234.60	257.50
0.5	68.59	77.21	89.04	105.10	118.40	132.30	151.80	167.60	184.00
1	46.98	52.95	61.15	72.26	81.42	90.96	104.40	115.20	126.50
3	21.06	23.70	27.33	32.24	36.32	40.58	46.58	51.41	56.44
6	12.58	14.14	16.30	19.21	21.64	24.18	27.75	30.64	33.63
12	7.54	8.47	9.75	11.48	12.94	14.46	16.59	18.32	20.11
18	5.78	6.54	7.59	9.01	10.15	11.34	13.01	14.36	15.77
24	4.77	5.44	6.33	7.56	8.52	9.52	10.93	12.06	13.24
48	3.25	3.70	4.31	5.15	5.83	6.56	7.60	8.44	9.35
72	2.51	2.85	3.33	3.97	4.51	5.08	5.89	6.55	7.26
96	2.03	2.32	2.70	3.22	3.66	4.13	4.80	5.34	5.93
120	1.71	1.94	2.26	2.70	3.07	3.47	4.02	4.48	4.97

b) Warrill Creek Catchment to Amberley

Storm Duration	Rainfall Intensity mm/hr for ARI (Years)								
	5	10	20	50	100	200	500	1000	2000
0.25	97.34	108.80	124.60	146.00	164.10	182.80	208.90	229.80	251.30
0.5	69.09	77.18	88.44	103.60	116.40	129.70	148.20	163.00	178.30
1	47.17	52.69	60.37	70.71	79.46	88.51	101.10	111.30	121.70
3	21.45	23.98	27.50	32.25	36.24	40.37	46.13	50.75	55.51
6	12.93	14.47	16.61	19.50	21.91	24.41	27.89	30.69	33.56
12	7.82	8.76	10.07	11.83	13.30	14.81	16.93	18.62	20.37
18	6.01	6.79	7.86	9.32	10.47	11.67	13.33	14.67	16.04
24	4.98	5.66	6.58	7.85	8.82	9.83	11.23	12.35	13.51
48	3.37	3.84	4.46	5.32	6.00	6.72	7.72	8.52	9.36
72	2.60	2.95	3.44	4.10	4.63	5.18	5.95	6.57	7.22
96	2.09	2.38	2.77	3.30	3.73	4.18	4.81	5.32	5.85
120	1.75	1.99	2.32	2.76	3.12	3.50	4.03	4.45	4.90

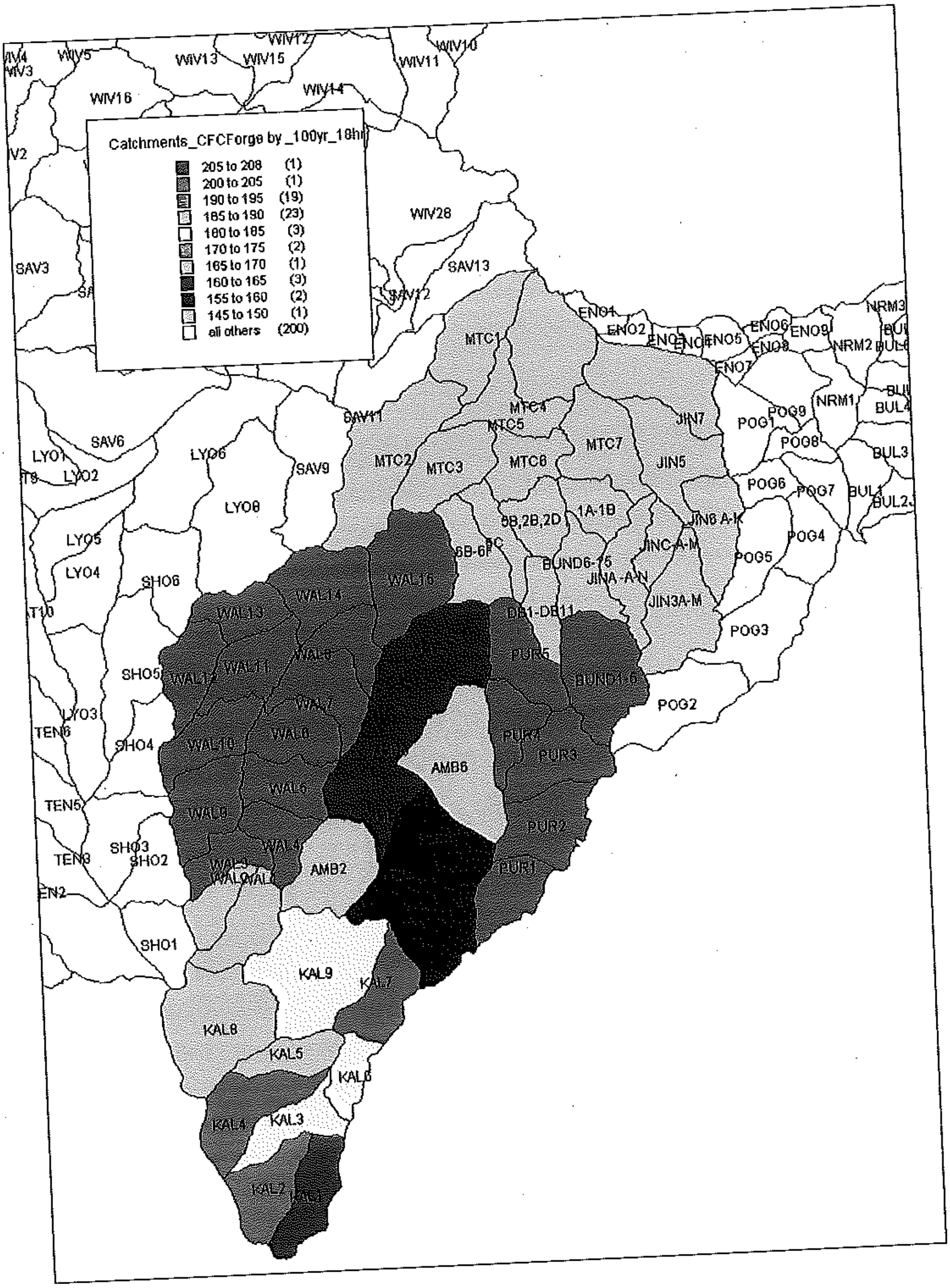


Figure 4 **Example of Spatial Variation of Storm Rainfall – Bremer River Catchment**

3. Adjustment of Rainfall Losses

In order to utilise the new design rainfall data with the RAFTS model, it was appropriate to reconsider the appropriate rainfall losses to use in the design runs of the model. It was beyond the scope of work of this commission to re-calibrate the RAFTS model parameters.

This component was further limited to refining the rainfall initial loss, with the continuing loss of 1mm/hr as used in the latest of the previous modelling (SKM 2003 and Sargent Consulting 2006) adopted throughout.

In order to provide a basis for comparison of modelled flows and design flows estimated from flood frequency analysis of flow records within the catchment, new flood frequency analyses were undertaken and compared to those available from the previous studies.

3.1. Flood Frequency Analysis

The key locations in the Bremer River catchment for which streamflow records are available are:

- Warrill Creek at Amberley;
- Bremer River at Walloon; and
- Purga Creek at Loamside.

SKM (2003) determined that the most suitable statistical distribution to describe flood flows in the Brisbane River catchment was the Generalised Pareto (GP) distribution, so this has been used here as the primary distribution, with the log-Pearson Type III (LP3) distribution used for comparative purposes in some instances.

Table 2 shows the results of the flood frequency analyses for the annual maximum series for each of these gauging stations and **Figure 5** shows these in graphical form.

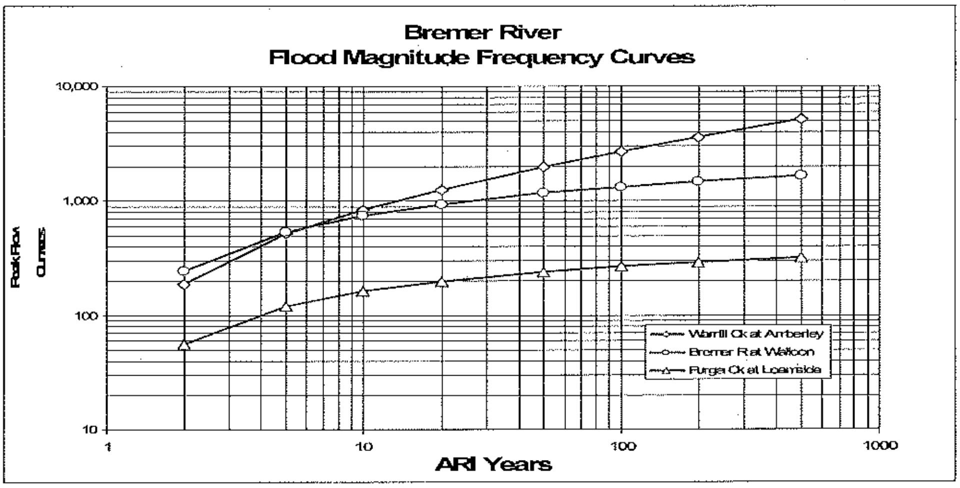


Figure 5 **Bremer River – Flood Magnitude Frequency Curves**

Table 2 Flood Frequency Analysis Bremer River Catchment

Waterway	Location	Period of Record	Catchment area km2	Fitted Distribution	Peak flow (cumecs) for ARI (Years)								Comment
					2	5	10	20	50	100	200	500	
Warrill Ck	Amberley	1962-2004	920	GP	187	512	835	1,244	1,958	2,670	3,570	5,140	Current Study
		1962-1998		LP3	173	445	747	1,150	1,865	2,585			FFA SKM 2000
Bremer R	Walloon	1963-2003	620	GP	244	540	745	935	1,165	1,325	1,475	1,650	Current Study
				LP3	200	564	780	934	1,065	1,126	1,166	1,198	tending to upper bound
Purga Ck	Loamside	1975-2004	215	GP	56	120	162	198	240	268	292	319	Current Study Upper bound unreasonable
		1974-1998		LP3	44	159	202	267	364	447			FFA SKM 2000 noted values low
			NOTE	GP	Generalised Pareto Distribution								
				LP3	Log Pearson Type III Distribution								

Table 3 Bremer River Catchment Peak Discharge per km^2

Waterway	Location	Period of Record	Catchment area km2	Fitted Distribution	Peak flow (cumecs) for ARI (Years)								Comment
					2	5	10	20	50	100	200	500	
Warrill Ck	Amberley	1962-2004	920	GP	0.20	0.56	0.91	1.35	2.13	2.90	3.88	5.59	Current Study
		1962-1998		LP3	0.19	0.48	0.81	1.25	2.03	2.81			FFA SKM 2000
Bremer R	Walloon	1963-2003	620	GP	0.39	0.87	1.20	1.51	1.88	2.14	2.38	2.66	Current Study
				LP3	0.32	0.91	1.26	1.51	1.72	1.82	1.88	1.93	tending to upper bound
Purga Ck	Loamside	1975-2004	215	GP	0.26	0.56	0.75	0.92	1.12	1.25	1.36	1.48	Current Study Upper bound unreasonable
		1974-1998		LP3	0.20	0.74	0.94	1.24	1.69	2.08			FFA SKM 2000 noted values low
			NOTE	GP	Generalised Pareto Distribution								
				LP3	Log Pearson Type III Distribution								

Table 3 and **Figure 6** show these flows on a discharge per km^2 basis. Storm rainfall intensities are slightly higher in the upper Bremer River catchment and in the Purga Creek catchment than in the Warrill Creek catchment (see **Figure 4**) due to orographic effects. In respect of Warrill Creek at Amberley compared to Bremer River at Walloon, the discharge per km^2 is lower for ARI less than 30 years, but greater for higher ARI events. This could be due to different catchment hydrology or to data errors.

These differences could be due to a number of factors such as different soil characteristics affecting initial and continuing loss rates, different ground cover affecting initial loss rates, losses to groundwater, or greater temporary storage of floodwaters, or could be due to data errors at one or other of the gauging stations.

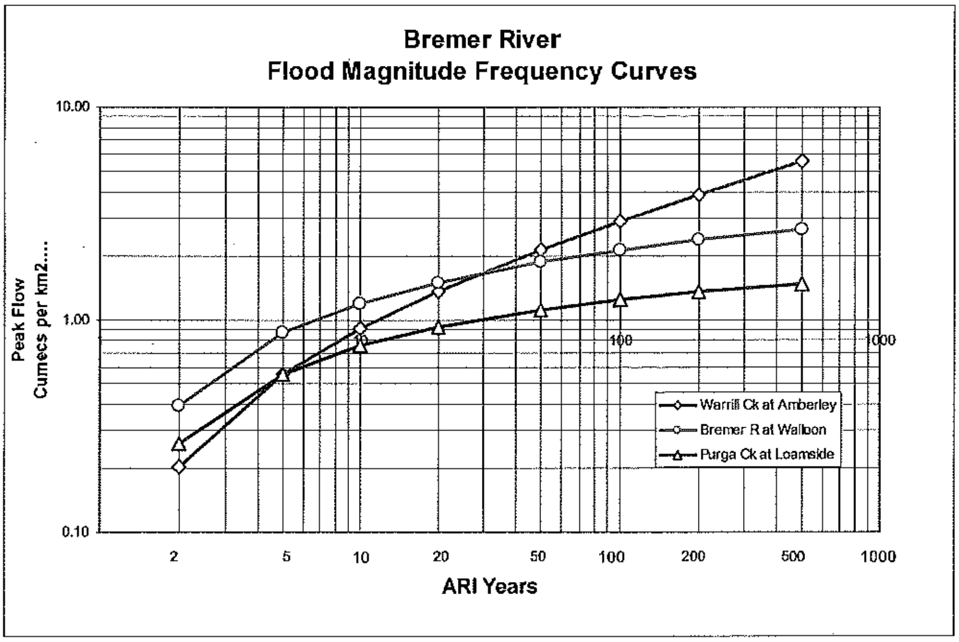


Figure 6 **Bremer River Discharge per km^2**

In order to shed further light on these apparent anomalies, records of other stations in the Brisbane River catchment were inspected, using the results from analyses presented in SKM 2003. Details of these gauging stations are given in **Table 4**. The comparison of these records is shown in **Figures 7** and **8.**

Figure 7 shows discharge per km^2 for Brisbane River at Gregors Creek, Lockyer Creek at Lyons Bridge and Cressbrook Creek at Rosentreters Bridge. The slopes of these additional curves are all similar and similar to that for Warrill Creek at Amberley. This suggests that the Amberley record is the more likely to be reliable than either the Walloon or Loamside records.

In order to rectify the apparent anomaly in the initial losses required to fit the RAFTS model (**Section 3.2** refers), further regional analysis was undertaken to estimate regional flood frequency curves.

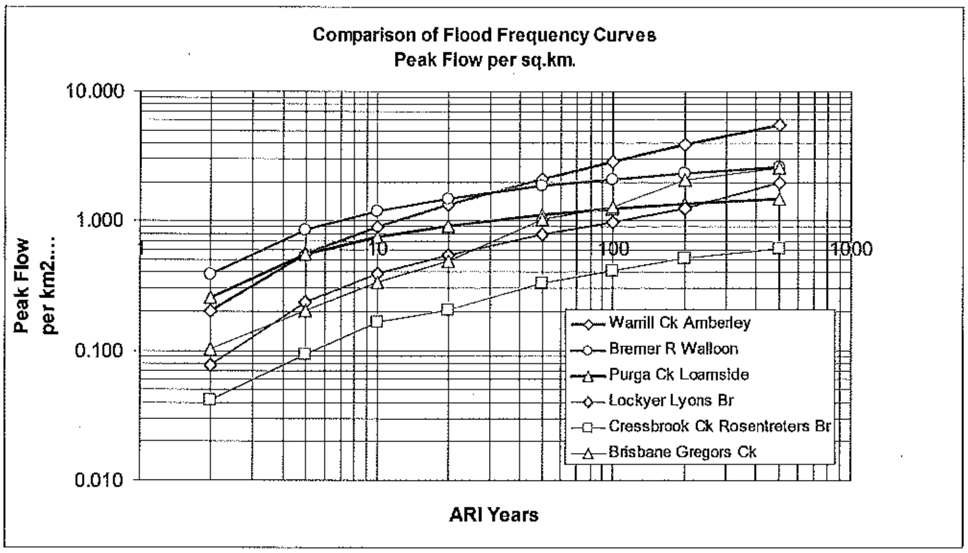


Figure 7 **Brisbane River and Bremer River Discharge per km^2**

Table 4 **Summary Details of other Brisbane River Catchment Gauging Stations used**

Waterway	Location	Period of Record	Catchment Area km^2
Lockyer Ck	Lyons Bridge	1964 - 1988	2550
Cressbroook Ck	Rosentreters Bridge	1986 - 2002	477
Brisbane River	Gregors Creek	1962 - 2002	3885

This was done using the index flood method (IEAust 1987) in which a regression equation is used to estimate an index flood, taken here as the 2 year ARI flood (**Q_2**) and a dimensionless flood growth curve used to estimate foods for other ARIs.

As the rainfall regime is similar across the inland parts of the Brisbane/Bremer River catchments in which all of these stations lie, the relationship for **Q_2** was based on catchment area alone. **Figure 8** shows this relationship. Even though the higher flood estimates for the stations Bremer River at Walloon and Purga Creek at Loamside were found to be suspect, the lower ARI values should be more reasonable, so these were included in this phase of the analysis. The correlation coefficient of the regression equation was improved significantly by excluding the data from the Cressbrook Creek gauging station from this analysis.

This resulted in the following estimator for **Q_2** as a function of catchment area:

$$\mathbf{Q_2} = 4.4515\,\mathbf{A}^{0.533} \quad (R^2 = 0.72)$$

Where:
Q_2 is the estimated 2 year ARI peak flow (m^3/s);
A is the catchment area in km^2; and
R is the correlation coefficient of the regression.

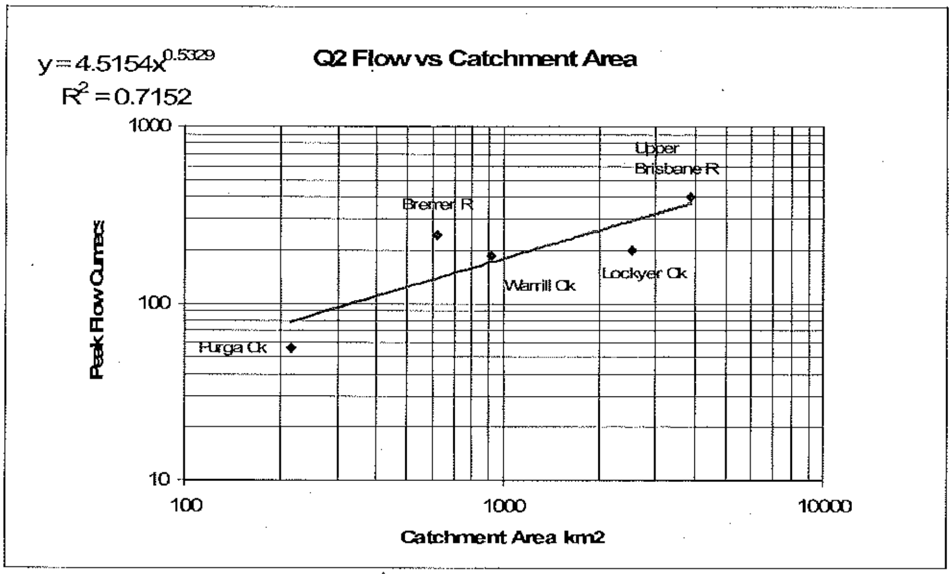


Figure 8 **Q_2 vs Catchment Area**

The flood frequency growth curves for each station (i.e. graph of $\mathbf{Q_t/Q_2}$ where t = ARI) is given in **Figure 9** from which it can be seen that the curves for Walloon and Loamside are considerable lower than those for the other stations.

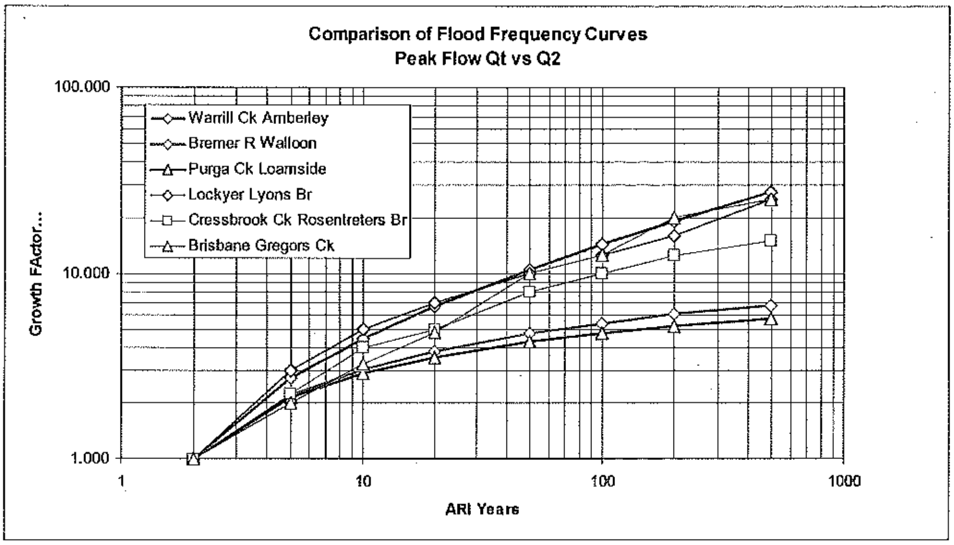


Figure 9 **Flood Frequency Growth Curves**

A median growth curve was determined excluding the 2 anomalous station records, which was then used in conjunction with the estimation of $\mathbf{Q_2}$ based on catchment area to provide an independent estimate of the flood frequency curves for Walloon and Loamside. These curves are shown in **Figure 10** and **Table 5** from which it can be seen that the noted anomalies are removed by this process.

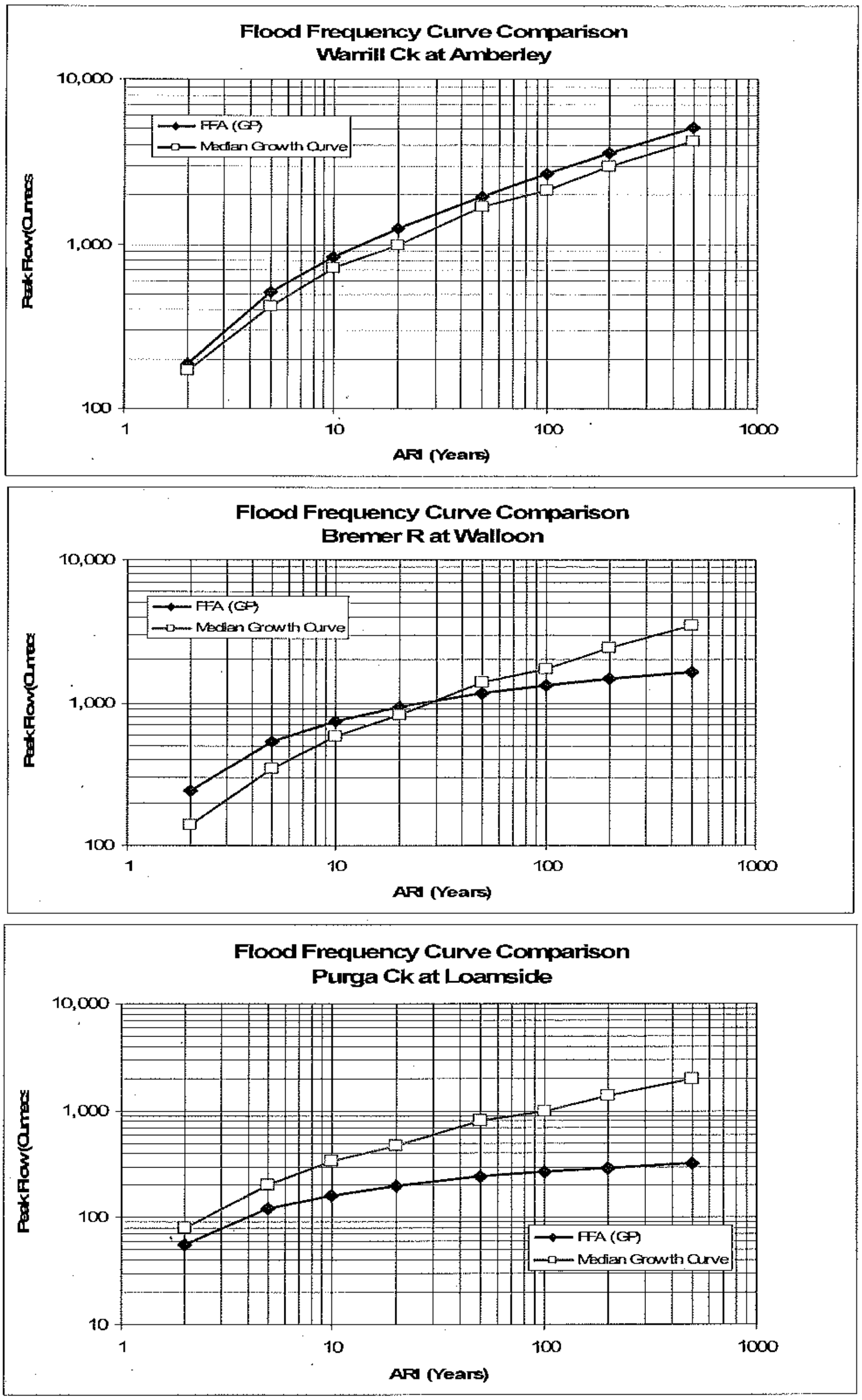


Figure 10 Comparison of Flood Frequency Curves

Table 5 **Flood Frequency Curves for Bremer River Catchment Stations based on Regional Analysis**

River	Location	Catchment area km^2	Q_2 m^3/s	Q_5 m^3/s	Q_{10} m^3/s	Q_{20} m^3/s	Q_{50} m^3/s	Q_{100} m^3/s	Q_{200} m^3/s	Q_{500} m^3/s
Warrill Ck	Amberley	920	170	420	720	990	1,700	2,130	2,980	4,250
Bremer R	Walloon	620	140	350	590	820	1,400	1,750	2,460	3,500
Purga Ck	Loamside	215	80	200	340	470	800	1,000	1,400	2,000

The RAFTS model was subsequently refitted to these median curves as described in the next section (**Section 3.2**).

3.2. RAFTS Sub Catchment Models

The RAFTS model re-calibration was initially undertaken using the flood frequency curves for Amberley, Walloon and Loamside based on direct data analysis. Subsequently, this was repeated using the regional growth curves given in **Table 5**. In order to maximise consistency with flood frequency curves, initial losses were adjusted so as to provide reasonable level of agreement between the RAFTS estimates of design flows and those from both the direct and regional flood frequency analysis.

In order for the modelled flows to be representative of design flows at the locations listed above, it was necessary to use design rainfalls for the individual catchments draining to the above locations, rather than the whole of the Bremer River catchment. The RAFTS model was modified accordingly, and run with the appropriate design rainfalls from the new dataset. These used design rainfalls for each individual model sub-area using the FORGE IFD procedures outlined in **Section 2** hereof.

These model runs were undertaken for storm durations of 3 to 24 hours and for average recurrence intervals (ARIs) of 5 to 500 years in order to determine the critical duration for each of the catchments for each ARI, and then the initial loss was varied in order to bring the modelled peak flow into reasonable agreement to that from the flood frequency analysis.

The critical storm durations were found to be 18 hours for all ARIs for Amberley and Walloon whilst for Loamside the critical storm duration was 6 hours for all ARIs.

In all of the model runs, the continuing loss was assumed to be 1mm/hr as was assumed in the most recent RAFTS modelling (SKM 2003 and Sargent Consulting 2006).

Figure 11 shows the initial losses in respect of each of the three calibration stations. The fitted initial losses for Warrill Creek at Amberley ranged from 65mm for 5 year ARI to zero at 100 year ARI and greater. As the initial loss could not be negative, it was not possible to match the RAFTS and FFA flows for 200 and 500 year ARIs. This observed reduction in initial loss with increasing ARI is reasonable.

However, the relationship between initial loss and ARI was reversed for the records at Walloon and Loamside, which is counter-intuitive and unreasonable. This adds weight to the possibility that the flow records at the latter stations are anomalous.

In order to rectify this anomaly in the initial losses required to fit the RAFTS model, the regional flood frequency analysis described in **Section 3.1** hereof was utilised.

Revised flood frequency curves were produced for each key location based on the regional analysis, and the process of varying the initial loss to reasonably fit the frequency curve was repeated. The initial loss variation was significantly different in this case, as shown in **Figure 12.**

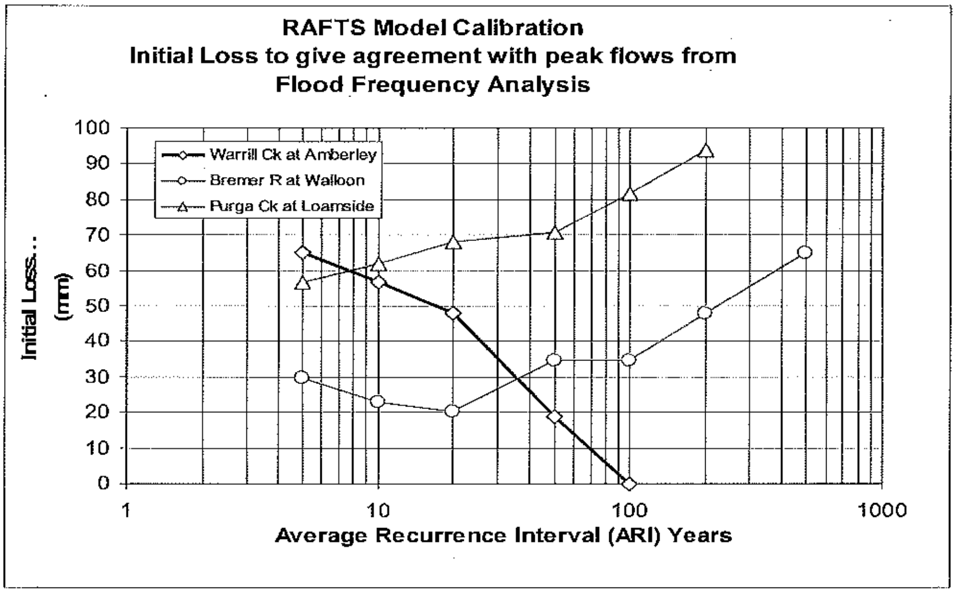


Figure 11 RAFTS Model Initial Calibration – Initial Loss

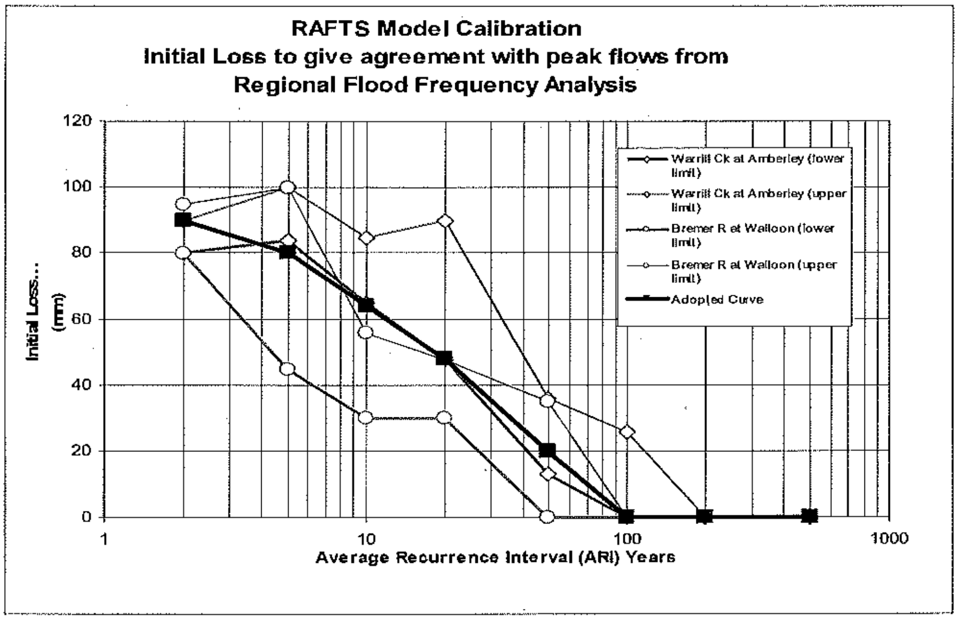


Figure 12 RAFTS Model Calibration with Regional Curves – Initial Loss

Figure 12 shows that the anomalous values from the initial calibration have been reversed, with initial loss generally reducing as ARI increases for all three locations.

An average curve was fitted, as shown in **Figure 12,** and used for design flow estimation. It was considered more appropriate to use averaged values throughout the catchment than to vary the values on a sub-catchment basis. The fitted frequency curve from the RAFTS modelling on this basis is given in **Table 6**.

Comparing the values in **Tables 5** and **6**, it can be seen that good agreement was obtained for ARIs of up to 100 years, but that once the modelled initial loss became zero, flows at higher ARIs were underestimated. This may well be reasonable, as streamflow based flood frequency analysis is of low accuracy where the ARI is many times the length of record, and rainfall based analysis, on which the RAFTS modelling is based, may be more accurate due to the longer rainfall records from which the FORGE design rainfalls have been derived. The curves are shown graphically in **Figure 13**.

In order to be able to utilise the RAFTS model over the whole of the Bremer River catchment, it was necessary to make some assumptions regarding the appropriate initial loss to use for the parts of the catchment not covered by the three gauging stations. This was based on the area weighted mean of the values for the three individual catchments, which was considered to be more appropriate than the simple mean.

3.3. Conclusions

Given all of the above, the following conclusions were drawn:

- There are apparent anomalies in the direct flood frequency curves for Bremer River at Walloon and Purga Creek at Loamside but it was outside the scope of work of this commission to undertake a detailed data review in order to resolve these anomalies;

- The use of a regional flood frequency analysis using the index flood methodology improved the ability to match predicted design flood flows from flood frequency analysis and from RAFTS modelling;

- In order to reasonably match flows modelled in RAFTS using the FORGE design rainfalls, the values of initial loss used in the model must reduce as the ARI increases;

- Given that the initial loss obtained from RAFTS modelling reduced to zero for ARIs of 100 years and greater it was not possible to match the flood frequency curve figures for higher ARIs. However, as the fitted flood frequency distributions are tentative in respect of the more extreme floods, and that rainfall based estimates are more reliable in this regard due to their longer record length, this may be reasonable; and

- Given the uncertainties apparent from this process to better define design initial losses, it was appropriate to consider the possible accuracy of the estimates by undertaking a sensitivity analysis.

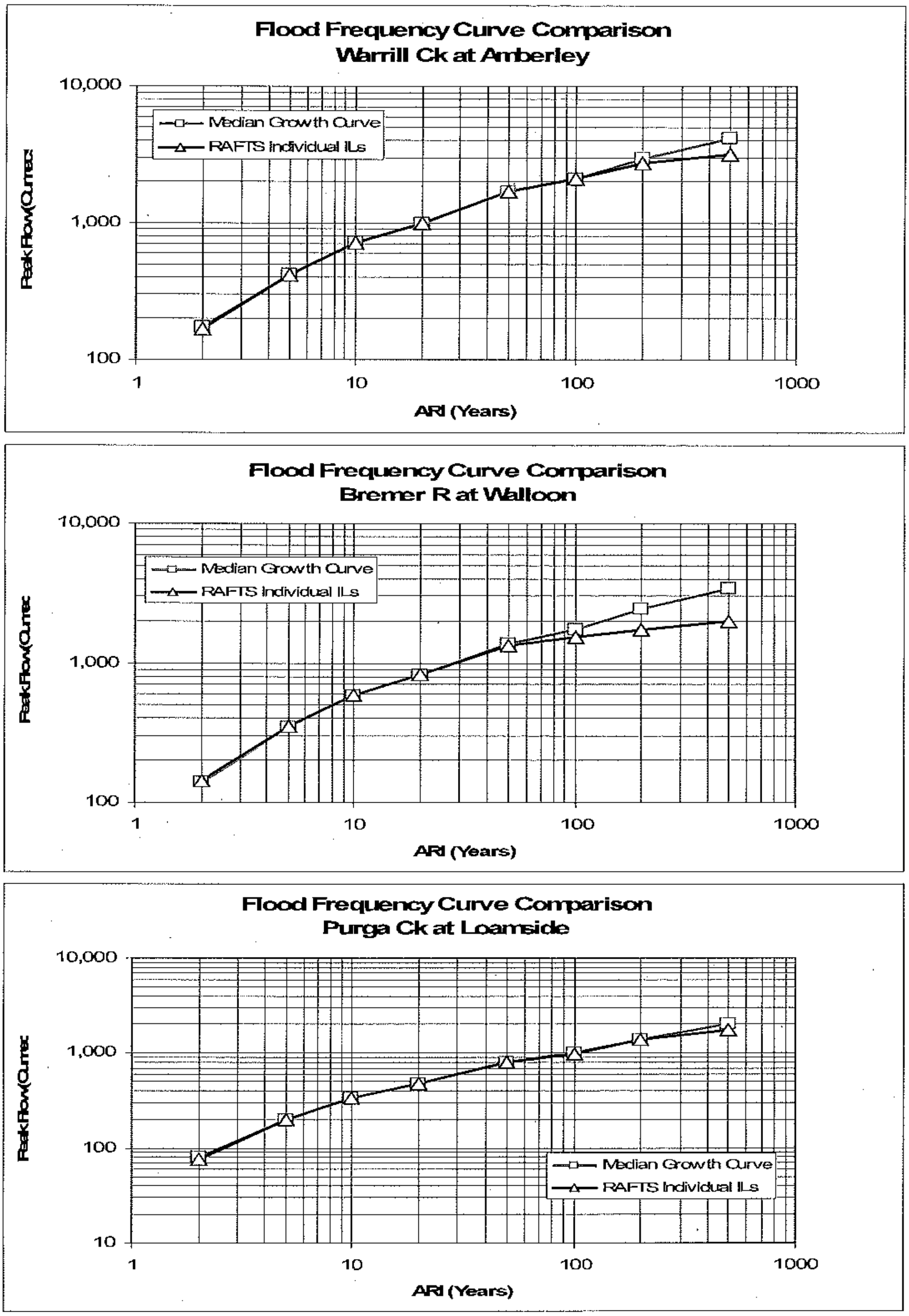


Figure 13 Comparison of Flood Frequency Curves

Table 6 Flood Frequency Curves for Bremer River Catchment Gauging Stations based on RAFTS Modelling

River	Location	Q_2 m^3/s	Q_5 m^3/s	Q_{10} m^3/s	Q_{20} m^3/s	Q_{50} m^3/s	Q_{100} m^3/s	Q_{200} m^3/s	Q_{500} m^3/s
Warrill Ck	Amberley	170	460	720	1,000	1,700	2,130	2,700	3,200
Bremer R	Walloon	145	350	590	820	1,350	1,530	1,700	2,000
Purga Ck	Loamside	80	240	330	470	800	1,000	1,400	1,750

4. RAFTS Modelling for Design Flows

The design peak flood flows for the Bremer River catchment, for the Brisbane River downstream of Savages Crossing to the Ipswich/Brisbane local government boundary at Gailes, and for the Brisbane River tributaries within Ipswich were obtained using the RAFTS model with initial loss computed as discussed in **Section 3** hereof, together with assumed design input hydrographs at Savages Crossing consistent with the 6,000 m^3/s design flow for 100 year ARI as recommended by the Independent Review Panel (Mein et al 2003).

The following paragraphs outline the design rainfall data used, the Savages Crossing hydrographs, the results obtained and sensitivity analyses. **Section 5** discusses the new results and compares them with those from previous studies.

The outputs from the RAFTS model for individual sub areas were subsequently used to prepare boundary condition hydrographs for the MIKE 11 hydraulic model as outlined in **Section 6** hereof.

4.1. Design Inputs

4.1.1 Design Rainfalls

This modelling is seeking primarily, to determine the design flows to input to the hydraulic model which result in the maximum peak water levels in the lower Bremer River (i.e. from Ipswich CBD to the confluence with the Brisbane River) for a given ARI.

In view of this aim, the appropriate design rainfalls are those pertaining to the whole of the Bremer River catchment, for which the IFD table had been given in **Table 1 (a)**. When the FORGE procedure to compute IFD tables is carried out for the individual sub areas, not only is there some spatial variation, the values are higher because the smaller catchment size results in a higher areal reduction factor.

In order to preserve the design rainfalls for the whole of the Bremer River catchment, the catchment rainfalls for individual sub areas were weighted by the ratio of the mean catchment rainfall computed from the sub area rainfalls (weighted by their corresponding catchment areas) to the overall catchment rainfall.

These weights were computed for ARIs of 5, 10, 20, 50, 100, 200 and 500 years and for the range of storm durations available.

The weighted sub area rainfalls were then used in the RAFTS model.

The FORGE IFD curves do not give values for 2 year ARI, and these were estimated by factoring the 5 year values by the ratio of 2 year rainfall to 5 year rainfall (of the same duration) from the ARR rainfall data. It was necessary also to estimate rainfalls for intermediate durations not given by the FORGE analysis. These were estimated on the basis of factoring the values for the closest duration by the ratio of ARR rainfalls of the same durations and ARI.

4.1.2 Design Loss Rates

As discussed in **Section 3.3** hereof, it was found that, in order to achieve reasonable calibration between peak flows estimated from flood frequency analyses and from RAFTS modelling, it was necessary to adopt initial loss rates which decrease with ARI. The adopted values are given in **Table 7.**

Table 7 **Adopted Initial Losses**

ARI Years	Initial Loss mm
2	90
5	80
10	64
20	48
50	20
100	0
200	0
500	0

The values in **Table 7** were applied in respect of the catchments above the given locations, and the area weighted mean values were used for the sub-catchments further downstream i.e. both Bremer River and Brisbane River local inflows and tributary inflows.

In all cases an initial loss of 1mm was applied to the urbanised portion of the sub-areas, as was used in previous studies. A continuing loss rate of 1mm/hour was retained throughout.

4.2. Input Hydrographs at Savages Crossing

Under the current flow regime in the Brisbane River, the flow at Savages Crossing comprises the release from Wivenhoe Dam together with the natural inflow from Lockyer Creek and the local catchment downstream. These locations are shown in **Figure 14**.

In order for this study to be consistent with the adoption of a $\mathbf{Q_{100}}$ at Savages Crossing of 6,000 m^3/s, as recommended by the Brisbane River Flood Study Independent Review Panel (Mein et al 2003), it was desirous to use input hydrographs at that location which reflected this assumption.

It was also necessary to estimate hydrographs for the other flood event ARIs which were being considered.

This section outlines the estimation of a flood frequency curve for peak flows at Savages Crossing, and the estimation of the corresponding flow hydrographs.

Table 8 Estimation of Post –Dam Flood Frequency Curve for Savages Crossing

Data set	Fitted Distribution	Peak flow (cumecs) for ARI (Years)							
		2	5	10	20	50	100	200	500
"Dams" based on DNRM adjusted estimates (Source SKM (2003)									
1890-2000	GP	250	500	1,200	1,800	2,500	**3,590**	4,600	N/A
1890-2000	LP3	250	800	1,500	2,300	3,500	**4,920**	5,500	N/A
Growth Curve scaled to Q100									
1890-2000	GP	0.070	0.139	0.334	0.501	0.696	**1.000**	1.281	N/A
1890-2000	LP3	0.051	0.163	0.305	0.467	0.711	**1.000**	1.118	N/A
Independent Review Panel (2003) post dams based on average growth curve		360	910	1,920	2,910	4,220	**6,000**	7,200	9,000
Monte Carlo Analysis (Sargent Consulting 2005) post dams based on average growth curve		270	680	1,440	2,180	3,170	**4,500**	5,400	N/A

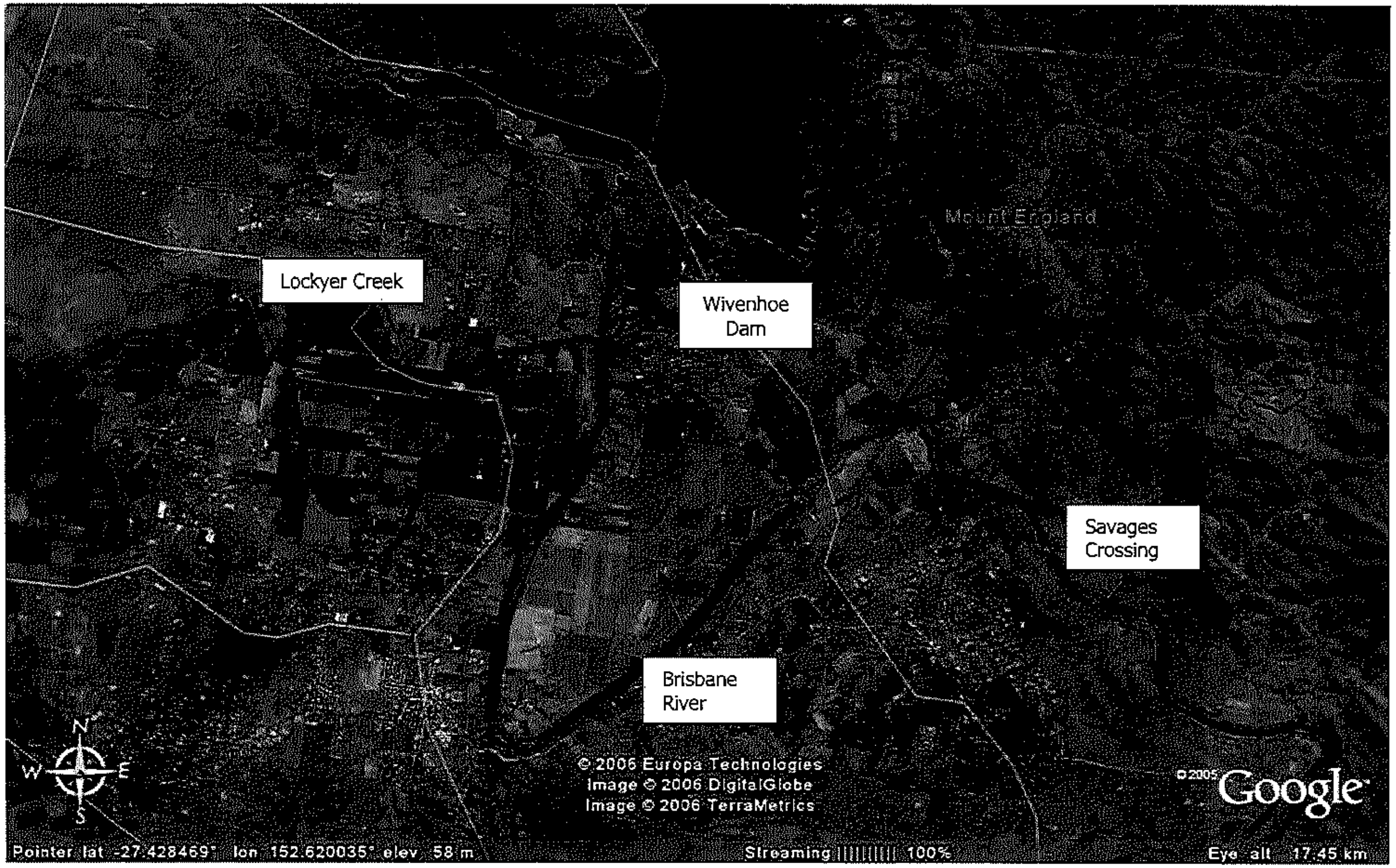


Figure 14 Location Map – Savages Crossing (Source: Google Earth)

4.2.1 Flood Frequency Curves

SKM (2003) undertook a comprehensive analysis of flood magnitude/frequency relationships for Savages Crossing using both pre-dam and post-dam data. The curves for post-dams data are reproduced here in **Table 8**. These curves which were obtained by the fitting of different statistical distributions (Generalised Pareto and log Pearson Type III distributions) to the data set prepared by DNRM to account for the effect of Somerset and Wivenhoe Dams.

For the current study, these curves were standardised into flood frequency growth curves by dividing by the appropriate $\mathbf{Q_{100}}$ value, and the two curves, which did not differ greatly, were averaged. These are also given in **Table 8.**

Finally, the averaged growth curve was scaled to give a $\mathbf{Q_{100}}$ of 6,000m^3/s, which gave estimated values for ARIs from 2years to 200 years. The curve was extended to 500 Year ARI "by eye" as shown in **Figure 15.**

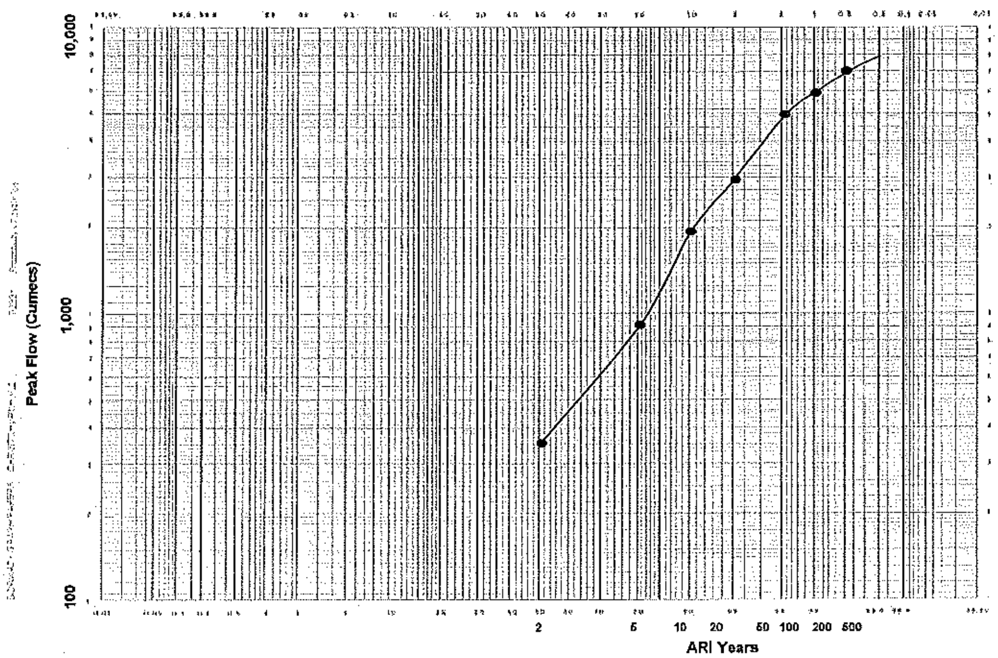


Figure 15 **Estimated Flood Frequency Curve - Brisbane River at Savages Crossing**

4.2.2 Hydrograph Estimation

Hydrographs for Savages Crossing for a range of peak flows were available from the "Monte Carlo" analysis undertaken as another component of the *Ipswich Rivers Flood Study Rationalisation Project* (Sargent Consulting 2006).

These hydrographs were obtained using the RAFTS model in conjunction with the DNRM Wivenhoe operations model and so reflect the combined Wivenhoe/Lockyer Creek flows under current operating conditions.

A typical hydrograph with a peak flow of 6,000m^3/s is shown in **Figure 16**. The Monte Carlo runs available had peak flows at Savages Crossing ranging from 1,870 m^3/s to 8,370m^3/s. Hydrographs for ARIs of 2 years to 500 years were estimated by scaling the nearest available hydrograph to give the appropriate peak flow.

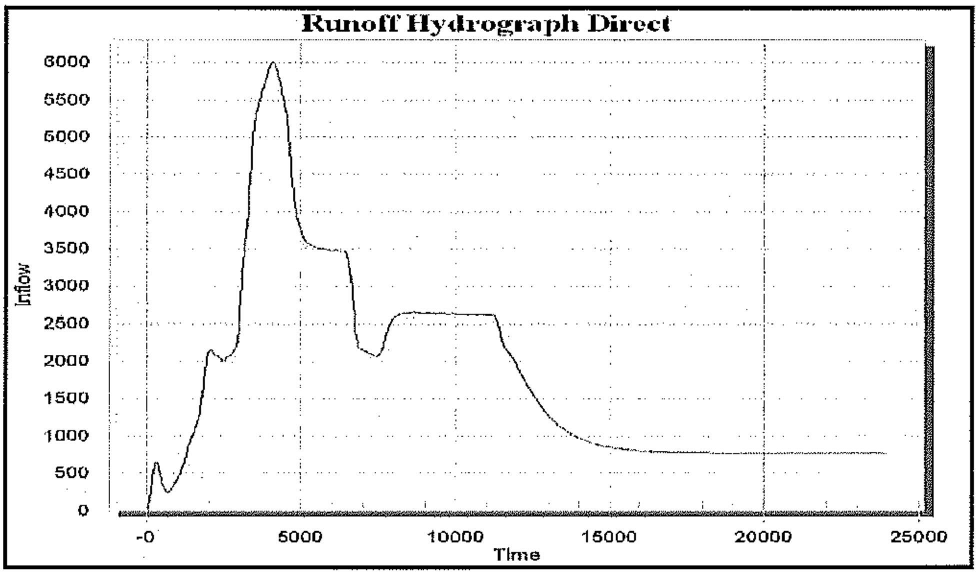


Figure 16 Typical Hydrograph – Brisbane River at Savages Crossing

4.3. Resulting Design Flows

Design flows were estimated for a range of storm durations from 1 hour to 72 hours for ARIs of 2, 5, 10, 20, 50, 100, 200 and 500 years. These results are given in **Appendix C** for key locations.

A summary table of the maximum estimated peak flows across the range of durations at key locations for the range ARIs used is given in **Table 9.**

Table 10 summarises the critical duration for each of the key locations for each ARI. This shows a significant decrease in the critical duration with increasing ARI at most locations. This is due to the adoption of relatively high initial losses at low ARIs decreasing with increasing ARI, and is reasonable in the light of the adopted initial loss rates.

Figure 17 shows the flood frequency curves for Bremer River at Walloon, Warrill Creek at Amberley and Purga Creek at Loamside from the RAFTS modelling, from the flood frequency analysis and from the median regional growth curves.

Discussion of the new flood frequency curves is given in **Section 5** where these are compared with results from previous studies.

It should be noted that the estimated flows at locations where there are many contributing sub-areas will be subject to revision when the MIKE 11 hydraulic model is re-run with the new design flows, as the latter takes full account of the temporary storage of floodwaters on the floodplain which is only approximated in RAFTS.

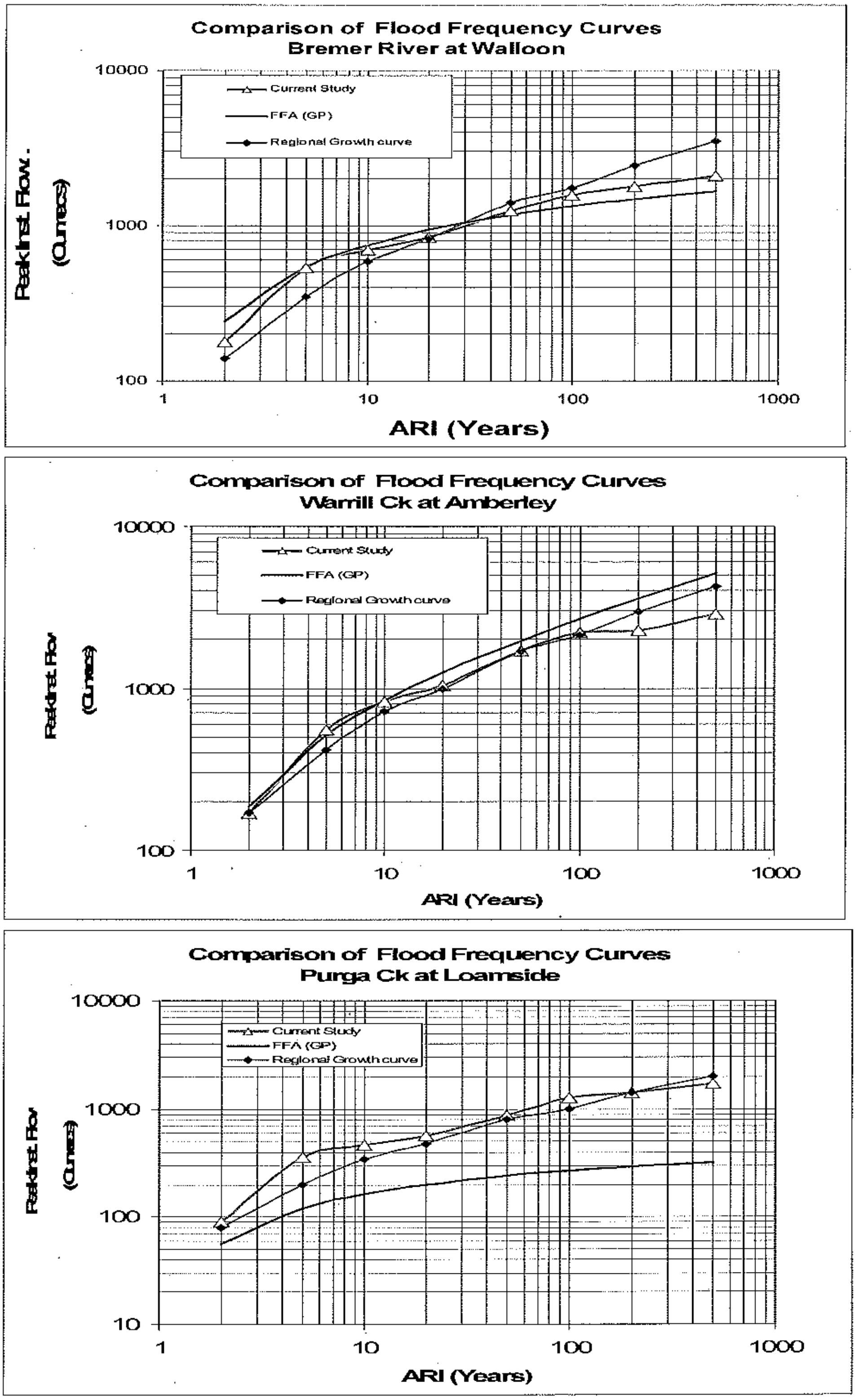


Figure 17 Flood Frequency Curves

Table 9 Summary of Peak Flow Estimates

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for ARI Years							
			2	5	10	20	50	100	200	500
Brisbane R	Savages Crossing	SAV-OUT	360	910	1900	2900	4200	6000	7200	8000
	Mt Crosby	MTC-OUT	360	910	1900	2900	4200	6000	7200	8000
Warrill Ck	Kalbar	KAL-OUT	130	440	600	730	990	1400	1610	1900
	Amberley	AMB-OUT	170	560	840	1050	1710	2220	2300	2900
Purga Ck	Loamside	PUR-OUT	90	360	460	560	880	1250	1400	1700
Bremer R	Walloon	WAL-OUT	180	540	700	850	1260	1590	1800	2100
Deebing Ck	U/s Bremer R	DB-OUT	21	50	63	76	120	170	200	230
Ironpot Ck	U/s Bremer R	IP-OUT	14	40	46	55	110	150	180	200
Mihi Ck	U/s Bremer R	MH-OUT	13	18	20	24	56	83	95	110
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	7	20	26	33	76	120	130	160
Bremer R	David Trumpy Br	2C#	370	1200	1580	1770	2410	3060	3200	3600
Bundamba Ck	U/s Bremer R	BUND15	40	140	190	220	310	430	500	580
Bremer R	D/s Bundamba Ck	IPS-OUT	370	1200	1600	1800	2430	3070	3300	3600
Six Mile Ck	u/s Brisbane R	JINAO	24	60	80	94	180	250	280	330
Goodna Ck	u/s Brisbane R	JINCG	11	30	36	44	86	120	140	160
Woogaroo Ck	u/s Brisbane R	JIN3M	40	130	160	190	320	460	520	620
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	26	80	105	120	190	270	310	360

Table 10 Summary of Critical Durations

Waterway	Location	Rafts Node	Critical Duration (Hours) for ARI Years							
			2	5	10	20	50	100	200	500
Warrill Ck	Kalbar	KAL-OUT	48	48	36	12	12	12	12	12
	Amberley	AMB-OUT	48	48	36	18	18	18	18	4.5
Purga Ck	Loamside	PUR-OUT	36	48	36	6	6	6	4.5	3
Bremer R	Walloon	WAL-OUT	36	72	36	12	12	12	12	12
Deebing Ck	U/s Bremer R	DB-OUT	36	48	36	6	6	6	4.5	4.5
Ironpot Ck	U/s Bremer R	IP-OUT	36	48	36	3	3	3	3	3
Mihi Ck	U/s Bremer R	MH-OUT	1	1	18	2	2	2	2	2
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	48	48	18	2	2	2	2	2
Bremer R	David Trumpy Br	2C#	48	48	36	18	18	18	12	12
Bundamba Ck	U/s Bremer R	BUND15	48	48	36	12	6	6	12	12
Bremer R	D/s Bundamba Ck	IPS-OUT	48	48	36	18	18	18	24	12
Six Mile Ck	u/s Brisbane R	JINAO	48	48	36	3	3	3	3	2
Goodna Ck	u/s Brisbane R	JINCG	48	48	36	3	3	3	3	3
Woogaroo Ck	u/s Brisbane R	JIN3M	48	48	36	6	6	3	3	3
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	48	48	36	6	6	6	6	6

4.4. Sensitivity Analysis

The initial loss was the only variable which was modified in the new analysis apart from using the new CRC-FORGE rainfall analysis.

As discussed in **Section 4.3**, it was found that the adoption of initial loss values which deceased as ARI increased, led to increases in the critical duration for the lower ARIs.

SKM (2000) adopted continuing losses varying across sub-catchments from 0.5mm/hr to 2.5mm/hr throughout together with initial loss rates varying from zero to 5mm for 100 year ARI; zero to 20mm for 50 year ARI; zero to 40mm for 20 year ARI, 15mm to 55mm for 10 year ARI; 15 to 70mm for 5 year and 2 year ARI.

In its more recent study (SKM 2003) adopted 10mm initial loss and 1mm/hr continuing loss in respect of the 100 year ARI event.

Sargent Consulting (2006) in a "Monte Carlo" analysis, adopted a triangular distribution for initial loss with its most likely value at 10mm (mode) in a range from 0 to 50mm. This analysis related to 100 year ARI only.

The ranges in initial loss rates adopted in the current study and in SKM (2000) are compared in **Figure 18** which shows that whilst there is considerable overlap, the values adopted in the current study are generally higher than those adopted by SKM (2000).

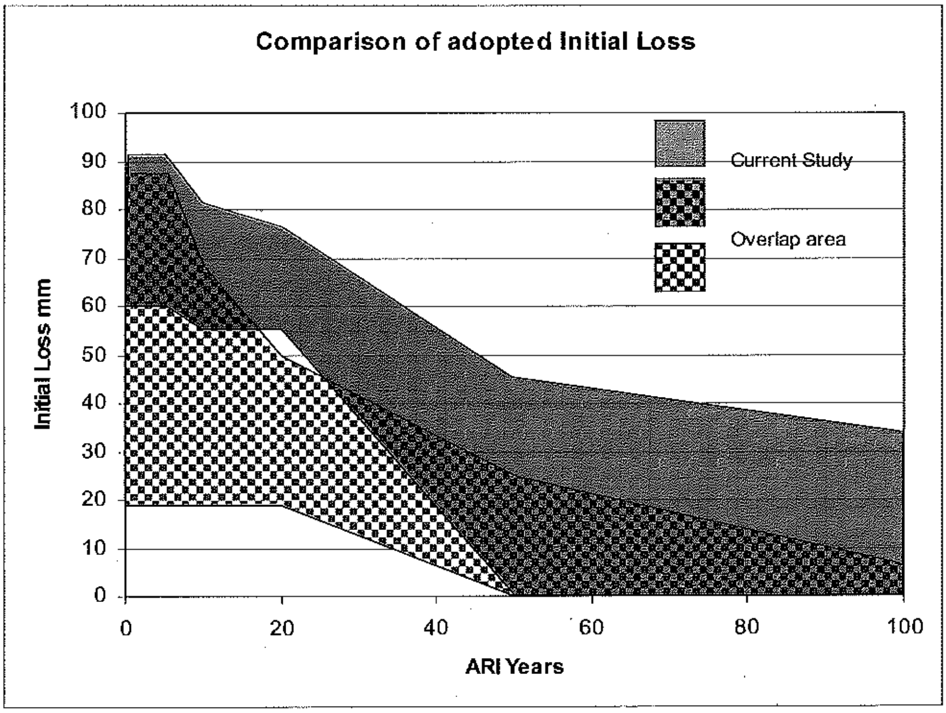


Figure 18 Comparison of Initial Losses

In order to test the impact of the adopted initial loss and continuing loss on the results, the effect on peak flow estimates of an extreme initial loss of 10mm for all ARIs up to 100 years was tested.

It was not considered appropriate to test sensitivity to continuing loss, as the continuing loss had been set to 1mm/hour in the calibration runs used to determine the adopted initial loss values.

This procedure has effectively lumped all of the calibration errors, whether they be data errors, gauging station rating errors, parameter errors or systemic model errors, into the calibrated initial loss values.

The results from this analysis are summarised in **Table 11** and are shown graphically for Bremer River at Walloon, Warrill Creek at Amberley and Purga Creek at Loamside in **Figure 19.** The full results and graphs for other locations are given in **Appendix E.**

These results show that the estimated peak flood flows are sensitive to the assumed initial loss particularly at low ARI, with this sensitivity reducing as the ARI increases. This is because of the increased difference between the adopted and sensitivity value of the initial loss as the ARI reduces.

The results given in **Appendix D** also demonstrate that the reduction in initial loss in the sensitivity runs results in a reduction in the critical duration for the smaller catchments.

Table 11 Results of Sensitivity Testing with Initial Loss of 10mm

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for ARI Years					
			2	5	10	20	50	100
Brisbane R	Savages Crossing	SAV-OUT	360	910	1900	2900	4200	6000
	Mt Crosby	MTC-OUT	360	910	1900	2900	4200	6000
Warrill Ck	Kalbar	KAL-OUT	415	620	745	910	1110	1300
	Amberley	AMB-OUT	685	1000	1190	1450	1820	2110
Purga Ck	Loamside	PUR-OUT	365	530	635	780	970	1135
Bremer R	Walloon	WAL-OUT	530	760	885	1060	1305	1500
Deebing Ck	U/s Bremer R	DB-OUT	57	73	92	109	132	154
Ironpot Ck	U/s Bremer R	IP-OUT	50	71	83	100	121	140
Mihi Ck	U/s Bremer R	MH-OUT	24	35	42	51	65	75
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	32	46	56	68	86	100
Bremer R	David Trumpy Br	2C#	1360	1660	1845	2120	2550	2910
Bundamba Ck	U/s Bremer R	BUND15	140	202	230	288	342	405
Bremer R	D/s Bundamba Ck	IPS-OUT	1380	1670	1855	2130	2560	2920
Six Mile Ck	u/s Brisbane R	JINAO	83	117	136	162	197	227
Goodna Ck	u/s Brisbane R	JINCG	41	57	67	79	95	110
Woogaroo Ck	u/s Brisbane R	JIN3M	146	195	240	289	350	410
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	92	117	147	177	213	247

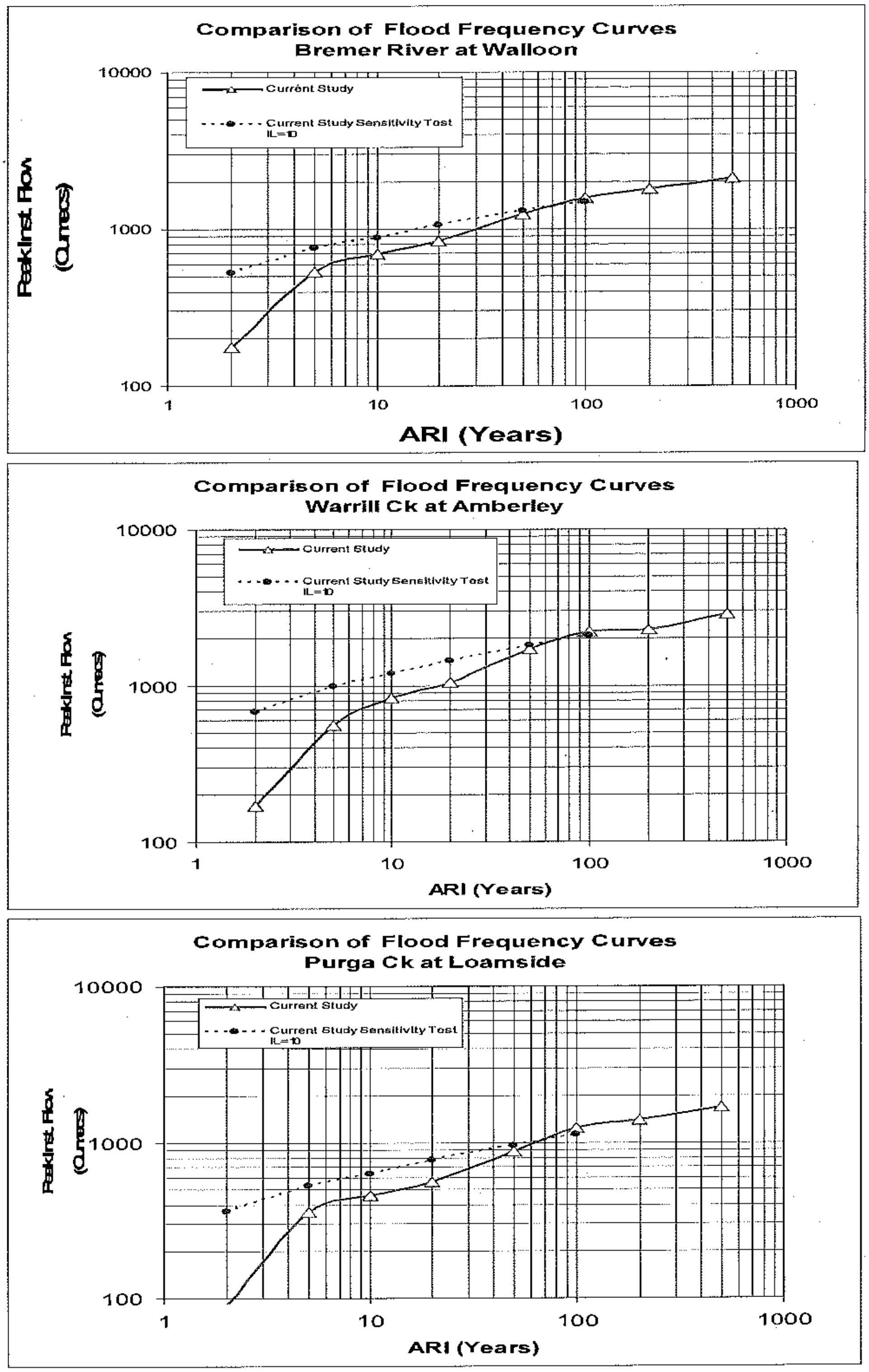


Figure 19 Sensitivity Testing with Initial Loss of 10mm

5. Comparison with Previous Results

In this section, the results from the current analysis are compared with those from the sensitivity testing and from previous analyses, and recommendations made in respect of the adopted design values.

Previous estimates were obtained from SKM (2000), SKM (2003), KBR (2002) and Sargent Consulting (2006). The latter contained estimates for 100 year ARI only for Bremer River and Warrill Creek only based on a *Monte Carlo* analysis undertaken as a separate component of the current project.

Figure 20 shows the various flood frequency curves for Warrill Creek at Amberley. Compared to the direct flood frequency curves and the curve from KBR (2002), the curve from the current study produces higher estimates of peak flows for ARIs less than about 10 years and lower estimates for ARIs greater than 20 years. In the case of the median regional flood frequency curve, the cross over point is at about 30 year ARI. The *Monte Carlo* estimate for 100 year ARI is consistent with the new curve, and should be slightly lower as this was based on rainfalls for the whole Brisbane River catchment whereas the current study is based on rainfalls for the Bremer River sub-catchment.

The sensitivity test results show unrealistically high values for ARIs of 20 years and lower.

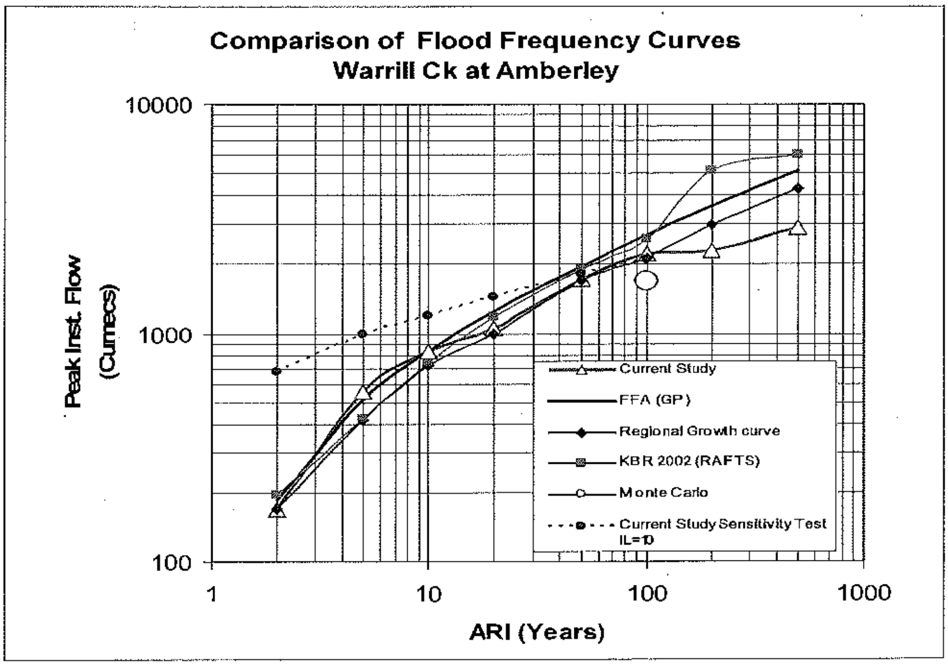


Figure 20 **Flood Frequency Curves – Warrill Creek at Amberley**

Figure 21 shows the corresponding curves for Bremer River at Walloon. This is similar to the Warrill Creek curves except that, in this case, the current study values are higher than the previous estimates from KBR (2002) up to 100 year ARI. Again the sensitivity test values are very high for low ARIs.

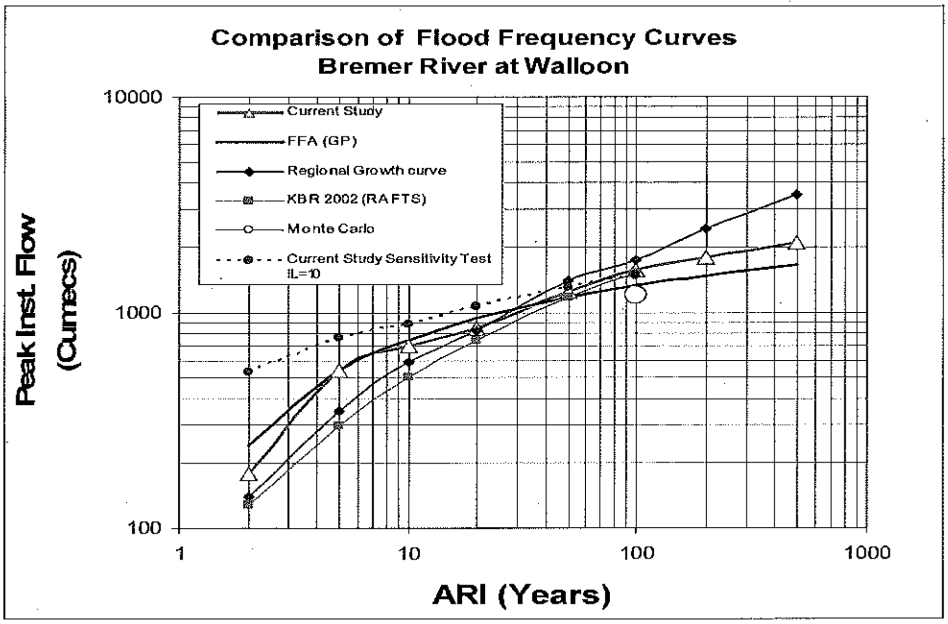


Figure 21 Flood Frequency Curves – Bremer River at Walloon

Figure 22 shows the curves for Purga Creek at Loamside. In this case, the new curve is higher than the KBR (2002) curve for 5 year ARI, and higher than the median regional curve up to about 40 year ARI.

Figure 23 shows the curves for Bremer River at Ipswich. There is good agreement with the *Monte Carlo* estimate for 100 year ARI, but relatively poor agreement with the median regional growth curve.

The new curves for the tributaries were all lower than those given by SKM(2000) as illustrated by **Figures 24** and **25** which show the results for Bundamba Creek and Woogaroo Creek respectively.

The corresponding diagrams for the other tributaries are given in **Appendix E.**

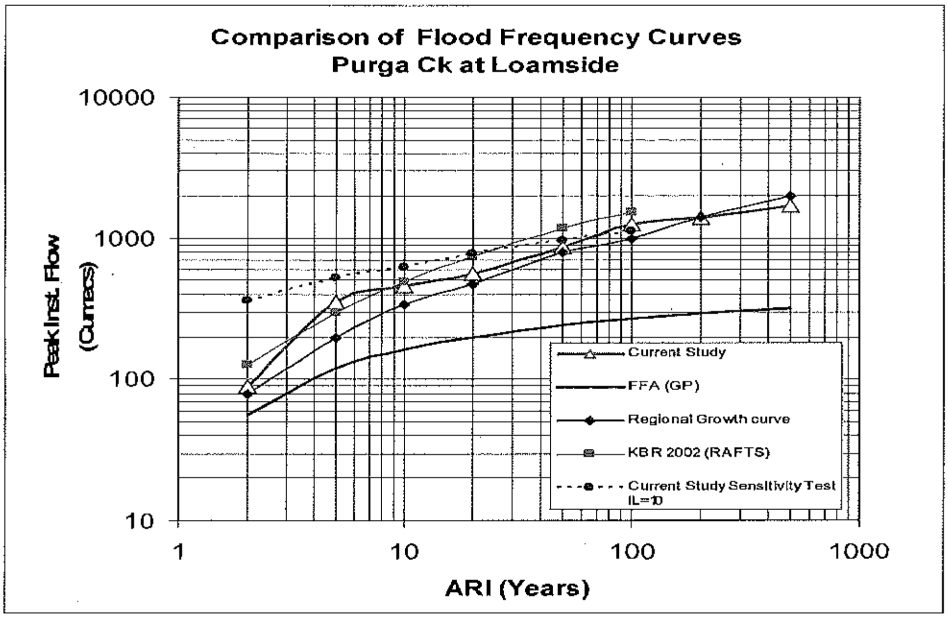


Figure 22 **Flood Frequency Curves – Purga Creek at Loamside**

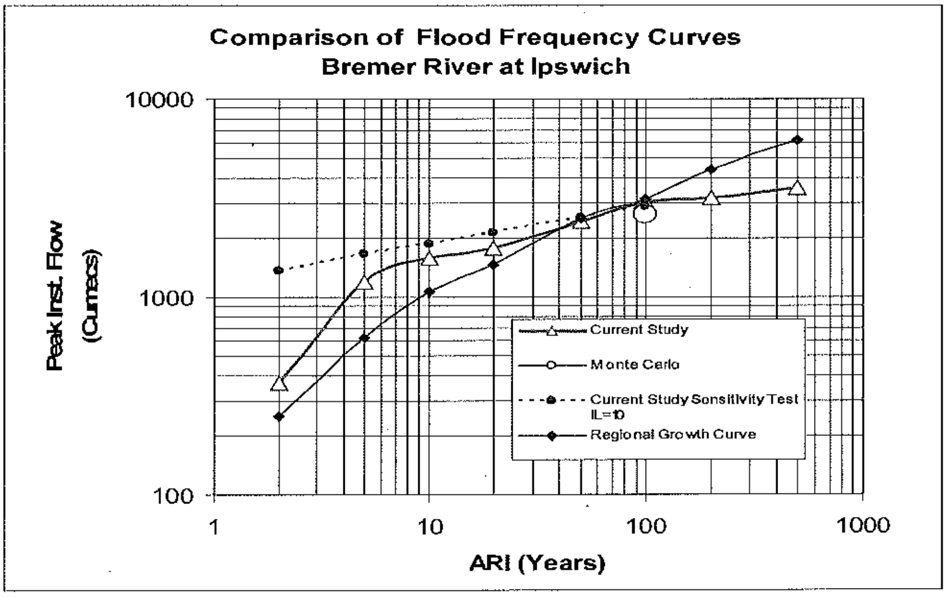


Figure 23 **Flood Frequency Curves – Bremer River at Ipswich**

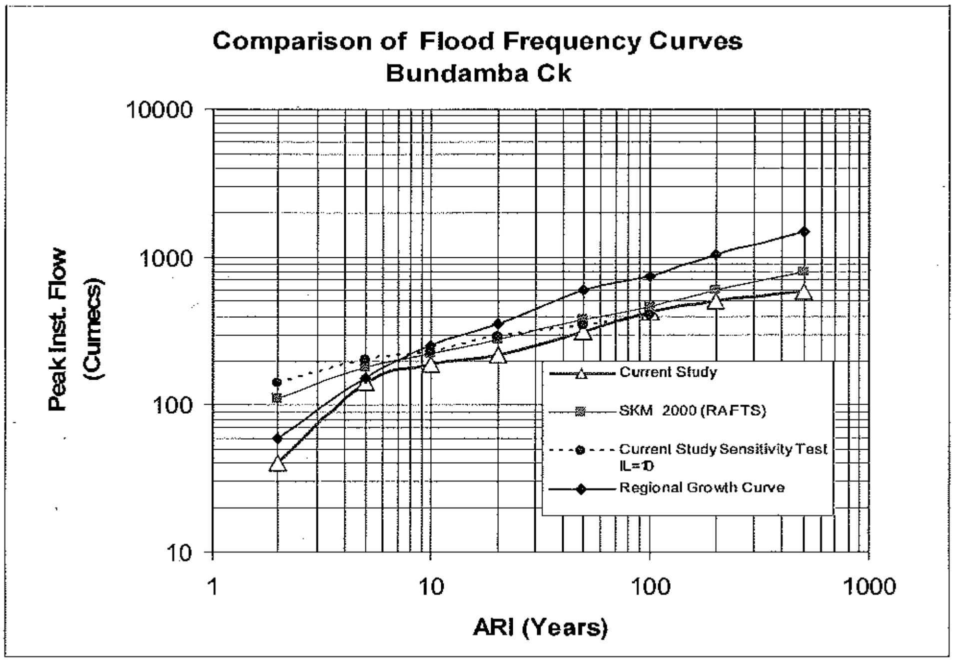


Figure 24 Flood Frequency Curves – Bundamba Creek at Bremer River

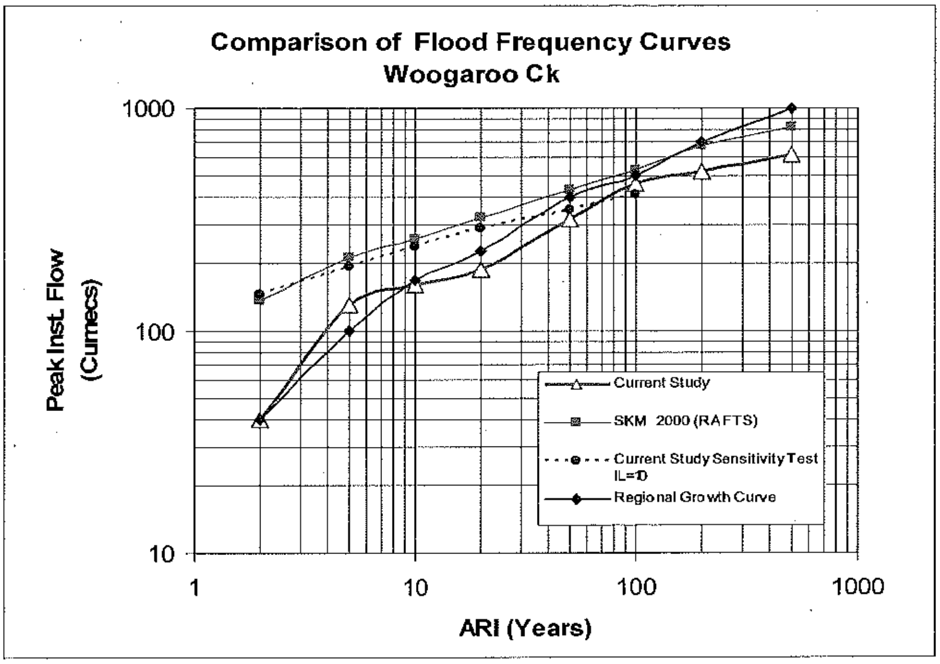


Figure 25 Flood Frequency Curves – Woogaroo Creek at Brisbane River

In **Section 3**, it was concluded that the records for Warrill Creek at Amberley were the most reliable of those available, principally because the flood frequency growth curve was similar to those of other stations in the Brisbane River catchment. Given that conclusion, it is appropriate to give greater weight to the results for Amberley in this comparison.

Also as none of the streamflow records are of sufficient length to estimate flood flows at higher ARIs with reasonable accuracy, rainfall based estimates are preferable for ARIs of about 100 years and above.

Taking these factors into account, it was considered that the results from the new modelling are the best estimates available because these are based on the most recent rainfall data (CRC-FORGE data and methodology) and reasonable assumptions of initial losses.

Hence, it is recommended that the detailed results from the new modelling be used in the new design runs to be undertaken using the recently updated MIKE 11 hydraulic model under a separate component of this project.

It is also recommended that the flood frequency curves be revised using the MIKE 11 model results, as the latter takes full account of temporary flood plain storage whereas this is only approximated in the RAFTS model.

6. Boundary Conditions for MIKE 11 Model

The principal use of the flows from the RAFTS modelling is the derivation of the input flows to the MIKE 11 model. To this end, the RAFTS hydrographs for each combination of ARI and storm duration have been converted to MIKE 11 time series format so that they can be used for this purpose.

The has been done using a DHI utility (rafts2dfs0.exe) to convert RAFTS output files to ASCII text files, then using the file import routines in MIKE 11 to complete the conversion. These files are provided on CD-ROM.

7. References

DEPARTMENT OF NATURAL RESOURCES AND MINES (2005) Extreme Rainfall Estimation Project - CRCFORGE and (CRC) ARF Techniques - Queensland and Border Locations - Development and Application - Final Report

HALLIBURTON KBR (2002a) *Local Storm Flood Mapping - Final Report* prepared for Ipswich City Council

HALLIBURTON KBR (2002b) *Ipswich Rivers Flood Study Phase 3 - Final Report* prepared for Ipswich City Council

INSTITUTION OF ENGINEERS AUSTRALIA (1987 and updates) *Australian Rainfall and Runoff – A Guide to Flood Estimation*

MEIN R, APELT C, MACINTOSH J, WEINMANN E (2003) *Review of Brisbane River Flood Study – Independent Review Panel Report* prepared for Brisbane City Council

SARGENT CONSULTING (2003) *Brief Review of Flood Frequency Analysis and Discharge Rating Curve for Brisbane River at Moggill Gauge* prepared for Ipswich City Council

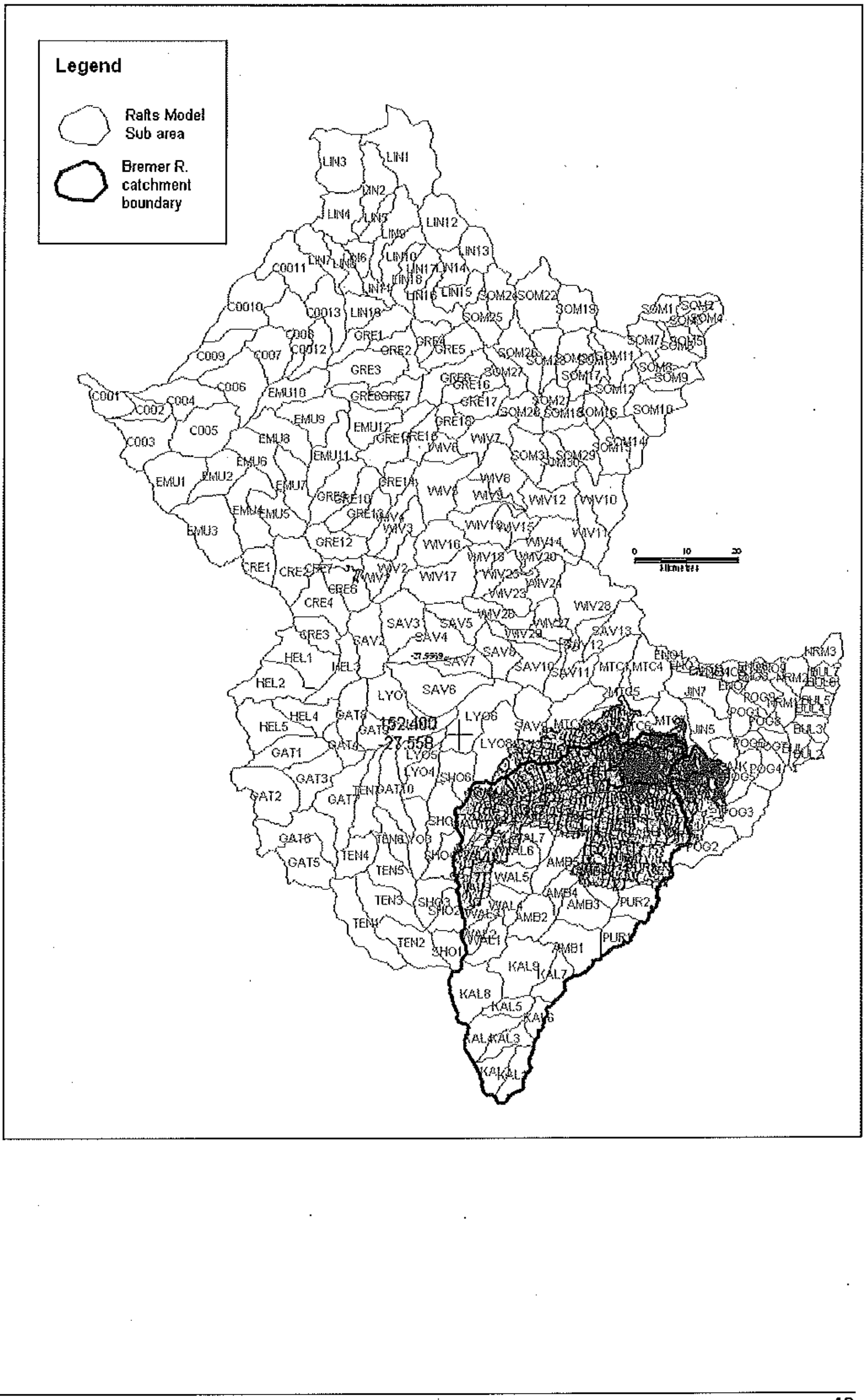
SARGENT CONSULTING (2006) *Ipswich Rivers Flood Study Rationalisation Project Phase 3 "Monte Carlo" Analysis of Design Flows Final Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

SINCLAIR KNIGHT MERZ (2000) *Ipswich Rivers Flood Study Phase 1 & Phase 2 - Final Report* prepared for Ipswich Rivers Improvement Trust in association with Ipswich City Council

SINCLAIR KNIGHT MERZ (2003) *Brisbane River Flood Study – Further Estimates of Flood Frequency incorporating Dam Operations and CRC-FORGE Rainfall Estimates – Brisbane River* prepared for Brisbane City Council

Appendices

Appendix A RAFTS Sub Areas



Appendix B Flood Frequency Analysis

Bremer River at Walloon

Annual Maximum Series
for Hydrologic Year (October – September)
Year ending shown

Year	Discharge	Cunnane plotting position ARI Years
1963	352	2.34
1964	219	1.91
1965	521	4.79
1966	69	1.39
1967	503	4.29
1968	542	6.24
1969	71.5	1.44
1970	10.3	1.10
1971	747	8.96
1972	140	1.67
1972	449	3.27
1973	7.4	1.07
1974	216	1.82
1976	989	68.67
1977	388.5	2.64
1978	142.3	1.75
1979	42.3	1.30
1980	80	1.49
1981	531.6	5.42
1982	482.7	3.89
1983	722.9	7.36
1984	288.1	2.10
1985	26.1	1.19
1986	45	1.35
1987	34.8	1.23
1988	888	25.75
1989	389.5	2.82
1990	346.4	2.22
1991	263.1	2.00
1992	795.6	11.44
1993	21.4	1.16
1994	37	1.26
1995	17	1.13
1996	834.7	15.85
1998	83.5	1.55
1997	397.7	3.03
1999	450.9	3.55
2000	132.2	1.61
2001	378.3	2.48
2002	0.3	1.04
2003	0.2	1.01

Fitted Generalised Pareto Distribution

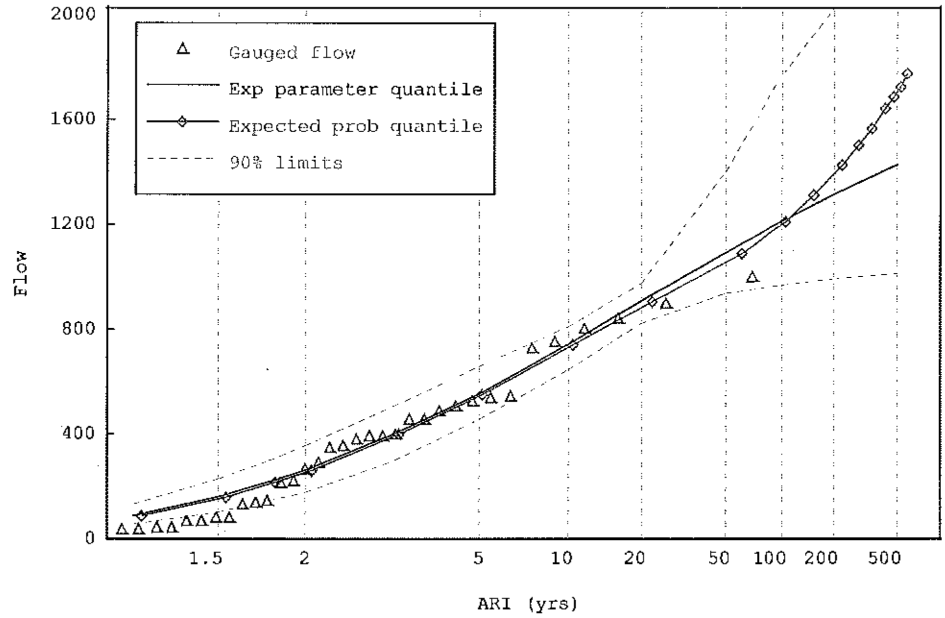
ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	3.7	2.4	5.4
1.1	35	22	50
1.25	81	52	114
1.5	145	95	198
1.75	199	131	263
2	244	164	321
3	379	279	483
5	540	419	648
10	745	599	874
20	935	760	1127
50	1165	866	1726
100	1325	936	2324
200	1473	977	3070
500	1653	1016	4344
1000	1777	1033	5587

Fitted Log Pearson Type III Distribution

ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	0.2	0.0	1.5
1.1	9.1	2.4	23
1.25	36	15	69
1.5	91	49	151
1.75	148	89	230
2	200	127	299
3	367	260	508
5	564	434	741
10	780	634	976
20	934	790	1169
50	1066	930	1391
100	1127	1000	1518
200	1167	1042	1626
500	1199	1072	1734
1000	1213	1085	1792

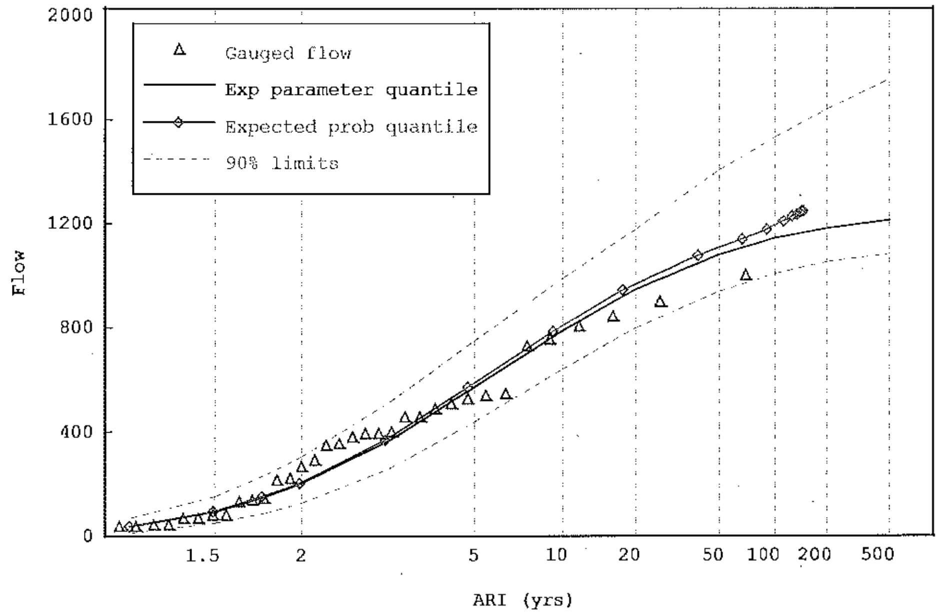
Bremer R at Walloon Annual Maximum Series

Normal probability plot: Generalised Pareto



Bremer R at Walloon Annual Maximum Serie

Normal probability plot: Log Pearson III



Warrill Creek at Amberley

Annual Maximum Series
for Hydrologic Year (October – September)
Year ending shown

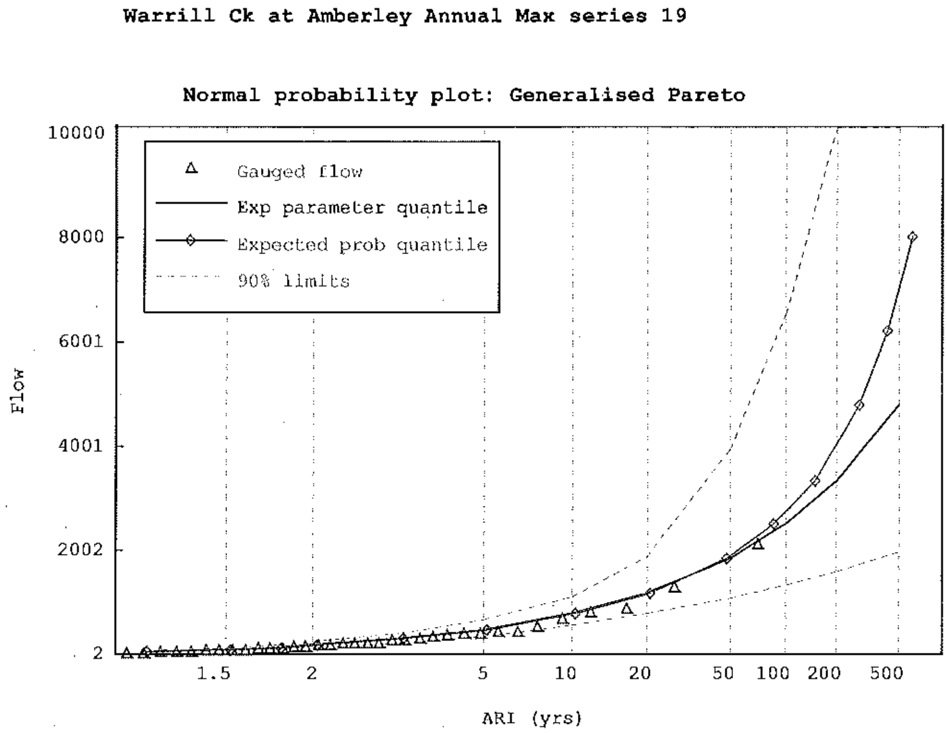
Year	Discharge	Cunnane plotting position ARI Years
1963	383	3.98
1964	216	2.27
1965	60	1.29
1965	137	1.79
1967	330	3.35
1968	403	4.91
1969	119	1.65
1969	36.8	1.22
1971	881	16.23
1972	102	1.53
1973	403	4.4
1974	2108	70.33
1975	286	3.1
1976	1286	26.37
1977	224	2.4
1978	127	1.72
1979	99.5	1.48
1980	163	1.87
1981	285	2.89
1981	236	2.71
1983	437	5.55
1983	188	2.05
1984	63.1	1.34
1986	23.7	1.12
1987	23.6	1.09
1988	542	7.54
1989	227	2.54
1990	345	3.64
1991	679	9.17
1991	807	11.72
1992	26.5	1.15
1994	79.2	1.38
1995	23.1	1.07
1996	449	6.39
1997	30	1.19
1998	47.6	1.26
1999	200	2.15
1999	89.1	1.43
2001	107	1.59
2002	2.2	1.01
2003	6.4	1.04
2004	171	1.95

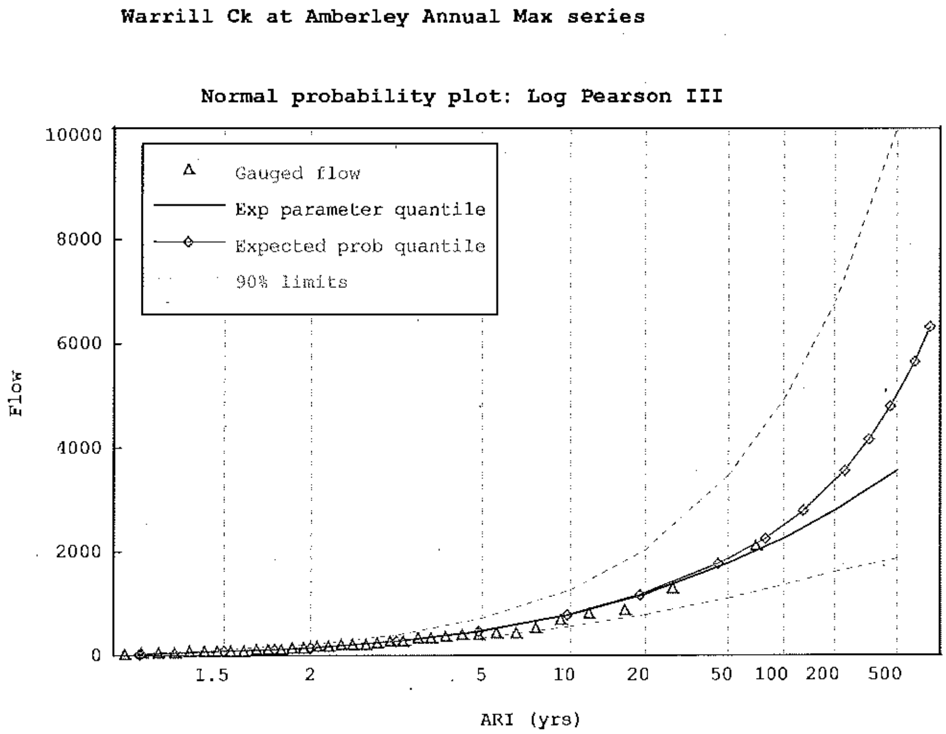
Fitted Generalised Pareto Distribution

ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	3.5	2.2	4.7
1.1	23	15	33
1.25	54	35	76
1.5	99	66	140
1.75	140	95	198
2	177	123	249
3	301	218	412
5	483	358	646
10	784	561	1102
20	1165	773	1852
50	1826	1071	3897
100	2479	1311	6444
200	3302	1560	11102
500	4730	1937	20867
1000	6142	2223	31137

Fitted Log Pearson Type III Distribution

ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	3.0	0.7	7.9
1.1	20	9	34
1.25	45	26	70
1.5	86	56	127
1.75	124	84	180
2	161	110	233
3	288	203	417
5	481	339	716
10	797	555	1241
20	1171	790	2004
50	1744	1111	3426
100	2230	1350	4867
200	2755	1585	6683
500	3501	1852	10054
1000	4099	2037	13468


Warrill Ck at Amberley Annual Max series 19
Normal probability plot: Generalised Pareto
Gauged flow
Exp parameter quantile
Expected prob quantile
90% limits
10000
8000
6001
4001
2002
2
Flow
1.5
2
5
10
20
50
100
200
500
ARI (yrs)


Warrill Ck at Amberley Annual Max series
Normal probability plot: Log Pearson III
Gauged flow
Exp parameter quantile
Expected prob quantile
90% limits
10000
8000
6000
4000
2000
0
Flow
1.5
2
5
10
20
50
100
200
500
ARI (yrs)

Purga Creek at Loamside

Annual Maximum Series
for Hydrologic Year (October – September)
Year ending shown

Year	Discharge	Cunnane plotting position ARI Years
1975	75.7	2.4
1976	184	50.33
1976	86.8	3.51
1978	76.6	2.6
1979	37	1.72
1980	134.5	4.58
1981	77.4	2.85
1981	59.1	2.07
1983	143	5.39
1983	53.7	1.94
1985	0.6	1.02
1985	1.2	1.09
1987	2	1.18
1988	150	6.57
1989	111	3.97
1990	159	8.39
1991	47.4	1.82
1991	165	11.62
1993	11.4	1.62
1994	1.6	1.14
1995	3.8	1.4
1996	179	18.88
1996	2.8	1.28
1997	2.8	1.23
1999	65.3	2.22
1999	6.3	1.47
2001	3.2	1.34
2002	0.6	1.06
2003	9.2	1.54
2004	81.3	3.15

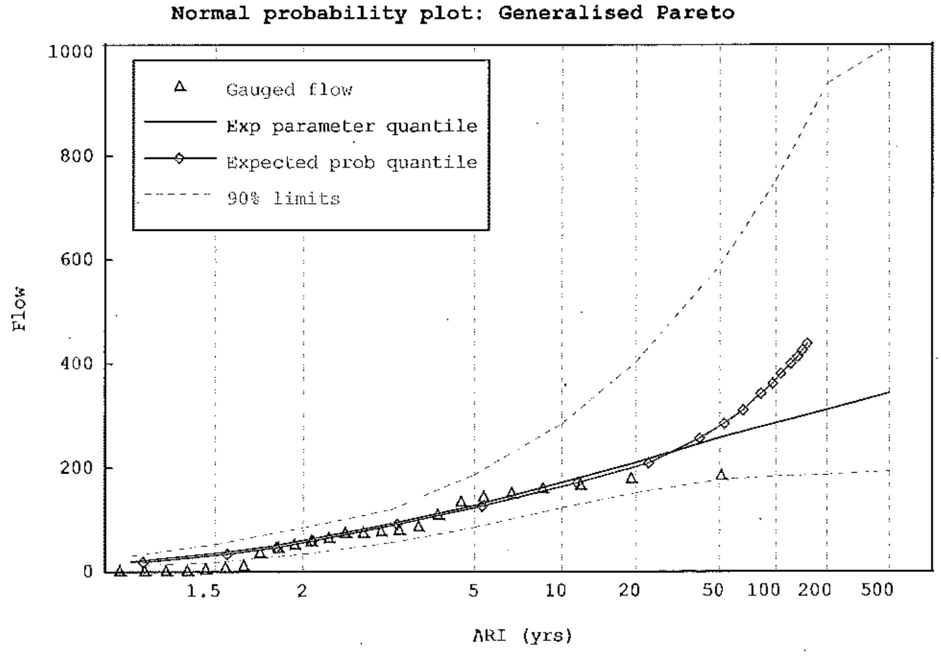
Fitted Generalised Pareto Distribution

ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	1.2	0.7	1.8
1.1	8.4	4.9	13
1.25	19	11	30
1.5	34	20	50
1.75	46	28	66
2	56	35	79
3	86	56	114
5	120	83	149
10	162	124	208
20	198	153	281
50	240	174	419
100	268	182	547
200	292	188	700
500	319	189	947
1000	337	190	1176

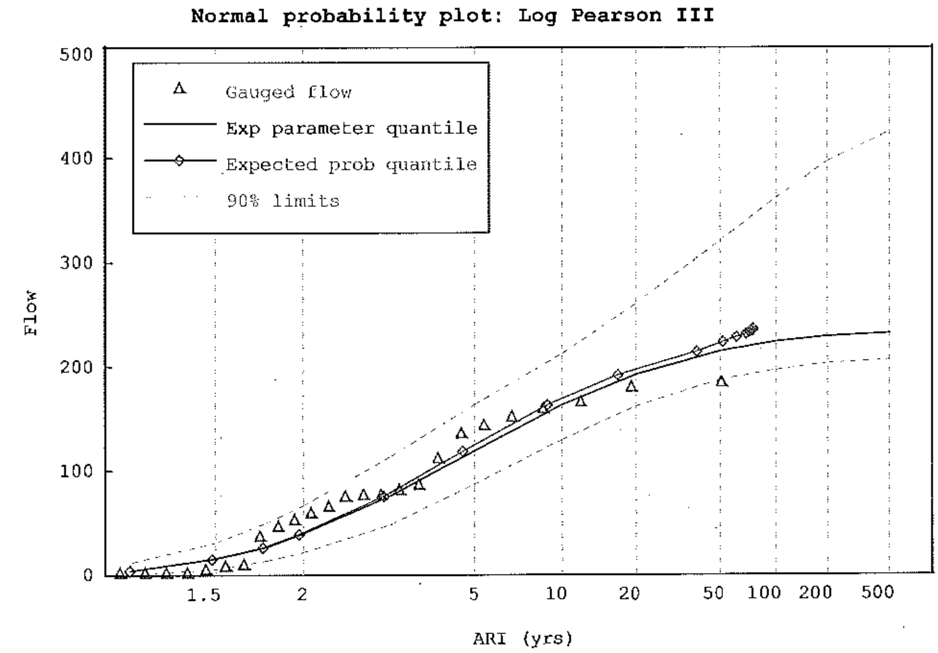
Fitted Log Pearson Type III Distribution

ARI Years	Peak Flow Cumecs	90% Confidence Limits	
1.01	0.01	0	0.18
1.1	1.1	0.2	4.0
1.25	5.4	1.6	13.3
1.5	16	7.0	32
1.75	27	14	50
2	39	21	66
3	75	49	114
5	117	86	161
10	161	128	209
20	190	159	256
50	212	185	317
100	221	195	357
200	226	200	391
500	230	203	420
1000	231	204	440

Purga Ck at Loamside



Purga Ck at Loamside



Appendix C Peak Flows from RAFTS Design Runs

Table C1 Peak Flows 2 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	360	360	360	360	360	360	360	360	360	360	360	360
	Mt Crosby	MTC-OUT	360	360	360	360	360	360	360	360	360	360	360	360
Warrill Ck	Kalbar	KAL-OUT	0	0	0	0	0	0	0	0	2	75	**132**	121
	Amberley	AMB-OUT	0	0	0	0	0	0	0	0	2	77	150	**173**
Purga Ck	Loamside	PUR-OUT	0	0	0	0	0	0	0	0	1	70	86	**89**
Bremer R	Walloon	WAL-OUT	0	0	0	0	0	0	0	0	3	130	**184**	160
Deebing Ck	U/s Bremer R	DB-OUT	**21**	21	20	18	18	15	15	12	14	13	15	14
Ironpot Ck	U/s Bremer R	IP-OUT	7	6	6	6	6	5	4	4	4	12	**14**	10
Mihi Ck	U/s Bremer R	MH-OUT	**13**	10	10	10	8	8	7	7	7	5	5	4
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	2	2.5	2	2	2	2	2	1.5	1.5	6	7	5
Bremer R	David Trumpy Br	2C#	15	17	18	18	19	18	18	12	17	203	333	**368**
Bundamba Ck	U/s Bremer R	BUND15	53	47	45	**41**	39	36	35	30	35	30	**38**	37
Bremer R	D/s Bundamba Ck	IPS-OUT	61	59	58	51	54	45	46	35	45	205	340	**374**
Six Mile Ck	u/s Brisbane R	JINAO	8	7	7	6	6	5	7	4	5	19	**24**	18
Goodna Ck	u/s Brisbane R	JINCG	11	12	12	11	11	9	10	7	8	8	**11**	8
Woogaroo Ck	u/s Brisbane R	JIN3M	9	8	9	8	8	6	9	5	6	28	**38**	33
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	16	13	12	11	11	10	9	9	9	19	**26**	22

Denotes critical duration

Table C2 Peak Flows 5 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	910	910	910	910	910	910	910	910	910	910	910	910
	Mt Crosby	MTC-OUT	910	910	910	910	910	910	910	910	910	910	910	910
Warrill Ck	Kalbar	KAL-OUT	0	0	0	0	0	3	42	184	228	**438**	396	423
	Amberley	AMB-OUT	0	0	0	0	0	3	43	223	288	554	**564**	555
Purga Ck	Loamside	PUR-OUT	0	0	0	0	0	12	46	165	185	**360**	289	338
Bremer R	Walloon	WAL-OUT	0	0	0	0	0	29	92	259	306	**536**	496	522
Deebing Ck	U/s Bremer R	DB-OUT	29	29	27	24	23	19	20	30	27	**51**	40	47
Ironpot Ck	U/s Bremer R	IP-OUT	10	8	8	7.5	7	6	8	30	22	**39**	31	33
Mihi Ck	U/s Bremer R	MH-OUT	**18**	13	13	13	11	10	9	13	11	16	14	13
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	3.5	3.5	3	3	3	3	4	17	14	**21**	19	19
Bremer R	David Trumpy Br	2C#	20	22	24	24	25	37	136	460	597	1145	**1200**	1130
Bundamba Ck	U/s Bremer R	BUND15	70	63	59	54	50	47	46	68	74	**140**	118	130
Bremer R	D/s Bundamba Ck	IPS-OUT	81	80	76	68	69	59	138	464	603	1160	**1220**	1160
Six Mile Ck	u/s Brisbane R	JINAO	11	10	9	8	8	7	13	47	39	**63**	56	61
Goodna Ck	u/s Brisbane R	JINCG	15	16	16	14	15	12	13	23	18	**28**	26	28
Woogaroo Ck	u/s Brisbane R	JIN3M	12	11	12	11	11	8	19	72	66	**126**	105	118
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	21	18	15	15	14	13	13	49	44	**82**	65	76

Denotes critical duration

Table C3 Peak Flows 10 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
	Mt Crosby	MTC-OUT	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Warrill Ck	Kalbar	KAL-OUT	0	0	21	63	140	200	272	435	328	**595**	485	580
	Amberley	AMB-OUT	0	0	31	93	187	270	357	547	560	**840**	815	805
Purga Ck	Loamside	PUR-OUT	0	0.5	41	80	135	191	227	373	262	**460**	350	445
Bremer R	Walloon	WAL-OUT	0	1	82	142	215	291	354	536	444	690	605	**700**
Deebing Ck	U/s Bremer R	DB-OUT	33	32	30	27	26	35	37	48	33	**63**	47	57
Ironpot Ck	U/s Bremer R	IP-OUT	11	10	12	17	24	33	30	41	26	**46**	36	39
Mihi Ck	U/s Bremer R	MH-OUT	20	15	15	14	12	15	13	**20**	13	19	16	15
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	4	4	5	10	14	19	17	**26**	16	**26**	22	22
Bremer R	David Trumpy Br	2C#	23	25	125	251	410	570	720	1175	1145	**1575**	1535	1570
Bundamba Ck	U/s Bremer R	BUND15	80	71	67	61	58	79	92	135	95	**190**	140	170
Bremer R	D/s Bundamba Ck	IPS-OUT	92	91	128	254	413	577	728	1185	1160	1590	1570	**1600**
Six Mile Ck	u/s Brisbane R	JINAO	13	11	19	27	39	54	49	74	47	**78**	66	72
Goodna Ck	u/s Brisbane R	JINCG	17	18	20	16	18	26	22	35	22	**36**	30	34
Woogaroo Ck	u/s Brisbane R	JIN3M	13	12	24	36	61	83	89	125	80	**158**	124	140
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	24	20	27	31	40	60	62	76	52	**105**	77	92

[ ] Denotes critical duration

Table C4 Peak Flows 20 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
	Mt Crosby	MTC-OUT	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
Warrill Ck	Kalbar	KAL-OUT	53	143	270	330	435	492	447	625	445	**725**	595	710
	Amberley	AMB-OUT	117	270	380	485	574	660	575	1015	866	**1054**	1020	1010
Purga Ck	Loamside	PUR-OUT	75	170	268	338	417	434	427	505	325	**555**	430	485
Bremer R	Walloon	WAL-OUT	140	260	362	435	525	590	680	820	625	835	735	**850**
Deebing Ck	U/s Bremer R	DB-OUT	42	46	47	53	63	64	60	59	46	**76**	56	68
Ironpot Ck	U/s Bremer R	IP-OUT	26	37	47	50	56	46	40	49	40	**55**	44	46
Mihi Ck	U/s Bremer R	MH-OUT	24	21	24	24	24	**24**	17	24	17	23	19	18
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	11	22	32	32	32	**33**	24	32	23	31	26	26
Bremer R	David Trumpy Br	2C#	280	585	835	1030	1240	1400	1510	1710	1565	**1770**	1710	1755
Bundamba Ck	U/s Bremer R	BUND15	95	86	109	128	153	165	173	189	124	**220**	170	210
Bremer R	D/s Bundamba Ck	IPS-OUT	285	595	845	1045	1255	1420	1530	1720	1600	1780	1740	**1810**
Six Mile Ck	u/s Brisbane R	JINAO	36	58	80	84	89	87	74	88	66	**94**	79	86
Goodna Ck	u/s Brisbane R	JINCG	31	41	**44**	38	42	40	35	42	31	42	36	40
Woogaroo Ck	u/s Brisbane R	JIN3M	38	80	121	142	164	158	144	151	122	**190**	150	165
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	45	59	80	88	103	101	101	94	76	**123**	92	110

[ ] Denotes critical duration

Table C5 Peak Flows 50 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220
	Mt Crosby	MTC-OUT	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220	4220
Warrill Ck	Kalbar	KAL-OUT	460	595	745	800	940	925	**990**	950	925	890	760	860
	Amberley	AMB-OUT	845	1160	1275	1380	1440	1450	1350	**1710**	1390	1315	1340	1230
Purga Ck	Loamside	PUR-OUT	470	655	790	840	**875**	815	735	625	680	665	570	635
Bremer R	Walloon	WAL-OUT	580	750	855	955	1030	1120	1180	**1255**	1100	1020	950	1025
Deebing Ck	U/s Bremer R	DB-OUT	90	100	110	116	**123**	102	103	71	100	89	81	77
Ironpot Ck	U/s Bremer R	IP-OUT	84	100	**106**	100	98	71	77	59	85	63	67	67
Mihi Ck	U/s Bremer R	MH-OUT	51	**56**	53	41	43	39	36	28	37	26	27	31
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	63	**76**	72	57	60	52	48	38	50	36	37	44
Bremer R	David Trumpy Br	2C#	1480	1650	1760	1880	2020	2115	2235	**2410**	2240	2065	2060	2065
Bundamba Ck	U/s Bremer R	BUND15	187	237	265	280	**310**	295	315	260	240	270	215	250
Bremer R	D/s Bundamba Ck	IPS-OUT	1500	1660	1770	1880	2030	2120	2240	**2425**	2280	2070	2100	2145
Six Mile Ck	u/s Brisbane R	JINAO	147	172	**178**	158	160	115	130	105	132	109	100	118
Goodna Ck	u/s Brisbane R	JINCG	72	84	**86**	76	74	56	61	50	65	51	47	53
Woogaroo Ck	u/s Brisbane R	JIN3M	215	272	305	306	**320**	236	255	185	260	217	200	213
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	145	170	175	182	**192**	170	180	116	166	138	153	127

Denotes critical duration

Table C6 Peak Flows 100 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
	Mt Crosby	MTC-OUT	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Warrill Ck	Kalbar	KAL-OUT	806	965	1150	885	1340	1280	**1395**	1240	1295	1030	1090	1000
	Amberley	AMB-OUT	1535	1930	2110	2150	2110	2000	1850	**2220**	1830	1530	1585	1460
Purga Ck	Loamside	PUR-OUT	853	1090	1250	**1250**	1233	1020	945	**720**	1005	765	860	870
Bremer R	Walloon	WAL-OUT	930	1110	1250	1310	1440	1510	**1590**	1540	1460	1170	1095	1190
Deebing Ck	U/s Bremer R	DB-OUT	138	157	165	**170**	168	134	136	94	145	102	122	115
Ironpot Ck	U/s Bremer R	IP-OUT	130	145	**154**	140	137	107	116	77	115	84	96	90
Mihi Ck	U/s Bremer R	MH-OUT	83	**83**	76	65	58	54	48	41	57	43	44	37
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	105	**115**	104	88	80	74	70	54	77	57	59	52
Bremer R	David Trumpy Br	2C#	1855	2105	2320	2470	2655	2755	2925	**3055**	2840	2380	2450	2355
Bundamba Ck	U/s Bremer R	BUND15	305	363	400	410	**433**	415	436	308	383	310	320	300
Bremer R	D/s Bundamba Ck	IPS-OUT	1865	2110	2325	2470	2660	2765	2930	**3070**	2940	2390	2495	2455
Six Mile Ck	u/s Brisbane R	JINAO	230	**250**	247	215	213	172	182	130	190	143	158	162
Goodna Ck	u/s Brisbane R	JINCG	103	115	**118**	103	103	81	88	60	87	66	72	72
Woogaroo Ck	u/s Brisbane R	JIN3M	362	420	**455**	434	436	332	361	232	370	267	320	310
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	228	247	247	268	**270**	228	217	171	230	171	200	184

[ ] Denotes critical duration

Table C7 Peak Flows 200 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
	Mt Crosby	MTC-OUT	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200	7200
Warrill Ck	Kalbar	KAL-OUT	920	1100	1310	1380	1520	1460	**1605**	1250	1480	1180	1265	1160
	Amberley	AMB-OUT	1780	2250	2450	2475	2430	2280	2120	**2260**	2085	1755	1840	1700
Purga Ck	Loamside	PUR-OUT	995	1180	**1370**	**1370**	1350	1130	1040	820	1100	875	940	950
Bremer R	Walloon	WAL-OUT	1050	1250	1400	1485	1625	1700	**1790**	1740	1660	1335	1250	1370
Deebing Ck	U/s Bremer R	DB-OUT	157	180	190	**195**	192	155	152	106	164	116	140	130
Ironpot Ck	U/s Bremer R	IP-OUT	145	165	**175**	155	155	120	130	86	130	95	108	103
Mihi Ck	U/s Bremer R	MH-OUT	95	**95**	86	75	66	62	54	47	65	49	50	42
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	120	**130**	120	100	90	85	79	63	87	66	68	59
Bremer R	David Trumpy Br	2C#	1990	2290	2550	2725	2935	3065	**3235**	3190	3185	2720	2825	2720
Bundamba Ck	U/s Bremer R	BUND15	350	415	450	470	490	470	**495**	350	435	350	365	345
Bremer R	D/s Bundamba Ck	IPS-OUT	2000	2300	2550	2730	2940	3070	3250	3200	**3300**	2730	2880	2830
Six Mile Ck	u/s Brisbane R	JINAO	260	**280**	**280**	245	240	195	207	147	212	160	180	185
Goodna Ck	u/s Brisbane R	JINCG	115	130	**135**	120	117	92	100	68	100	75	83	83
Woogaroo Ck	u/s Brisbane R	JIN3M	415	480	**520**	495	495	380	410	265	420	305	370	355
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	255	285	280	305	**306**	260	245	195	260	195	230	210

[ ] Denotes critical duration

Table C8 Peak Flows 500 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)											
			1	2	3	4.5	6	9	12	18	24	36	48	72
Brisbane R	Savages Crossing	SAV-OUT	4220	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
	Mt Crosby	MTC-OUT	4220	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Warrill Ck	Kalbar	KAL-OUT	1080	1290	1535	1620	1790	1715	**1855**	1495	1735	1390	1510	1390
	Amberley	AMB-OUT	2155	2710	2780	**2940**	2890	2675	2450	2710	2435	2085	2280	2060
Purga Ck	Loamside	PUR-OUT	1205	1540	**1740**	1700	1670	1325	1315	960	1375	1030	1190	1225
Bremer R	Walloon	WAL-OUT	1215	1450	1635	1720	1880	1970	**2080**	2015	1930	1560	1485	1610
Deebing Ck	U/s Bremer R	DB-OUT	187	210	222	**228**	225	180	175	125	190	135	165	155
Ironpot Ck	U/s Bremer R	IP-OUT	168	188	**200**	182	180	140	153	100	150	110	125	120
Mihi Ck	U/s Bremer R	MH-OUT	**110**	**110**	101	86	76	73	63	56	75	57	59	49
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	147	**156**	140	118	106	101	91	75	103	77	79	69
Bremer R	David Trumpy Br	2C#	2215	2590	2875	3115	3300	3380	**3585**	3565	3545	3190	3320	3220
Bundamba Ck	U/s Bremer R	BUND15	410	480	530	545	575	557	**580**	415	525	415	435	410
Bremer R	D/s Bundamba Ck	IPS-OUT	2220	2595	2880	3120	3305	3385	**3595**	3580	3635	3200	3390	3360
Six Mile Ck	u/s Brisbane R	JINAO	302	**328**	325	283	283	224	240	172	247	188	213	220
Goodna Ck	u/s Brisbane R	JINCG	135	150	**155**	137	136	106	117	79	115	87	98	99
Woogaroo Ck	u/s Brisbane R	JIN3M	492	565	**615**	580	580	445	480	315	495	360	435	425
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	300	337	323	355	**360**	305	284	228	303	226	270	250

Denotes critical duration

Appendix D Peak Flows from RAFTS Sensitivity Testing with Initial Loss of 10mm

Table D1 Peak Flows 2 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)									
			1	2	3	4.5	6	9	12	18	24	36
Brisbane R	Savages Crossing	SAV-OUT	360	360	360	360	360	360	360	360	360	360
	Mt Crosby	MTC-OUT	360	360	360	360	360	360	360	360	360	360
Warrill Ck	Kalbar	KAL-OUT	205	265	330	355	**415**	405	410	370	368	350
	Amberley	AMB-OUT	303	415	485	530	595	600	585	**685**	545	485
Purga Ck	Loamside	PUR-OUT	170	235	290	320	**365**	350	315	265	275	265
Bremer R	Walloon	WAL-OUT	265	330	385	425	485	520	520	**530**	460	425
Deebing Ck	U/s Bremer R	DB-OUT	39	44	49	52	**57**	48	48	31	46	39
Ironpot Ck	U/s Bremer R	IP-OUT	38	45	**50**	47	48	35	37	26	41	29
Mihi Ck	U/s Bremer R	MH-OUT	21	23	**24**	19	21	15	19	12	17	12
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	24	30	**32**	26	28	18	25	15	23	16
Bremer R	David Trumpy Br	2C#	620	815	960	1060	1210	1230	1230	**1360**	1080	1030
Bundamba Ck	U/s Bremer R	BUND15	79	99	115	120	**140**	130	133	110	110	108
Bremer R	D/s Bundamba Ck	IPS-OUT	625	825	970	1070	1230	1250	1240	**1380**	1130	1050
Six Mile Ck	u/s Brisbane R	JINAO	65	77	**83**	73	77	55	62	47	64	49
Goodna Ck	u/s Brisbane R	JINCG	33	39	**41**	36	37	29	30	23	31	22
Woogaroo Ck	u/s Brisbane R	JIN3M	86	110	133	133	**146**	108	113	77	115	97
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	66	77	83	85	**92**	79	84	50	78	64

[ ] Denotes critical duration

Table D2 Peak Flows 5 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)									
			1	2	3	4.5	6	9	12	18	24	36
Brisbane R	Savages Crossing	SAV-OUT	910	910	910	910	910	910	910	910	910	910
	Mt Crosby	MTC-OUT	910	910	910	910	910	910	910	910	910	910
Warrill Ck	Kalbar	KAL-OUT	320	410	495	515	595	570	**620**	540	555	495
	Amberley	AMB-OUT	505	675	775	815	880	890	850	**1000**	800	710
Purga Ck	Loamside	PUR-OUT	285	385	473	495	**530**	500	470	365	430	385
Bremer R	Walloon	WAL-OUT	390	495	570	600	670	720	**760**	750	680	585
Deebing Ck	U/s Bremer R	DB-OUT	58	66	**73**	75	79	64	68	43	67	54
Ironpot Ck	U/s Bremer R	IP-OUT	57	66	**71**	67	66	51	54	35	59	40
Mihi Ck	U/s Bremer R	MH-OUT	32	**35**	34	24	29	22	27	17	26	19
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	39	**46**	**46**	38	40	28	36	22	34	24
Bremer R	David Trumpy Br	2C#	960	1240	1450	1510	1560	1580	1630	**1660**	1520	1480
Bundamba Ck	U/s Bremer R	BUND15	120	150	175	177	197	183	**202**	156	168	155
Bremer R	D/s Bundamba Ck	IPS-OUT	970	1250	1465	1530	1580	1590	1640	**1670**	1600	1500
Six Mile Ck	u/s Brisbane R	JINAO	98	114	**117**	102	105	79	90	64	93	67
Goodna Ck	u/s Brisbane R	JINCG	48	55	**57**	51	51	40	44	31	44	30
Woogaroo Ck	u/s Brisbane R	JIN3M	135	170	**195**	194	204	154	170	107	170	135
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	97	110	118	122	125	106	**117**	73	115	88

Table D3 Peak Flows 10 Year ARI

Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)									
		1	2	3	4.5	6	9	12	18	24	36
Savages Crossing	SAV-OUT	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Mt Crosby	MTC-OUT	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Kalbar	KAL-OUT	380	480	585	610	700	675	**745**	650	675	595
Amberley	AMB-OUT	630	840	960	995	1050	1055	1005	**1190**	965	860
Loamside	PUR-OUT	350	475	580	595	**635**	585	550	420	520	460
Walloon	WAL-OUT	460	580	670	700	780	840	**885**	880	795	692
U/s Bremer R	DB-OUT	68	79	86	89	**92**	74	80	50	82	63
U/s Bremer R	IP-OUT	67	78	**83**	79	76	60	65	41	69	46
U/s Bremer R	MH-OUT	39	**42**	40	33	33	27	32	20	32	23
U/s Bremer R	SC-OUT	48	**56**	54	45	46	35	42	26	42	30
David Trumpy Br	2C#	1150	1490	1570	1605	1685	1725	1800	**1845**	1695	1590
U/s Bremer R	BUND15	145	180	203	208	**230**	215	240	180	205	190
D/s Bundamba Ck	IPS-OUT	1160	1500	1580	1620	1700	1730	1810	**1855**	1780	1600
Moggill	JIN###	1720	1740	1750	1765	1900	2000	2120	2380	2310	2980
u/s Brisbane R	JINAO	115	135	**136**	120	121	94	105	74	110	78
u/s Brisbane R	JINCG	56	64	**67**	60	60	47	52	35	53	36
u/s Brisbane R	JIN3M	165	200	235	230	**240**	185	205	125	205	158
u/s Brisbane R	JIN6	115	130	140	142	**147**	124	135	90	135	105
Jindalee	JIN-OUT	1720	1740	1750	1765	1900	2000	2120	2380	2310	2980

[ ] Denotes critical duration

Table D4 Peak Flows 20 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)									
			1	2	3	4.5	6	9	12	18	24	36
Brisbane R	Savages Crossing	SAV-OUT	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
	Mt Crosby	MTC-OUT	2910	2910	2910	2910	2910	2910	2910	2910	2910	2910
Warrill Ck	Kalbar	KAL-OUT		580	710	745	855	815	**910**	800	815	725
	Amberley	AMB-OUT		1060	1200	1240	1295	1285	1220	**1450**	1160	1055
Purga Ck	Loamside	PUR-OUT		600	730	750	**780**	700	660	510	655	555
Bremer R	Walloon	WAL-OUT		700	805	845	930	1000	**1060**	1050	965	835
Deebing Ck	U/s Bremer R	DB-OUT		96	105	108	**109**	86	95	59	100	76
Ironpot Ck	U/s Bremer R	IP-OUT		93	**100**	94	92	74	79	49	84	58
Mihi Ck	U/s Bremer R	MH-OUT		**51**	48	41	40	34	37	24	40	29
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT		**68**	66	55	56	44	51	32	53	38
Bremer R	David Trumpy Br	2C#		1600	1710	1770	1890	1950	2060	**2120**	1970	1770
Bundamba Ck	U/s Bremer R	BUND15		220	250	255	277	262	**288**	216	248	220
Bremer R	D/s Bundamba Ck	IPS-OUT		1610	1720	1780	1900	1960	2070	**2130**	2050	1780
Six Mile Ck	u/s Brisbane R	JINAO		160	**162**	145	145	115	127	88	135	96
Goodna Ck	u/s Brisbane R	JINCG		76	**79**	71	71	56	62	42	64	45
Woogaroo Ck	u/s Brisbane R	JIN3M		255	283	280	**289**	220	250	151	252	190
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6		157	166	172	**177**	149	160	110	165	123

☐ Denotes critical duration

Table D5 Peak Flows 50 Year ARI

Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)								
			2	3	4.5	6	9	12	18	24	36
Brisbane R	Savages Crossing	SAV-OUT	4220	4220	4220	4220	4220	4220	4220	4220	4220
	Mt Crosby	MTC-OUT	4220	4220	4220	4220	4220	4220	4220	4220	4220
Warrill Ck	Kalbar	KAL-OUT	715	880	925	1050	1005	**1110**	1010	1020	890
	Amberley	AMB-OUT	1390	1560	1620	1630	1590	1485	**1820**	1490	1310
Purga Ck	Loamside	PUR-OUT	790	940	955	**970**	860	790	625	775	665
Bremer R	Walloon	WAL-OUT	865	985	1070	1140	1220	1285	**1305**	1190	1020
Deebing Ck	U/s Bremer R	DB-OUT	120	127	**132**	132	105	110	72	114	90
Ironpot Ck	U/s Bremer R	IP-OUT	115	**121**	112	108	85	89	59	93	64
Mihi Ck	U/s Bremer R	MH-OUT	**65**	58	48	47	38	41	28	44	32
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	**86**	80	65	65	51	57	38	59	42
Bremer R	David Trumpy Br	2C#	1790	1940	2060	2200	2280	2410	**2550**	2370	2065
Bundamba Ck	U/s Bremer R	BUND15	277	307	317	**342**	323	348	266	295	270
Bremer R	D/s Bundamba Ck	IPS-OUT	1800	1940	2065	2200	2280	2420	**2560**	2440	2070
Six Mile Ck	u/s Brisbane R	JINAO	197	**197**	173	172	132	145	105	150	108
Goodna Ck	u/s Brisbane R	JINCG	93	**95**	84	82	64	70	50	71	50
Woogaroo Ck	u/s Brisbane R	JIN3M	318	**350**	344	**350**	265	290	185	290	222
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	190	197	209	**213**	178	187	133	188	144

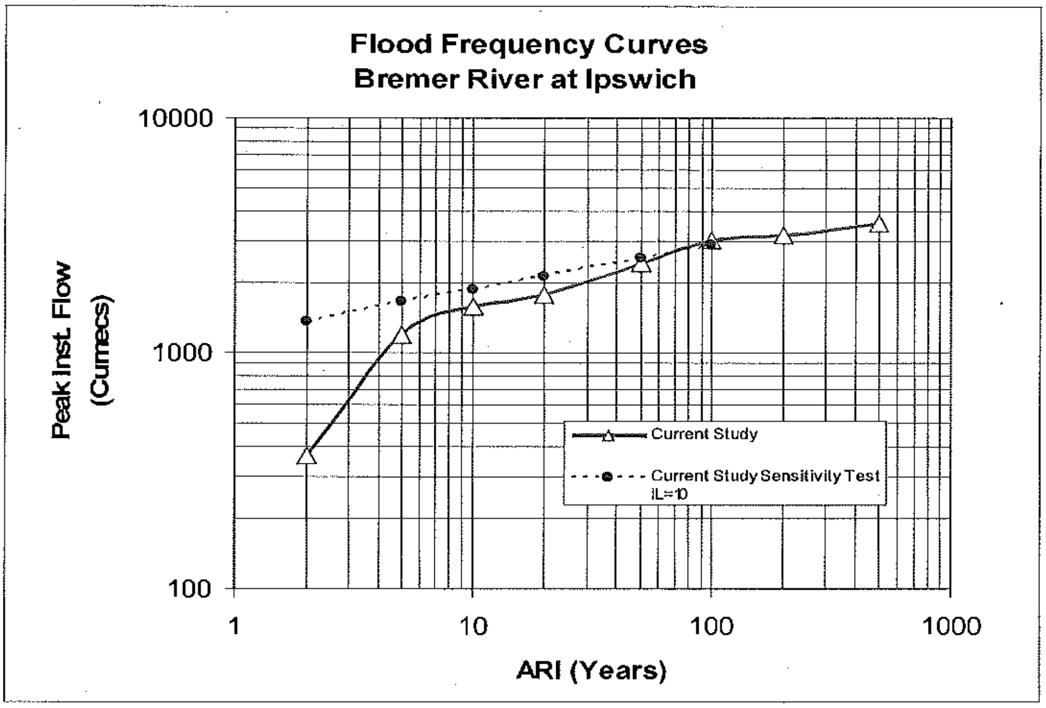
☐ Denotes critical duration

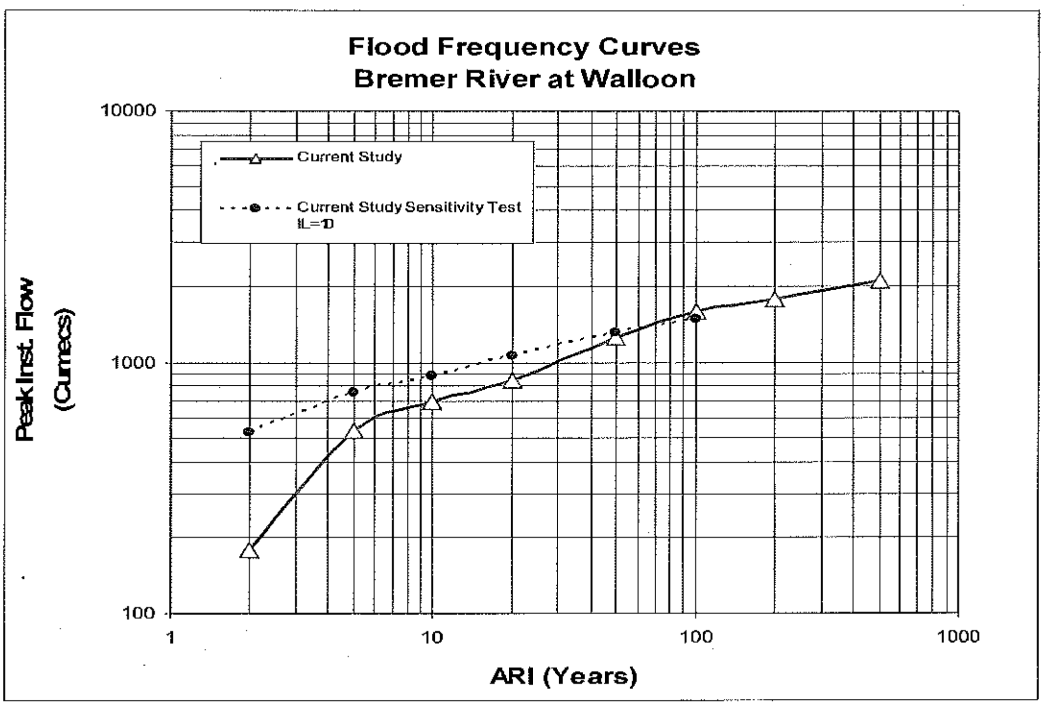
Table D6 Peak Flows 100 Year ARI

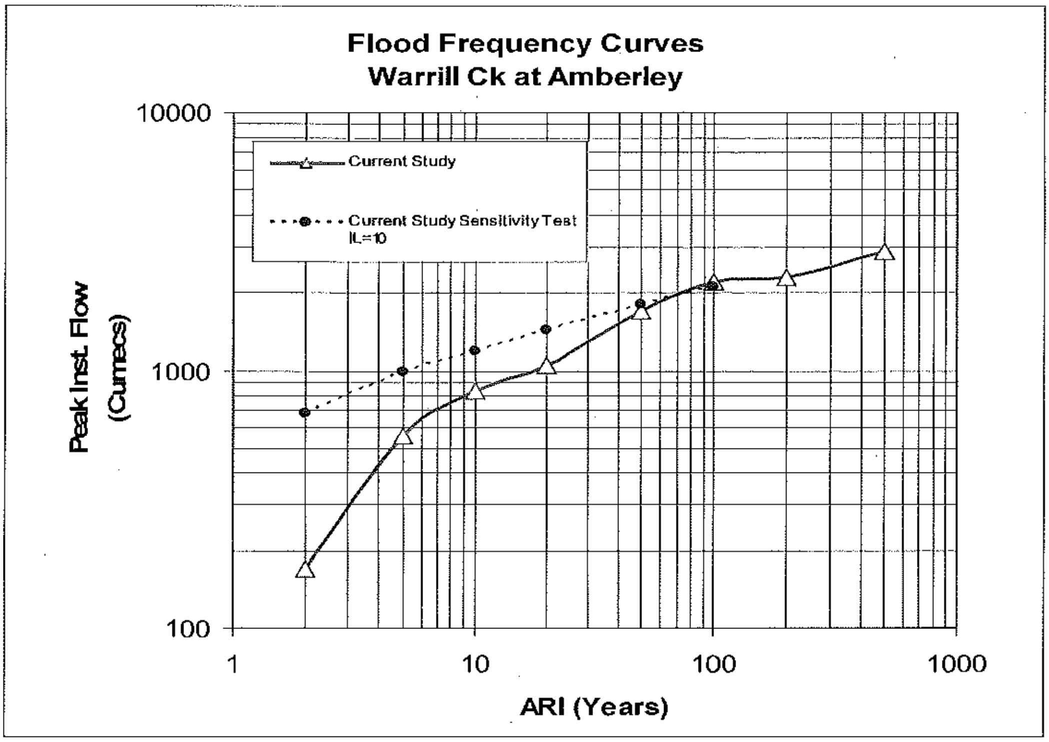
Waterway	Location	Rafts Node	Peak Flow (Cumecs) for Storm Duration (Hours)								
			2	3	4.5	6	9	12	18	24	36
Brisbane R	Savages Crossing	SAV-OUT	6000	6000	6000	6000	6000	6000	6000	6000	6000
	Mt Crosby	MTC-OUT	6000	6000	6000	6000	6000	6000	6000	6000	6000
Warrill Ck	Kalbar	KAL-OUT	845	1020	1090	1230	1170	**1300**	1170	1190	1030
	Amberley	AMB-OUT	1670	1860	1930	1910	1860	1720	**2110**	1735	1530
Purga Ck	Loamside	PUR-OUT	950	1125	1130	**1135**	990	910	720	910	765
Bremer R	Walloon	WAL-OUT	1000	1130	1200	1315	1405	1480	**1500**	1380	1170
Deebing Ck	U/s Bremer R	DB-OUT	138	148	**154**	153	120	127	83	133	102
Ironpot Ck	U/s Bremer R	IP-OUT	130	**140**	129	125	98	105	67	106	75
Mihi Ck	U/s Bremer R	MH-OUT	**75**	68	56	54	45	47	32	52	38
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	**100**	94	77	75	62	66	44	70	50
Bremer R	David Trumpy Br	2C#	1950	2150	2290	2450	2570	2740	**2910**	2710	2360
Bundamba Ck	U/s Bremer R	BUND15	325	360	370	400	377	**405**	305	345	310
Bremer R	D/s Bundamba Ck	IPS-OUT	1960	2160	2300	2460	2580	2750	**2920**	2770	2360
Six Mile Ck	u/s Brisbane R	JINAO	**227**	226	200	200	153	166	120	175	125
Goodna Ck	u/s Brisbane R	JINCG	106	**110**	97	95	74	81	57	82	58
Woogaroo Ck	u/s Brisbane R	JIN3M	375	**410**	400	403	305	338	214	340	255
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	220	227	242	**247**	206	214	156	217	164

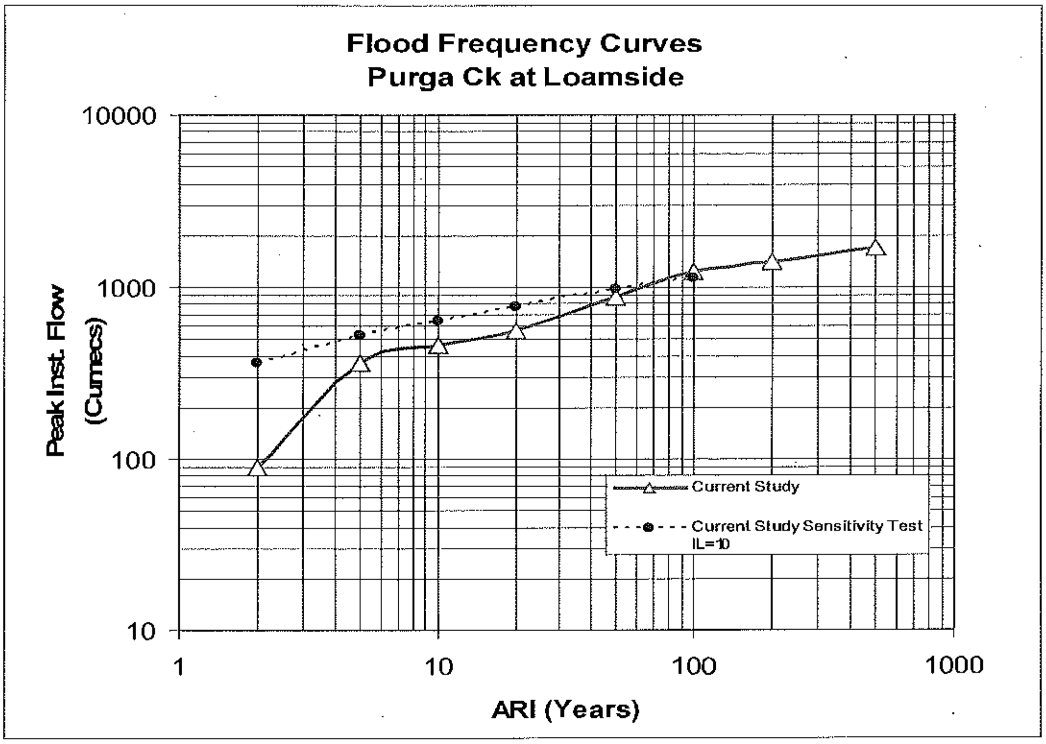
[ ] Denotes critical duration

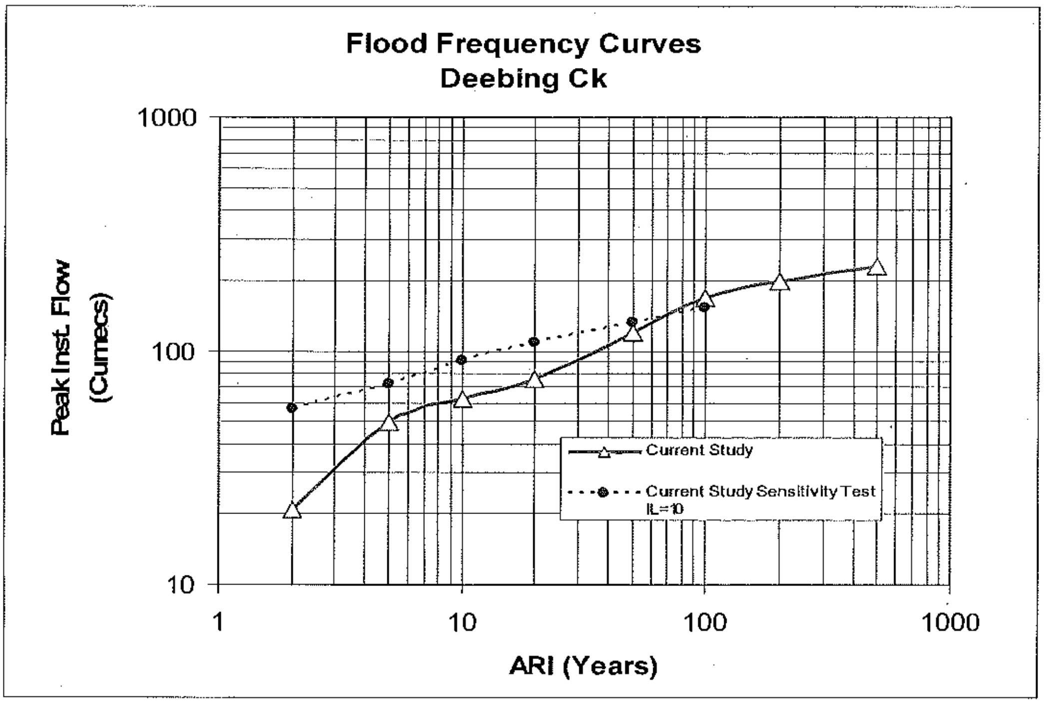
Appendix E **Design Flood Frequency Curves**

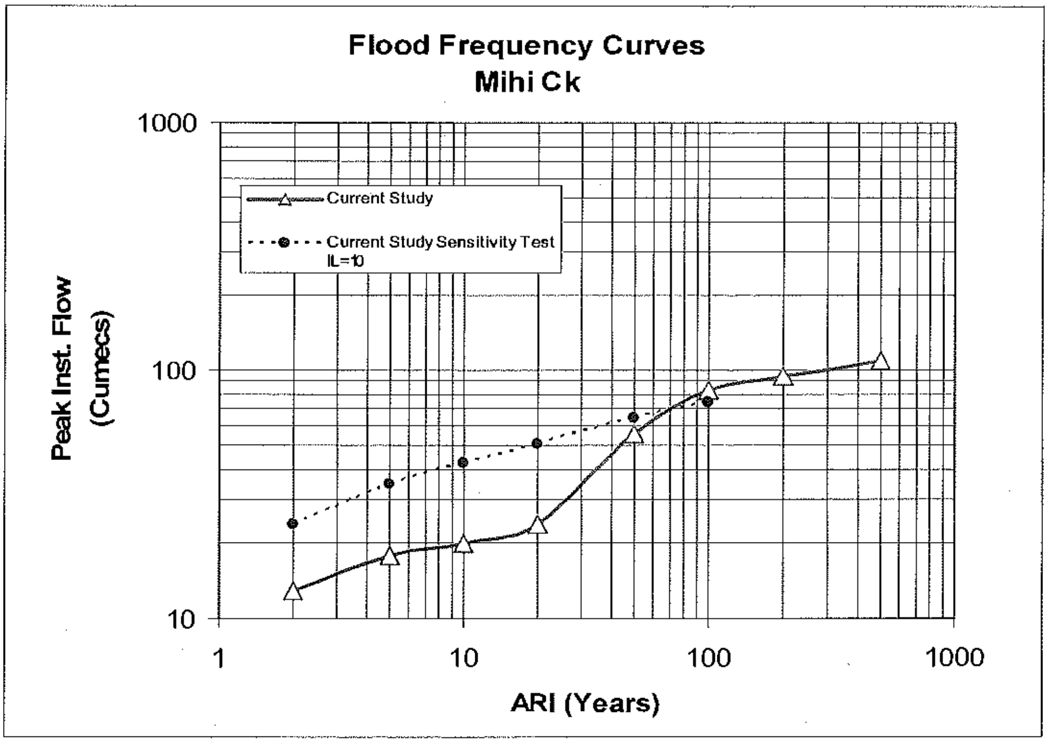


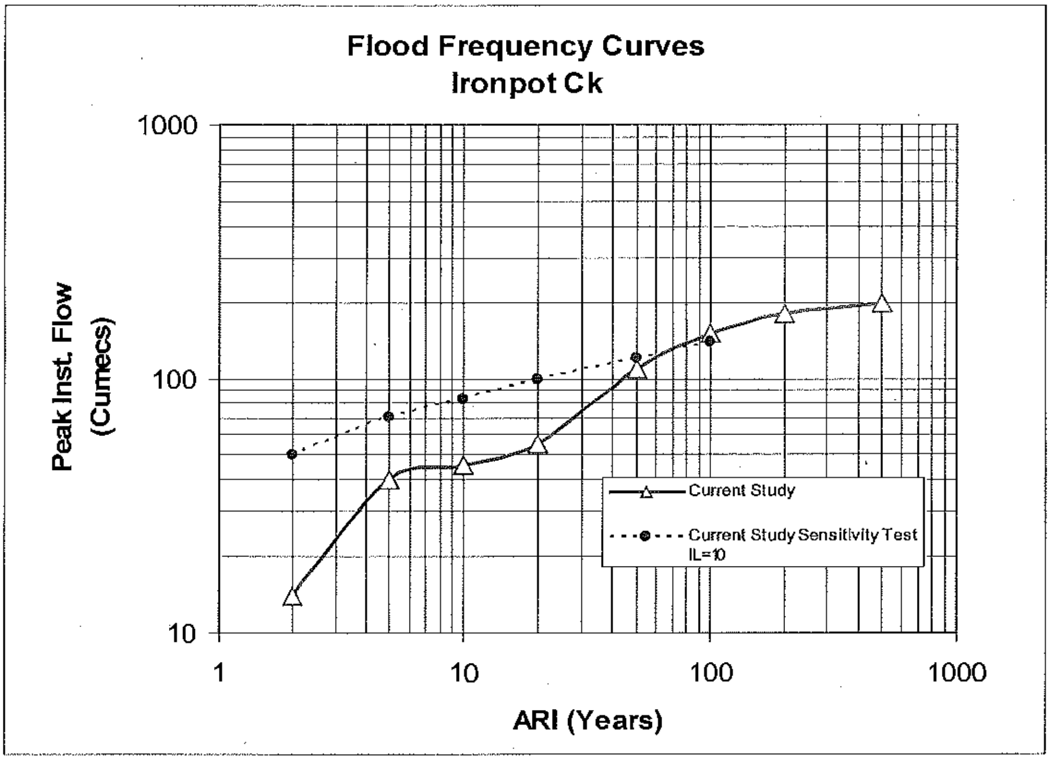


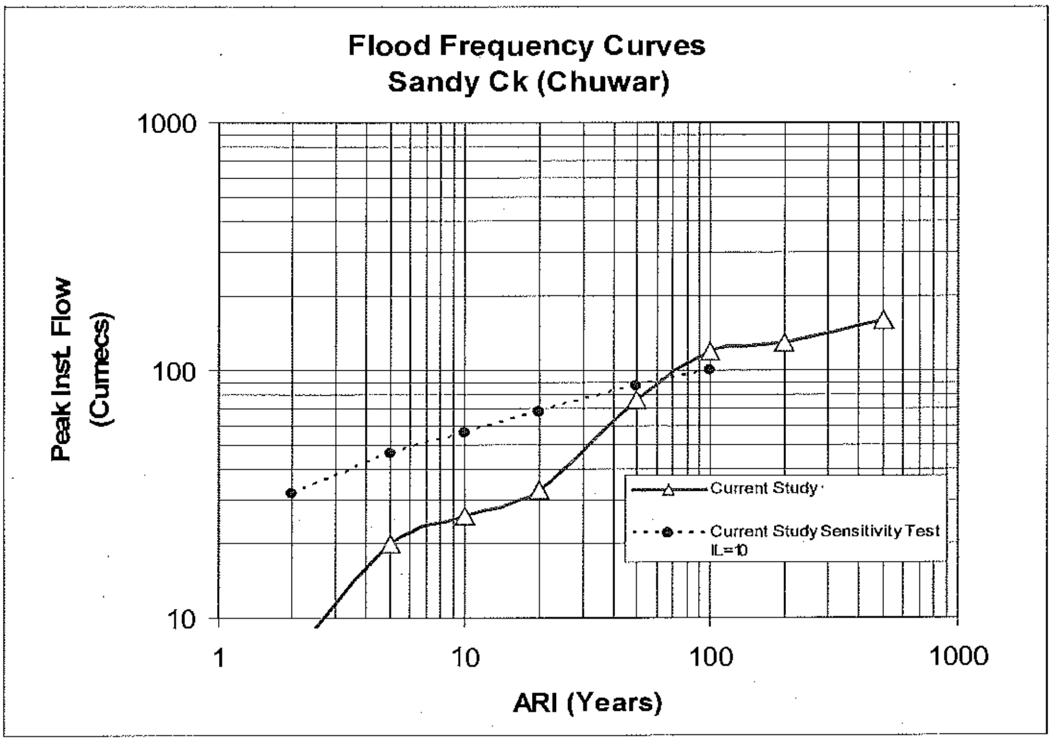

Flood Frequency Curves
Warrill Ck at Amberley
Current Study
Current Study Sensitivity Test IL=10
Peak Inst. Flow (Cumecs)
10000
1000
100
1
10
100
1000
ARI (Years)

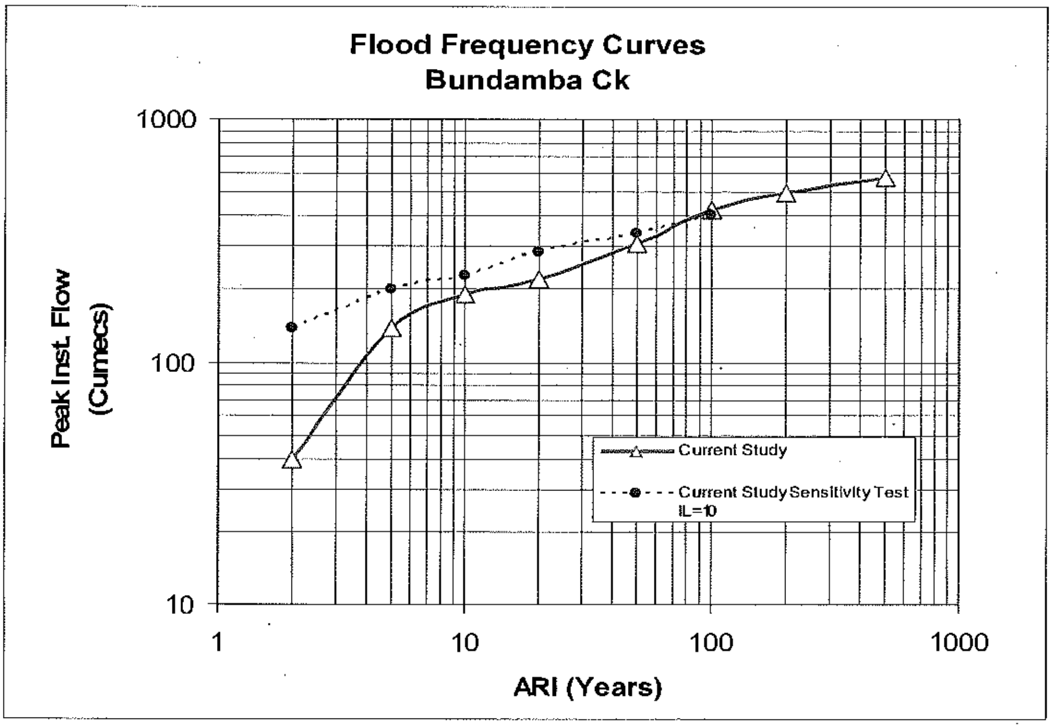

Flood Frequency Curves
Purga Ck at Loamside
Current Study
Current Study Sensitivity Test IL=10
Peak Inst. Flow (Cumecs)
10000
1000
100
10
1
10
100
1000
ARI (Years)

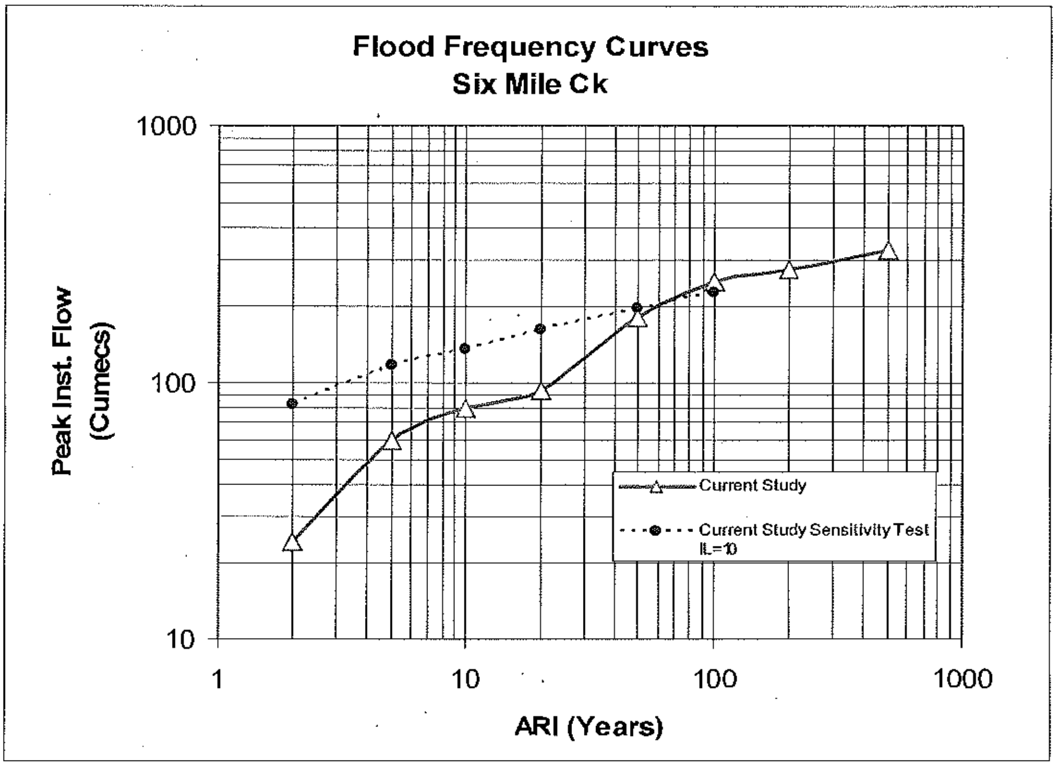

Flood Frequency Curves
Deebing Ck
Peak Inst. Flow (Cumecs)
1000
100
10
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10

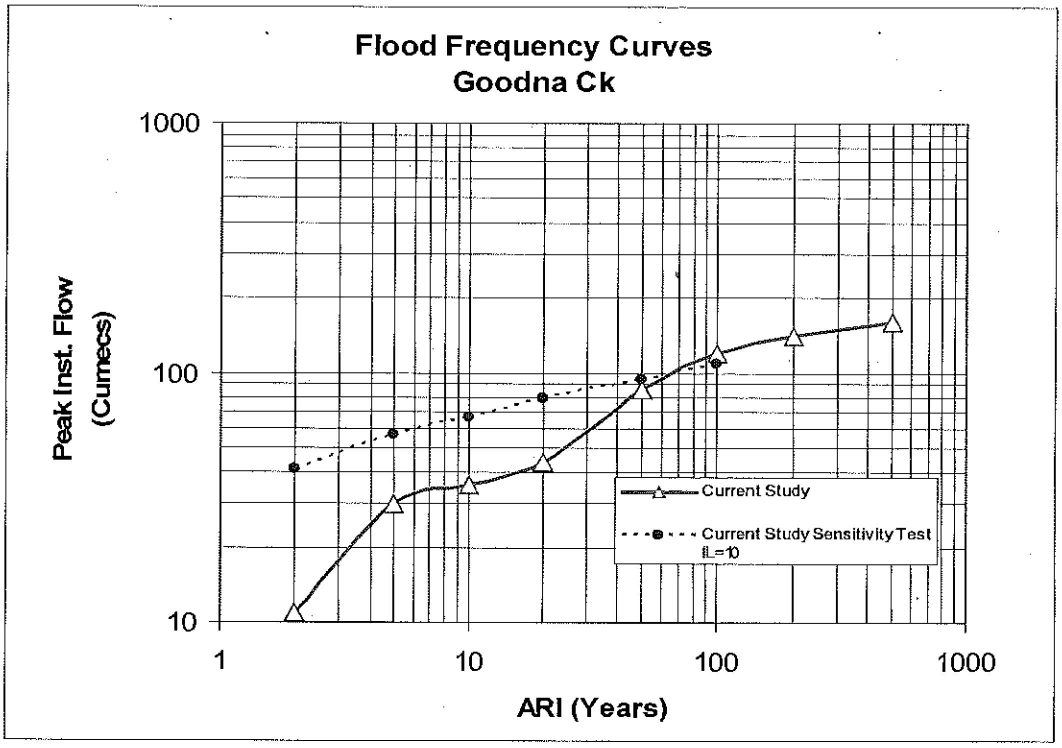

Flood Frequency Curves
Mihi Ck
Peak Inst. Flow (Cumecs)
1000
100
10
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10

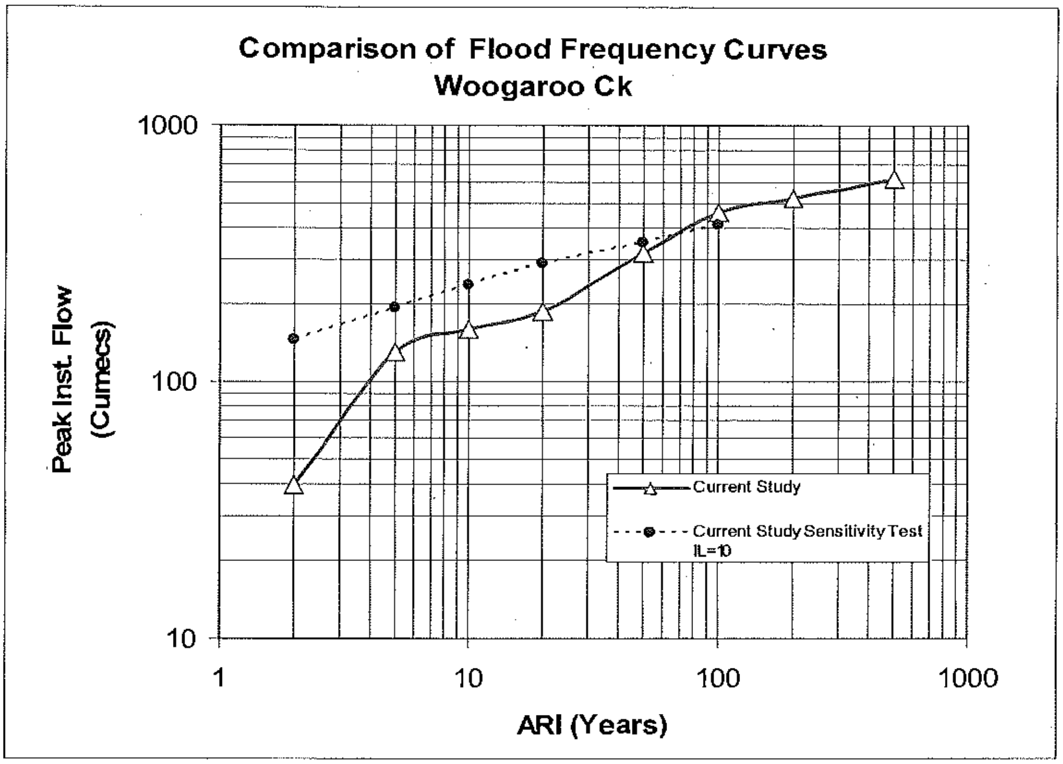

Flood Frequency Curves
Ironpot Ck
1000
100
10
Peak Inst. Flow
(Cumecs)
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test
IL=10

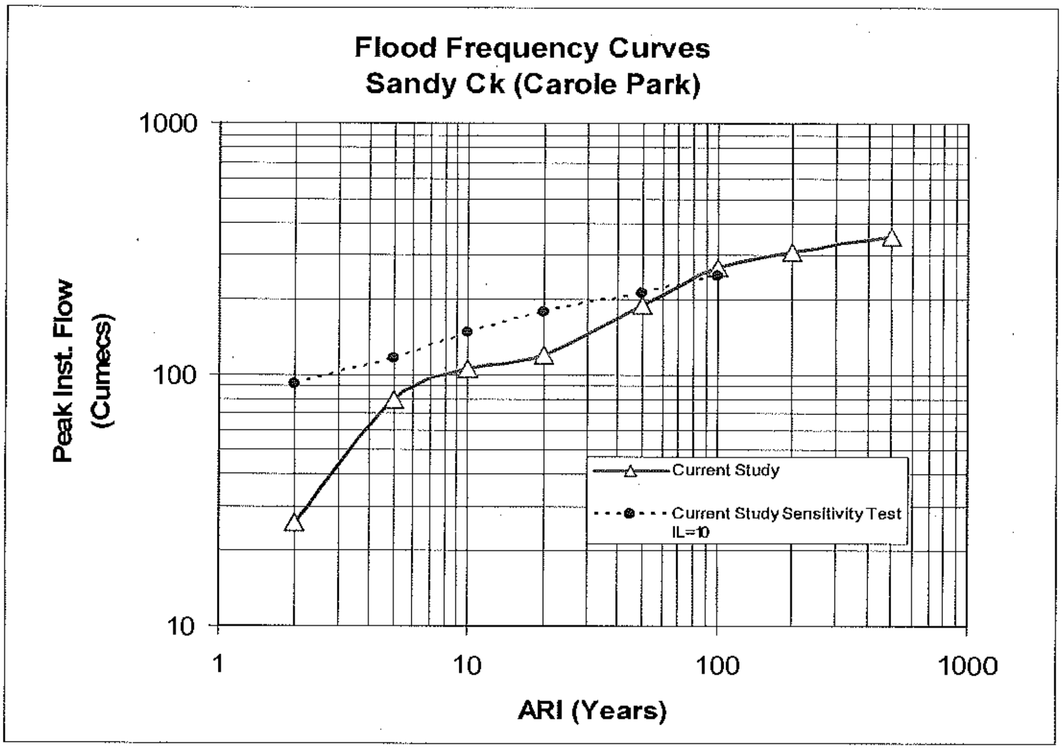

Flood Frequency Curves
Sandy Ck (Chuwar)
1000
100
10
Peak Inst. Flow
(Cumecs)
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test
IL=10


Flood Frequency Curves
Bundamba Ck
Peak Inst. Flow (Cumecs)
1000
100
10
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10


Flood Frequency Curves
Six Mile Ck
Peak Inst. Flow (Cumecs)
1000
100
10
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10


Flood Frequency Curves
Goodna Ck
1000
100
10
Peak Inst. Flow (Cumecs)
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10


Comparison of Flood Frequency Curves
Woogaroo Ck
1000
100
10
Peak Inst. Flow (Cumecs)
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test IL=10


Flood Frequency Curves
Sandy Ck (Carole Park)
Peak Inst. Flow
(Cumecs)
1000
100
10
1
10
100
1000
ARI (Years)
Current Study
Current Study Sensitivity Test
IL=10

Queensland Government
Department of Emergency Services

DOTAR
DEPARTMENT OF TRANSPORT AND REGIONAL SE[illegible]

Ipswich Rivers Improvement Trust

Natural Disaster Risk Management Studies Program

Ipswich Rivers Improvement Trust

Ipswich Rivers Flood Study Rationalisation Project

Phase 3

Re-estimation of Design Flood Levels Final Report

December 2006

Sargent Consulting

Sargent Consulting
ABN 74 424 370 508
11 Redwood Place
THE GAP
Queensland 4061
Tel 0419 311160
Fax 07 35110440
Email dms@sargentconsulting.com.au
Job No 06008

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Study Rationalisation Project
Phase 3

Re-estimation of Design Flood Levels – Final Report

Table of Contents

ICC.005.2884

List of Tables

List of Figures

List of Figures (Continued)

Executive Summary

Introduction

The objective of the Ipswich Rivers Flood Study Rationalisation Project (IRFSRP) is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC), in order to facilitate the preparation of new flood maps.

The IRFSRP is being conducted in parallel with the Brisbane Valley Flood Damage Minimisation Study (BVFDMS) which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

One of the outstanding issues that is being investigated as part of the IRFSRP is the catchment hydrology, in particular the definition of design flows as estimated using the RAFTS model which has previously been established for studies for both ICC and BCC.

Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz) and for the rural areas in 2002 (Halliburton KBR), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

In addition, in response to apparent anomalies with predicted 20 year ARI flood levels in particular, Council commissioned Sargent Consulting (SC) in 2002 to review the current flood models. That review (SC 2003) concluded that the current hydraulic model (MIKE 11) calibration is skewed towards the replication of major floods with the result that water levels for smaller floods are overestimated, and that the design flows estimated using the RAFTS model (SKM 2000) may be overly conservative.

As a consequence of the issues noted above, the current hydrologic and hydraulic models are known to have some inconsistencies, and the flood levels used by the two local government areas for town planning controls are no longer compatible.

Resolution of these matters is required urgently by ICC so that:

- *The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and*
- *The current development of emergency response flood mapping is not compromised.*

As part of this project DHI Water and Environment *was commissioned to review, and subsequently upgrade, the existing MIKE11 model.*

Scope of Work

The current commission comprises the re-calibration of the MIKE 11 hydraulic model and the use of the model together with recently re-estimated design flows to re-estimate design flood levels throughout the major watercourses in Ipswich.

This entailed:

a) *Establishment of MIKE11 model files and input data files for the four flood events to be used for calibration;*

b) *Running the model for individual events and modifying roughness and other model parameters to obtain a reasonable match of observed and estimated flood levels for individual events;*

c) *Comparison of the model roughness required for calibration of individual events, with a view to determining an overall parameter set which results in a satisfactory replication of all the calibration events, including sensitivity testing and commenting on likely model accuracy and sources of error;*

d) *Setting up the design phase model with the adopted parameter set;*

e) *Running the model to estimate flood levels for inflows across a range of design ARIs and storm durations;*

f) *Determining the critical flood level profiles for each ARI;*

g) *Reporting on the above including plans and longitudinal flood profiles.*

The scope of work was extended during the project to include:

h) An initial investigation into the possibility of physical changes in the Brisbane River in the vicinity of its confluence with the Bremer River.

Draft reports were prepared covering items a) to c) and d) to h) respectively (Sargent Consulting 2006b, 2006c). This report has been compiled by consolidating the two draft reports taking into account review comments received regarding the draft reports.

Recent Model Review and Upgrade

The MIKE 11 models for Ipswich Rivers were developed initially for the Ipswich Rivers Flood Study Phases 2 and 3.

As a consequence of issues raised from interpretation of the results from these models, and subsequent application of the models, a number of issues were raised, resulting in DHI Water & Environment (DHI) being commissioned to review and subsequently upgrade, the structure of the models including merging the urban and rural area models into a single model, and improving the numerical stability of the models enabling larger time steps to be used.

Hydraulic Model Calibration

The MIKE 11 model used in the current commission is the model handed over to ICC by DHI following the model review and upgrade projects outlined above.

As there have been no significant flood events since the previous model calibrations, there were no new datasets and the four events utilised in the previous work were again adopted. These were:

- *January 1974; Jun 1983; April/May 1989; and May 1996.*

The 1974 flood was a major regional flood event with peak flows in the lower Brisbane River exceeding 9,000m³/s, and in the lower Bremer River peak flows of about 4,000m³/s. This event, which resulted from the landfall of Tropical Cyclone Wanda, occurred prior to the construction of Wivenhoe Dam. Under post-dam conditions, this flow is well in excess of the best estimate of the 100 year average recurrence interval (ARI) flow of 6,000m³/s (Mein et al 2003).

In contrast, the largest of the other calibration events, in May 1996, had peak flows of about 3,500m³/s and 2,500m³/s in the lower Brisbane River and lower Bremer River respectively.

One of the objectives of the current re-calibration has been to develop a consistent set of roughness parameters which can be used with confidence across the range of floods covered by the calibration data, and it was hoped that the recent model review and upgrades would have improved the fitting of the model to enable this to be achieved

The basic calibration strategy was to develop a set of model parameters to satisfactorily replicate flood levels in the 3 smaller flood events, and then to modify the parameters for floodplain flows above the levels reached in those events in order to also replicate the much larger 1974 event. If this could be achieved, the parameter set could be used over the full range of design floods (from 2 year to 500 year ARI), or at least over that part of the range encompassed by the design events.

Discussion of Results

The model calibration process confirmed that it is not possible to use a single set of roughness parameters to satisfactorily replicate the flood levels in the four calibration events, and that it has been necessary to utilise the ability of the model to vary roughness with water level to be able to include these variations in a single hydraulic parameter file.

Although this degree of variation in roughness between events is not physically realistic, this approach is considered to be justifiable, given the need to develop a single parameter file which can be used in the design case, and to make the best available use of the calibration data, the reasons for this variation should be considered.

The following are considered to be possible reasons for the apparent change in model roughness between the smaller and large flood events:

- *Possible physical changes in the river system since 1974;*
- *Errors introduced by the model structure; and*
- *Errors in the boundary conditions (hydrologic inputs) to the model.*

These possible reasons are discussed in the body of the report.

Sensitivity Testing

Sensitivity testing was undertaken in respect of the following:

- *Inappropriate roughness parameters (due to physical change); and*
- *Uncertainty in hydrologic inputs.*

These tests indicated that the model results were sensitive to both of these potential sources of error.

Conclusions

It was concluded that it was possible to calibrate the MIKE 11 model to the 1996 and 1974 and to verify the fitted model with the small floods in 1983 and 1989 to an acceptable degree.

However, this was achieved only by varying model roughness between that required to fit the 1996 and 1974 events within the one data file using a facility within MIKE 11 to vary roughness with flow depth.

This is considered to be a legitimate means of calibration in this context because of the large disparity which existed between roughness parameters fitted to individual events.

The possible reasons for this disparity have been considered and commented upon. These are:

- *Possible physical changes in the river system since 1974;*
- *Errors introduced by the model structure; and*
- *Errors in the hydrologic inputs to the model.*

Physical Changes

Given that the 1974 flood in the Brisbane River/Bremer River catchment was the largest experienced in the 20th Century, and that anecdotal evidence (A. Underwood pers. comm.), pictorial evidence, and the modelled velocities show that this event had sufficient power to cause extensive erosion, it is considered to be quite likely that the current river and creek channels have a greater flow carrying capacity than that at the time of the 1974 flood. In this case, modelling the 1974 flood with current channel geometry would need hydraulic roughness to be increased to match historic water levels as has been found to be the case.

Also there was substantial dredging in the Brisbane River for much of the 20th Century, ending only in 1998, which has deepened the Brisbane River and resulted in its tidal limit moving upstream from about Indooroopilly at the time of European settlement to Mt. Crosby Weir on the Brisbane River and Ipswich on the Bremer River.

Dredging can induce bed erosion in both upstream and downstream directions and this may have occurred, or still be taking place.

Sensitivity testing indicated that use of roughness values appropriate at the start of the 1974 event could overestimate peak flood levels at key locations by 2.8m to 3.5m in the Goodna to Moggill reach of the Brisbane River and 3.3m in the lower Bremer River.

Model Structure
The MIKE 11 model has been structured (SKM 2000, KBR 2002, DHI 2006) with cross-sections and chainages following the river channel. During a major flood event in which substantial floodplain flow occurs, there can be a considerable shortening of the effective flowpath length.

If the effective or flowpath distance between sections is overestimated in the model, the water surface slope will be underestimated and the temporary flood storage will be overestimated. Both of these lead to higher roughness being required in the model to compensate for the incorrect distance.

It was concluded that this is a factor in the different apparent roughness values obtained when fitting the much larger 1974 flood event.

Hydrologic Inputs
With the exception of the downstream boundary condition, the other boundary conditions (of which there are some 160) are upstream and local flow hydrograph inputs. If the inflows into a particular branch of the model had been overestimated, this would lead to the roughness (required to match historic levels) being underestimated and vice versa.

Current best practice is to calibrate the hydrologic and hydraulic models "in tandem" and to test the sensitivity of model outcomes to parameter variation "in tandem". This approach was possible in this instance, as the calibration of the hydrologic model was undertaken as part of Phase 2 of the Ipswich Rivers Flood Study (SKM 2000) using the RAFTS model and the flow inputs for the calibration floods have been taken from the previous work.

Limited sensitivity testing of the likely scale of error in the hydrologic inputs showed that the model results are sensitive to these changes resulting in differences in peak flood levels, all other factors remaining as before, of the order of 0.6m to 3m in the Bremer River; 0.9 to 1.9m in Warrill Creek and 0.9 to 1.1m in Purga Creek; and up to 0.6m in Brisbane River (even though no changes to Brisbane River flows were include din the test).

It is considered that the possible physical changes probably have a greater impact on the behaviour of the hydraulic model than those resulting from deficiencies in the structure of the model, and uncertainty in the hydrologic inputs.

Recommendations
It was recommended that a brief investigation into whether significant river widening/deepening has occurred since the 1974 flood be undertaken in order to determine whether the calibrated model is overconservative in respect of design flood events and to confirm the recommended hydraulic roughness parameters to be used for design event modelling and flood extent mapping.

In the absence of this investigation, it is recommended that the conservative approach be adopted, that is to use the composite hydraulic roughness parameter file which models the variation between small and large events as evidenced by the 1996 and 1974 historic flood data.

An initial investigation limited to the Brisbane River adjacent to the Bremer River confluence was subsequently undertaken as part of the design phase work. Whilst this added further credence to the hypothesis that significant physical change has occurred in *the Brisbane River, this was not of sufficient scope to conclude that these changes have occurred more widely though the Ipswich Rivers.*

Design Phase Hydraulic Modelling

The Ipswich MIKE 11 model was run for ARI's of 2, 5, 10, 20, 50, 100, 200 and 500 years with flow inputs obtained from design runs of the RAFTS model for storm durations of 1, 2, 3, 4.5, 6, 9, 12, 18, 24, 36, 48 and 72 hours for each ARI, i.e. a total of 96 model runs. The maximum water levels for each ARI are summarised, for key locations, in Table ES1. Complete tabulation of maximum water level, maximum flow and maximum average velocity are given in appendices to the report which also includes longitudinal flood profiles along each of the main waterways.

The table of design flows at key points was updated from that given in Sargent Consulting (2006b) based on the peak flows in the hydraulic model which accounts for temporary flood storage more realistically than the RAFTS model. These flows are given in ***Table ES2****.*

Sensitivity Testing

The sensitivity of the results has been tested, for 100 year ARI only in respect of the following uncertainties in the hydraulic modelling:

- *Hydraulic roughness;*
- *Design flows including potential climate change impacts;*
- *The downstream boundary condition; and*
- *Storm surge and tide including potential climate change impacts.*

These uncertainties were tested by running the model with variations in each of these parameters, within a range considered to be reasonable, and the results are presented in this section. More limited sensitivity testing was carried out for 20 year ARI.

The sensitivity testing has confirmed that model results are sensitive to: changes in waterway geometry which impact on the apparent hydraulic roughness required for replication of historic flood levels; possible errors in flood flow estimates; limitations in the schematisation of the model; and to the potential impact of climate change on design rainfalls.

The sensitivity testing has also shown that flood levels in Ipswich are insensitive to storm surge levels, within current estimates, including allowance for climate change impacts; and have low sensitivity to the adopted stage – discharge rating curve at Jindalee.

Table ES1 Design Flood Levels at Key Locations

Watercourse	Location	Chainage	Estimated Peak Water Level (m AHD) for ARI							
		m	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
Brisbane River	Mt. Crosby	988160	8.69	10.66	13.81	15.70	19.89	22.73	22.71	24.16
	Moggill	1006300	2.02	5.65	8.34	10.30	13.48	14.98	15.97	17.53
	Goodna	1014610	2.00	5.23	7.84	9.52	12.22	13.55	14.50	16.01
	Jindalee	1028680	2.00	4.49	6.71	7.80	9.50	10.36	10.96	12.09
Bremer River	One Mile Bridge	1004590	8.45	11.64	13.63	15.56	17.69	20.74	21.49	24.14
	Wulkeraka Bridge	1006510	7.14	10.61	12.17	13.94	16.26	19.23	20.17	22.70
	Hancock Bridge	1008390	6.17	9.78	11.48	13.31	15.54	17.99	19.04	21.20
	David Trumpy Bridge	1012050	4.38	7.56	9.60	11.36	14.09	15.28	16.65	18.28
	Bundamba Creek	1020450	2.86	6.41	8.80	10.70	13.89	15.23	16.50	18.14
Bremer River (Mid)	Rosewood	11478	37.90	38.71	39.01	39.19	39.43	40.59	41.43	42.82
	Walloon	23968	22.55	24.59	25.17	25.55	25.97	26.20	26.60	29.15
	Three Mile Bridge	29515	15.00	17.62	18.73	20.01	21.73	23.57	23.85	26.03
Bremer River (Upper)	Adams Bridge	16506	78.30	79.69	80.06	80.40	80.85	81.16	81.28	81.46
	Stokes Crossing	23829	60.10	61.44	61.74	62.09	62.97	63.77	64.00	64.41
Bundamba Creek	Ripley	16395	50.21	51.18	51.40	51.58	54.14	57.47	56.87	57.13
	Cunningham Highway	28480	24.20	25.36	26.07	26.25	26.57	26.70	26.72	26.97
	Blackstone Road	31980	18.40	20.03	20.50	20.85	21.58	21.84	21.87	22.32
	Brisbane Road	34305	15.10	17.06	17.51	17.67	17.94	18.05	18.09	18.38
	Gledson Road	36005	10.75	12.80	13.28	13.56	14.17	15.24	16.51	18.14
Goodna Creek	Duncan St	12020	13.17	13.58	13.90	14.23	15.03	15.32	15.80	16.46
	Brisbane Road	14155	6.93	7.50	8.08	9.81	12.58	13.94	14.91	16.46
	U/s Brisbane Terrace	14735	5.41	5.91	8.06	9.81	12.58	13.94	14.91	16.46
Purga Creek	Peak Crossing	2986	48.94	48.94	48.94	48.94	48.94	48.94	49.01	49.22
	Loamside	15309	24.65	25.97	26.40	26.70	27.18	27.65	27.72	28.09
Western Ck	Kuss Rd	9772	50.18	52.92	54.10	55.64	55.67	55.99	56.17	56.97
Warrill Creek	Harrisville	4779	50.88	51.37	51.55	51.67	52.03	52.24	52.25	52.29
	Amberley	25710	22.82	24.78	25.39	25.74	26.30	27.04	27.32	27.98
Warrill Creek (Upper)	Kalbar	19442	72.61	75.16	76.17	76.30	76.78	77.42	77.66	77.97
Woogaroo Creek	Parker St	15800	7.77	10.03	10.41	10.68	12.23	13.55	14.51	16.01
	Edna St	15860	7.55	9.69	10.16	10.47	12.22	13.55	14.51	16.01
	Brisbane Rd	17370	3.70	5.73	7.89	9.52	12.22	13.55	14.51	16.01
	Brisbane Terrace	17760	3.12	5.32	7.87	9.52	12.22	13.55	14.50	16.01

Table ES2 Peak Design Flows at Key Locations

Waterway	Location	Peak Flow (Cumecs) for ARI Years							
		2	5	10	20	50	100	200	500
Brisbane R	Savages Crossing	400	960	1900	2700	4300	5600	5800	6300
	Mt Crosby	400	980	1900	2700	4200	5500	5700	6000
Warrill Ck	Kalbar	170	520	700	850	1400	1800	1900	2200
	Amberley	185	550	800	1050	1700	2250	2300	3200
Purga Ck	Loamside	130	260	330	410	630	900	940	1200
Bremer R	Walloon	240	640	820	950	1100	1180	1210	2200
Deebing Ck	U/s Bremer R	15	50	60	75	130	190	195	230
Ironpot Ck	U/s Bremer R	14	40	47	60	120	190	220	230
Mihi Ck	U/s Bremer R	13	16	21	25	55	60	70	80
Sandy Ck (Chuwar)	U/s Bremer R	7	20	26	31	66	95	100	110
Bremer R	David Trumpy Br	440	1100	1500	2100	3050	3200	3300	4400
Bundamba Ck	U/s Bremer R	40	160	210	240	340	400	420	430
Bremer R	D/s Bundamba Ck	450	1100	1450	1950	3000	3250	3300	4400
Brisbane R	Moggill	820	2000	3200	4200	5500	6300	6900	7900
Six Mile Ck	u/s Brisbane R	20	60	65	75	125	170	200	240
Goodna Ck	u/s Brisbane R	11	30	36	45	85	120	140	160
Woogaroo Ck	u/s Brisbane R	40	120	150	180	300	420	470	540
Sandy Ck (Carole Park)	u/s Brisbane R	10	20	26	31	65	100	120	130
Brisbane R	Jindalee	920	2100	3300	4100	5400	6200	6700	7600

Discussion of Results

The results presented herein are based on the current best estimates of flood hydrology and river hydraulics in the Brisbane/Bremer River system.

Since previous modelling was undertaken, both the hydrologic and hydraulic models have been reviewed and modified to take account of: new design rainfall data; the consensus view on the 100 year ARI design flow in the Brisbane River downstream of Wivenhoe dam; and the correction of a number of identified anomalies.

It should be expected then, that the new estimates are more reliable than the previous estimates. However, there is still considerable uncertainty regarding the accuracy of the estimated flood levels principally as a result of the inability to determine a consistent set of hydraulic parameters which replicate the flood levels observed in floods since 1974.

Comparison with Previous Flood Level Estimates

Previous flood level estimates are available from Phases 2 and 3 of the Ipswich Rivers Flood Study (SKM 2000 and KBR 2002 respectively). In addition, estimates for the 20 year ARI flood are available from the maps produced at the time of former City Engineer, Mr. Bob Gamble, referred to herein as the Gamble maps.

A comparison was made between the new flood level estimates and previous estimates and this is summarised in ***Table ES3****. Full details of these differences are presented in the body of the report.*

Discussion, Conclusions and Recommendations

The design flood levels and flows presented in this report are the result of upgrading and re-calibrating the hydraulic model together with the use of recently revised design flows (Sargent Consulting 2006b). As such, these estimates are based on the most up to date information available and should supersede previous flood estimates.

However, the re-modelling process has identified that there is still considerable uncertainty in respect of these estimates.

The following paragraphs summarise the advances which have been made since the previous estimates; the scale of the remaining uncertainties and their possible causes; recommendations in respect of using these estimates for planning purposes; and recommendations for further work to reduce the scale of the remaining uncertainties.

Table ES3 *Comparison of Current and Previous Flood Level Estimates at Key Locations*

Watercourse	Location	Chainage	Difference in Estimated Peak Water Level (m) between current study and IRFS Phases 2 & 3 for ARI								New 100 yr - previous 50 yr
		m	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years	
Brisbane River	Mt. Crosby	988160	0.30	0.01	-0.84	-6.39	-4.89	-4.38	-4.28	-4.42	-2.05
	Moggill	1006300	-0.04	1.49	1.20	-3.20	-2.71	-3.28	-3.36	-3.08	-1.21
	Goodna	1014610	0.31	1.68	1.84	-2.52	-2.46	-3.15	-3.27	-3.02	-1.13
	Jindalee	1028680	0.77	2.43	2.91	-0.84	-1.50	-2.42	-2.83	-2.86	-0.64
Bremer River	One Mile Bridge	1004580	-3.33	-3.92	-4.34	-5.16	-5.19	-3.73	-4.06	-3.24	-2.14
	Wulkuraka Bridge	1006490	-3.39	-3.54	-4.62	-5.61	-5.39	-4.02	-4.09	-3.53	-2.44
	Hancock Bridge	1008390	-3.08	-3.17	-4.21	-5.12	-4.95	-4.06	-3.97	-3.47	-2.50
	David Trumpy Bridge	1012050	-2.13	-2.38	-2.81	-3.72	-2.85	-3.32	-2.94	-2.51	-1.66
	Bundamba Creek	1020450	-2.52	-2.21	-2.32	-3.21	-2.38	-3.07	-3.00	-2.59	-1.04
Bremer River (Mid)	Rosewood	11478	0.36	0.46	0.35	0.20	-0.17	0.55	0.97	2.21	0.99
	Walloon	23968	1.57	2.25	1.78	1.38	0.64	-0.30	-1.65	0.32	0.87
	Three Mile Bridge (SKM)	100000	-1.34	-1.65	-2.64	-3.80	-4.00	-3.60	-4.20	-3.74	-2.16
	Three Mile Bridge (KBR)	29515	-0.08	0.01	-0.53	-0.79	-1.32	-1.13	-3.88	-2.43	N/A
Bremer River (Upper)	Adams Bridge	16506	0.05	0.58	0.22	-0.03	-0.15	-0.11	-0.43	-0.38	N/A
	Stokes Crossing	23829	0.18	0.50	0.31	0.31	0.10	0.39	-0.67	-0.64	N/A
Bundamba Creek	Ripley	16395	-2.36	-2.13	-2.29	-2.60	-0.57	2.41	1.32	1.12	2.76
	Cunningham Highway	28480	-1.03	-0.24	0.30	0.25	0.27	0.12	-0.33	-0.53	0.40
	Blackstone Road	31980	-0.86	0.06	0.19	0.17	0.45	0.42	0.03	-0.02	0.71
	Brisbane Road	34305	-0.21	1.00	1.08	0.76	0.47	-0.25	-1.42	-2.36	0.58
	Gledson Road	36005	-0.05	1.34	1.45	-0.36	-2.11	-3.06	-2.99	-2.59	-1.04
Goodna Creek	Duncan St	12020	-1.06	-1.48	-1.33	-1.18	-0.57	-1.82	-2.39	-2.96	-0.28
	Brisbane Road	14155	-0.74	-0.63	-0.37	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
	U/s Brisbane Terrace	14735	-1.06	-1.45	0.47	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
Purga Creek	Peak Crossing	2986	0.67	0.46	0.26	0.08	-0.17	-0.34	-0.46	-0.49	N/A
	Loamside	15309	-1.62	-0.77	-0.65	-0.65	-0.55	-0.32	-0.48	-0.76	N/A
Western Ck	Kuss Rd	9772	1.57	2.23	2.31	3.50	3.03	2.81	2.78	3.44	N/A
Warrill Creek	Harrisville	4779	1.03	1.20	1.21	1.05	1.10	1.22	0.50	0.37	N/A
	Amberley (SKM)	25710	-0.38	0.28	-0.13	-0.76	-1.02	-1.18	-1.36	-2.12	N/A
	Amberley (KBR)	25710	0.41	1.25	1.06	0.02	-0.79	-0.55	-1.86	-1.54	N/A
Warrill Creek (Upper)	Kalbar	19442	-0.71	0.87	0.48	-0.14	-0.25	0.02	-0.35	-0.39	N/A
Woogaroo Creek	Parker St	15800	-1.80	-0.28	-0.13	-1.36	-2.45	-3.16	-3.26	-3.02	-1.13
	Edna St	15860	-1.49	-0.07	-0.02	-1.57	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Rd	17370	-2.27	-1.15	0.58	-2.52	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Terrace	17760	-2.85	-1.56	0.56	-2.52	-2.46	-3.16	-3.27	-3.02	-1.13
		Max	1.57	2.43	2.91	3.50	3.03	2.81	2.78	3.44	2.76
		Min	-3.39	-3.92	-4.62	-6.39	-5.39	-4.38	-4.28	-4.42	-2.50

Discussion

Model Improvements

The following improvements in both the design flow estimates used in this modelling (Sargent Consulting 2006b), and in the hydraulic model (Sargent Consulting 2006c and this report), are all regarded as having improved the accuracy of the new flood estimates compared to previous estimates:

- *The design flood flows for the Brisbane River have been reduced from previous estimates and are consistent with the findings and recommendations of the Independent Review Panel Report on Brisbane River flood studies (Mein et al 2003);*

- *The design flood flows for the rest of the catchment i.e. Bremer River catchment and Brisbane River downstream of Wivenhoe Dam, have been re-estimated based on new design rainfall data known as CRC-FORGE (DNRM 2004), together with modifications to the design values of initial loss used in the RAFTS model which has results in improved flow estimates (Sargent Consulting 2006b);*

- *Review of the MIKE 11 hydraulic model (DHI 2005) and subsequent improvements to the model schematisation including merging of the previous urban and rural are models (from the Ipswich Rivers Flood Study Phases 2 and 3 respectively), hydraulic computations and representation of bridge structures (DHI 2006);*

- *Recalibration of the MIKE 11 model resulting in a single composite model which can be used across the modelled range of flood events from 2 year to 500 year ARI (Sargent Consulting 2006c).*

Uncertainty

The re-modelling process has identified considerable uncertainty which is reflected in the new estimates of design flood levels. These uncertainties are evident in it not being possible to use the same hydraulic roughness parameters to satisfactorily replicate flood levels over the range of historic events available for model calibration, and from the results of the sensitivity tests presented herein.

It is unlikely that the hydraulic roughness would have changed significantly over this period of time, so the apparent change in fitting the model to these events is related either to other physical changes or to systemic problems with the hydrologic and/or hydraulic models.

Uncertainty in estimated flood levels is greater on those tributaries in which no calibration data was available, and in which roughness values have been based on those estimated from elsewhere in the system. These include Deebing Creek, Mihi Creek, Ironpot Creek, Franklinvale Creek and Western Creek.

Conclusions

All hydrologic and hydraulic analysis and modelling contain uncertainties: these can be related to natural variability in hydrologic processes; modelling uncertainties which recognise that no model can fully represent the real world response to rainfall on the catchment; potential climate change impacts; and knowledge uncertainty which reflects errors in the data used and in assumptions made in the model.

This study has attempted to identify these uncertainties, which should be taken account of in using the results of this study for town planning and infrastructure design purposes.

Sensitivity testing undertaken in the design phase has confirmed that model results are sensitive to: changes in waterway geometry which impact on the apparent hydraulic roughness required for replication of historic flood levels; possible errors in flood flow estimates; limitations in the schematisation of the model; and to the potential impact of climate change on design rainfalls.

The sensitivity testing has also shown that flood levels in Ipswich are insensitive to storm surge levels, within current estimates, including allowance for climate change impacts; and have low sensitivity to the adopted stage – discharge rating curve at Jindalee.

Whilst the sensitivity test results presented herein go some way to quantifying the major uncertainties, it would require a Monte Carlo simulation approach, which is outside the scope of the current study, to provide further quantification of the uncertainties.

In summary, the study has concluded that:

- *The new design flood levels represent improved estimates as they reflect recent upgrades in design rainfalls, recent re-modelling of design flows and significant upgrades to the hydraulic model;*
- *Notwithstanding the above statement, the study has shown that there is considerable residual uncertainty in the design flood levels estimates which should be taken into account when establishing flood levels for town planning and infrastructure design;*
- *A number of conclusions were drawn from the initial investigation of physical change to the width and depth of the Brisbane River in the vicinity of its confluence with the Bremer River. These were:*
  - *Confirmation that both deepening and widening have occurred in that reach particularly between 1970 and 1978 which period encompasses both the peak of dredging activities and the 1974 flood;*
  - *The conclusion that both of these effects have increased the flow carrying capacity of the Brisbane River in this reach;*
  - *Indications that the scale of these changes is commensurate with that required to rectify the anomaly in calibrating the hydraulic model to the 1974 flood and to later events;*
  - *That it is reasonable to infer that the impacts of dredging affect all of the tidal reaches of the Bremer and Brisbane Rivers in a similar fashion, although it is not possible to quantify this impact without further work;*
  - *That it was not possible to differentiate between the relative effects of the 1974 flood and dredging on the widening and deepening observed in the reach investigated; and*
  - *That, if the findings of this initial investigation were confirmed to be applicable to the whole of the modelled area, the roughness parameters obtained by calibrating to the 1974 flood levels with the more recent cross-section data would not be representative of current conditions.*

Recommendations

Uncertainty Allowance

Having considered the results from the various sensitivity tests undertaken, it is clear that there is considerable uncertainty regarding the estimated design flood levels.

It is important that this uncertainty be recognised in the flood levels that Ipswich City Council adopts for town planning and infrastructure design purposes. This should be recognised by adding an uncertainty allowance to the estimated flood levels.

Leaving aside possible impacts of climate change over the next few decades, it is recommended that, to make a reasonable allowance for this uncertainty, the 100 year and 20 year ARI design flood estimates have an uncertainty allowance of 1m to 2m added to them.

If possible climate change impacts are taken into account; it would be prudent to add a further 1m to the uncertainty allowance.

Recommendations for Further Work

The following additional work is recommended in order to reduce the uncertainties remaining in the model results:

- *Re-schematisation of parts of the MIKE 11 model to better represent floodplain storage in areas in which floodplain flowpath length is significantly reduced;*
- *Re-schematisation of Western Creek, the current schematisation of which is unrealistic and causes numerical stability problems in the model;*
- *Review of the schematisation of sections of the model where calibration errors were excessive;*
- *Re-estimation of design flows using the Bureau of Meteorology's URBS model and CRC-FORGE design rainfalls;*
- *Extension of the investigation into physical changes in the river channel for the whole model area, with a view to estimating cross-sections prior to the 1974 flood; re-calibrating the model with the 1974 flood and revised cross-sections, when it would be expected that there will be improved agreement between 1974 and 1996 calibrations allowing the uncertainty in hydraulic roughness parameters to be considerably reduced. More detail of the scope of this work is given in* ***Appendix J;***
- *Re-estimation of design flood levels on the basis of the revised flows and hydraulic parameters;*
- *Uncertainty analysis using a Monte Carlo approach to estimate the distribution of uncertainties and hence to better quantify the uncertainties.*

1 Introduction

The objective of the *Ipswich Rivers Flood Study Rationalisation Project (IRFSRP)* is to resolve a number of anomalies which have arisen between estimated flood flows and flood levels in the Lower Brisbane River and the Bremer River catchment in studies undertaken in recent years by Ipswich City Council (ICC) and Brisbane City Council (BCC). The resolution of these anomalies will allow more reliable flood mapping to be prepared.

The IRFSRP is being conducted in parallel with the *Brisbane Valley Flood Damage Minimisation Study (BVFDMS)* which is being undertaken by BCC in conjunction with other Local Authorities in the catchment including ICC. One of the objectives of the latter is the development of a common methodology for collation of data and damage assessment across the Brisbane River catchment.

These two projects are being undertaken in a collaborative framework both to ensure the commonality goal is achieved and to ensure there is no duplication of effort.

As the current Brisbane/Bremer River RAFTS model has been developed at considerable expense and has been widely used by both ICC and BCC as the basis of flood event modelling for some time, there is no incentive to change the modelling platform at this time.

Figure 1 is a map of the Brisbane River catchment showing key locations whilst **Figure 2** shows the Bremer River catchment in more detail.

1.1 Background

Detailed flood studies have been undertaken for the Brisbane and Bremer River catchments such that flood extent mapping for a range of flood frequencies are available.

However, since detailed flood studies for the urban areas of Ipswich were completed in 2000 (Sinclair Knight Merz 2000) and for the rural areas in 2002 (Halliburton KBR 2002), there have been a number of developments relating to flood studies in the Brisbane River which have resulted in the current flood studies and the corresponding flood extent maps no longer being compatible with those for Brisbane City.

These include:

- Updating of flood hydrology for Wivenhoe Dam operations and the construction of *fuse plug* spillways;
- Availability of new rainfall design data (CRC-FORGE) and a new estimate of probable maximum flood (PMF);
- Revised flood modelling for Brisbane City Council; and
- Review of the latter by an Independent Review Panel which has led to the 100 year ARI design flood flow for the lower Brisbane River being reduced from 8,000m^3/s to 6,000m^3/s.

In addition, in response to apparent anomalies with predicted 20 year ARI flood levels in particular, Council commissioned Sargent Consulting (SC) in 2002 to review the current flood models. That review (SC 2003) concluded that the current hydraulic model (MIKE 11) calibration is skewed towards the replication of major floods with the result that water levels for smaller floods are overestimated, and that the design flows estimated using the RAFTS model (SKM 2000) may be overly conservative.

As a consequence of the issues noted above, the current hydrologic and hydraulic models are known to have some inconsistencies, and the flood levels used by the two local government areas for town planning controls are no longer compatible.

Resolution of these matters is required urgently by ICC so that:

- The flood overlay in the Ipswich Planning Scheme can be confirmed or updated; and
- The current development of emergency response flood mapping is not compromised.

Other relevant components of this overall project on which the current commission builds are:

- Review and revision of the MIKE 11 hydraulic model by *DHI Water and Environment* (DHI 2005, 2006); and
- Re-estimation of design flows using the RAFTS model (Sargent Consulting 2006a).

Figure 1 shows the Brisbane River catchment and **Figure 2** shows key locations and also the RAFTS model sub-catchment specification.

1.2 Scope of Work

The current commission comprises the re-calibration of the MIKE 11 hydraulic model and the use of the model together with recently re-estimated design flows to re-estimate design flood levels throughout the major watercourses in Ipswich.

This entailed:

a) Establishment of MIKE11 model files and input data files for the four flood events to be used for calibration;

b) Running the model for individual events and modifying roughness and other model parameters to obtain a reasonable match of observed and estimated flood levels for individual events;

c) Comparison of the model roughness required for calibration of individual events, with a view to determining an overall parameter set which results in a satisfactory replication of all the calibration events, including sensitivity testing and commenting on likely model accuracy and sources of error;

d) Setting up the design phase model with the adopted parameter set;

e) Running the model to estimate flood levels for inflows across a range of design ARIs and storm durations;

f) Determining the critical flood level profiles for each ARI;

g) Reporting on the above including plans and longitudinal flood profiles.

The scope of work was extended during the project to include:

h) An initial investigation into the possibility of physical changes in the Brisbane River in the vicinity of its confluence with the Bremer River.

Draft reports were prepared covering items a) to c) and d) to h) respectively (Sargent Consulting 2006b, 2006c). This report has been compiled by consolidating the two draft reports taking into account review comments received regarding the draft reports.

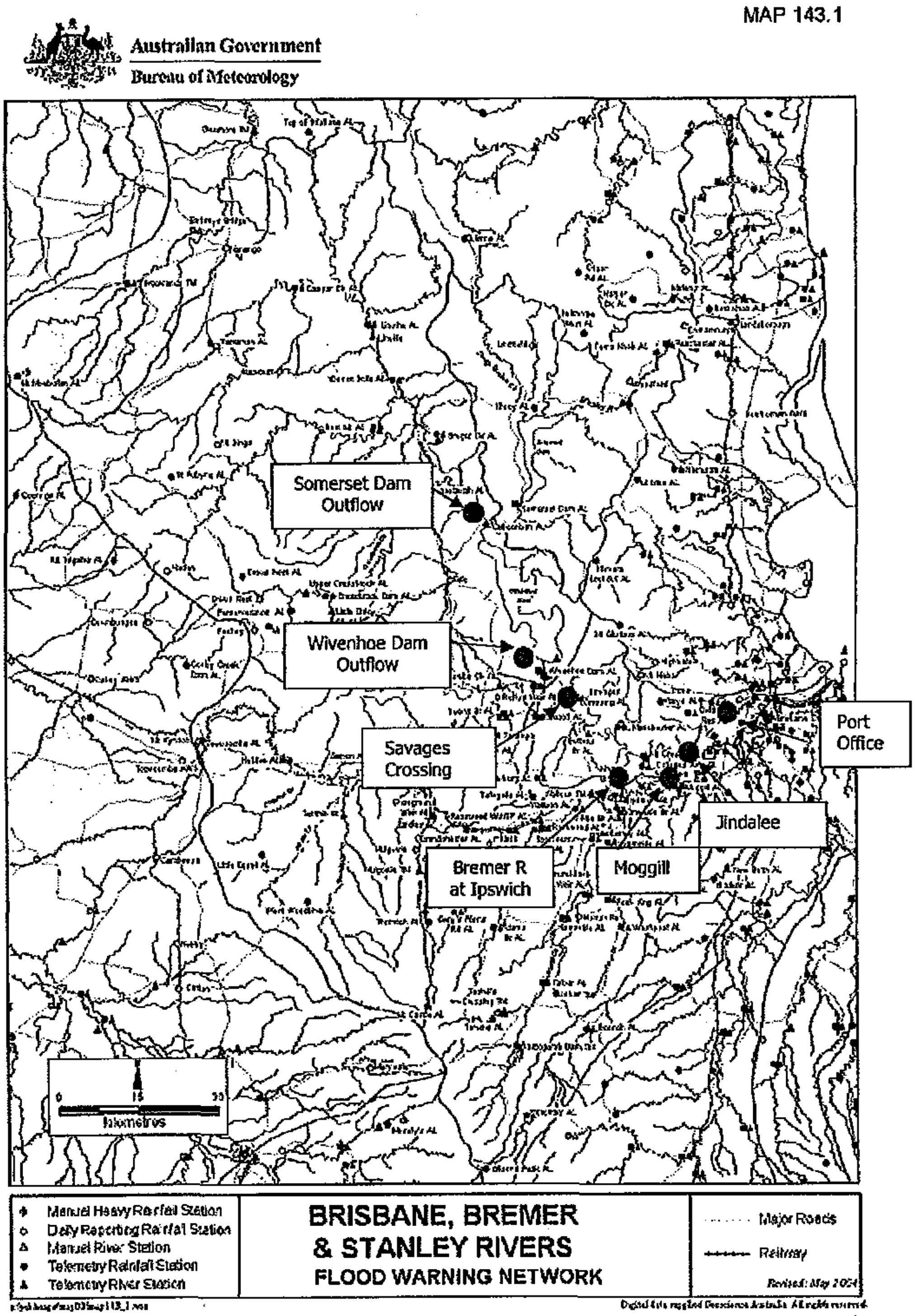


Figure 1 **Brisbane River Catchment Map**

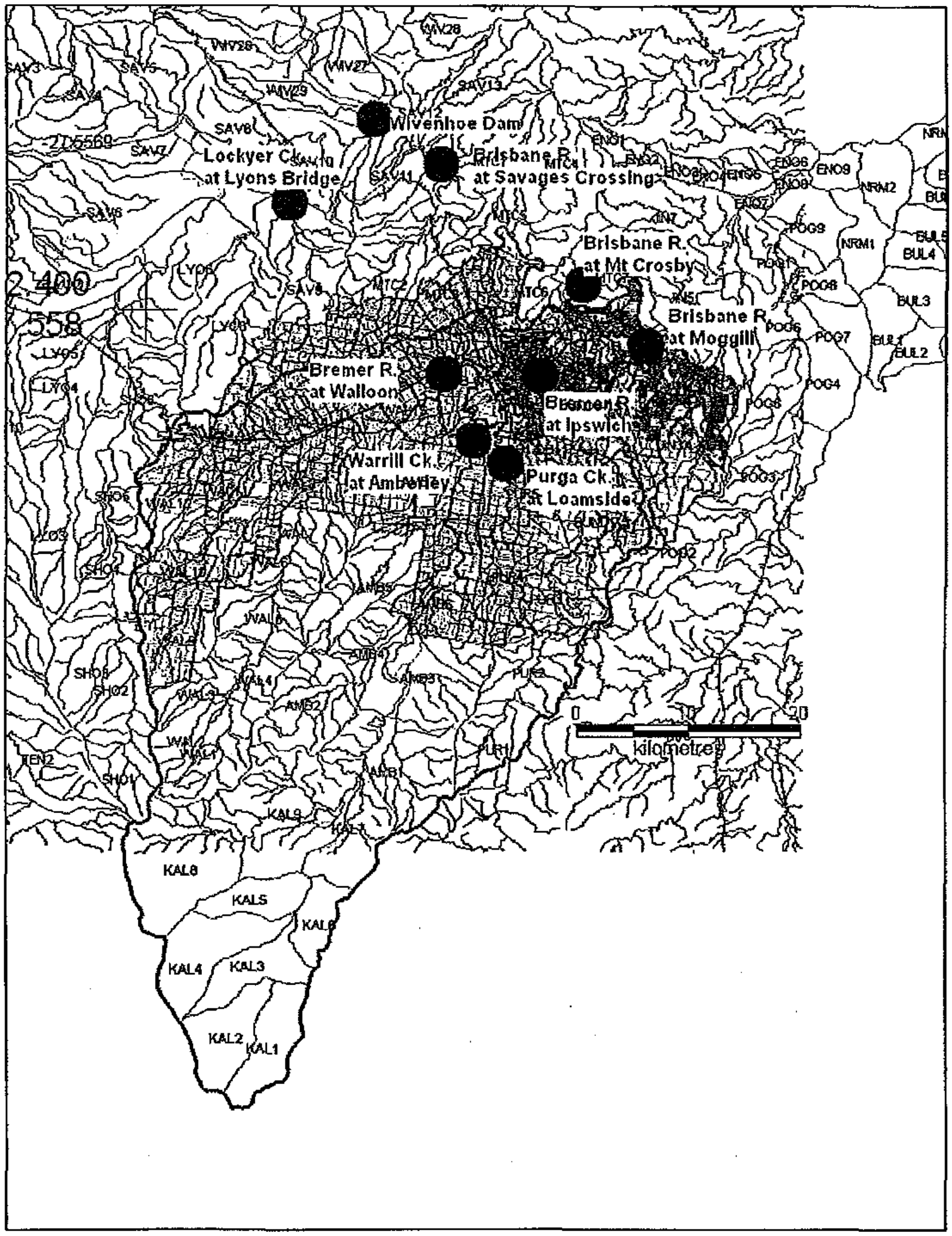


Figure 2 Bremer River Catchment showing RAFTS Sub-areas and Key Locations

2 Recent Model Review and Upgrade

The MIKE 11 models for Ipswich Rivers were developed initially for the Ipswich Rivers Flood Study Phases 2 and 3.

In Phase 2 of the Ipswich Rivers Flood Study (SKM 2000), the model was established for the urban areas of Ipswich from just downstream of Three Mile Bridge on the Bremer River; downstream from Amberley on Warrill Creek; and the Brisbane River from about Savages Crossing to the Brisbane River Bar.

In Phase 3 of the Ipswich Rivers Flood Study(KBR 2002), a separate model was developed which extended from the upstream reaches of the Bremer River and Warrill Creek to Three Mile Bridge on the Bremer River.

As a consequence of issues raised from interpretation of the results from these models, and subsequent application of the models, a number of issues were raised, resulting in *DHI Water & Environment* (DHI) being commissioned to review the structure of the models with a view to merging the Phase 2 and Phase 3 models into a single model, and to increasing the numerical stability of the models enabling larger time steps to be used. DHI was also commissioned by Brisbane City Council to undertake a similar review in respect of that part of the model of the Brisbane River within Brisbane City.

The DHI review resulted in further work being undertaken to resolve some of the issues shown by the review, and to merge the two Ipswich models. The following paragraphs outline the main outcomes from this work. Reference should be made to DHI's reports (DHI 2005, DHI 2006) for further detail.

The inclusion of this summary here is pertinent to the current commission as it is the version of the model as updated by DHI which has formed the starting point for the current work.

2.1 Model Review

Following its review of the Ipswich components of the MIKE 11 models, DHI recommended the following modifications:

- Include accurate aerial photographic background image to ensure positional accuracy of the model branches and cross-sections.

- Model schematisation:
    - Re-schematise the Rail North and Rail South branches using link channels;
    - Remove closely spaced grid points;
    - Include link channels in place of artificial slots in connecting cross-sections;
    - Check model chainages against registered photographic images;
    - Update branch layouts and cross-section extents in areas of cross-section overlap in order to eliminate storage duplication; and
    - Divide channel and floodplain flows into separate branches for excessively wide floodplain sections.

- Cross-sections
  - Remove all artificial slots; and
  - Increase the number of processed data in some cross-sections to between 20 and 40.

- Numerical parameters
  - Centre the numerical scheme using a delta value of 0.55; and
  - Define stable static initial condition to allow the model to cold start correctly.

- Simulation time step
  - Update the model time step to between 30 seconds and 1 minute (dependant on sensitivity testing).

- Model calibration
  - Re-calibrate over bank flood events using previous flood study information.

2.2 Model Upgrade

Subsequent to the model review and further discussions, DHI was commissioned to undertake upgrading of the model on the basis of most but not all of the recommendations listed in **Section 2.1** together with:

- Merging of the Phase 2 and Phase 3 models into a single model;

- Reversal of cross-section orientation to comply with the "looking downstream" convention for left and right;

- Changing the method of computation of hydraulic radius to "hydraulic radius, total area" throughout the model; and

- Updating a number of the bridges in the model from their original culvert and overflow weir specification to the bridge specification now available in MIKE 11.

The notable exception was that the recommendation to divide channel and floodplain flows into separate branches for excessively wide floodplain sections was not undertaken, and is thus still an issue in the current model.

DHI (2006) recommended the following be undertaken in future model upgrades:

- General
  - Re-development of the model to incorporate separate floodplain branches throughout the model to overcome the overestimation of floodplain storage which results form the current configuration.

- Specific
  - Re-schematisation of the Woogaroo Creek branch;
  - Re-schematisation of the Sandy Creek (Camira/Carole Park) branch, the lower part of which is not in Ipswich;
  - Conversion of a number of bridges from culvert/weir configuration to bridge configuration; and

- o Complete re-schematisation of the Rail North, Rail South and Western Creek branches which currently represent Western Creek in the model.

3 Hydraulic Model Calibration

The MIKE 11 model used in the current commission is the model handed over to ICC by DHI following the model review and upgrade projects outlined above.

This comprised the following model files:

Network file:	Basin
Cross section file:	Basin
Hydraulic parameter files:	Basin_1974Initiallevel; Basin_1983Initiallevel; and Basin_1989Initiallevel.
Simulation (run) files:	Basin_1974; Basin_1983; and Basin_1989.
Time series files:	Individual sub-catchment files for 1974, 1983, and 1996 events (from SKM 2000).

In addition to the above, SKM time series files for the 1996 event, and KBR sub-catchment files for the upper catchment (Phase 3) model for 1974, 1983, 1989 and 1996 events were utilised.

The time series files for the calibration events were derived using the RAFTS model as fitted to the records for these events (see SKM 2000, KBR 2002).

Layout diagrams for the MIKE 11 model are given in **Appendix A.**

3.1 Data Available for Re-Calibration

As there have been no significant flood events since the previous model calibrations, there were no new datasets and the four events utilised in the previous work were again adopted. These were:

- January 1974;
- Jun 1983;
- April/May 1989; and
- May 1996.

The 1974 flood was a major regional flood event with peak flows in the lower Brisbane River exceeding 9,000m^3/s, and in the lower Bremer River peak flows of about 4,000m^3/s. This event, which resulted from the landfall of Tropical Cyclone Wanda, occurred prior to the construction of Wivenhoe Dam. Under post-dam conditions, this flow is well in excess of the best estimate of the 100 year average recurrence interval (ARI) flow of 6,000m^3/s (Mein et al 2003).

In contrast, the largest of the other calibration events, in May 1996, had peak flows of about 3,500m^3/s and 2,500m^3/s in the lower Brisbane River and lower Bremer River respectively.

Stage hydrographs were available at Mt. Crosby and Moggill on the Brisbane River, at Walloon, Three Mile Bridge, One Mile Bridge and David Trumpy Bridge on the Bremer River, Amberley on Warrill Creek and Loamside on Purga Creek for all of the events, and at the Brisbane Port Office for the 1974 and 1996 events only. Calibrated streamflows are reliably estimated only at Mt. Crosby, Walloon and Amberley gauging stations.

For the 1974 flood there are extensive records of peak flood levels at intermediate points obtained from post-flood survey of high water marks and debris lines.

For the 1996 flood there are additional gauge readings from the ALERT system of flood warning gauges although many of these did cover the whole event.

SKM (2000) and KBR (2002) disaggregated the total streamflows into sub-catchment inflows for inputs to the MIKE 11 model, by application of the RAFTS model using the rainfall and streamflow records available.

For a detailed description of these flood events and fitting of the RAFTS and MIKE 11 models to these events, reference should be made to SKM (2000) and KBR (2002).

3.2 Further Model Modifications

Of the recommendations made by DHI (2006), as outlined in **Section 2.2** hereof, only the reformulation of some of the hydraulic structures using the bridge hydraulics computations were included in the current commission. These structures are listed in **Table 1.**

Table 1 Hydraulic Structures Converted to Bridge Formulation

Structure Name	Model Branch (Abbreviation)	Model Chainage m
Kholo Bridge	Brisbane R (BNE)	957511
Blackstone Road Bridge	Bundamba Creek (BUND)	31990
Ipswich Road Bridge	Woogaroo Creek (WOOG)	17340
Warwick Road Bridge	Deebing Creek (DEEB)	17072

In addition, the bridge structure at One Mile Bridge on Bremer River was modified to be more representative of the overflow over the bridge abutments and of the flow split between the One Mile Bridge (Bremer River) and the adjacent Deebing Creek Bridge.

Further, a number of other changes were made to the model in order to overcome execution (run time) errors. These were:

- Model instability in the *Rail North* and *Rail South* branches which depict flow in Western Creek to the north and south of the railway line. Cross-sections in these branches duplicated the flow area as the full floodplain cross section was depicted in both branches. Not only did this result in instability issues, this was clearly unrepresentative, resulting in overestimation of channel capacity and of flood storage. This was overcome by deleting the appropriate part of the cross-sections in the respective branches.

- The processed data for all cross-sections was recomputed;

- The rating curves for all hydraulic structures were recomputed; and

- Initial conditions were refined.

3.3 Comment on Previous Model Calibration

SKM (2000) noted that it was not possible to derive a set of roughness parameters which produced consistent results across the range of flood events for which calibration data were available. Consequently, greater weight was given to the calibration for the largest recorded event (1974) and the use of the parameters from the fitting of this event were used in the estimation of design flows from 2 year to 500 year ARI. SKM(2000) attributed this inconsistency primarily to energy losses at river bends which are not explicitly modelled in MIKE 11 and which increase with the higher velocities associated with the larger floods. This approach was likely to have been overconservative for small to intermediate design floods up to say 20 year ARI.

KBR (2002) in calibrating the model for the upper Bremer River catchment (KBR 2002) did not report this difficulty, but there is a significant difference in the fitted levels between the major and minor flood events e.g. at Bremer River at Walloon, the 1974 peak was underestimated by 0.10m but the 1983, 1989 and 1996 peaks were overestimated by 0.30m, 0.03m and 0.33m respectively, whilst for Warrill Creek at Amberley, the 1983 and 1996 peaks were underestimated by 0.17m and 0.19m whilst the 1989 and 1974 peaks were overestimated by 0.55m and 0.23m respectively.

One of the objectives of the current re-calibration has been to develop a consistent set of roughness parameters which can be used with confidence across the range of floods covered by the calibration data, and it was hoped that the recent model review and upgrades would have improved the fitting of the model to enable this to be achieved.

3.4 Re-Calibration Strategy and Results

The basic calibration strategy was to develop a set of model parameters to satisfactorily replicate flood levels in the 3 smaller flood events, and then to modify the parameters for floodplain flows above the levels reached in those events in order to also replicate the much larger 1974 event. If this could be achieved, the parameter set could be used over the full range of design floods (from 2 year to 500 year ARI), or at least over that part of the range encompassed by the design events.

Where a hydrologic model is used to estimate tributary and local flow inputs to use as boundary conditions for a hydraulic model, it is preferable for the two models to be calibrated "in tandem" as variations in the parameters of the hydrologic model may affect the outcomes from the hydraulic model. However, in this case the hydrologic model had been fitted to the calibration events in previous studies and it was outside the scope of the current study to revise this model fitting.

3.4.1 Initial Checks

Prior to undertaking the calibration runs of the MIKE 11 model, some checks were conducted on the calibration data as follows:

- Records of observed flood peaks were checked against ICC and BOM records; and

- Flood level hydrographs and estimated flow hydrographs were obtained from BOM for their URBS model and cross-checked for consistency with the RAFTS model flow hydrographs.

The checking of peak height records showed some minor anomalies which were resolved together with three locations at which recorded levels were to State Datum (SD) and not to Australian Height Datum (AHD). ICC provided conversions for these stations as listed in **Table 2**.

Table 2 State Datum to Australian Height Datum Conversions

Location	Adjustment to elevation in SD to give elevation in AHD
Rosewood	+0.203m
Harrisville	-0.096m

One of the possible sources of error in the model calibration phase is inaccuracy in the flow inputs to the MIKE 11 model. In both the Phase 2 and Phase 3 studies, the sub-catchment flows, which are the boundary conditions inflows to the MIKE 11 model were estimated from the fitting of the RAFTS model to observed flows at gauging stations throughout the Brisbane/Bremer River catchments. "Observed" flows are obtained from observed records of water level to which a stage-discharge or rating curve is applied to estimate flows. Where the gauging stations are tidally affected or otherwise affected by conditions further downstream (backwater affected) the rating curve is not unique, and considerable errors may be introduced.

The adequacy of the calibration of the RAFTS model depends on its schematisation (subdivision of the catchment into sub-areas and sub-catchments, and adequacy of flow routing in the model); the accuracy and representativeness of rainfall data available for calibration; the accuracy of the streamflow data available for calibration; and systemic errors with the model. Although the model calibration was thorough and comprehensive, there could still be significant inaccuracy in the modelled flow hydrographs.

A means of cross-checking the adequacy of the modelled hydrology was available via the Bureau of Meteorology's (BOM) URBS models. The Queensland Flood Warning Centre of BOM uses the URBS model to estimate flows and flood levels for its flood warning operations and has models for the Brisbane and Bremer River catchments. Whilst this model is similar to RAFTS, it differs from it in a number of details. The BOM model has been fitted to a larger number of flood events than the RAFTS model and provides an independent check.

Table 3 shows the sub-division of the BOM URBS model into its major sub-catchments, showing the number of sub-areas in each sub-catchment. The equivalent values of the RAFTS model are also shown.

Table 3 URBS and RAFTS sub-catchments and sub-areas

URBS Model	Area (km^2)	No of Subareas URBS	No of Subareas RAFTS
Stanley R to Junction	1516	75	32
Upper Brisbane R to Wivenhoe	5399	93	98
Lockyer Ck to O'Reillys	2947	89	36
Bremer R to Walloon	634	39	15
Warrill Ck to Amberley	917	64	14
Purga Ck to Loamside	211	22	5
Lower Brisbane R	1757	78	170
TOTAL	13381	460	370

It can be seen from **Table 3** that not only does the URBS model have a greater number of sub areas overall than the RAFTS model (460 compared to 370), this is particularly true in the Ipswich parts of the catchments where together the catchments Bremer River to Walloon, Warrill Creek to Amberley and Purga Creek to Loamside are represented by 125 sub-areas in the URBS model but only 34 sub-areas in the RAFTS model.

Tables 4 and **5** summarise a comparison of peak flows at key locations for the floods of 1974, 1989 and 1996 (the 1983 flood was omitted as there were too few recorded flows). It should be noted that BOM's primary interest is in respect of the replication of flood levels and not flows, and that they have derived their own rating curves to maximise this. Hence the BOM flow estimates from URBS are compared against those from their rating curves and not against the DNRM rating curves.

From **Tables 4** and **5**, it can be seen that for the large flood in 1974, both the RAFTS and URBS models give consistent results for the Brisbane River locations, but the peak flows estimated from RAFTS are about 50% higher than those from URBS for Warrill Creek at Amberley, Bremer River at Ipswich and Purga Creek at Loamside but are reasonably close for Bremer River at Walloon (-5%).

Table 4 Comparison of Peak Flood Flows from RAFTS and URBS Models

Location	Peak Flows (Cumecs) 1974				1989				1996			
	Recorded DNR	RAFTS	BOM rating	URBS	Recorded DNR	RAFTS	BOM rating	URBS	Recorded DNR	RAFTS	BOM rating	URBS
Brisbane R at Mt Crosby	7460	7561	8325	7996	1400	1190	1440	1630	2000	2102	2333	2388
Brisbane R at Moggill	9530	9551	9942	10226	1200	1612	1659	2058	2800	3324	2804	2829
Brisbane R at Jindalee	9500	9421	10236	10253	n.a.	1586	n.a.	2034	n.a.	3347	n.a.	2933
Brisbane R at Brisbane (Port Office)	9800	9331	10193	10178	n.a.	1929	3009	1984	n.a.	3382	3737	3096
Warrill Ck at Amberley	2100	2310	1432	1466	230	287	160	280	450	326	424	417
Bremer R at Walloon	n.a.	1449	n.a.	1503	390	215	179	265	835	514	611	583
Bremer R at Ipswich	4000	4860	n.a.	3180	770	1020	572	537	1280	2237	1046	1213
Purga Ck at Loamside	400	840	505	475	110	243	117	76	180	482	206	193

NOTE: Recorded values estimated from rating curves used by BOM

Table 5 Comparison of Peak Flood Flows Variations from RAFTS and URBS Models

Location	Variation from Recorded Peak Flow (Percent) 1974		1989		1996		Average Variation from Recorded Peak Flow (Percent)	
	URBS	RAFTS	URBS	RAFTS	URBS	RAFTS	URBS	RAFTS
Brisbane R at Mt Crosby	-4%	1%	13%	-15%	2%	5%	4%	-3%
Brisbane R at Moggill	3%	0%	24%	34%	1%	19%	9%	18%
Brisbane R at Jindalee	0%	-1%	n.a.	n.a.	n.a.	n.a.	0%	-1%
Brisbane R at Brisbane (Port Office)	0%	-5%	-34%	n.a.	-17%	n.a.	-17%	-5%
Warrill Ck at Amberley	2%	10%	76%	25%	-2%	-28%	25%	2%
Bremer R at Walloon	n.a.	n.a.	48%	-45%	-5%	-38%	22%	-42%
Bremer R at Ipswich	n.a.	22%	-6%	32%	16%	75%	5%	43%
Purga Ck at Loamside	-6%	110%	-35%	121%	-6%	168%	-16%	133%
MEAN	-0.8%	19.6%	12.3%	25.4%	-1.5%	33.3%	4.1%	18.2%
Standard Deviation	3.5%	40.8%	41.1%	56.3%	10.0%	77.0%	15.4%	52.0%

For the 1996 event, there is again reasonable agreement for the Brisbane River stations apart from a near 20% discrepancy at Moggill. For the Bremer River locations, the peak flow from RAFTS are 12% and 22% less than that from URBS for Bremer River at Walloon and Warrill Creek at Amberley respectively, but 85% and 250% greater for Bremer River at Ipswich and Purga Creek at Loamside respectively.

There are similar discrepancies in respect of the 1989 event, with the RAFTS estimate of flow for Bremer River at Ipswich being almost twice that given by URBS and that for Purga River at Loamside being over three times the URBS value. For the Brisbane River locations, the RAFTS estimates are 22% to 27% lower for Mt. Crosby, Moggill and Jindalee but only 3% lower at Brisbane Port Office.

Table 5 shows the comparison in terms of variation from the peak flows given by the DNRM and BOM rating curves for each of the three events examined and overall. In all cases, there is a greater departure from the mean in the RAFTS flows compared to the BOM flows, and greater variability (as shown by the standard deviations).

Whilst this comparison is superficial, it does indicate a relatively high degree of uncertainty in the flows obtained from the RAFTS model for the calibration events.

Some of this uncertainty may not appear in the individual sub-area flows which are used as inputs to the MIKE 11 model, as one of the shortcomings in the RAFTS model is the lumping of temporary floodplain storage into discrete model storages at major confluences. However, this cannot be quantified.

Whilst no results are available for comparative single sub-area flows in the 2 models, **Figures 3** and **4** show observed flows for Bremer River at Adams Bridge for the 1974 and 1996 floods together with flows estimated from the RAFTS and URBS models. The RAFTS model has 4 sub-areas to this point and the URBS model 6 sub-areas, so this is a reasonable illustration of performance for a small number of sub areas.

In respect of the 1974 flood, it can be seen from **Figure 3** that the URBS model hydrograph produced a similar peak to the recorded hydrograph but the RAFTS hydrograph overestimated the peak by over 50%. Similarly in terms of flow volume, the URBS model underestimated the volume by 6%, but the RAFTS model overestimated the volume by 45%.

However, it can be seen from **Figure 4** that, in respect of the 1996 flood, the RAFTS model more closely estimates the peak flow (although this is the second peak whereas the first peak was actually the highest). Rafts estimated the peak flow within 1% but URBS was 30% low. In volume terms, RAFTS underestimated the flood volume by 15% and URBS by 27%.

Whilst the information presented above is not conclusive in respect of whether RAFTS or URBS better replicates the hydrology of historic flood events, it is clear that there is considerable uncertainty, even in emulating an historic event. In view of this uncertainty, the effect of significant variations in the input hydrology on flood levels must be considered by sensitivity testing. This is considered in **Section 3.6** hereof.

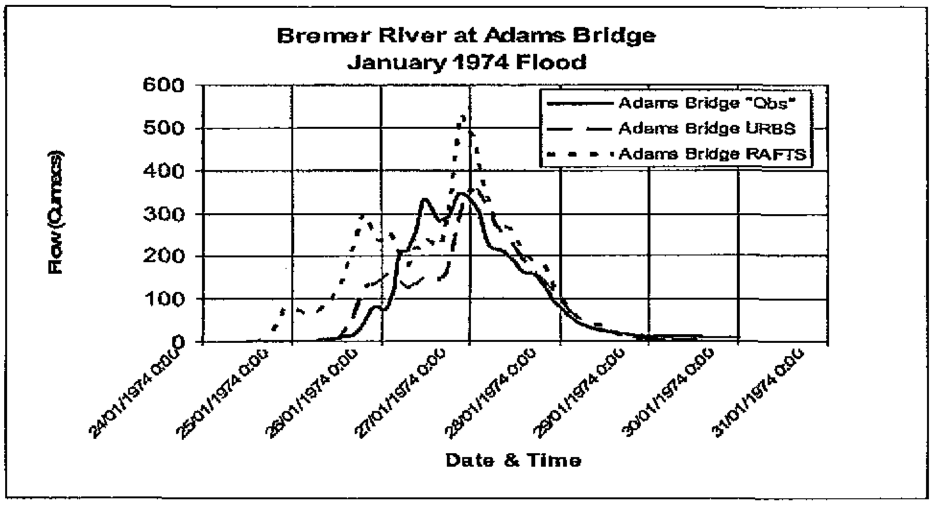


Figure 3 **1974 Flood Hydrographs – Bremer River at Adams Bridge**

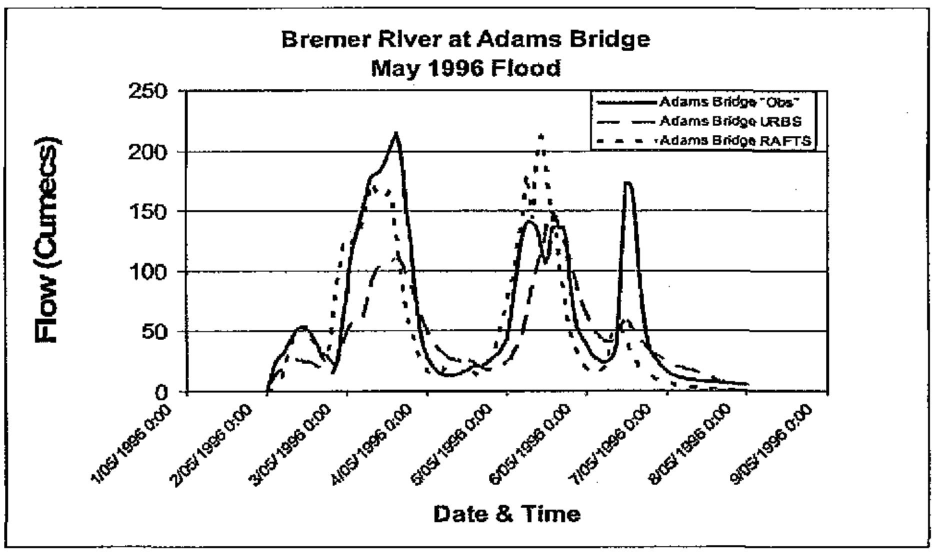


Figure 4 **1996 Flood Hydrographs – Bremer River at Adams Bridge**

3.4.2 Calibration

As outlined at the start of this section, the basic calibration strategy was to develop a set of model parameters to satisfactorily replicate flood levels in the 3 smaller flood events, and then to modify the parameters for floodplain flows above the levels reached in those events in order to also replicate the much larger 1974 event.

As more data were available for the 1996 flood event this was calibrated first, and the model fit checked against the 1983 and 1989 events.

Initially the model was run right to the Brisbane River Bar, but was later truncated to terminate at the Jindalee gauge in order to remove some areas of instability and uncertainty in the model which have no impact on flood levels in Ipswich but which were hampering calibration of the model.

Longitudinal profiles along those watercourses with calibration data showing estimated and observed flood levels are given in **Appendix B.** A listing of the adopted roughness parameters are given in **Appendix C.** In those tributaries in which no calibration data were available, default values of roughness were used.

a) 1996 Event

The May 1996 flood resulted in major flood levels being reached in the Bremer River at Walloon and in Warrill Creek at Amberley and moderate flood levels in the Bremer River at Ipswich. The lower Brisbane River reached its highest levels since the 1974 flood even though there was no flood release from Wivenhoe Dam.

Observed flood levels were available for this event at a number of points on the Brisbane and Bremer Rivers, including a number of ALERT flood warning stations as follows:

- Brisbane River at Mt. Crosby, Moggill, Goodna and Jindalee (estimated from BOM modelling);
- Bremer River at Stokes Crossing, Adams Bridge, Rosewood, Walloon, Three Mile Bridge, Perry Street, One Mile Bridge, Hancock Bridge and David Trumpy Bridge;
- Bundamba Creek at Ripley, Harding Street, Blackstone Road and Brisbane Road;
- Purga Creek at Loamside;
- Western Creek at Kuss Road;
- Warrill Creek at Kalbar, Harrisville, and Amberley; and
- Woogaroo Creek at Parker Street, Edna Street, Brisbane Road and Brisbane Terrace.

The differences between estimated and observed peak levels were as follows:

- Brisbane River Mt. Crosby -0.11m, Moggill 0.00m, Goodna -0.01m and Jindalee 0.00m (starting point);
- Bremer River at Stokes Crossing 0.50m, Adams Bridge -0.16m, Rosewood -0.10m, Walloon (Alert) -0.15m, Walloon (DNRM) -0.06m, Three Mile Bridge 0.05m, Perry Street 0.55m, One Mile Bridge -0.05m, Hancock Bridge 0.05m and David Trumpy Bridge -0.04m;
- Bundamba Creek at Ripley -0.10m, Harding Street -0.21m, Blackstone Road -0.10m and Brisbane Road -0.11m;
- Purga Creek at Loamside 0.03m;
- Western Creek at Kuss Road 0.13m;
- Warrill Creek at Kalbar 0.51m, Harrisville -0.16m, and Amberley 0.05m; and
- Woogaroo Creek at Parker Street -0.64m, Edna Street 0.38m, and Brisbane Road -0.54m.

The estimated peak levels were within ±0.1m at a number of key points and were within ±0.2m at all of the gauging stations except Warrill Creek at Kalbar. There was a difference of 0.55m on Bremer River at Perry Street but the latter record is questionable as the recorded level (16.75m) is the same as that at One Mile Bridge about 1400m downstream.

Levels on Bundamba Creek were within ±0.3m except for -0.35m at Harding Street.

Comparison of estimated and observed water level hydrographs for key locations are given in **Figures 5** to **14.**

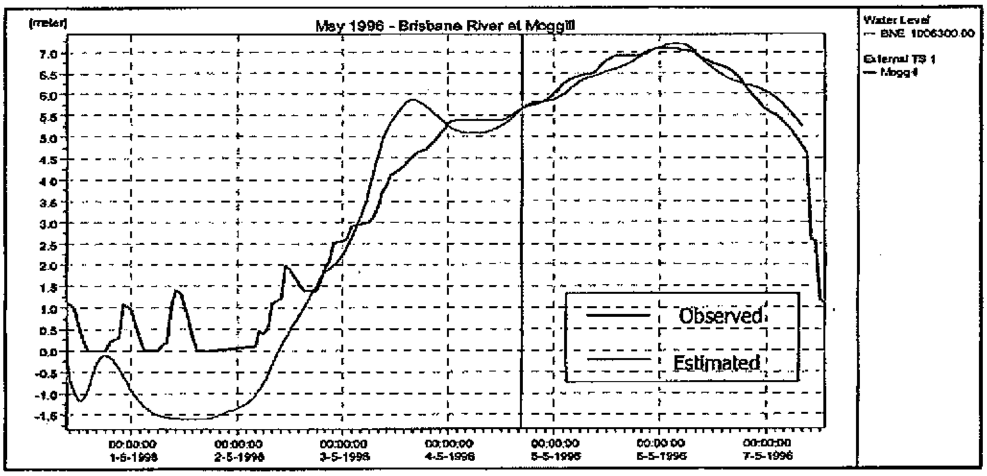


Figure 5 May 1996 Flood Hydrographs – Brisbane River at Moggill

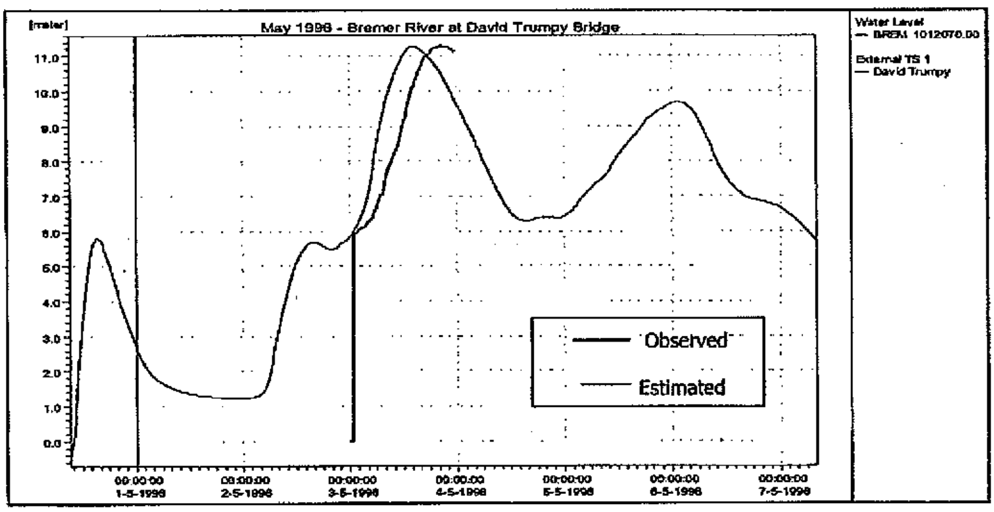


Figure 6 May 1996 Flood Hydrographs – Bremer River at Ipswich

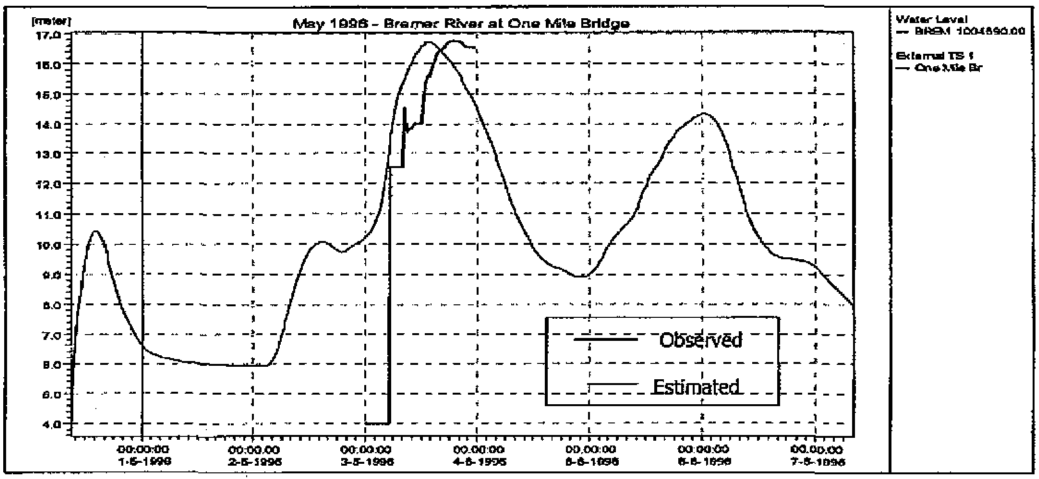


Figure 7 May 1996 Flood Hydrographs – Bremer River at One Mile Bridge

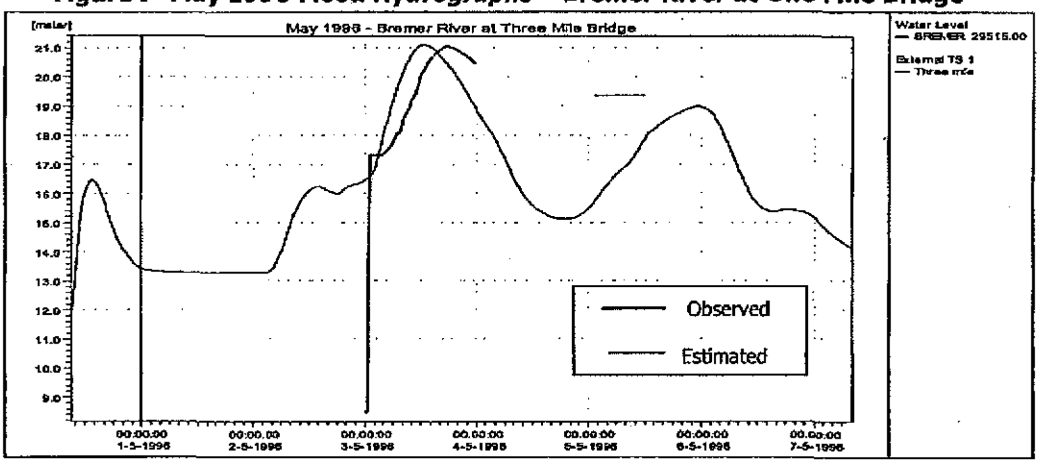


Figure 8 May 1996 Flood Hydrographs – Bremer River at Three Mile Bridge

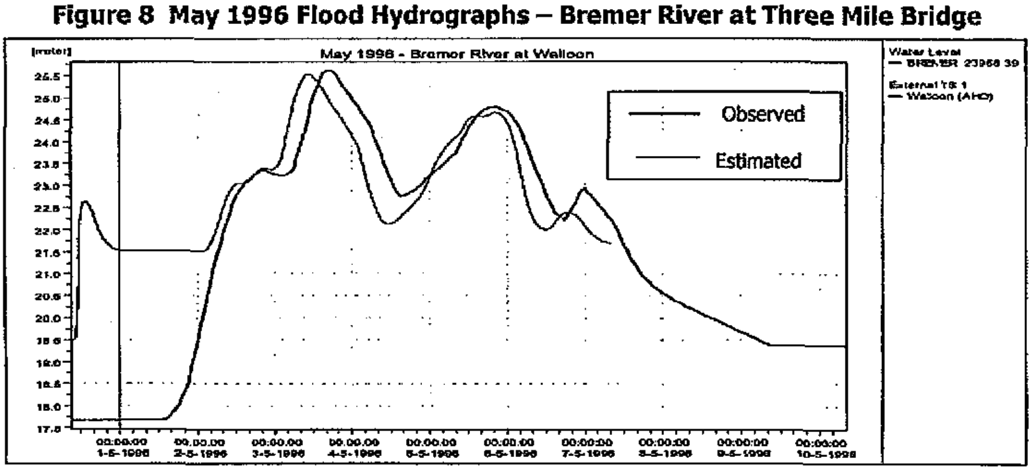


Figure 9 May 1996 Flood Hydrographs – Bremer River at Walloon

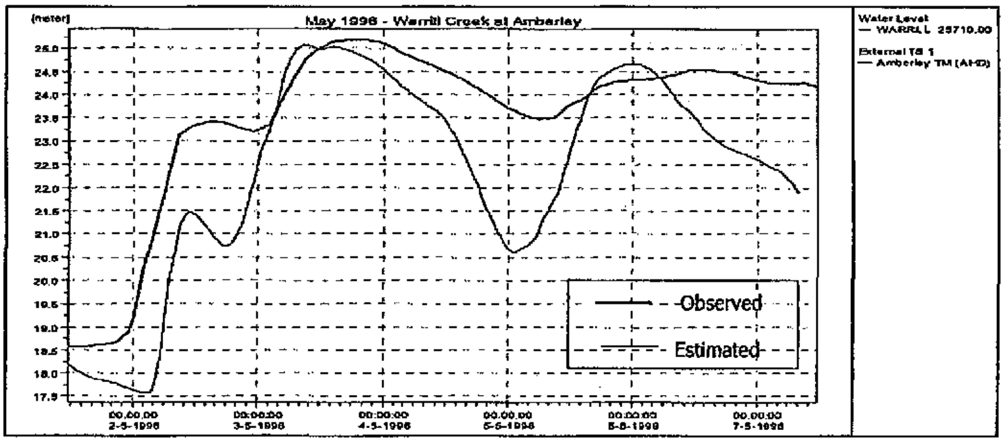


Figure 10 May 1996 Flood Hydrographs – Warrill Creek at Amberley

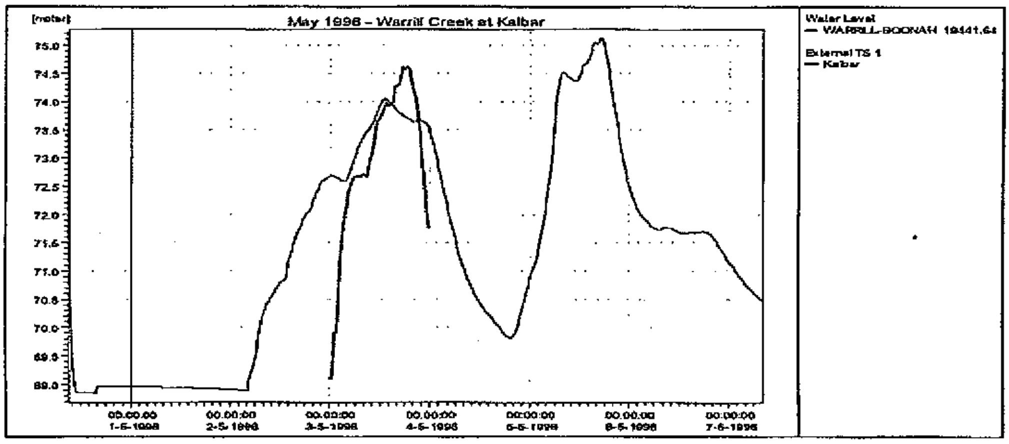


Figure 11 May 1996 Flood Hydrographs – Warrill Creek at Kalbar

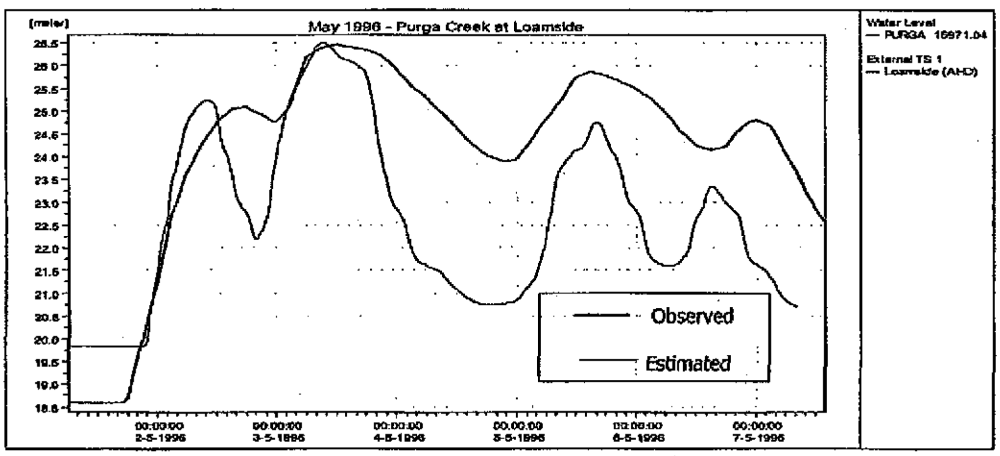


Figure 12 May 1996 Flood Hydrographs – Purga Creek at Loamside

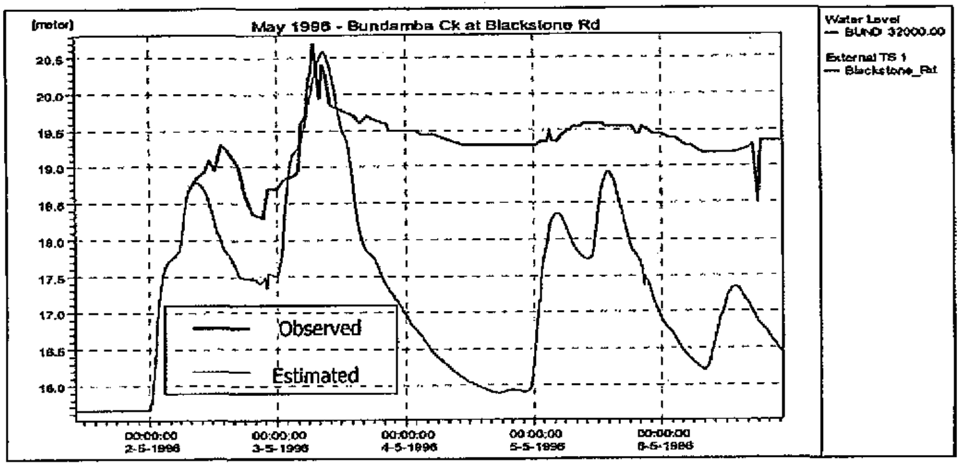


Figure 13 May 1996 Flood Hydrographs – Bundamba Creek at Blackstone Road

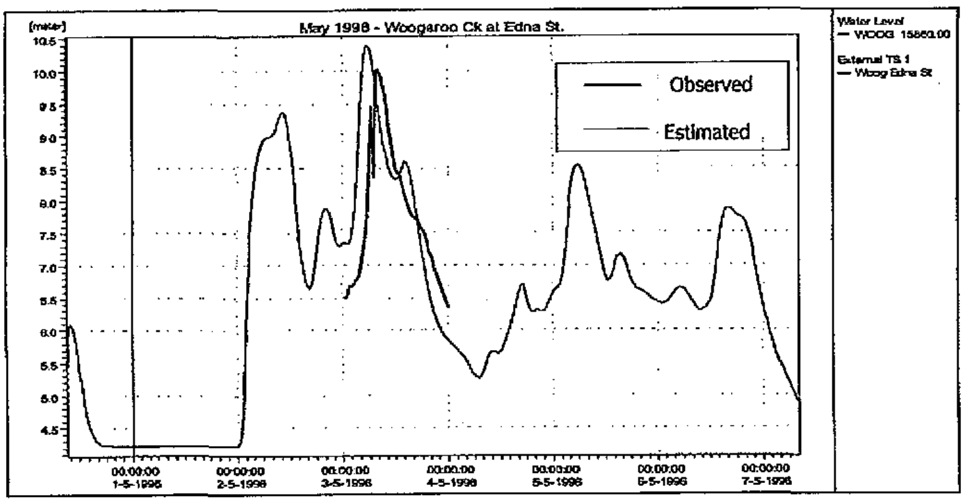


Figure 14 May 1996 Flood Hydrographs – Woogaroo Creek at Edna Street

As can be seen from these hydrographs, this was a complex event with multiple peaks, with a single peak in the Brisbane River, two peaks in the Bremer River and Warrill Creek, and four peaks in Purga Creek, Bundamba Creek, Woogaroo Creek and the minor creeks.

Whilst the modelled hydrographs replicate the peak levels reasonable well, they also show that:

- The estimated peaks are earlier than the observed peaks by between 3 and 8 hours at the various locations; and
- The estimated hydrographs recede faster than in reality.

These factors both tend to indicate that the model is underestimating floodplain storage.

b) 1989 Event

The small flood event in late April 1989 is the smallest of the flood events available for calibration of the hydraulic model.

Fewer recorded flood level records were available for this event, these being at:

- Brisbane River at Mt. Crosby, and Moggill only;
- Bremer River at Adams Bridge, Walloon, Three Mile Bridge, One Mile Bridge, and David Trumpy Bridge;
- Bundamba Creek at Harding Street, Blackstone Road, and Brisbane Road;
- Purga Creek at Loamside; and
- Warrill Creek at Kalbar, Harrisville, and Amberley.

As there was no recorded hydrograph at Jindalee for this event, the downstream boundary condition was represented by a stage-discharge rating curve. This rating curve was developed by smoothing the rating curves obtained from MIKE 11 for the 1996 and 1974 events, and is given in **Appendix D**.

This model was run with the parameters as determined for the larger 1996 flood with the following differences between estimated and observed peak levels:

- Brisbane River Mt. Crosby -0.2m, and Moggill 0.48m;
- Bremer River at Adams Bridge -1.21m, Walloon (DNRM) -0.27m, Three Mile Bridge -0.11m, One Mile Bridge 0.06m, and David Trumpy Bridge 0.17m;
- Bundamba Creek at Harding Street 0.48m, Blackstone Road 0.88m and Brisbane Road 1.91m;
- Purga Creek at Loamside 0.69m; and
- Warrill Creek at Kalbar -1.70m, Harrisville 0.49m, and Amberley 2.49m.

Whilst these results were good at Mt. Crosby, One Mile Bridge, Three Mile Bridge and David Trumpy Bridge; acceptable at Walloon; they were very poor and unsatisfactory at the other points.

As it was not considered appropriate to vary the roughness parameters between these three small flood events, these results were carried forward to the discussion regarding potential reasons for these poor results in **Section 3.5** hereof.

The modelled longitudinal profiles for these events and the observed peak flood levels are shown in **Appendix B** whilst **Figures 15** to **21** show observed and modelled hydrographs at key locations.

As can be seen from these hydrographs, although the peak levels are well replicated at the Brisbane River gauging stations, the modelled hydrograph shapes are different and the modelled peak is about 18 hours early at Moggill but is about 4 days late at Mt. Crosby.

In the Bremer River, Warrill Creek and Purga Creek there is a first modelled peak which is entirely absent in the observed record, and the modelled main peak is 4 to 8 hours early than the actual peak. This tends to indicate that the initial loss used with the RAFTS model was too low generating runoff too early in the event.

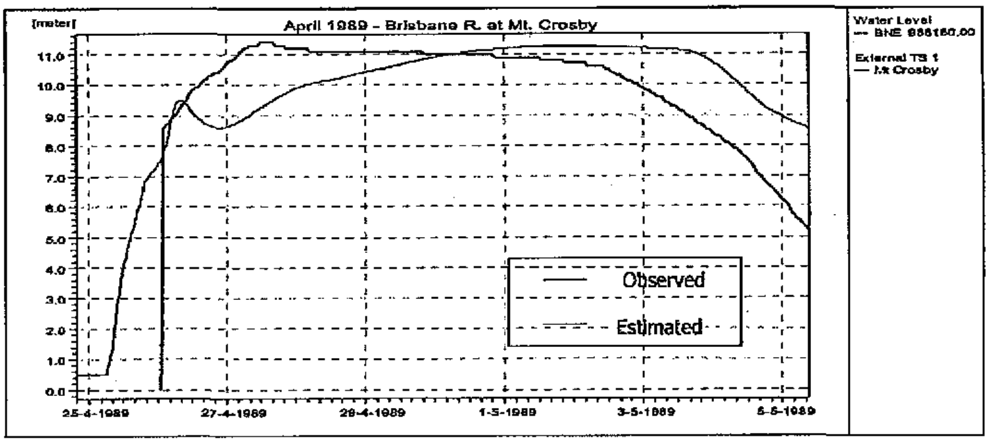


Figure 15 April 1989 Flood Hydrographs – Brisbane River at Mt. Crosby

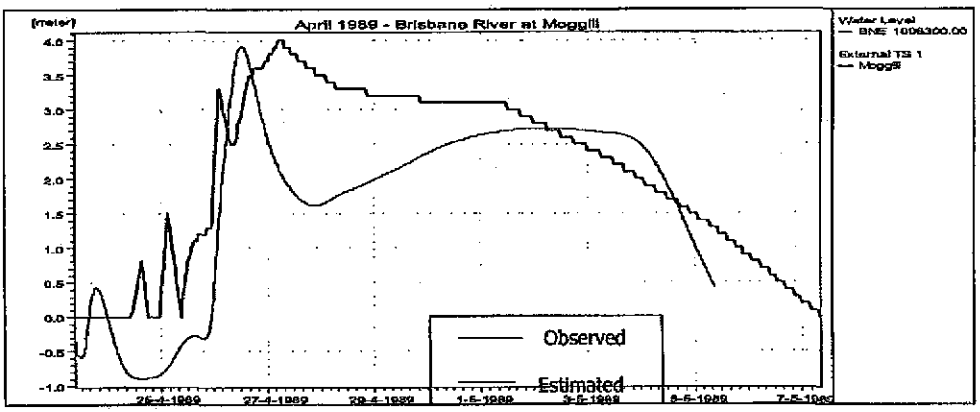


Figure 16 April 1989 Flood Hydrographs – Brisbane River at Moggill

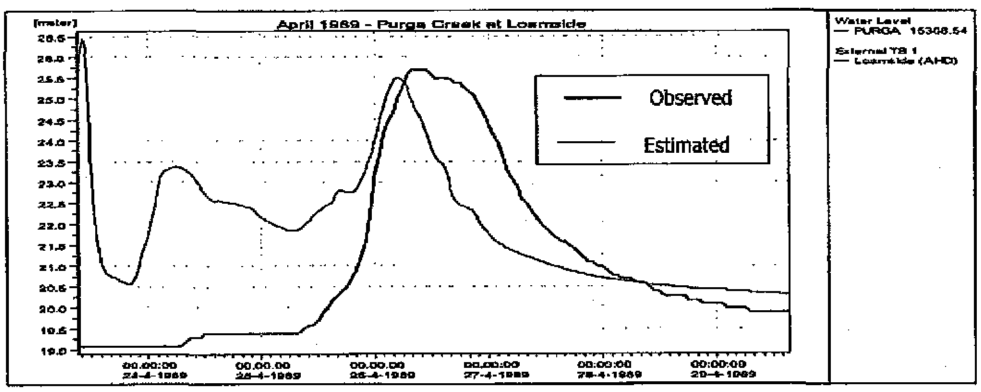


Figure 17 April 1989 Flood Hydrographs – Purga Creek at Loamside

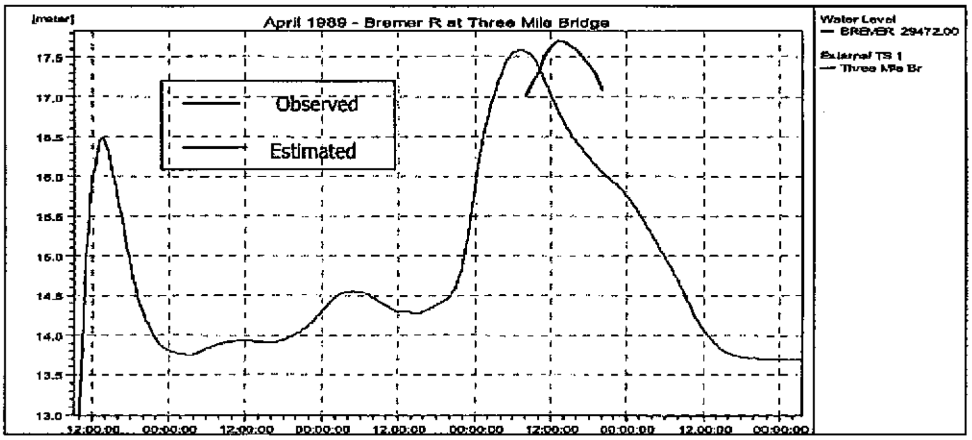


Figure 18 April 1989 Flood Hydrographs -Bremer River at Three Mile Bridge

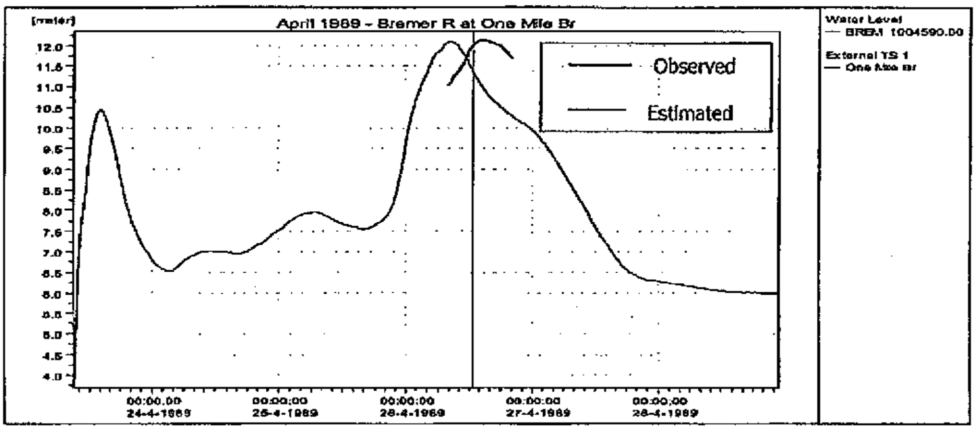


Figure 19 April 1989 Flood Hydrographs - Bremer River at One Mile Bridge

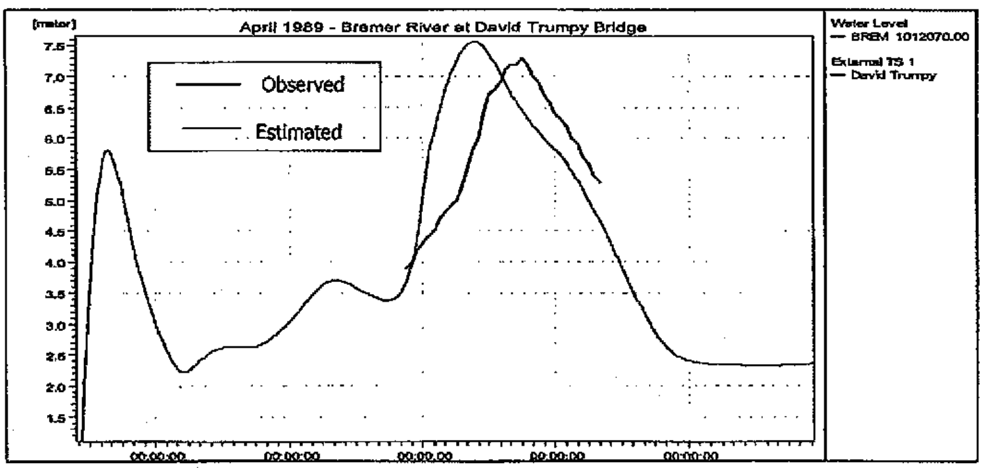


Figure 20 April 1989 Flood Hydrographs - Bremer River at Ipswich

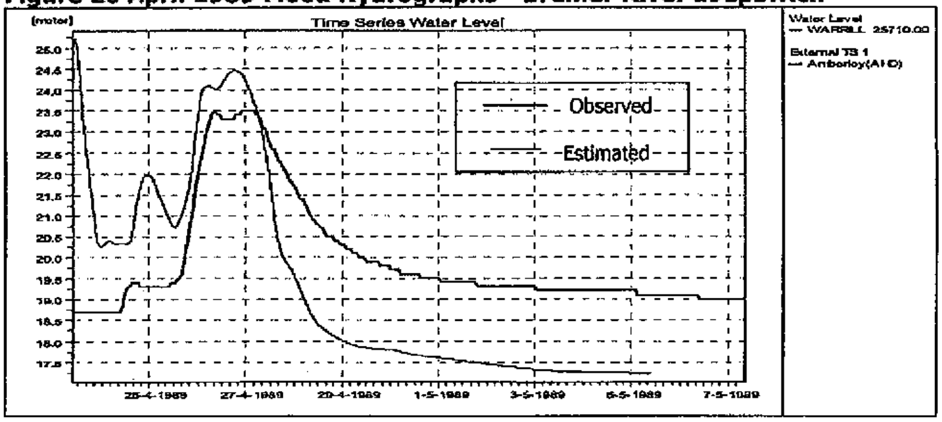


Figure 21 April 1989 Flood Hydrographs – Warrill Creek at Amberley

c) 1983 Event

The minor flood event in late April 1983 had observed flood levels available at the following locations:

- Brisbane River at Mt. Crosby, and Moggill only;
- Bremer River at Stokes Crossing, Adams Bridge, Rosewood, Walloon, Three Mile Bridge, Phillip Street, One Mile Bridge, and David Trumpy Bridge;
- Bundamba Creek at Harding Street, Blackstone Road, Brisbane Road and Gledson Street;
- Purga Creek at Loamside;
- Western Creek at Kuss Road;
- Warrill Creek at Kalbar, Harrisville, and Amberley; and
- Woogaroo Creek at Brisbane Road and Brisbane Terrace .

As for the 1989 event, there was no recorded hydrograph available at Jindalee and the stage-discharge rating curve developed for Jindalee (**Appendix D**) was used as the downstream boundary condition.

This model was run with the parameters as determined for the larger 1996 flood with the following differences between estimated and observed peak levels:

- Brisbane River Mt. Crosby -0.27m, and Moggill 2.37m;
- Bremer River at Stokes Crossing -0.50m, Adams Bridge -0.62m, Rosewood -0.49m, Walloon (DNRM) 0.35m, Three Mile Bridge 0.45m, Phillip Street -2.37m, One Mile Bridge 0.87m, and David Trumpy Bridge -0.02m;
- Bundamba Creek at Harding Street 0.08m, Blackstone Road 0.36m, Brisbane Road 1.28m and Gledson Street 0.54m ;
- Purga Creek at Loamside 1.12m;
- Western Creek at Kuss Road 2.59m;
- Warrill Creek at Kalbar -1.99m, Harrisville 0.11m, and Amberley 0.85m; and
- Woogaroo Creek at Brisbane Road 1.87m and Brisbane Terrace 2.85m.

Whilst these results were good at David Trumpy Bridge, Harrisville and Harding Street; and acceptable at Mt. Crosby, Walloon and Blackstone Road; they were very poor and unsatisfactory at the other points.

As it was not considered appropriate to vary the roughness parameters between these three small flood events, these results were carried forward to the discussion regarding potential reasons for these poor results in **Section 3.5** hereof.

The *modelled longitudinal profiles* for these events and the observed peak flood levels are shown in **Appendix B** whilst **Figures 22** to **29** show observed and modelled hydrographs at key locations.

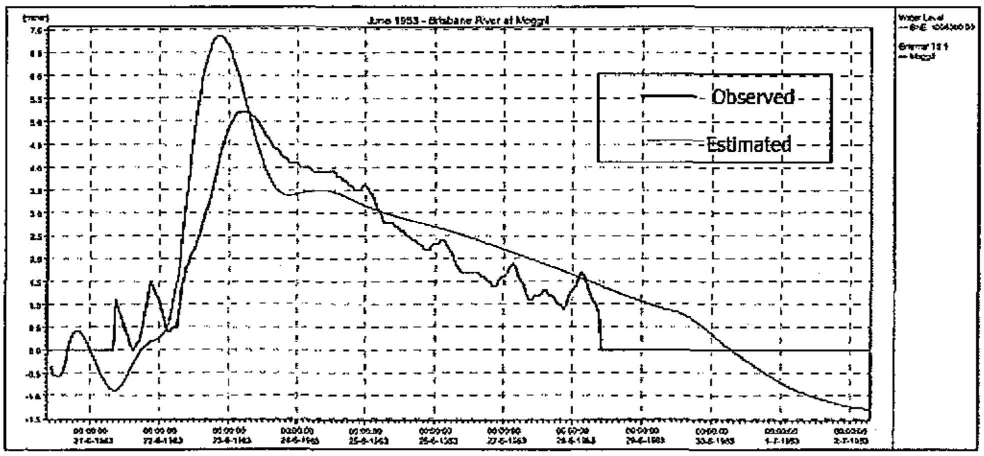


Figure 22 June 1983 Flood Hydrographs – Brisbane River at Moggill

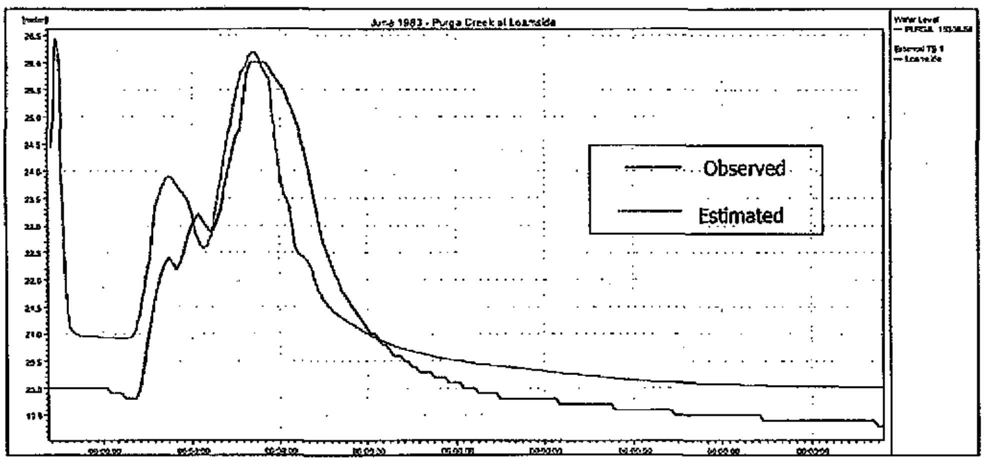


Figure 23 June 1983 Flood Hydrographs – Purga Creek at Loamside

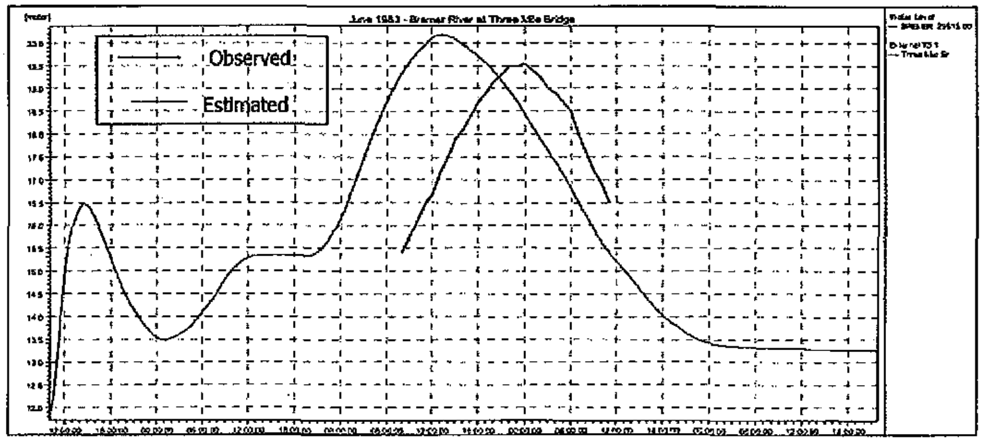


Figure 24 June 1983 Flood Hydrographs -Bremer River at Three Mile Bridge

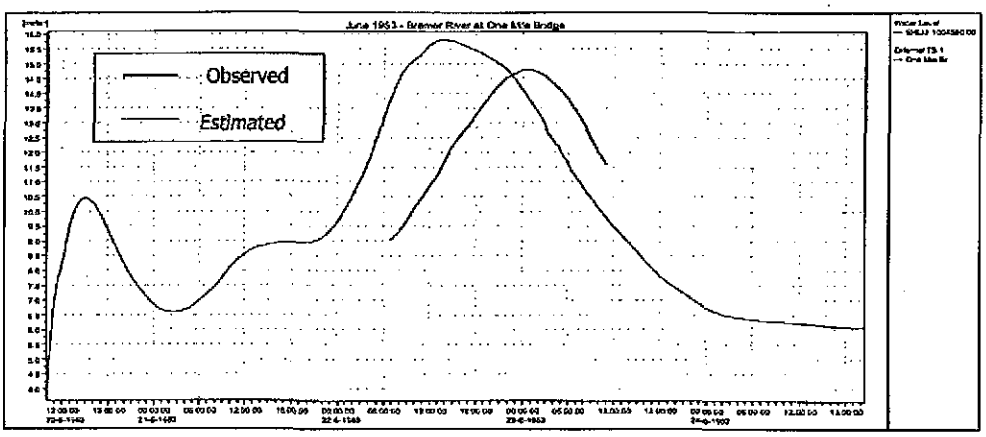


Figure 25 June 1983 Flood Hydrographs - Bremer River at One Mile Bridge

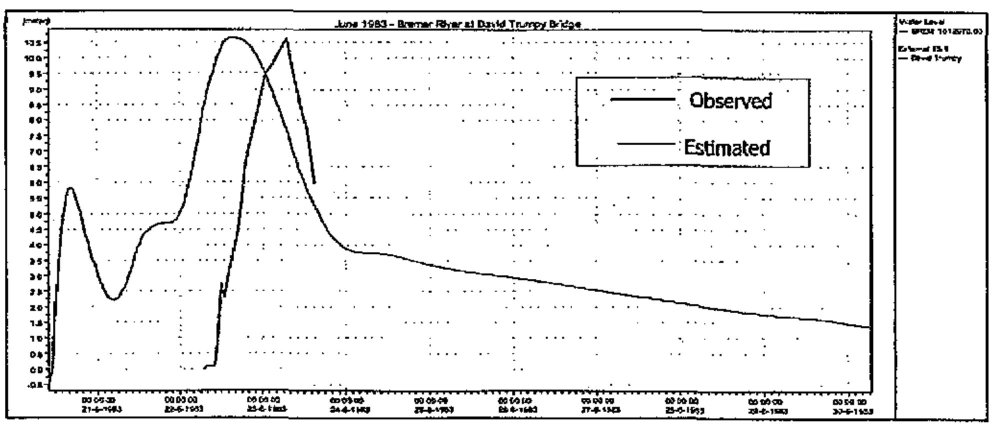


Figure 26 June 1983 Flood Hydrographs - Bremer River at Ipswich

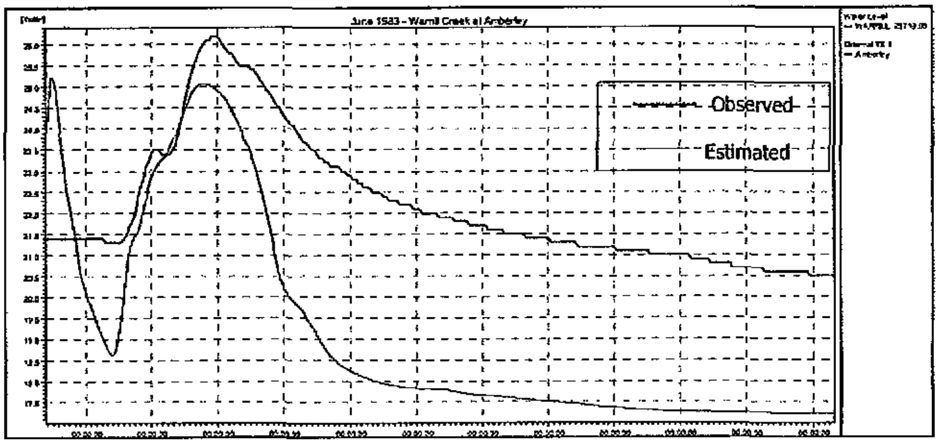


Figure 27 June 1983 Flood Hydrographs – Warrill Creek at Amberley

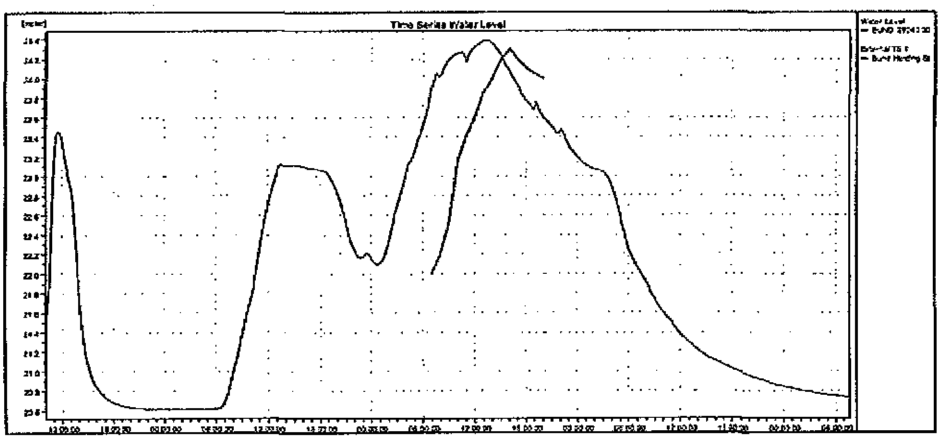


Figure 28 June 1983 Flood Hydrographs – Bundamba Creek at Harding St.

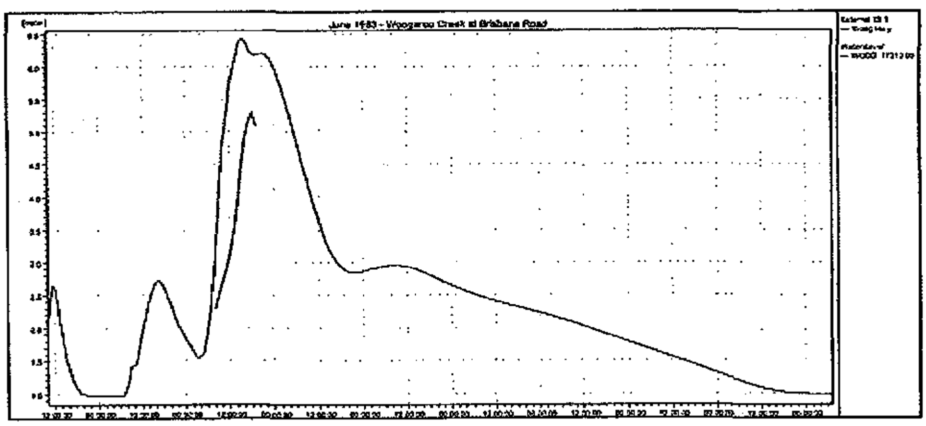


Figure 29 June 1983 Flood Hydrographs –Woogaroo Creek at Brisbane Rd.

As can be seen from these hydrographs, except for Purga Creek in which the timing of the peak is well replicated, the modelled peaks are 6 to 12 hours early at all other locations.

d) 1974 Event

The 1974 event is the largest event available for calibration and was the largest recorded in Ipswich in the 20th century, reaching 20.7m at the Ipswich flood gauge. Since European settlement, only the 1893 flood was higher.

This flood caused widespread damage with approximately **2,000 properties** affected in Ipswich, of which **41 properties were swept away** and **600 fully submerged.**

In addition to flood level records at the gauging stations, a large number of peak levels were recorded after the event by survey of high water marks and debris lines. In total, historic flood levels are available at some 180 locations for this event.

A summary of the availability of historic flood levels is as follows:

- Brisbane River at Mt. Crosby, Moggill, Goodna and Jindalee plus peak levels at about 60 locations;
- Bremer River at Stokes Crossing, Adams Bridge, Rosewood, Walloon, Three Mile Bridge, One Mile Bridge, Hancock Bridge and David Trumpy Bridge plus peak levels at about 50 locations;
- Peak flood levels at Bundamba Creek at Ripley, Patrick Street, Harding Street, Blackstone Road, Brisbane Road and Gledson Street and 17 other locations;
- Purga Creek at Loamside;
- Western Creek at Kuss Road;
- Warrill Creek at Kalbar, Harrisville, and Amberley;
- Peak flood levels at 12 locations on Goodna Creek; and
- Peak flood levels on Woogaroo Creek at Parker Street, Edna Street, and Brisbane Terrace and at 10 other locations.

As stated in **Section 3.4** hereof, the basic calibration strategy was to develop a set of model parameters to satisfactorily replicate flood levels in the 3 smaller flood events, and then to modify the parameters for floodplain flows above the levels reached in those events in order to also replicate the much larger 1974 event.

It was initially intended to achieve this fit to the much large 1974 flood by varying the model roughness for flood levels above those reached in the 1996 (and the other minor calibration events) using the horizontal roughness distribution facility within MIKE 11 to account for the higher roughness on the floodplain. However, it was found that the overall roughness could not be increased sufficiently in this manner even if inordinately high values of floodplain roughness were used.

This is consistent with the findings of SKM (2000) in which different roughness values were needed to calibrate to the 1974 flood.

In order to overcome the problem of having different roughness parameters (and hence different MIKE 11 hydraulic parameter files) for the different events, recourse was made to using the vertical variation of hydraulic roughness in MIKE 11 (in the cross-section processed data).

Unlike the horizontal roughness variation which varies roughness only in that part of the cross-section to the left and/or right of the low flow section, the vertical roughness parameter, which is applied on an elevation basis, varies the roughness of the whole cross-section when a particular level is reached. Using this parameter requires variation on a cross-section by cross-section basis.

Using this approach, it was possible to obtain a satisfactory calibration for the 1974 flood using the same parameter file as that used for the smaller floods.

Using this approach, the hydraulic roughness becomes a function of water level. Whilst this is not likely to be realistic physically, this is a legitimate means of calibration in this instance in which there are a number of issues resulting in the apparent inconsistencies in hydraulic roughness.

Whilst some of the variations in roughness required to calibrate this event are simply due to the larger number of calibration points giving greater opportunity to fit varying roughness along the river/creek profiles, the bulk of this is believed to be due to physical changes in the river system, problems with the model structure and the boundary conditions. These issues are canvassed in **Section 3.5** hereof.

The modelled longitudinal profiles for these events and the observed peak flood levels are shown in **Appendix B** whilst **Figures 30** to **35** show observed and modelled hydrographs at key locations.

The differences between estimated and observed peak levels were as follows:

- Brisbane River Mt. Crosby -0.11m, Moggill -0.05m, Goodna -0.17m and Jindalee 0.00m (starting point);
- Bremer River at Stokes Crossing 0.11m, Adams Bridge 0.12m, Rosewood -0.23m, Walloon (DNRM) -0.13m, Three Mile Bridge 0.09m, One Mile Bridge 0.01m, Wulkuraka Bridge -0.08m, Hancock Bridge -.18m and David Trumpy Bridge -0.10m;
- Bundamba Creek at Ripley -2.98m, Patrick Street -0.97m, Harding Street 0.03m, Blackstone Road -0.02m, Brisbane Road -0.07m and Gledson Street -0.07m;
- Goodna Creek at Duncan Street 0.19m, Ipswich Road -0.11m, and Brisbane Terrace 0.19m;
- Purga Creek at Loamside -0.06m;
- Western Creek at Kuss Road 0.65m;
- Warrill Creek at Kalbar -0.66m, Harrisville 0.52m, and Amberley 0.05m; and
- Woogaroo Creek at Parker Street -0.29m, Edna Street -0.19m, Brisbane Road -0.09m and Brisbane Terrace 0.32m.

The estimated peak levels were within ±0.1m at a number of key points and were within ±0.2m at all of the gauging stations except Bremer River at Rosewood and Warrill Creek at Kalbar and Harrisville.

Levels on Bundamba Creek were within ±0.1m in the lower reaches but could not be matched in the upper reaches. Levels along Woogaroo Creek were not well replicated but were dictated by Brisbane River backwater and could not be calibrated further.

Comparison of estimated and observed water level hydrographs for key locations is given in **Figures 30 to 35.**

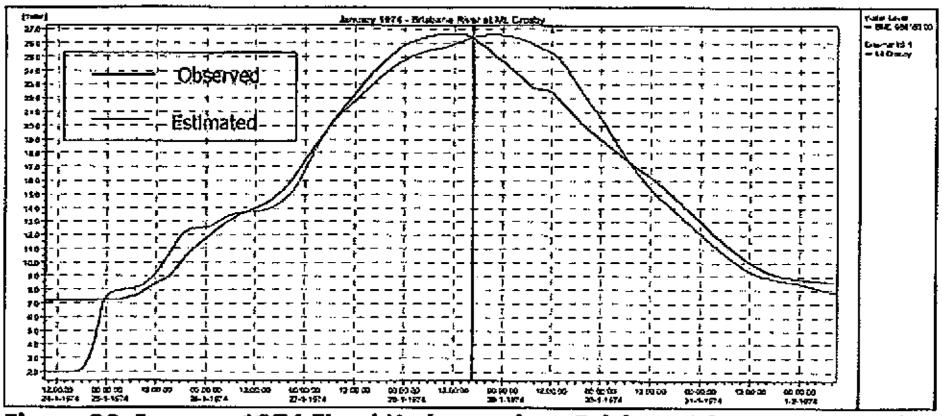


Figure 30 January 1974 Flood Hydrographs – Brisbane River at Mt. Crosby

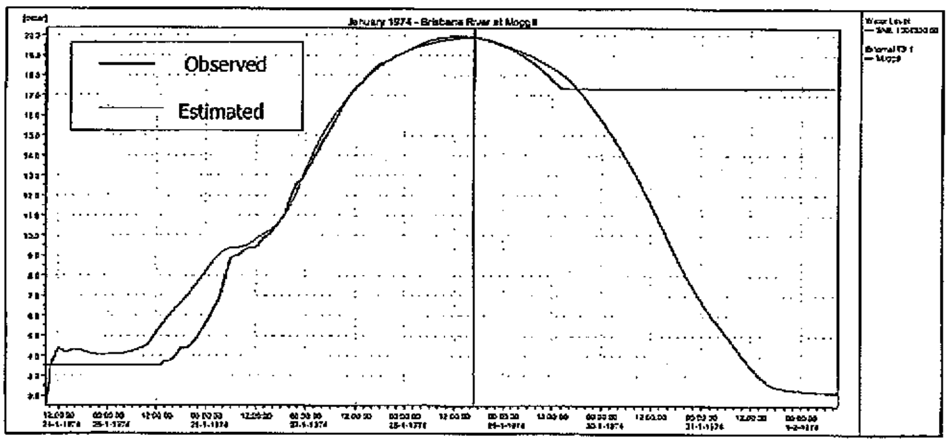


Figure 31 January 1974 Flood Hydrographs – Brisbane River at Moggill

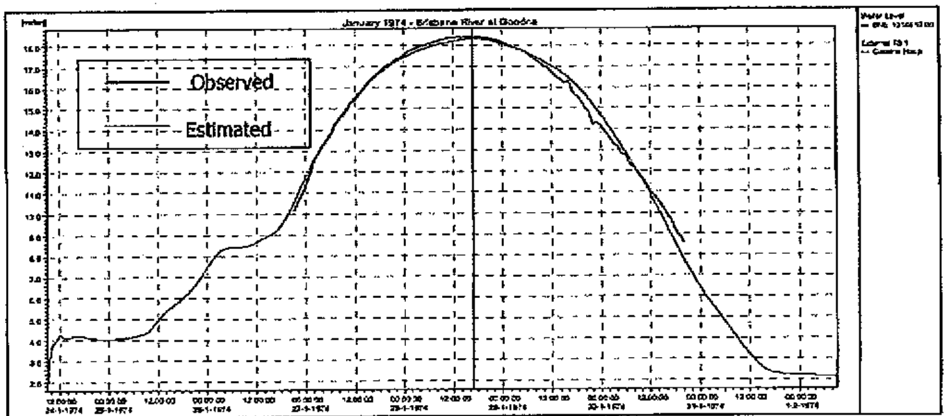


Figure 32 January 1974 Flood Hydrographs – Brisbane River at Goodna

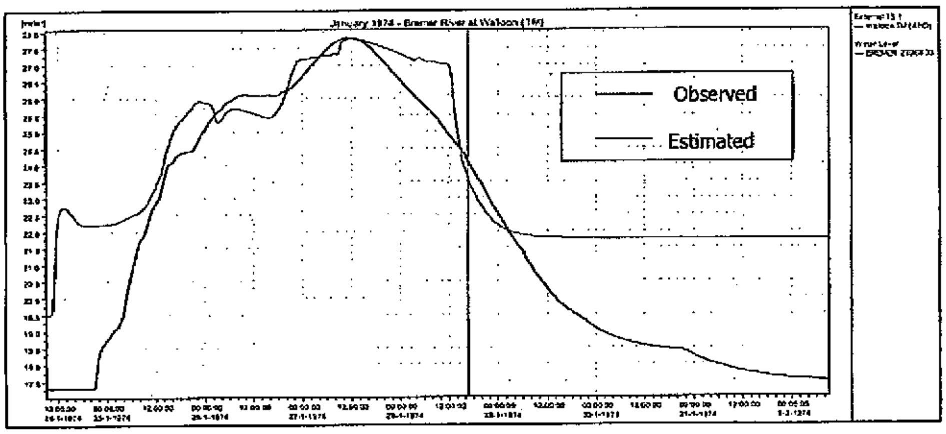


Figure 33 January 1974 Flood Hydrographs -Bremer River at Walloon

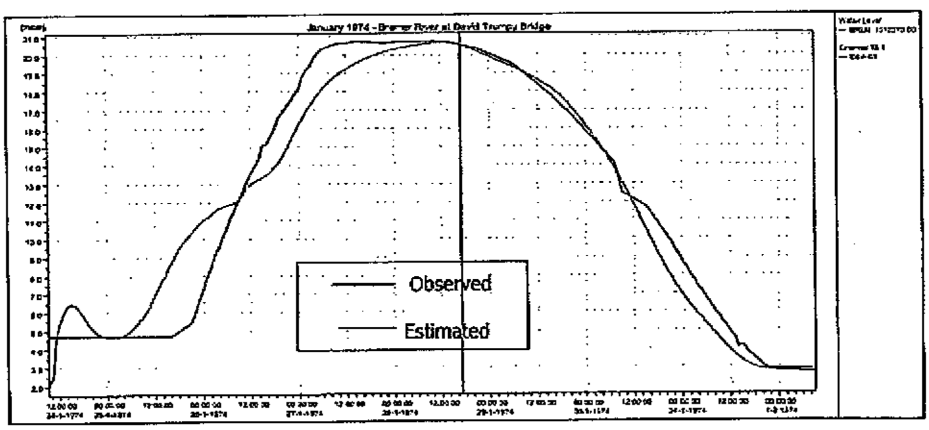


Figure 34 January 1974 Flood Hydrographs - Bremer River at Ipswich

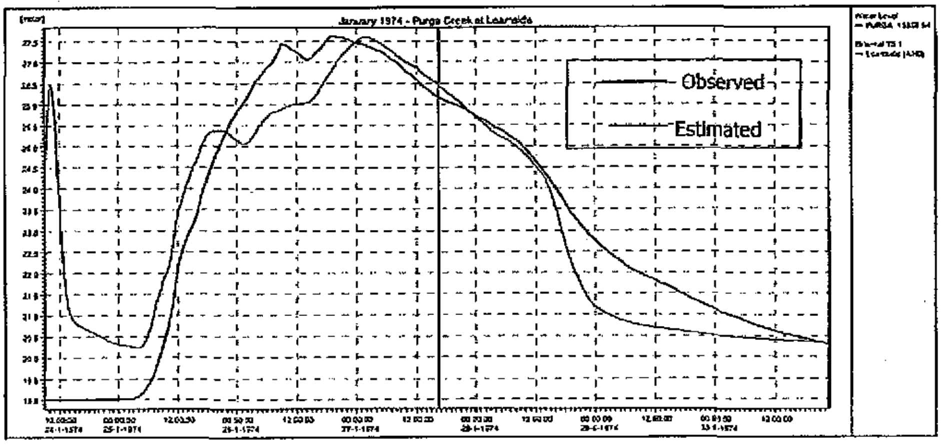


Figure 35 January 1974 Flood Hydrographs – Purga Creek at Loamside

As can be seen from these hydrographs, this event has a single peak and its timing is replicated much better than in the other calibration events.

3.5 Discussion of Results

The model calibration process as outlined in **Section 3.4** has confirmed that it is not possible to use a single set of roughness parameters to satisfactorily replicate the flood levels in the four calibration events, and that it has been necessary to utilise the ability of the model to vary roughness with water level to be able to include these variations in a single hydraulic parameter file.

Although this degree of variation in roughness between events is not physically realistic, this approach is considered to be justifiable, given the need to develop a single parameter file which can be used in the design case, and to make the best available use of the calibration data, the reasons for this variation should be considered.

The following are considered to be possible reasons for the apparent change in model roughness between the smaller and large flood events:

- Possible physical changes in the river system since 1974;
- Errors introduced by the model structure; and
- Errors in the boundary conditions (hydrologic inputs) to the model.

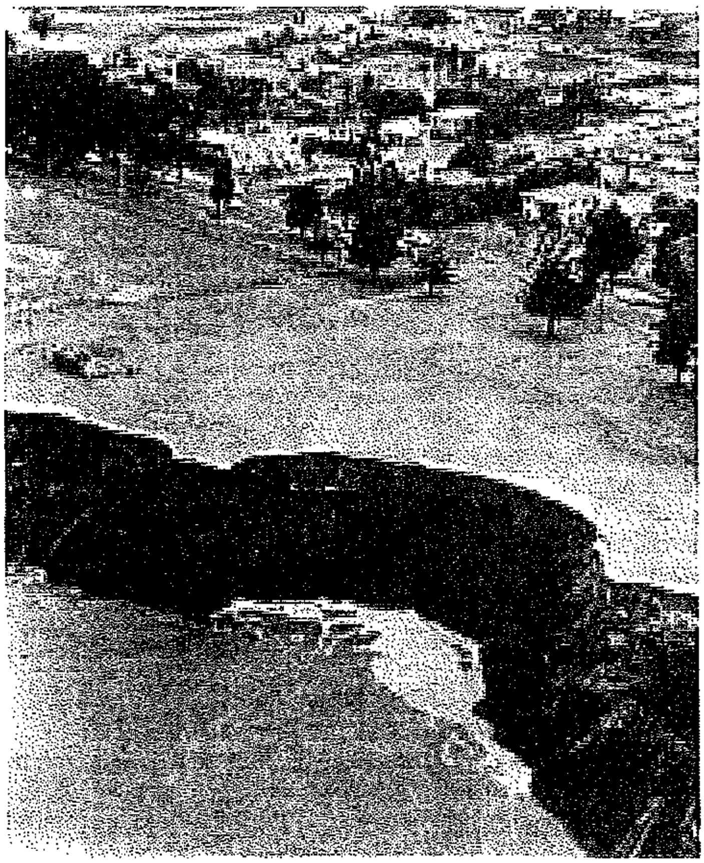
These possible reasons are discussed in the following paragraphs.

3.5.1 Physical Change

It is possible that the degree of discrepancy in the calibration results between the 1974 flood and the smaller floods in the 1980s and 1990s results from physical changes which have occurred during or since the 1974 flood. Enlargement of the channel cross-section could have resulted from, for example:

- Significant erosion (channel deepening/widening) following the 1974 flood;
- Dredging in the lower reaches of the Brisbane River for sand and gravel extraction purposes; or
- Shortening due to meander cut-off, which would increase water surface slope and initiate an episode of headwards erosion.

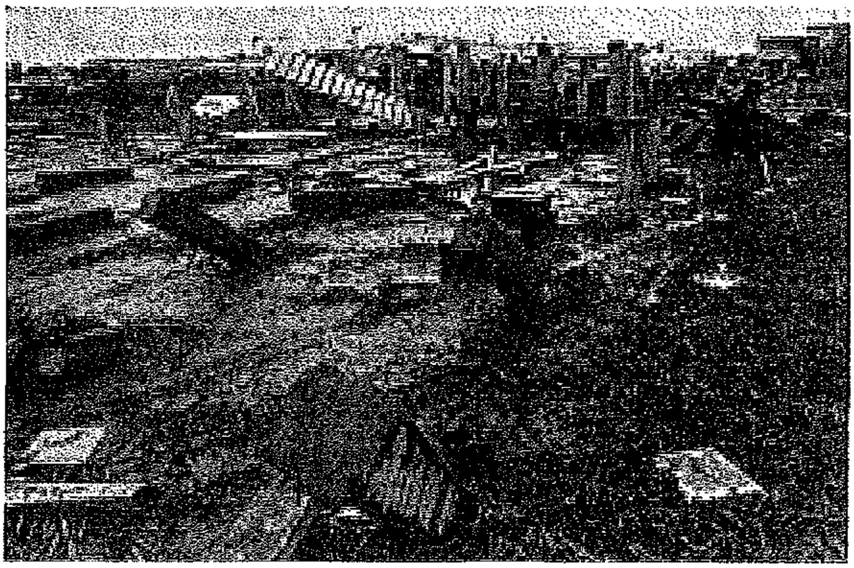
The following photographs, reproduced from the Bureau of Meteorology's report on the 1974 floods (BOM 1974) show evidence of severe erosion during that event. The first photograph shows severe bank erosion at Goodna; and the second shows house stumps remaining after destruction by flooding (one of 41 houses in Ipswich which washed away). This would have resulted from high flow velocities which would have been capable of causing severe erosion.



The aftermath of the flood: Severe erosion of the banks of the Brisbane River at Goodna

Brisbane *Sunday Sun*

Photograph reproduced from Bureau of Meteorology (1974)



A graveyard of house stumps in Ipswich, where 41 houses were washed away.
Queensland Times Ipswich

Photograph reproduced from Bureau of Meteorology (1974)

Figure 36 shows flood level and velocity hydrographs for the Brisbane River at Goodna for the 1974 flood.

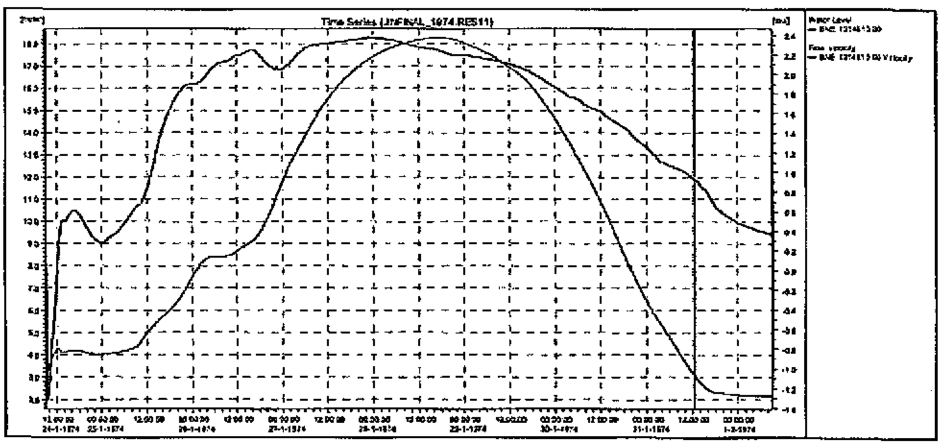


Figure 36 Flood Level and Velocity – Brisbane River at Goodna - 1974 Flood

Figure 36 shows that in the 1974 flood, the peak mean velocity of 2.4ms^{-1} was reached about 18 hours prior to the maximum water level of about 18m at Goodna. The peak was followed by a period of rapid recession in which the water level dropped 15m in about 60 hours, an average of 0.25m per hour.

During the recession phase the velocity reduced steadily but was still about 1ms^{-1} at the end of this time. These relatively high velocities together with the "rapid drawdown" in the recession phase would have been the main causes of erosion. During "rapid drawdown" high pore water pressures can occur in the bank soil material leading to slope failure.

It should be noted that as this was after the peak flow, any increase in channel capacity resulting from the erosion, even if this were widespread, would have had no impact on the peak flood level reached.

The 1974 calibration results show that peak velocities of $1.5ms^{-1}$ to $2.5ms^{-1}$ were common though the model except for some of the minor creeks, so erosion could have been extensive.

Similar maximum velocities were reached during the 1996 event, but the drawdown effect was much smaller than in 1974. Nonetheless, even the relatively small events could be resulting in bank erosion.

In smaller events, some of the eroded material may be deposited further downstream before reaching the ocean, but in major events such as in 1974, it is likely that a large proportion of the sediment would be carried to the ocean forming a flood plume.

An episode of erosion such as that during a major flood can trigger ongoing erosion especially if there is a shortening of the river's length due to a meander cut-off for example. It is also possible that the system's equilibrium is not significantly upset and the balance of erosion and deposition continues as before. However, the period since the 1974 flood has been free of major floods and it is unlikely that any major erosion which occurred then has been reversed.

Hence, it is quite likely that the current river and creek channels have a greater flow carrying capacity than that at the time of the 1974 flood. In this case, modelling the 1974 flood with current channel geometry would need hydraulic roughness to be increased to match historic water levels as has been found to be the case.

Dredging for sand and gravel extraction in the Brisbane River occurred for most of the 20th century (Davie et al 1990) and ended in 1998. Annual extraction peaked in the mid 1970s at about $1,500,000m^3$/annum and by 1990 had declined to about $400,000m^3$/annum.

Erskine in Davie et al (1990) describes how extraction of river bed material can lead to river bed degrading in both upstream and downstream directions. **Figure 37** reproduced from Erskine's paper outlines this process.

The profound impact that the dredging has had on the river is illustrated by the tidal limit which was around Indooroopilly at the time of European settlement now reaches Mt. Crosby on the Brisbane River (prevented from further upstream progression by the weir) and Ipswich on the Bremer River.

Whilst the impact of dredging is expected to be greatest in the Brisbane River upstream as far as Mt. Crosby Weir, it could also extend into the Bremer River system and Brisbane River tributaries, if headwards erosion has been initiated in these waterways.

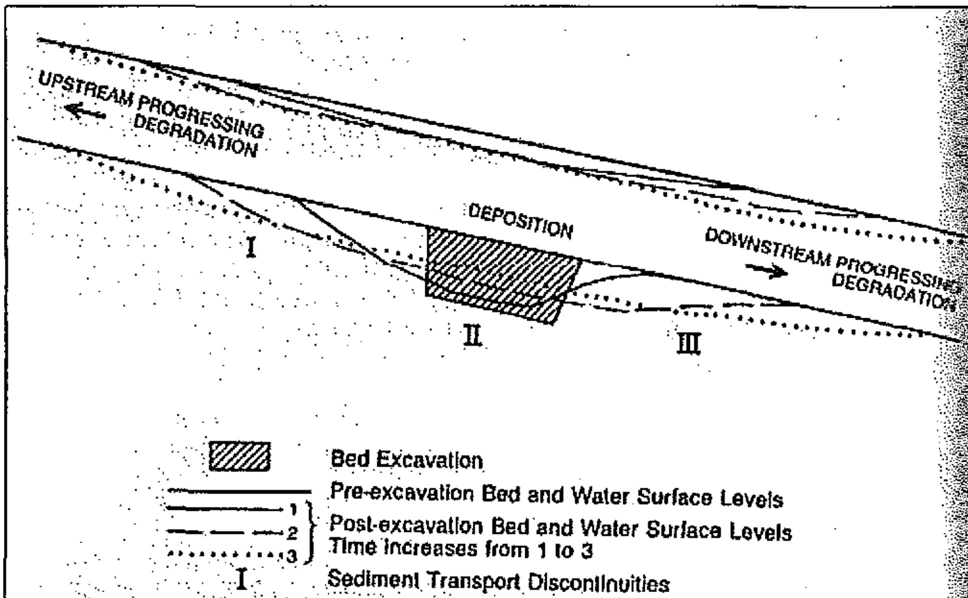


Figure 1: *Diagrammatic representation of extraction-induced degradation during channel recovery following excavation. Water surface levels refer to the same, constant discharge.*

Figure 37 **River Bed Degradation following Bed Material Extraction**
(Reproduced from Erskine W. in Davie et al 1990)

A brief investigation into physical changes in the Brisbane River in the vicinity of its confluence with the Bremer River was subsequently undertaken and is reported in **Appendix I** hereof.

The degree of conservatism was tested by running the 1974 event with the roughness parameters for the 1996 flood (with no adjustment for higher floods) as discussed in **Section 3.6** hereof.

3.5.2 Model Structure

The MIKE 11 model has been structured (SKM 2000, KBR 2002, DHI 2006) with cross-sections and chainages following the river channel. During a major flood event in which substantial floodplain flow occurs, there can be a considerable shortening of the effective flowpath length. This is illustrated in **Figure 36,** which shows that part of the Bremer River around its confluence with Warrill Creek near Amberley.

Figure 36 shows the flood extents for floods reaching 17m and 24m at One Mile Bridge, approximately the levels reached in the 1996 and 1974 floods respectively. It can be seen from this figure that the 17m flood follows the path of the river channel whilst the 24m flood results in a wider flood extent with flow across the top of the meanders. In addition to the MIKE 11 cross-sections shown in **Figure 38,** the cross-sections which apply to the floodplain portion of the flow in the 24m flood are also shown, marked A to D. Comparing the direct distances A-B, B-C, C-D, these are substantially less than their distances in the MIKE 11 model. Distances A-B and B-C are only 40% of the MIKE 11 distance whilst C-D is 70%.

In model calibration, the roughness is varied to replicate the observed flood heights at various points. If the effective or flowpath distance between sections is overestimated in the model, the water surface slope will be underestimated and the temporary flood storage will be overestimated. Both of these lead to higher roughness being required in the model to compensate for the incorrect distance.

If the effect of foreshortening in the model in overbank floods were the only factor, the roughness increase to compensate for the shortening would be in the ratio of the square root of the model distance to the overbank distance. In the example, this ratio is a maximum of 1.6 (square root of 2.5 or 1/0.4). This is not enough to explain all of the differences needed to achieve calibration.

3.5.3 Boundary Conditions

With the exception of the downstream boundary condition, the other boundary conditions (of which there are some 160) are upstream and local flow hydrograph inputs. If the inflows into a particular branch of the model had been overestimated, this would lead to the roughness required to match historic levels being underestimated and vice versa.

Current best practice is to calibrate the hydrologic and hydraulic models "in tandem" and to test the sensitivity of model outcomes to parameter variation "in tandem". For example, changes to the assumed initial losses or continuing loss rate in the hydrologic model do not necessarily have a uniform impact on estimated flows across the catchment, and a certain combination of parameters may lead to improved performance in the hydraulic model.

This approach has not been possible in this instance, as the calibration of the hydrologic model was undertaken as part of Phase 2 of the Ipswich Rivers Flood Study (SKM 2000) using the RAFTS model and the flow inputs for the calibration floods have been taken from the previous work.

Alternative estimates of flows for the calibration events are available from the Bureau of Meteorology's URBS model as reported in **Section 3.4.1** hereof. The comparison of RAFTS and URBS model peak flows in **Table 4** tends to indicate that the RAFTS flows for the 1974 event were, if anything, overestimated which would lead to the required roughness being underestimated. However, at most locations the roughness has to be higher to model the 1974 event, which is inconsistent with the above observation.

Although this remains a potential issue affecting the accuracy of the model calibration, it has not been possible to quantify this impact.

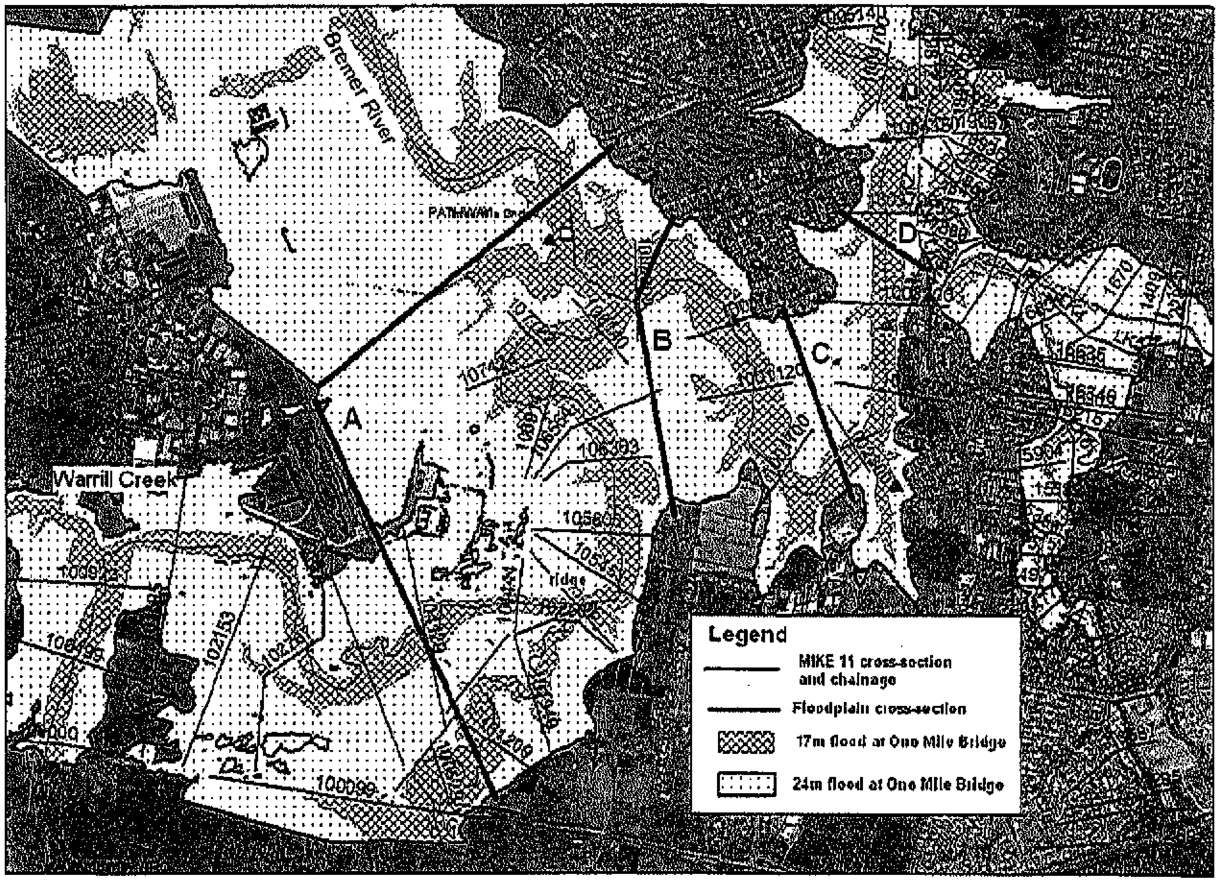


Figure 38 Illustration of flowpath shortening during flood

3.6 Sensitivity Testing

Sensitivity testing was undertaken in respect of the following:

- Inappropriate roughness parameters (due to physical change); and
- Uncertainty in hydrologic inputs.

3.6.1 Roughness Parameters

The effect of using an inappropriate set of roughness parameters was tested by running the model with boundary conditions for the 1974 event but with the roughness parameters for the 1996 flood (with no adjustment for higher floods). This resulted in:

Brisbane River

- Reductions in peak level upstream of Mt. Crosby ranging from 1.35m to 2.5m and of 1.85m at Mt. Crosby;
- Reductions in peak level between Mt. Crosby and Moggill ranging from 0.7m to 3.5m and of 3.4m at Moggill;
- Reductions in peak level between Moggill and Goodna ranging from 2.5m to 3.4m and of 2.8m at Goodna;
- Reductions in peak level between Moggill and Goodna ranging from 2.5m to 3.4m and of 2.8m at Goodna; and
- Reductions in peak level between Goodna and Jindalee ranging from 0m to 2.8m.

Bremer River

- Reductions in peak level at Adams Bridge of 0.01m and of 0.27m at Stokes Crossing;
- Reductions in peak level at Rosewood of 0.55m and of 0.73m at Walloon;
- Reductions in peak level at Three Mile Bridge of 2.21m and of 4.4m at One Mile Bridge; and
- Reductions in peak level at David Trumpy Bridge of 3.19m and of 3.35m at the confluence of Bundamba Creek.

Warrill Creek

- An increase in peak level at Kalbar of 3.68m and at Harrisville of 2.5m; and
- Reductions in peak level at Amberley of 0.85m and of 2.3m at the confluence with Bremer River.

Bundamba Creek

- Reductions in peak level at Ripley of 2.6m, and of 0.24m at Blackstone Road;
- Reductions in peak level at of 1.3m at Brisbane Road and at Gledson St of 3.35m; but
- An increase in peak level at Harding Street of 1.4m and at the Cunningham Highway of 0.6m.

Six Mile Creek

- Reductions in peak level of 2.76m from Brisbane River to Duncan St reducing to 0m at the upstream model boundary.

Goodna Creek

- Reductions in peak level of 2.6m from Brisbane River to downstream of Bailey Street reducing to 0m at the upstream model boundary.

Woogaroo Creek

- Reductions in peak level of 2.7m from Brisbane River to upstream of Parker Street reducing to 0m at Eric Street; but
- Increasing upstream of Eric Street to a maximum increase of 1.5m where it passes near to the end of Eugene Street, then reducing to 0m at the upstream model boundary.

3.6.2 Hydrologic Uncertainty

The effect of the possible scale of hydrologic errors was tested by scaling the hydrologic inputs for the Bremer River, Warrill Creek and Purga Creek for the 1974 flood event only so that the peak flows in the RAFTS model matched those at rhe DNRM gauging stations on those watercourses. These ratios were taken from the information given in **Tables 4** and **5** with the input hydrographs for these events scaled by factors of 0.91 for Warrill Creek, 0.82 for the Bremer River and its tributaries, and 0.48 for Purga Creek. All other inputs were the same, and the composite 1974/1996 roughness parameter file was used.

Although this does not indicate the change in roughness required to rectify errors of this magnitude, the differences in water level from this test are useful as an indicator of the sensitivity of model outputs to changes in the hydrologic inputs.

This test produced the following results:

- Peak flood levels in the Bremer River were lowered by amounts ranging from 0.6m at the confluence with the Brisbane River to 0.9m at the confluence with Warrill Creek; increasing to 3.0m at Walloon then reducing in an upstream direction to 1.1m at Rosewood and 0.2m at Adams Bridge;

- Peak flood levels in Warrill Creek were lowered by amounts ranging from 0.9m at the confluence with the Bremer River to 1.15m at Amberley, reaching a maximum of 1.9m about midway between Amberley and Harrisville, then reducing to less than 0.1m at Harrisville;

- Peak flood levels in Purga Creek were lowered by amounts ranging from 0.95m at the confluence with the Bremer River and 1.0m at Loamside, then reducing in an upstream direction to 0.1m at the upstream model boundary;

- Peak flood levels in the Brisbane River were lowered by amounts ranging from 0.6m at Moggill to 0.2m upstream to Mt. Crosby. Downstream from Moggill the difference reduced to zero at Jindalee as the same downstream boundary condition was used.

This test has demonstrated that the model results are quite sensitive to the possible scale of errors in the hydrologic inputs.

3.7 Conclusions

It was possible to calibrate the MIKE 11 model to the 1996 and 1974 and to verify the fitted model with the small floods in 1983 and 1989 to an acceptable degree.

However, this was achieved only by varying model roughness between that required to fit the 1996 and 1974 events within the one data file using a facility within MIKE 11 to vary roughness with flow depth.

This is considered to be a legitimate means of calibration in this context because of the large disparity which existed between roughness parameters fitted to individual events.

The possible reasons for this disparity have been considered and commented upon. These are:

- Possible physical changes in the river system since 1974;
- Errors introduced by the model structure; and
- Errors in the hydrologic inputs to the model.

Physical Change
Given that the 1974 flood in the Brisbane River/Bremer River catchment was the largest experienced in the 20th Century, and that anecdotal evidence (A. Underwood pers. comm.), pictorial evidence, and the modelled velocities show that this event had sufficient power to cause extensive erosion, it is considered to be quite likely that the current river and creek channels have a greater flow carrying capacity than that at the time of the 1974 flood. In this case, modelling the 1974 flood with current channel geometry would need hydraulic roughness to be increased to match historic water levels as has been found to be the case.

Also there was substantial dredging in the Brisbane River for much of the 20th Century, ending only in 1998, which has deepened the Brisbane River and resulted in its tidal limit moving upstream from about Indooroopilly at the time of European settlement to Mt. Crosby Weir on the Brisbane River and Ipswich on the Bremer River.

Dredging can induce bed erosion in both upstream and downstream directions and this may have occurred, or still be taking place.

Sensitivity testing indicated that use of roughness values appropriate at the start of the 1974 event, could overestimate peak flood levels at key locations by 2.8m to 3.5m in the Goodna to Moggill reach of the Brisbane River and 3.3m in the lower Bremer River.

A brief investigation into physical changes in the Brisbane River in the vicinity of its confluence with the Bremer River was subsequently undertaken and is reported in **Appendix I** hereof.

Model Structure
The MIKE 11 model has been structured (SKM 2000, KBR 2002, DHI 2006) with cross-sections and chainages following the river channel. During a major flood event in which substantial floodplain flow occurs, there can be a considerable shortening of the effective flowpath length.

If the effective or flowpath distance between sections is overestimated in the model, the water surface slope will be underestimated and the temporary flood storage will be overestimated. Both of these lead to higher roughness being required in the model to compensate for the incorrect distance.

It was concluded that this is a factor in the different apparent roughness values obtained when fitting the much larger 1974 flood event.

Hydrologic Inputs

If the inflows into a particular branch of the model had been overestimated, this would lead to the roughness (required to match historic levels) being underestimated and vice versa.

Current best practice is to calibrate the hydrologic and hydraulic models "in tandem" and to test the sensitivity of model outcomes to parameter variation "in tandem". This approach was possible in this instance, as the calibration of the hydrologic model was undertaken as part of Phase 2 of the Ipswich Rivers Flood Study (SKM 2000) using the RAFTS model and the flow inputs for the calibration floods have been taken from the previous work.

Limited sensitivity testing of the likely scale of error in the hydrologic inputs showed that the model results are sensitive to these changes resulting in differences in peak flood levels, all other factors remaining as before, of the order of 0.6m to 3m in the Bremer River; 0.9 to 1.9m in Warrill Creek and 0.9 to 1.1m in Purga Creek; and up to 0.6m in Brisbane River (even though no changes to Brisbane River flows were include din the test).

3.8 Recommendations

It is recommended that a brief investigation into whether significant river widening/deepening has occurred since the 1974 flood be undertaken in order to determine whether the calibrated model is overconservative in respect of design flood events and to confirm the recommended hydraulic roughness parameters to be used for design event modelling and flood extent mapping.

In the absence of this investigation, it is recommended that the conservative approach be adopted, that is to use the composite hydraulic roughness parameter file which models the variation between small and large events as evidenced by the 1996 and 1974 historic flood data.

4 Design Flood Level Estimation

This section describes the design phase hydraulic modelling, sensitivity tests undertaken and discussion of the results obtained.

4.1 Design Phase Hydraulic Modelling

The Ipswich MIKE 11 model was run for ARI's of 2, 5, 10, 20, 50, 100, 200 and 500 years with flow inputs obtained from design runs of the RAFTS model for storm durations of 1, 2, 3, 4.5, 6, 9, 12, 18, 24, 36, 48 and 72 hours for each ARI, i.e. a total of 96 model runs. The RAFTS modelling of these design flows is reported upon in Sargent Consulting (2006b).

These design flows were input as model boundary conditions at over 150 locations throughout the model area. These are the same input locations as used in the *Ipswich* Rivers Flood Study Phase 2 (SKM 2000) and Phase 3 (KBR 2002) models.

Hydraulic roughness parameters as determined in the calibration phase of the current project (Sargent Consulting 2006c) were utilised throughout.

The downstream boundary condition comprised a stage – discharge rating curve for Jindalee also as derived in the calibration phase of this project and as given in Sargent Consulting (2006c).

The maximum water level, discharge and average velocity for each model cross-section was tabulated in spreadsheet form for each ARI and the storm duration giving the overall maximum water level at each cross-section (i.e. critical duration) was determined. These maximum water levels for each ARI were then carried to a summary spreadsheet. Values at key points are given in **Table 6.**

Longitudinal profiles of peak water level for each of the main watercourses are given in **Appendix E.** The design peak water levels are reproduced in full in **Appendix F,** whilst **Appendices G** and **H** list the corresponding discharges and average velocities respectively. The results of sensitivity tests as described in the next section are given in **Appendix I.**

The table of design flows at key points was updated from that given in Sargent Consulting (2006b) based on the peak flows in the hydraulic model which accounts for temporary flood storage more realistically than the RAFTS model. These flows are given in **Table 7.**

Table 8 compares the values of peak design flows in **Table 7** with the corresponding table in *Sargent Consulting* (2006b – Table 9), expressing differences between the peak flows in percentage terms (of the RAFTS estimate). It can be seen form **Table 8** that there are some marked variations in these differences. In the hydraulic model, the flows input to the model are upstream flows, tributary inputs and local runoff, and the temporary flood water storage is computed based on the channel and floodplain geometry to give flows throughout the model. In the hydrologic model RAFTS, the flood storage component is concentrated in a small number of conceptual storages, typically at the downstream of each of the major tributaries. It is to be expected, therefore, that the RAFTS total flow estimates will be high at locations upstream of the conceptual storages, and possibly low immediately downstream of these storages.

Table 6 Design Flood Levels at Key Locations

Watercourse	Location	Chainage m	Estimated Peak Water Level (m AHD) for ARI 2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
Brisbane River	Mt. Crosby	988160	8.69	10.66	13.81	15.70	19.89	22.73	22.71	24.16
	Moggill	1006300	2.02	5.65	8.34	10.30	13.48	14.98	15.97	17.53
	Goodna	1014610	2.00	5.23	7.84	9.52	12.22	13.55	14.50	16.01
	Jindalee	1028680	2.00	4.49	6.71	7.80	9.50	10.36	10.96	12.09
Bremer River	*One Mile Bridge*	1004590	8.45	11.64	13.63	15.56	17.69	20.74	21.49	24.14
	Wulkeraka Bridge	1006510	7.14	10.61	12.17	13.94	16.26	19.23	20.17	22.70
	Hancock Bridge	1008390	6.17	9.78	11.48	13.31	15.54	17.99	19.04	21.20
	David Trumpy Bridge	1012050	4.38	7.56	9.60	11.36	14.09	15.28	16.65	18.28
	Bundamba Creek	1020450	2.86	6.41	8.80	10.70	13.89	15.23	16.50	18.14
Bremer River (Mid)	Rosewood	11478	37.90	38.71	39.01	39.19	39.43	40.59	41.43	42.82
	Walloon	23968	22.55	24.59	25.17	25.55	25.97	26.20	26.60	29.15
	Three Mile Bridge	29515	15.00	17.62	18.73	20.01	21.73	23.57	23.85	26.03
Bremer River (Upper)	Adams Bridge	16506	78.30	79.69	80.06	80.40	80.85	81.16	81.28	81.46
	Stokes Crossing	23829	60.10	61.44	61.74	62.09	62.97	63.77	64.00	64.41
Bundamba Creek	Ripley	16395	50.21	51.18	51.40	51.58	54.14	57.47	56.87	57.13
	Cunningham Highway	28480	24.20	25.36	26.07	26.25	26.57	26.70	26.72	26.97
	Blackstone Road	31980	18.40	20.03	20.50	20.85	21.58	21.84	21.87	22.32
	Brisbane Road	34305	15.10	17.06	17.51	17.67	17.94	18.05	18.09	18.38
	Gledson Road	36005	10.75	12.80	13.28	13.56	14.17	15.24	16.51	18.14
Goodna Creek	Duncan St	12020	13.17	13.58	13.90	14.23	15.03	15.32	15.80	16.46
	Brisbane Road	14155	6.93	7.50	8.08	9.81	12.58	13.94	14.91	16.46
	U/s Brisbane Terrace	14735	5.41	5.91	8.06	9.81	12.58	13.94	14.91	16.46
Purga Creek	Peak Crossing	2986	48.94	48.94	48.94	48.94	48.94	48.94	49.01	49.22
	Loamside	15309	24.65	25.97	26.40	26.70	27.18	27.65	27.72	28.09
Western Ck	Kuss Rd	9772	50.18	52.92	54.10	55.64	55.67	55.99	56.17	56.97
Warrill Creek	Harrisville	4779	50.88	51.37	51.55	51.67	52.03	52.24	52.25	52.29
	Amberley	25710	22.82	24.78	25.39	25.74	26.30	27.04	27.32	27.98
Warrill Creek (Upper)	Kalbar	19442	72.61	75.16	76.17	76.30	76.78	77.42	77.66	77.97
Woogaroo Creek	Parker St	15800	7.77	10.03	10.41	10.68	12.23	13.55	14.51	16.01
	Edna St	15860	7.55	9.69	10.16	10.47	12.22	13.55	14.51	16.01
	Brisbane Rd	17370	3.70	5.73	7.89	9.52	12.22	13.55	14.51	16.01
	Brisbane Terrace	17760	3.12	5.32	7.87	9.52	12.22	13.55	14.50	16.01

Table 7 Peak Design Flows at Key Locations

Waterway	Location	Peak Flow (Cumecs) for ARI Years							
		2	5	10	20	50	100	200	500
Brisbane R	Savages Crossing	400	960	1900	2700	4300	5600	5800	6300
	Mt Crosby	400	980	1900	2700	4200	5500	5700	6000
Warrill Ck	Kalbar	170	520	700	850	1400	1800	1900	2200
	Amberley	185	550	800	1050	1700	2250	2300	3200
Purga Ck	Loamside	130	260	330	410	630	900	940	1200
Bremer R	Walloon	240	640	820	950	1100	1180	1210	2200
Deebing Ck	U/s Bremer R	15	50	60	75	130	190	195	230
Ironpot Ck	U/s Bremer R	14	40	47	60	120	190	220	230
Mihi Ck	U/s Bremer R	13	16	21	25	55	60	70	80
Sandy Ck (Chuwar)	U/s Bremer R	7	20	26	31	66	95	100	110
Bremer R	David Trumpy Br	440	1100	1500	2100	3050	3200	3300	4400
Bundamba Ck	U/s Bremer R	40	160	210	240	340	400	420	430
Bremer R	D/s Bundamba Ck	450	1100	1450	1950	3000	3250	3300	4400
Brisbane R	Moggill	820	2000	3200	4200	5500	6300	6900	7900
Six Mile Ck	u/s Brisbane R	20	60	65	75	125	170	200	240
Goodna Ck	u/s Brisbane R	11	30	36	45	85	120	140	160
Woogaroo Ck	u/s Brisbane R	40	120	150	180	300	420	470	540
Sandy Ck (Carole Park)	u/s Brisbane R	10	20	26	31	65	100	120	130
Brisbane R	Jindalee	920	2100	3300	4100	5400	6200	6700	7600

Table 8 Differences in Peak Flows between Hydraulic and Hydrologic Models

Waterway	Location	Rafts Node	Differences in Peak Flow % for ARI Years between MIKE 11 and RAFTS							
			2	5	10	20	50	100	200	500
Brisbane R	Savages Crossing	SAV-OUT	11%	5%	0%	-7%	2%	-7%	-19%	-21%
	Mt Crosby	MTC-OUT	11%	8%	0%	-7%	0%	-8%	-21%	-25%
Warrill Ck	Kalbar	KAL-OUT	31%	18%	17%	16%	41%	29%	18%	16%
	Amberley	AMB-OUT	9%	-2%	-5%	0%	-1%	1%	0%	10%
Purga Ck	Loamside	PUR-OUT	44%	-28%	-28%	-27%	-28%	-28%	-33%	-29%
Bremer R	Walloon	WAL-OUT	33%	19%	17%	12%	-13%	-26%	-33%	5%
Deebing Ck	U/s Bremer R	DB-OUT	-31%	0%	-5%	-2%	8%	12%	-3%	0%
Ironpot Ck	U/s Bremer R	IP-OUT	1%	0%	2%	9%	9%	27%	22%	15%
Mihi Ck	U/s Bremer R	MH-OUT	0%	-10%	4%	5%	-2%	-28%	-26%	-27%
Sandy Ck (Chuwar)	U/s Bremer R	SC-OUT	-2%	0%	-2%	-5%	-13%	-21%	-23%	-31%
Bremer R	David Trumpy Br	2C#	19%	-8%	-5%	19%	27%	5%	3%	22%
Bundamba Ck	U/s Bremer R	BUND15	0%	14%	11%	9%	10%	-7%	-16%	-26%
Bremer R	D/s Bundamba Ck	IPS-OUT	22%	-8%	-9%	8%	23%	6%	0%	22%
Brisbane R	Moggill	JIN###	-7%	-2%	10%	9%	3%	-4%	-1%	-1%
Six Mile Ck	u/s Brisbane R	JINAO	-17%	0%	-19%	-20%	-30%	-32%	-29%	-27%
Goodna Ck	u/s Brisbane R	JINCG	0%	0%	-1%	2%	-1%	0%	0%	0%
Woogaroo Ck	u/s Brisbane R	JIN3M	0%	-8%	-6%	-5%	-6%	-9%	-10%	-13%
Sandy Ck (Carole Park)	u/s Brisbane R	JIN6	-62%	-75%	-75%	-74%	-66%	-63%	-61%	-64%
Brisbane R	Jindalee	JIN-OUT	5%	3%	14%	4%	1%	-6%	-4%	-5%

It would also be expected that the impact of the conceptual storages will vary with flood magnitude.

The differences are relatively small for the Brisbane River as the flows are controlled primarily by the releases from Wivenhoe Dam which are the same in both models, and the flow differences are in a band of +10% to -25%.

For the Bremer River, Warrill Creek and Purga Creek and the minor tributaries, the differences typically range from about +40% to -30%. The greatest differences were found with Sandy Creek (Camira/Carole Park) in which all the flows were lower in the hydraulic model by 60% to 75% of the RAFTS estimates. There were no conceptual storages in this and other minor catchments in the RAFTS model and this accounts for the overestimation of total flows in the RAFTS model.

The peak flows from the MIKE 11 model, which are based on the RAFTS upstream and local flows, give more reliable estimates of total flows than those from the RAFTS model and the values in **Table 7** (and **Appendix G**) should be used.

4.2 Sensitivity Testing

The sensitivity of the results has been tested, for 100 year ARI only in respect of the following uncertainties in the hydraulic modelling:

- Hydraulic roughness:
- Design flows including potential climate change impacts;
- The downstream boundary condition; and
- Storm surge and tide including potential climate change impacts;

These uncertainties were tested by running the model with variations in each of these parameters, within a range considered to be reasonable, and the results are presented in this section. More limited sensitivity testing was carried out for 20 year ARI.

Table 9 shows the results of these tests for the key locations listed in **Table 6**.

4.2.1 Hydraulic Roughness

As discussed in Sargent Consulting (2006c), in order to develop a single roughness parameter data file, it was necessary to use a composite approach to develop a compromise between the roughness parameters obtained from fitting the 1974 major flood and the minor floods of 1996, 1989 and 1983. This compromise was based on varying the hydraulic roughness with the flood level.

As discussed in Sargent Consulting (2006c), this difference may be due to: physical changes in the river geometry since the 1974 flood; hydrologic errors in the model; or to schematisation issues, but in the absence of further investigation in this regard, the compromise approach has been adopted. This is discussed further in sections 2.3, and hereof.

In order to quantify the scale of this impact the 100 year ARI runs were repeated using the roughness values required to calibrate to the 1974 and 1996 events.

Table 9 Sensitivity Test Results at Key Locations

Watercourse	Location	Chainage	Estimated Peak Water Level (m AHD) and difference in level (m) for 100 Year ARI										
		m	Design (Composite n) m AHD	1974 n m AHD	Difference m	1996 n m AHD	Difference m	D/s Boundary BOM rating m AHD	Difference m	Flows +25% m AHD	Difference m	with 2.5m surge m AHD	Difference m
Brisbane River	Mt. Crosby	988160	22.73	23.92	1.19	21.92	-0.81	22.53	-0.20	24.91	2.18	22.73	0.00
	Moggill	1006300	14.98	15.99	1.01	13.33	-1.65	14.26	-0.72	17.19	2.21	15.00	0.02
	Goodna	1014610	13.55	14.54	0.99	12.56	-0.99	12.71	-0.84	15.70	2.15	13.60	0.05
	Jindalee	1028680	10.36	10.54	0.18	11.10	0.74	9.23	-1.13	11.86	1.50	10.51	0.15
Bremer River	One Mile Bridge	1004590	20.74	23.60	2.86	17.57	-3.17	20.42	-0.32	22.29	1.55	20.74	0.00
	Wulkeraka Bridge	1006490	19.28	22.28	3.00	15.97	-3.31	18.82	-0.46	21.04	1.76	19.28	0.00
	Hancock Bridge	1008390	17.99	20.86	2.87	15.32	-2.67	17.50	-0.49	19.63	1.64	17.99	0.00
	David Trumpy Bridge	1012050	15.28	17.24	1.96	13.64	-1.64	14.56	-0.72	17.54	2.26	15.29	0.01
	Bundamba Creek	1020450	15.23	16.63	1.40	13.50	-1.73	14.50	-0.73	17.50	2.27	15.25	0.02
Bremer River (Mid)	Rosewood	11478	40.59	41.98	1.39	39.94	-0.65	40.49	-0.10	41.32	0.73	40.59	0.00
	Walloon	23968	26.20	28.46	2.26	25.75	-0.45	26.19	-0.01	26.96	0.76	26.20	0.00
	Three Mile Bridge	29515	23.57	25.41	1.84	21.85	-1.72	23.51	-0.06	24.38	0.81	23.57	0.00
Bremer River (Upper)	Adams Bridge	16506	81.16	81.46	0.30	81.11	-0.05	80.99	-0.17	81.19	0.03	81.16	0.00
	Stokes Crossing	23829	63.77	64.21	0.44	63.47	-0.30	63.41	-0.36	63.80	0.03	63.77	0.00
Bundamba Creek	Ripley	16395	57.47	57.73	0.26	53.91	-3.56	57.47	0.00	57.53	0.06	57.47	0.00
	Cunningham Highway	28480	26.70	26.93	0.23	27.07	0.37	26.70	0.00	26.73	0.03	26.70	0.00
	Blackstone Road	31980	21.84	22.31	0.47	21.58	-0.26	21.87	0.03	22.32	0.48	21.84	0.00
	Brisbane Road	34305	18.05	18.00	-0.05	18.79	0.74	18.08	0.03	18.38	0.33	18.05	0.00
	Gledson Road	36005	15.24	16.68	1.44	14.51	-0.73	17.50	2.26	18.14	2.90	15.24	0.00
Goodna Creek	Duncan St	12020	15.32	15.32	0.00	15.39	0.07	16.13	0.81	16.46	1.14	15.32	0.00
	Brisbane Road	14155	13.94	14.95	1.01	12.94	-1.00	14.37	0.43	16.46	2.52	13.94	0.00
	U/s Brisbane Terrace	14735	13.94	14.95	1.01	12.94	-1.00	14.37	0.43	16.46	2.52	13.94	0.00
Purga Creek	Peak Crossing	2986	48.94	48.94	0.00	48.95	0.01	48.94	0.00	49.22	0.28	48.94	0.00
	Loamside	15309	27.65	27.39	-0.26	28.11	0.46	27.45	-0.20	28.09	0.44	27.65	0.00
Western Ck	Kuss Rd	9772	55.99	56.20	0.21	57.03	1.04	55.99	0.00	56.02	0.03	55.99	0.00
Warrill Creek	Harrisville	4779	52.24	52.13	-0.11	53.47	1.23	52.24	0.00	52.26	0.02	52.24	0.00
	Amberley	25710	27.04	30.43	3.39	26.62	-0.42	27.04	0.00	27.21	0.17	27.04	0.00
Warrill Creek (Upper)	Kalbar	19442	77.42	77.45	0.03	80.72	3.30	77.42	0.00	77.64	0.22	77.42	0.00
Woogaroo Creek	Parker St	15800	13.55	14.54	0.99	12.56	-0.99	12.71	-0.84	15.70	2.15	13.55	0.00
	Edna St	15860	13.55	14.54	0.99	12.56	-0.99	12.71	-0.84	15.70	2.15	13.55	0.00
	Brisbane Rd	17370	13.55	14.54	0.99	12.56	-0.99	12.71	-0.84	15.70	2.15	13.55	0.00
	Brisbane Terrace	17760	13.55	14.54	0.99	12.56	-0.99	12.71	-0.84	15.70	2.15	13.55	0.00

These results as given in **Table 9** show that:

- With the 1974 roughness values 100 year ARI flood levels were, in round figures:
  - about 1m higher in the Ipswich reach of the Brisbane River;
  - 1.4 to 3m higher in the Bremer River downstream of Rosewood;
  - 3.4m higher in Warrill Creek at Amberley; and
  - 0.3m lower in Purga Creek at Loamside.

- With the 1996 roughness values 100 year ARI flood levels were, in round figures:
  - about 1m to 1.6m lower in the Ipswich reach of the Brisbane River;
  - 1.6 to 3.3m lower in the Bremer River downstream of Rosewood;
  - 0.4m lower in Warrill Creek at Amberley; and
  - 0.5m higher in Purga Creek at Loamside.

4.2.2 Flow Inputs

The best available guide to the likely scale of errors in peak flow estimation in the Brisbane River catchment is given in Sargent Consulting (2006a) in which *"Monte Carlo"* simulation was used to test the variation in individual estimates of flows in the catchment. Although limited to consideration of the 100 year ARI flows only, this gave a useful insight into the likely range of values. Using the 90% confidence band values given in Sargent Consulting (2006a) at key locations, these were converted to percentage variation from the central estimates, and these values are given in **Table 10.**

Table 10 90% Confidence Limits in Estimation of 100 Year ARI Peak Flows

Location	Percentage Variation from Best Estimate Peak Flow	
	Lower Limit	Upper Limit
Brisbane River at Savages Crossing	-44%	+55%
Brisbane River at Moggill and Port Office	-33%	+33%
Bremer River at Walloon	-25%	+25%
Warrill Creek at Amberley	-27%	+22%
Bremer River at Ipswich	-23%	+20%
MEDIAN	**-27%**	**+25%**
NOTE: Source – Sargent Consulting 2006a for post-dam conditions		

The median upper limit value from this table of +25% was used as the basis of the sensitivity test. This was modelled by factoring all flow inputs by 1.25, giving the results in **Table 9.**

These results indicate increases in 100 Year ARI flood levels, in round figures, of:

- 2.2m in the Ipswich reach of the Brisbane River;
- 1.5m to 2.3m in the Bremer River downstream of One Mile Bridge;
- 0.7m to 0.8m in the Bremer River between Rosewood and One Mile Bridge reducing to near zero at Adams Bridge; and
- Less than 0.2m in Warrill Creek.

Design flows are also sensitive to the potential impacts of climate change. There is no firm guidance at present regarding the likely impact of climate change on flood flows.

CSIRO (2006), in its summary of likely climate change in South East Queensland to 2030, cites an increase in 20 year ARI rainfall in the range 0 to 30%. The high end of this range is equivalent to what is now a 50 Year ARI rainfall. No figures are given for 100 year ARI rainfall but applying an increase of 30% would mean that what is now a 500 Year ARI rainfall would become the 100 year ARI rainfall. These are very significant changes over only a few decades.

If these changes in rainfalls occurred, other things being equal, there would be a similar change in flow frequency i.e. a current 50 year ARI flow will be the new 20 year ARI flow and extending this to the higher flows, the current 500 year ARI flow may become the new 100 year ARI flow.

The impact of this on flood levels can be seen by the differences between these events with current ARI estimates in **Table 6**. Statistics of these differences are given in **Table 11** which show median increases of 1.4m for 20 year ARI and of 1.6m for 100 year ARI.

4.2.3 Downstream Boundary Condition

It was decided to locate the downstream boundary of the model at Jindalee for the following reasons:

- This location was expected to be sufficiently far downstream of the Ipswich/Brisbane local government boundary that uncertainties in the boundary condition would have little or no effect within Ipswich;
- The location is one at which at least some historic flood records were available for model calibration; and
- To avoid additional uncertainties resulting from including the Brisbane River downstream of Jindalee in the model.

The downstream boundary condition of the model was set as a stage – discharge rating curve which was derived from the calibration runs for the 1974 and 1996 floods Sargent Consulting 2006c). The Bureau of Meteorology (BOM) also has derived a rating curve for Jindalee based on their URBS modelling. The latter is derived from the statistical fitting of a hydrologic model is less physically realistic than that derived from the hydraulic model. However, the BOM rating curve represents a reasonable alternative curve with which to test the sensitivity of the model results.

Figure 39 shows the MIKE 11 and BOM rating curves for Jindalee. It can be seen from **Figure 39** that, except for very high and very low discharges, for a given discharge at Jindalee, the BOM curve has a lower water level, this difference being as high as 1.8m for flows of 3,000m^3/s to 4,000m^3/s. Jindalee is some 14km downstream of the Ipswich/Brisbane local government boundary at Goodna, so the levels at Goodna and upstream were not expected to be unduly influenced by that at Goodna.

The extent of this influence was determined by re-running the critical duration event for the Bremer and Brisbane Rivers for using the BOM rating curve as the downstream boundary and determining the upstream extent of the difference in levels.

River levels at Jindalee are influenced by tidal variations, but this is not taken account of using the stage – discharge rating curve. The tidal effect is at largely damped out during a major flood event. The sensitivity of the results to tidal fluctuation is taken considered in **Section 4.2.4** hereof.

It can be seen from the results given in **Table 9** that using the BOM rating curve for Jindalee resulted in the following differences to the 100 year ARI estimated flood levels:

- 0.2m to 0.8m lower in the Ipswich reach of the Brisbane River;
- 0.3m to 0.7m lower in the Bremer River downstream of One Mile Bridge;
- Zero to 0.1m lower in the Bremer River between Rosewood and One Mile Bridge; and
- No discernable difference in Warrill Creek.

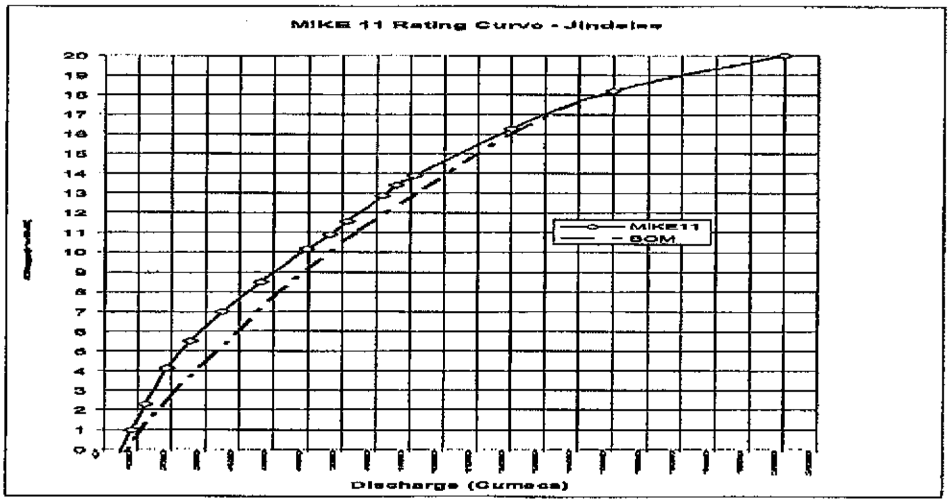


Figure 39 Stage Discharge Rating Curves for Jindalee

4.2.4 Storm Surge plus Tide and Greenhouse Effect

The most recent advice in s regard to design values of storm surge plus tide (known as storm tide) for southeast Queensland is given by DNRM et al (2004) which quotes a 100 year ARI storm surge plus tide of 1.44m AHD at Nudgee Beach, increasing to 1.89m AHD when predicted *Greenhouse Effect* impacts are included. The corresponding 500 year ARI values are 1.75m and 2.46m AHD respectively.

These figures compare to a 100 year ARI storm surge level at the Western Inner Bar of the Brisbane River of 2.14m AHD adopted in SKM (2000) and a corresponding value with *Greenhouse Effect* of 2.50m AHD.

The values adopted in SKM (2000) have been used herein as they are more conservative and provide a direct comparison.

These values were incorporated into the model by separate runs of the Brisbane River model downstream of Jindalee using the 100 year storm surge values as the downstream boundary condition, together with the 100 year Jindalee flows from the current study, and adopting the 1974 calibration roughness values.

This ignored the flows from the tributaries downstream of Jindalee. However, this is regarded as satisfactory for the current purpose of sensitivity testing, especially as these tributaries do not make a significant contribution to the peak flow in the lower Brisbane River.

The modelled water level hydrograph at Jindalee was then applied as the downstream hydrograph to the 100 year, 72 hour storm Ipswich model and the results compared to those from the main design run.

These results (see **Table 9**) show that within Ipswich, the 100 year estimated flood levels are not sensitive to storm surge effects, with a maximum increase in the model results of 0.05m at Goodna, reducing to zero at Mt. Crosby, and a maximum of 0.02m in the Bremer River reducing to zero at and upstream of Hancock Bridge. This is consistent with the findings in SKM (2000) in this regard.

4.3 Discussion of Results

The results presented herein are based on the current best estimates of flood hydrology and river hydraulics in the Brisbane/Bremer River system.

Since previous modelling was undertaken, both the hydrologic and hydraulic models have been reviewed and modified to take account of: new design rainfall data; the consensus view on the 100 year ARI design flow in the Brisbane River downstream of Wivenhoe dam; and the correction of a number of identified anomalies.

It should be expected then, that the new estimates are more reliable than the previous estimates. However, there is still considerable uncertainty regarding the accuracy of the estimated flood levels principally as a result of the inability to determine a consistent set of hydraulic parameters which replicate the flood levels observed in floods since 1974.

As discussed in the calibration phase report for this study (Sargent Consulting 2006c) and in **Section 2.2.1** hereof, the new design flow model runs have been based on a composite hydraulic parameter set in which model roughness varies with water level. Whilst this enables a single hydraulic parameter file to be used for the full range of flows tested which satisfactorily replicates the 1974 and 1996 floods, it is acknowledged that this is not physically realistic.

Sargent Consulting (2006c) noted the following possible reasons for the apparent change in model roughness between the smaller and large flood events as:

- Possible physical changes in the river system since 1974;
- Errors introduced by the model structure; and
- Errors in the boundary conditions (hydrologic inputs) to the model.

Sargent Consulting (2006c) concluded that the former was considered most likely to be the major factor in this regard, and recommended an investigation of river widths and cross-section information to see if this could be confirmed.

Whilst it has not been possible within the scope of this study to investigate this in depth, an initial investigation was undertaken in respect of the reach of the Brisbane River upstream and downstream of the Bremer River junction. This investigation is outlined in **Appendix I** and has shown:

- At least for the Brisbane River from about 1.5km upstream of the Bremer River confluence to about 5km downstream, there is evidence of increasing river width since about 1970, with the bulk of the increase occurring between 1970 and 1978;
- There is compelling evidence that dredging operations in the Brisbane River and Bremer River have significantly lowered the river bed levels by about 5m to 10m

between Mount Crosby and the Bremer River confluence and about 10m from the confluence downstream;

- The disappearance of an island downstream of the Six Mile Creek confluence between 1970 and 1978, probably from sand extraction, is further evidence of channel widening/deepening; and

- There is weaker evidence that a significant amount of this bed degradation took place in the mid to late 1970s.

A computational check on a single cross-section, where the widening was typical of the reach investigated, showed that the possible combination of widening and deepening is consistent with the scale of cross-section change needed to replicate the 1974 flood levels with the roughness from the 1996 flood calibration.

It was concluded from this investigation, that there has been significant river channel widening and deepening of the Brisbane River, between 1.5km upstream and 5km downstream of the Bremer River confluence, since about 1970 and that most of this has occurred between 1970 and 1978. As this period includes the 1974 flood, and was also the peak period of dredging activity, it was concluded that the increase in channel capacity over that period is due largely to both of these causes, but it has not been possible to quantify the relative impacts.

Without expanding the investigation to the whole of the model area, it is not possible to confirm whether this reach is typical, although it can reasonably be inferred that the whole of the tidal reaches of the Brisbane and Bremer River have been affected to at least some degree by the dredging operations.

The sensitivity testing outlined in **Section 2.2** hereof has attempted to quantify the uncertainties in the estimated design flood levels, particularly in respect of the 100 year ARI design event

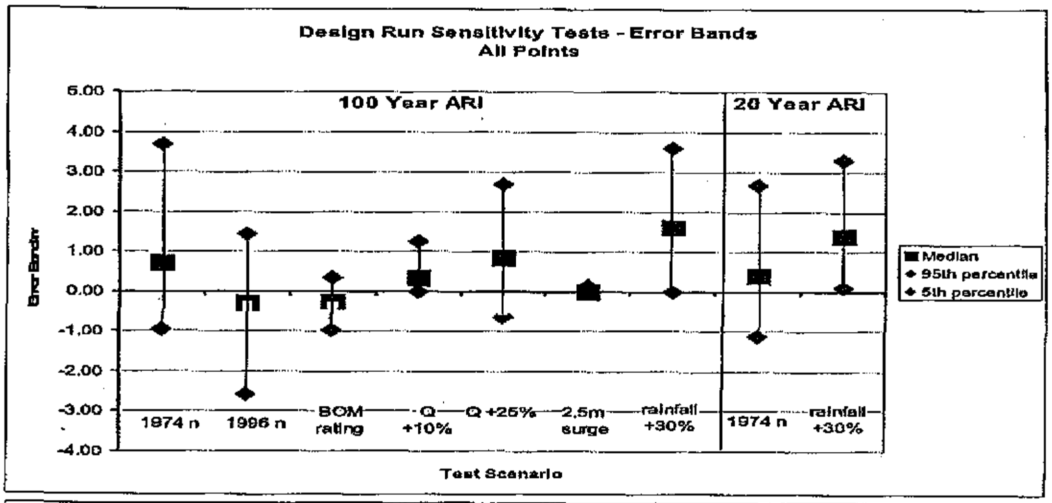
Statistical analysis of the sensitivity test results provides a quantitative estimate of the uncertainty inherent in the results. Statistics are given for the differences between the estimated water level at each cross-section in the sensitivity test and the corresponding value in the design runs. The 5^{th} and 95^{th} percentiles of the distribution of values were estimated assuming that the differences are normally distributed. These statistics are summarised in **Table 11** and illustrated graphically in **Figure 40**. Results are presented for all points in the model and separately for the Brisbane River and Bremer River.

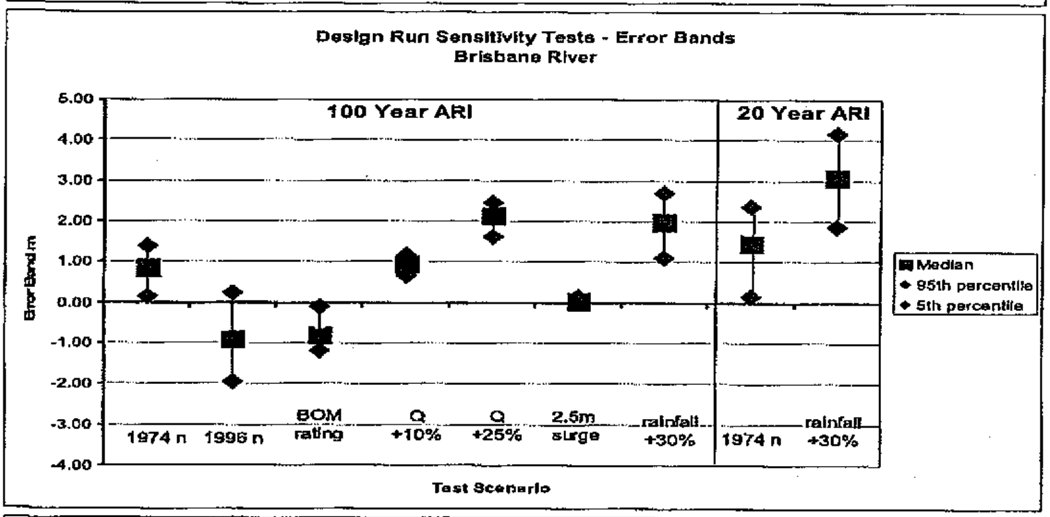
Excluding the climate change scenarios, the median differences for the various tests are about 1m overall and up to 2m for the Brisbane and Bremer Rivers. The climate change scenarios tested increase the median differences to 3m.

These tests do not consider combinations of test scenarios. To do so effectively would require a *Monte Carlo* approach which is outside the scope of work of the current commission.

Table 11 Statistical Summary from Sensitivity Test Results

Model Region and Statistics	Sensitivity Test Statistics (m) for Test Scenarios below								
	100 Year ARI							20 Year ARI	
	1974n	1996n	BOM rating	+10%Q	+25%Q	2.5m surge	Climate change +30% rainfall	1974 n	Climate change +30% rainfall
Whole Model									
Median	0.72	-0.29	-0.26	0.34	0.85	0.00	1.62	0.40	1.40
Standard Deviation	1.12	1.22	0.40	0.47	1.01	0.04	1.22	1.15	1.18
Maximum	6.53	4.97	1.61	3.50	6.34	0.15	6.79	4.99	4.21
Minimum	-1.26	-5.15	-1.14	-0.20	-0.49	-0.31	-0.01	-2.86	0.00
95th percentile	3.68	1.43	0.34	1.25	2.69	0.13	3.60	2.67	3.30
5th percentile	-0.95	-2.57	-0.97	0.00	-0.65	0.07	0.00	-1.12	0.10
Brisbane R									
Median	0.86	-0.92	-0.79	0.95	2.13	0.03	1.98	1.45	3.07
Standard Deviation	0.36	0.66	0.33	0.15	0.26	0.04	0.46	0.67	0.72
Maximum	1.46	0.57	-0.03	1.13	2.98	0.15	2.58	2.43	4.21
Minimum	-0.48	-2.09	-1.14	0.59	1.50	0.00	0.95	-0.23	1.70
95th percentile	1.38	0.24	-0.09	1.16	2.45	0.14	2.70	2.37	4.17
5th percentile	0.15	-1.94	-1.18	0.67	1.61	0.11	1.10	0.15	1.86
Bremer R									
Median	1.84	-1.68	-0.28	0.93	1.55	0.00	2.91	2.05	1.85
Standard Deviation	1.10	1.02	0.29	0.40	0.85	0.02	0.99	0.77	1.09
Maximum	6.53	2.06	0.01	3.41	6.34	0.02	6.79	3.29	3.30
Minimum	-0.13	-3.40	-0.75	0.03	0.18	-0.07	0.51	0.05	0.13
95th percentile	3.89	0.37	0.12	1.36	2.90	0.07	4.45	3.06	3.65
5th percentile	0.36	-3.00	-0.85	0.04	0.10	0.03	1.20	0.51	0.07





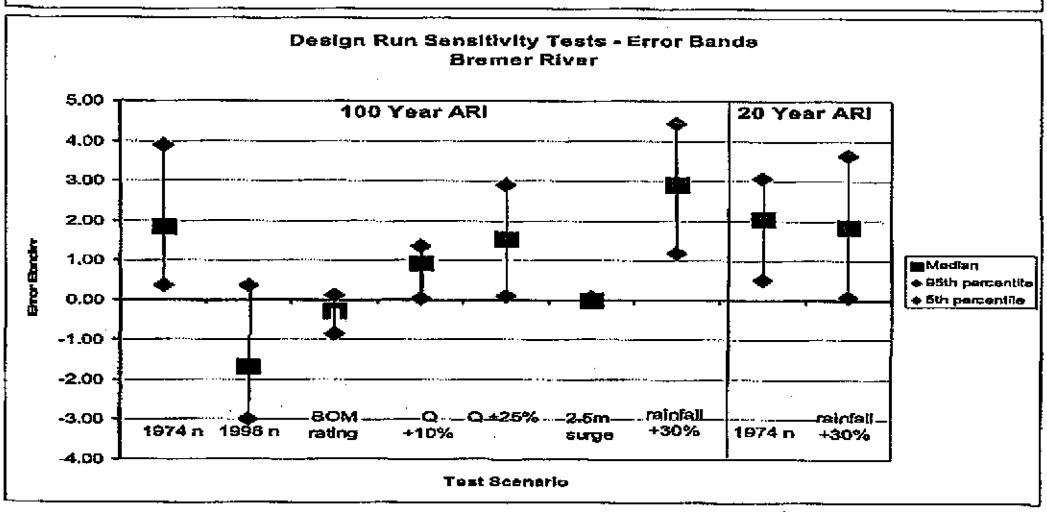


Figure 40 Box – Whisker Plots for Sensitivity Tests

5 Comparison with Previous Flood Level Estimates

Previous flood level estimates are available from Phases 2 and 3 of the Ipswich Rivers Flood Study (SKM 2000 and KBR 2002 respectively). In addition, estimates for the 20 year ARI flood are available from the maps produced at the time of former City Engineer, Mr. Bob Gamble, referred to herein as the *Gamble* maps.

A summary of design peak flood levels at key locations from the previous Ipswich Rivers Flood Study (SKM (2000) for the Ipswich urban area (downstream of Three Mile Bridge) and from KBR (2002) for the upper catchment (upstream of Three Mile Bridge)) is given in **Table 12. Table 13** compares the corresponding values from the current study and from the previous study. Where the interim flood layer in the current Ipswich Town Plan is based on the previous 50 year ARI flood level maps as an estimator of the current 100 year ARI levels, the new 100 year ARI estimates are also compared to the previous 50 year ARI estimates in **Table 13.**

At a few locations, estimates of flood levels were available from both the previous studies, and these have also been included in **Table 13.**

Table 14 compares the 20 year ARI flood level estimates from the current study with those from the *Gamble* maps and from the Ipswich Rivers Flood Study. The values from the Gamble maps have been taken from Sargent Consulting (2002b).

The following observations were drawn from these tables:

- For the Brisbane River, the new estimates are generally lower than the previous estimates, except for ARIs of 10 years and less. The higher levels for the low ARIs reflect the increase in design flows for these events. The reduced levels for higher ARIs reflect both the reduction in peak flows e.g. 100 year ARI at Savages Crossing reduced from 8,800m^3/s to 6,000m^3/s; and the composite roughness (which is generally less than that for the 1974 flood calibration which was used for the previous design flow estimates). The new estimates are 2.5m lower at Goodna, 3.2m lower at Moggill and 6.4m lower at Mt. Crosby compared to the IRFS values for 20 year ARI; and 0.5m at Goodna and 3.0m and Moggill compared the *Gamble* maps. For 100 year ARI, the new estimates are 3.2m lower at Goodna, 3.3m lower at Moggill, and 4.9m lower at Mt. Crosby than those from the IRFS.

- For the lower Bremer River, the new estimates are lower than the previous estimates for all ARIs investigated. These reductions in level were greatest for 20 year ARI being over 5m lower at One Mile Bridge, Wulkuraka Bridge and Hancock Bridge, 3.7m lower at Ipswich (David Trumpy Bridge) and 3.2m lower at the confluence with Bundamba Creek compared to the IRFS estimates. The new estimates have smaller differences compared to the 20 year ARI estimates in the *Gamble* maps, being 0.44m lower at One Mile Bridge, 1.6m – 2.0m lower at Wulkuraka Bridge, 0.25m – 0.7m lower at Hancock bridge, 2.1m lower at Ipswich (David Trumpy Bridge) and 2.7m lower at the confluence with Bundamba Creek. For 100 year ARI, the new estimates are 3.1m to 4.1m lower than those from the IRFS.

Table 12 Flood Level Estimates at Key Locations from Ipswich Rivers Flood Study (Sources SKM 2000, KBR 2002)

Watercourse	Location	Chainage	Difference in Estimated Peak Water Level (m) between current study and IRFS Phases 2 & 3 for ARI								New 100 yr - previous 50 yr
		m	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years	
Brisbane River	Mt. Crosby	988160	0.30	0.01	-0.84	-6.39	-4.89	-4.38	-4.28	-4.42	-2.05
	Moggill	1006300	-0.04	1.49	1.20	-3.20	-2.71	-3.28	-3.36	-3.08	-1.21
	Goodna	1014610	0.31	1.68	1.84	-2.52	-2.46	-3.15	-3.27	-3.02	-1.13
	Jindalee	1028680	0.77	2.43	2.91	-0.84	-1.50	-2.42	-2.83	-2.86	-0.64
Bremer River	One Mile Bridge	1004590	-3.33	-3.92	-4.34	-5.16	-5.19	-3.73	-4.06	-3.24	-2.14
	Wulkuraka Bridge	1006490	-3.39	-3.54	-4.62	-5.61	-5.39	-4.02	-4.09	-3.53	-2.44
	Hancock Bridge	1008390	-3.08	-3.17	-4.21	-5.12	-4.95	-4.06	-3.97	-3.47	-2.50
	David Trumpy Bridge	1012050	-2.13	-2.38	-2.81	-3.72	-2.85	-3.32	-2.94	-2.51	-1.66
	Bundamba Creek	1020450	-2.52	-2.21	-2.32	-3.21	-2.38	-3.07	-3.00	-2.59	-1.04
Bremer River (Mid)	Rosewood	11478	0.36	0.46	0.35	0.20	-0.17	0.55	0.97	2.21	0.99
	Walloon	23968	1.57	2.25	1.78	1.38	0.64	-0.30	-1.65	0.32	0.87
	Three Mile Bridge (SKM)	100000	-1.34	-1.65	-2.64	-3.80	-4.00	-3.60	-4.20	-3.74	-2.16
	Three Mile Bridge (KBR)	29515	-0.08	0.01	-0.53	-0.79	-1.32	-1.13	-3.88	-2.43	N/A
Bremer River (Upper)	Adams Bridge	16506	0.05	0.58	0.22	-0.03	-0.15	-0.11	-0.43	-0.38	N/A
	Stokes Crossing	23829	0.18	0.50	0.31	0.31	0.10	0.39	-0.67	-0.64	N/A
Bundamba Creek	Ripley	16395	-2.36	-2.13	-2.29	-2.60	-0.57	2.41	1.32	1.12	2.76
	Cunningham Highway	28480	-1.03	-0.24	0.30	0.26	0.27	0.12	-0.33	-0.53	0.40
	Blackstone Road	31980	-0.86	0.06	0.19	0.17	0.45	0.42	0.03	-0.02	0.71
	Brisbane Road	34305	-0.21	1.00	1.08	0.76	0.47	-0.25	-1.42	-2.36	0.58
	Gledson Road	36005	-0.05	1.34	1.45	-0.36	-2.11	-3.06	-2.99	-2.59	-1.04
Goodna Creek	Duncan St	12020	-1.06	-1.48	-1.33	-1.18	-0.57	-1.82	-2.39	-2.96	-0.28
	Brisbane Road	14155	-0.74	-0.63	-0.37	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
	U/s Brisbane Terrace	14735	-1.06	-1.45	0.47	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
Purga Creek	Peak Crossing	2986	0.67	0.46	0.26	0.08	-0.17	-0.34	-0.46	-0.49	N/A
	Loamside	15309	-1.62	-0.77	-0.85	-0.65	-0.55	-0.32	-0.48	-0.76	N/A
Western Ck	Kuss Rd	9772	1.57	2.23	2.31	3.50	3.03	2.81	2.78	3.44	N/A
Warrill Creek	Harrisville	4779	1.03	1.20	1.21	1.05	1.10	1.22	0.50	0.37	N/A
	Amberley (SKM)	25710	-0.38	0.28	-0.13	-0.76	-1.02	-1.18	-1.36	-2.12	N/A
	Amberley (KBR)	25710	0.41	1.25	1.06	0.02	-0.79	-0.55	-1.86	-1.54	N/A
Warrill Creek (Upper)	Kalbar	19442	-0.71	0.87	0.48	-0.14	-0.25	0.02	-0.35	-0.39	N/A
Woogaroo Creek	Parker St	15800	-1.80	-0.28	-0.13	-1.36	-2.45	-3.16	-3.26	-3.02	-1.13
	Edna St	15860	-1.49	-0.07	-0.02	-1.57	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Rd	17370	-2.27	-1.15	0.58	-2.52	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Terrace	17760	-2.85	-1.56	0.56	-2.52	-2.46	-3.16	-3.27	-3.02	-1.13
		Max	1.57	2.43	2.91	3.50	3.03	2.81	2.78	3.44	2.76
		Min	-3.39	-3.92	-4.62	-6.39	-5.39	-4.38	-4.28	-4.42	-2.50

Table 13 Comparison of Current and Previous Flood Level Estimates at Key Locations

Watercourse	Location	Chainage	Difference in Estimated Peak Water Level (m) between current study and IRFS Phases 2 & 3 for ARI								New 100 yr
		m	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years	- previous 50 yr
Brisbane River	Mt. Crosby	988160	0.30	0.01	-0.84	-6.39	-4.89	-4.38	-4.28	-4.42	-2.05
	Moggill	1006300	-0.04	1.49	1.20	-3.20	-2.71	-3.28	-3.36	-3.08	-1.21
	Goodna	1014610	0.31	1.68	1.84	-2.52	-2.46	-3.15	-3.27	-3.02	-1.13
	Jindalee	1028680	0.77	2.43	2.91	-0.84	-1.50	-2.42	-2.83	-2.86	-0.64
Bremer River	One Mile Bridge	1004590	-3.33	-3.92	-4.34	-5.16	-5.19	-3.73	-4.06	-3.24	-2.14
	Wulkeraka Bridge	1006490	-3.39	-3.54	-4.62	-5.61	-5.39	-4.02	-4.09	-3.53	-2.44
	Hancock Bridge	1008390	-3.08	-3.17	-4.21	-5.12	-4.95	-4.06	-3.97	-3.47	-2.50
	David Trumpy Bridge	1012050	-2.13	-2.38	-2.81	-3.72	-2.85	-3.32	-2.94	-2.51	-1.66
	Bundamba Creek	1020450	-2.52	-2.21	-2.32	-3.21	-2.38	-3.07	-3.00	-2.59	-1.04
Bremer River (Mid)	Rosewood	11478	0.36	0.46	0.35	0.20	-0.17	0.55	0.97	2.21	0.99
	Walloon	23968	1.57	2.25	1.78	1.38	0.64	-0.30	-1.65	0.32	0.87
	Three Mile Bridge (SKM)	100000	-1.34	-1.65	-2.64	-3.80	-4.00	-3.60	-4.20	-3.74	-2.16
	Three Mile Bridge (KBR)	29515	-0.08	0.01	-0.53	-0.79	-1.32	-1.13	-3.88	-2.43	0.52
Bremer River (Upper)	Adams Bridge	16506	0.05	0.58	0.22	-0.03	-0.15	-0.11	-0.43	-0.38	0.16
	Stokes Crossing	23829	0.18	0.50	0.31	0.31	0.10	0.39	-0.67	-0.64	0.90
Bundamba Creek	Ripley	16395	-2.36	-2.13	-2.29	-2.60	-0.57	2.41	1.32	1.12	2.76
	Cunningham Highway	28480	-1.03	-0.24	0.30	0.26	0.27	0.12	-0.33	-0.53	0.40
	Blackstone Road	31980	-0.86	0.06	0.19	0.17	0.45	0.42	0.03	-0.02	0.71
	Brisbane Road	34305	-0.21	1.00	1.08	0.76	0.47	-0.25	-1.42	-2.36	0.58
	Gledson Road	36005	-0.05	1.34	1.45	-0.36	-2.11	-3.06	-2.99	-2.59	-1.04
Goodna Creek	Duncan St	12020	-1.06	-1.48	-1.33	-1.18	-0.57	-1.82	-2.39	-2.96	-0.28
	Brisbane Road	14155	-0.74	-0.63	-0.37	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
	U/s Brisbane Terrace	14735	-1.06	-1.45	0.47	-2.66	-2.53	-3.20	-3.28	-2.96	-1.17
Purga Creek	Peak Crossing	2986	0.67	0.46	0.26	0.08	-0.17	-0.34	-0.46	-0.49	-0.17
	Loamside	15309	-1.62	-0.77	-0.65	-0.65	-0.55	-0.32	-0.48	-0.76	-0.08
Western Ck	Kuss Rd	9772	1.57	2.23	2.31	3.50	3.03	2.81	2.78	3.44	3.35
Warrill Creek	Harrisville	4779	1.03	1.20	1.21	1.05	1.10	1.22	0.50	0.37	1.31
	Amberley (SKM)	25710	-0.38	0.28	-0.13	-0.76	-1.02	-1.18	-1.36	-2.12	-0.28
	Amberley (KBR)	25710	0.41	1.25	1.06	0.02	-0.79	-0.55	-1.86	-1.54	-0.05
Warrill Creek (Upper)	Kalbar	19442	-0.71	0.87	0.48	-0.14	-0.25	0.02	-0.35	-0.39	0.39
Woogaroo Creek	Parker St	15800	-1.80	-0.28	-0.13	-1.36	-2.45	-3.16	-3.26	-3.02	-1.13
	Edna St	15860	-1.49	-0.07	-0.02	-1.57	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Rd	17370	-2.27	-1.15	0.58	-2.52	-2.46	-3.16	-3.26	-3.02	-1.13
	Brisbane Terrace	17760	-2.85	-1.56	0.56	-2.52	-2.46	-3.16	-3.27	-3.02	-1.13
		Max	1.57	2.43	2.91	3.50	3.03	2.81	2.78	3.44	3.35
		Min	-3.39	-3.92	-4.62	-6.39	-5.39	-4.38	-4.28	-4.42	-2.50

Table 14 Comparison of Current and Previous Flood Level Estimates for 20 Year ARI at Key Locations

Watercourse	Location	Chainage	Estimated Peak Water Level (m AHD) for 20 Year ARI						
		m	Current Study	SKM (2000)	Difference m	KBR (2000)	Difference m	Gamble Maps	Difference m
Brisbane River	Mt. Crosby	988160	15.70	22.09	-6.39			-	-
	Bremer River confluence	1005870	10.34	13.50	-3.16			13.30	-2.96
	Moggill	1006300	10.30	13.50	-3.20			13.30	-3.00
	Goodna Ck confluence	1012475	9.81	12.47	-2.66			11.00	-1.19
	Woogaroo Ck confluence (Goodna)	1014610	9.52	12.04	-2.52			10.00	-0.48
	Jindalee	1028680	7.80	8.64	-0.84			-	-
Bremer River	Warrill Ck confluence	1000000	19.79	23.81	-4.02	20.70	-0.91	21.00	-1.21
	One Mile Bridge	1004590	15.56	20.72	-5.16			16.00	-0.44
	Wulkeraka Bridge (u/s)	1006490	14.00	19.61	-5.67			16.00	-2.00
	Wulkeraka Bridge (d/s)	1006510	13.94	19.54	-5.67			15.50	-1.56
	Ironpot Ck confluence	1008000	13.50	18.66	-5.16			14.00	-0.50
	Hancock Bridge (u/s)	1008390	13.31	18.43	-5.12			14.00	-0.69
	Hancock Bridge (d/s)	1008420	13.25	18.21	-4.96			13.50	-0.25
	Mihi Ck confluence	1009856	12.45	16.86	-4.41			13.50	-1.05
	David Trumpy Bridge	1012050	11.36	15.08	-3.72			13.50	-2.14
	Bundamba Creek	1020450	10.70	13.91	-3.21			13.40	-2.70
	Brisbane River confluence	1028490	10.34	13.50	-3.16			13.30	-2.96

- For the upper Bremer River, the differences are less but are still significant. At Three Mile Bridge, the new estimate of 20 year ARI flood level is 3.8m lower than that from IRFS Phase 2 but only 0.8m lower than that from IRFS Phase 3. Further upstream the new 20 year ARI estimates are higher than the IRFS estimates by 1.4m at Walloon, 0.2m at Rosewood and 0.3m at Stokes Crossing, reducing to near zero at Adams Bridge. For 100 year ARI, the new estimates are 3.6m and 1.1m lower than the IRFS Phase2 and IRFS Phase 3 estimates respectively, 0.3m lower at Walloon, 0.5m higher at Rosewood, 0.4m higher at Stokes Crossing and 0.4m lower at Adams Crossing.

- For Warrill Creek, the 20 year ARI estimates are 0.8m lower than that from IRFS Phase 2, but the same as that from IRFS Phase 3 at Amberley, 1m higher at Harrisville and 0.1m lower at Kalbar compared to IRFS Phase 2. For 100 year ARI, the new estimates are 1.2m and 0.6m lower at Amberley than the IRFS Phase 2 and Phase 3 estimates respectively, 1.2m higher at Harrisville and the same at Kalbar.

- For Bundamba Creek, the new 20 year ARI estimates are 0.4m lower at Gledson Road, 0.8m higher at Brisbane Road, 0.2m higher at Blackstone Road, 0.3m higher at the Cunningham Highway but 2.6m lower at Ripley. For 100 year ARI, these differences are 3.1m, 0.3m, 0.4m, 0.1m lower and 2.4m higher respectively.

- For Goodna Creek, the new 20 year ARI estimates are 2.7m lower at Brisbane Terrace and at Brisbane Road, and 1.2m lower at Duncan Street. For 100 year ARI, these differences are 3.2m and 1.8m lower respectively.

- For Purga Creek, the new 20 year ARI estimates are 0.7m lower at Loamside and 0.1m higher at Peak Crossing. For 100 year ARI, these differences are 0. lower at both locations.

- For Western Creek at Kuss Road, the new estimates are 1.6m to 3.5m higher across all ARIs with a maximum at 20 year ARI. The 100 year ARI difference is 2.8m higher. However, as pointed out by DHI, the Western Creek part of the model is poorly schematised and results should be treated with caution.

- For Woogaroo Creek, the new 20 year ARI estimates are 2.5m lower at Brisbane Terrace and at Brisbane Road, 1.6m lower at Edna Street and 1.4m lower at Parker Street. For 100 year ARI, these differences are 3.2m at all of these locations due to increased backwater form the Brisbane River.

6 Discussion, Conclusions and Recommendations

The design flood levels and flows presented in this report are the result of upgrading and re-calibrating the hydraulic model together with the use of recently revised design flows (Sargent Consulting 2006b). As such, these estimates are based on the most up to date information available and should supersede previous flood estimates.

However, the re-modelling process has identified that there is still considerable uncertainty in respect of these estimates.

The following paragraphs summarise the advances which have been made since the previous estimates; the scale of the remaining uncertainties and their possible causes; recommendations in respect of using these estimates for planning purposes; and recommendations for further work to reduce the scale of the remaining uncertainties.

6. Discussion

6.1.1 Model Improvements

The following improvements in both the design flow estimates used in this modelling (Sargent Consulting 2006b), and in the hydraulic model (Sargent Consulting 2006c and this report), are all regarded as having improved the accuracy of the new flood estimates compared to previous estimates:

- The design flood flows for the Brisbane River have been reduced from previous estimates and are consistent with the findings and recommendations of the *Independent Review Panel Report* on Brisbane River flood studies (Mein et al 2003);

- The design flood flows for the rest of the catchment i.e. Bremer River catchment and Brisbane River downstream of Wivenhoe Dam, have been re-estimated based on new design rainfall data known as CRC-FORGE (DNRM 2004), together with modifications to the design values of initial loss used in the RAFTS model which has results in improved flow estimates (Sargent Consulting 2006b);

- Review of the MIKE 11 hydraulic model (DHI 2005) and subsequent improvements to the model schematisation including merging of the previous urban and rural are models (from the Ipswich Rivers Flood Study Phases 2 and 3 respectively), hydraulic computations and representation of bridge structures (DHI 2006);

- Recalibration of the MIKE 11 model resulting in a single composite model which can be used across the modelled range of flood events from 2 year to 500 year ARI (Sargent Consulting 2006c).

6.1.2 Uncertainty

The re-modelling process has identified considerable uncertainty which is reflected in the new estimates of design flood levels. These uncertainties are evident in it not being possible to use the same hydraulic roughness parameters to satisfactorily replicate flood levels over the range of historic events available for model calibration, and from the results of the sensitivity tests presented herein.

It is unlikely that the hydraulic roughness would have changed significantly over this period of time, so the apparent change in fitting the model to these events is related either to other physical changes or to systemic problems with the hydrologic and/or hydraulic models.

Uncertainty in estimated flood levels is greater on those tributaries in which no calibration data was available, and in which roughness values have been based on those estimated from elsewhere in the system. These include Deebing Creek, Mihi Creek, Ironpot Creek, Franklinvale Creek and Western Creek.

a) Conclusions from Calibration Phase

In the calibration phase of the study (Sargent Consulting 2006c), the following possible reasons for the anomaly in model roughness between the smaller and large flood events were identified:

- Possible physical changes in the river system since 1974;
- Errors introduced by the model structure; and
- Errors in the boundary conditions (hydrologic inputs) to the model.

Reference should be made to Sargent Consulting (2006c) for a full discussion on these issues, but these are summarised below:

i) Physical Change

It is possible that the 1974 flood, which was the largest experienced in the Brisbane River/Bremer River catchment in the 20th Century, would have resulted in significant erosion which would have increased the flow carrying capacity of the river channels. This is supported by pictorial and anecdotal evidence (A. Underwood pers. comm.).

Also there was substantial dredging in the Brisbane River for much of the 20th Century, which peaked in the 1970s then declined and ceased in 1998. As well as the effect of direct lowering of the river bed by the removal of sand and gravel, dredging can induce bed erosion in both upstream and downstream directions and this may have occurred, and may still be taking place.

The hydraulic model is based on cross-section geometry dating from 1998 and later, so if, in reality, the waterway cross-section area was generally lower in 1974, the model would overestimate the temporary storage and result in lower water levels for a given roughness. In forcing the model to replicate the historic flood levels, this would result in higher than expected roughnesses being required to achieve model fit.

Sensitivity testing indicated that use of roughness values appropriate at the start of the 1974 event, could overestimate peak flood levels at key locations by 2.8m to 3.5m in the Goodna to Moggill reach of the Brisbane River and 3.3m in the lower Bremer River.

ii) Model Structure

The MIKE 11 model has been structured (SKM 2000, KBR 2002, DHI 2006) with cross-sections and chainages following the river channel. During a major flood event in which substantial floodplain flow occurs, there can be a considerable shortening of the effective flowpath length.

If the effective or flowpath distance between sections is overestimated in the model, the water surface slope will be underestimated and the temporary flood storage will be overestimated, again leading to higher roughness being required in the model to compensate for the incorrect distance.

It was concluded that this is a factor in the different apparent roughness values obtained when fitting the much larger 1974 flood event. However, it was not possible to quantify this impact without further refinement of the hydraulic model.

iii) Hydrologic Inputs

If the inflows into a particular branch of the model had been overestimated, this would lead to the roughness required to match historic levels being underestimated and vice versa.

Current best practice is to calibrate the hydrologic and hydraulic models "in tandem" and to test the sensitivity of model outcomes to parameter variation "in tandem". This approach was not possible in this instance, as the calibration of the hydrologic model was undertaken as part of Phase 2 of the Ipswich Rivers Flood Study (SKM 2000) using the RAFTS model, and the flow inputs for the calibration floods have been taken from this previous work.

Limited sensitivity testing of the likely scale of error in the hydrologic inputs showed that the model results are sensitive to these changes resulting in differences in peak flood levels, all other factors remaining as before, of the order of 0.6m to 3m in the Bremer River; 0.9 to 1.9m in Warrill Creek; 0.9 to 1.1m in Purga Creek; and up to 0.6m in Brisbane River (even though no changes to Brisbane River flows were included in the test).

b) Design Phase Sensitivity Testing

Sensitivity testing undertaken in the design phase has confirmed that model results are sensitive to: changes in waterway geometry which impact on the apparent hydraulic roughness required for replication of historic flood levels; possible errors in flood flow estimates; limitations in the schematisation of the model; and to the potential impact of climate change on design rainfalls.

The sensitivity testing has also shown that flood levels in Ipswich are insensitive to storm surge levels, within current estimates, including allowance for climate change impacts; and have low sensitivity to the adopted stage – discharge rating curve at Jindalee.

The median values of changes in flood levels from the sensitivity tests are given in **Table 10.** For 100 year ARI, these are an increase of 0.7m with the 1974 roughness from the 1974 flood; a decrease of -0.3m using the 1996 roughness calibration; increases of 0.3m and 0.9m for flow increases of 10% and 25% respectively; zero change for 2.5m surge; and a decrease of 0.3m using an alternative rating curve at Jindalee.

Median values were higher for the Brisbane River and Bremer River parts of the modelled system as shown in **Table 10.** Individual cross-section values range by greater amounts as shown by the 5^{th} and 95^{th} percentile values in **Table 10** with the highest 95% values being 3.7m.

A further test for 20 year ARI for the hydraulic roughness anomaly produced an overall median increase of 0.4m compared to 0.7m for the 100 year ARI test.

Design flows are sensitive to the potential impacts of climate change. There is no firm guidance at present regarding the likely impact of climate change on flood flows. CSIRO (2006), in its summary of likely climate change in South East Queensland to 2030, cites an increase in 20 year ARI rainfall in the range 0 to 30%. The high end of this range is equivalent to what is now a 50 Year ARI rainfall. No figures are given for 100 year ARI rainfall but applying an increase of 30% would mean that what is now a 500 Year ARI rainfall would become the 100 year ARI rainfall. These are very significant changes over only a few decades.

If these changes in rainfalls occurred, other things being equal, there would be a similar change in flow frequency i.e. a current 50 year ARI flow will be the new 20 year ARI flow and extending this to the higher flows, the current 500 year ARI flow may become the new 100 year ARI flow.

Sensitivity testing for this scenario resulted in median increases in flood levels of 1.4m for 20 year ARI and 1.6m for 100 year ARI.

c) **Initial Investigation into Physical Changes**

Whilst it has not been possible within the scope of this study to investigate the scale and impact of physical changes in the river system in detail, the scope of work was widened to include an initial investigation in respect of the reach of the Brisbane River upstream and downstream of the Bremer River junction. This investigation, outlined in **Appendix I** has shown:

- At least for the Brisbane River from about 1.5km upstream of the Bremer River confluence to about 5km downstream, there is evidence of increasing river width since about 1970, with the bulk of the increase occurring between 1970 and 1978;
- There is compelling evidence that dredging operations in the Brisbane River and Bremer River have significantly lowered the river bed levels by about 5m to 10m between Mount Crosby and the Bremer River confluence and about 10m from the confluence downstream;
- The disappearance of an island downstream of the Six Mile Creek confluence between 1970 and 1978, probably from sand extraction, is further evidence of channel widening/deepening; and
- There is weaker evidence that a significant amount of this bed degradation took place in the mid to late 1970s.

A computational check on a single cross-section, where the widening was typical of the reach investigated, showed that the possible combination of widening and deepening is consistent with the scale of cross-section change needed to replicate the 1974 flood levels with the roughness from the 1996 flood calibration.

It was concluded from this investigation, that there has been significant river channel widening and deepening of the Brisbane River, between 1.5km upstream and 5km downstream of the Bremer River confluence, since about 1970 and that most of this has occurred between 1970 and 1978. As this period includes the 1974 flood, and was also the peak period of dredging activity, it was concluded that the increase in channel capacity over that period is due primarily to both of these causes, but it has not been possible to identify the relative impacts. It is not possible to confirm whether this reach is typical without expanding the investigation to the whole of the model area.

Based on the conclusions of this brief investigation into physical channel change, and assuming these are typical at least of the Brisbane River and lower Bremer River, it is now considered that the 1974 calibration roughness values are not appropriate and that flood levels are unlikely to be underestimated to this degree.

6.2 Conclusions

All hydrologic and hydraulic analysis and modelling contain uncertainties: these can be related to natural variability in hydrologic processes; modelling uncertainties which recognise that no model can fully represent the real world response to rainfall on the catchment; potential climate change impacts; and knowledge uncertainty which reflects errors in the data used and in assumptions made in the model.

This study has attempted to identify these uncertainties, which should be taken account of in using the results of this study for town planning and infrastructure design purposes.

Sensitivity testing undertaken in the design phase has confirmed that model results are sensitive to: changes in waterway geometry which impact on the apparent hydraulic roughness required for replication of historic flood levels; possible errors in flood flow estimates; limitations in the schematisation of the model; and to the potential impact of climate change on design rainfalls.

The sensitivity testing has also shown that flood levels in Ipswich are insensitive to storm surge levels, within current estimates, including allowance for climate change impacts; and have low sensitivity to the adopted stage – discharge rating curve at Jindalee.

Whilst the sensitivity test results presented herein go some way to quantifying the major uncertainties, it would require a *Monte Carlo* simulation approach, which is outside the scope of the current study, to provide further quantification of the uncertainties.

In summary, the study has concluded that:

- The new design flood levels represent improved estimates as they reflect recent upgrades in design rainfalls, recent re-modelling of design flows and significant upgrades to the hydraulic model;
- Notwithstanding the above statement, the study has shown that there is considerable residual uncertainty in the design flood levels estimates which should be taken into account when establishing flood levels for town planning and infrastructure design;
- A number of conclusions were drawn from the initial investigation of physical change to the width and depth of the Brisbane River in the vicinity of its confluence with the Bremer River. These were:
  - Confirmation that both deepening and widening have occurred in that reach particularly between 1970 and 1978 which period encompasses both the peak of dredging activities and the 1974 flood;

- The conclusion that both of these effects have increased the flow carrying capacity of the Brisbane River in this reach;
- Indications that the scale of these changes is commensurate with that required to rectify the anomaly in calibrating the hydraulic model to the 1974 flood and to later events;
- That it is reasonable to infer that the impacts of dredging affect all of the tidal reaches of the Bremer and Brisbane Rivers in a similar fashion, although it is not possible to quantify this impact without further work;
- That it was not possible to differentiate between the relative effects of the 1974 flood and dredging on the widening and deepening observed in the reach investigated; and
- That, if the findings of this initial investigation were confirmed to be applicable to the whole of the modelled area, the roughness parameters obtained by calibrating to the 1974 flood levels with the more recent cross-section data would not be representative of current conditions.

6.3 Recommendations

6.3.1 Uncertainty Allowance

Having considered the results from the various sensitivity tests undertaken, it is clear that there is considerable uncertainty regarding the estimated design flood levels.

It is important that this uncertainty be recognised in the flood levels that Ipswich City Council adopts for town planning and infrastructure design purposes. This should be recognised by adding an *uncertainty allowance* to the estimated flood levels.

Leaving aside possible impacts of climate change over the next few decades, it is recommended that, to make a reasonable allowance for this uncertainty, the 100 year and 20 year ARI design flood estimates have an *uncertainty allowance* of 1m to 2m added to them.

If possible climate change impacts are taken into account; it would be prudent to add a further 1m to the *uncertainty allowance*.

6.3.2 Recommendations for Further Work

The following additional work is recommended in order to reduce the uncertainties remaining in the model results:

- Re-schematisation of parts of the MIKE 11 model to better represent floodplain storage in areas in which floodplain flowpath length is significantly reduced;
- Re-schematisation of Western Creek, the current schematisation of which is unrealistic and causes numerical stability problems in the model;
- Review of the schematisation of sections of the model where calibration errors were excessive;

- Re-estimation of design flows using the Bureau of Meteorology's URBS model and CRC-FORGE design rainfalls;
- Extension of the investigation into physical changes in the river channel for the whole model area, with a view to estimating cross-sections prior to the 1974 flood; re-calibrating the model with the 1974 flood and revised cross-sections, when it would be expected that there will be improved agreement between 1974 and 1996 calibrations allowing the uncertainty in hydraulic roughness parameters to be considerably reduced. *More detail of the scope of this work is given in* **Appendix I**;
- Re-estimation of design flood levels on the basis of the revised flows and hydraulic parameters; and
- Uncertainty analysis using a *Monte Carlo* approach to estimate the distribution of uncertainties and hence to better quantify the uncertainties.

7 References

Davie P., Stock E., & Choy D.L. (eds.) (1990) *The Brisbane River – A Source Book for the Future* Australian Littoral Society in association with the Queensland Museum

BUREAU OF METEOROLOGY (1974) *Brisbane Floods January 1974*

CSIRO (2006) *Climate Change Scenarios for Initial Assessment of Risk in Accordance with Risk Management Guidance* prepared for the Australian Greenhouse Office, Department of Environment & Heritage, Canberra

DEPARTMENT OF NATURAL RESOURCES AND MINES, DEPARTMENT OF EMERGENCY SERVICES AND ENVIRONEMNTAL PROTECTION AGENCY (2004) *Queensland Climate Change and Community Vulnerability to Tropical Cyclones – Ocean Hazards Assessment Stage 3 Report – Surge Plus Tide Statistics for Selected Open Coast Locations along the Queensland East Coast*

DEPARTMENT OF NATURAL RESOURCES AND MINES (2005) Extreme Rainfall Estimation Project - CRCFORGE and (CRC) ARF Techniques - Queensland and Border Locations - Development and Application - Final Report

DHI WATER & ENVIRONMENT (2005) *MIKE 11 Model Review Ipswich Rivers – Final Report* prepared for Ipswich City Council

DHI WATER & ENVIRONMENT (2006) *Ipswich River MIKE 11 Model Upgrade – Final Report* prepared for Ipswich City Council

HALLIBURTON KBR (2002) *Ipswich Rivers Flood Study Phase 3 - Final Report* prepared for Ipswich City Council

MEIN R, APELT C, MACINTOSH J, WEINMANN E (2003) *Review of Brisbane River Flood Study – Independent Review Panel Report* prepared for Brisbane City Council

SARGENT CONSULTING (2002a) *Brief Review of Flood Frequency Analysis and Discharge Rating Curve for Brisbane River at Moggill Gauge* prepared for Ipswich City Council

SARGENT CONSULTING (2002b) *Composite Mapping for 20 Year ARI – Review and Recommendations* prepared for Ipswich City Council

SARGENT CONSULTING (2003) *Brief Review of Flood Frequency Analysis and Discharge Rating Curve for Brisbane River at Moggill Gauge* prepared for Ipswich City Council

SARGENT CONSULTING (2006a) *Ipswich Rivers Flood Study Rationalisation Project - Phase 3 "Monte Carlo" Analysis of Design Flows - Final Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

SARGENT CONSULTING (2006b) *Ipswich Rivers Flood Study Rationalisation Project Phase 3 Re-estimation of Design Flows – Final Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

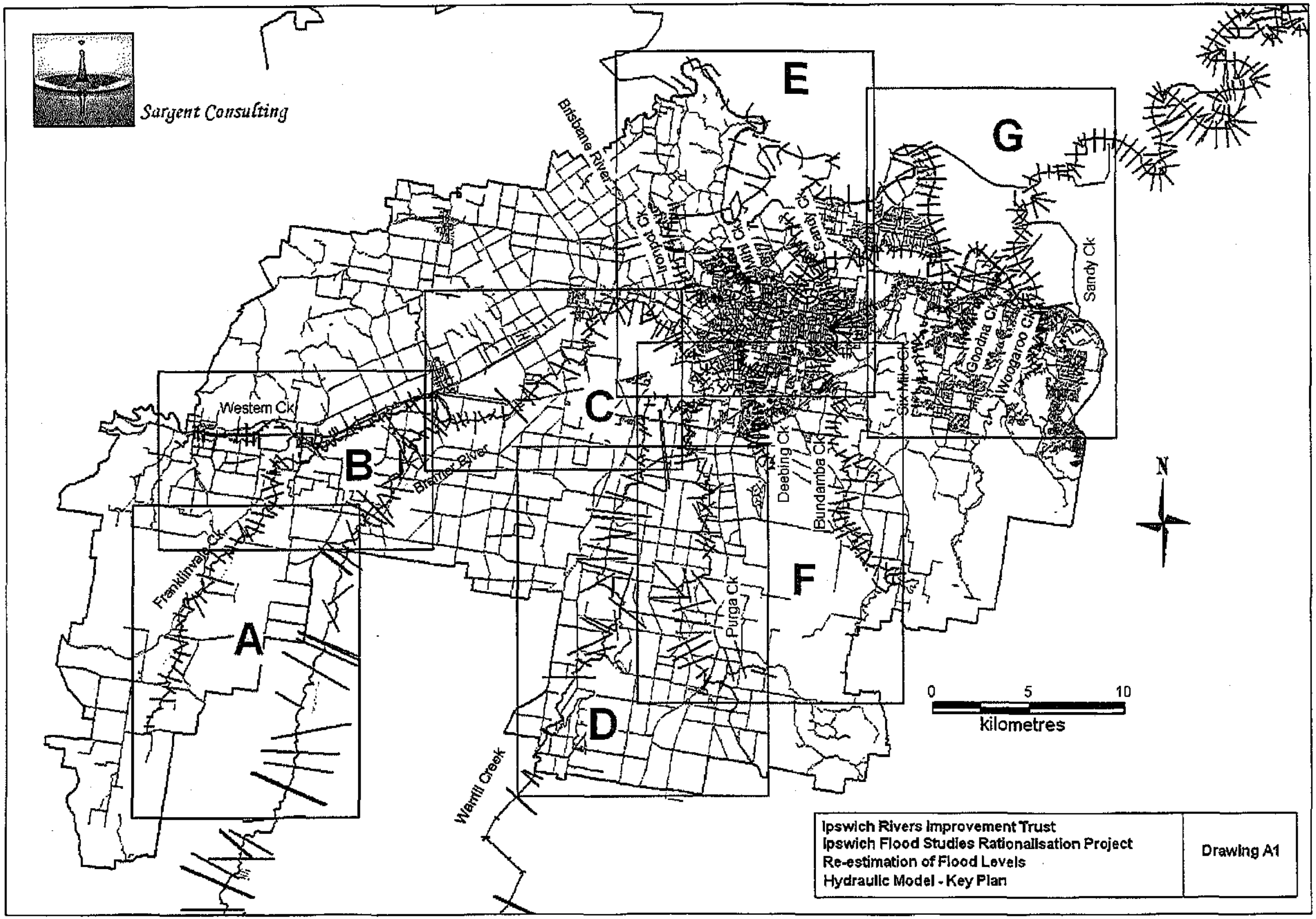
SARGENT CONSULTING (2006c) *Ipswich Rivers Flood Study Rationalisation Project Phase 3 Re-estimation of Design Flood Levels – Hydraulic Model Calibration Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

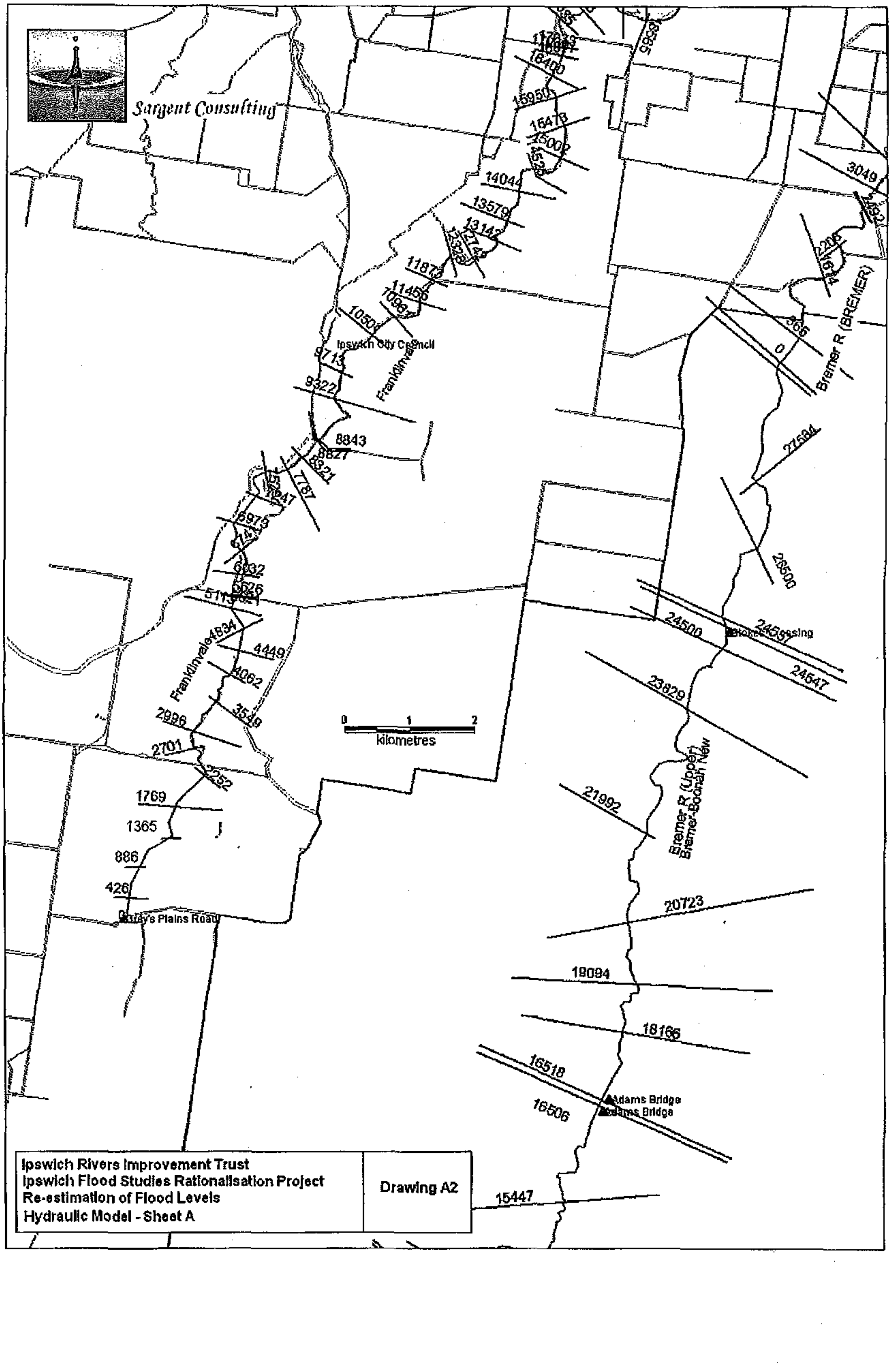
SARGENT CONSULTING (2006d) *Ipswich Rivers Flood Study Rationalisation Project Phase 3 Re-estimation of Design Flood Levels – Hydraulic Model Calibration Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

SINCLAIR KNIGHT MERZ (2000) *Ipswich Rivers Flood Study Phase 1 & Phase 2 - Final Report* prepared for Ipswich Rivers Improvement Trust in association with Ipswich City Council

Appendices

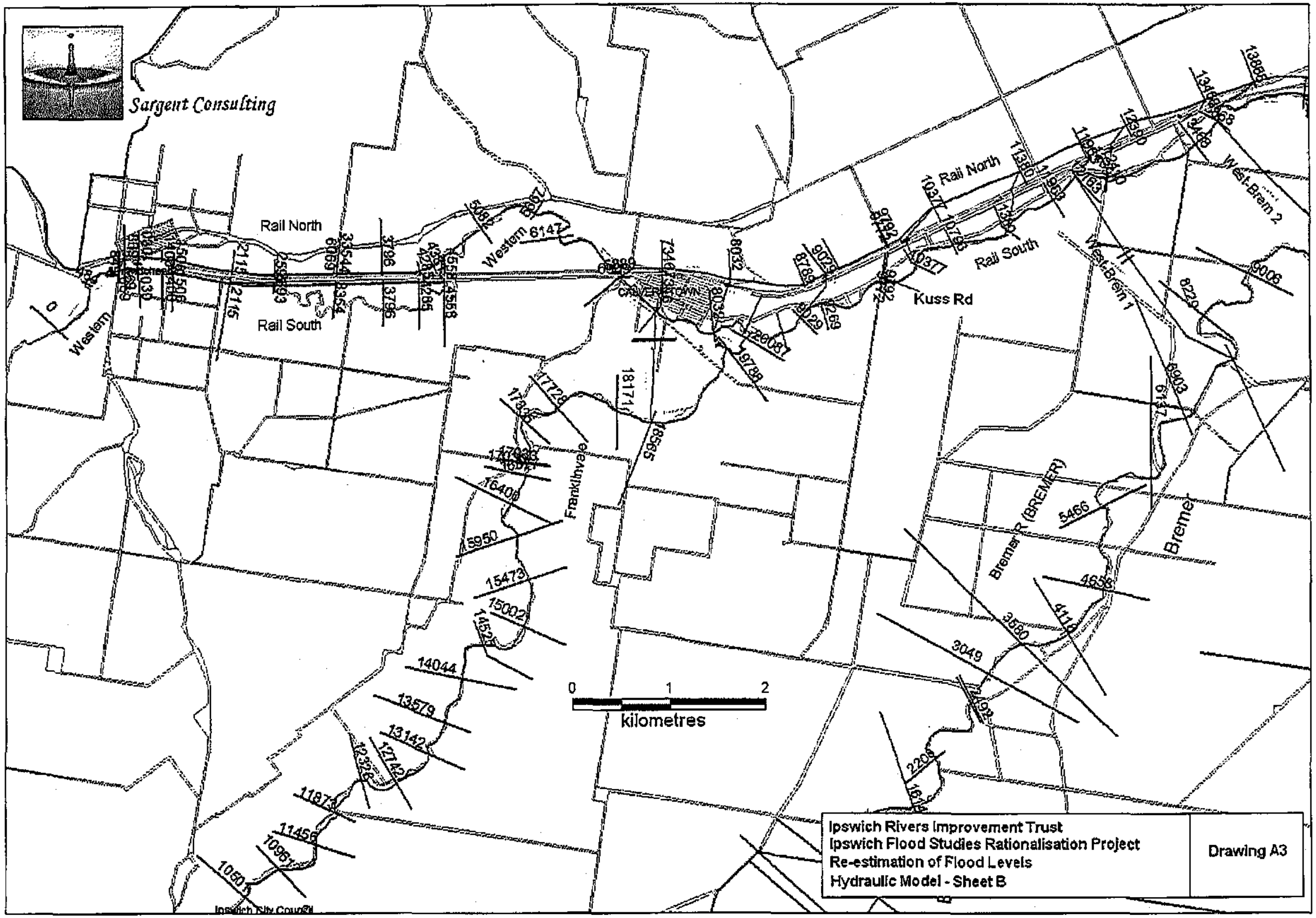
Appendix A MIKE 11 Model Layout

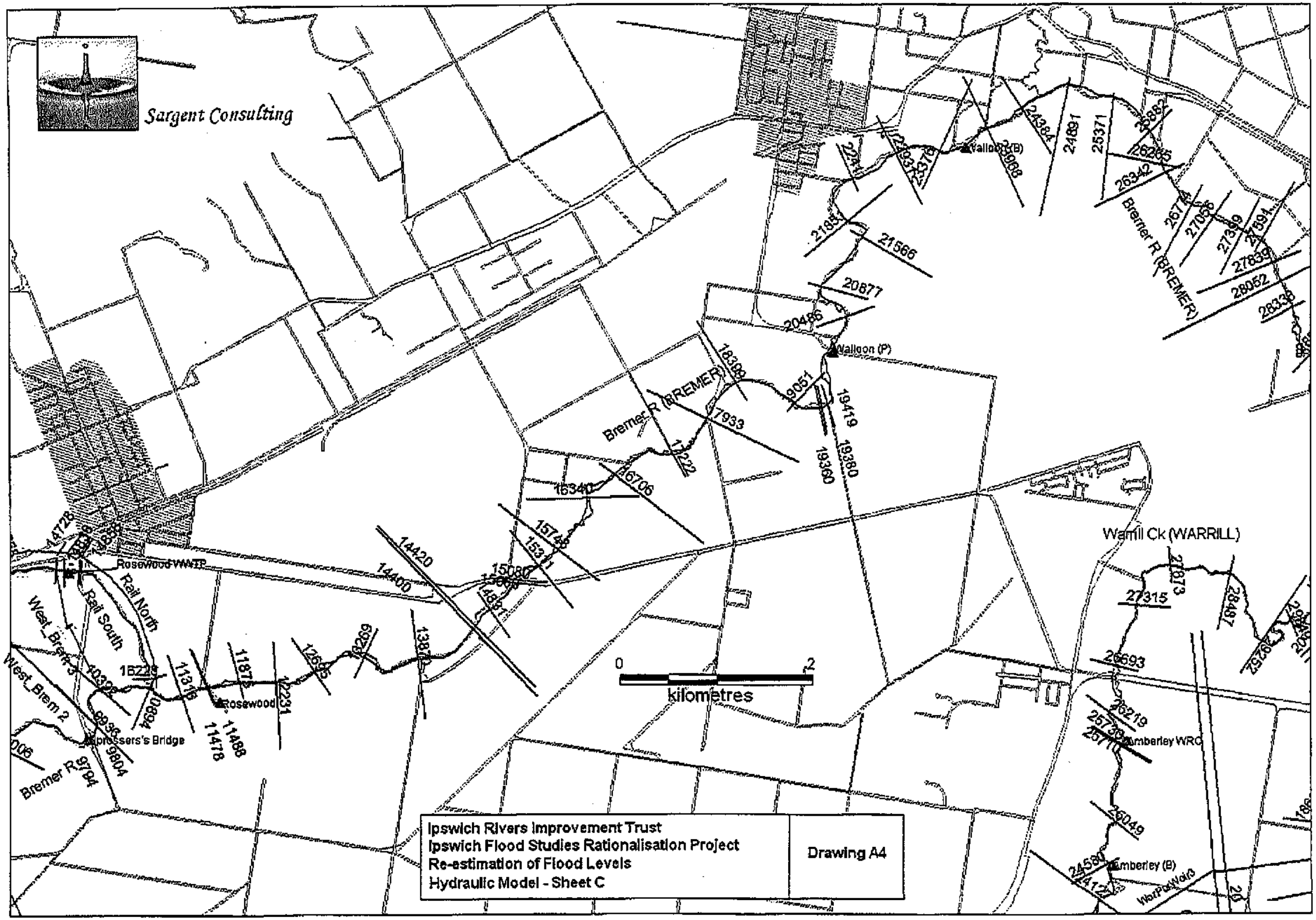

Sargent Consulting
E
G
Brisbane River
Ironpot Ck
Sandy Ck
Sandy Ck
Goodna Ck
Woogaroo Ck
Six Mile Ck
Western Ck
C
B
Bremer River
Deebing Ck
Bundamba Ck
N
Franklinvale Ck
A
F
Purga Ck
0
5
10
kilometres
D
Warrill Creek
Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Key Plan
Drawing A1



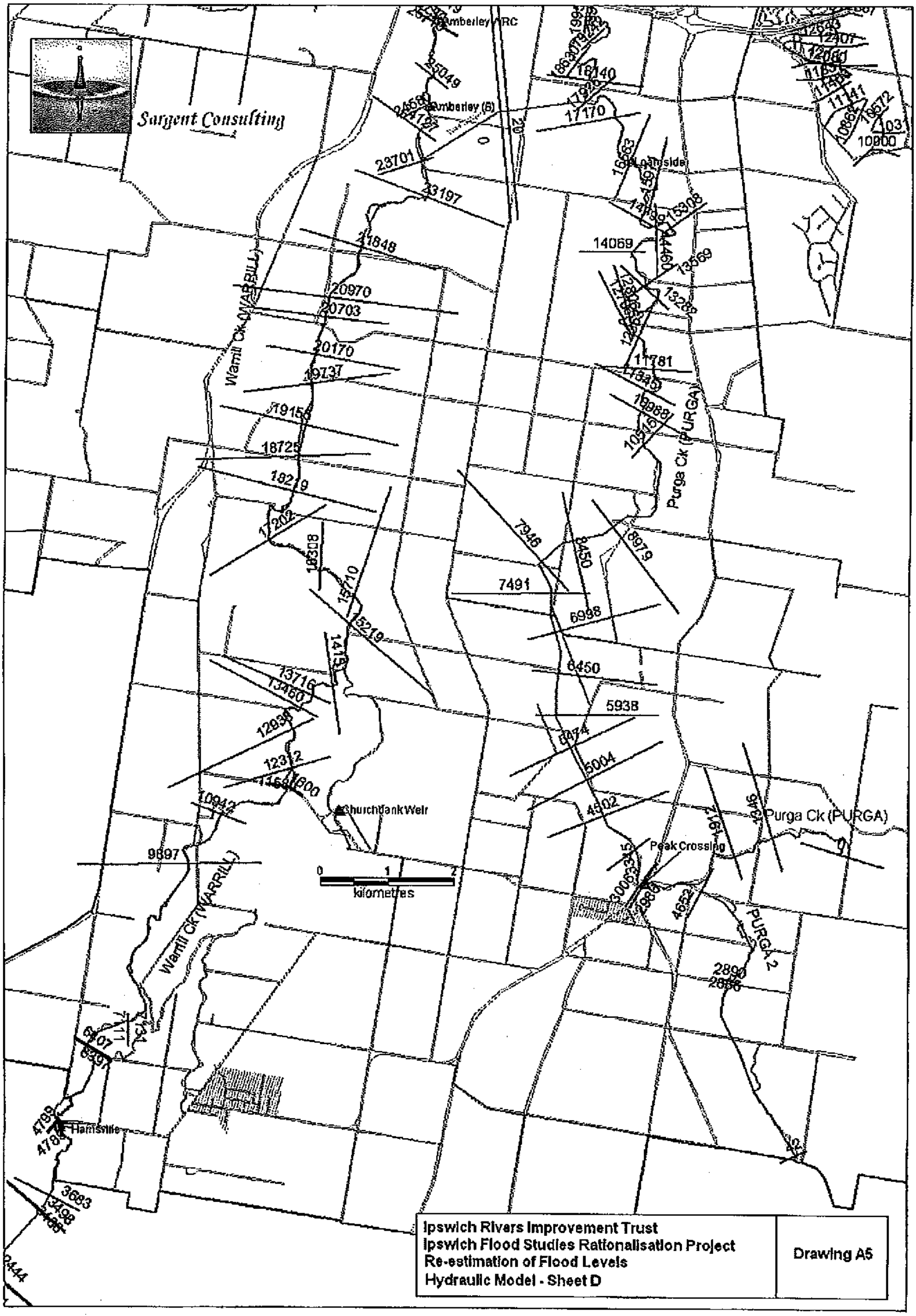
Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet A

Drawing A2


Sargent Consulting
Rail North
Rail South
Western
Rail North
Rail South
West-Brem 2
West-Brem 1
Kuss Rd
Franklinvale
Bremer
Bremer R (BREMER)
0 1 2
kilometres
Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet B
Drawing A3


Sargent Consulting
Bremer R (BREMER)
Warrill Ck (WARRILL)
Walloon (B)
Walloon (P)
Rosewood WWTP
Rosewood
Rail North
Rail South
West_Brem 3
West_Brem 2
Bremer R
Amberley WRC
Amberley (B)
Warrill Weir3
0
2
kilometres
Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet C
Drawing A4

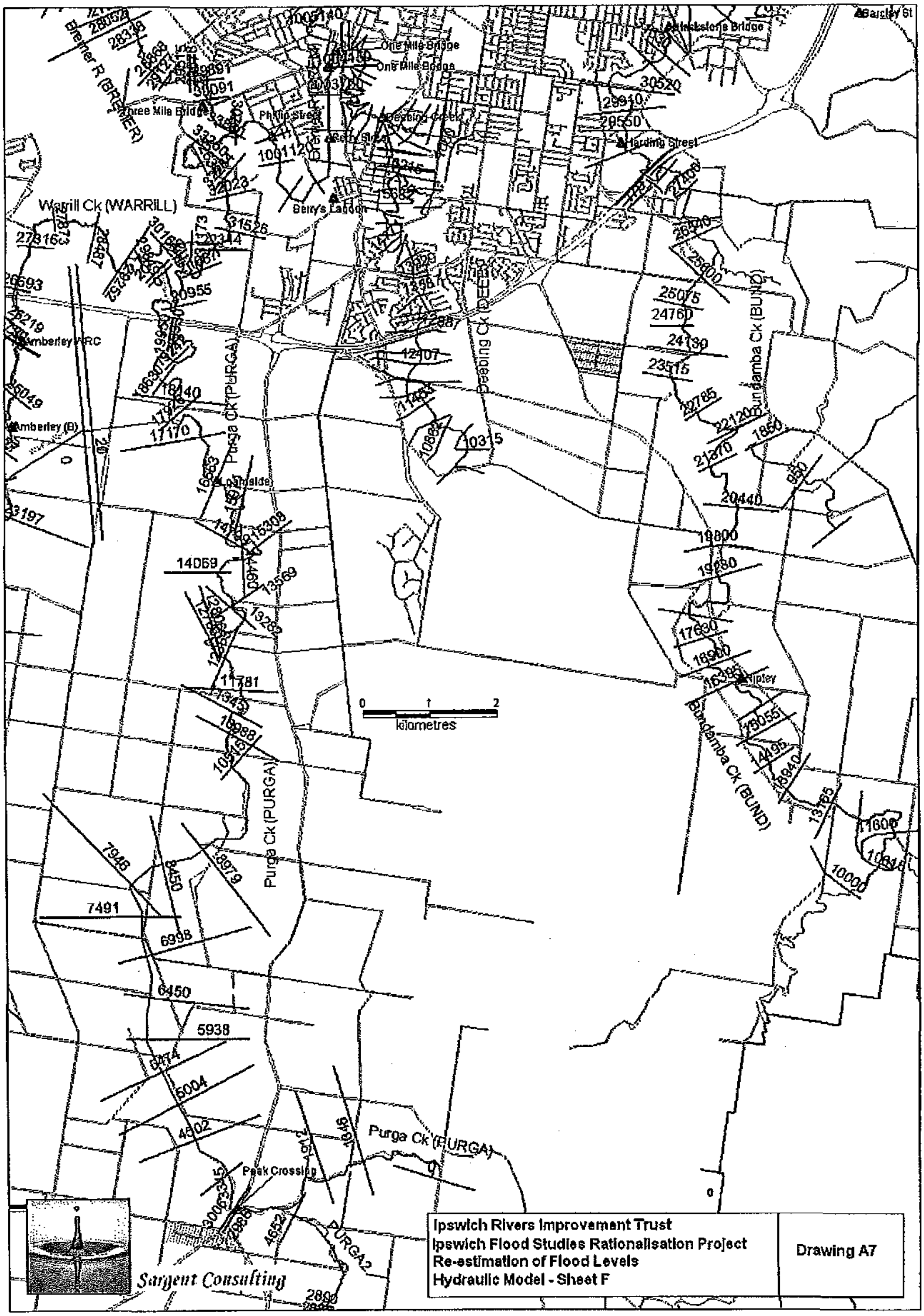
ICC.005.2975



Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet D

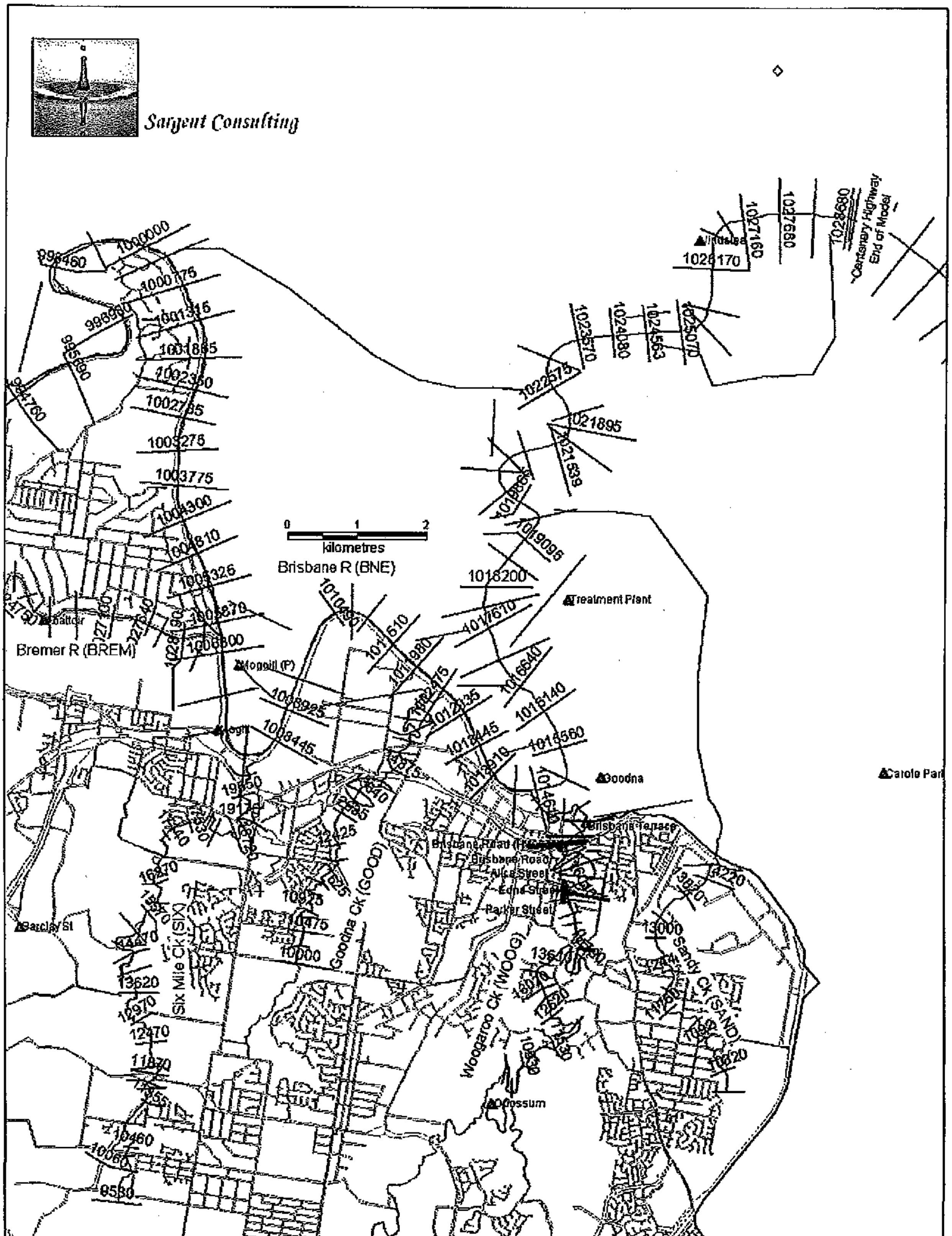
Drawing A5


Sargent Consulting
Lake Manchester
Brisbane R (BNE)
Mt Crosby
College's Crossing
kilometres
Bremer R (BREMER)
Ironpot Ck (IRON)
Warrill CK (WARRILL)
Bundamba Ck (BUND)
Hanlon St
Ipswich Stream Bridge
Marsden Parade (City)
Gaollers Crossing
One Mile Bridge
Blackstone Bridge
Harding Street
Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet E
Drawing A6



Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet F

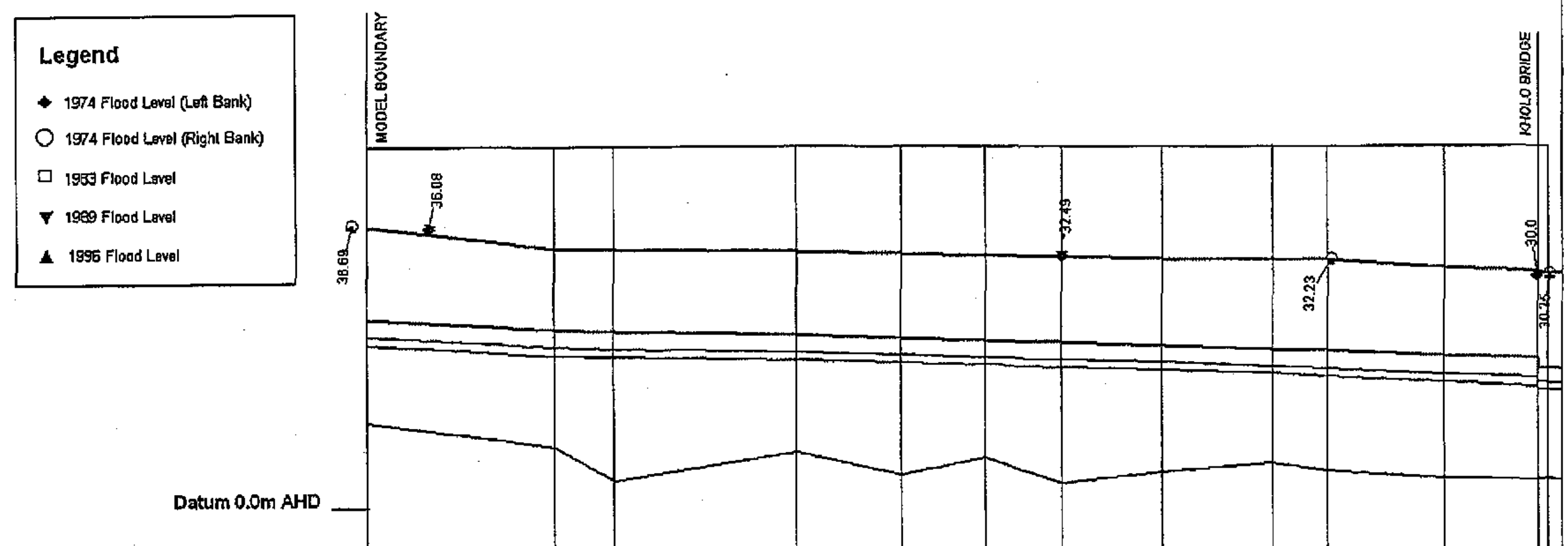
Drawing A7



Ipswich Rivers Improvement Trust
Ipswich Flood Studies Rationalisation Project
Re-estimation of Flood Levels
Hydraulic Model - Sheet G

Drawing A8

Appendix B Longitudinal Profiles – Calibration

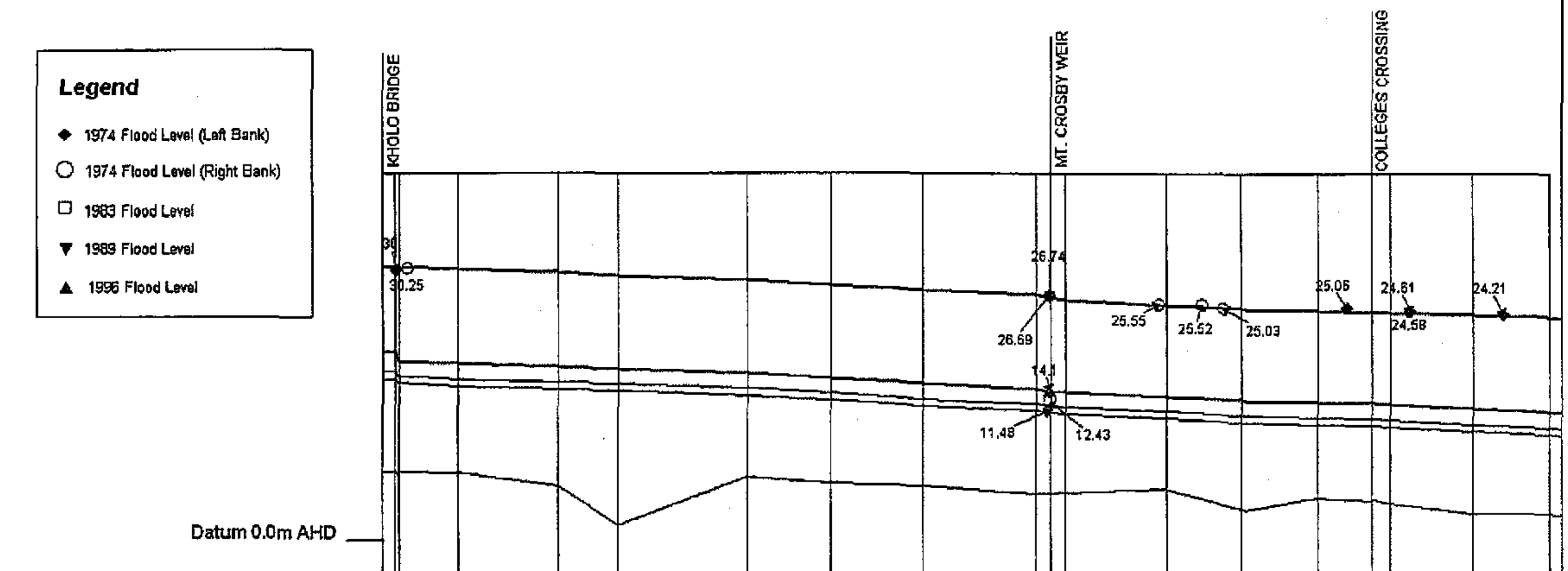


Modelled 1974 Peak Flood Level m AHD	36.40	33.59	33.42	33.05	32.83	32.67	32.47	32.22	32.06	32.05	31.07	30.53
Modelled 1983 Peak Flood Level m AHD	22.02	20.60	20.31	19.79	19.42	19.04	18.81	18.42	17.91	17.53	16.58	16.03
Modelled 1989 Peak Flood Level m AHD	20.93	19.44	19.26	18.79	18.46	18.10	17.87	17.51	17.03	16.63	15.66	15.09
Modelled 1996 Peak Flood Level m AHD	24.23	22.86	22.66	22.09	21.72	21.37	21.18	20.82	20.36	20.13	19.47	19.09
Bed Level	10.80	7.61	3.13	6.78	3.86	6.09	2.73	4.28	5.56	4.50	3.37	3.39
MIKE 11 Chainage m	964,170	965,610	967,410	969,790	971,160	972,260	973,260	974,580	976,020	976,750	978,200	979,507

Sargent Consulting

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Flood Levels - Hydraulic Model Calibration
Longitudinal Profile - Brisbane River - MIKE 11 Chainage 964.170 - 979.507

Profile C1

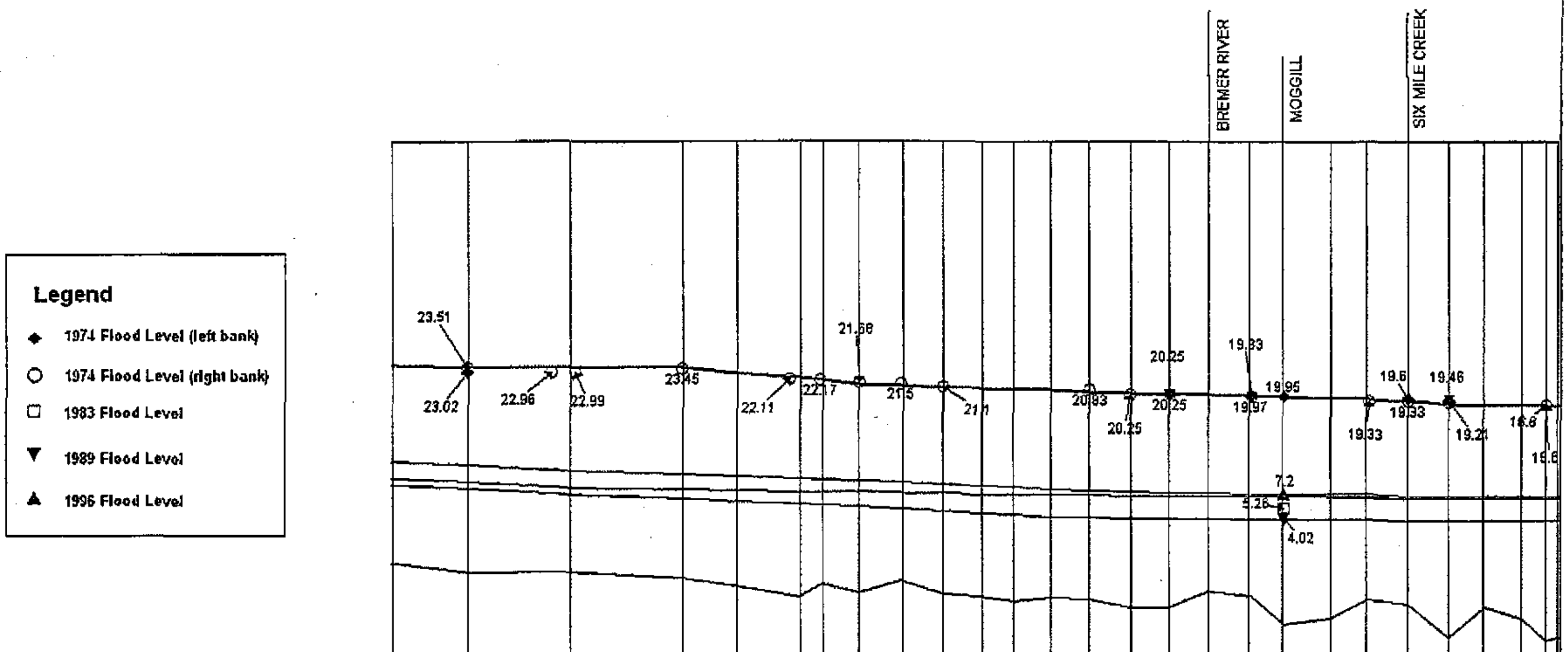


Modelled 1974 Peak Flood Level m AHD	30.53	30.51	30.25	29.72	29.37	28.69	28.19	27.49	26.96	26.60
Modelled 1983 Peak Flood Level m AHD	15.03	15.99	15.58	15.11	14.88	14.27	13.73	13.04	12.40	12.16
Modelled 1989 Peak Flood Level m AHD	15.08	15.06	14.60	14.13	13.92	13.32	12.77	12.11	11.51	11.28
Modelled 1996 Peak Flood Level m AHD	19.09	17.93	17.56	17.07	16.81	16.20	15.66	14.96	14.24	13.99
Bed Level	3.39	3.32	3.16	1.36	-3.73	2.53	1.85	1.51	0.54	0.52
MIKE 11 Chainage m	979,507	979,530	980,330	981,660	982,460	984,160	985,260	986,480	987,960	988,160

Modelled 1974 Peak Flood Level m AHD	26.58	25.46	25.15	24.75	24.52	24.43	24.24	23.87
Modelled 1983 Peak Flood Level m AHD	12.06	11.30	10.90	10.62	10.48	10.38	9.79	9.31
Modelled 1989 Peak Flood Level m AHD	11.16	10.35	9.90	9.66	9.51	9.42	8.84	8.35
Modelled 1996 Peak Flood Level m AHD	13.92	13.27	12.87	12.50	12.46	12.35	11.72	11.26
Bed Level	0.59	1.10	-1.44	0.00	-0.26	-0.69	-2.00	-2.05
MIKE 11 Chainage m	988,170	989,700	990,700	991,710	992,420	992,670	993,760	994,760

Sargent Consulting

Ipswich Rivers Improvement Trust Ipswich Rivers Flood Studies Rationalisation Project Re-estimation of Flood Levels - Hydraulic Model Calibration *Longitudinal Profile - Brisbane River - MIKE 11 Chainage 979.507 - 994.760*	**Profile C2**



Chainage m	994,760	995,690	996,980	998,460	999,160	1,000,000	1,000,265	1,000,775	1,001,315	1,001,865	1,002,350	1,002,785	1,003,275
Modelled 1974 Peak Flood Level m AHD	23.87	23.54	23.56	23.56	22.89	22.28	22.05	21.48	21.26	21.03	21.00	20.90	20.77
Modelled 1983 Peak Flood Level m AHD	9.31	8.87	8.37	8.21	8.13	8.06	8.03	7.98	7.95	7.88	7.83	7.80	7.76
Modelled 1989 Peak Flood Level m AHD	8.35	7.91	7.18	6.59	6.27	5.99	5.88	5.69	5.49	5.20	4.93	4.75	4.69
Modelled 1996 Peak Flood Level m AHD	11.26	10.82	10.14	9.65	9.33	9.08	8.97	8.78	8.64	8.39	8.15	8.02	7.84
Bed Level m AHD	-2.05	-3.15	-3.00	-3.93	-4.97	-6.40	-4.70	-5.80	-4.20	-5.90	-6.30	-5.90	-6.40

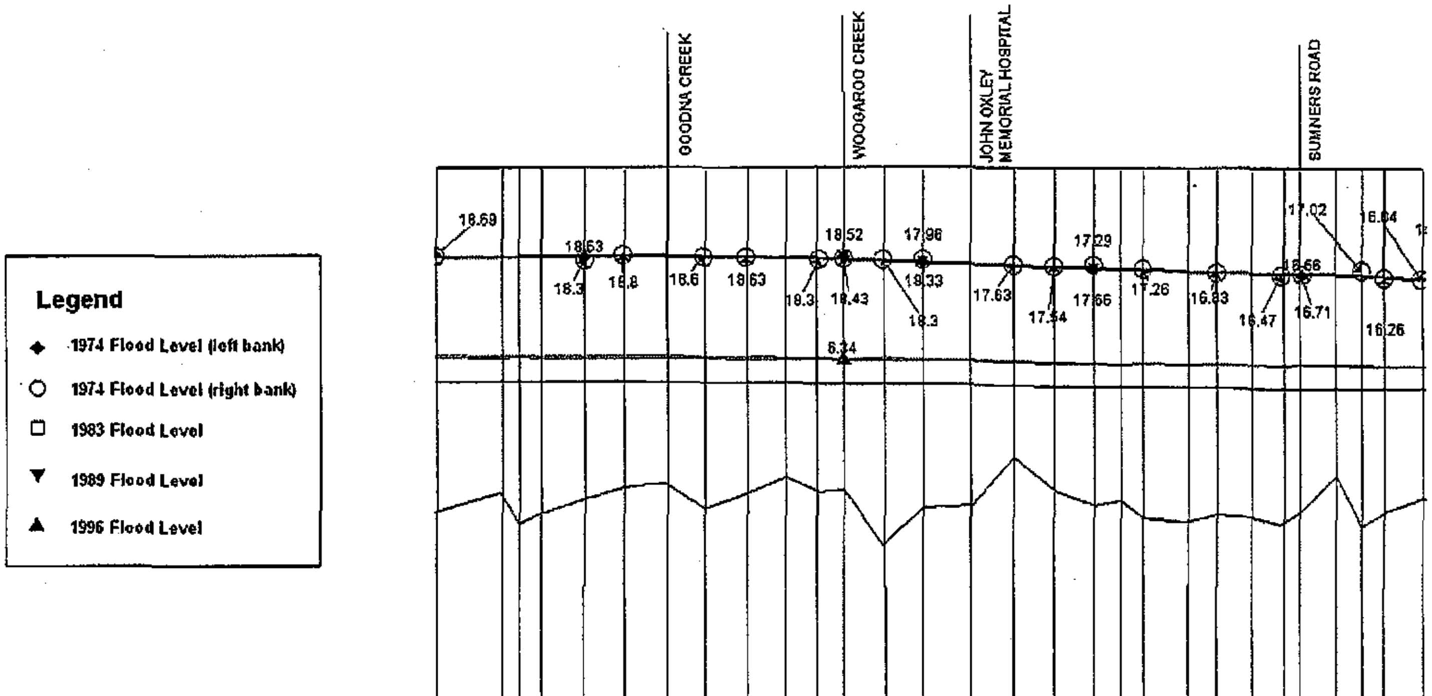
Chainage m	1,003,775	1,004,300	1,004,810	1,005,325	1,005,870	1,006,300	1,006,910	1,007,410	1,007,920	1,008,445	1,008,925	1,009,400	1,009,720
Modelled 1974 Peak Flood Level m AHD	20.60	20.34	20.30	20.20	20.07	19.90	19.74	19.62	19.33	18.96	18.79	18.79	18.74
Modelled 1983 Peak Flood Level m AHD	7.73	7.69	7.67	7.65	7.63	7.63	7.60	7.60	7.48	7.48	7.48	7.45	7.43
Modelled 1989 Peak Flood Level m AHD	4.65	4.59	4.56	4.52	4.50	4.50	4.48	4.45	4.37	4.37	4.36	4.35	4.33
Modelled 1996 Peak Flood Level m AHD	7.71	7.50	7.40	7.29	7.20	7.20	7.15	7.14	6.95	6.97	6.93	6.89	6.87
Bed Level m AHD	-6.50	-7.50	-7.50	-5.50	-8.10	-9.70	-9.00	-6.60	-7.10	-11.50	-7.60	-9.00	-12.00

Sargent Consulting

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels - Hydraulic Model Calibration
Longitudinal Profile - Brisbane River - MIKE 11 Chainage 994.760 - 1,009.720

Profile C3

ICC.005.2983



Modelled 1974 Peak Flood Level m AHD	18.74	18.65	18.68	18.68	18.74	18.74	18.74	18.62	18.62	18.52
Modelled 1983 Peak Flood Level m AHD	7.44	7.36	7.36	7.36	7.36	7.34	7.33	7.28	7.27	7.20
Modelled 1989 Peak Flood Level m AHD	4.33	4.28	4.28	4.28	4.27	4.25	4.23	4.21	4.20	4.14
Modelled 1996 Peak Flood Level m AHD	6.87	6.74	6.76	6.74	6.72	6.69	6.66	6.58	6.56	6.43
Bed Level m AHD	-12.0	-9.8	-13.4	-12.3	-10.5	-9.1	-8.7	-11.7	-9.9	-8.0
Chainage m	1,009,720	1,010,490	1,010,725	1,010,980	1,011,510	1,011,950	1,012,475	1,012,935	1,013,445	1,013,910

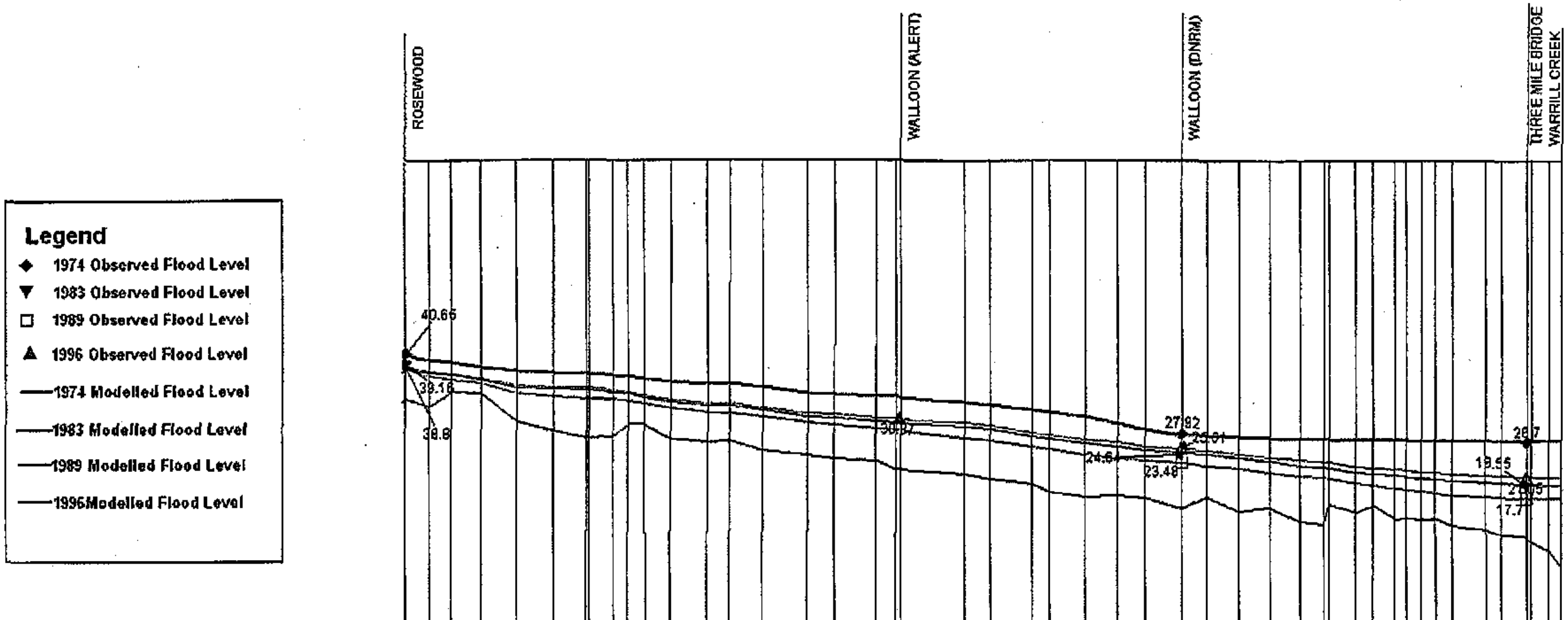
Modelled 1974 Peak Flood Level m AHD	18.46	18.31	18.17	17.93	17.77	17.72	17.31	17.31	17.13	17.13
Modelled 1983 Peak Flood Level m AHD	7.18	7.14	7.17	7.12	7.09	7.06	6.92	6.93	6.88	6.91
Modelled 1989 Peak Flood Level m AHD	4.13	4.11	4.11	4.09	4.07	4.02	3.93	3.92	3.89	3.90
Modelled 1996 Peak Flood Level m AHD	6.40	6.33	6.38	6.29	6.27	6.17	5.93	5.92	5.90	5.88
Bed Level m AHD	-9.8	-9.4	-16.1	-11.6	-11.2	-5.5	-9.5	-11.3	-10.7	-12.7
Chainage m	1,014,310	1,014,610	1,015,050	1,015,560	1,016,140	1,016,640	1,017,130	1,017,610	1,017,920	1,018,200

Modelled 1974 Peak Flood Level m AHD	16.90	16.82	16.78	16.62	16.62	16.62	16.52	16.28	16.07
Modelled 1983 Peak Flood Level m AHD	6.85	6.83	6.83	6.79	6.81	6.81	6.79	6.74	6.72
Modelled 1989 Peak Flood Level m AHD	3.87	3.86	3.85	3.82	3.83	3.82	3.81	3.78	3.77
Modelled 1996 Peak Flood Level m AHD	5.78	5.75	5.73	5.65	5.69	5.69	5.64	5.56	5.52
Bed Level m AHD	-13.2	-12.3	-12.6	-13.4	-11.7	-7.7	-13.8	-12.0	-10.4
Chainage m	1,018,725	1,019,095	1,019,490	1,019,855	1,020,115	1,020,525	1,020,830	1,021,095	1,021,539

Sargent Consulting

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels - Hydraulic Model Calibration
Longitudinal Profile - Brisbane River - MIKE 11 Chainage 1,009.720 - 1,021.539

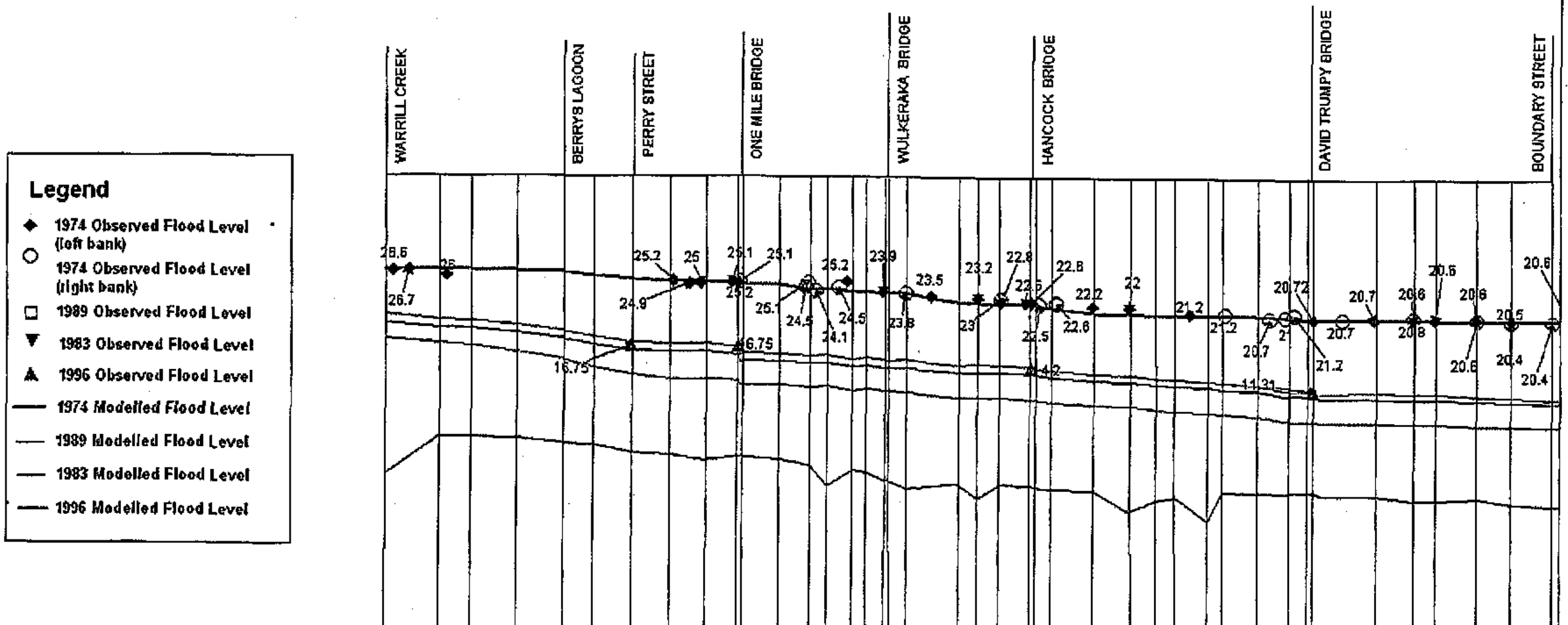
Profile C4



Chainage m Model Branch BREMER	Bed Level m AHD	Modelled 1996 Peak Flood Level m AHD	Modelled 1989 Peak Flood Level m AHD	Modelled 1983 Peak Flood Level m AHD	Modelled 1974 Peak Flood Level m AHD
11,477	33.50	38.06	38.31	38.74	40.42
11,874	32.11	37.86	37.24	37.66	38.74
12,231	34.57	37.50	36.82	37.29	39.30
12,695	34.40	36.79	36.02	36.55	38.70
13,269	29.83	35.71	34.38	35.39	38.17
13,870	28.22	35.39	33.80	35.08	37.68
14,400	27.11	35.25	33.52	34.96	37.49
14,420	27.11	34.93	33.47	34.61	37.49
14,831	27.45	34.86	33.45	34.56	37.27
15,060	29.41	34.52	33.16	34.15	37.07
15,311	29.41	33.97	32.70	33.59	36.75
15,748	26.90	33.33	32.02	32.93	36.23
16,340	26.45	32.73	31.33	32.38	35.88
16,706	26.68	32.64	31.09	32.28	35.79
17,222	25.05	32.05	30.44	31.69	35.25
17,933	24.49	31.02	29.53	30.53	34.47
18,399	23.77	30.83	29.19	30.29	34.28
19,051	23.39	30.29	28.56	29.71	33.69
19,380	22.12	30.25	28.22	29.66	33.72
20,465	21.38	29.63	27.25	29.02	32.92
20,877	20.72	29.24	26.81	28.62	32.62
21,565	19.92	28.07	25.96	27.53	31.80
21,851	18.63	27.77	25.53	27.12	31.43
22,410	17.99	27.06	24.62	26.42	30.64
22,931	18.17	26.53	24.12	25.90	29.61
23,376	17.83	25.95	23.60	25.37	28.66
23,969	16.11	25.55	23.21	24.99	27.79
24,384	18.00	25.28	22.99	24.72	27.70
24,891	15.77	24.84	22.57	24.29	27.53
25,371	16.24	24.29	21.90	23.63	27.34
25,882	14.07	23.82	21.31	23.00	27.18
26,265	13.73	23.52	21.10	22.65	27.11
26,342	16.88	23.41	20.85	22.53	27.09
26,774	16.54	22.73	20.07	21.89	27.01
27,056	15.45	22.51	19.77	21.65	26.98
27,399	15.54	22.29	19.39	21.39	26.94
27,591	14.41	22.10	19.11	21.15	26.91
27,839	14.34	21.88	18.79	20.91	26.89
28,052	14.50	21.78	18.56	20.79	26.87
28,338	13.35	21.53	18.16	20.51	26.84
28,868	12.55	21.30	17.92	20.74	26.81
29,127	11.74	21.22	17.65	20.15	26.80
29,515	11.12	21.11	17.75	20.01	26.79
29,535	10.63	21.09	17.75	19.98	26.78
30,091	6.40	20.94	17.56	19.84	26.75

Sargent Consulting

Ipswich Rivers Improvement Trust Ipswich Rivers Flood Studies Rationalisation Project Re-estimation of Design Flood Levels - Hydraulic Model Calibration Longitudinal Profile Bremer River - Rosewood - Warrill Creek	Profile C5

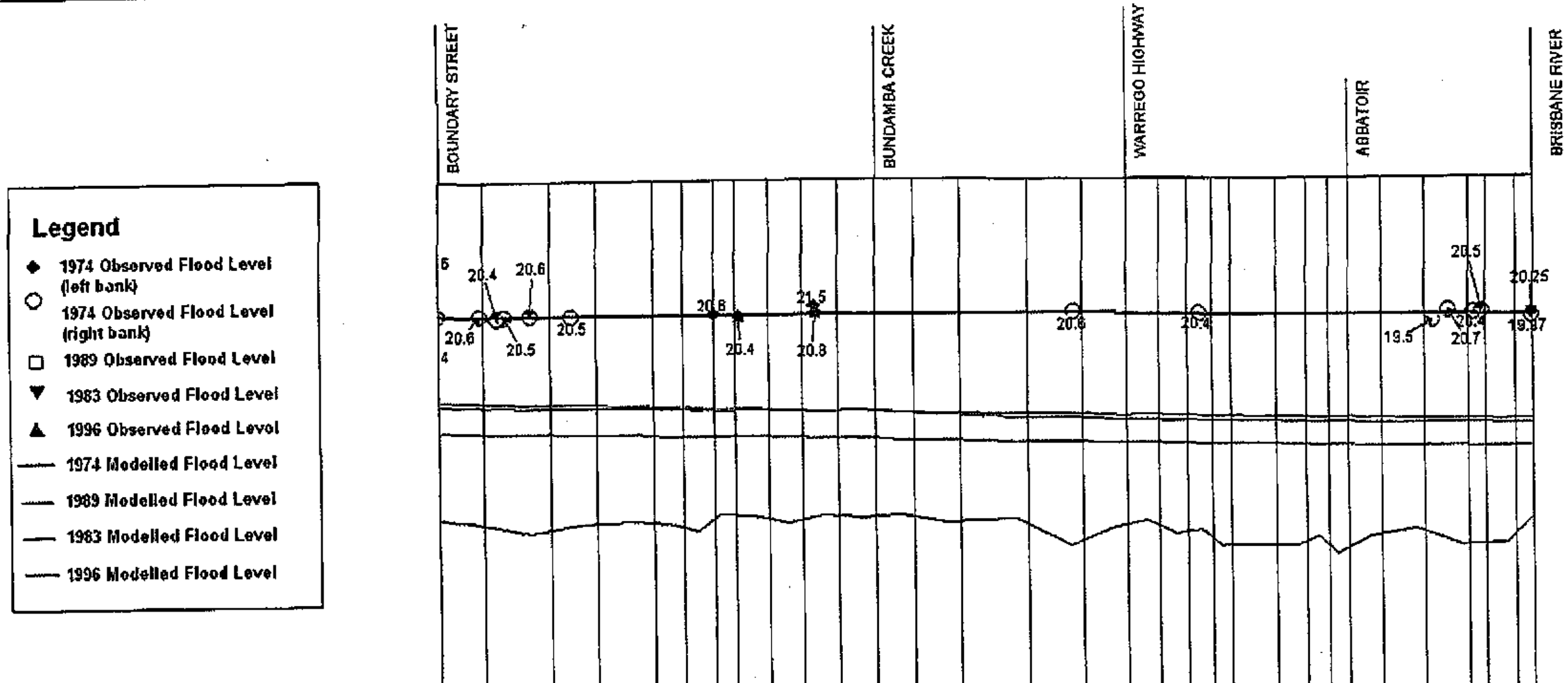


Chainage m Model Branch BREM	Bed Level m AHD	Modelled 1996 Peak Flood Level m AHD	Modelled 1989 Peak Flood Level m AHD	Modelled 1983 Peak Flood Level m AHD	Modelled 1974 Peak Flood Level m AHD
1,000,000	0.00	20.94	17.66	19.84	26.75
1,000,700	5.00	20.29	17.06	19.24	26.70
1,001,120	5.00	20.11	16.77	19.05	26.70
1,001,700	4.80	19.46	15.96	18.43	26.63
1,002,300	4.20	18.73	15.03	17.69	26.42
1,002,700	4.00	18.00	14.07	16.98	26.02
1,003,200	3.00	17.30	13.12	16.26	25.50
1,003,700	2.71	17.10	12.49	16.03	25.22
1,004,150	2.00	17.10	12.46	16.01	25.17
1,004,590	2.50	16.70	12.21	15.67	25.11
1,004,610	2.63	15.90	11.79	14.93	24.99
1,005,140	2.20	15.63	11.72	14.76	24.75
1,005,520	1.40	15.47	11.55	14.54	24.22
1,005,740	-1.24	15.47	11.55	14.54	24.22
1,006,180	-0.76	15.30	11.29	14.34	24.02
1,006,250	0.56	14.99	11.29	14.34	24.02
1,006,510	-0.50	14.92	11.01	13.98	23.82
1,006,780	-1.58	14.92	10.83	13.98	23.78
1,007,440	-0.76	14.47	10.33	13.53	22.73
1,007,700	-2.76	14.47	10.33	13.53	22.66
1,008,000	-1.03	14.45	10.24	13.49	22.44
1,008,390	-1.09	14.12	10.03	13.28	22.42
1,008,410	-1.09	14.10	9.97	13.17	22.32
1,008,660		13.79	9.71	12.69	22.02
1,009,210	-1.63	13.41	9.35	12.54	21.46
1,009,675	-4.40	13.24	9.22	12.39	21.29
1,010,020	-2.90	12.83	8.81	12.25	21.14
1,010,280	-2.40	12.79	8.69	11.95	21.14
1,010,700	-5.50	12.54	8.55	11.72	21.14
1,010,890	-1.80	12.30	8.37	11.50	21.12
1,011,320	-1.80	12.09	8.09	11.29	21.12
1,011,810	-1.71	11.51	7.68	10.79	20.98
1,012,050	-1.71	11.38	7.59	10.62	20.87
1,012,070	-1.65	11.27	7.50	10.58	20.62
1,012,870	-2.10	11.19	7.37	10.51	20.60
1,013,380	-2.70	11.00	7.20	10.34	20.60
1,013,700	-2.70	10.99	7.15	10.34	20.60
1,014,220	-2.50	10.67	6.94	10.08	20.57
1,014,640	-3.20	10.58	6.88	10.02	20.54
1,015,180	-3.50	10.29	6.71	9.81	20.54

Sargent Consulting

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels - Hydraulic Model Calibration
Longitudinal Profile - Bremer River - Warrill Creek - Boundary Street

Profile C6

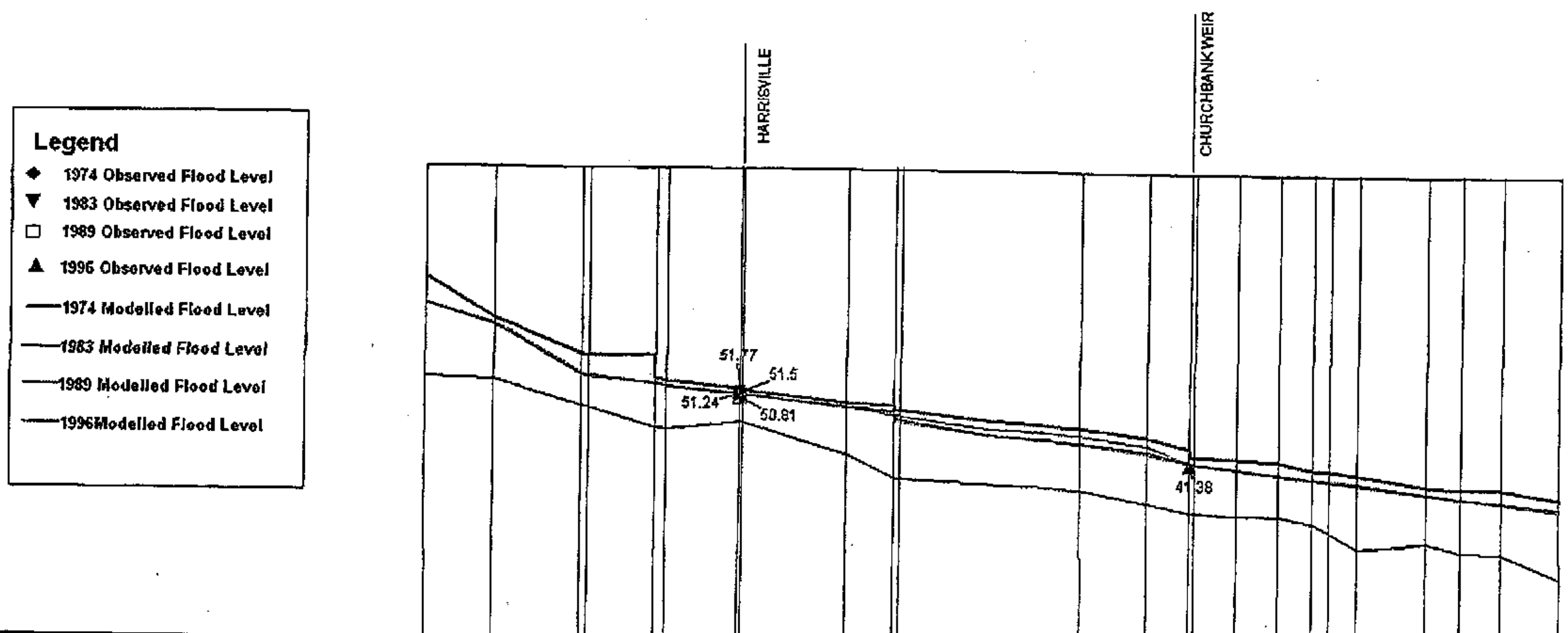


Chainage m Model Branch BREM	Modelled 1974 Peak Flood Level m AHD	Modelled 1983 Peak Flood Level m AHD	Modelled 1989 Peak Flood Level m AHD	Modelled 1996 Peak Flood Level m AHD	Bed Level m AHD
1,015,180	20.54	9.81	6.71	10.29	-3.50
1,015,710	20.54	9.81	6.68	10.29	-3.60
1,016,510	20.54	9.62	6.54	10.03	-5.20
1,017,080	20.53	9.56	6.46	9.94	-4.20
1,017,750	20.53	9.51	6.38	9.86	-3.90
1,018,140	20.53	9.40	6.21	9.70	-4.20
1,018,500	20.53	9.32	6.21	9.57	-5.10
1,018,760	20.53	9.26	6.09	9.46	-3.20
1,019,150	20.53	9.25	6.09	9.45	-3.40
1,019,580	20.53	9.09	5.97	9.18	-4.20
1,020,000	20.53	8.97	5.81	8.97	-3.30
1,020,450	20.53	8.97	5.80	8.97	-3.30
1,020,920	20.52	8.86	5.61	8.77	-3.40
1,021,460	20.52	8.72	6.52	8.54	-4.20
1,022,300	20.51	8.54	5.29	8.14	-4.00
1,022,950	20.51	8.54	5.22	8.12	-7.20
1,023,510	20.25	8.33	5.10	7.74	-4.92
1,023,870	20.25	8.31	5.06	7.73	-4.20
1,024,220	20.25	8.20	4.96	7.63	-5.90
1,024,520	20.25	8.20	4.93	7.63	-5.20
1,024,750	20.24	8.19	4.93	7.63	-7.20
1,025,300	20.23	8.14	4.89	7.58	-7.20
1,025,670	20.22	8.05	4.80	7.51	-7.20
1,025,920	20.21	7.99	4.77	7.47	-6.20
1,026,150	20.21	7.99	4.77	7.47	-8.20
1,026,560	20.21	7.90	4.71	7.40	-6.20
1,027,100	20.20	7.82	4.64	7.34	-5.20
1,027,640	20.17	7.77	4.60	7.30	-7.20
1,027,840	20.16	7.72	4.57	7.27	-7.20
1,028,190	20.12	7.63	4.50	7.20	-7.10
1,028,490	20.07	7.63	4.49	7.20	-7.10

Sargent Consulting

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels - Hydraulic Model Calibration
Longitudinal Profile - Bremer River - Boundary Street - Brisbane River

Profile C7

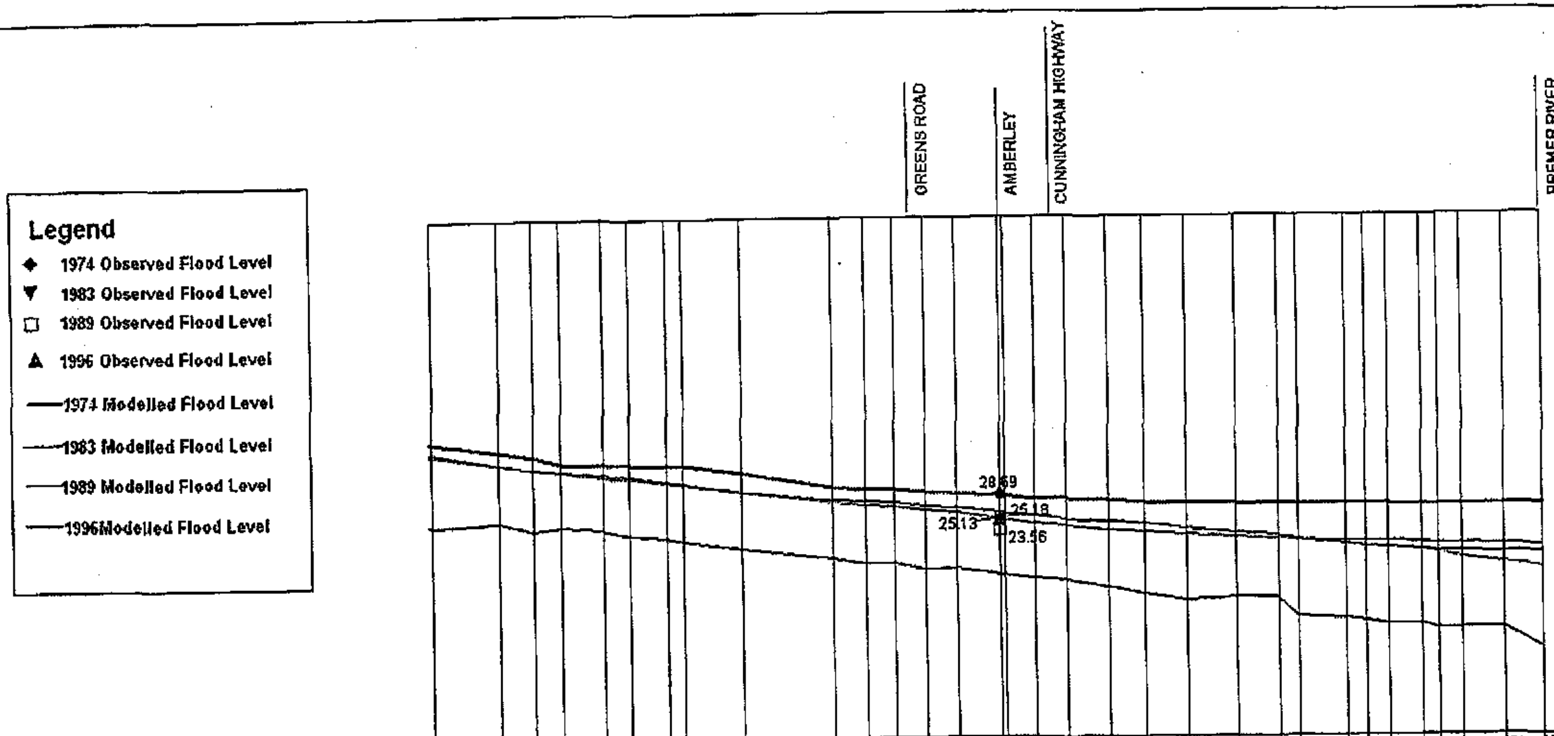


Modelled 1974 Peak Flood Level m AHD	69.09	62.71	57.05	57.05	53.62	53.40	52.29	51.78	50.27	49.85	49.31	46.94
Modelled 1983 Peak Flood Level m AHD	64.97	61.68	53.94	53.93	52.73	52.48	51.36	51.35	49.62	48.99	47.87	44.62
Modelled 1989 Peak Flood Level m AHD	65.07	61.75	53.97	53.97	52.78	52.53	51.30	51.28	49.47	48.90	47.45	44.39
Modelled 1996 Peak Flood Level m AHD	65.00	62.11	54.25	54.25	53.19	52.65	51.34	51.31	49.58	48.96	48.34	45.77
Bed Level m AHD	53.78	53.24	49.26	49.26	46.09	45.89	46.98	46.98	42.29	38.63	38.63	37.35
Chainage m Model Branch WARRILL	0	1,033	2,424	2,444	3,483	3,683	4,779	4,799	6,397	7,111	7,131	9,697

Modelled 1974 Peak Flood Level m AHD	45.58	43.94	42.76	42.42	41.97	41.00	40.74	40.14	38.51	38.14	38.14	36.62
Modelled 1983 Peak Flood Level m AHD	43.34	41.68	41.66	40.78	40.01	39.36	39.13	38.89	37.41	36.62	36.03	35.18
Modelled 1989 Peak Flood Level m AHD	43.04	41.68	41.66	40.78	40.01	39.36	39.13	38.88	37.41	36.62	36.03	35.18
Modelled 1996 Peak Flood Level m AHD	44.26	41.68	41.68	40.89	40.04	39.36	39.04	38.51	37.19	36.58	35.84	34.84
Bed Level m AHD	35.33	34.05	34.05	33.68	33.70	37.56	31.31	28.87	29.82	28.58	28.39	24.62
Chainage m Model Branch WARRILL	10,942	11,580	11,600	12,312	12,938	13,460	13,716	14,151	15,218	15,710	16,308	17,202

Sargent Consulting

Ipswich Rivers Improvement Trust Ipswich Rivers Flood Studies Rationalisation Project Re-estimation of Design Flood Levels - Hydraulic Model Calibration Longitudinal Profile Warrill Creek CHainage 0 - 17.202	Profile C8



Chainage m Model Branch WARRILL	17,202	18,219	18,725	19,155	19,737	20,170	20,703	20,970
Modelled 1974 Peak Flood Level m AHD	36.62	35.34	34.55	33.61	33.29	33.27	33.08	33.07
Modelled 1983 Peak Flood Level m AHD	35.18	33.48	32.85	32.49	32.04	31.67	30.83	30.49
Modelled 1989 Peak Flood Level m AHD	35.18	33.48	32.85	32.49	32.04	31.67	30.83	30.49
Modelled 1996 Peak Flood Level m AHD	34.84	33.48	32.85	32.32	31.71	31.33	30.69	30.32
Bed Level m AHD	24.62	25.16	23.79	24.41	24.08	23.06	22.81	22.17

Chainage m Model Branch WARRILL	21,848	23,197	23,701	24,127	24,580	25,049	25,710	25,730
Modelled 1974 Peak Flood Level m AHD	32.03	29.72	29.51	29.45	29.10	29.10	28.74	28.49
Modelled 1983 Peak Flood Level m AHD	29.29	28.01	27.73	27.56	27.03	26.79	26.06	25.98
Modelled 1989 Peak Flood Level m AHD	29.29	28.01	27.73	27.66	27.03	26.78	26.05	25.98
Modelled 1996 Peak Flood Level m AHD	29.19	27.60	27.24	26.99	26.53	26.11	25.23	25.21
Bed Level m AHD	20.98	19.52	18.72	18.72	17.78	18.15	17.11	17.11

Chainage m Model Branch WARRILL	26,219	26,693	27,315	27,873	28,497	29,252	29,849	30,164
Modelled 1974 Peak Flood Level m AHD	28.00	27.85	27.73	27.45	27.24	27.15	27.05	26.98
Modelled 1983 Peak Flood Level m AHD	25.49	25.01	24.52	24.31	23.63	22.90	22.58	22.04
Modelled 1989 Peak Flood Level m AHD	25.49	25.01	24.52	24.31	23.63	22.90	22.58	22.04
Modelled 1996 Peak Flood Level m AHD	24.48	23.96	23.49	23.15	22.72	22.27	22.05	21.87
Bed Level m AHD	16.52	16.23	15.31	14.17	13.26	13.60	13.66	10.75

Chainage m Model Branch WARRILL	30,886	31,173	31,526	32,023	32,284	32,634	33,250	33,860
Modelled 1974 Peak Flood Level m AHD	26.93	26.91	26.91	26.90	26.86	26.83	26.82	26.75
Modelled 1983 Peak Flood Level m AHD	21.19	20.93	20.71	20.33	20.17	20.03	19.92	19.84
Modelled 1989 Peak Flood Level m AHD	21.19	20.92	20.71	20.32	19.89	19.09	18.42	17.66
Modelled 1996 Peak Flood Level m AHD	21.65	21.58	21.51	21.39	21.27	21.14	21.04	20.94
Bed Level m AHD	10.38	10.10	9.50	9.60	9.00	9.00	9.00	6.00

Sargent Consulting

Ipswich Rivers Improvement Trust Ipswich Rivers Flood Studies Rationalisation Project Re-estimation of Design Flood Levels - Hydraulic Model Calibration Longitudinal Profile Warrill Creek Chainage 17.202 - Bremer River	Profile C9

Appendix C Roughness Values

Brisbane River

Flowpath & Chainage	n min	n max
BNE 960170.00	0.065	0.065
BNE 962070.00	0.065	0.065
BNE 964170.00	0.065	0.195
BNE 966610.00	0.065	0.065
BNE 967410.00	0.047	0.065
BNE 969790.00	0.047	0.065
BNE 971160.00	0.055	0.065
BNE 972260.00	0.060	0.065
BNE 973260.00	0.066	0.066
BNE 973280.00	0.066	0.066
BNE 974580.00	0.047	0.067
BNE 976020.00	0.048	0.069
BNE 976750.00	0.069	0.097
BNE 978280.00	0.071	0.120
BNE 979507.00	0.050	0.073
BNE 979515.00	0.072	0.129
BNE 979530.00	0.072	0.115
BNE 980330.00	0.073	0.087
BNE 981660.00	0.074	0.089
BNE 982460.00	0.075	0.090
BNE 984160.00	0.076	0.091
BNE 985260.00	0.077	0.093
BNE 985260.00	0.077	0.093
BNE 986480.00	0.078	0.094
BNE 987960.00	0.080	0.087
BNE 988160.00	0.080	0.192
BNE 988170.00	0.076	0.192
BNE 988360.00	0.076	0.160
BNE 989700.00	0.058	0.080
BNE 990700.00	0.076	0.080
BNE 990760.00	0.076	0.112
BNE 991710.00	0.072	0.080
BNE 992420.00	0.072	0.165
BNE 992450.00	0.076	0.128
BNE 992470.00	0.076	0.096
BNE 992670.00	0.024	0.080
BNE 993760.00	0.072	0.080
BNE 994760.00	0.076	0.136
BNE 994760.00	0.076	0.136
BNE 995690.00	0.008	0.080
BNE 996980.00	0.008	0.080
BNE 996980.00	0.008	0.080
BNE 998460.00	0.072	0.080
BNE 998460.00	0.072	0.080
BNE 999160.00	0.076	0.160
BNE 1000000.00	0.064	0.080
BNE 1000285.00	0.076	0.176
BNE 1000285.00	0.076	0.176
BNE 1000775.00	0.077	0.123
BNE 1001315.00	0.073	0.118
BNE 1001315.00	0.073	0.118
BNE 1001865.00	0.028	0.071
BNE 1002350.00	0.070	0.070
BNE 1002785.00	0.070	0.084
BNE 1003275.00	0.066	0.084
BNE 1003775.00	0.066	0.098
BNE 1004300.00	0.066	0.070
BNE 1004810.00	0.066	0.070
BNE 1005325.00	0.066	0.140
BNE 1005325.00	0.066	0.140
BNE 1005870.00	0.026	0.043
BNE 1005870.00	0.026	0.043
BNE 1006300.00	0.026	0.078
BNE 1006300.00	0.028	0.078
BNE 1006910.00	0.028	0.084
BNE 1007410.00	0.028	0.078
BNE 1007920.00	0.028	0.090
BNE 1008195.00	0.028	0.093
BNE 1008195.00	0.028	0.093
BNE 1008445.00	0.028	0.095
BNE 1008925.00	0.028	0.036
BNE 1008925.00	0.028	0.036
BNE 1009400.00	0.028	0.036
BNE 1009720.00	0.017	0.028
BNE 1009720.00	0.017	0.028
BNE 1010490.00	0.017	0.028
BNE 1010725.00	0.017	0.028
BNE 1010980.00	0.017	0.028
BNE 1011510.00	0.011	0.028
BNE 1011510.00	0.011	0.028
BNE 1011960.00	0.017	0.028
BNE 1012475.00	0.028	0.028
BNE 1012475.00	0.028	0.028
BNE 1012935.00	0.028	0.034
BNE 1013445.00	0.026	0.034
BNE 1013680.00	0.028	0.035
BNE 1013680.00	0.028	0.035
BNE 1013910.00	0.028	0.036
BNE 1014310.00	0.026	0.045
BNE 1014610.00	0.034	0.095
BNE 1014610.00	0.034	0.095
BNE 1015090.00	0.034	0.099
BNE 1015560.00	0.034	0.092

BNE 1015850.00	0.034	0.078
BNE 1015850.00	0.034	0.078
BNE 1016140.00	0.034	0.084
BNE 1016640.00	0.019	0.035
BNE 1016640.00	0.019	0.035
BNE 1017130.00	0.034	0.053
BNE 1017130.00	0.034	0.053
BNE 1017610.00	0.034	0.057
BNE 1017610.00	0.034	0.057
BNE 1017920.00	0.034	0.076
BNE 1018200.00	0.034	0.076
BNE 1018725.00	0.034	0.065
BNE 1019095.00	0.034	0.065
BNE 1019490.00	0.034	0.065
BNE 1019490.00	0.034	0.065
BNE 1019865.00	0.034	0.057
BNE 1020115.00	0.034	0.068
BNE 1020525.00	0.034	0.076
BNE 1020525.00	0.034	0.076
BNE 1020830.00	0.034	0.103
BNE 1021095.00	0.034	0.091
BNE 1021639.00	0.034	0.091
BNE 1021715.00	0.034	0.087
BNE 1021895.00	0.034	0.091
BNE 1022105.00	0.034	0.091
BNE 1022575.00	0.027	0.034
BNE 1022575.00	0.027	0.034
BNE 1023040.00	0.027	0.034
BNE 1023570.00	0.027	0.035
BNE 1024080.00	0.027	0.035
BNE 1024080.00	0.027	0.035
BNE 1024563.00	0.034	0.068
BNE 1024563.00	0.034	0.068
BNE 1025070.00	0.034	0.068
BNE 1025360.00	0.034	0.106
BNE 1025590.00	0.034	0.053
BNE 1025590.00	0.034	0.053
BNE 1026170.00	0.034	0.053
BNE 1026680.00	0.034	0.053
BNE 1026900.00	0.038	0.053
BNE 1027160.00	0.038	0.053
BNE 1027680.00	0.038	0.053
BNE 1028180.00	0.038	0.053
BNE 1028405.13	0.038	0.063
BNE 1028405.13	0.038	0.063
BNE 1028680.00	0.038	0.076

Bremer River

Flowpath & Chainage	n min	n max
BREM 1000000.00	0.065	0.065
BREM 1000700.00	0.008	0.065
BREM 1001120.00	0.015	0.065
BREM 1001700.00	0.015	0.065
BREM 1002300.00	0.053	0.095
BREM 1002700.00	0.051	0.095
BREM 1003200.00	0.050	0.120
BREM 1003200.00	0.050	0.120
BREM 1003700.00	0.020	0.050
BREM 1003840.00	0.020	0.055
BREM 1003840.00	0.020	0.055
BREM 1004150.00	0.020	0.044
BREM 1004320.00	0.020	0.049
BREM 1004320.00	0.020	0.049
BREM 1004590.00	0.031	0.087
BREM 1004610.00	0.031	0.102
BREM 1004700.00	0.031	0.062
BREM 1004700.00	0.031	0.062
BREM 1005140.00	0.031	0.112
BREM 1005520.00	0.031	0.088
BREM 1005740.00	0.031	0.068
BREM 1006090.00	0.031	0.068
BREM 1006250.00	0.031	0.062
BREM 1006490.00	0.031	0.062
BREM 1006510.00	0.031	0.062
BREM 1006760.00	0.031	0.062
BREM 1007440.00	0.031	0.099
BREM 1007700.00	0.031	0.068
BREM 1008000.00	0.031	0.056
BREM 1008000.00	0.031	0.056
BREM 1008390.00	0.031	0.050
BREM 1008410.00	0.046	0.074
BREM 1008420.00	0.046	0.074
BREM 1008660.00	0.046	0.101
BREM 1009210.00	0.046	0.101
BREM 1009675.00	0.046	0.101
BREM 1009675.00	0.046	0.101
BREM 1009856.00	0.046	0.072
BREM 1009856.00	0.046	0.072
BREM 1010020.00	0.046	0.046
BREM 1010280.00	0.023	0.046
BREM 1010700.00	0.023	0.046
BREM 1010890.00	0.023	0.046
BREM 1011320.00	0.023	0.046
BREM 1011700.00	0.046	0.115
BREM 1011790.00	0.046	0.133

BREM 1011610.00	0.046	0.143
BREM 1012050.00	0.046	0.147
BREM 1012070.00	0.025	0.034
BREM 1012200.00	0.025	0.034
BREM 1012870.00	0.025	0.036
BREM 1013380.00	0.025	0.034
BREM 1013700.00	0.025	0.028
BREM 1014220.00	0.025	0.028
BREM 1014640.00	0.025	0.028
BREM 1015160.00	0.025	0.028
BREM 1015445.00	0.025	0.028
BREM 1015445.00	0.025	0.028
BREM 1015710.00	0.025	0.028
BREM 1016110.00	0.025	0.028
BREM 1016110.00	0.025	0.028
BREM 1016510.00	0.025	0.028
BREM 1017080.00	0.025	0.028
BREM 1017750.00	*0.025*	*0.034*
BREM 1018140.00	0.025	0.034
BREM 1018320.00	0.025	0.034
BREM 1018320.00	0.025	0.034
BREM 1018500.00	0.025	0.034
BREM 1018630.00	0.024	0.028
BREM 1018630.00	0.024	0.028
BREM 1018760.00	0.022	0.028
BREM 1019150.00	0.025	0.028
BREM 1019580.00	0.025	0.034
BREM 1020000.00	0.025	0.048
BREM 1020000.00	0.025	0.048
BREM 1020450.00	0.025	0.048
BREM 1020450.00	0.025	0.048
BREM 1020600.00	0.025	0.048
BREM 1020600.00	0.025	0.048
BREM 1020920.00	0.025	0.048
BREM 1021460.00	0.025	0.048
BREM 1022300.00	0.025	0.048
BREM 1022950.00	0.025	0.048
BREM 1023490.00	0.025	0.048
BREM 1023510.00	0.025	0.048
BREM 1023870.00	0.025	0.048
BREM 1024220.00	0.025	0.048
BREM 1024520.00	0.025	0.048
BREM 1024750.00	0.025	0.042
BREM 1025300.00	0.025	0.042
BREM 1025670.00	0.025	0.042
BREM 1025920.00	0.025	0.042
BREM 1026150.00	0.025	0.042
BREM 1026560.00	0.025	0.042
BREM 1027100.00	0.025	0.042
BREM 1027640.00	0.025	0.070
BREM 1027840.00	0.025	0.090
BREM 1028190.00	0.025	0.090
BREM 1028190.00	0.025	0.090

Bremer Creek u/s of Warrill Creek

Flowpath & Chainage	n	n
	min	max
BREMER 0.00	0.055	0.132
BREMER 364.80	0.055	0.132
BREMER 1613.63	0.055	0.132
BREMER 2207.67	0.055	0.132
BREMER 2472.00	0.055	0.132
BREMER 2492.00	0.055	0.132
BREMER 2522.88	0.055	0.132
BREMER 3048.80	0.055	0.132
BREMER 3579.79	0.055	0.132
BREMER 4117.69	0.055	0.132
BREMER 4658.71	0.055	0.132
BREMER 5466.45	0.055	0.132
BREMER 6137.27	0.055	0.132
BREMER 6902.98	0.055	0.132
BREMER 7597.00	0.055	0.132
BREMER 7597.00	0.055	0.132
BREMER 8229.47	0.055	0.132
BREMER 9006.19	0.055	0.132
BREMER 9783.66	0.055	0.132
BREMER 9803.66	0.055	0.132
BREMER 9936.00	0.055	0.132
BREMER 9936.00	0.055	0.132
BREMER 10391.00	0.055	0.132
BREMER 10391.00	0.055	0.132
BREMER 10391.51	0.055	0.132
BREMER 10893.66	0.027	0.049
BREMER 10893.66	0.027	0.049
BREMER 11315.68	*0.027*	*0.035*
BREMER 11477.63	0.027	0.117
BREMER 11487.63	0.027	0.162
BREMER 11674.52	0.027	0.118
BREMER 12230.92	0.027	0.162
BREMER 12694.60	0.027	0.083
BREMER 13268.91	0.027	0.128
BREMER 13870.20	0.027	0.162
BREMER 14389.82	0.027	0.162
BREMER 14400.00	0.027	0.162
BREMER 14420.00	0.027	0.162
BREMER 14831.22	0.027	0.162
BREMER 15060.00	0.027	0.162
BREMER 15080.00	0.027	0.162

BREMER 15311.88	0.027	0.162
BREMER 15747.83	0.027	0.162
BREMER 16340.42	0.027	0.162
BREMER 16706.22	0.027	0.144
BREMER 17221.72	0.027	0.162
BREMER 17933.08	0.027	0.135
BREMER 18398.80	0.027	0.162
BREMER 19050.94	0.027	0.162
BREMER 19360.00	0.027	0.162
BREMER 19380.00	0.027	0.162
BREMER 19419.49	0.045	0.227
BREMER 20465.54	0.065	0.325
BREMER 20876.67	0.065	0.325
BREMER 21565.85	0.065	0.325
BREMER 21851.32	0.065	0.325
BREMER 22410.57	0.065	0.325
BREMER 22931.36	0.065	0.325
BREMER 23375.87	0.065	0.325
BREMER 23968.39	0.065	0.110
BREMER 24384.46	0.065	0.110
BREMER 24891.36	0.065	0.110
BREMER 25371.48	0.065	0.110
BREMER 25882.25	0.065	0.110
BREMER 26285.02	0.065	0.110
BREMER 26341.55	0.065	0.110
BREMER 26773.64	0.065	0.110
BREMER 27056.11	0.065	0.110
BREMER 27398.71	0.065	0.110
BREMER 27591.25	0.065	0.110
BREMER 27839.23	0.065	0.110
BREMER 28051.84	0.065	0.110
BREMER 28338.03	0.065	0.110
BREMER 28868.29	0.065	0.110
BREMER 29126.92	0.065	0.110
BREMER 29472.00	0.065	0.110
BREMER 29515.00	0.005	0.068
BREMER 29535.00	0.004	0.052
BREMER 29578.00	0.004	0.052
BREMER 29891.00	0.004	0.052
BREMER 30091.00	0.020	0.052
BREMER 30791.00	0.020	0.052

Upper Bremer River (Boonah Shire)

Flowpath & Chainage	n min	n max
BREMER-BOONAHNEW 9869.00	0.030	0.030
BREMER-BOONAHNEW 10456.43	0.030	0.030
BREMER-BOONAHNEW 11917.00	0.030	0.030
BREMER-BOONAHNEW 11937.00	0.030	0.030
BREMER-BOONAHNEW 12500.00	0.030	0.030
BREMER-BOONAHNEW 13405.41	0.030	0.030
BREMER-BOONAHNEW 13930.22	0.030	0.030
BREMER-BOONAHNEW 13938.22	0.030	0.030
BREMER-BOONAHNEW 14368.66	0.030	0.030
BREMER-BOONAHNEW 15447.36	0.030	0.030
BREMER-BOONAHNEW 16506.06	0.030	0.030
BREMER-BOONAHNEW 16518.08	0.030	0.030
BREMER-BOONAHNEW 18166.50	0.030	0.030
BREMER-BOONAHNEW 19093.71	0.030	0.030
BREMER-BOONAHNEW 20723.30	0.030	0.030
BREMER-BOONAHNEW 21991.71	0.030	0.030
BREMER-BOONAHNEW 23828.91	0.030	0.030
BREMER-BOONAHNEW 24500.00	0.075	0.075
BREMER-BOONAHNEW 24546.71	0.075	0.075
BREMER-BOONAHNEW 24556.71	0.075	0.075
BREMER-BOONAHNEW 24600.00	0.075	0.075
BREMER-BOONAHNEW 26500.72	0.075	0.084
BREMER-BOONAHNEW 27584.32	0.075	0.120
BREMER-BOONAHNEW 29213.00	0.075	0.075

Bundamba Creek

Flowpath & Chainage	n min	n max
BUND 10000.00	0.020	0.020
BUND 10307.50	0.020	0.020
BUND 10615.00	0.020	0.020
BUND 11107.50	0.020	0.020
BUND 11600.00	0.020	0.020
BUND 11968.33	0.020	0.020
BUND 12336.67	0.020	0.020
BUND 12705.00	0.020	0.020
BUND 13165.00	0.020	0.020
BUND 13552.50	0.020	0.020
BUND 13940.00	0.020	0.020
BUND 14217.50	0.020	0.020
BUND 14495.00	0.020	0.180
BUND 14775.00	0.020	0.020
BUND 15055.00	0.020	0.020
BUND 15377.50	0.020	0.020
BUND 15700.00	0.020	0.134
BUND 16047.50	0.020	0.162

BUND 16395.00	0.020	0.171
BUND 16647.50	0.020	0.100
BUND 16900.00	0.020	0.111
BUND 17215.00	0.020	0.100
BUND 17530.00	0.020	0.180
BUND 17885.00	0.020	0.115
BUND 18307.50	0.020	0.101
BUND 18730.00	0.020	0.180
BUND 18760.00	0.020	0.180
BUND 19015.00	0.020	0.100
BUND 19280.00	0.020	0.180
BUND 19540.00	0.020	0.149
BUND 19800.00	0.020	0.119
BUND 20120.00	0.020	0.149
BUND 20440.00	0.020	0.180
BUND 20905.00	0.020	0.106
BUND 21370.00	0.020	0.127
BUND 21745.00	0.020	0.100
BUND 22120.00	0.020	0.180
BUND 22120.00	0.020	0.180
BUND 22452.50	0.020	0.100
BUND 22785.00	0.020	0.065
BUND 23150.00	0.020	0.101
BUND 23515.00	0.020	0.137
BUND 23822.50	0.020	0.130
BUND 24130.00	0.020	0.078
BUND 24445.00	0.020	0.082
BUND 24760.00	0.020	0.118
BUND 25075.00	0.020	0.180
BUND 25327.50	0.020	0.100
BUND 25580.00	0.020	0.180
BUND 25600.00	0.020	0.180
BUND 26070.00	0.020	0.180
BUND 26540.00	0.020	0.180
BUND 26760.00	*0.020*	*0.020*
BUND 27280.00	0.020	0.020
BUND 27380.00	0.020	0.020
BUND 27400.00	0.020	0.023
BUND 27655.00	0.020	0.020
BUND 27675.00	0.020	0.020
BUND 28010.00	0.020	0.025
BUND 28350.00	0.020	0.035
BUND 28350.00	0.020	0.035
BUND 28480.00	0.020	0.043
BUND 28530.00	0.020	0.059
BUND 28560.00	0.020	0.067
BUND 28630.00	0.020	0.100
BUND 28630.00	0.020	0.100
BUND 28935.00	0.020	0.045
BUND 29240.00	0.020	0.047
BUND 29550.00	0.080	0.088
BUND 29910.00	0.080	0.080
BUND 30215.00	0.060	0.096
BUND 30520.00	0.002	0.080
BUND 30940.00	0.080	0.080
BUND 31360.00	0.080	0.080
BUND 31630.00	0.080	0.240
BUND 31980.00	0.080	0.165
BUND 32000.00	0.080	0.122
BUND 32150.00	0.065	0.104
BUND 32350.00	0.065	0.091
BUND 32370.00	0.065	0.091
BUND 32675.00	0.055	0.065
BUND 32980.00	0.049	0.065
BUND 33320.00	0.045	0.065
BUND 33660.00	0.036	0.065
BUND 34000.00	0.036	0.065
BUND 34000.00	0.036	0.065
BUND 34260.00	0.036	0.065
BUND 34305.00	0.036	0.065
BUND 34345.00	0.036	0.065
BUND 34395.00	0.044	0.080
BUND 34760.00	0.044	0.080
BUND 35050.00	0.044	0.080
BUND 35100.00	0.044	0.080
BUND 35120.00	0.056	0.080
BUND 35520.00	0.056	0.080
BUND 35540.00	0.035	0.080
BUND 35730.00	0.056	0.080
BUND 36005.00	0.056	0.080
BUND 36025.00	0.056	0.080
BUND 36297.50	0.056	0.080
BUND 36570.00	0.056	0.080
BUND 36840.00	*0.042*	*0.080*
BUND 37110.00	0.028	0.080
BUND 37510.00	0.040	0.080
BUND 37910.00	0.052	0.080
BUND 37910.00	0.052	0.080
BUND 38280.00	0.056	0.080
BUND 38722.50	0.056	0.080
BUND 39165.00	0.056	0.080
BUND 39546.67	0.056	0.080
BUND 39928.33	0.056	0.080
BUND 40310.00	0.056	0.080
BUND 40670.00	0.056	0.080
BUND 41030.00	0.056	0.080
BUND 41049.04	0.056	0.080

Goodna Creek

Flowpath & Chainage	n min	n max
GOOD 10000.00	0.060	0.060
GOOD 10275.00	0.060	0.060
GOOD 10475.00	0.060	0.060
GOOD 10705.00	0.060	0.060
GOOD 10925.00	0.060	0.060
GOOD 11335.00	0.060	0.060
GOOD 11625.00	0.060	0.060
GOOD 11945.00	0.060	0.060
GOOD 12020.00	0.060	0.060
GOOD 12044.00	0.060	0.060
GOOD 12155.00	0.060	0.060
GOOD 12425.00	0.060	0.060
GOOD 12680.00	0.060	0.080
GOOD 12935.00	0.060	0.060
GOOD 13275.00	0.060	0.060
GOOD 13475.00	0.060	0.060
GOOD 13675.00	0.060	0.060
GOOD 14155.00	0.060	0.060
GOOD 14195.00	0.054	0.060
GOOD 14265.00	0.054	0.060
GOOD 14375.00	0.054	0.060
GOOD 14555.00	0.060	0.060
GOOD 14575.00	0.054	0.060
GOOD 14615.00	0.054	0.060
GOOD 14635.00	0.054	0.060
GOOD 14735.00	0.054	0.060
GOOD 14695.00	0.054	0.060
GOOD 14905.00	0.060	0.060
GOOD 14920.00	0.060	0.060
GOOD 14930.00	0.060	0.060
GOOD 14975.00	0.060	0.060
GOOD 15350.00	0.060	0.060
GOOD 15645.00	0.060	0.060
GOOD 16175.00	0.048	0.060
GOOD 16355.00	0.060	0.060
GOOD 16525.00	0.060	0.060
GOOD 16725.00	0.060	0.060

Six Mile Creek

Flowpath & Chainage	n min	n max
SIX 9530.00	0.065	0.065
SIX 10060.00	0.065	0.065
SIX 10310.00	0.065	0.085
SIX 10365.00	0.065	0.085
SIX 10380.00	0.065	0.085
SIX 10460.00	0.065	0.085
SIX 10920.00	0.065	0.085
SIX 11355.00	0.065	0.085
SIX 11570.00	0.085	0.085
SIX 11670.00	0.065	0.085
SIX 11770.00	0.065	0.163
SIX 11800.00	0.065	0.163
SIX 11870.00	0.065	0.085
SIX 12010.00	0.065	0.085
SIX 12470.00	0.065	0.085
SIX 12970.00	0.065	0.085
SIX 13520.00	0.065	0.085
SIX 14045.00	0.065	0.065
SIX 14470.00	0.065	0.085
SIX 14800.00	0.065	0.071
SIX 15170.00	0.065	0.085
SIX 15570.00	0.065	0.085
SIX 15910.00	0.065	0.085
SIX 16270.00	0.065	0.085
SIX 16470.00	0.065	0.085
SIX 16720.00	0.065	0.085
SIX 17140.00	0.065	0.163
SIX 17270.00	0.065	0.085
SIX 17530.00	0.065	0.163
SIX 17930.00	0.065	0.093
SIX 18270.00	0.065	0.163
SIX 18720.00	0.065	0.085
SIX 18970.00	0.065	0.085
SIX 19170.00	0.065	0.085
SIX 19370.00	0.065	0.085
SIX 19650.00	0.067	0.085
SIX 19790.00	0.065	0.085
SIX 19870.00	0.065	0.065
SIX 20000.00	0.065	0.085
SIX 20140.00	0.065	0.085
SIX 20160.00	0.065	0.085
SIX 20235.00	0.065	0.085

Purga Creek

Flowpath & Chainage	n min	n max
PURGA 0.00	0.030	0.030
PURGA 1345.80	0.030	0.030
PURGA 1912.30	0.030	0.030
PURGA 2986.00	0.030	0.030
PURGA 2986.00	0.030	0.030
PURGA 3006.00	0.030	0.030
PURGA 3345.71	0.030	0.030
PURGA 4502.41	0.030	0.030
PURGA 5004.51	0.030	0.030
PURGA 5474.54	0.030	0.030
PURGA 5938.99	0.030	0.030
PURGA 6450.77	0.030	0.030
PURGA 6997.75	0.030	0.030
PURGA 7491.67	0.030	0.030
PURGA 7945.62	0.030	0.030
PURGA 8450.21	0.030	0.030
PURGA 8978.82	0.030	0.030
PURGA 10515.22	0.030	0.030
PURGA 10988.20	0.030	0.030
PURGA 11344.89	0.030	0.030
PURGA 11781.18	0.030	0.030
PURGA 12363.30	0.030	0.030
PURGA 12786.29	0.030	0.030
PURGA 12806.29	0.030	0.030
PURGA 13281.62	0.030	0.030
PURGA 13569.12	0.030	0.030
PURGA 14068.76	0.030	0.030
PURGA 14480.16	0.030	0.030
PURGA 14799.07	0.030	0.030
PURGA 15308.54	0.030	0.030
PURGA 15971.04	0.030	0.030
PURGA 16563.37	0.030	0.030
PURGA 17169.76	0.030	0.030
PURGA 17826.32	0.030	0.030
PURGA 17826.32	0.030	0.030
PURGA 18140.67	0.030	0.030
PURGA 18629.82	0.030	0.030
PURGA 19241.91	0.030	0.030
PURGA 19930.56	0.030	0.030
PURGA 19950.56	0.030	0.030
PURGA 20954.56	0.030	0.030
PURGA 20954.56	0.030	0.030
PURGA 21686.56	0.030	0.030
PURGA 21686.56	0.030	0.030
PURGA 22344.00	0.030	0.030
PURGA_2 42.00	0.030	0.030
PURGA_2 279.00	0.030	0.030
PURGA_2 516.00	0.030	0.030
PURGA_2 753.00	0.030	0.030
PURGA_2 990.00	0.030	0.030
PURGA_2 1227.00	0.030	0.030
PURGA_2 1464.00	0.030	0.030
PURGA_2 1701.00	0.030	0.030
PURGA_2 1938.00	0.030	0.030
PURGA_2 2175.00	0.030	0.030
PURGA_2 2412.00	0.030	0.030
PURGA_2 2649.00	0.030	0.030
PURGA_2 2886.00	0.030	0.030
PURGA_2 2890.00	0.030	0.030
PURGA_2 3110.25	0.030	0.030
PURGA_2 3330.50	0.030	0.030
PURGA_2 3550.75	0.030	0.030
PURGA_2 3771.00	0.030	0.030
PURGA_2 3991.25	0.030	0.030
PURGA_2 4211.50	0.030	0.030
PURGA_2 4431.75	0.030	0.030
PURGA_2 4652.00	0.030	0.030

Warrill Creek

Flowpath & Chainage	n min	n max
WARRILL 0.00	0.090	0.090
WARRILL 1033.45	0.024	0.090
WARRILL 2424.10	0.009	0.090
WARRILL 2444.10	0.009	0.090
WARRILL 3488.49	0.009	0.090
WARRILL 3498.49	0.010	0.090
WARRILL 3683.49	0.041	0.090
WARRILL 4778.90	0.009	0.090
WARRILL 4798.90	0.017	0.090
WARRILL 6397.07	0.025	0.090
WARRILL 6407.07	0.026	0.090
WARRILL 7111.27	0.009	0.090
WARRILL 7131.27	0.024	0.090
WARRILL 8514.13	0.041	0.090
WARRILL 9896.98	0.009	0.090
WARRILL 10941.75	0.010	0.090
WARRILL 11579.99	0.009	0.090
WARRILL 11599.99	0.009	0.090
WARRILL 12312.49	0.006	0.060
WARRILL 12938.26	0.006	0.060
WARRILL 13459.92	0.006	0.060
WARRILL 13716.44	0.006	0.060
WARRILL 14151.04	0.006	0.060
WARRILL 15218.95	0.006	0.060

WARRILL 15709.63	0.006	0.060
WARRILL 16308.32	0.006	0.060
WARRILL 17201.96	0.006	0.060
WARRILL 18218.98	0.006	0.060
WARRILL 18724.52	0.006	0.060
WARRILL 19155.35	0.007	0.060
WARRILL 19737.18	0.006	0.060
WARRILL 20169.55	0.006	0.060
WARRILL 20702.56	0.006	0.060
WARRILL 20969.75	0.006	0.060
WARRILL 21648.19	0.006	0.060
WARRILL 23198.78	0.006	0.060
WARRILL 23701.37	0.006	0.060
WARRILL 23701.37	0.006	0.060
WARRILL 24126.72	0.006	0.060
WARRILL 24580.02	0.006	0.060
WARRILL 25048.56	0.008	0.065
WARRILL 25710.00	0.039	0.065
WARRILL 25730.00	0.039	0.065
WARRILL 26219.35	0.033	0.055
WARRILL 26693.35	0.033	0.055
WARRILL 27315.35	0.033	0.055
WARRILL 27873.35	0.033	0.055
WARRILL 28487.35	0.033	0.055
WARRILL 29252.35	0.033	0.055
WARRILL 29849.35	0.033	0.055
WARRILL 29849.35	0.033	0.055
WARRILL 30164.35	0.033	0.055
WARRILL 30164.35	0.033	0.055
WARRILL 30886.35	0.033	0.055
WARRILL 30886.35	0.033	0.055
WARRILL 31173.35	0.033	0.055
WARRILL 31526.35	0.033	0.055
WARRILL 32023.35	0.033	0.055
WARRILL 32284.35	0.033	0.055
WARRILL 32634.35	0.033	0.055
WARRILL 33250.35	0.033	0.055
WARRILL 33860.35	0.039	0.065

Upper Warrill Creek

Flowpath & Chainage	n min	n max
WARRILL-BOONAH 0.00	0.018	0.018
WARRILL-BOONAH 1763.90	0.016	0.018
WARRILL-BOONAH 2771.21	0.016	0.018
WARRILL-BOONAH 3385.00	0.014	0.018
WARRILL-BOONAH 3400.00	0.018	0.018
WARRILL-BOONAH 4501.05	0.012	0.018
WARRILL-BOONAH 5743.62	0.017	0.018
WARRILL-BOONAH 6448.72	0.015	0.018
WARRILL-BOONAH 7295.14	0.018	0.018
WARRILL-BOONAH 8223.07	0.014	0.018
WARRILL-BOONAH 9097.24	0.018	0.018
WARRILL-BOONAH 10614.64	0.016	0.018
WARRILL-BOONAH 12056.67	0.018	0.018
WARRILL-BOONAH 13180.04	0.018	0.018
WARRILL-BOONAH 14463.88	0.013	0.018
WARRILL-BOONAH 14878.92	0.009	0.017
WARRILL-BOONAH 15984.89	0.018	0.018
WARRILL-BOONAH 16994.69	0.016	0.018
WARRILL-BOONAH 17217.61	0.015	0.018
WARRILL-BOONAH 18308.24	0.009	0.018
WARRILL-BOONAH 18901.08	0.009	0.018
WARRILL-BOONAH 19441.64	0.011	0.018
WARRILL-BOONAH 19461.64	0.013	0.018
WARRILL-BOONAH 20991.60	0.009	0.018
WARRILL-BOONAH 22471.48	0.009	0.018
WARRILL-BOONAH 23063.09	0.010	0.018
WARRILL-BOONAH 24050.26	0.009	0.018
WARRILL-BOONAH 25131.10	0.009	0.018
WARRILL-BOONAH 26305.71	0.009	0.018
WARRILL-BOONAH 26315.71	0.009	0.018
WARRILL-BOONAH 28136.46	0.009	0.018
WARRILL-BOONAH 29113.49	0.009	0.018
WARRILL-BOONAH 30795.00	0.009	0.018
WARRILL-BOONAH 30815.00	0.009	0.018

Woogaroo Creek

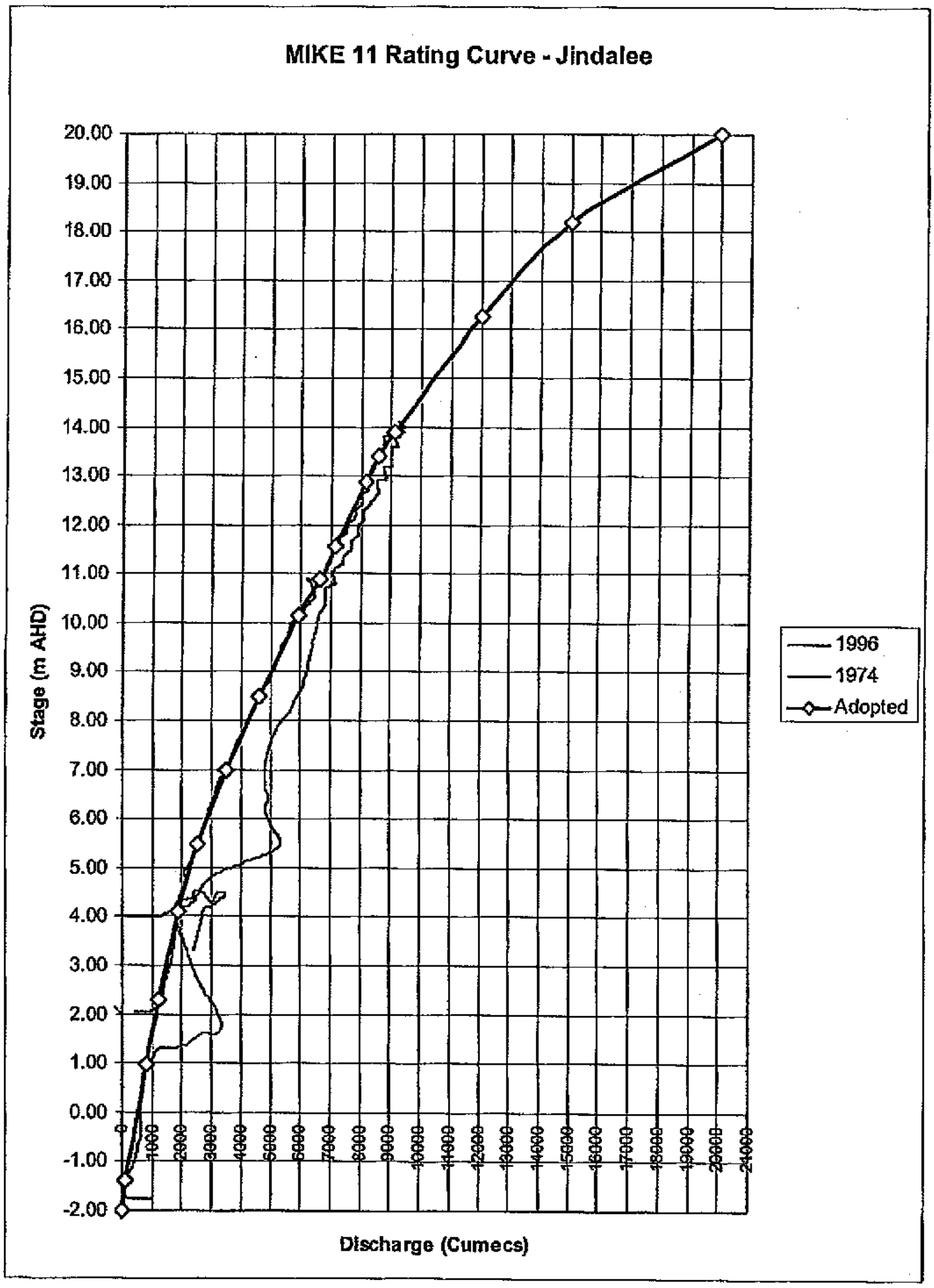
Flowpath & Chainage	n min	n max
WOOG 10000.00	0.072	0.072
WOOG 10450.00	0.072	0.072
WOOG 10930.00	0.072	0.072
WOOG 11150.00	0.072	0.072
WOOG 11530.00	0.072	0.072
WOOG 12030.00	0.072	0.072
WOOG 12130.00	0.072	0.072
WOOG 12620.00	0.072	0.072
WOOG 12930.00	0.072	0.072
WOOG 13070.00	0.072	0.072
WOOG 13250.00	0.072	0.072
WOOG 13510.00	0.072	0.072
WOOG 13550.00	0.072	0.072
WOOG 13640.00	0.072	0.072
WOOG 13800.00	0.072	0.072
WOOG 13800.00	0.072	0.072
WOOG 13995.00	0.072	0.072
WOOG 13995.00	0.072	0.072
WOOG 14070.00	0.072	0.072
WOOG 14100.00	0.072	0.072
WOOG 14180.00	0.072	0.072
WOOG 14160.00	0.072	0.072
WOOG 14450.00	0.072	0.072
WOOG 14790.00	0.072	0.072
WOOG 14850.00	0.072	0.072
WOOG 14950.00	0.072	0.072
WOOG 15050.00	0.072	0.072
WOOG 15150.00	0.072	0.072
WOOG 15150.00	0.072	0.072
WOOG 15230.00	0.072	0.072
WOOG 15300.00	0.072	0.072
WOOG 15370.00	0.072	0.072
WOOG 15470.00	0.072	0.072
WOOG 15520.00	0.072	0.072
WOOG 15600.00	0.072	0.072
WOOG 15720.00	0.072	0.072
WOOG 15800.00	0.072	0.072
WOOG 15840.00	0.090	0.090
WOOG 15860.00	0.090	0.090
WOOG 15960.00	0.090	0.090
WOOG 15990.00	0.070	0.070
WOOG 16010.00	0.070	0.070
WOOG 16125.00	0.070	0.070
WOOG 16150.00	0.070	0.070
WOOG 16275.00	0.070	0.070
WOOG 16440.00	0.070	0.070
WOOG 16600.00	0.070	0.070
WOOG 16700.00	0.070	0.070
WOOG 16850.00	0.070	0.070
WOOG 16900.00	0.070	0.070
WOOG 17050.00	0.070	0.070
WOOG 17125.00	0.070	0.070
WOOG 17275.00	0.070	0.070
WOOG 17310.00	0.070	0.070
WOOG 17370.00	0.080	0.080
WOOG 17440.00	0.080	0.080
WOOG 17460.00	0.080	0.080
WOOG 17500.00	0.060	0.060
WOOG 17550.00	0.060	0.060
WOOG 17580.00	0.060	0.060
WOOG 17600.00	0.060	0.060
WOOG 17615.00	0.060	0.060
WOOG 17750.00	0.060	0.060
WOOG 17760.00	0.060	0.060
WOOG 17780.00	0.060	0.060
WOOG 17950.00	0.060	0.060
WOOG 17960.00	0.060	0.060
WOOG 18250.00	0.060	0.060
WOOG 18250.00	0.060	0.060
WOOG 18500.00	0.060	0.060
WOOG 18760.00	0.060	0.060
WOOG 18900.00	0.060	0.060
WOOG 19075.00	0.060	0.060

Western Creek (Rail South)

Flowpath & Chainage	n min	n max
RAILSOUTH 869.00	0.060	0.060
RAILSOUTH 1030.00	0.046	0.060
RAILSOUTH 1030.00	0.046	0.060
RAILSOUTH 1400.00	0.060	0.060
RAILSOUTH 1400.00	0.060	0.060
RAILSOUTH 1506.31	0.033	0.060
RAILSOUTH 2115.00	0.016	0.060
RAILSOUTH 2115.00	0.016	0.060
RAILSOUTH 2593.10	0.012	0.060
RAILSOUTH 3353.67	0.060	0.060
RAILSOUTH 3798.28	0.039	0.060
RAILSOUTH 4265.00	0.012	0.060
RAILSOUTH 4285.00	0.012	0.060
RAILSOUTH 4361.13	0.012	0.060
RAILSOUTH 4558.00	0.060	0.060
RAILSOUTH 6909.00	0.012	0.060
RAILSOUTH 7346.00	0.012	0.060

RAILSOUTH 7345.00	0.012	0.060
RAILSOUTH 8032.00	0.012	0.060
RAILSOUTH 8032.00	0.012	0.060
RAILSOUTH 8324.00	0.012	0.060
RAILSOUTH 8324.00	0.012	0.060
RAILSOUTH 8789.28	0.014	0.060
RAILSOUTH 9029.00	0.024	0.060
RAILSOUTH 9029.00	0.024	0.060
RAILSOUTH 9269.34	0.020	0.060
RAILSOUTH 9771.72	0.033	0.060
RAILSOUTH 9791.72	0.038	0.060
RAILSOUTH 10377.00	0.012	0.060
RAILSOUTH 10377.00	0.012	0.060
RAILSOUTH 10796.10	0.012	0.060
RAILSOUTH 11379.38	0.012	0.060
RAILSOUTH 11380.00	0.012	0.060
RAILSOUTH 11380.00	0.012	0.060
RAILSOUTH 11963.54	0.019	0.060
RAILSOUTH 12163.00	0.014	0.060
RAILSOUTH 12163.00	0.014	0.060
RAILSOUTH 12390.00	0.012	0.060
RAILSOUTH 12410.00	0.019	0.060
RAILSOUTH 13468.00	0.015	0.060
RAILSOUTH 13468.00	0.015	0.060
RAILSOUTH 13868.00	0.060	0.060
RAILSOUTH 13868.00	0.060	0.060
RAILSOUTH 14628.00	0.014	0.060
RAILSOUTH 14628.00	0.014	0.060
RAILSOUTH 14728.00	0.017	0.060
RAILSOUTH 14728.00	0.017	0.060
RAILSOUTH 14838.00	0.060	0.060
RAILSOUTH 14858.00	0.060	0.060
RAILSOUTH 16228.00	0.032	0.060

Appendix D Jindalee Rating Curve



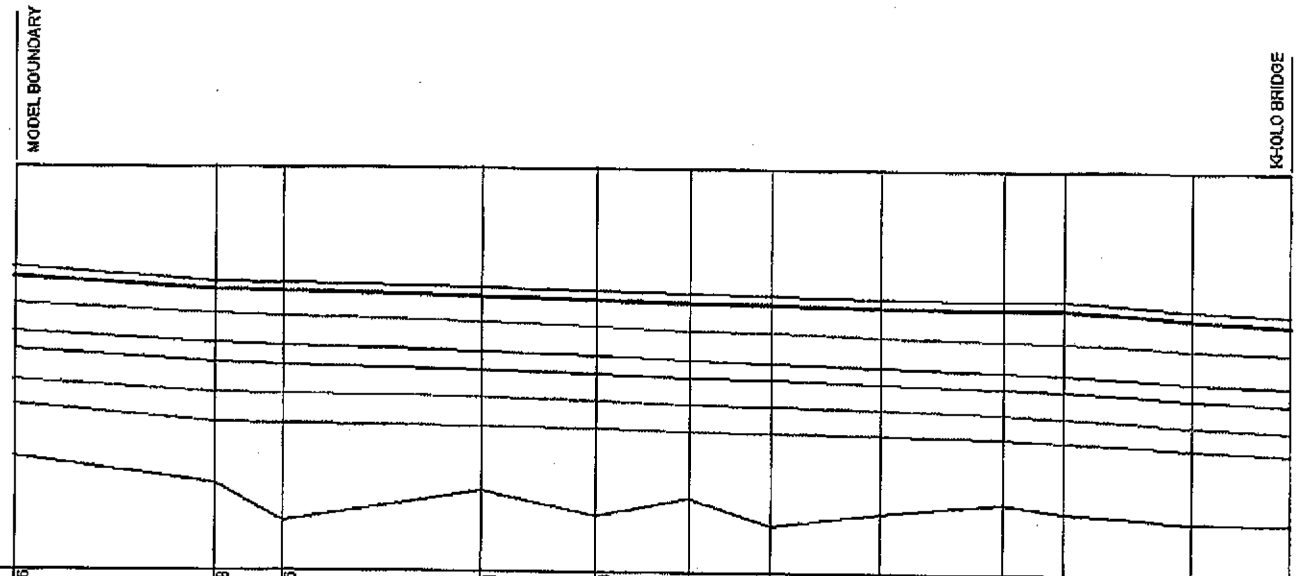
Appendix E Longitudinal Profiles- Design

Legend

Estimated Flood Levels

ARI (Years)

500
200
100
50
20
10
5
2



Chainage m Model Branch BNE	964,170	966,810	967,410	969,790	971,160	972,280
Modelled 500 Year ARI Peak Flood Level m AHD	38.6	31.8	31.6	31.1	30.8	30.5
Modelled 200 Year ARI Peak Flood Level m AHD	32.3	30.8	30.6	30.1	29.7	29.4
Modelled 100 Year ARI Peak Flood Level m AHD	32.2	30.7	30.5	29.9	29.6	29.2
Modelled 50 Year ARI Peak Flood Level m AHD	29.1	27.9	27.6	26.9	26.5	26.1
Modelled 20 Year ARI Peak Flood Level m AHD	25.7	24.3	24.1	23.4	22.9	22.5
Modelled 10 Year ARI Peak Flood Level m AHD	23.6	22.1	21.9	21.3	20.9	20.5
Modelled 5 Year ARI Peak Flood Level m AHD	20.0	18.5	18.3	17.9	17.6	17.2
Modelled 2 Year ARI Peak Flood Level m AHD	17.0	14.8	14.7	14.5	14.3	14.0
Bed Level m AHD	10.80	7.61	3.13	6.79	3.86	8.08

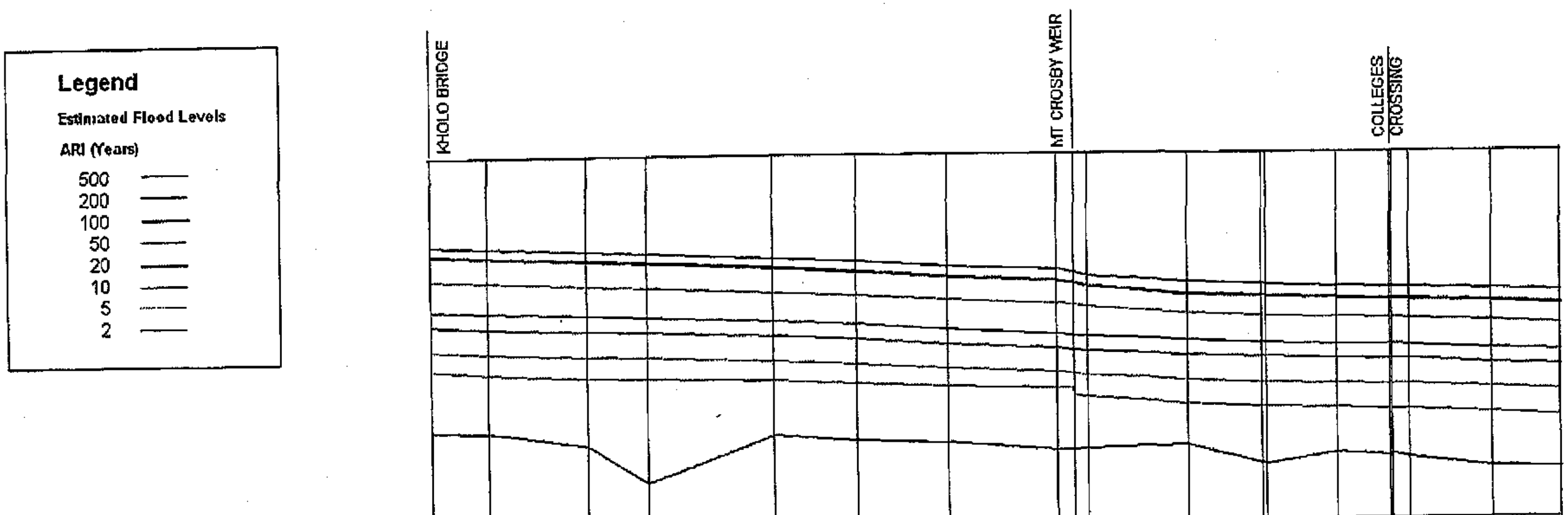
Chainage m Model Branch BNE	973,260	974,580	976,020	976,750	978,280	979,507
Modelled 500 Year ARI Peak Flood Level m AHD	30.3	30.1	29.9	29.9	28.9	28.2
Modelled 200 Year ARI Peak Flood Level m AHD	29.3	29.0	28.8	28.8	27.7	27.0
Modelled 100 Year ARI Peak Flood Level m AHD	29.1	28.8	28.6	28.6	27.5	26.8
Modelled 50 Year ARI Peak Flood Level m AHD	25.9	25.5	25.0	24.9	24.1	23.6
Modelled 20 Year ARI Peak Flood Level m AHD	22.3	21.8	21.3	21.0	20.1	19.6
Modelled 10 Year ARI Peak Flood Level m AHD	20.3	19.8	19.3	19.0	18.1	17.5
Modelled 5 Year ARI Peak Flood Level m AHD	17.0	16.7	16.3	15.8	14.9	14.3
Modelled 2 Year ARI Peak Flood Level m AHD	13.8	13.6	13.3	12.9	12.1	11.6
Bed Level m AHD	2.73	4.29	5.58	4.50	3.37	3.32

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Brisbane River
MIKE 11 Chainage 964.170 - 979.507

Profile E1



Modelled 500 Year ARI Peak Flood Level m AHD	28.2	27.9	27.4	27.0	26.4	25.8	25.1	24.6	24.2	23.8	22.9	22.6	22.5	22.2	22.0	22.0	21.9	21.7	21.3
Modelled 200 Year ARI Peak Flood Level m AHD	27.0	26.7	26.1	25.8	25.0	24.5	23.7	23.1	22.7	22.3	21.3	21.0	21.0	20.7	20.5	20.5	20.4	20.2	19.8
Modelled 100 Year ARI Peak Flood Level m AHD	26.8	26.5	26.0	25.6	24.9	24.4	23.6	23.0	22.7	22.3	21.3	20.9	20.9	20.6	20.4	20.3	20.3	20.0	19.5
Modelled 50 Year ARI Peak Flood Level m AHD	23.6	23.3	22.8	22.4	21.8	21.3	20.6	20.1	19.9	19.6	18.6	18.3	18.2	18.0	17.8	17.8	17.7	17.4	17.0
Modelled 20 Year ARI Peak Flood Level m AHD	19.6	19.3	18.8	18.5	17.9	17.4	16.6	15.9	15.6	15.6	15.1	14.7	14.7	14.4	14.3	14.3	14.2	13.8	13.4
Modelled 10 Year ARI Peak Flood Level m AHD	17.5	17.2	16.7	16.5	15.9	15.4	14.7	14.0	13.7	13.7	13.2	12.8	12.8	12.6	12.5	12.4	12.4	11.8	11.5
Modelled 5 Year ARI Peak Flood Level m AHD	14.3	13.8	13.3	13.1	12.6	12.0	11.4	10.9	10.5	10.4	9.8	9.4	9.4	9.2	9.1	9.0	9.0	8.5	8.1
Modelled 2 Year ARI Peak Flood Level m AHD	11.6	11.0	10.4	10.3	9.9	9.4	9.0	6.8	7.7	7.5	6.6	6.1	6.1	5.9	5.7	5.7	5.6	5.1	4.6
Bed Level m AHD	2.84	3.16	1.36	-3.73	2.63	1.85	1.51	0.54	0.52	0.60	1.10	-1.44	-1.59	0.00	-0.26	-0.39	-0.69	-2.00	-2.06
Chainage m Model Branch BNE	979,530	980,330	981,680	982,460	984,160	985,260	986,480	987,980	988,160	988,170	989,700	990,700	990,760	991,710	992,420	992,470	992,670	993,760	994,760

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Brisbane River
MIKE 11 Chainage 979.530 - 994.760

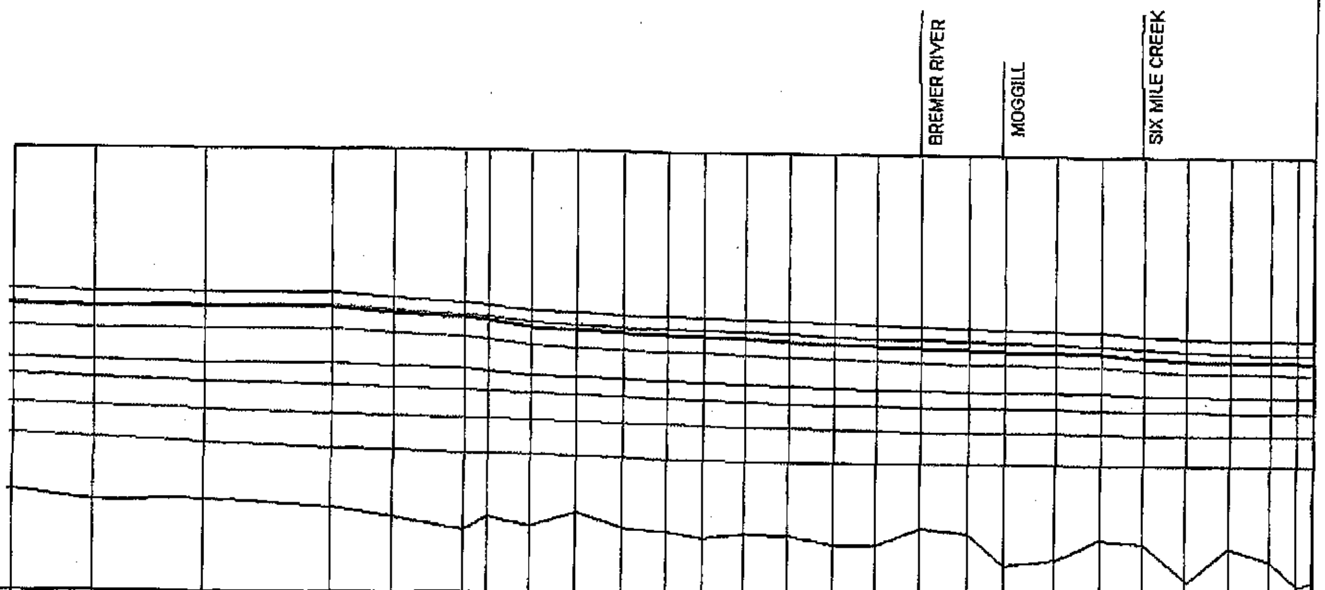
Profile E2

Legend

Estimated Flood Levels

ARI (Years)

500
200
100
50
20
10
5
2



Modelled 500 Year ARI Peak Flood Level m AHD	21.3	21.0	21.0	21.0	20.5	20.0	19.7	19.2	18.9
Modelled 200 Year ARI Peak Flood Level m AHD	19.8	19.5	19.5	19.5	19.0	18.6	18.3	17.7	17.5
Modelled 100 Year ARI Peak Flood Level m AHD	19.5	19.2	19.2	19.2	18.7	18.2	17.9	17.2	16.9
Modelled 50 Year ARI Peak Flood Level m AHD	17.0	16.8	16.8	16.8	16.4	16.1	15.8	15.2	14.9
Modelled 20 Year ARI Peak Flood Level m AHD	13.4	13.0	12.8	12.8	12.5	12.3	12.1	11.7	11.6
Modelled 10 Year ARI Peak Flood Level m AHD	11.5	11.1	10.6	10.3	10.0	9.8	9.7	9.6	9.5
Modelled 5 Year ARI Peak Flood Level m AHD	8.1	7.8	7.4	7.0	6.8	6.7	6.6	6.5	6.4
Modelled 2 Year ARI Peak Flood Level m AHD	4.6	4.1	3.5	3.0	2.8	2.6	2.6	2.5	2.4
Bed Level m AHD	-2.05	-3.15	-3.00	-3.93	-4.97	-6.40	-4.70	-5.80	-4.20
Chainage m Model Branch BNE	994,760	995,690	996,980	998,460	999,160	1,000,000	1,000,285	1,000,775	1,001,315

Modelled 500 Year ARI Peak Flood Level m AHD	18.7	18.7	18.6	18.4	18.3	18.0	18.0	17.8	17.7
Modelled 200 Year ARI Peak Flood Level m AHD	17.2	17.2	17.1	16.9	16.7	16.5	16.4	16.3	16.1
Modelled 100 Year ARI Peak Flood Level m AHD	16.6	16.5	16.4	16.1	15.6	15.6	15.5	15.3	15.1
Modelled 50 Year ARI Peak Flood Level m AHD	14.7	14.6	14.5	14.3	14.2	13.9	13.8	13.7	13.6
Modelled 20 Year ARI Peak Flood Level m AHD	11.3	11.1	11.0	10.9	10.8	10.6	10.5	10.4	10.3
Modelled 10 Year ARI Peak Flood Level m AHD	9.3	9.1	9.0	8.9	8.8	8.6	8.5	8.4	8.4
Modelled 5 Year ARI Peak Flood Level m AHD	6.3	6.2	6.1	6.0	5.9	5.8	5.8	5.7	5.6
Modelled 2 Year ARI Peak Flood Level m AHD	2.3	2.2	2.1	2.0	2.0	2.0	2.0	2.0	2.0
Bed Level m AHD	-5.90	-6.30	-5.90	-6.40	-6.50	-7.50	-7.60	-5.50	-6.10
Chainage m Model Branch BNE	1,001,865	1,002,350	1,002,785	1,003,275	1,003,775	1,004,300	1,004,810	1,005,325	1,005,870

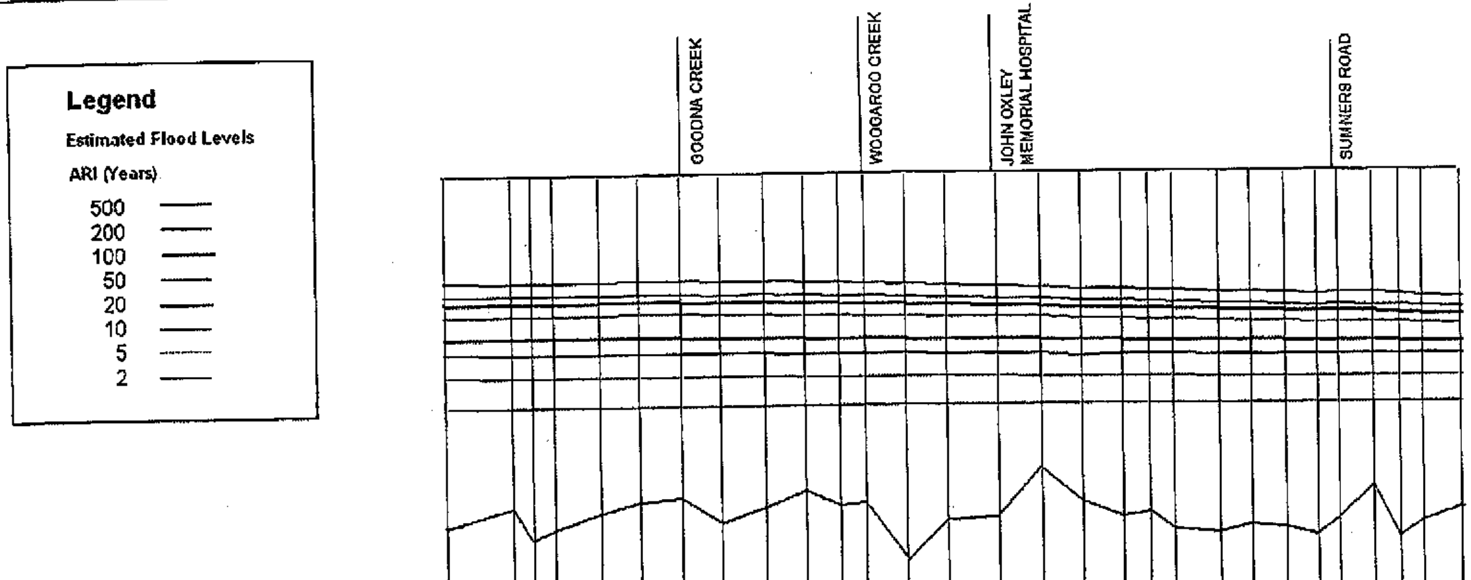
Modelled 500 Year ARI Peak Flood Level m AHD	17.5	17.4	17.3	17.0	16.6	16.5	16.5	16.5
Modelled 200 Year ARI Peak Flood Level m AHD	16.0	15.8	15.8	15.5	15.1	14.9	14.9	14.9
Modelled 100 Year ARI Peak Flood Level m AHD	15.0	14.9	14.8	14.5	14.1	14.0	13.9	13.9
Modelled 50 Year ARI Peak Flood Level m AHD	13.5	13.4	13.4	13.0	12.7	12.6	12.6	12.6
Modelled 20 Year ARI Peak Flood Level m AHD	10.3	10.3	10.3	10.1	10.0	9.9	9.9	9.9
Modelled 10 Year ARI Peak Flood Level m AHD	8.3	8.3	8.3	8.2	8.2	8.2	8.2	8.2
Modelled 5 Year ARI Peak Flood Level m AHD	5.6	5.6	5.6	5.5	5.5	5.5	5.5	5.5
Modelled 2 Year ARI Peak Flood Level m AHD	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Bed Level m AHD	-9.70	-9.00	-6.60	-7.10	-11.50	-7.60	-9.00	-12.00
Chainage m Model Branch BNE	1,006,300	1,006,910	1,007,410	1,007,920	1,008,445	1,008,925	1,009,400	1,009,720

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Brisbane River
MIKE 11 Chainage 994.760 - 1.009.720

Profile E3



Chainage m Model Branch BNE	1,009,720	1,010,490	1,010,725	1,010,980	1,011,510	1,011,980	1,012,475	1,012,935	1,013,445	1,013,910	1,014,310	1,014,610	1,015,080	1,015,560	1,016,140
Modelled 500 Year ARI Peak Flood Level m AHD	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.2	16.1	16.0	15.9	15.7	15.6
Modelled 200 Year ARI Peak Flood Level m AHD	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.8	14.8	14.7	14.6	14.5	14.5	14.3	14.2
Modelled 100 Year ARI Peak Flood Level m AHD	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.8	13.8	13.7	13.6	13.6	13.5	13.4	13.3
Modelled 50 Year ARI Peak Flood Level m AHD	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.5	12.5	12.4	12.3	12.2	12.2	12.1	12.0
Modelled 20 Year ARI Peak Flood Level m AHD	9.9	9.8	9.8	9.8	9.8	9.8	9.8	9.7	9.7	9.6	9.6	9.5	9.5	9.5	9.4
Modelled 10 Year ARI Peak Flood Level m AHD	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.0	8.0	8.0	7.9	7.9	7.9	7.8	7.8
Modelled 5 Year ARI Peak Flood Level m AHD	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.3	5.3	5.3	5.3	5.2	5.2	5.2	5.2
Modelled 2 Year ARI Peak Flood Level m AHD	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Bed Level m AHD	-12.0	-9.8	-13.4	-12.3	-10.5	-9.1	-9.7	-11.7	-9.9	-8.0	-9.8	-9.4	-16.1	-11.6	-11.2

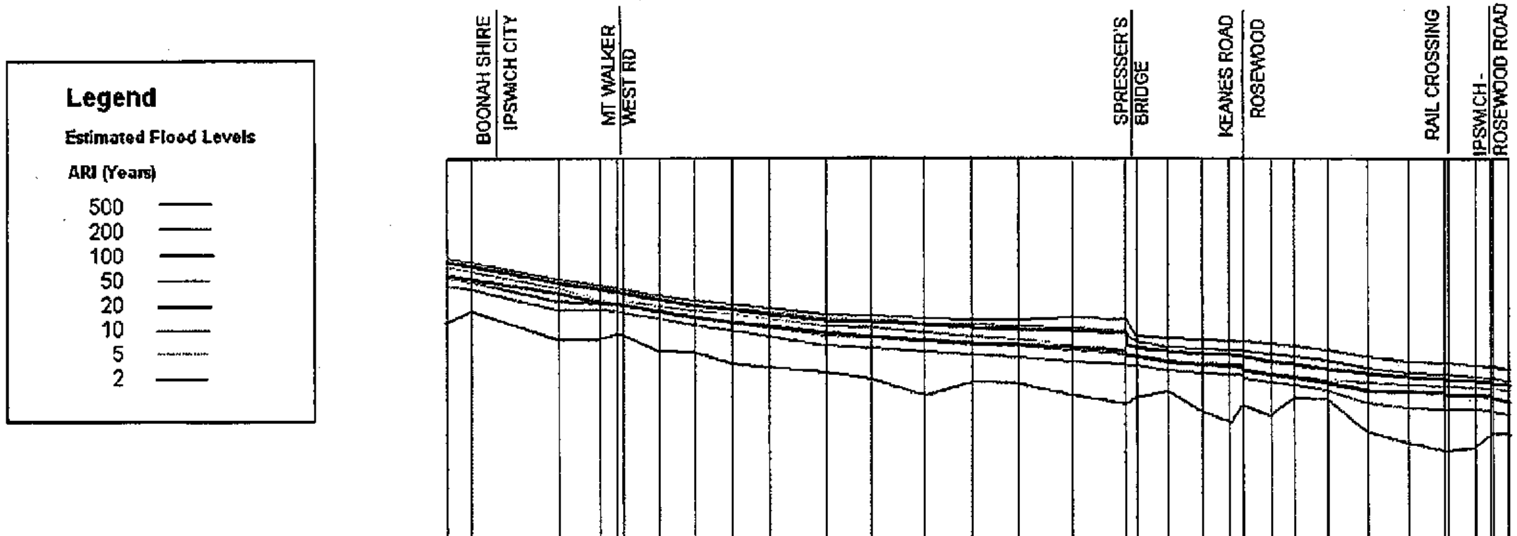
Chainage m Model Branch BNE	1,016,640	1,017,130	1,017,610	1,017,920	1,018,200	1,018,725	1,019,095	1,019,490	1,019,865	1,020,115	1,020,525	1,020,830	1,021,095	1,021,539
Modelled 500 Year ARI Peak Flood Level m AHD	15.5	15.2	15.2	15.0	15.0	14.8	14.7	14.6	14.5	14.5	14.5	14.4	14.2	14.0
Modelled 200 Year ARI Peak Flood Level m AHD	14.2	13.8	13.8	13.7	13.7	13.4	13.3	13.3	13.2	13.2	13.2	13.1	12.9	12.7
Modelled 100 Year ARI Peak Flood Level m AHD	13.3	13.0	13.0	12.8	12.8	12.8	12.6	12.5	12.4	12.4	12.4	12.3	12.1	12.0
Modelled 50 Year ARI Peak Flood Level m AHD	12.0	11.7	11.7	11.6	11.5	11.4	11.3	11.3	11.2	11.2	11.2	11.1	11.0	10.9
Modelled 20 Year ARI Peak Flood Level m AHD	9.4	9.2	9.2	9.2	9.2	9.1	9.0	9.0	9.0	9.0	9.0	8.9	8.8	8.8
Modelled 10 Year ARI Peak Flood Level m AHD	7.8	7.7	7.6	7.6	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.4	7.4
Modelled 5 Year ARI Peak Flood Level m AHD	5.2	5.1	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.9	4.9	4.9
Modelled 2 Year ARI Peak Flood Level m AHD	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Bed Level m AHD	-5.5	-9.5	-11.3	-10.7	-12.7	-13.2	-12.3	-12.6	-13.4	-11.7	-7.7	-13.8	-12.0	-10.4

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Brisbane River
MIKE 11 Chainage 1,009,720 - 1,021,539

Profile E4



Chainage m / Model Branch BREMER	0	365	1514	2208	2472	3049	3580	4118	4659	5466	6137	6903	7597	8229	9006
Modelled 500 Year ARI Peak Flood Level m AHD	54.7	54.1	51.8		50.7	49.2	48.5	48.0	47.4	46.6	46.4		46.8	46.0	46.0
Modelled 200 Year ARI Peak Flood Level m AHD	54.4	53.8	51.4	50.4	49.9	48.9	48.1	47.5	46.8	45.9	45.7	45.3	45.0	44.9	44.7
Modelled 100 Year ARI Peak Flood Level m AHD	54.2	53.5	51.2	50.2	49.8	48.7	47.9	47.3	46.6	45.6	45.4	45.0	44.7	44.6	44.3
Modelled 50 Year ARI Peak Flood Level m AHD	53.6	52.9	50.4	48.8	48.6	47.8	47.1	46.6	46.0	44.9	44.6	44.0	43.4	43.0	42.2
Modelled 20 Year ARI Peak Flood Level m AHD	52.2	51.6	49.7	48.3	48.0	47.0	46.2	45.4	44.8	43.9	43.4	42.8	42.5	42.2	41.8
Modelled 10 Year ARI Peak Flood Level m AHD	52.0	51.3	48.6	48.2	48.0	46.9	46.1	45.3	44.7	43.6	43.2	42.6	42.3	42.0	41.6
Modelled 5 Year ARI Peak Flood Level m AHD	51.8	51.2	48.4	48.0	47.9	46.9	46.0	45.2	44.5	43.5	43.0	42.4	42.1	41.8	41.3
Modelled 2 Year ARI Peak Flood Level m AHD	50.7	50.2	47.3	47.2	47.0	45.9	45.1	44.3	43.4	42.0	41.7	41.2	40.8	40.4	39.9
Bed Level m AHD	45.47	47.11	43.00	42.91	43.72	41.40	41.07	39.55	38.93	38.23	37.23	34.87	36.79	36.72	34.96

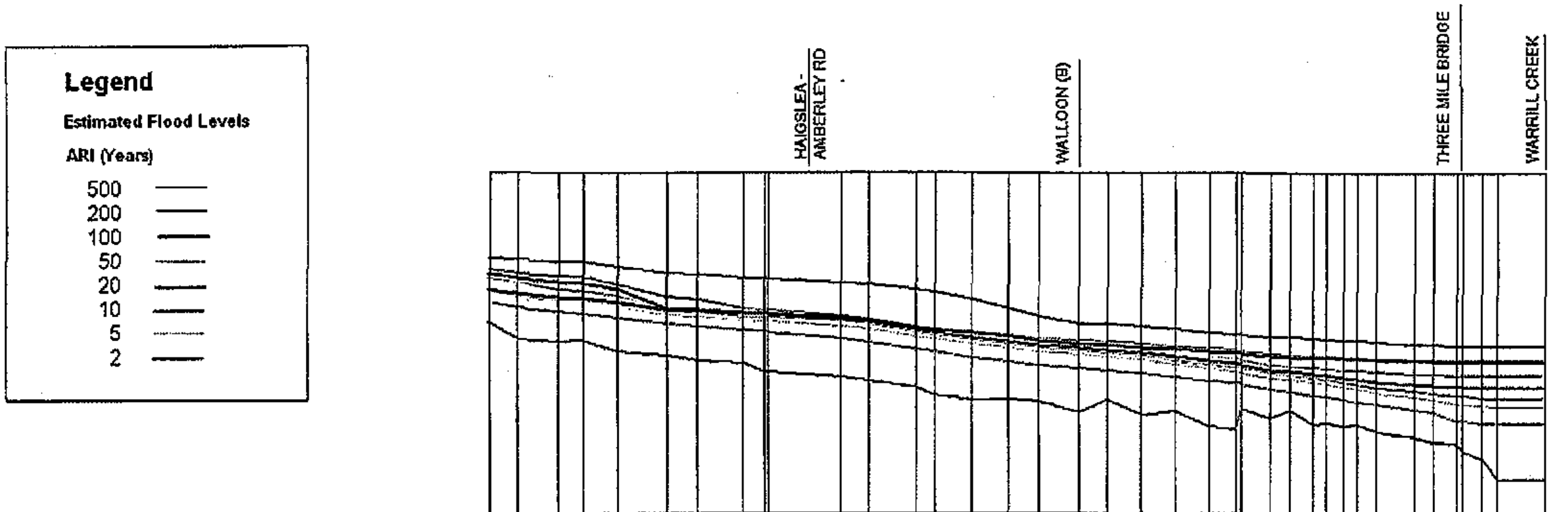
Chainage m / Model Branch BREMER	9604	9936	10392	10894	11315	11488	11875	12230	12694	13269	13870 14390	14420	14831	15080	15312
Modelled 500 Year ARI Peak Flood Level m AHD	46.0	43.6	43.1	43.0	42.9	42.8	42.4	42.1	41.6	40.5	39.8	39.7	39.4	39.1	38.8
Modelled 200 Year ARI Peak Flood Level m AHD	44.3	42.7	42.0	41.7	41.5	41.4	41.0	40.6	40.0	38.9	38.2	38.0	37.7	37.5	37.1
Modelled 100 Year ARI Peak Flood Level m AHD	43.9	42.0	41.3	40.9	40.7	40.6	39.9	39.5	38.8	38.1	37.5	37.3	36.8	36.8	36.4
Modelled 50 Year ARI Peak Flood Level m AHD	41.6	40.7	40.1	39.8	39.5	38.9	38.1	37.8	37.2	36.8	36.5	36.3	36.1	35.9	35.8
Modelled 20 Year ARI Peak Flood Level m AHD	41.3	40.6	39.9	39.5	39.2	38.6	37.9	37.6	36.9	35.8	35.5	35.3	35.0	34.6	34.1
Modelled 10 Year ARI Peak Flood Level m AHD	41.0	40.5	39.8	39.3	39.2	38.5	37.8	37.5	36.7	35.7	35.3	35.2	34.8	34.5	33.9
Modelled 5 Year ARI Peak Flood Level m AHD	40.7	40.3	39.5	39.1	39.1	38.3	37.6	37.3	36.5	35.3	35.0	34.9	34.5	34.3	33.5
Modelled 2 Year ARI Peak Flood Level m AHD	39.4	39.3	38.5	38.2	38.0	37.5	36.9	36.5	35.7	33.9	33.3	33.0	32.9	32.7	32.3
Bed Level m AHD	33.70	34.59	35.59	32.65	31.18	33.50	32.11	34.57	34.40	29.83	28.22 27.11	27.11	27.45	29.41	29.41

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust Ipswich Rivers Flood Studies Rationalisation Project Re-estimation of Design Flood Levels Longitudinal Profile - Bremer River Ipswich/Boonah Boundary - Rosewood	**Profile E5**

ICC.005.3006



Chainage m / Model Branch BREMER	15312	15748	16340	16706	17222	17933	18399	19051	19380	20486	20877	21566
Modelled 500 Year ARI Peak Flood Level m AHD	38.8	38.5	38.2	38.1	37.4	36.5	36.3	35.9	35.6	35.0	34.8	34.1
Modelled 200 Year ARI Peak Flood Level m AHD	37.1	36.6	36.1	36.0	34.9	33.0	32.6	31.4	31.1	30.2	29.8	28.6
Modelled 100 Year ARI Peak Flood Level m AHD	36.4	35.9	35.3	35.1	34.1	31.4	31.2	30.7	30.6	30.0	29.7	28.6
Modelled 50 Year ARI Peak Flood Level m AHD	35.8	35.3	34.1	33.9	33.2	31.3	31.1	30.6	30.5	29.9	29.6	28.5
Modelled 20 Year ARI Peak Flood Level m AHD	34.2	33.6	32.9	32.8	32.2	31.2	31.0	30.4	30.4	29.7	29.3	28.1
Modelled 10 Year ARI Peak Flood Level m AHD	33.9	33.2	32.7	32.6	32.0	30.9	30.7	30.1	30.0	29.4	29.0	27.8
Modelled 5 Year ARI Peak Flood Level m AHD	33.5	32.9	32.3	32.2	31.6	30.4	30.2	29.6	29.5	28.8	28.3	27.3
Modelled 2 Year ARI Peak Flood Level m AHD	32.3	31.6	30.9	30.6	30.0	29.1	28.8	28.2	27.8	26.9	26.4	25.4
Bed Level m AHD	29.41	26.90	26.45	26.68	25.05	24.49	23.77	23.39	22.12	21.38	20.72	19.92

Chainage m / Model Branch BREMER	21851	22411	22931	23376	23968	24384	24891	25371	25882	26342	26774	27056
Modelled 500 Year ARI Peak Flood Level m AHD	33.8	32.7	30.4	30.2	29.2	29.0	28.7	28.3	27.8	27.6	27.3	27.2
Modelled 200 Year ARI Peak Flood Level m AHD	28.3	27.9	27.4	26.9	26.6	26.4	26.2	25.8	25.5	25.3	24.8	24.6
Modelled 100 Year ARI Peak Flood Level m AHD	28.2	27.7	27.2	26.6	26.2	26.0	25.6	25.3	25.1	24.8	24.4	24.3
Modelled 50 Year ARI Peak Flood Level m AHD	28.1	27.5	27.0	26.4	26.0	25.7	25.3	24.7	24.3	23.9	23.2	23.0
Modelled 20 Year ARI Peak Flood Level m AHD	27.7	27.1	26.6	26.0	25.6	25.3	24.8	24.2	23.7	23.0	22.5	22.2
Modelled 10 Year ARI Peak Flood Level m AHD	27.4	26.7	26.2	25.6	25.2	24.9	24.5	23.8	23.2	22.7	22.0	21.7
Modelled 5 Year ARI Peak Flood Level m AHD	26.8	26.1	25.5	25.0	24.6	24.3	23.9	23.2	22.6	22.0	21.3	21.0
Modelled 2 Year ARI Peak Flood Level m AHD	25.0	24.1	23.6	23.0	22.6	22.3	21.8	21.3	20.8	20.4	19.6	19.3
Bed Level m AHD	18.63	17.99	18.17	17.83	16.11	18.00	15.77	16.23	14.07	16.09	15.45	16.54

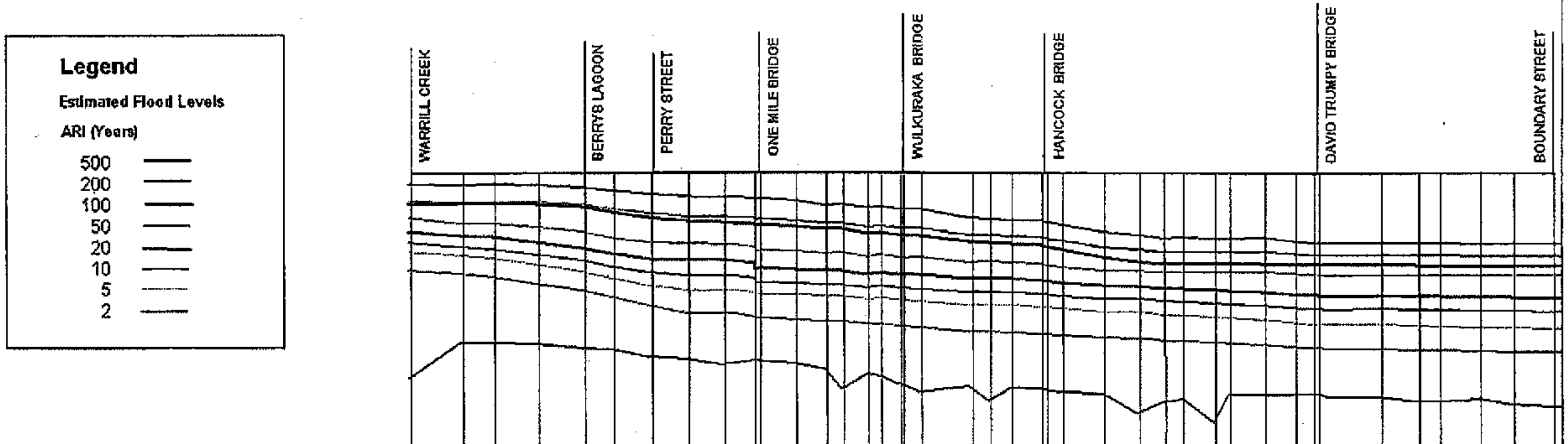
Chainage m / Model Branch BREMER	27359	27591	27859	28052	28338	28858	29127	29578	29891	30091	30791
Modelled 500 Year ARI Peak Flood Level m AHD	27.0	26.9	26.8	26.7	26.4	26.1	26.1	26.0	26.0	26.0	26.0
Modelled 200 Year ARI Peak Flood Level m AHD	24.5	24.4	24.4	24.3	24.1	24.0	23.9	23.8	23.8	23.8	23.8
Modelled 100 Year ARI Peak Flood Level m AHD	24.2	24.1	24.0	24.0	23.8	23.7	23.6	23.6	23.5	23.5	23.5
Modelled 50 Year ARI Peak Flood Level m AHD	22.8	22.7	22.5	22.4	22.2	21.9	21.8	21.7	21.6	21.6	21.6
Modelled 20 Year ARI Peak Flood Level m AHD	21.9	21.6	21.3	21.1	20.7	20.4	20.2	20.0	19.8	19.8	19.7
Modelled 10 Year ARI Peak Flood Level m AHD	21.4	21.0	20.7	20.4	19.9	19.4	19.1	18.7	18.4	18.4	18.3
Modelled 5 Year ARI Peak Flood Level m AHD	20.7	20.4	20.0	19.7	19.2	18.5	18.2	17.5	17.2	17.1	17.1
Modelled 2 Year ARI Peak Flood Level m AHD	18.8	18.5	18.2	17.9	17.3	16.8	16.2	15.1	14.6	14.6	14.6
Bed Level m AHD	14.41	14.66	14.34	14.50	13.35	12.55	11.87	10.34	9.18	6.61	6.46

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Bremer River
Rosewood - Warrill Creek

Profile E6



Chainage m Model Branch BREM	1,000,000	1,000,700	1,001,120	1,001,700	1,002,300	1,002,700	1,003,200	1,003,700	1,004,150	1,004,590	1,004,610	1,005,140	1,005,520	1,005,740
Modelled 500 Year ARI Peak Flood Level m AHD	26.0	25.9	25.9	25.8	25.6	25.2	24.6	24.3	24.2	24.1	24.1	23.8	23.3	23.3
Modelled 200 Year ARI Peak Flood Level m AHD	23.8	23.7	23.7	23.6	23.3	22.8	22.2	21.6	21.6	21.3	21.3	21.2	20.9	20.9
Modelled 100 Year ARI Peak Flood Level m AHD	23.6	23.4	23.4	23.3	23.0	22.4	21.6	21.1	21.0	20.7	20.6	20.4	20.1	20.1
Modelled 50 Year ARI Peak Flood Level m AHD	21.6	20.9	20.8	20.4	19.8	18.9	18.3	18.1	18.1	17.7	17.3	17.1	16.8	16.9
Modelled 20 Year ARI Peak Flood Level m AHD	19.8	19.2	19.0	18.3	17.5	16.8	16.2	15.9	15.9	15.6	14.8	14.7	14.5	14.5
Modelled 10 Year ARI Peak Flood Level m AHD	18.3	17.7	17.5	16.7	15.9	15.0	14.3	13.9	13.9	13.6	13.0	12.9	12.7	12.7
Modelled 5 Year ARI Peak Flood Level m AHD	17.1	16.5	16.2	15.4	14.5	13.6	12.6	12.0	12.0	11.6	11.4	11.3	11.2	11.2
Modelled 2 Year ARI Peak Flood Level m AHD	14.6	14.1	13.7	12.8	12.0	11.1	9.8	8.8	8.8	8.5	8.2	8.0	7.8	7.8
Bed Level m AHD	0.00	5.00	5.00	4.80	4.20	4.00	3.00	2.71	2.00	2.50	2.53	2.20	1.40	-1.24

Chainage m Model Branch BREM	1,006,080	1,006,250	1,006,510	1,006,780	1,007,440	1,007,700	1,008,000	1,008,390	1,008,410	1,009,680	1,009,210	1,009,675	1,010,020
Modelled 500 Year ARI Peak Flood Level m AHD	22.8	23.0	22.8	22.7	21.5	21.5	21.3	21.2	21.1	20.7	19.8	19.3	19.0
Modelled 200 Year ARI Peak Flood Level m AHD	20.4	20.2	20.2	20.2	19.4	19.3	19.1	19.0	18.9	18.6	17.6	17.4	17.1
Modelled 100 Year ARI Peak Flood Level m AHD	19.5	19.5	19.3	19.2	18.4	18.3	18.1	18.0	17.9	17.4	16.4	15.8	15.5
Modelled 50 Year ARI Peak Flood Level m AHD	16.7	16.3	16.3	16.3	15.7	15.8	15.7	15.5	15.3	15.0	14.6	14.6	14.5
Modelled 20 Year ARI Peak Flood Level m AHD	14.3	14.3	14.0	14.0	13.6	13.6	13.5	13.3	13.3	13.0	12.7	12.6	12.3
Modelled 10 Year ARI Peak Flood Level m AHD	12.5	12.5	12.2	12.1	11.7	11.7	11.7	11.5	11.4	11.2	10.9	10.8	10.6
Modelled 5 Year ARI Peak Flood Level m AHD	10.8	10.7	10.6	10.5	10.1	10.1	10.0	9.8	9.7	9.5	9.1	9.1	8.7
Modelled 2 Year ARI Peak Flood Level m AHD	7.5	7.5	7.1	7.0	6.5	6.5	6.4	6.2	6.1	6.0	6.7	5.6	5.3
Bed Level m AHD	0.76	0.56	-0.50	-1.58	-0.76	-2.76	-1.03	-1.09	-1.09		-1.63	-4.40	-2.90

Chainage m Model Branch BREM	1,010,280	1,010,700	1,010,890	1,011,320	1,011,810	1,012,050	1,012,070	1,012,870	1,013,390	1,013,700	1,014,220	1,014,640	1,015,180
Modelled 500 Year ARI Peak Flood Level m AHD	19.0	18.9	18.9	18.9	18.5	18.3	18.3	18.2	18.2	18.2	18.2	18.2	18.2
Modelled 200 Year ARI Peak Flood Level m AHD	17.1	17.1	17.1	17.1	16.9	16.8	16.7	16.6	16.5	16.6	16.6	16.5	16.6
Modelled 100 Year ARI Peak Flood Level m AHD	15.5	15.4	15.4	15.4	15.4	15.4	15.3	15.3	15.3	15.3	15.3	15.3	15.3
Modelled 50 Year ARI Peak Flood Level m AHD	14.5	14.4	14.4	14.4	14.3	14.1	14.1	14.1	14.0	14.0	14.0	14.0	14.0
Modelled 20 Year ARI Peak Flood Level m AHD	12.2	12.1	11.9	11.8	11.5	11.4	11.4	11.3	11.2	11.2	11.1	11.1	11.0
Modelled 10 Year ARI Peak Flood Level m AHD	10.6	10.3	10.2	10.0	9.7	9.6	9.6	9.5	9.4	9.4	9.3	9.2	9.1
Modelled 5 Year ARI Peak Flood Level m AHD	8.6	8.5	8.3	8.1	7.6	7.6	7.5	7.5	7.3	7.3	7.1	7.1	6.9
Modelled 2 Year ARI Peak Flood Level m AHD	5.2	5.1	5.0	4.8	4.6	4.4	4.4	4.2	4.1	4.0	3.9	3.8	3.7
Bed Level m AHD	-2.40	-5.50	-1.80	-1.80	-1.71	-1.71	-1.65	-2.10	-2.70	-2.70	-2.50	-3.20	-3.50

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Bremer River
Warrill Creek - Boundary Street

Profile E7

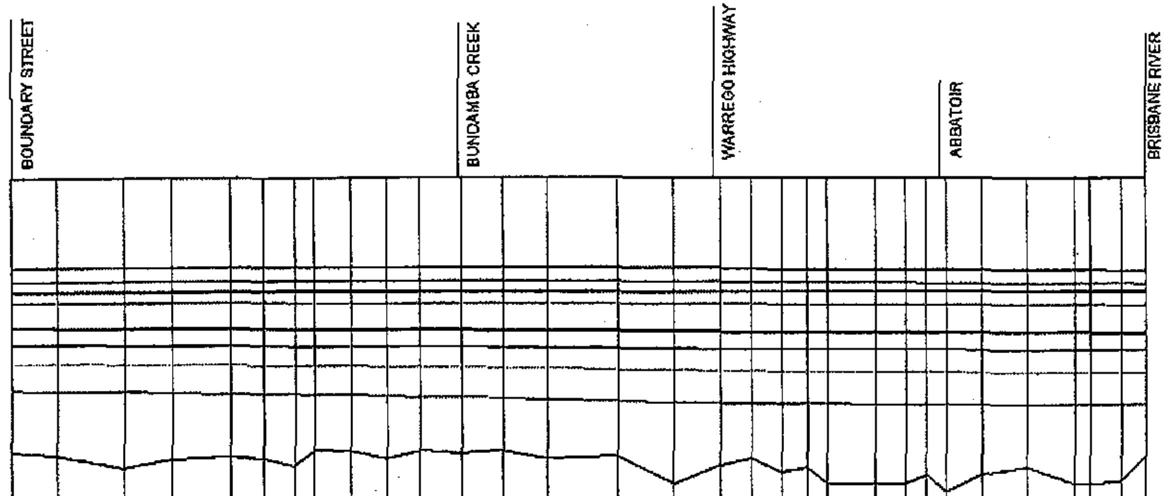
ICC.005.3008

Legend

Estimated Flood Levels

ARI (Years)

- 500
- 200
- 100
- 50
- 20
- 10
- 5
- 2



Chainage m, Model Branch BREM	1,015,180	1,015,710	1,016,510	1,017,080	1,017,750	1,018,140	1,018,500	1,018,760	1,019,150	1,019,580	1,020,000	1,020,450	1,020,920	1,021,460	1,022,300	1,022,950
Modelled 500 Year ARI Peak Flood Level m AHD	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.1	18.1	18.1	18.1	18.1	18.1
Modelled 200 Year ARI Peak Flood Level m AHD	16.6	16.6	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5
Modelled 100 Year ARI Peak Flood Level m AHD	15.3	15.3	15.3	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2
Modelled 50 Year ARI Peak Flood Level m AHD	14.0	14.0	14.0	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.8	13.8
Modelled 20 Year ARI Peak Flood Level m AHD	11.0	11.0	10.9	10.9	10.8	10.8	10.8	10.8	10.8	10.7	10.7	10.7	10.7	10.6	10.6	10.6
Modelled 10 Year ARI Peak Flood Level m AHD	9.1	9.1	9.0	9.0	9.0	8.9	8.9	8.9	8.9	8.8	8.8	8.8	8.7	8.7	8.6	8.6
Modelled 5 Year ARI Peak Flood Level m AHD	6.9	6.9	6.8	6.8	6.7	6.6	6.6	6.5	6.5	6.5	6.4	6.4	6.3	6.2	6.1	6.1
Modelled 2 Year ARI Peak Flood Level m AHD	3.7	3.7	3.6	3.5	3.4	3.3	3.3	3.2	3.1	3.1	2.9	2.9	2.7	2.6	2.4	2.3
Bed Level m AHD	-3.50	-3.60	-5.20	-4.20	-3.90	-4.20	-5.10	-3.20	-3.40	-4.20	-3.30	-3.30	-3.40	-4.20	-4.00	-7.20

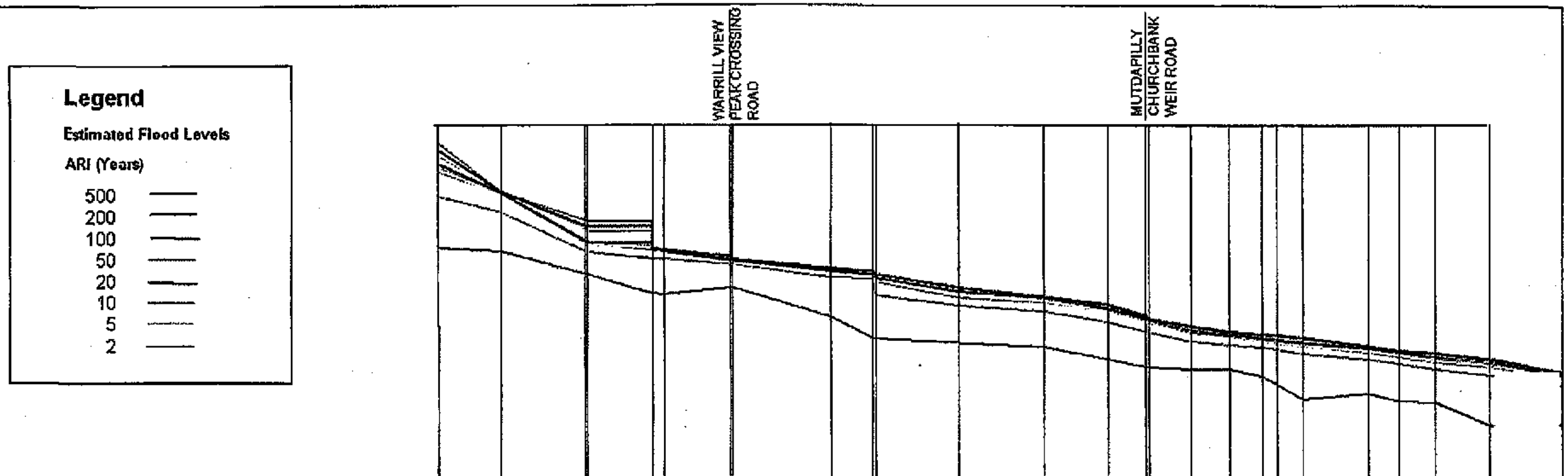
Chainage m, Model Branch BREM	1,023,510	1,023,870	1,024,220	1,024,520	1,024,760	1,025,300	1,025,670	1,025,920	1,026,150	1,026,560	1,027,100	1,027,640	1,027,840	1,028,190	1,028,490
Modelled 500 Year ARI Peak Flood Level m AHD	18.0	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.8	17.8	17.8	17.7
Modelled 200 Year ARI Peak Flood Level m AHD	16.4	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.2	16.2	16.2	16.1
Modelled 100 Year ARI Peak Flood Level m AHD	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.1	15.1
Modelled 50 Year ARI Peak Flood Level m AHD	13.8	13.8	13.8	13.8	13.8	13.8	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.6	13.6
Modelled 20 Year ARI Peak Flood Level m AHD	10.5	10.5	10.5	10.5	10.5	10.5	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.3	10.3
Modelled 10 Year ARI Peak Flood Level m AHD	8.6	8.6	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.4	8.4	8.4	8.4	8.4	8.4
Modelled 5 Year ARI Peak Flood Level m AHD	6.0	6.0	5.9	5.9	6.9	6.9	5.8	5.8	5.8	5.8	5.7	5.7	5.7	5.6	5.6
Modelled 2 Year ARI Peak Flood Level m AHD	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0	2.0
Bed Level m AHD	-4.92	[illegible]	-5.90	-5.20	-7.20	-7.20	-7.20	-6.20	-8.20	-6.20	-5.20	-7.20	-7.20	-7.10	-7.10

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for *town planning or infrastructure design purposes*

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile - Bremer River
Boundary Street - Brisbane River

Profile E8



Chainage m / Model Branch WARRILL	0	1,033	2,424	2,444	3,488		3,683	4,779	4,798	6,397	7,111	7,131	8,514
Modelled 500 Year ARI Peak Flood Level m AHD	70.6	62.8	58.0	58.0	58.0	53.7	63.4	52.3	51.8	50.3	49.9	49.2	47.2
Modelled 200 Year ARI Peak Flood Level m AHD	69.7	62.7	57.1	57.1	57.1	53.7	53.4	52.3	51.8	50.2	49.8	49.2	47.1
Modelled 100 Year ARI Peak Flood Level m AHD	68.6	62.7	57.1	57.1	57.1	53.5	53.4	52.2	51.7	50.2	49.8	49.2	47.1
Modelled 50 Year ARI Peak Flood Level m AHD	68.5	62.7	56.4	56.4	66.4	53.5	53.3	52.0	51.7	50.1	49.6	49.0	46.8
Modelled 20 Year ARI Peak Flood Level m AHD	67.2	62.6	54.6	54.6	54.3	53.3	53.1	51.7	51.5	49.9	49.4	48.7	46.5
Modelled 10 Year ARI Peak Flood Level m AHD	66.8	62.6	54.5	54.5	54.1	53.3	53.1	51.6	51.5	49.8	49.2	48.6	46.3
Modelled 5 Year ARI Peak Flood Level m AHD	66.0	62.4	54.2	54.2	53.4	53.0	52.7	51.4	51.4	49.7	49.0	48.0	45.5
Modelled 2 Year ARI Peak Flood Level m AHD	62.0	59.4	53.0	53.0	52.0	52.0	51.8	50.9	50.9	48.8	48.5	45.7	44.2
Bed Level m AHD	53.76	53.24	49.26	49.26	46.09		45.89	46.98	46.98	42.29	38.63	38.63	

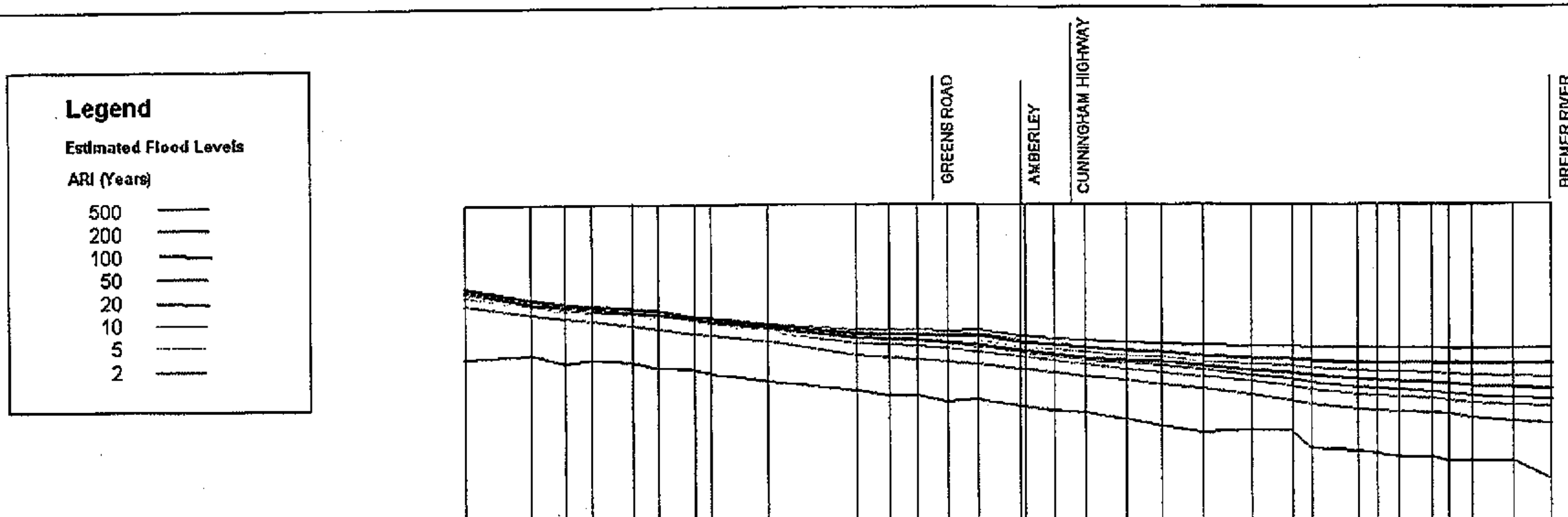
Chainage m / Model Branch WARRILL	9,897	10,942	11,580	11,600	12,312	12,938	13,480	13,716	14,151	15,218	15,710	16,308	17,202
Modelled 500 Year ARI Peak Flood Level m AHD	45.7	44.4	42.6	42.1	40.9	40.0	39.6	39.5	39.1	37.5	36.9	36.4	35.5
Modelled 200 Year ARI Peak Flood Level m AHD	45.5	44.3	42.5	42.1	40.8	39.9	39.5	39.3	39.0	37.5	36.7	36.3	35.4
Modelled 100 Year ARI Peak Flood Level m AHD	45.6	44.3	42.5	42.1	40.7	39.9	39.4	39.3	39.0	37.5	36.7	36.2	35.3
Modelled 50 Year ARI Peak Flood Level m AHD	45.5	44.0	42.1	41.9	40.4	39.7	39.2	39.0	38.6	37.4	36.6	36.0	35.2
Modelled 20 Year ARI Peak Flood Level m AHD	45.4	43.8	41.9	41.8	40.2	39.5	39.0	38.7	38.2	37.2	36.5	35.0	35.0
Modelled 10 Year ARI Peak Flood Level m AHD	45.3	43.6	41.7	41.7	39.9	39.2	38.7	38.4	38.0	37.0	36.3	35.4	34.6
Modelled 5 Year ARI Peak Flood Level m AHD	44.7	43.3	41.4	41.4	39.7	39.0	38.3	38.0	37.6	36.5	35.8	34.8	34.1
Modelled 2 Year ARI Peak Flood Level m AHD	43.2	41.6	39.9	39.9	38.4	37.9	37.4	37.0	36.4	35.3	34.6	33.8	32.7
Bed Level m AHD	37.35	35.33	34.06	34.06	33.68	33.70	32.56	31.31	28.87	29.82	28.58	28.39	24.62

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile Warrill Creek
Chainage 0 - 17.202

Profile E9



Chainage m Model Branch WARRILL	17,202	18,219	18,725	19,155	19,737	20,170	20,703	20,970	21,848	23,197	23,701	24,127	24,580	25,049	25,710	25,730	26,219	26,693	27,315	27,873	28,487	29,252	29,849	30,164	30,886	31,173	31,526	32,023	32,284	32,634	33,250	33,880
Modelled 500 Year ARI Peak Flood Level m AHD	35.5	33.6	33.0	32.7	32.2	31.8	30.9	30.7	29.8	28.9	28.9	28.9	28.6	28.3	28.0	27.9	27.5	27.3	27.0	26.8	26.6	26.5	26.4	26.3	26.2	26.2	26.2	26.2	26.1	26.1	26.1	
Modelled 200 Year ARI Peak Flood Level m AHD	35.4	33.5	32.9	32.6	32.1	31.8	30.9	30.6	29.7	28.4	28.3	28.2	28.2	28.2	27.3	26.9	26.6	26.3	25.8	25.5	25.0	24.6	24.5	24.2	24.1	24.1	24.1	24.0	23.9	23.9	23.9	23.8
Modelled 100 Year ARI Peak Flood Level m AHD	35.3	33.5	32.8	32.6	32.1	31.8	30.9	30.6	29.5	28.3	28.2	28.1	28.0	28.0	27.0	26.9	26.6	26.2	25.7	25.5	25.0	24.6	24.4	24.1	23.9	23.9	23.9	23.8	23.7	23.6	23.6	23.5
Modelled 50 Year ARI Peak Flood Level m AHD	35.2	33.4	32.7	32.6	32.1	31.7	30.8	30.5	29.3	28.1	27.8	27.7	27.2	27.1	26.3	26.3	25.8	25.4	24.9	24.7	24.1	23.6	23.4	23.0	22.6	22.6	22.5	22.3	22.1	21.9	21.8	21.6
Modelled 20 Year ARI Peak Flood Level m AHD	35.0	33.0	32.4	32.1	31.7	31.3	30.5	30.2	29.1	27.8	27.5	27.3	27.0	26.6	25.7	25.7	25.1	24.5	24.1	23.9	23.4	22.7	22.4	22.0	21.4	21.2	21.1	20.9	20.6	20.3	20.0	19.8
Modelled 10 Year ARI Peak Flood Level m AHD	34.6	32.8	32.1	31.9	31.5	31.1	30.3	30.0	29.1	27.5	27.3	27.1	26.7	26.2	25.4	25.4	24.7	24.1	23.7	23.4	22.8	22.0	21.5	20.9	20.0	19.8	19.7	19.4	19.2	18.8	18.5	18.3
Modelled 5 Year ARI Peak Flood Level m AHD	34.1	32.5	31.8	31.6	31.2	30.7	30.0	29.7	28.7	26.9	26.6	26.4	26.0	25.5	24.8	24.8	24.2	23.6	22.9	22.4	21.8	21.0	20.3	19.8	19.0	18.9	18.6	18.3	18.0	17.6	17.3	17.1
Modelled 2 Year ARI Peak Flood Level m AHD	32.7	31.3	30.7	30.2	29.6	29.0	28.3	28.1	27.1	25.0	24.5	24.3	24.0	23.6	22.8	22.8	22.3	21.8	21.2	20.6	19.8	19.0	18.1	17.5	16.7	16.5	16.4	16.2	15.9	15.5	15.0	14.6
Bed Level m AHD	24.62	25.16	23.79	24.41	24.08	23.06	22.81	22.17	20.98	19.52	18.72	18.72	17.78	18.15	17.11	17.11	16.52	16.23	15.31	14.17	13.26	13.60	13.66	10.75	10.38	10.10	9.50	9.50	9.00	9.00	9.00	6.00

Sargent Consulting

NOTE
An uncertainty allowance, to be determined by Ipswich City Council, is to be added to the flood levels shown in this drawing prior to their use for town planning or infrastructure design purposes

Ipswich Rivers Improvement Trust
Ipswich Rivers Flood Studies Rationalisation Project
Re-estimation of Design Flood Levels
Longitudinal Profile Warrill Creek
Chainage 17.202 - Bremer River

Profile E10

Appendix F Maximum Flood Levels - Design

Appendix F **Maximum Flood Levels - Design**

NOTE: An uncertainty allowance, of an amount to be determined by Ipswich City Council must be added to the modelled peak water levels prior to their use for town planning, infrastructure design or any other purpose

Flowpath/Chainage	Location	Bed Level	Peak Water Level (m AHD) for ARI							
		m AHD	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
BNE 964170.00	Model Boundary	10.80	17.00	19.95	23.57	25.69	29.12	32.34	32.18	33.61
BNE 966610.00		7.61	14.84	18.46	22.07	24.30	27.85	30.82	30.67	31.77
BNE 967410.00		3.13	14.73	18.30	21.85	24.07	27.64	30.64	30.49	31.59
BNE 969790.00		6.78	14.48	17.88	21.26	23.39	26.93	30.11	29.94	31.14
BNE 971160.00		3.86	14.28	17.59	20.86	22.93	26.45	29.74	29.56	30.80
BNE 972260.00		6.09	14.01	17.24	20.47	22.51	26.08	29.41	29.24	30.48
BNE 973260.00		2.73	13.83	17.02	20.25	22.28	25.87	29.27	29.10	30.34
BNE 973260.00		2.73	13.83	17.02	20.25	22.28	25.87	29.27	29.10	30.34
BNE 974580.00		4.29	13.61	16.70	19.84	21.83	25.46	29.01	28.84	30.10
BNE 976020.00		5.56	13.32	16.26	19.32	21.25	24.99	28.82	28.64	29.92
BNE 976750.00		4.50	12.94	15.84	18.97	20.99	24.87	28.78	28.60	29.89
BNE 978280.00		3.37	12.13	14.85	18.05	20.14	24.10	27.69	27.52	28.85
BNE 979507.00	Kholo Bridge	3.32	11.59	14.28	17.53	19.63	23.63	27.02	26.84	28.24
BNE 979515.00		2.84	11.59	14.28	17.53	19.62	23.63	27.01	26.84	28.24
BNE 979530.00		3.39	11.58	14.25	17.50	19.60	23.61	27.00	26.83	28.23
BNE 980330.00		3.16	11.04	13.75	17.16	19.30	23.33	26.70	26.53	27.94
BNE 981660.00		1.36	10.38	13.29	16.70	18.80	22.79	26.12	25.97	27.39
BNE 982460.00		-3.73	10.30	13.11	16.46	18.62	22.44	25.76	25.61	27.04
BNE 984160.00		2.53	9.87	12.55	15.87	17.89	21.77	25.02	24.90	26.35
BNE 985260.00		1.85	9.43	12.01	15.36	17.36	21.27	24.46	24.35	25.83
BNE 985260.00		1.85	9.43	12.01	15.36	17.36	21.27	24.46	24.35	25.83
BNE 986460.00		1.51	9.03	11.40	14.69	16.64	20.61	23.70	23.62	25.10
BNE 987960.00		0.54	8.79	10.87	14.04	15.93	20.07	23.12	23.07	24.55
BNE 988160.00	Mt Crosby Weir	0.52	8.69	10.66	13.81	15.70	19.89	22.73	22.71	24.16
BNE 988170.00		0.52	7.68	10.53	13.74	15.64	19.85	22.71	22.69	24.14
BNE 988360.00		0.60	7.51	10.40	13.65	15.56	19.62	22.31	22.31	23.76
BNE 989700.00		1.10	6.57	9.76	13.16	15.09	18.62	21.29	21.35	22.88
BNE 990700.00		-1.44	6.12	9.40	12.80	14.71	18.28	20.94	21.04	22.58
BNE 990760.00		-1.59	6.10	9.38	12.77	14.67	18.23	20.89	20.99	22.53
BNE 991710.00		0.00	5.89	9.17	12.55	14.44	17.99	20.56	20.69	22.22
BNE 992420.00		-0.39	5.72	9.05	12.45	14.32	17.83	20.36	20.51	22.03
BNE 992450.00	Colleges Crossing	-0.26	5.70	9.05	12.44	14.32	17.82	20.35	20.50	22.02
BNE 992470.00		-0.26	5.69	9.04	12.43	14.31	17.81	20.34	20.49	22.01
BNE 992670.00		-0.69	5.60	8.97	12.35	14.24	17.74	20.26	20.42	21.94
BNE 993760.00		-2.00	5.14	8.51	11.83	13.78	17.41	19.96	20.15	21.71
BNE 994760.00		-2.06	4.58	8.14	11.46	13.39	17.03	19.53	19.77	21.33
BNE 994760.00		-2.06	4.58	8.14	11.46	13.39	17.03	19.53	19.77	21.33
BNE 995690.00		-3.15	4.10	7.82	11.12	13.04	16.74	19.19	19.46	21.00
BNE 996980.00		-3.00	3.53	7.35	10.61	12.84	16.76	19.22	19.48	21.03
BNE 996980.00		-3.00	3.53	7.35	10.61	12.84	16.76	19.22	19.48	21.03
BNE 998460.00		-3.93	2.98	6.99	10.27	12.80	16.75	19.21	19.48	21.02
BNE 998460.00		-3.93	2.98	6.99	10.27	12.80	16.75	19.21	19.48	21.02
BNE 999160.00		-4.97	2.78	6.82	10.03	12.52	16.36	18.66	18.99	20.47
BNE 1000000.00		-6.40	2.62	6.67	9.83	12.30	16.05	18.20	18.57	19.97
BNE 1000285.00		-4.70	2.58	6.61	9.74	12.06	15.79	17.89	18.31	19.73
BNE 1000285.00		-4.70	2.58	6.61	9.74	12.06	15.79	17.89	18.31	19.73
BNE 1000775.00		-5.80	2.50	6.50	9.60	11.65	15.19	17.18	17.72	19.17
BNE 1001315.00		-4.20	2.39	6.41	9.49	11.56	14.92	16.87	17.47	18.94
BNE 1001315.00		-4.20	2.39	6.41	9.49	11.56	14.92	16.87	17.47	18.94
BNE 1001865.00		-5.90	2.27	6.27	9.28	11.32	14.69	16.58	17.23	18.72
BNE 1002350.00		-6.30	2.17	6.15	9.09	11.13	14.61	16.49	17.18	18.68
BNE 1002785.00		-6.90	2.11	6.08	9.00	11.04	14.51	16.37	17.07	18.58
BNE 1003275.00		-6.40	2.04	5.98	8.85	10.87	14.31	16.12	16.89	18.43
BNE 1003775.00		-6.50	2.03	5.91	8.76	10.78	14.16	15.89	16.71	18.25
BNE 1004300.00		-7.50	2.02	5.80	8.58	10.57	13.91	15.56	16.45	18.01
BNE 1004810.00		-7.50	2.02	5.75	8.50	10.50	13.84	15.47	16.39	17.95
BNE 1005325.00		-5.50	2.02	5.69	8.42	10.42	13.73	15.31	16.27	17.84
BNE 1005325.00		-5.50	2.02	5.69	8.42	10.42	13.73	15.31	16.27	17.84
BNE 1005870.00		-6.10	2.02	5.64	8.35	10.34	13.60	15.13	16.14	17.71
BNE 1005870.00		-6.10	2.02	5.64	8.35	10.34	13.60	15.13	16.14	17.71
BNE 1006300.00	Moggill	-9.70	2.02	5.65	8.34	10.30	13.48	14.98	15.97	17.53
BNE 1006300.00		-9.70	2.02	5.65	8.34	10.30	13.48	14.98	15.97	17.53
BNE 1006910.00		-9.00	2.02	5.62	8.32	10.27	13.39	14.86	15.84	17.38
BNE 1007410.00		-8.60	2.02	5.60	8.32	10.27	13.36	14.82	15.78	17.28

BNE 1007920.00	Six Mile Ck	-7.10	2.02	5.52	8.20	10.06	13.02	14.49	15.45	16.98
BNE 1008195.00		-9.41	2.02	5.53	8.21	10.00	12.83	14.29	15.26	16.78
BNE 1008195.00		-9.41	2.02	5.53	8.21	10.00	12.83	14.29	15.26	16.78
BNE 1008445.00		-11.50	2.02	5.53	8.21	9.98	12.73	14.14	15.10	16.63
BNE 1008925.00		-7.60	2.02	5.51	8.19	9.93	12.62	13.98	14.94	16.47
BNE 1008925.00		-7.60	2.02	5.51	8.19	9.93	12.62	13.98	14.94	16.47
BNE 1009400.00		-9.00	2.02	5.49	8.16	9.88	12.59	13.94	14.91	16.46
BNE 1009720.00		-12.00	2.02	5.48	8.15	9.87	12.57	13.92	14.89	16.43
BNE 1009720.00		-12.00	2.02	5.48	8.15	9.87	12.57	13.92	14.89	16.43
BNE 1010490.00		-9.80	2.02	5.42	8.06	9.78	12.49	13.84	14.80	16.34
BNE 1010725.00		-13.40	2.02	5.43	8.08	9.81	12.52	13.86	14.82	16.36
BNE 1010980.00		-12.30	2.02	5.42	8.07	9.80	12.52	13.87	14.83	16.37
BNE 1011510.00		-10.50	2.02	5.41	8.07	9.81	12.56	13.91	14.88	16.42
BNE 1011510.00		-10.50	2.02	5.41	8.07	9.81	12.56	13.91	14.88	16.42
BNE 1011980.00		-9.10	2.01	5.39	8.06	9.82	12.60	13.96	14.94	16.48
BNE 1012475.00	Goodna Ck	-8.70	2.01	5.38	8.05	9.81	12.58	13.94	14.91	16.46
BNE 1012475.00		-8.70	2.01	5.38	8.05	9.81	12.58	13.94	14.91	16.46
BNE 1012935.00		-11.70	2.00	5.34	7.99	9.73	12.47	13.82	14.78	16.31
BNE 1013445.00		-9.90	2.00	5.33	7.98	9.72	12.47	13.84	14.81	16.37
BNE 1013680.00		-8.94	2.00	5.31	7.95	9.68	12.42	13.78	14.75	16.30
BNE 1013680.00		-8.94	2.00	5.31	7.95	9.68	12.42	13.78	14.75	16.30
BNE 1013910.00		-8.00	2.00	5.27	7.91	9.62	12.36	13.70	14.67	16.20
BNE 1014310.00		-9.80	2.00	5.26	7.88	9.58	12.30	13.64	14.60	16.14
BNE 1014610.00	Woogaroo Ck	-9.40	2.00	5.23	7.84	9.52	12.22	13.55	14.50	16.01
BNE 1014610.00		-9.40	2.00	5.23	7.84	9.52	12.22	13.55	14.50	16.01
BNE 1015090.00		-16.10	2.01	5.25	7.86	9.53	12.21	13.52	14.46	15.90
BNE 1015560.00		-11.60	2.01	5.21	7.80	9.45	12.10	13.39	14.30	15.69
BNE 1015850.00		-11.40	2.01	5.20	7.79	9.43	12.06	13.35	14.25	15.63
BNE 1015850.00		-11.40	2.01	5.20	7.79	9.43	12.06	13.35	14.25	15.63
BNE 1016140.00		-11.20	2.01	5.20	7.78	9.41	12.03	13.30	14.19	15.56
BNE 1016640.00		-5.50	2.01	5.15	7.75	9.38	12.00	13.27	14.15	15.51
BNE 1016640.00		-5.50	2.01	5.15	7.75	9.38	12.00	13.27	14.15	15.51
BNE 1017130.00		-9.50	2.01	5.05	7.59	9.19	11.74	12.98	13.84	15.18
BNE 1017130.00		-9.50	2.01	5.05	7.59	9.19	11.74	12.98	13.84	15.18
BNE 1017610.00		-11.30	2.01	5.05	7.61	9.20	11.70	12.95	13.82	15.17
BNE 1017610.00		-11.30	2.01	5.05	7.61	9.20	11.70	12.95	13.82	15.17
BNE 1017920.00		-10.70	2.01	5.01	7.56	9.13	11.57	12.80	13.65	14.99
BNE 1018200.00		-12.70	2.01	5.02	7.59	9.16	11.58	12.80	13.65	15.01
BNE 1018725.00		-13.20	2.01	4.99	7.52	9.05	11.40	12.58	13.42	14.76
BNE 1019095.00		-12.30	2.01	4.97	7.51	9.03	11.33	12.51	13.33	14.68
BNE 1019490.00		-12.60	2.01	4.96	7.50	9.01	11.30	12.46	13.28	14.63
BNE 1019490.00		-12.60	2.01	4.96	7.50	9.01	11.30	12.46	13.28	14.63
BNE 1019865.00		-13.40	2.00	4.93	7.45	8.93	11.18	12.32	13.14	14.48
BNE 1020115.00		-11.70	2.00	4.95	7.48	8.97	11.22	12.37	13.19	14.53
BNE 1020525.00		-7.70	2.00	4.94	7.48	8.96	11.20	12.35	13.16	14.51
BNE 1020525.00		-7.70	2.00	4.94	7.48	8.96	11.20	12.35	13.16	14.51
BNE 1020830.00		-13.80	2.00	4.93	7.45	8.91	11.13	12.26	13.06	14.39
BNE 1021095.00		-12.00	2.00	4.89	7.39	8.83	11.00	12.11	12.89	14.18
BNE 1021539.00		-10.40	2.00	4.88	7.38	8.79	10.91	11.97	12.72	13.97
BNE 1021715.00		-10.50	2.00	4.88	7.37	8.78	10.88	11.93	12.67	13.92
BNE 1021895.00		-12.80	2.00	4.87	7.36	8.76	10.84	11.88	12.61	13.86
BNE 1022105.00		-15.60	2.00	4.86	7.33	8.71	10.76	11.78	12.50	13.72
BNE 1022575.00		-9.80	2.00	4.84	7.30	8.66	10.70	11.71	12.41	13.62
BNE 1022575.00		-9.80	2.00	4.84	7.30	8.66	10.70	11.71	12.41	13.62
BNE 1023040.00		-14.40	2.00	4.79	7.22	8.57	10.61	11.61	12.32	13.53
BNE 1023570.00		-12.80	2.00	4.77	7.19	8.53	10.57	11.57	12.27	13.46
BNE 1024080.00		-10.00	2.00	4.74	7.16	8.51	10.56	11.57	12.27	13.48
BNE 1024080.00		-10.00	2.00	4.74	7.16	8.51	10.56	11.57	12.27	13.48
BNE 1024563.00		-10.10	2.00	4.72	7.12	8.45	10.48	11.49	12.20	13.41
BNE 1024563.00		-10.10	2.00	4.72	7.12	8.45	10.48	11.49	12.20	13.41
BNE 1025070.00		-10.70	2.00	4.70	7.07	8.38	10.36	11.36	12.06	13.27
BNE 1025360.00		-12.50	2.00	4.68	7.03	8.31	10.24	11.21	11.89	13.07
BNE 1025590.00		-12.80	2.00	4.65	6.98	8.23	10.11	11.05	11.70	12.85
BNE 1025590.00		-12.80	2.00	4.65	6.98	8.23	10.11	11.05	11.70	12.85
BNE 1026170.00		-11.60	2.00	4.63	6.95	8.16	10.02	10.94	11.58	12.72
BNE 1026680.00		-12.40	2.00	4.61	6.92	8.10	9.93	10.86	11.50	12.64
BNE 1026900.00		-14.00	2.00	4.59	6.89	8.07	9.88	10.80	11.44	12.58
BNE 1027160.00		-15.90	2.00	4.57	6.85	8.01	9.79	10.70	11.32	12.45
BNE 1027680.00		-11.30	2.00	4.56	6.83	7.97	9.76	10.67	11.30	12.43
BNE 1028180.00		-12.60	2.00	4.54	6.79	7.91	9.69	10.60	11.23	12.37
BNE 1028405.13		-11.38	2.00	4.52	6.76	7.86	9.62	10.52	11.14	12.28
BNE 1028405.13		-11.38	2.00	4.52	6.76	7.86	9.62	10.52	11.14	12.28
BNE 1028680.00	Jindalee	-9.90	2.00	4.49	6.71	7.80	9.50	10.36	10.96	12.09
BREM 1000000.00		0.00	14.55	17.07	18.29	19.79	21.59	23.54	23.82	26.02

BREM 1000700.00		5.00	14.11	16.50	17.72	19.16	20.86	23.33	23.64	25.89
BREM 1001120.00		5.00	13.67	16.18	17.47	18.99	20.75	23.37	23.68	25.93
BREM 1001700.00		4.80	12.84	15.38	16.71	18.29	20.37	23.27	23.59	25.84
BREM 1002300.00	Berry's Lagoon	4.20	11.99	14.50	15.86	17.51	19.78	22.97	23.33	25.60
BREM 1002700.00		4.00	11.07	13.57	15.04	16.76	18.92	22.36	22.81	25.16
BREM 1003200.00	Perry St	3.00	9.83	12.59	14.29	16.15	18.31	21.57	22.16	24.63
BREM 1003200.00		3.00	9.83	12.59	14.29	16.15	18.31	21.57	22.16	24.63
BREM 1003700.00		2.71	8.81	11.90	13.91	15.91	18.11	21.05	21.73	24.31
BREM 1003840.00		2.49	8.82	11.92	13.91	15.90	18.09	21.00	21.70	24.29
BREM 1003840.00		2.49	8.82	11.92	13.91	15.90	18.09	21.00	21.70	24.29
BREM 1004150.00		2.00	8.84	11.95	13.92	15.90	18.07	20.96	21.66	24.27
BREM 1004320.00		2.20	8.77	11.88	13.85	15.82	17.97	20.89	21.61	24.22
BREM 1004320.00		2.20	8.77	11.88	13.85	15.82	17.97	20.89	21.61	24.22
BREM 1004590.00	One Mile Bridge	2.53	8.45	11.64	13.63	15.56	17.69	20.74	21.49	24.14
BREM 1004610.00	*One Mile Bridge*	2.53	8.27	11.41	12.90	14.64	17.04	20.53	21.31	24.02
BREM 1004700.00		2.50	8.17	11.40	12.95	14.83	17.31	20.61	21.36	24.05
BREM 1004700.00		2.50	8.17	11.40	12.95	14.83	17.31	20.61	21.36	24.05
BREM 1005140.00		2.20	7.98	11.33	12.88	14.66	17.11	20.39	21.15	23.76
BREM 1005520.00		1.40	7.82	11.18	12.71	14.45	16.79	20.01	20.80	23.23
BREM 1005740.00		-1.24	7.78	11.18	12.73	14.52	16.93	20.05	20.85	23.35
BREM 1006090.00		0.76	7.42	10.78	12.29	14.02	16.36	19.48	20.37	22.83
BREM 1006250.00		0.56	7.49	10.94	12.49	14.27	16.66	19.57	20.46	22.97
BREM 1006490.00	Wulkeraka Bridge	-0.50	7.21	10.68	12.24	14.00	16.33	19.28	20.23	22.76
BREM 1006510.00	Wulkeraka Bridge	-0.50	7.14	10.61	12.17	13.94	16.26	19.23	20.17	22.70
BREM 1006780.00		-1.58	6.98	10.50	12.14	13.97	16.33	19.20	20.17	22.72
BREM 1007440.00		-0.76	6.52	10.04	11.73	13.53	15.70	18.40	19.38	21.61
BREM 1007700.00		-2.76	6.51	10.05	11.75	13.58	15.80	18.31	19.28	21.47
BREM 1008000.00		-1.03	6.38	9.96	11.67	13.50	15.70	18.12	19.12	21.25
BREM 1008000.00		-1.03	6.38	9.96	11.67	13.50	15.70	18.12	19.12	21.25
BREM 1008390.00		-1.09	6.17	9.78	11.48	13.31	15.54	17.99	19.04	21.20
BREM 1008410.00	Hancock Bridge	-1.09	6.12	9.73	11.43	13.22	15.36	17.86	18.93	21.11
BREM 1008420.00	Hancock Bridge	-1.23	6.16	9.76	11.47	13.25	15.32	17.80	18.89	21.05
BREM 1008660.00		-1.53	5.99	9.50	11.23	12.99	14.97	17.39	18.55	20.67
BREM 1009210.00		-1.63	5.74	9.19	10.94	12.69	14.61	16.40	17.78	19.79
BREM 1009675.00		-4.40	5.64	9.08	10.84	12.57	14.55	15.80	17.35	19.32
BREM 1009675.00		-4.40	5.64	9.08	10.84	12.57	14.55	15.80	17.35	19.32
BREM 1009856.00		-3.61	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
BREM 1009856.00		-3.61	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
BREM 1010020.00		-2.90	5.34	8.73	10.55	12.27	14.46	15.44	17.11	18.91
BREM 1010280.00		-2.40	5.24	8.63	10.49	12.24	14.47	15.47	17.13	19.02
BREM 1010700.00		-5.50	5.13	8.49	10.34	12.07	14.44	15.44	17.11	18.93
BREM 1010890.00		-1.80	5.01	8.33	10.19	11.91	14.40	15.42	17.09	18.84
BREM 1011320.00		-1.80	4.79	8.08	10.03	11.79	14.40	15.43	17.12	18.97
BREM 1011700.00		-1.80	4.55	7.72	9.72	11.46	14.30	15.38	16.91	18.54
BREM 1011790.00		-1.71	4.48	7.64	9.65	11.40	14.26	15.36	16.84	18.47
BREM 1011810.00		-1.71	4.43	7.59	9.60	11.35	14.22	15.33	16.80	18.43
BREM 1012050.00	David Trumpy Bridge	-1.65	4.38	7.56	9.60	11.36	14.09	15.28	16.65	18.28
BREM 1012070.00	David Trumpy Bridge	-1.65	4.35	7.53	9.57	11.33	14.07	15.27	16.63	18.25
BREM 1012200.00		-2.10	4.28	7.44	9.49	11.25	14.05	15.27	16.61	18.24
BREM 1012870.00		-2.10	4.23	7.45	9.52	11.29	14.05	15.27	16.61	18.24
BREM 1013380.00		-2.70	4.11	7.31	9.42	11.21	14.04	15.27	16.61	18.24
BREM 1013700.00		-2.70	4.04	7.26	9.41	11.21	14.03	15.26	16.60	18.24
BREM 1014220.00		-2.50	3.90	7.09	9.26	11.08	13.99	15.25	16.57	18.20
BREM 1014640.00		-3.20	3.84	7.05	9.23	11.05	13.98	15.25	16.55	18.18
BREM 1015180.00		-3.50	3.72	6.91	9.11	10.96	13.96	15.25	16.54	18.17
BREM 1015445.00		-3.65	3.68	6.90	9.13	10.99	13.98	15.25	16.56	18.19
BREM 1015445.00		-3.65	3.68	6.90	9.13	10.99	13.98	15.25	16.56	18.19
BREM 1015710.00		-3.80	3.65	6.89	9.13	11.00	13.98	15.25	16.56	18.19
BREM 1016110.00		-4.50	3.59	6.83	9.07	10.95	13.97	15.25	16.55	18.18
BREM 1016110.00		-4.50	3.59	6.83	9.07	10.95	13.97	15.25	16.55	18.18
BREM 1016510.00		-5.20	3.55	6.79	9.01	10.90	13.95	15.25	16.54	18.17
BREM 1017080.00		-4.20	3.47	6.75	8.98	10.87	13.94	15.24	16.53	18.16
BREM 1017750.00		-3.90	3.38	6.70	8.95	10.86	13.94	15.24	16.53	18.15
BREM 1018140.00		-4.20	3.29	6.60	8.91	10.83	13.93	15.24	16.52	18.15
BREM 1018320.00		-4.65	3.28	6.60	8.89	10.82	13.93	15.24	16.52	18.15
BREM 1018320.00		-4.65	3.28	6.60	8.89	10.82	13.93	15.24	16.52	18.15
BREM 1018500.00		-5.10	3.28	6.59	8.88	10.80	13.92	15.24	16.51	18.14
BREM 1018630.00		-4.15	3.24	6.56	8.86	10.78	13.92	15.24	16.52	18.15
BREM 1018630.00		-4.15	3.24	6.56	8.86	10.78	13.92	15.24	16.52	18.15
BREM 1018760.00		-3.20	3.19	6.53	8.84	10.75	13.92	15.24	16.52	18.15
BREM 1019150.00		-3.40	3.14	6.54	8.86	10.78	13.92	15.24	16.52	18.15
BREM 1019580.00		-4.20	3.08	6.46	8.81	10.72	13.91	15.24	16.52	18.15
BREM 1020000.00		-3.30	2.93	6.38	8.77	10.68	13.89	15.24	16.51	18.14
BREM 1020000.00		-3.30	2.93	6.38	8.77	10.68	13.89	15.24	16.51	18.14

BREM 1020450.00	Bundamba Ck	-3.60	2.86	6.41	8.80	10.70	13.89	15.23	16.50	18.14
BREM 1020450.00	Bundamba Ck	-3.60	2.86	6.41	8.80	10.70	13.89	15.23	16.50	18.14
BREM 1020600.00		-3.54	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
BREM 1020600.00		-3.54	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
BREM 1020920.00		-3.40	2.68	6.27	8.73	10.66	13.88	15.23	16.50	18.14
BREM 1021460.00		-4.20	2.60	6.22	8.69	10.61	13.85	15.23	16.49	18.13
BREM 1022300.00		-4.00	2.41	6.10	8.63	10.59	13.84	15.23	16.48	18.12
BREM 1022950.00		-7.20	2.31	6.07	8.63	10.59	13.84	15.22	16.47	18.12
BREM 1023490.00		-4.92	2.24	5.99	8.57	10.53	13.81	15.22	16.45	18.09
BREM 1023510.00		-4.92	2.21	5.96	8.54	10.51	13.79	15.18	16.34	17.93
BREM 1023870.00		-4.20	2.19	5.97	8.55	10.52	13.79	15.18	16.34	17.94
BREM 1024220.00		-5.90	2.12	5.91	8.51	10.48	13.77	15.17	16.32	17.92
BREM 1024520.00		-5.20	2.08	5.90	8.52	10.50	13.77	15.18	16.32	17.92
BREM 1024750.00		-7.20	2.08	5.90	8.52	10.49	13.76	15.17	16.31	17.91
BREM 1025300.00		-7.20	2.06	5.87	8.50	10.47	13.75	15.17	16.30	17.90
BREM 1025670.00		-7.20	2.06	5.82	8.47	10.46	13.74	15.17	16.30	17.89
BREM 1025920.00		-6.20	2.05	5.80	8.46	10.44	13.73	15.17	16.29	17.88
BREM 1026150.00		-8.20	2.05	5.80	8.46	10.44	13.73	15.17	16.29	17.88
BREM 1026560.00		-6.20	2.05	5.76	8.43	10.42	13.72	15.16	16.28	17.87
BREM 1027100.00		-5.20	2.03	5.73	8.41	10.40	13.69	15.16	16.27	17.86
BREM 1027640.00		-7.20	2.02	5.70	8.39	10.38	13.67	15.15	16.24	17.83
BREM 1027840.00		-7.20	2.02	5.68	8.38	10.37	13.65	15.15	16.23	17.81
BREM 1028190.00		-7.10	2.02	5.64	8.35	10.34	13.61	15.13	16.17	17.76
BREM 1028190.00		-7.10	2.02	5.64	8.35	10.34	13.61	15.13	16.17	17.76
BREM 1028490.00	Brisbane River	-4.10	2.02	5.64	8.35	10.34	13.60	15.13	16.14	17.71
BREMER 0.00		45.47	50.70	51.82	51.98	52.18	53.56	54.17	54.36	54.68
BREMER 364.80		47.11	50.17	51.17	51.34	51.64	52.88	53.54	53.75	54.09
BREMER 1613.53		43.00	47.32	48.42	48.62	49.70	50.39	51.22	51.41	51.76
BREMER 2207.67		42.91	47.19	48.09	48.24	48.34	48.83	50.19	50.37	50.74
BREMER 2472.00		43.72	47.06	47.85	48.00	48.09	48.58	49.83	49.99	50.34
BREMER 2492.00		43.72	46.95	47.84	47.99	48.07	48.57	49.82	49.98	50.33
BREMER 2522.86		43.72	46.89	47.78	47.93	48.01	48.54	49.76	49.92	50.27
BREMER 3048.80		41.40	45.90	46.76	46.88	46.99	47.84	48.72	48.90	49.24
BREMER 3579.79		41.07	45.08	45.97	46.08	46.18	47.06	47.87	48.07	48.48
BREMER 4117.69		39.55	44.33	45.17	45.31	45.44	46.63	47.31	47.51	47.99
BREMER 4658.71		38.93	43.37	44.51	44.67	44.83	45.98	46.60	46.81	47.37
BREMER 5466.45		38.24	42.03	43.45	43.64	43.85	44.91	45.62	45.91	46.59
BREMER 6137.27		37.24	41.68	43.00	43.19	43.36	44.59	45.41	45.72	46.41
BREMER 6902.98		34.87	41.15	42.40	42.61	42.79	43.95	45.01	45.28	45.97
BREMER 7597.00		36.79	40.77	42.13	42.32	42.50	43.43	44.72	45.00	45.75
BREMER 7597.00		36.79	40.77	42.13	42.32	42.50	43.43	44.72	45.00	45.75
BREMER 8229.47		36.72	40.41	41.81	42.01	42.24	43.03	44.56	44.87	45.71
BREMER 9006.19		34.96	39.92	41.33	41.57	41.82	42.24	44.30	44.67	46.15
BREMER 9784.00		33.70	39.43	40.73	41.03	41.28	41.58	43.87	44.32	46.02
BREMER 9804.00		33.70	39.37	40.45	40.67	40.79	40.97	42.24	43.47	49.03
BREMER 9936.00		34.59	39.25	40.27	40.50	40.56	40.74	41.95	42.74	43.57
BREMER 9936.00		34.59	39.25	40.27	40.50	40.56	40.74	41.95	42.74	43.57
BREMER 10391.00		35.59	38.53	39.52	39.75	39.89	40.12	41.27	41.97	43.14
BREMER 10391.00		35.59	38.53	39.52	39.75	39.89	40.12	41.27	41.97	43.14
BREMER 10391.51		35.59	38.53	39.52	39.74	39.89	40.12	41.27	41.97	43.14
BREMER 10893.66		32.65	38.16	39.09	39.34	39.51	39.75	40.88	41.67	42.96
BREMER 10893.66		32.65	38.16	39.09	39.34	39.51	39.75	40.88	41.67	42.96
BREMER 11315.68		31.18	38.02	38.87	39.11	39.27	39.49	40.74	41.54	42.88
BREMER 11477.63	Rosewood	33.50	37.90	38.71	39.01	39.19	39.43	40.59	41.43	42.82
BREMER 11487.63	Rosewood	33.50	37.51	38.29	38.50	38.64	38.90	40.58	41.42	42.81
BREMER 11874.52		32.11	36.86	37.64	37.82	37.94	38.10	39.91	40.96	42.43
BREMER 12230.92		34.57	36.46	37.26	37.46	37.59	37.79	39.46	40.61	42.10
BREMER 12694.60		34.40	35.72	36.52	36.74	36.87	37.22	38.82	40.01	41.55
BREMER 13268.91		29.83	33.85	35.34	35.65	35.80	36.81	38.09	38.93	40.53
BREMER 13670.20		28.22	33.25	35.01	35.33	35.46	36.51	37.54	38.20	39.84
BREMER 14389.82		27.11	33.04	34.89	35.21	35.33	36.28	37.31	37.99	39.67
BREMER 14400.00		27.11	33.04	34.89	35.20	35.32	36.27	37.31	37.99	39.67
BREMER 14420.00		27.11	32.95	34.54	34.88	35.04	36.27	37.31	37.98	39.66
BREMER 14831.22		27.46	32.94	34.50	34.81	34.95	36.05	37.05	37.71	39.36
BREMER 15060.00		29.41	32.74	34.34	34.68	34.81	35.92	36.79	37.48	39.15
BREMER 15080.00		29.41	32.71	34.08	34.48	34.63	35.91	36.78	37.46	39.04
BREMER 15311.88		29.41	32.27	33.54	33.90	34.18	35.81	36.44	37.13	38.81
BREMER 15747.83		26.90	31.55	32.88	33.24	33.60	35.27	35.85	36.56	38.45
BREMER 16340.42		26.45	30.88	32.33	32.65	32.93	34.14	35.25	36.14	38.22
BREMER 16706.22		26.68	30.61	32.23	32.56	32.82	33.85	35.09	36.02	38.13
BREMER 17221.72		25.05	30.02	31.63	31.97	32.21	33.13	34.11	34.86	37.43
BREMER 17933.08		24.49	29.13	30.43	30.89	31.17	31.30	31.36	33.02	36.52
BREMER 18398.80		23.77	28.81	30.18	30.69	30.99	31.13	31.21	32.63	36.29
BREMER 19050.94		23.39	28.20	29.57	30.10	30.44	30.59	30.71	31.40	35.85

BREMER 19360.00		22.12	28.04	29.51	30.07	30.38	30.52	30.64	31.08	35.69
BREMER 19380.00		22.12	27.82	29.48	30.06	30.37	30.51	30.63	31.08	35.64
BREMER 19419.49	Walloon Alert	22.12	27.80	29.47	30.04	30.35	30.49	30.62	31.06	35.62
BREMER 20485.54		21.38	26.89	28.77	29.41	29.72	29.94	30.04	30.18	35.00
BREMER 20876.67		20.72	26.37	28.31	28.96	29.30	29.63	29.72	29.77	34.78
BREMER 21565.85		19.92	25.44	27.27	27.79	28.12	28.45	28.57	28.63	34.13
BREMER 21851.32		18.63	25.01	26.82	27.37	27.73	28.10	28.23	28.32	33.81
BREMER 22410.57		17.99	24.07	26.06	26.69	27.10	27.53	27.70	27.87	32.69
BREMER 22931.36		18.17	23.56	25.53	26.15	26.56	26.97	27.15	27.40	31.39
BREMER 23375.87		17.83	23.00	24.98	25.58	25.96	26.38	26.58	26.91	30.22
BREMER 23968.39	Walloon TM	16.11	22.55	24.69	25.17	25.55	25.97	26.20	26.60	29.15
BREMER 24384.48		18.00	22.30	24.34	24.90	25.28	25.71	25.97	26.43	29.00
BREMER 24891.36		15.77	21.82	23.92	24.45	24.82	25.25	25.61	26.16	28.68
BREMER 25371.48		16.24	21.25	23.22	23.80	24.23	24.71	25.30	25.82	28.26
BREMER 25882.25		14.07	20.83	22.52	23.18	23.70	24.25	25.06	25.51	27.82
BREMER 26265.02		13.73	20.56	22.15	22.81	23.34	24.00	24.91	25.33	27.61
BREMER 26341.55		16.89	20.41	22.03	22.70	23.22	23.89	24.83	25.25	27.56
BREMER 26773.64		15.45	19.61	21.31	21.99	22.48	23.22	24.39	24.79	27.30
BREMER 27056.11		16.54	19.26	21.04	21.71	22.18	23.02	24.26	24.64	27.17
BREMER 27398.71		14.41	18.80	20.69	21.38	21.87	22.82	24.15	24.51	27.01
BREMER 27591.25		14.66	18.51	20.36	21.04	21.59	22.67	24.08	24.44	26.89
BREMER 27839.23		14.34	18.17	19.97	20.66	21.27	22.47	24.00	24.35	26.75
BREMER 28051.84		14.50	17.87	19.71	20.44	21.11	22.39	23.95	24.28	26.65
BREMER 28338.03		13.35	17.33	19.12	19.91	20.72	22.15	23.81	24.13	26.43
BREMER 28868.29		12.55	16.75	18.49	19.37	20.36	21.92	23.68	23.98	26.14
BREMER 29126.92		11.87	16.22	18.21	19.14	20.23	21.84	23.64	23.93	26.05
BREMER 29472.00		11.62	15.07	17.66	18.76	20.02	21.74	23.57	23.85	26.03
BREMER 29515.00	Three Mile Bridge	11.12	15.00	17.62	18.73	20.01	21.73	23.57	23.85	26.03
BREMER 29535.00	Three Mile Bridge	11.12	14.99	17.50	18.66	20.00	21.73	23.56	23.84	26.02
BREMER 29578.00		10.64	14.95	17.48	18.66	20.00	21.73	23.56	23.84	26.02
BREMER 29891.00		9.18	14.64	17.15	18.37	19.83	21.62	23.54	23.82	26.02
BREMER 30091.00		6.51	14.59	17.12	18.36	19.83	21.61	23.54	23.82	26.02
BREMER 30791.00		6.46	14.55	17.07	18.29	19.79	21.59	23.54	23.82	26.02
BREMER-BOONAHNEW 9869.00		101.14	101.60	102.22	102.40	102.52	102.89	103.25	103.42	103.66
BREMER-BOONAHNEW 10466.43		97.07	98.11	99.33	99.60	99.63	99.74	99.88	99.96	100.07
BREMER-BOONAHNEW 11917.00		91.70	93.38	94.64	94.94	95.18	95.83	96.40	96.57	96.77
BREMER-BOONAHNEW 11937.00		91.70	93.01	94.06	94.30	94.49	95.07	95.49	95.55	95.66
BREMER-BOONAHNEW 12500.00		88.44	90.27	91.35	91.60	91.82	92.23	92.40	92.49	92.65
BREMER-BOONAHNEW 13405.41		85.34	87.07	87.79	87.91	88.03	88.41	88.82	88.99	89.24
BREMER-BOONAHNEW 13930.22		82.54	84.95	86.95	87.08	87.16	87.35	87.49	87.55	87.62
BREMER-BOONAHNEW 13938.22		82.54	84.72	85.71	86.30	86.37	86.46	86.61	86.67	86.77
BREMER-BOONAHNEW 14368.66		81.95	83.82	84.95	85.55	85.59	85.72	85.85	85.91	86.01
BREMER-BOONAHNEW 15447.36		79.02	79.88	80.95	81.27	81.60	82.25	82.50	82.58	82.70
BREMER-BOONAHNEW 16506.06	Adams Bridge	76.10	78.30	79.69	80.06	80.40	80.85	81.16	81.28	81.46
BREMER-BOONAHNEW 16518.06		76.10	76.95	77.94	78.21	78.54	79.27	80.00	80.29	80.78
BREMER-BOONAHNEW 18166.50		70.02	71.74	73.21	73.44	73.82	74.47	75.14	75.43	76.03
BREMER-BOONAHNEW 19093.71		68.10	69.61	71.12	71.62	72.24	72.67	72.77	72.81	72.89
BREMER-BOONAHNEW 20723.30		64.53	65.23	66.36	66.69	66.94	67.39	67.86	68.01	68.31
BREMER-BOONAHNEW 21991.71		62.64	64.85	65.83	66.09	66.31	66.69	67.12	67.27	67.54
BREMER-BOONAHNEW 23828.91	Stokes Crossing	57.28	60.10	61.44	61.74	62.09	62.97	63.77	64.00	64.41
BREMER-BOONAHNEW 24500.00		56.63	59.10	60.60	60.89	61.23	62.01	63.18	63.06	63.57
BREMER-BOONAHNEW 24546.71		56.63	59.04	60.53	60.81	61.15	61.93	63.01	62.96	63.47
BREMER-BOONAHNEW 24556.71		56.63	58.88	60.51	60.79	61.13	61.90	62.68	62.94	63.46
BREMER-BOONAHNEW 24600.00		56.63	58.80	60.42	60.71	61.05	61.81	62.58	62.84	63.36
BREMER-BOONAHNEW 26500.72		50.00	54.99	56.59	57.05	57.58	57.91	58.34	58.52	58.91
BREMER-BOONAHNEW 27584.32		49.32	53.87	55.02	55.46	55.96	56.43	56.88	57.03	57.30
BREMER-BOONAHNEW 29213.00		45.47	50.70	51.82	51.98	52.18	53.56	54.17	54.36	54.68
BUND 10000.00		78.68	79.44	79.93	80.04	80.14	80.43	80.70	81.00	81.20
BUND 10307.50		76.48	77.19	77.56	77.66	77.74	77.97	78.23	79.56	79.94
BUND 10615.00		74.27	75.57	75.57	75.57	75.57	75.66	75.95	79.14	79.50
BUND 11107.50		72.28	72.99	73.38	73.50	73.61	73.97	74.28	77.67	77.96
BUND 11600.00		70.29	71.06	71.70	71.87	72.03	72.38	72.72	75.50	75.81
BUND 11968.33		68.55	69.20	69.68	69.80	69.91	70.28	70.68	70.80	71.08
BUND 12336.67		66.82	67.53	67.97	68.09	68.20	68.55	68.94	69.00	69.34
BUND 12705.00		65.08	65.89	66.36	66.48	66.59	66.98	67.41	67.40	67.87
BUND 13165.00		63.33	64.20	64.79	64.93	65.06	65.52	66.09	66.20	66.65
BUND 13552.50		59.70	60.79	61.58	61.77	61.96	62.47	63.71	64.00	64.5
BUND 13940.00		56.07	57.69	58.80	58.98	59.15	59.71	62.93	62.00	63.89
BUND 14217.50		55.34	56.67	57.54	57.74	57.93	58.46	62.97	63.00	63.91
BUND 14495.00		54.61	55.66	56.49	56.69	56.88	57.46	61.30	61.50	62.11
BUND 14775.00		54.19	54.99	55.70	55.86	56.01	56.48	57.43	58.93	59.01
BUND 15055.00		53.76	54.45	55.11	55.27	55.42	55.91	57.34	58.86	58.97
BUND 15377.50		52.47	53.45	54.40	54.60	54.78	55.36	57.33	58.89	58.99
BUND 15700.00		51.17	52.87	53.89	54.08	54.24	54.84	57.25	58.62	58.82

BUND 16047.50		50.20	51.36	52.43	52.62	52.78	54.18	56.62	57.70	57.92
BUND 16395.00	Ripley	49.22	50.21	51.18	51.40	51.58	54.14	55.72	56.87	57.13
BUND 16647.50		49.01	49.84	50.64	50.82	51.00	53.86	55.21	56.50	56.77
BUND 16900.00		48.80	49.34	50.07	50.25	50.43	53.55	54.73	55.80	56.09
BUND 17215.00		47.51	48.12	48.95	49.15	49.35	53.46	54.29	54.95	55.29
BUND 17530.00		46.22	47.05	48.05	48.32	48.59	52.32	53.47	54.07	54.41
BUND 17885.00		44.61	45.67	46.81	47.10	47.37	50.40	52.40	52.96	53.27
BUND 18307.50		43.88	44.96	46.20	46.50	46.79	49.08	52.07	52.62	52.93
BUND 18730.00	Ripley Rd Bridge	43.14	44.26	45.52	45.82	46.13	47.32	50.78	51.42	51.87
BUND 18750.00	Ripley Rd Bridge	43.14	43.92	44.92	45.15	45.38	45.93	50.58	51.04	51.34
BUND 19015.00		41.54	42.58	43.68	43.93	44.17	44.71	48.99	49.58	49.95
BUND 19280.00		39.93	41.66	42.73	42.97	43.19	43.71	47.82	48.30	48.66
BUND 19540.00		39.75	41.05	41.90	42.10	42.29	42.81	46.29	46.69	47.21
BUND 19800.00		39.57	40.46	41.23	41.42	41.61	42.21	45.86	46.25	46.88
BUND 20120.00		38.50	39.44	40.45	40.71	40.93	41.74	45.57	45.99	46.68
BUND 20440.00		37.43	38.64	39.92	40.18	40.40	41.41	44.71	45.25	46.21
BUND 20905.00		36.50	37.92	39.13	39.38	39.59	40.70	42.77	43.70	45.09
BUND 21370.00		35.56	37.13	38.26	38.50	38.71	39.61	41.80	42.49	43.53
BUND 21745.00		34.95	36.38	37.49	37.68	37.87	38.83	41.15	41.49	42.61
BUND 22120.00		34.33	35.65	36.91	37.16	37.38	37.93	39.74	40.67	42.29
BUND 22120.00		34.33	35.65	36.91	37.16	37.38	37.93	39.74	40.67	42.29
BUND 22452.50		33.49	34.75	36.17	36.53	36.81	37.45	37.65	39.08	41.97
BUND 22785.00		32.64	34.21	35.70	36.01	36.28	36.82	37.02	37.45	41.26
BUND 23150.00		32.39	33.97	35.40	35.70	35.93	36.41	36.68	37.15	40.35
BUND 23515.00		32.13	33.81	35.19	35.46	35.70	36.14	36.53	37.09	39.92
BUND 23822.50		32.13	33.52	34.76	35.02	35.28	35.72	36.27	36.75	39.51
BUND 24130.00		32.13	33.18	34.24	34.52	34.79	35.25	35.82	36.19	37.93
BUND 24445.00		30.16	31.48	32.54	32.83	33.14	34.01	35.65	36.06	36.32
BUND 24760.00		28.18	30.08	31.47	32.12	32.69	33.96	35.57	35.88	36.07
BUND 25075.00		27.29	29.76	31.35	32.05	32.65	33.75	35.09	35.36	35.54
BUND 25327.50		27.08	29.71	31.31	31.90	32.34	33.39	34.70	34.95	35.17
BUND 25580.00		26.87	29.55	31.31	31.79	32.06	33.01	34.60	34.86	35.08
BUND 25600.00		26.87	28.98	31.30	31.77	32.03	32.92	34.48	34.70	34.91
BUND 26070.00		26.20	27.91	30.51	30.90	31.10	31.57	34.15	34.36	34.61
BUND 26540.00		25.52	26.95	27.98	28.28	28.47	28.90	31.22	31.34	32.49
BUND 26780.00		24.83	25.82	26.97	27.37	27.59	28.00	28.14	28.15	31.33
BUND 27280.00		22.12	25.37	26.74	27.13	27.36	27.71	27.83	27.85	30.51
BUND 27380.00	Patrick St Bridge	22.12	25.35	26.70	27.08	27.31	27.65	27.78	27.80	30.13
BUND 27400.00	Patrick St Bridge	22.12	25.34	26.65	26.94	27.10	27.39	27.58	27.65	30.08
BUND 27655.00		22.12	25.31	26.61	26.76	26.89	27.11	27.33	27.42	29.28
BUND 27675.00		22.12	25.20	26.47	26.71	26.87	27.17	27.43	27.52	29.32
BUND 28010.00		22.12	24.55	25.73	26.25	26.41	26.81	27.12	27.24	28.67
BUND 28350.00		22.10	24.23	25.39	26.09	26.27	26.63	26.80	26.87	27.42
BUND 28350.00		22.10	24.23	25.39	26.09	26.27	26.63	26.80	26.87	27.42
BUND 28480.00	Cunningham Hwy	22.09	24.20	25.36	26.07	26.25	26.57	26.68	26.72	26.97
BUND 28530.00		22.09	24.09	24.75	26.00	26.18	26.44	26.54	26.57	26.78
BUND 28560.00		22.66	24.02	24.70	26.01	26.15	26.39	26.47	26.50	26.69
BUND 28630.00		22.44	23.88	24.56	25.84	25.95	26.17	26.24	26.26	26.48
BUND 28630.00		22.44	23.88	24.56	25.84	25.95	26.17	26.24	26.26	26.48
BUND 28935.00		21.47	23.29	24.21	24.48	24.63	25.02	25.21	25.27	25.78
BUND 29240.00	Harding Street	20.50	23.19	24.15	24.40	24.55	24.94	25.17	25.20	25.68
BUND 29550.00		19.38	22.88	23.92	24.18	24.34	24.72	24.97	25.01	25.45
BUND 29910.00		18.00	22.12	23.50	23.81	23.99	24.36	24.66	24.73	25.19
BUND 30215.00		18.17	21.89	23.24	23.55	23.74	24.08	24.40	24.48	25.00
BUND 30520.00		18.34	21.40	22.89	23.25	23.47	23.92	24.25	24.34	24.91
BUND 30940.00		17.47	20.56	22.22	22.66	22.90	23.55	23.80	24.01	24.59
BUND 31360.00		16.59	19.96	21.26	21.60	21.83	22.55	23.09	23.28	23.92
BUND 31630.00		16.69	19.39	20.59	20.95	21.23	22.04	22.55	22.69	23.30
BUND 31980.00	Blackstone Rd	15.46	18.40	20.03	20.50	20.85	21.58	21.84	21.87	22.32
BUND 32000.00	Blackstone Rd	15.46	18.39	19.94	20.37	20.77	21.55	21.82	21.85	22.31
BUND 32150.00		15.00	18.14	19.72	20.14	20.57	21.27	21.49	21.51	21.89
BUND 32350.00		14.15	17.67	19.26	19.65	19.90	20.63	20.82	20.83	21.14
BUND 32370.00		14.15	17.66	19.25	19.64	19.89	20.56	20.74	20.75	21.05
BUND 32675.00		14.27	17.04	18.67	19.07	19.29	19.82	20.01	20.02	20.31
BUND 32980.00		14.38	16.62	18.26	18.69	18.91	19.37	19.53	19.54	19.80
BUND 33320.00		13.31	15.87	17.57	18.03	18.22	18.56	18.68	18.70	18.96
BUND 33660.00		12.52	15.40	17.23	17.68	17.85	18.18	18.30	18.33	18.61
BUND 34000.00		12.06	15.28	17.13	17.58	17.74	18.03	18.14	18.18	18.46
BUND 34000.00		12.06	15.28	17.13	17.58	17.74	18.03	18.14	18.18	18.46
BUND 34260.00		11.50	15.11	17.07	17.52	17.68	17.96	18.07	18.10	18.40
BUND 34305.00	Brisbane Rd	11.03	15.10	17.06	17.51	17.67	17.94	18.05	18.09	18.38
BUND 34345.00	Brisbane Rd	11.03	15.09	16.89	17.31	17.50	17.83	17.99	18.03	18.36
BUND 34395.00		11.00	15.03	16.77	17.18	17.36	17.69	17.84	17.88	18.18
BUND 34760.00		11.00	14.58	16.01	16.31	16.49	16.97	17.17	17.22	18.15

BUND 35050.00		10.25	13.64	14.94	15.31	15.54	16.08	16.28	16.51	18.15
BUND 35100.00		10.25	13.41	14.78	15.19	15.44	16.01	16.21	16.51	18.15
BUND 35120.00		10.25	13.40	14.77	15.17	15.38	15.93	16.14	16.51	18.14
BUND 35520.00		9.30	12.50	13.97	14.38	14.61	15.10	15.26	16.51	18.14
BUND 35540.00		9.30	12.49	13.96	14.37	14.59	15.08	15.24	16.51	18.14
BUND 35730.00		9.00	11.92	13.42	13.84	14.08	14.57	15.24	16.51	18.14
BUND 36005.00	Gledson St	8.09	10.75	12.80	13.28	13.56	14.17	15.24	16.51	18.14
BUND 36025.00	Gledson St	8.09	10.74	12.77	13.18	13.41	13.93	15.23	16.50	18.14
BUND 36297.50		7.13	10.28	12.36	12.82	13.08	13.89	15.23	16.50	18.14
BUND 36570.00		6.16	9.54	11.53	12.03	12.29	13.89	15.23	16.50	18.14
BUND 36840.00		5.58	8.77	10.66	11.16	11.44	13.89	15.23	16.50	18.14
BUND 37110.00		5.00	8.42	10.31	10.82	11.12	13.89	15.23	16.50	18.14
BUND 37510.00		4.65	8.10	10.02	10.53	10.84	13.89	15.23	16.50	18.14
BUND 37910.00		4.29	7.38	9.23	9.76	10.71	13.89	15.23	16.50	18.14
BUND 37910.00		4.29	7.38	9.23	9.76	10.71	13.89	15.23	16.50	18.14
BUND 38280.00		3.50	6.17	8.25	8.96	10.71	13.89	15.23	16.50	18.14
BUND 38722.50		2.25	5.28	7.72	8.91	10.70	13.89	15.23	16.50	18.14
BUND 39165.00		1.00	4.43	6.88	8.87	10.70	13.89	15.23	16.50	18.14
BUND 39546.67		0.83	3.67	6.52	8.84	10.70	13.89	15.23	16.50	18.14
BUND 39928.33		0.67	3.36	6.47	8.82	10.70	13.89	15.23	16.50	18.14
BUND 40310.00		0.50	3.20	6.45	8.81	10.70	13.89	15.23	16.50	18.14
BUND 40670.00		0.50	3.06	6.43	8.81	10.70	13.89	15.23	16.50	18.14
BUND 41030.00		0.50	2.87	6.41	8.80	10.70	13.89	15.23	16.50	18.14
BUND 41049.04	Bremer River	0.50	2.86	6.41	8.80	10.70	13.89	15.23	16.50	18.14
DEEB 10000.00		44.71	45.14	45.79	45.92	46.06	46.67	47.03	47.16	47.33
DEEB 10315.00		44.49	44.81	45.13	45.21	45.29	45.70	45.95	46.05	46.18
DEEB 10588.50		42.01	42.38	42.74	42.83	42.93	43.29	43.57	43.68	43.83
DEEB 10862.00		39.52	40.35	40.72	40.80	40.89	41.32	41.63	41.73	41.87
DEEB 11141.00		39.80	40.09	40.34	40.40	40.46	40.90	41.22	41.29	41.38
DEEB 11453.00		39.64	39.70	39.87	39.92	39.96	40.21	40.38	40.43	40.49
DEEB 11837.00		34.66	35.22	35.50	35.58	35.67	36.11	36.47	36.62	36.85
DEEB 12111.00		32.00	33.16	33.75	33.89	34.03	34.73	35.28	35.49	35.72
DEEB 12377.00		30.00	30.77	31.45	31.55	31.67	32.28	32.77	32.95	33.19
DEEB 12643.00		28.00	28.75	29.45	29.56	29.67	30.25	30.71	30.92	31.15
DEEB 12927.00		25.74	26.80	27.42	27.54	27.63	28.12	28.54	28.72	28.94
DEEB 12947.00		25.87	26.46	27.03	27.16	27.29	27.93	28.40	28.57	28.78
DEEB 13165.00		24.80	25.70	26.22	26.32	26.43	27.03	27.47	27.65	27.89
DEEB 13295.00		24.30	25.20	25.84	25.97	26.09	26.72	27.18	27.41	27.70
DEEB 13587.00		24.00	24.84	25.44	25.55	25.66	26.28	26.80	27.05	27.38
DEEB 13888.00		23.00	23.95	24.61	24.76	24.91	25.70	26.33	26.62	26.99
DEEB 13922.00		23.00	23.80	24.33	24.44	24.56	25.09	25.44	25.59	25.78
DEEB 14201.00		23.00	23.50	23.60	23.67	23.75	24.11	24.35	24.47	24.60
DEEB 14486.00		21.50	21.90	22.30	22.37	22.43	22.72	22.98	23.10	24.25
DEEB 14771.00		20.00	20.66	20.89	20.96	21.04	21.42	21.80	21.98	24.25
DEEB 14979.00		18.50	19.52	20.09	20.24	20.39	20.86	21.23	21.54	24.25
DEEB 15159.00		18.00	18.75	19.31	19.45	19.59	20.04	20.76	21.54	24.25
DEEB 15336.00		16.80	18.12	18.86	19.02	19.17	19.69	20.76	21.54	24.25
DEEB 15682.00		16.50	17.78	18.45	18.57	18.68	19.15	20.76	21.54	24.25
DEEB 15682.00		16.50	17.78	18.45	18.57	18.68	19.15	20.76	21.54	24.25
DEEB 15904.00		16.30	17.26	17.82	17.92	18.03	18.62	20.76	21.54	24.25
DEEB 16035.00		15.83	16.73	17.43	17.59	17.75	18.46	20.76	21.54	24.25
DEEB 16035.00		15.83	16.73	17.43	17.59	17.75	18.46	20.76	21.54	24.25
DEEB 16120.00		15.52	16.64	17.37	17.53	17.69	18.41	20.76	21.54	24.25
DEEB 16215.00		15.00	16.50	17.20	17.35	17.49	18.15	20.76	21.54	24.25
DEEB 16215.00		15.00	16.50	17.20	17.35	17.49	18.15	20.76	21.54	24.25
DEEB 16303.00		15.00	16.19	16.93	17.08	17.23	17.91	20.76	21.54	24.25
DEEB 16340.00		15.00	16.04	16.79	16.94	17.09	17.80	20.76	21.54	24.25
DEEB 16609.00		13.50	*15.08*	*16.00*	*16.22*	16.43	17.40	20.76	21.54	24.25
DEEB 16635.00		13.50	15.07	15.98	16.20	16.41	17.40	20.76	21.54	24.25
DEEB 16635.00		13.50	15.07	15.98	16.20	16.41	17.40	20.76	21.54	24.25
DEEB 16854.00		13.50	14.90	15.60	15.79	15.97	17.40	20.76	21.54	24.25
DEEB 16960.00		13.00	14.83	15.46	15.64	15.83	17.40	20.76	21.54	24.25
DEEB 16960.00		13.00	14.83	15.46	15.64	15.83	17.40	20.76	21.54	24.25
DEEB 17064.00		12.50	14.81	15.39	15.58	15.77	17.40	20.76	21.54	24.25
DEEB 17064.00		12.50	14.81	15.39	15.58	15.77	17.40	20.76	21.54	24.25
DEEB 17080.00		12.20	14.53	15.35	15.53	15.73	17.40	20.76	21.54	24.25
DEEB 17317.00		12.72	14.23	14.99	15.20	15.42	17.39	20.76	21.54	24.25
DEEB 17609.00		12.47	13.57	14.41	14.72	14.98	17.39	20.76	21.54	24.25
DEEB 17697.00		11.34	13.46	14.15	14.50	14.84	17.39	20.76	21.54	24.25
DEEB 17697.00		11.34	13.46	14.15	14.50	14.84	17.39	20.76	21.54	24.25
DEEB 17717.00		11.34	12.62	13.89	14.25	14.83	17.39	20.76	21.54	24.25
DEEB 17902.00		10.15	12.19	13.53	13.98	14.83	17.39	20.76	21.54	24.25
DEEB 17927.00		10.15	11.84	13.40	13.79	14.83	17.39	20.76	21.54	24.24
DEEB 18337.00		8.47	11.69	13.12	13.52	14.83	17.39	20.76	21.54	24.24

DEEB 18357.00	8.47	11.68	13.07	13.50	14.83	17.39	20.76	21.54	24.24
DEEB 18478.00	8.40	11.61	12.96	13.40	14.83	17.39	20.76	21.54	24.24
DEEB 18502.00	8.35	11.06	12.28	12.96	14.83	17.39	20.76	21.54	24.23
DEEB 18670.00	8.30	10.41	11.44	12.96	14.83	17.39	20.76	21.54	24.23
DEEB 18670.00	8.30	10.41	11.44	12.96	14.83	17.39	20.76	21.54	24.23
DEEB 18795.00	8.25	9.75	11.41	12.96	14.83	17.39	20.76	21.53	24.23
DEEB 18936.00	7.62	9.10	11.40	12.96	14.83	17.39	20.76	21.53	24.22
DEEB 19112.00	6.28	8.24	11.40	12.96	14.83	17.39	20.76	21.52	24.21
DEEB 19132.00	6.28	8.18	11.40	12.95	14.83	17.39	20.75	21.52	24.20
DEEB 19247.00	5.89	8.17	11.40	12.95	14.83	17.39	20.75	21.51	24.17
DEEB 19247.00	5.89	8.17	11.40	12.95	14.83	17.39	20.75	21.51	24.17
DEEB 19401.00	4.07	8.17	11.40	12.95	14.83	17.37	20.73	21.49	24.19
DEEB 19537.00	4.61	8.17	11.40	12.95	14.83	17.35	20.67	21.43	24.12
DEEB 19607.00	3.78	8.17	11.40	12.95	14.83	17.34	20.66	21.41	24.08
DEEB 19702.00	3.30	8.17	11.40	12.95	14.83	17.33	20.64	21.39	24.07
DEEB 19827.00	2.94	8.17	11.40	12.95	14.83	17.32	20.62	21.37	24.07
DEEB 19847.00	2.94	8.17	11.40	12.95	14.83	17.30	20.58	21.33	24.03
DEEB 19912.00	2.50	8.17	11.40	12.95	14.83	17.31	20.61	21.36	24.05
FRANKLINVALE 0.00	125.00	126.47	128.13	128.26	128.38	128.66	128.91	129.04	129.20
FRANKLINVALE 425.97	122.00	124.26	125.83	126.03	126.16	126.51	126.82	127.00	127.23
FRANKLINVALE 885.68	118.47	121.15	122.92	123.20	123.44	123.88	124.27	124.47	124.69
FRANKLINVALE 1365.29	114.89	117.23	118.83	119.19	119.51	120.27	120.84	121.09	121.26
FRANKLINVALE 1768.94	110.93	112.87	114.42	114.78	115.09	115.72	115.98	116.14	116.28
FRANKLINVALE 2251.85	106.79	108.61	109.64	109.90	110.14	110.65	111.15	111.40	111.72
FRANKLINVALE 2700.97	102.13	105.68	107.77	108.16	108.52	109.26	109.81	110.05	110.35
FRANKLINVALE 2996.01	101.95	104.85	106.86	107.23	107.56	108.15	108.57	108.76	109.00
FRANKLINVALE 3548.88	99.41	102.75	104.84	105.09	105.33	105.86	106.26	106.44	106.68
FRANKLINVALE 4061.92	99.14	101.73	103.71	103.88	104.05	104.42	104.72	104.85	105.00
FRANKLINVALE 4449.29	97.46	100.42	102.28	102.45	102.62	102.96	103.25	103.35	103.48
FRANKLINVALE 4833.58	97.17	99.07	101.02	101.14	101.27	101.60	101.81	101.91	102.05
FRANKLINVALE 5112.51	94.51	96.79	99.30	99.56	99.85	100.39	100.65	100.78	100.93
FRANKLINVALE 5621.00	91.72	94.87	97.88	98.23	98.48	98.85	99.08	99.18	99.31
FRANKLINVALE 5626.00	91.72	94.84	97.60	97.90	98.08	98.55	98.84	98.98	99.15
FRANKLINVALE 6032.32	90.04	93.19	95.16	95.40	95.67	96.19	96.46	96.60	96.75
FRANKLINVALE 6470.57	89.41	92.07	93.53	93.77	94.03	94.39	94.69	94.82	95.00
FRANKLINVALE 6973.07	87.79	91.02	92.29	92.45	92.59	92.92	93.21	93.33	93.47
FRANKLINVALE 7246.79	87.65	90.10	91.58	91.72	91.85	92.13	92.37	92.47	92.59
FRANKLINVALE 7528.59	87.48	89.27	90.44	90.60	90.69	90.93	91.16	91.26	91.39
FRANKLINVALE 7787.11	86.50	88.25	89.54	89.67	89.78	90.04	90.29	90.40	90.54
FRANKLINVALE 8320.85	85.31	87.31	88.54	88.70	88.82	89.04	89.25	89.35	89.48
FRANKLINVALE 8827.31	82.39	85.60	86.91	86.98	87.05	87.18	87.31	87.37	87.47
FRANKLINVALE 8843.31	82.39	84.77	86.40	86.59	86.84	87.04	87.27	87.36	87.46
FRANKLINVALE 9321.57	80.39	82.79	84.44	84.69	84.82	85.18	85.48	85.62	85.76
FRANKLINVALE 9712.81	79.17	81.34	83.13	83.48	83.73	84.31	84.72	84.88	85.06
FRANKLINVALE 10500.52	76.44	78.40	79.66	80.03	80.44	81.20	81.59	81.73	81.90
FRANKLINVALE 10961.24	74.77	77.04	78.52	78.88	79.34	79.97	80.31	80.42	80.55
FRANKLINVALE 11455.91	73.23	75.74	77.14	77.38	77.48	77.79	78.07	78.18	78.34
FRANKLINVALE 11873.29	71.36	74.55	75.91	76.09	76.22	76.54	76.83	76.94	77.09
FRANKLINVALE 12328.45	69.88	73.21	73.78	73.96	74.07	74.40	74.67	74.78	74.92
FRANKLINVALE 12742.32	68.90	71.17	72.07	72.31	72.48	72.97	73.34	73.45	73.61
FRANKLINVALE 13141.89	68.05	70.51	71.09	71.23	71.33	71.61	71.86	71.96	72.09
FRANKLINVALE 13578.62	66.37	69.57	70.42	70.53	70.60	70.80	71.00	71.09	71.20
FRANKLINVALE 14043.78	65.62	68.36	69.32	69.40	69.46	69.62	69.79	69.86	69.96
FRANKLINVALE 14524.77	62.81	65.97	67.21	67.36	67.44	67.71	67.96	68.07	68.20
FRANKLINVALE 15001.90	62.52	65.41	66.52	66.65	66.74	66.97	67.18	67.27	67.37
FRANKLINVALE 15473.17	61.22	64.52	65.23	65.38	65.45	65.65	65.88	65.96	66.05
FRANKLINVALE 15950.15	59.76	63.30	64.06	64.18	64.29	64.61	64.96	65.07	65.23
FRANKLINVALE 16400.35	58.33	62.59	63.33	63.50	63.62	63.93	64.25	64.36	64.50
FRANKLINVALE 16877.42	57.73	61.42	62.03	62.16	62.24	62.49	62.79	62.91	63.09
FRANKLINVALE 17030.13	57.54	61.17	61.73	61.83	61.99	62.16	62.45	62.57	62.74
FRANKLINVALE 17033.13	57.54	61.17	61.69	61.82	61.94	62.15	62.44	62.56	62.73
FRANKLINVALE 17335.54	57.16	60.41	61.04	61.16	61.26	61.48	61.76	61.88	62.04
FRANKLINVALE 17728.16	55.97	59.38	60.04	60.21	60.33	60.58	60.87	60.99	61.16
FRANKLINVALE 18170.90	55.38	57.99	59.02	59.21	59.40	59.72	60.09	60.23	60.43
FRANKLINVALE 18565.51	53.95	57.10	58.30	58.53	58.75	59.07	59.37	59.46	59.63
FRANKLINVALE 18565.51	53.95	57.10	58.30	58.53	58.75	59.07	59.37	59.46	59.63
FRANKLINVALE 19787.88	50.40	53.81	55.52	55.73	55.95	56.29	56.39	56.55	57.33
FRANKLINVALE 19787.88	50.40	53.81	55.52	55.73	55.95	56.29	56.39	56.55	57.33
FRANKLINVALE 20087.00	47.56	53.45	55.21	55.30	55.39	56.04	55.84	56.19	57.39
GOOD 10000.00	21.00	22.08	22.19	22.27	22.37	22.73	22.97	23.08	23.19
GOOD 10275.00	19.00	20.29	20.42	20.54	20.67	21.03	21.33	21.45	21.56
GOOD 10475.00	19.00	19.75	19.85	19.94	20.04	20.32	20.56	20.66	20.75
GOOD 10705.00	17.50	18.52	18.67	18.80	18.88	19.09	19.31	19.43	19.45
GOOD 10925.00	15.50	16.87	17.18	17.35	17.54	18.02	18.37	18.73	18.62

GOOD 11335.00		14.00	14.94	15.23	15.37	15.53	16.04	16.37	16.78	16.66
GOOD 11625.00		13.50	14.39	14.69	14.85	15.01	15.54	15.86	16.28	16.46
GOOD 11945.00		12.00	13.40	13.82	14.11	14.38	15.12	15.42	15.90	16.46
GOOD 12020.00	Duncan St	11.87	13.17	13.58	13.90	14.23	15.03	15.32	15.60	16.46
GOOD 12044.00	Duncan St	11.58	13.13	13.46	13.59	13.67	14.14	14.60	14.91	16.46
GOOD 12155.00		11.50	12.85	13.14	13.30	13.37	13.82	14.11	14.91	16.46
GOOD 12425.00		11.00	12.16	12.44	12.58	12.67	13.12	13.94	14.91	16.46
GOOD 12680.00		10.50	11.57	11.82	11.93	12.00	12.58	13.94	14.91	16.46
GOOD 12935.00		10.00	11.13	11.47	11.58	11.65	12.58	13.94	14.91	16.46
GOOD 13275.00		10.00	10.81	11.14	11.24	11.31	12.58	13.94	14.91	16.46
GOOD 13475.00		10.00	10.56	10.88	11.01	11.07	12.58	13.94	14.91	16.46
GOOD 13675.00		10.00	10.25	10.45	10.53	10.59	12.58	13.94	14.91	16.46
GOOD 14155.00	Ipswich Rd	5.90	6.93	7.50	8.08	9.81	12.58	13.94	14.91	16.46
GOOD 14195.00	Ipswich Rd	5.10	6.63	7.33	8.07	9.81	12.58	13.94	14.91	16.46
GOOD 14265.00		5.10	6.50	7.21	8.07	9.81	12.58	13.94	14.91	16.46
GOOD 14375.00		5.00	6.45	7.17	8.07	9.81	12.58	13.94	14.91	16.46
GOOD 14555.00		5.10	6.27	7.06	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14575.00		4.88	6.25	7.05	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14615.00		4.88	6.00	6.46	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14635.00		4.80	6.00	6.33	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14735.00	U/s Brisbane Terrace	4.20	5.41	5.91	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14895.00		2.60	4.60	5.83	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14905.00		2.58	4.59	5.81	8.06	9.81	12.58	13.94	14.91	16.46
GOOD 14920.00		2.58	4.45	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 14930.00		2.58	4.43	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 14975.00		2.50	4.38	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 15350.00		2.50	3.91	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 15845.00		1.00	3.03	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 16175.00		1.00	2.45	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 16355.00		1.00	2.19	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 16525.00		1.00	2.04	5.38	8.05	9.81	12.58	13.94	14.91	16.46
GOOD 16725.00	Brisbane River	-1.95	2.01	5.38	8.05	9.81	12.58	13.94	14.91	16.46
HWAY LEFT 0.00		0.00	25.57	25.73	25.94	26.03	26.50	26.78	26.93	27.41
HWAY LEFT 170.00		0.00	24.69	24.94	25.85	25.99	26.49	26.78	26.87	27.41
HWAY LEFT 170.00		0.00	24.69	24.94	25.85	25.99	26.49	26.78	26.87	27.41
HWAY LEFT 290.00		0.00	24.63	24.88	25.85	25.99	26.48	26.77	26.86	27.40
HWAY LEFT 310.00		0.00	24.02	24.58	25.84	25.96	26.18	26.27	26.27	26.50
HWAY LEFT 390.00		0.00	23.88	24.56	25.84	25.95	26.17	26.26	26.26	26.48
IRON 10000.00		74.77	74.86	74.92	74.94	74.97	75.12	75.24	75.28	75.32
IRON 10274.00		69.60	69.69	69.69	69.69	69.71	69.78	69.84	69.86	69.89
IRON 10563.00		63.78	63.87	63.87	63.88	63.88	63.96	64.02	64.04	64.06
IRON 10725.00		59.49	59.57	59.58	59.58	59.60	59.68	59.74	59.76	59.78
IRON 11001.00		49.51	49.64	49.72	49.76	49.80	49.99	50.13	50.18	50.24
IRON 11422.00		44.42	44.54	44.60	44.63	44.67	44.84	44.97	45.29	45.07
IRON 11765.00		39.70	40.00	40.12	40.20	40.26	40.59	40.75	41.10	40.87
IRON 11794.00		39.69	39.92	40.04	40.12	40.18	40.51	40.67	40.98	40.79
IRON 12052.00		38.97	39.24	39.42	39.50	39.57	39.89	39.97	40.01	40.05
IRON 12335.00		35.20	35.49	35.68	35.77	35.85	36.19	36.33	36.39	36.46
IRON 12618.00		31.43	31.93	32.22	32.35	32.47	33.08	33.58	33.77	33.97
IRON 12658.00		31.40	31.90	32.18	32.30	32.41	32.92	33.28	33.43	33.55
IRON 12962.50		30.57	30.83	31.00	31.07	31.13	31.48	31.67	31.80	31.84
IRON 13267.00		29.73	29.88	29.99	30.04	30.08	30.33	30.50	30.71	30.64
IRON 13766.00		24.71	25.59	25.99	26.12	26.25	26.84	27.16	27.57	27.45
IRON 14107.00		24.80	25.17	25.47	25.58	25.69	26.16	26.45	26.57	26.69
IRON 14456.00		22.51	23.01	23.43	23.57	23.68	24.23	24.63	24.79	24.92
IRON 14805.00		20.21	21.21	21.69	21.83	21.98	22.68	23.12	23.30	23.46
IRON 15139.00		19.64	20.17	20.47	20.55	20.65	21.10	21.41	21.54	21.67
IRON 15407.00		19.66	19.90	20.09	20.15	20.22	20.56	20.81	20.96	21.25
IRON 15700.00		18.37	18.55	18.70	18.74	18.80	19.09	19.30	19.42	21.25
IRON 15887.00		14.82	15.38	15.83	15.92	16.04	16.63	18.12	19.12	21.25
IRON 16198.50		12.84	13.69	14.20	14.33	14.50	15.70	18.12	19.12	21.25
IRON 16510.00		10.87	12.20	12.90	13.05	13.50	15.70	18.12	19.12	21.25
IRON 16827.00		8.66	10.20	10.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 17093.00		6.18	9.21	10.22	11.67	13.50	15.70	18.12	19.12	21.25
IRON 17336.00		7.03	8.92	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 17628.00		6.30	8.49	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 17884.00		6.30	7.63	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18031.00		4.83	6.38	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18156.00		3.18	6.38	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18263.00		3.03	6.38	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18363.00		1.33	6.38	9.97	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18384.00		1.31	6.38	9.96	11.67	13.50	15.70	18.12	19.12	21.25
IRON 18584.00		-1.03	6.38	9.96	11.67	13.50	15.70	18.12	19.12	21.25
MIHI 11310.00		11.50	12.32	12.47	12.59	12.70	14.51	15.58	17.21	19.16

MIHI 11468.00		10.66	11.38	11.53	11.62	12.45	14.51	15.58	17.21	19.16
MIHI 11708.00		9.12	10.36	10.53	10.74	12.45	14.51	15.58	17.21	19.16
MIHI 11968.00		8.13	9.62	9.80	10.74	12.45	14.51	15.58	17.21	19.16
MIHI 12094.00		7.70	9.08	9.20	10.74	12.45	14.51	15.58	17.21	19.16
MIHI 12094.00		7.70	9.08	9.20	10.74	12.45	14.51	15.58	17.21	19.16
MIHI 12230.00		7.23	8.37	8.97	10.74	12.45	14.51	15.58	17.21	19.15
MIHI 12485.00		6.08	7.00	8.97	10.74	12.45	14.51	15.58	17.20	19.15
MIHI 12630.00		3.36	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
MIHI 12764.00		2.41	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
MIHI 12921.00		0.93	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
MIHI 13121.00		-2.90	5.56	8.97	10.74	12.45	14.51	15.58	17.20	19.15
PURGA 0.00		60.36	60.62	60.78	60.82	60.87	60.95	61.03	61.06	61.13
PURGA 1345.80		55.36	55.54	55.70	55.74	55.78	55.87	55.94	55.96	56.02
PURGA 1912.30		46.93	51.26	51.26	51.26	51.26	51.26	51.38	51.46	51.67
PURGA 2986.00		45.73	48.94	48.94	48.94	48.94	48.94	48.94	49.01	49.22
PURGA 2986.00		45.73	48.94	48.94	48.94	48.94	48.94	48.94	49.01	49.22
PURGA 3006.00		45.73	48.89	48.89	48.89	48.89	48.89	48.93	49.00	49.20
PURGA 3345.71		45.72	48.16	48.16	48.16	48.16	48.30	48.54	48.60	48.75
PURGA 4502.41		44.40	46.71	46.71	46.71	46.74	46.92	47.10	47.16	47.30
PURGA 5004.51		42.00	44.74	44.74	44.81	44.89	45.08	45.29	45.36	45.50
PURGA 5474.54		40.13	44.03	44.08	44.17	44.26	44.45	44.78	44.93	45.06
PURGA 5938.99		38.68	43.30	43.40	43.52	43.66	43.85	44.24	44.39	44.49
PURGA 6450.77		38.31	42.48	42.58	42.67	42.73	42.89	43.03	43.06	43.15
PURGA 6997.75		38.28	41.17	41.29	41.69	41.74	41.87	42.00	42.04	42.16
PURGA 7491.57		38.83	40.06	40.13	40.20	40.27	40.37	40.47	40.50	40.60
PURGA 7945.62		38.11	38.71	38.77	38.82	38.87	39.00	39.13	39.16	39.25
PURGA 8450.21		35.98	37.26	37.36	37.42	37.46	37.58	37.71	37.75	37.87
PURGA 8978.82		32.50	34.96	35.26	35.35	35.43	35.65	35.83	35.86	36.01
PURGA 10515.22		29.28	32.98	33.56	33.69	33.83	34.09	34.31	34.35	34.57
PURGA 10988.20		29.84	32.48	33.10	33.20	33.31	33.54	33.72	33.76	33.96
PURGA 11344.89		28.37	31.85	32.55	32.70	32.83	33.10	33.34	33.39	33.64
PURGA 11781.18		27.69	30.72	31.76	32.07	32.26	32.65	32.94	33.00	33.28
PURGA 12363.30		26.03	29.67	30.84	31.21	31.44	31.86	32.20	32.27	32.58
PURGA 12786.29		24.26	29.06	30.17	30.52	30.77	31.21	31.59	31.66	31.99
PURGA 12806.29		24.26	29.31	30.02	30.40	30.66	31.13	31.52	31.59	31.91
PURGA 13281.62		24.32	28.09	29.32	29.78	30.02	30.52	30.86	30.93	31.24
PURGA 13569.12		23.00	27.44	28.71	29.25	29.53	30.07	30.43	30.51	30.85
PURGA 14068.76		22.13	26.57	27.72	28.19	28.49	29.05	29.44	29.51	29.86
PURGA 14460.16		22.07	26.13	27.35	27.79	28.08	28.59	28.90	28.96	29.26
PURGA 14799.07		20.93	25.43	26.63	27.08	27.39	27.97	28.33	28.39	28.69
PURGA 15308.54	Loamside	19.88	24.65	25.97	26.40	26.70	27.18	27.65	27.72	28.09
PURGA 15971.04		19.75	24.12	25.60	26.07	26.46	26.91	27.38	27.46	27.87
PURGA 16563.37		18.52	23.67	25.07	25.55	26.08	26.38	26.73	26.79	27.09
PURGA 17169.76		18.02	22.86	24.12	24.60	25.42	25.70	25.92	25.95	26.42
PURGA 17826.32		17.38	22.21	23.58	24.02	24.90	25.05	25.24	25.28	26.35
PURGA 17826.32		17.38	22.21	23.58	24.02	24.90	25.05	25.24	25.28	26.35
PURGA 18140.67		17.52	21.77	23.24	23.68	24.50	24.79	24.98	25.01	26.33
PURGA 18629.82		16.90	21.28	22.68	23.09	23.35	24.19	24.48	24.51	26.32
PURGA 19241.91		16.74	20.45	21.73	22.14	22.48	23.53	24.09	24.20	26.31
PURGA 19930.56		15.67	19.20	21.02	21.50	21.90	23.00	23.94	24.15	26.30
PURGA 19950.56		15.67	19.19	21.00	21.49	21.88	22.99	23.94	24.14	26.30
PURGA 20954.56		13.06	18.39	20.11	20.69	21.51	22.74	23.88	24.09	26.27
PURGA 20954.56		13.06	18.39	20.11	20.69	21.51	22.74	23.88	24.09	26.27
PURGA 21686.56		13.31	17.35	19.14	20.02	21.43	22.64	23.86	24.07	26.25
PURGA 21686.56		13.31	17.35	19.14	20.02	21.43	22.64	23.86	24.07	26.25
PURGA 22344.00	Warrill Ck	10.38	16.68	19.04	20.01	21.41	22.61	23.85	24.05	26.24
PURGA_2 42.00		56.19	58.77	60.24	60.57	60.86	61.52	61.95	62.09	62.30
PURGA_2 279.00		55.68	58.19	59.69	60.03	60.32	60.98	61.40	61.52	61.73
PURGA_2 516.00		55.18	57.60	59.14	59.49	59.79	60.44	60.85	60.95	61.17
PURGA_2 753.00		54.67	57.02	58.59	58.96	59.26	59.89	60.30	60.38	60.62
PURGA_2 990.00		54.17	56.44	58.05	58.43	58.73	59.33	59.73	59.82	60.06
PURGA_2 1227.00		53.66	55.85	57.51	57.90	58.20	58.77	59.17	59.26	59.51
PURGA_2 1464.00		53.15	55.27	56.98	57.37	57.66	58.22	58.61	58.71	58.97
PURGA_2 1701.00		52.65	54.69	56.46	56.84	57.13	57.68	58.07	58.17	58.44
PURGA_2 1938.00		52.14	54.11	55.95	56.31	56.58	57.14	57.53	57.64	57.92
PURGA_2 2175.00		51.64	53.53	55.45	55.78	56.04	56.61	57.01	57.12	57.41
PURGA_2 2412.00		51.13	52.95	54.95	55.25	55.49	56.07	56.49	56.60	56.88
PURGA_2 2649.00		50.62	52.39	54.45	54.70	54.85	55.51	56.02	56.09	56.27
PURGA_2 2886.00		50.12	51.89	54.04	54.09	54.10	54.81	55.62	55.79	55.90
PURGA_2 2890.00		49.94	51.61	52.91	53.24	53.61	54.16	55.19	55.23	55.42
PURGA_2 3110.25		49.41	50.90	51.90	52.04	52.16	52.42	52.86	52.97	53.10
PURGA_2 3330.50		48.89	50.29	51.58	51.75	51.90	52.20	52.56	52.61	52.80
PURGA_2 3550.75		48.36	49.73	51.14	51.42	51.63	52.00	52.33	52.40	52.59
PURGA_2 3771.00		47.83	49.19	50.56	50.95	51.23	51.73	52.14	52.21	52.37

PURGA_2 3991.25	47.31	48.65	49.96	50.34	50.69	51.39	51.82	51.92	52.13
PURGA_2 4211.50	46.76	48.16	49.37	49.70	50.01	50.77	51.26	51.38	51.64
PURGA_2 4431.75	46.25	48.11	48.79	49.04	49.27	49.81	50.42	50.61	50.94
PURGA_2 4652.00	45.73	48.13	48.13	48.26	48.37	48.66	48.94	49.01	49.22
RAILNORTH 869.00	79.43	82.35	83.66	83.97	84.20	84.83	85.02	85.13	85.29
RAILNORTH 1030.00	80.00	82.18	83.01	83.24	83.42	83.98	84.17	84.27	84.46
RAILNORTH 1400.00	77.00	78.73	79.53	79.70	79.84	80.21	80.34	80.42	80.91
RAILNORTH 1506.31	76.80	78.48	79.31	79.47	79.59	79.92	80.06	80.16	80.73
RAILNORTH 2115.00	76.98	77.20	77.75	77.79	77.84	78.00	78.21	78.38	78.72
RAILNORTH 2593.10	77.67	77.70	77.73	77.75	77.76	77.76	77.77	77.91	78.10
RAILNORTH 3353.67	73.60	73.70	73.70	73.70	73.73	73.79	73.88	73.99	74.20
RAILNORTH 3796.28	70.89	71.00	71.00	71.00	71.03	71.13	71.27	71.69	72.26
RAILNORTH 4285.00	67.35	67.50	67.83	68.16	68.44	69.26	70.01	70.32	70.68
RAILNORTH 4285.00	67.35	67.50	67.83	68.16	68.44	69.26	70.01	70.32	70.68
RAILNORTH 4381.13	65.88	66.48	67.83	68.16	68.44	69.26	70.01	70.32	70.68
RAILNORTH 4558.00	64.00	66.48	67.83	68.16	68.44	69.26	70.01	70.32	70.68
RAILNORTH 4558.00	64.00	66.48	67.83	68.16	68.44	69.26	70.01	70.32	70.68
RAILNORTH 5082.00	61.18	63.06	64.32	64.58	64.81	65.49	66.18	66.47	66.80
RAILNORTH 6909.00	59.64	59.75	59.75	59.75	59.75	59.75	59.75	59.75	59.75
RAILNORTH 7346.00	56.98	57.10	57.10	57.10	57.10	57.10	57.10	57.10	57.10
RAILNORTH 7346.00	56.98	57.10	57.10	57.10	57.10	57.10	57.10	57.10	57.10
RAILNORTH 8032.00	55.94	56.03	56.04	56.04	56.04	56.04	56.04	56.04	56.04
RAILNORTH 8032.00	55.94	56.03	56.04	56.04	56.04	56.04	56.04	56.04	56.04
RAILNORTH 8789.28	53.26	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40
RAILNORTH 9029.00	52.00	52.50	52.61	52.61	52.61	52.63	52.66	52.67	52.68
RAILNORTH 9029.00	52.00	52.50	52.61	52.61	52.61	52.63	52.66	52.67	52.68
RAILNORTH 9269.34	52.22	52.30	52.33	52.34	52.34	52.34	52.35	52.36	52.37
RAILNORTH 9771.72	50.72	51.04	51.28	51.29	51.30	51.30	51.31	51.31	51.32
RAILNORTH 9791.72	50.72	51.00	51.25	51.26	51.27	51.27	51.28	51.28	51.29
RAILNORTH 10377.00	49.86	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
RAILNORTH 10377.00	49.88	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
RAILNORTH 10796.10	47.88	48.20	48.32	48.34	48.35	48.35	48.36	48.37	48.38
RAILNORTH 11379.36	47.53	47.75	47.78	47.83	47.85	47.88	47.92	47.94	47.97
RAILNORTH 11380.00	47.53	47.75	47.77	47.83	47.85	47.88	47.92	47.94	47.97
RAILNORTH 11380.00	47.53	47.75	47.77	47.83	47.85	47.88	47.92	47.94	47.97
RAILNORTH 11963.00	46.30	46.35	46.35	46.35	46.35	46.58	46.81	46.83	46.85
RAILNORTH 11963.00	46.30	46.35	46.35	46.35	46.35	46.58	46.81	46.83	46.85
RAILNORTH 12390.00	43.50	43.55	43.55	43.55	43.55	43.97	44.63	44.67	44.73
RAILNORTH 13468.00	43.40	43.45	43.45	43.45	43.45	43.54	43.90	43.96	43.99
RAILNORTH 13468.00	43.40	43.45	43.45	43.45	43.45	43.54	43.90	43.96	43.99
RAILNORTH 13868.00	40.68	41.60	41.60	41.60	41.60	41.60	41.94	41.98	42.96
RAILNORTH 13868.00	40.68	41.60	41.60	41.60	41.60	41.60	41.94	41.98	42.96
RAILNORTH 14628.00	41.52	41.60	41.60	41.60	41.60	41.60	41.62	41.67	42.96
RAILNORTH 14728.00	40.00	41.60	41.60	41.60	41.60	41.60	41.60	41.67	42.96
RAILNORTH 14728.00	40.00	41.60	41.60	41.60	41.60	41.60	41.60	41.67	42.96
RAILNORTH 14838.00	41.52	41.60	41.60	41.60	41.60	41.60	41.60	41.67	42.96
RAILNORTH 14858.00	41.52	41.52	41.52	41.52	41.52	41.52	41.52	41.67	42.96
RAILNORTH 16228.00	39.03	39.03	39.09	39.34	39.51	39.75	40.88	41.67	42.96
RAILSOUTH 869.00	79.43	82.35	83.66	83.97	84.20	84.83	85.02	85.13	85.29
RAILSOUTH 1030.00	79.30	82.28	83.48	83.74	83.90	84.33	84.40	84.44	84.48
RAILSOUTH 1030.00	79.30	82.28	83.48	83.74	83.90	84.33	84.40	84.44	84.48
RAILSOUTH 1400.00	79.50	81.23	82.33	82.49	82.54	82.73	82.95	83.06	83.19
RAILSOUTH 1400.00	79.50	81.23	82.33	82.49	82.54	82.73	82.95	83.06	83.19
RAILSOUTH 1506.31	76.44	79.98	81.50	81.54	81.58	81.73	81.93	82.11	82.37
RAILSOUTH 2115.00	71.90	76.15	77.75	77.79	77.83	77.99	78.20	78.37	78.71
RAILSOUTH 2115.00	71.90	76.15	77.75	77.79	77.83	77.99	78.20	78.37	78.71
RAILSOUTH 2593.10	69.90	72.60	73.58	73.83	74.08	74.93	75.82	76.02	76.28
RAILSOUTH 3353.67	66.33	69.96	71.63	72.01	72.37	73.15	73.81	73.93	74.08
RAILSOUTH 3796.28	65.80	68.71	70.17	70.50	70.82	71.16	71.24	71.31	71.43
RAILSOUTH 4285.00	63.83	67.13	68.25	68.42	68.80	69.30	70.07	70.41	70.82
RAILSOUTH 4285.00	63.83	67.13	68.25	68.42	68.80	69.30	70.07	70.41	70.82
RAILSOUTH 4381.13	63.73	67.07	68.25	68.42	68.80	69.30	70.07	70.41	70.81
RAILSOUTH 4558.00	64.00	66.50	67.86	68.20	68.49	69.32	70.12	70.47	70.88
RAILSOUTH 6909.00	54.09	57.04	58.21	58.23	58.26	58.34	58.45	58.51	58.59
RAILSOUTH 7346.00	52.00	55.54	56.48	56.54	56.62	56.96	57.42	57.59	58.24
RAILSOUTH 7346.00	52.00	55.54	56.48	56.54	56.62	56.96	57.42	57.59	58.24
RAILSOUTH 8032.00	49.94	53.48	55.22	55.33	55.43	56.15	56.04	56.31	57.23
RAILSOUTH 8032.00	49.94	53.48	55.22	55.33	55.43	56.15	56.04	56.31	57.23
RAILSOUTH 8324.00	47.56	53.45	55.21	55.30	55.39	56.04	55.84	56.19	57.39
RAILSOUTH 8324.00	47.56	53.45	55.21	55.30	55.39	56.04	55.84	56.19	57.39
RAILSOUTH 8789.28	47.56	52.78	55.10	55.15	55.32	56.63	55.54	56.16	60.70
RAILSOUTH 9029.00	47.56	52.21	54.71	55.00	55.02	55.67	55.53	56.16	59.46
RAILSOUTH 9029.00	47.56	52.21	54.71	55.00	55.02	55.67	55.53	56.16	59.46
RAILSOUTH 9269.34	46.65	51.56	54.07	54.20	54.74	55.67	55.99	56.16	58.59

RAILSOUTH 9771.72	Kuss Rd	44.79	50.18	52.92	54.10	55.64	55.67	55.99	56.17	56.97
RAILSOUTH 9791.72		44.79	50.16	52.90	53.64	53.87	54.90	54.71	55.37	55.67
RAILSOUTH 10377.00		43.58	49.24	52.01	52.40	52.54	52.96	53.10	53.23	55.46
RAILSOUTH 10377.00		43.58	49.24	52.01	52.40	52.54	52.96	53.10	53.23	55.46
RAILSOUTH 10796.10		43.21	48.64	51.23	51.57	51.80	52.59	52.73	52.96	54.42
RAILSOUTH 11379.36		42.00	47.57	49.90	50.63	50.67	51.63	51.39	51.79	52.76
RAILSOUTH 11380.00		42.00	47.57	49.90	50.53	50.68	51.63	51.40	51.78	52.76
RAILSOUTH 11380.00		42.00	47.57	49.90	50.53	50.68	51.63	51.40	51.78	52.76
RAILSOUTH 11963.54		42.39	46.01	47.28	47.66	47.77	48.18	47.96	48.50	49.00
RAILSOUTH 12163.00		41.89	45.42	46.06	46.21	46.47	46.92	47.00	47.52	47.92
RAILSOUTH 12163.00		41.89	45.42	46.06	46.21	46.47	46.92	47.00	47.52	47.92
RAILSOUTH 12390.00		40.80	45.07	45.79	45.97	46.32	46.94	47.09	47.59	47.84
RAILSOUTH 12410.00		40.80	45.05	45.76	45.81	45.88	46.04	46.06	46.16	46.52
RAILSOUTH 13468.00		37.10	43.38	43.78	43.83	43.84	43.91	43.91	44.13	44.41
RAILSOUTH 13468.00		37.10	43.38	43.78	43.83	43.84	43.91	43.91	44.13	44.41
RAILSOUTH 13868.00		36.80	42.03	42.41	42.75	42.75	42.99	43.02	43.25	43.90
RAILSOUTH 13868.00		36.80	42.03	42.41	42.75	42.75	42.99	43.02	43.25	43.90
RAILSOUTH 14628.00		35.09	39.94	40.44	40.67	40.78	41.06	41.38	41.84	43.00
RAILSOUTH 14628.00		35.09	39.94	40.44	40.67	40.78	41.06	41.38	41.84	43.00
RAILSOUTH 14728.00		35.09	39.82	40.33	40.54	40.67	40.93	41.30	41.82	42.99
RAILSOUTH 14728.00		35.09	39.82	40.33	40.54	40.67	40.93	41.30	41.82	42.99
RAILSOUTH 14838.00		35.09	39.67	40.19	40.39	40.53	40.77	41.24	41.80	42.99
RAILSOUTH 14858.00		35.09	39.61	40.14	40.38	40.52	40.76	41.23	41.79	42.99
RAILSOUTH 16228.00	Bremer River	32.65	38.16	39.09	39.34	39.51	39.75	40.88	41.67	42.96
REEDY 1000.00		25.86	26.39	26.48	26.51	26.60	26.85	27.07	27.14	27.25
REEDY 1271.00		24.76	25.10	25.18	25.23	25.31	25.48	25.61	25.66	25.74
REEDY 1542.00		23.66	23.91	23.97	24.00	24.06	24.23	24.33	24.36	24.42
REEDY 1542.00		23.66	23.91	23.97	24.00	24.06	24.23	24.33	24.36	24.42
REEDY 1995.00		16.98	17.29	17.49	17.55	17.65	18.20	20.76	21.54	24.25
REEDY 1995.00		16.98	17.29	17.49	17.55	17.65	18.20	20.76	21.54	24.25
REEDY 2139.00		15.00	16.50	17.20	17.35	17.49	18.15	20.76	21.54	24.25
SAND 10000.00		41.90	43.10	43.51	43.64	43.75	44.26	44.63	44.74	44.87
SAND 10320.00		41.50	42.68	42.98	43.07	43.16	43.60	43.93	44.03	44.15
SAND 10520.00		41.30	42.10	42.31	42.37	42.42	42.68	42.85	42.91	43.00
SAND 10920.00		39.50	40.13	40.44	40.56	40.68	41.10	41.32	41.42	41.48
SAND 11040.00		38.98	39.66	40.19	40.37	40.54	40.99	41.20	41.29	41.35
SAND 11062.00		38.96	39.37	39.63	39.71	39.79	40.21	40.46	40.58	40.66
SAND 11240.00		37.50	38.31	38.46	38.55	38.63	39.00	39.28	39.40	39.50
SAND 11518.00		36.63	37.15	37.56	37.69	37.83	38.06	38.33	38.47	38.58
SAND 11540.00		36.63	37.05	37.38	37.48	37.58	38.05	38.33	38.42	38.52
SAND 11760.00		35.00	36.10	36.51	36.64	36.77	37.26	37.58	37.69	37.80
SAND 11998.00		34.93	35.41	35.66	35.78	35.86	36.43	36.80	36.86	36.92
SAND 12020.00		34.93	35.31	35.59	35.67	35.75	36.16	36.45	36.63	36.69
SAND 12120.00		34.00	34.60	34.85	34.95	35.03	35.57	35.87	36.04	36.10
SAND 12440.00		32.70	33.77	34.04	34.11	34.17	34.50	34.73	34.88	34.94
SAND 12690.00		30.00	31.19	31.29	31.42	31.55	32.25	32.70	32.93	33.10
SAND 13020.00		28.50	29.43	29.85	29.96	30.06	30.64	31.01	31.24	31.48
SAND 13320.00		27.75	28.37	28.67	28.75	28.82	29.20	29.46	29.75	29.70
SAND 13820.00		27.00	27.29	27.51	27.57	27.63	27.96	28.20	28.47	28.41
SAND 14220.00		24.75	25.49	25.74	25.80	25.85	26.14	26.36	26.93	26.58
SAND 14620.00		23.00	24.00	24.23	24.32	24.39	24.80	25.12	26.37	25.41
SAND 14700.00		21.14	23.83	23.97	24.07	24.14	24.54	24.85	25.97	25.12
SAND 14740.00		21.14	23.83	23.96	24.07	24.13	24.51	24.79	25.90	25.00
SAND 14820.00		22.50	23.45	23.71	23.81	23.87	24.24	24.48	25.50	24.67
SAND 15220.00		19.99	21.05	21.37	21.49	21.59	21.99	22.14	23.07	22.30
SAND 15620.00		17.49	18.62	19.08	19.21	19.32	19.94	20.07	21.14	20.20
SAND 15620.00		17.49	18.62	19.08	19.21	19.32	19.94	20.07	21.14	20.20
SAND 15992.00		16.27	17.15	17.65	17.74	17.83	18.33	18.72	19.67	18.90
SAND 16364.00		15.06	15.83	16.36	16.46	16.53	16.97	17.31	18.36	17.62
SAND 16721.00		14.11	14.85	15.39	15.52	15.57	15.87	16.12	17.27	16.36
SAND 17078.00		13.16	13.88	14.38	14.54	14.66	14.90	15.09	16.23	15.28
SAND 17435.00		12.21	12.86	13.30	13.44	13.55	13.91	14.05	15.04	14.63
SAND 17873.33		10.81	11.20	11.48	11.57	11.64	12.07	12.46	13.29	14.63
SAND 18311.67		9.40	9.80	9.97	10.04	10.11	11.30	12.46	13.29	14.63
SAND 18750.00		7.99	8.40	8.57	8.65	9.02	11.30	12.46	13.29	14.63
SAND 19195.71		7.01	7.77	7.77	7.77	9.02	11.30	12.46	13.29	14.63
SAND 19641.43		6.02	7.14	7.14	7.51	9.02	11.30	12.46	13.29	14.63
SAND 20087.14		5.04	6.51	6.51	7.51	9.02	11.30	12.46	13.29	14.63
SAND 20532.86		4.06	5.89	5.89	7.51	9.02	11.30	12.46	13.29	14.63
SAND 20978.57		3.07	5.26	5.26	7.51	9.02	11.30	12.46	13.29	14.63
SAND 21424.29		2.09	4.63	4.97	7.51	9.02	11.30	12.46	13.28	14.63
SAND 21870.00		1.10	4.14	4.97	7.51	9.02	11.30	12.46	13.28	14.63
SAND 22270.00		0.74	3.93	4.97	7.51	9.02	11.30	12.46	13.28	14.63
SAND 22670.00		0.37	3.67	4.97	7.51	9.02	11.30	12.46	13.28	14.63

SAND 23070.00		0.00	3.09	4.97	7.51	9.01	11.30	12.46	13.28	14.63
SAND 23070.00		0.00	3.09	4.97	7.51	9.01	11.30	12.46	13.28	14.63
SAND 23340.00		-0.50	2.46	4.97	7.51	9.01	11.30	12.46	13.28	14.63
SAND 23610.00		-1.00	2.09	4.97	7.51	9.01	11.30	12.46	13.28	14.63
SAND 23900.00		-12.60	2.01	4.96	7.50	9.01	11.30	12.46	13.28	14.63
SCH 10000.00		29.46	29.56	29.64	29.67	29.70	29.85	29.96	29.98	30.05
SCH 10340.00		20.46	21.01	21.48	21.59	21.65	21.94	22.18	22.23	22.37
SCH 10600.00		16.95	17.68	17.83	17.88	17.95	18.37	18.77	18.83	18.95
SCH 10810.00		16.77	17.22	17.64	17.71	17.80	18.24	18.58	18.63	18.82
SCH 11110.00		14.68	15.45	15.92	15.97	16.03	16.39	16.76	16.79	18.14
SCH 11382.80		14.80	15.00	15.21	15.27	15.34	15.98	16.49	16.55	18.14
SCH 11610.00		13.67	14.23	14.58	14.67	14.76	15.22	15.57	16.50	18.14
SCH 11887.00		9.00	9.53	10.08	10.20	10.70	13.88	15.23	16.50	18.14
SCH 11927.00		8.50	9.14	9.62	9.98	10.70	13.88	15.23	16.50	18.14
SCH 12167.00		7.50	8.94	9.58	9.75	10.70	13.88	15.23	16.50	18.14
SCH 12287.00		7.42	8.65	9.25	9.41	10.70	13.88	15.23	16.50	18.14
SCH 12435.00		7.00	8.26	8.89	9.01	10.70	13.88	15.23	16.50	18.14
SCH 12462.80		7.00	8.25	8.86	8.97	10.70	13.88	15.23	16.50	18.14
SCH 12805.60		7.00	7.64	8.08	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13060.00		3.65	6.17	6.68	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13060.00		3.65	6.17	6.68	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13209.00		5.00	5.74	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13598.50		2.50	3.38	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13757.00		1.46	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13757.61		1.44	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13757.61		1.44	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SCH 13972.00		-2.63	2.82	6.39	8.79	10.70	13.88	15.23	16.50	18.14
SIX 9530.00		46.50	46.96	47.17	47.25	47.32	47.62	47.86	47.94	48.05
SIX 10060.00		38.50	39.60	40.27	40.45	40.62	41.45	42.05	42.40	42.82
SIX 10310.00		36.00	37.25	37.94	38.23	38.46	39.45	40.19	40.77	41.20
SIX 10365.00		36.00	37.03	37.76	38.07	38.29	39.31	40.07	40.68	41.06
SIX 10380.00		35.80	37.01	37.73	38.04	38.27	39.28	39.97	40.53	40.84
SIX 10460.00		35.00	36.63	37.50	37.81	38.01	39.00	39.68	40.32	40.61
SIX 10920.00		34.50	35.55	36.25	36.40	36.57	37.35	37.90	38.75	38.75
SIX 11355.00		31.80	33.47	34.26	34.41	34.65	35.24	35.69	35.86	35.89
SIX 11570.00		30.20	32.16	32.86	32.94	33.02	33.48	33.78	33.91	34.02
SIX 11670.00	Baily St	29.50	31.54	32.32	32.40	32.49	33.08	33.43	33.57	33.68
SIX 11770.00		29.20	31.44	32.17	32.20	32.25	32.78	33.13	33.27	33.37
SIX 11800.00		28.74	31.38	32.03	32.11	32.23	32.74	33.10	33.24	33.34
SIX 11870.00		28.80	31.27	31.84	31.93	32.05	32.53	32.90	33.04	33.15
SIX 12010.00		28.60	30.80	31.23	31.39	31.59	32.11	32.52	32.65	32.79
SIX 12470.00		28.20	29.17	29.73	29.96	30.09	30.70	31.08	31.13	31.33
SIX 12970.00		25.50	26.72	27.03	27.13	27.19	27.47	27.68	27.70	27.83
SIX 13620.00		22.50	24.52	24.88	24.94	25.00	25.31	25.50	25.51	25.65
SIX 14045.00		22.00	22.76	23.01	23.07	23.13	23.42	23.62	23.64	23.78
SIX 14470.00		19.00	21.00	21.70	21.83	21.94	22.47	22.73	22.75	22.96
SIX 14800.00		18.50	20.49	21.17	21.29	21.40	21.87	22.17	22.26	22.45
SIX 15170.00		17.00	18.49	19.43	19.67	19.89	20.64	21.36	21.52	21.87
SIX 15570.00		16.50	18.41	19.40	19.63	19.85	20.57	21.30	21.46	21.81
SIX 15910.00		16.50	18.40	19.38	19.60	19.82	20.51	21.24	21.40	21.73
SIX 16270.00		16.00	17.99	18.95	19.20	19.40	20.13	21.00	21.15	21.49
SIX 16470.00		16.00	17.29	18.11	18.33	18.49	19.10	19.84	19.95	20.26
SIX 16720.00		15.00	15.80	15.98	16.09	16.18	16.46	16.73	16.81	17.02
SIX 17140.00		10.50	11.87	13.13	13.39	13.58	14.22	14.78	15.26	16.78
SIX 17270.00		10.00	11.67	12.94	13.19	13.38	13.99	14.51	15.26	16.78
SIX 17530.00		9.50	11.18	12.34	12.57	12.74	13.26	14.29	15.26	16.78
SIX 17930.00		8.50	10.05	10.92	11.14	11.29	12.83	14.29	15.26	16.78
SIX 18270.00		7.50	9.15	9.81	10.01	10.15	12.83	14.29	15.26	16.78
SIX 18720.00		3.50	5.82	7.06	8.24	10.00	12.83	14.29	15.26	16.78
SIX 18970.00		2.00	4.56	5.88	8.23	10.00	12.83	14.29	15.26	16.78
SIX 19170.00		0.50	3.87	5.56	8.22	10.00	12.83	14.29	15.26	16.78
SIX 19370.00		0.50	3.16	5.55	8.22	10.00	12.83	14.29	15.26	16.78
SIX 19650.00		0.50	2.12	5.54	8.22	10.00	12.83	14.29	15.26	16.78
SIX 19790.00		-0.73	2.08	5.54	8.22	10.00	12.83	14.29	15.26	16.78
SIX 19870.00		-0.65	2.07	5.53	8.21	10.00	12.83	14.29	15.26	16.78
SIX 20000.00		-0.70	2.04	5.53	8.21	10.00	12.83	14.29	15.26	16.78
SIX 20140.00		-1.30	2.04	5.53	8.21	10.00	12.83	14.29	15.26	16.78
SIX 20160.00		-1.30	2.03	5.53	8.21	10.00	12.83	14.29	15.26	16.78
SIX 20235.00	Brisbane River	-1.38	2.02	5.53	8.21	10.00	12.83	14.29	15.26	16.78
SMALL 1000.00		21.50	22.09	22.18	22.23	22.30	22.50	22.70	22.78	24.25
SMALL 1228.00		20.50	21.25	21.37	21.42	21.49	21.74	21.96	22.04	24.25
SMALL 1257.00		20.00	20.98	21.12	21.17	21.25	21.52	21.74	21.82	24.25
SMALL 1409.00		18.50	19.74	19.84	19.90	19.99	20.30	20.76	21.54	24.25
SMALL 1670.00		16.70	17.56	17.66	17.72	17.81	18.13	20.76	21.54	24.25

SMALL 1670.00		16.70	17.56	17.66	17.72	17.81	18.13	20.76	21.54	24.25
SMALL 1888.00		14.70	15.82	15.92	15.97	16.06	17.40	20.76	21.54	24.25
SMALL 1990.00		13.77	15.15	15.43	15.60	15.79	17.40	20.76	21.54	24.25
SMALL 1990.00		13.77	15.15	15.43	15.60	15.79	17.40	20.76	21.54	24.25
SMALL 2128.00		12.50	14.81	15.39	15.58	15.77	17.40	20.76	21.54	24.25
WARRILL 0.00		53.78	61.99	66.01	66.78	67.21	68.46	69.56	69.69	70.64
WARRILL 1033.45		53.24	59.43	62.42	62.55	62.57	62.67	62.74	62.74	62.82
WARRILL 2424.10		49.26	53.05	54.22	54.48	54.59	56.36	57.08	57.09	58.00
WARRILL 2444.10		49.26	53.04	54.22	54.45	54.58	56.36	57.07	57.08	58.00
WARRILL 3488.49		46.09	51.97	53.36	54.08	54.52	56.35	57.07	57.10	57.99
WARRILL 3498.49		46.09	51.95	53.03	53.26	53.31	63.45	53.62	53.65	53.67
WARRILL 3683.49		45.89	51.83	52.74	53.05	53.10	53.26	53.44	53.44	53.49
WARRILL 4778.90	Harrisville	46.98	50.88	51.37	51.55	51.67	52.03	52.24	52.25	52.29
WARRILL 4798.90	Harrisville	46.98	50.87	51.33	51.46	51.53	51.65	51.77	51.74	51.79
WARRILL 6397.07		42.29	48.78	49.65	49.80	49.89	50.09	50.25	50.24	50.30
WARRILL 6407.07		42.29	48.78	49.63	49.79	49.87	50.07	50.24	50.23	50.29
WARRILL 7111.27		38.63	48.49	49.01	49.23	49.35	49.59	49.82	49.82	49.92
WARRILL 7131.27		38.63	45.73	47.99	48.61	48.72	48.95	49.20	49.20	49.23
WARRILL 8514.13		37.99	44.16	45.46	46.27	46.53	46.76	47.05	47.11	47.18
WARRILL 9896.98		37.35	43.18	44.67	45.26	45.37	45.46	45.60	45.61	45.66
WARRILL 10941.75		35.33	41.57	43.36	43.56	43.78	44.01	44.29	44.31	44.43
WARRILL 11579.99		34.06	39.88	41.36	41.68	41.67	42.12	42.45	42.48	42.59
WARRILL 11599.99		34.06	39.87	41.36	41.67	41.83	41.94	42.07	42.09	42.13
WARRILL 12312.49		33.65	38.40	39.65	39.90	40.17	40.44	40.74	40.78	40.85
WARRILL 12938.26		33.68	37.86	39.01	39.23	39.46	39.70	39.88	39.91	40.02
WARRILL 13459.92		32.56	37.37	38.33	38.69	38.99	39.19	39.42	39.45	39.56
WARRILL 13716.44		31.31	37.00	38.03	38.40	38.70	38.96	39.28	39.31	39.45
WARRILL 14151.04		28.87	36.36	37.56	37.98	38.24	38.60	38.95	38.98	39.11
WARRILL 15218.95		29.82	35.33	36.54	36.97	37.16	37.35	37.52	37.52	37.54
WARRILL 15709.63		28.58	34.61	35.81	36.30	36.49	36.61	36.74	36.75	36.85
WARRILL 16308.32		28.39	33.77	34.82	35.35	35.79	36.01	36.23	36.26	36.42
WARRILL 17201.96		24.62	32.65	34.12	34.59	34.97	35.17	35.33	35.35	35.47
WARRILL 18218.98		25.16	31.32	32.49	32.77	33.01	33.35	33.47	33.49	33.59
WARRILL 18724.52		23.79	30.68	31.80	32.11	32.36	32.72	32.84	32.86	32.96
WARRILL 19155.35		24.41	30.24	31.59	31.89	32.14	32.51	32.59	32.64	32.68
WARRILL 19737.18		24.08	29.64	31.17	31.49	31.69	32.06	32.11	32.12	32.16
WARRILL 20169.55		23.06	29.01	30.68	31.05	31.31	31.68	31.82	31.81	31.81
WARRILL 20702.56		22.81	28.34	29.96	30.29	30.53	30.84	30.91	30.92	30.92
WARRILL 20969.75		22.17	28.13	29.72	30.01	30.17	30.51	30.60	30.61	30.71
WARRILL 21848.19		20.99	27.14	28.73	29.05	29.14	29.31	29.48	29.65	29.84
WARRILL 23196.78		19.53	24.95	26.87	27.50	27.80	28.07	28.34	28.44	28.92
WARRILL 23701.37		18.72	24.53	26.60	27.26	27.51	27.80	28.16	28.31	28.88
WARRILL 23701.37		18.72	24.53	26.60	27.26	27.51	27.80	28.16	28.31	28.88
WARRILL 24126.72		18.72	24.33	26.37	27.10	27.33	27.65	28.10	28.26	28.88
WARRILL 24580.02		17.79	24.01	25.95	26.71	27.02	27.19	27.83	28.03	28.62
WARRILL 25048.56		18.15	23.56	25.54	26.24	26.63	27.07	28.00	28.20	28.83
WARRILL 25710.00	Amberley	17.11	22.82	24.78	25.39	25.74	26.30	27.04	27.32	27.98
WARRILL 25730.00	Amberley	17.11	22.81	24.77	25.37	25.68	26.23	26.94	26.94	27.85
WARRILL 26219.35		16.52	22.25	24.17	24.66	25.08	25.78	26.55	26.67	27.51
WARRILL 26693.35		16.23	21.77	23.60	24.13	24.51	25.39	26.23	26.26	27.32
WARRILL 27315.35		15.31	21.19	22.88	23.73	24.13	24.88	25.73	25.76	27.03
WARRILL 27873.35		14.17	20.55	22.39	23.41	23.94	24.65	25.48	25.51	26.80
WARRILL 28487.35		13.26	19.84	21.76	22.79	23.35	24.07	24.96	25.00	26.58
WARRILL 29252.35		13.60	19.02	20.98	22.01	22.68	23.56	24.60	24.64	26.45
WARRILL 29849.35		13.66	18.08	20.33	21.47	22.38	23.35	24.43	24.48	26.37
WARRILL 29849.35		13.66	18.08	20.33	21.47	22.38	23.35	24.43	24.48	26.37
WARRILL 30164.35		10.75	17.46	19.78	20.92	22.02	22.98	24.13	24.24	26.29
WARRILL 30164.35		10.75	17.46	19.78	20.92	22.02	22.98	24.13	24.24	26.29
WARRILL 30886.35		10.38	16.68	19.04	20.01	21.41	22.61	23.85	24.05	26.24
WARRILL 30886.35		10.38	16.68	19.04	20.01	21.41	22.61	23.85	24.05	26.24
WARRILL 31173.35		10.10	16.53	18.85	19.84	21.24	22.56	23.86	24.06	26.21
WARRILL 31526.35		9.50	16.38	18.64	19.68	21.10	22.48	23.85	24.06	26.22
WARRILL 32023.35		9.50	16.19	18.34	19.42	20.87	22.30	23.76	23.99	26.17
WARRILL 32284.35		9.00	15.92	18.01	19.16	20.63	22.09	23.66	23.91	26.11
WARRILL 32634.35		9.00	15.52	17.68	18.77	20.29	21.92	23.62	23.88	26.08
WARRILL 33250.35		9.00	14.96	17.31	18.49	20.01	21.80	23.62	23.88	26.09
WARRILL 33880.35	Bremer River	6.00	14.55	17.07	18.29	19.79	21.59	23.54	23.82	26.02
WARRILL-BOONAH 0.00		169.33	169.51	169.72	169.79	169.86	169.92	169.99	170.02	170.07
WARRILL-BOONAH 1763.90		144.96	145.79	146.32	146.46	146.57	146.79	146.92	146.97	147.04
WARRILL-BOONAH 2771.21		138.08	138.83	139.54	139.80	140.01	140.43	140.58	140.65	140.73
WARRILL-BOONAH 3385.00		133.86	135.27	136.58	136.98	137.27	138.10	138.22	138.28	138.50
WARRILL-BOONAH 3400.00		133.86	134.68	135.62	135.90	136.10	136.51	137.07	137.29	137.59
WARRILL-BOONAH 4501.05		128.01	129.41	130.04	130.22	130.37	130.50	130.62	130.66	130.73
WARRILL-BOONAH 5743.62		118.43	116.97	117.62	117.87	118.06	118.43	118.85	118.91	119.05

WARRILL-BOONAH 6448.72		114.18	114.88	115.68	115.97	116.21	116.51	116.84	116.92	117.07
WARRILL-BOONAH 7295.14		111.87	112.49	113.23	113.49	113.69	113.95	114.28	114.38	114.54
WARRILL-BOONAH 8223.07		108.84	109.74	110.51	110.76	110.95	111.34	111.56	111.63	111.73
WARRILL-BOONAH 9097.24		103.80	104.74	105.73	106.00	106.22	106.66	107.22	107.37	107.50
WARRILL-BOONAH 10614.64		98.27	98.91	99.64	99.88	100.07	100.45	100.82	100.92	101.05
WARRILL-BOONAH 12056.87		92.65	93.60	94.45	94.59	94.72	95.00	95.44	95.65	95.92
WARRILL-BOONAH 13180.04		87.39	88.23	89.22	89.55	89.82	90.33	90.95	91.12	91.31
WARRILL-BOONAH 14463.88		83.30	84.64	85.72	86.09	86.39	86.87	87.32	87.55	87.86
WARRILL-BOONAH 14878.92		83.30	84.07	84.87	85.20	85.47	86.01	86.72	87.04	87.46
WARRILL-BOONAH 15984.89		78.42	80.89	82.13	82.66	83.11	83.98	84.96	85.42	85.99
WARRILL-BOONAH 15994.89		78.42	80.86	81.17	81.62	81.97	82.68	83.11	83.27	83.46
WARRILL-BOONAH 17217.81		75.17	77.98	77.98	78.19	78.46	79.04	79.33	79.45	79.60
WARRILL-BOONAH 18308.24		74.20	75.40	76.19	76.47	76.59	77.03	77.81	78.16	78.41
WARRILL-BOONAH 18901.08		73.77	74.43	75.50	76.02	76.18	76.71	78.24	78.81	79.21
WARRILL-BOONAH 19441.64		68.76	72.61	75.16	76.17	76.30	76.78	77.42	77.66	77.97
WARRILL-BOONAH 19461.64		68.76	72.61	74.92	75.72	75.85	76.62	77.24	77.38	77.64
WARRILL-BOONAH 20991.60		66.90	70.35	72.68	73.28	73.65	75.21	76.11	76.24	76.67
WARRILL-BOONAH 22471.48		62.24	67.00	69.47	70.06	70.52	72.39	73.26	73.41	74.10
WARRILL-BOONAH 23063.09		62.45	66.56	69.22	69.79	70.31	71.81	72.61	72.71	73.47
WARRILL-BOONAH 24050.26		61.99	65.58	68.32	68.86	69.51	71.30	72.16	72.34	73.00
WARRILL-BOONAH 25131.10		60.19	64.29	67.23	68.00	68.66	70.39	71.25	71.39	72.18
WARRILL-BOONAH 26305.71		59.10	63.52	66.52	67.35	67.83	69.32	70.45	70.59	71.58
WARRILL-BOONAH 26315.71		59.10	63.39	66.51	67.34	67.83	69.32	70.45	70.59	71.58
WARRILL-BOONAH 28136.46		57.71	62.40	66.11	66.91	67.39	68.87	70.02	70.16	71.15
WARRILL-BOONAH 29113.49		55.80	62.12	66.12	66.96	67.45	68.97	70.22	70.38	71.45
WARRILL-BOONAH 30795.00		53.78	61.99	66.01	66.78	67.21	68.46	69.56	69.70	70.64
WARRILL-BOONAH 30815.00		53.78	61.99	66.01	66.78	67.21	68.46	69.56	69.69	70.64
WESTERN 0.00		85.99	87.28	88.70	89.05	89.34	90.12	90.85	91.19	91.43
WESTERN 494.00		83.82	85.01	86.60	86.94	87.22	87.96	88.66	88.83	89.06
WESTERN 849.00		79.43	82.37	83.73	84.05	84.29	84.87	85.07	85.20	85.37
WESTERN 869.00		79.43	82.35	83.66	83.97	84.20	84.83	85.02	85.13	85.29
WESTERN 5082.00		61.18	63.06	64.32	64.56	64.81	65.49	66.18	66.47	66.80
WESTERN 5666.88		58.10	60.47	62.15	62.49	62.81	63.62	64.34	64.64	64.89
WESTERN 6146.92		56.64	59.56	60.93	61.21	61.46	62.29	63.03	63.33	63.54
WESTERN 6888.85		54.09	57.05	58.22	58.25	58.29	59.05	59.70	59.97	60.25
WESTERN 6909.00		54.09	57.04	58.21	58.23	58.26	58.34	58.45	58.51	58.59
WOOG 10000.00		20.00	21.99	23.15	23.40	23.63	24.52	25.20	25.43	25.73
WOOG 10450.00		20.00	21.73	22.89	23.13	23.35	24.20	24.89	25.12	25.42
WOOG 10930.00		20.00	20.64	21.71	21.90	22.09	22.78	23.40	23.62	23.92
WOOG 11150.00		17.00	19.06	20.16	20.41	20.66	21.57	22.24	22.51	22.85
WOOG 11530.00		15.00	17.93	19.24	19.50	19.74	20.58	21.19	21.43	21.76
WOOG 12030.00		14.50	16.86	18.17	18.40	18.60	19.32	19.97	20.23	20.57
WOOG 12130.00		13.75	16.66	18.03	18.25	18.45	19.16	19.82	20.09	20.43
WOOG 12620.00		13.00	15.70	17.19	17.41	17.60	18.37	19.13	19.43	19.84
WOOG 12930.00		13.00	15.15	16.46	16.72	16.95	17.80	18.62	18.94	19.37
WOOG 13070.00		12.50	14.97	16.22	16.49	16.73	17.59	18.42	18.74	19.17
WOOG 13250.00		12.50	14.77	15.97	16.26	16.52	17.40	18.25	18.58	19.02
WOOG 13510.00		12.33	14.50	15.74	16.05	16.32	17.22	18.09	18.43	18.87
WOOG 13550.00		10.93	14.42	15.67	15.98	16.25	17.14	18.00	18.34	18.77
WOOG 13640.00		10.30	14.20	15.53	15.86	16.14	17.07	17.94	18.28	18.73
WOOG 13800.00		9.42	13.87	15.28	15.63	15.91	16.86	17.73	18.07	18.50
WOOG 13800.00		9.42	13.87	15.28	15.63	15.91	16.86	17.73	18.07	18.50
WOOG 13995.00		9.19	13.50	14.92	15.26	15.53	16.42	17.24	17.57	17.99
WOOG 13995.00		9.19	13.50	14.92	15.26	15.53	16.42	17.24	17.57	17.99
WOOG 14070.00		9.10	12.73	14.46	14.83	15.14	16.05	16.88	17.20	17.63
WOOG 14100.00		8.86	12.39	14.34	14.71	15.00	15.81	16.53	16.82	17.20
WOOG 14180.00		8.65	12.18	14.16	14.53	14.82	15.62	16.36	16.66	17.05
WOOG 14180.00		8.65	12.18	14.16	14.53	14.82	15.62	16.36	16.66	17.05
WOOG 14460.00		7.95	11.60	13.55	13.92	14.21	15.10	15.89	16.21	16.63
WOOG 14790.00		7.69	11.07	12.88	13.25	13.52	14.42	15.19	15.49	16.01
WOOG 14850.00		6.31	11.00	12.77	13.13	13.39	14.23	14.93	15.20	16.01
WOOG 14950.00		6.30	10.94	12.69	13.06	13.31	14.15	14.86	15.14	16.01
WOOG 15050.00		6.02	10.84	12.57	12.92	13.15	13.93	14.63	14.91	16.01
WOOG 15150.00		5.50	10.76	12.50	12.86	13.08	13.86	14.54	14.81	16.01
WOOG 15150.00		5.50	10.76	12.50	12.86	13.08	13.86	14.54	14.81	16.01
WOOG 15230.00		4.67	10.74	12.45	12.81	13.02	13.78	14.45	14.72	16.01
WOOG 15300.00		5.00	10.09	11.80	12.15	12.37	13.09	13.73	14.51	16.01
WOOG 15370.00		5.41	8.82	11.03	11.48	11.77	12.53	13.55	14.51	16.01
WOOG 15470.00		5.10	8.75	10.98	11.42	11.70	12.44	13.55	14.51	16.01
WOOG 15520.00		4.90	8.63	10.86	11.29	11.56	12.27	13.55	14.51	16.01
WOOG 15600.00		4.51	8.45	10.63	11.05	11.34	12.23	13.55	14.51	16.01
WOOG 15720.00		4.30	8.25	10.44	10.84	11.14	12.23	13.55	14.51	16.01
WOOG 15800.00	Parker St	4.18	7.77	10.03	10.41	10.68	12.23	13.55	14.51	16.01
WOOG 15840.00		3.50	7.63	9.93	10.29	10.54	12.23	13.55	14.51	16.01

WOOG 15860.00	Edna St	3.90	7.55	9.69	10.16	10.47	12.22	13.55	14.51	16.01
WOOG 15960.00		3.70	7.43	9.44	9.96	10.25	12.22	13.55	14.51	16.01
WOOG 15990.00		3.90	7.41	9.42	9.94	10.23	12.22	13.55	14.51	16.01
WOOG 16010.00		3.70	7.36	9.34	9.85	10.13	12.22	13.55	14.51	16.01
WOOG 16125.00		3.48	7.10	8.99	9.43	9.80	12.22	13.55	14.51	16.01
WOOG 16150.00		3.20	7.08	8.98	9.42	9.77	12.22	13.55	14.51	16.01
WOOG 16275.00		3.01	6.50	8.39	8.84	9.52	12.22	13.55	14.51	16.01
WOOG 16440.00		2.00	5.57	7.76	8.27	9.52	12.22	13.55	14.51	16.01
WOOG 16600.00		0.36	5.35	7.55	8.06	9.52	12.22	13.55	14.51	16.01
WOOG 16700.00		1.00	5.25	7.45	8.03	9.52	12.22	13.55	14.51	16.01
WOOG 16850.00		1.07	5.03	7.11	7.99	9.52	12.22	13.55	14.51	16.01
WOOG 16900.00		1.00	4.89	6.93	7.96	9.52	12.22	13.55	14.51	16.01
WOOG 17050.00		0.86	4.51	6.43	7.92	9.52	12.22	13.55	14.51	16.01
WOOG 17125.00		0.89	4.38	6.25	7.91	9.52	12.22	13.55	14.51	16.01
WOOG 17275.00		0.07	4.15	5.97	7.90	9.52	12.22	13.55	14.51	16.01
WOOG 17310.00		0.49	4.12	5.94	7.90	9.52	12.22	13.55	14.51	16.01
WOOG 17370.00	Brisbane Rd	0.48	3.70	5.73	7.89	9.52	12.22	13.55	14.51	16.01
WOOG 17440.00		-0.50	3.46	5.52	7.88	9.52	12.22	13.55	14.51	16.01
WOOG 17460.00		-0.50	3.41	5.46	7.88	9.52	12.22	13.55	14.50	16.01
WOOG 17500.00		0.45	3.37	5.40	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17550.00		0.53	3.33	5.36	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17580.00		0.50	3.19	5.34	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17600.00		-0.50	3.19	5.34	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17615.00		-1.55	3.19	5.34	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17750.00		-0.59	3.12	5.32	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17760.00	Brisbane Terrace	-0.60	3.12	5.32	7.87	9.52	12.22	13.55	14.50	16.01
WOOG 17780.00		-0.60	3.04	5.30	7.86	9.52	12.22	13.55	14.50	16.01
WOOG 17950.00		-0.60	2.89	5.27	7.86	9.52	12.22	13.55	14.50	16.01
WOOG 17960.00		-0.71	2.88	5.27	7.86	9.52	12.22	13.55	14.50	16.01
WOOG 18250.00		-0.95	2.62	5.25	7.85	9.52	12.22	13.55	14.50	16.01
WOOG 18250.00		-0.95	2.62	5.25	7.85	9.52	12.22	13.55	14.50	16.01
WOOG 18500.00		-1.15	2.39	5.24	7.84	9.52	12.22	13.55	14.50	16.01
WOOG 18750.00		-2.50	2.24	5.24	7.84	9.52	12.22	13.55	14.50	16.01
WOOG 18900.00		-2.07	2.01	5.23	7.84	9.52	12.22	13.55	14.50	16.01
WOOG 19075.00	Brisbane River	-9.40	2.00	5.23	7.84	9.52	12.22	13.55	14.50	16.01

Appendix G Maximum Discharges – Design

Appendix G   Maximum Discharges - Design

Flowpath/Chainage	Peak Discharge (cumecs) for ARI							
	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
BNE 929095.00	6	6	6	6	6	7	6	8
BNE 929470.00	1	1	1	3	6	11	11	14
BNE 929870.00	1	1	1	4	8	17	16	23
BNE 930545.00	1	1	1	7	14	26	25	35
BNE 931295.00	1	1	1	8	17	32	30	43
BNE 932620.00	1	1	2	11	23	41	39	54
BNE 933970.00	1	1	3	14	31	52	50	68
BNE 934445.00	1	1	3	15	36	62	60	80
BNE 934745.00	1	1	4	15	37	66	64	85
BNE 935470.00	1	1	4	16	40	75	72	96
BNE 936445.00	1	1	8	19	51	93	88	127
BNE 938295.00	0	0	16	28	76	132	126	176
BNE 941045.00	0	0	21	37	98	165	157	218
BNE 942945.00	0	0	29	47	119	196	188	264
BNE 943850.00	0	0	31	51	134	243	228	347
BNE 944135.00	0	0	32	52	137	270	235	372
BNE 944860.00	0	0	34	54	146	278	256	438
BNE 945870.00	0	0	37	58	162	310	286	482
BNE 946670.00	0	1	42	63	174	330	305	510
BNE 947370.00	0	2	45	66	183	344	319	529
BNE 947845.00	0	3	48	68	188	350	325	537
BNE 948745.00	0	6	55	74	200	372	346	567
BNE 949820.00	0	8	61	79	213	390	364	589
BNE 951295.00	0	13	73	90	235	419	393	624
BNE 953095.00	0	20	84	98	252	440	414	650
BNE 954395.00	0	25	94	107	274	473	446	690
BNE 955445.00	0	29	103	113	287	490	463	714
BNE 957370.00	4	36	114	121	312	543	513	780
BNE 959470.00	10	49	134	134	338	576	546	819
BNE 961120.00	13	58	157	151	380	645	612	941
BNE 963120.00	19	68	173	162	404	677	644	982
BNE 965390.00	397	964	1896	2719	4254	5575	5758	6303
BNE 967010.00	395	963	1896	2715	4243	5565	5758	6251
BNE 968600.00	393	963	1895	2712	4236	5559	5758	6220
BNE 970475.00	403	968	1899	2715	4251	5553	5758	6218
BNE 971710.00	402	968	1898	2713	4245	5546	5758	6189
BNE 972760.00	401	968	1897	2710	4239	5542	5758	6169
BNE 973920.00	400	967	1896	2707	4230	5536	5758	6143
BNE 975300.00	399	967	1895	2704	4222	5530	5758	6120
BNE 976385.00	398	967	1894	2702	4215	5526	5758	6104
BNE 977515.00	398	967	1893	2697	4195	5513	5758	6064
BNE 978893.50	397	967	1892	2695	4188	5508	5758	6051
BNE 979511.00	397	966	1892	2693	4183	5502	5758	6034
BNE 979522.50	397	966	1892	2693	4183	5502	5758	6034
BNE 979930.00	397	966	1891	2691	4179	5499	5758	6027
BNE 980995.00	397	966	1890	2688	4169	5493	5758	6015
BNE 982060.00	397	966	1890	2686	4165	5490	5758	6009
BNE 983310.00	407	985	1910	2689	4173	5488	5758	6015
BNE 984710.00	407	985	1909	2686	4166	5483	5758	6007
BNE 985870.00	407	984	1908	2684	4160	5480	5758	6000
BNE 987220.00	407	984	1907	2682	4154	5472	5758	5991
BNE 988060.00	407	983	1906	2680	4154	5472	5758	5983
BNE 988165.00	407	983	1906	2680	4154	5472	5758	5982
BNE 988265.00	407	983	1906	2679	4154	5472	5758	5981
BNE 989030.00	406	983	1906	2678	4142	5470	5758	5974
BNE 990200.00	405	981	1904	2674	4135	5465	5758	5957
BNE 990730.00	405	981	1903	2673	4134	5464	5758	5953
BNE 991235.00	405	981	1903	2672	4133	5463	5758	5950
BNE 992065.00	404	980	1902	2669	4128	5459	5758	5940

BNE 992435.00	404	979	1901	2668	4126	5458	5758	5935
BNE 992460.00	404	979	1901	2668	4126	5458	5758	5935
BNE 992570.00	404	979	1901	2668	4126	5458	5758	5934
BNE 993215.00	403	978	1900	2667	4123	5456	5758	5928
BNE 994260.00	403	978	1900	2665	4120	5453	5758	5915
BNE 995225.00	402	977	1899	2663	4114	5450	5758	5903
BNE 996335.00	401	976	1898	2662	4111	5448	5758	5893
BNE 997720.00	400	975	1897	2660	4106	5445	5758	5883
BNE 998810.00	397	974	1896	2658	4102	5443	5758	5872
BNE 999580.00	396	973	1896	2658	4100	5442	5758	5869
BNE 1000142.50	406	999	1935	2664	4113	5443	5758	5880
BNE 1000530.00	409	998	1935	2663	4108	5440	5758	5870
BNE 1001045.00	408	998	1934	2663	4107	5439	5758	5867
BNE 1001590.00	407	997	1934	2663	4104	5438	5758	5860
BNE 1002107.50	406	997	1934	2663	4103	5437	5758	5857
BNE 1002567.50	405	996	1933	2663	4101	5437	5758	5853
BNE 1003030.00	404	996	1933	2663	4099	5436	5758	5849
BNE 1003525.00	403	996	1933	2663	4097	5435	5758	5843
BNE 1004037.50	402	995	1933	2663	4096	5435	5758	5838
BNE 1004555.00	401	995	1932	2664	4094	5434	5758	5834
BNE 1005067.50	400	994	1932	2664	4092	5433	5758	5828
BNE 1005597.50	398	993	1932	2665	4088	5431	5758	5817
BNE 1006085.00	823	1963	3198	4154	5473	6259	6910	7882
BNE 1006605.00	823	1961	3196	4151	5471	6257	6906	7878
BNE 1007160.00	822	1962	3194	4147	5469	6253	6900	7868
BNE 1007665.00	822	1962	3192	4142	5467	6250	6895	7861
BNE 1008057.50	821	1962	3191	4140	5465	6248	6892	7857
BNE 1008320.00	823	1972	3192	4137	5463	6237	6877	7834
BNE 1008685.00	823	1973	3191	4136	5462	6236	6875	7831
BNE 1009162.50	822	1973	3190	4134	5461	6234	6872	7825
BNE 1009560.00	822	1973	3189	4132	5460	6232	6868	7820
BNE 1010105.00	821	1973	3188	4130	5458	6230	6865	7816
BNE 1010607.50	821	1974	3187	4129	5457	6229	6862	7812
BNE 1010852.50	821	1974	3186	4128	5457	6228	6861	7810
BNE 1011245.00	820	1974	3185	4127	5456	6227	6859	7807
BNE 1011745.00	820	1974	3184	4125	5455	6225	6855	7802
BNE 1012227.50	820	1974	3182	4122	5452	6221	6848	7793
BNE 1012705.00	821	1978	3178	4114	5443	6206	6816	7745
BNE 1013190.00	820	1978	3177	4113	5442	6205	6814	7743
BNE 1013562.50	820	1978	3176	4112	5441	6203	6810	7738
BNE 1013795.00	820	1978	3176	4111	5441	6202	6809	7735
BNE 1014110.00	820	1978	3175	4110	5440	6202	6808	7734
BNE 1014460.00	819	1979	3175	4109	5440	6201	6806	7732
BNE 1014850.00	822	1999	3205	4108	5435	6189	6783	7694
BNE 1015325.00	822	1999	3204	4106	5434	6188	6781	7691
BNE 1015705.00	821	1999	3204	4106	5434	6187	6779	7689
BNE 1015995.00	821	1999	3204	4105	5433	6186	6778	7687
BNE 1016390.00	821	1999	3204	4103	5432	6185	6776	7684
BNE 1016885.00	820	1999	3204	4101	5430	6183	6773	7681
BNE 1017370.00	820	1999	3204	4101	5430	6183	6771	7680
BNE 1017765.00	820	1999	3204	4100	5429	6182	6770	7678
BNE 1018060.00	820	1999	3204	4099	5429	6182	6769	7677
BNE 1018462.50	819	1999	3204	4098	5428	6181	6767	7674
BNE 1018910.00	819	1999	3204	4097	5427	6180	6766	7671
BNE 1019292.50	819	2004	3222	4097	5428	6179	6765	7670
BNE 1019677.50	820	2007	3230	4085	5412	6156	6712	7579
BNE 1019990.00	820	2007	3230	4084	5411	6156	6711	7578
BNE 1020320.00	820	2007	3230	4083	5411	6156	6710	7577
BNE 1020677.50	819	2008	3229	4082	5410	6155	6709	7575
BNE 1020962.50	819	2008	3229	4082	5410	6155	6708	7574
BNE 1021317.00	819	2008	3229	4081	5410	6154	6707	7574
BNE 1021627.00	819	2008	3229	4081	5409	6154	6707	7573
BNE 1021805.00	819	2008	3229	4081	5409	6154	6706	7572
BNE 1022000.00	819	2008	3229	4080	5409	6153	6706	7572
BNE 1022340.00	818	2008	3229	4080	5409	6153	6705	7571
BNE 1022807.50	822	2027	3267	4082	5413	6152	6701	7565

BNE 1023305.00	822	2027	3266	4082	5413	6151	6701	7564
BNE 1023825.00	822	2027	3266	4081	5413	6151	6700	7563
BNE 1024321.50	861	2027	3266	4081	5413	6151	6700	7563
BNE 1024816.50	898	2027	3266	4080	5412	6150	6698	7561
BNE 1025215.00	897	2027	3266	4080	5412	6150	6697	7560
BNE 1025475.00	900	2027	3266	4080	5412	6150	6697	7560
BNE 1025880.00	910	2027	3266	4080	5412	6150	6697	7560
BNE 1026425.00	938	2027	3267	4080	5412	6150	6697	7559
BNE 1026790.00	955	2050	3310	4086	5419	6151	6701	7564
BNE 1027030.00	955	2050	3310	4086	5419	6151	6701	7564
BNE 1027420.00	982	2050	3310	4086	5419	6151	6701	7564
BNE 1027930.00	958	2050	3310	4086	5419	6151	6700	7564
BNE 1028292.56	956	2050	3309	4085	5419	6151	6700	7563
BNE 1028542.56	921	2050	3309	4085	5418	6150	6700	7563
BREM 1000350.00	435	1060	1505	2121	3153	3553	3744	4574
BREM 1000910.00	435	1059	1504	2117	3150	3538	3724	4565
BREM 1001410.00	435	1058	1503	2114	3146	3518	3692	4555
BREM 1002000.00	435	1058	1502	2112	3145	3504	3670	4549
BREM 1002500.00	435	1059	1502	2111	3144	3492	3652	4546
BREM 1002950.00	435	1058	1501	2110	3144	3481	3635	4541
BREM 1003450.00	435	1058	1500	2107	3142	3469	3613	4422
BREM 1003770.00	435	1057	1499	2104	3141	3460	3596	4414
BREM 1003995.00	435	1057	1499	2103	3140	3444	3586	3748
BREM 1004235.00	435	1057	1498	2102	3139	3437	3581	3729
BREM 1004455.00	435	1057	1498	2101	2698	2951	3059	3070
BREM 1004600.00	435	1056	1498	2101	2698	2950	3058	3069
BREM 1004655.00	435	1056	1498	2101	2698	2949	3057	3067
BREM 1004920.00	435	1060	1498	2095	3098	3330	3376	4447
BREM 1005330.00	435	1060	1498	2094	3093	3324	3363	4444
BREM 1005630.00	435	1060	1498	2093	3092	3321	3358	4443
BREM 1005915.00	435	1060	1497	2092	3088	3315	3346	4440
BREM 1006170.00	435	1060	1497	2091	3087	3312	3340	4439
BREM 1006370.00	435	1060	1496	2091	3085	3309	3337	4437
BREM 1006500.00	435	1060	1496	2090	3084	3307	3336	4436
BREM 1006645.00	435	1060	1496	2089	3083	3305	3336	4436
BREM 1007110.00	435	1060	1495	2085	3079	3293	3330	4432
BREM 1007570.00	435	1059	1494	2084	3078	3289	3329	4431
BREM 1007850.00	435	1059	1493	2083	3077	3286	3327	4429
BREM 1008195.00	435	1061	1491	2081	3070	3245	3305	4407
BREM 1008400.00	435	1061	1491	2080	3068	3242	3301	4406
BREM 1008415.00	435	1061	1491	2080	3068	3242	3301	4406
BREM 1008540.00	435	1061	1490	2080	3067	3241	3301	4405
BREM 1008935.00	435	1061	1490	2079	3066	3237	3299	4403
BREM 1009442.50	434	1060	1489	2077	3063	3232	3295	4399
BREM 1009765.50	434	1060	1488	2076	3059	3216	3258	4187
BREM 1009938.00	435	1061	1486	2072	3056	3223	3275	4375
BREM 1010150.00	435	1061	1486	2071	3056	3222	3274	4374
BREM 1010490.00	435	1060	1484	2070	3054	3221	3271	4372
BREM 1010795.00	435	1060	1483	2069	3054	3220	3269	4371
BREM 1011105.00	435	1060	1483	2068	3053	3219	3268	4370
BREM 1011510.00	435	1059	1481	2066	3050	3217	3263	4366
BREM 1011745.00	435	1059	1480	2065	3049	3217	3261	4365
BREM 1011800.00	435	1059	1480	2065	3049	3216	3261	4365
BREM 1011930.00	435	1059	1479	2064	3049	3216	3260	4364
BREM 1012060.00	435	1059	1479	2064	3048	3215	3259	4363
BREM 1012135.00	435	1059	1479	2063	3048	3215	3259	4362
BREM 1012535.00	435	1058	1478	2062	3046	3214	3258	4358
BREM 1013125.00	434	1056	1475	2058	3042	3212	3256	4352
BREM 1013540.00	434	1055	1473	2055	3038	3210	3253	4345
BREM 1013960.00	434	1054	1471	2052	3034	3208	3251	4338
BREM 1014430.00	434	1054	1470	2050	3032	3208	3250	4333
BREM 1014910.00	434	1053	1468	2047	3030	3207	3249	4329
BREM 1015312.50	434	1052	1467	2045	3028	3206	3249	4325
BREM 1015577.50	434	1052	1466	2044	3026	3205	3248	4325
BREM 1015910.00	434	1052	1464	2040	3024	3204	3247	4326
BREM 1016310.00	434	1051	1462	2037	3021	3202	3245	4327

BREM 1016795.00	434	1050	1460	2034	3018	3201	3244	4328
BREM 1017415.00	434	1049	1458	2031	3015	3199	3242	4329
BREM 1017945.00	434	1047	1455	2027	3011	3198	3240	4330
BREM 1018230.00	434	1047	1453	2024	3009	3198	3239	4331
BREM 1018410.00	434	1046	1452	2023	3008	3197	3239	4331
BREM 1018565.00	434	1046	1451	2022	3008	3197	3238	4332
BREM 1018695.00	434	1046	1451	2021	3007	3196	3237	4332
BREM 1018955.00	434	1045	1450	2019	3006	3196	3236	4334
BREM 1019365.00	434	1044	1447	2016	3003	3194	3232	4337
BREM 1019790.00	434	1043	1446	2012	3000	3193	3229	4340
BREM 1020225.00	434	1043	1444	2008	2997	3191	3227	4288
BREM 1020525.00	451	1067	1484	2009	3101	3328	3358	4361
BREM 1020760.00	452	1066	1475	1994	3087	3328	3342	4452
BREM 1021190.00	452	1064	1472	1986	3078	3311	3332	4440
BREM 1021880.00	452	1064	1468	1980	3073	3324	3329	4437
BREM 1022625.00	452	1062	1460	1968	3060	3300	3322	4439
BREM 1023220.00	452	1059	1451	1954	3046	3271	3312	4443
BREM 1023500.00	451	1058	1450	1951	3044	3268	3311	4443
BREM 1023690.00	451	1057	1449	1950	3043	3266	3311	4444
BREM 1024045.00	451	1056	1446	1947	3040	3259	3309	4445
BREM 1024370.00	451	1055	1444	1945	3038	3256	3308	4445
BREM 1024635.00	451	1054	1441	1942	3035	3251	3307	4446
BREM 1025025.00	451	1053	1438	1939	3031	3246	3306	4447
BREM 1025485.00	451	1051	1435	1935	3028	3244	3305	4448
BREM 1025795.00	451	1050	1432	1932	3024	3243	3304	4449
BREM 1026035.00	451	1049	1431	1930	3022	3242	3303	4449
BREM 1026355.00	451	1048	1428	1928	3019	3241	3302	4450
BREM 1026830.00	452	1049	1426	1924	3016	3264	3302	4451
BREM 1027370.00	451	1047	1422	1920	3012	3256	3301	4453
BREM 1027740.00	451	1046	1420	1917	3009	3253	3300	4454
BREM 1028015.00	451	1045	1418	1915	3007	3250	3299	4455
BREM 1028340.00	451	1044	1417	1913	3005	3248	3299	4455
BREMER 182.40	104	311	372	428	683	1039	1166	1441
BREMER 989.17	103	311	372	426	660	1012	1139	1429
BREMER 1910.60	102	311	372	425	639	986	1120	1419
BREMER 2339.84	101	310	372	424	633	980	1116	1417
BREMER 2482.00	101	310	372	424	635	977	1114	1415
BREMER 2507.43	101	310	372	424	631	976	1114	1414
BREMER 2785.83	100	310	372	424	630	975	1110	1412
BREMER 3314.30	99	310	372	424	614	952	1088	1400
BREMER 3848.74	99	310	372	423	581	921	1060	1383
BREMER 4388.20	99	310	371	422	539	905	1046	1371
BREMER 5062.58	98	309	371	421	536	892	1031	1356
BREMER 5801.86	98	308	368	415	519	815	942	1332
BREMER 6520.13	97	306	367	414	506	776	902	1324
BREMER 7249.99	95	305	367	416	524	754	926	1355
BREMER 7913.23	108	437	526	593	703	952	1310	2022
BREMER 8617.83	107	436	526	591	634	926	1368	1957
BREMER 9395.10	106	435	527	594	633	914	1610	2849
BREMER 9793.66	112	447	549	608	657	935	27619	34247
BREMER 9870.00	112	448	550	608	658	936	2686	8527
BREMER 10163.50	139	540	724	793	933	1151	2043	2608
BREMER 10391.25	139	539	703	787	919	1145	1875	2333
BREMER 10642.58	138	539	692	787	908	1138	1827	2266
BREMER 11104.67	229	627	796	919	1091	1253	1656	2693
BREMER 11396.65	229	627	793	919	1090	1458	1623	2652
BREMER 11482.63	229	627	792	919	1090	1961	1607	2638
BREMER 11681.07	229	627	792	919	1090	1240	1571	2606
BREMER 12052.72	229	627	791	919	1089	1224	1524	2585
BREMER 12462.76	229	626	791	918	1089	1205	1511	2577
BREMER 12981.75	229	626	791	918	1089	1185	1505	2569
BREMER 13569.55	229	624	791	918	1088	1151	1490	2556
BREMER 14130.01	228	619	790	917	1083	1103	1437	2530
BREMER 14394.91	228	617	789	917	1078	1088	1410	2507
BREMER 14410.00	228	617	789	917	1078	1088	1409	2505
BREMER 14625.61	228	616	789	916	1066	1079	1398	2490

BREMER 14945.61	228	616	789	916	1058	1074	1394	2486
BREMER 15070.00	228	615	788	915	1083	1092	1391	2482
BREMER 15195.94	228	616	788	915	1046	1064	1387	2478
BREMER 15529.86	228	616	788	913	1009	1025	1374	2467
BREMER 16044.13	228	615	788	909	989	1019	1319	2443
BREMER 16523.32	228	615	787	906	975	994	1286	2423
BREMER 16963.97	228	614	786	903	956	977	1282	2415
BREMER 17577.40	228	614	786	903	951	976	1279	2410
BREMER 18165.94	228	613	785	902	951	975	1203	2378
BREMER 18724.87	228	613	784	902	951	975	1166	2359
BREMER 19205.47	228	612	783	902	951	974	1149	2333
BREMER 19370.00	228	612	783	902	951	974	1147	2322
BREMER 19399.74	228	612	783	902	951	974	1141	2320
BREMER 19952.52	228	612	782	901	951	974	1129	2287
BREMER 20681.11	228	611	781	902	954	973	1123	2211
BREMER 21221.26	242	639	823	955	1112	1161	1185	2232
BREMER 21708.59	242	639	823	954	1111	1160	1184	2224
BREMER 22130.95	242	638	822	954	1110	1158	1182	2221
BREMER 22670.96	242	637	821	953	1107	1156	1181	2219
BREMER 23153.61	241	637	820	952	1106	1154	1180	2214
BREMER 23672.13	241	637	820	951	1105	1152	1178	2202
BREMER 24176.44	242	636	819	951	1133	1180	1213	2191
BREMER 24637.92	242	636	819	951	1130	1175	1210	2186
BREMER 25131.42	242	636	819	950	1128	1172	1207	2181
BREMER 25626.87	242	635	818	949	1126	1166	1203	2177
BREMER 26073.64	242	635	817	949	1124	1158	1196	2176
BREMER 26303.28	242	635	817	948	1122	1154	1192	2174
BREMER 26557.59	242	635	817	948	1121	1150	1188	2172
BREMER 26914.87	242	634	816	948	1120	1142	1181	2170
BREMER 27227.41	242	634	816	947	1118	1136	1173	2170
BREMER 27494.98	242	634	816	947	1116	1131	1176	2170
BREMER 27715.24	242	634	815	946	1115	1126	1180	2170
BREMER 27945.54	242	634	815	946	1113	1121	1184	2169
BREMER 28194.94	242	634	815	945	1111	1115	1189	2170
BREMER 28603.16	243	635	817	947	1143	1150	1205	2172
BREMER 28997.60	243	635	816	944	1135	1136	1208	2172
BREMER 29299.46	243	635	816	942	1131	1129	1216	2173
BREMER 29493.50	243	635	815	942	1127	1121	1224	2174
BREMER 29525.00	244	991	815	942	1127	1120	1226	2174
BREMER 29556.50	243	635	815	941	1126	1118	1227	2174
BREMER 29734.50	243	635	815	939	1120	1110	1237	2175
BREMER 29991.00	242	635	815	938	1117	1103	1245	2175
BREMER 30441.00	240	635	814	934	1104	1121	1265	2176
BREMER-BOONAHNEW 10167.71	19	69	87	104	162	231	266	320
BREMER-BOONAHNEW 11191.71	19	68	87	104	162	230	265	319
BREMER-BOONAHNEW 11927.00	19	67	86	104	159	224	257	314
BREMER-BOONAHNEW 12218.50	31	110	140	169	261	369	427	519
BREMER-BOONAHNEW 12952.70	31	110	140	169	261	368	425	517
BREMER-BOONAHNEW 13667.81	44	156	197	239	374	534	616	743
BREMER-BOONAHNEW 13934.22	44	154	196	239	374	532	614	740
BREMER-BOONAHNEW 14163.44	44	153	196	239	374	533	614	740
BREMER-BOONAHNEW 14918.01	44	149	198	239	373	533	615	741
BREMER-BOONAHNEW 15976.71	43	147	187	234	367	531	614	738
BREMER-BOONAHNEW 16512.06	56	191	242	308	487	709	818	973
BREMER-BOONAHNEW 17342.28	56	190	239	304	476	679	771	921
BREMER-BOONAHNEW 18630.11	56	190	238	298	472	668	745	880
BREMER-BOONAHNEW 19908.51	56	188	234	287	471	667	744	879
BREMER-BOONAHNEW 21357.51	55	188	234	286	461	657	731	874
BREMER-BOONAHNEW 22910.31	71	232	286	356	569	822	915	1095
BREMER-BOONAHNEW 24164.46	71	231	285	354	563	816	907	1091
BREMER-BOONAHNEW 24523.35	71	231	285	353	560	809	900	1084
BREMER-BOONAHNEW 24551.71	71	231	285	353	559	1604	900	1084
BREMER-BOONAHNEW 24578.35	71	231	285	353	559	809	899	1083
BREMER-BOONAHNEW 25550.36	71	231	284	350	555	801	890	1072
BREMER-BOONAHNEW 27042.52	71	229	280	340	553	788	873	1046
BREMER-BOONAHNEW 28398.66	87	265	319	379	614	911	1015	1226

BREMLINKBRANCH1 5.00	0	0	0	0	0	0	0	0
BREMLINKBRANCH2 25.00	0	0	0	0	0	0	0	21
BUND 10153.75	10	37	47	57	94	382	169	202
BUND 10461.25	10	37	47	57	94	381	167	198
BUND 10861.25	9	37	47	56	94	381	165	195
BUND 11353.75	9	37	47	56	94	381	164	194
BUND 11784.17	13	49	62	75	127	388	309	257
BUND 12152.50	13	49	62	75	127	388	309	256
BUND 12520.83	13	49	62	75	127	388	309	256
BUND 12935.00	16	49	62	75	127	388	308	255
BUND 13358.75	15	49	62	75	127	387	308	254
BUND 13746.25	13	49	62	75	127	386	306	254
BUND 14078.75	13	49	62	75	126	385	301	249
BUND 14356.25	13	49	62	75	126	384	302	248
BUND 14635.00	13	49	62	75	126	384	302	248
BUND 14915.00	13	49	62	75	126	384	295	245
BUND 15216.25	13	49	62	75	126	383	293	242
BUND 15538.75	13	49	62	75	126	383	289	239
BUND 15873.75	21	85	106	129	211	408	358	391
BUND 16221.25	21	85	106	129	208	407	350	380
BUND 16521.25	21	85	106	129	202	405	332	366
BUND 16773.75	21	85	106	129	199	404	328	362
BUND 17057.50	21	85	106	129	194	404	326	361
BUND 17372.50	21	85	106	129	193	404	323	359
BUND 17707.50	21	85	106	129	193	403	320	356
BUND 18096.25	21	85	106	129	192	403	315	352
BUND 18518.75	21	85	106	129	193	401	309	348
BUND 18740.00	21	85	106	129	193	400	426	398
BUND 18882.50	21	85	106	129	192	400	307	344
BUND 19147.50	21	85	106	129	192	399	305	342
BUND 19410.00	21	85	106	129	192	399	305	341
BUND 19670.00	21	85	106	129	192	399	303	339
BUND 19960.00	21	85	106	129	192	397	300	336
BUND 20280.00	21	85	106	129	192	397	298	332
BUND 20672.50	26	105	132	159	231	406	318	379
BUND 21137.50	26	105	132	159	230	406	317	379
BUND 21557.50	26	105	132	159	230	406	315	376
BUND 21932.50	26	105	132	159	229	405	314	371
BUND 22286.25	31	127	159	191	272	411	330	391
BUND 22618.75	31	127	159	191	272	409	330	388
BUND 22967.50	31	127	159	191	272	406	329	382
BUND 23332.50	31	126	159	191	272	397	327	367
BUND 23668.75	31	126	159	191	272	380	323	346
BUND 23976.25	31	126	159	190	272	375	322	342
BUND 24287.50	31	126	159	190	272	373	321	346
BUND 24602.50	31	126	159	190	272	364	321	344
BUND 24917.50	34	135	173	204	290	362	331	346
BUND 25201.25	34	135	172	203	290	360	331	346
BUND 25453.75	34	134	172	203	290	358	330	345
BUND 25590.00	34	134	172	203	290	356	330	344
BUND 25835.00	34	133	172	202	290	354	329	344
BUND 26305.00	37	143	187	218	311	353	338	380
BUND 26660.00	37	143	187	218	311	353	349	417
BUND 27030.00	38	149	199	230	326	368	367	414
BUND 27330.00	38	150	199	230	326	369	365	417
BUND 27390.00	38	149	199	230	326	370	365	418
BUND 27527.50	38	153	199	230	326	395	363	1247
BUND 27665.00	38	223	232	230	326	730	362	788
BUND 27842.50	38	154	198	230	326	379	357	427
BUND 28180.00	38	149	198	230	326	364	354	435
BUND 28415.00	38	149	197	222	286	308	313	356
BUND 28510.00	38	149	197	222	286	308	313	357
BUND 28545.00	38	149	197	222	286	308	313	357
BUND 28595.00	38	149	197	222	286	308	313	357
BUND 28782.50	39	153	203	236	334	369	380	468
BUND 29087.50	39	153	202	235	332	369	376	452

BUND 29395.00	39	153	201	234	331	369	369	430
BUND 29730.00	39	152	201	233	330	369	365	430
BUND 30062.50	42	161	214	247	348	387	399	483
BUND 30367.50	42	161	213	246	345	385	396	481
BUND 30730.00	42	160	212	246	344	384	394	479
BUND 31150.00	42	160	212	245	343	384	393	479
BUND 31495.00	42	160	212	245	343	383	391	478
BUND 31805.00	42	160	212	244	341	383	388	478
BUND 31990.00	42	160	211	243	341	383	388	477
BUND 32075.00	42	160	211	243	341	383	388	477
BUND 32250.00	42	160	211	243	341	383	388	477
BUND 32360.00	42	160	211	242	341	383	388	477
BUND 32522.50	42	159	211	242	341	383	388	477
BUND 32827.50	41	159	211	242	341	383	388	477
BUND 33150.00	41	159	211	242	341	383	388	477
BUND 33490.00	41	159	210	242	341	383	388	477
BUND 33830.00	41	157	209	242	341	383	388	477
BUND 34130.00	41	158	211	244	343	387	395	486
BUND 34282.50	41	159	214	248	346	393	407	501
BUND 34325.00	41	159	214	248	346	393	407	501
BUND 34370.00	41	159	214	248	346	393	407	501
BUND 34577.50	41	159	214	248	345	393	407	501
BUND 34905.00	41	159	214	248	345	393	407	501
BUND 35075.00	41	159	214	248	345	393	407	501
BUND 35110.00	41	159	214	248	345	393	407	501
BUND 35320.00	41	159	214	248	345	393	407	501
BUND 35530.00	42	314	287	256	347	412	421	513
BUND 35635.00	42	160	215	250	347	400	417	513
BUND 35867.50	42	159	215	249	347	400	417	512
BUND 36015.00	42	159	215	249	347	400	417	512
BUND 36161.25	42	159	215	249	347	400	417	512
BUND 36433.75	42	159	215	249	346	400	417	511
BUND 36705.00	42	159	215	249	346	399	417	509
BUND 36975.00	41	159	214	248	346	399	416	505
BUND 37310.00	41	159	214	248	346	398	416	497
BUND 37710.00	41	158	214	248	346	398	416	485
BUND 38095.00	41	158	213	247	345	399	418	469
BUND 38501.25	41	158	213	245	344	397	416	452
BUND 38943.75	41	158	212	242	343	394	413	435
BUND 39355.83	41	158	212	240	343	396	415	433
BUND 39737.50	41	158	212	240	343	396	415	433
BUND 40119.17	41	158	212	240	343	396	415	433
BUND 40490.00	41	158	212	240	343	396	415	433
BUND 40850.00	41	158	212	240	343	396	415	433
BUND 41039.52	41	158	212	240	343	396	415	433
DEEB 10157.50	7	21	26	31	65	102	117	138
DEEB 10451.75	7	21	26	31	65	101	116	138
DEEB 10725.25	7	21	26	31	65	100	116	137
DEEB 11001.50	7	21	26	31	65	99	114	136
DEEB 11297.00	7	21	25	30	64	100	115	135
DEEB 11645.00	7	21	25	30	64	99	115	136
DEEB 11974.00	7	21	25	30	64	97	114	135
DEEB 12244.00	7	21	25	30	64	98	113	135
DEEB 12510.00	7	21	25	30	64	98	113	134
DEEB 12785.00	9	28	34	41	85	128	151	180
DEEB 12937.00	9	28	34	41	84	129	151	180
DEEB 13056.00	9	28	34	41	85	129	151	180
DEEB 13230.00	9	28	34	41	85	129	150	179
DEEB 13441.00	9	30	37	44	89	133	154	182
DEEB 13737.50	9	30	37	44	89	132	154	182
DEEB 13905.00	9	30	37	44	89	132	154	183
DEEB 14061.50	9	30	37	44	88	132	154	183
DEEB 14343.50	9	30	37	44	88	131	153	183
DEEB 14628.50	10	32	40	47	93	137	161	192
DEEB 14875.00	10	32	40	47	93	137	159	191
DEEB 15069.00	10	35	42	51	97	144	166	199

DEEB 15247.50	10	35	42	51	97	143	166	198
DEEB 15509.00	10	34	42	51	97	143	164	194
DEEB 15793.00	10	34	42	51	97	142	163	191
DEEB 15969.50	10	34	42	51	97	142	163	189
DEEB 16077.50	10	34	42	51	97	142	162	187
DEEB 16167.50	10	34	42	51	97	142	162	186
DEEB 16259.00	12	41	51	61	112	164	166	209
DEEB 16321.50	12	42	52	62	114	167	180	211
DEEB 16474.50	12	42	52	62	114	167	179	209
DEEB 16622.00	12	42	52	62	114	166	179	207
DEEB 16744.50	12	42	52	62	114	166	179	205
DEEB 16907.00	12	42	52	62	114	166	178	202
DEEB 17012.00	12	42	52	62	114	165	177	197
DEEB 17072.00	15	49	60	72	136	188	190	229
DEEB 17198.50	15	49	60	72	127	187	190	228
DEEB 17463.00	15	48	60	72	127	187	190	228
DEEB 17653.00	14	48	60	72	127	186	190	227
DEEB 17708.00	14	48	62	72	127	186	190	227
DEEB 17809.50	14	48	60	72	127	186	190	226
DEEB 17923.00	14	48	60	72	129	186	190	226
DEEB 18132.00	14	48	60	72	126	186	189	225
DEEB 18347.00	15	50	62	75	129	191	194	233
DEEB 18417.50	15	50	62	75	129	191	194	233
DEEB 18491.00	15	50	62	75	129	190	194	233
DEEB 18586.00	15	50	62	75	129	191	194	233
DEEB 18732.50	14	50	62	74	129	191	194	233
DEEB 18865.50	14	50	62	74	129	191	194	233
DEEB 19024.00	14	50	62	74	129	191	194	233
DEEB 19122.00	14	50	62	73	129	191	194	233
DEEB 19189.50	14	50	62	73	129	191	194	233
DEEB 19324.00	14	50	61	73	129	191	194	233
DEEB 19469.00	14	50	61	72	129	191	194	233
DEEB 19572.00	15	51	62	74	129	191	194	233
DEEB 19654.50	15	51	62	74	129	191	194	233
DEEB 19764.50	15	51	61	73	129	191	194	233
DEEB 19837.00	15	51	61	73	129	191	194	233
DEEB 19879.50	15	50	61	73	129	191	194	233
FRANKLINVALE 212.98	20	80	101	123	192	271	315	374
FRANKLINVALE 655.82	20	80	101	123	192	270	315	373
FRANKLINVALE 1125.48	20	80	101	123	192	270	314	373
FRANKLINVALE 1567.12	20	80	101	123	192	270	314	372
FRANKLINVALE 2010.40	20	80	101	123	191	269	313	372
FRANKLINVALE 2476.41	20	80	101	123	191	270	314	372
FRANKLINVALE 2848.49	40	160	201	245	380	538	625	744
FRANKLINVALE 3272.45	40	160	201	245	380	538	623	741
FRANKLINVALE 3805.40	40	159	201	245	379	536	619	737
FRANKLINVALE 4255.61	40	158	201	245	379	536	618	737
FRANKLINVALE 4641.44	40	158	201	244	379	535	616	735
FRANKLINVALE 4973.05	40	158	201	244	379	534	616	732
FRANKLINVALE 5366.76	40	158	201	244	378	534	615	733
FRANKLINVALE 5623.00	41	158	201	244	378	534	614	733
FRANKLINVALE 5829.16	40	158	201	244	378	534	614	733
FRANKLINVALE 6251.44	40	157	200	244	378	533	613	729
FRANKLINVALE 6721.82	40	158	200	244	377	533	611	728
FRANKLINVALE 7109.93	40	156	200	243	377	532	611	727
FRANKLINVALE 7387.69	40	156	200	243	377	532	611	726
FRANKLINVALE 7657.85	40	155	200	243	377	532	610	725
FRANKLINVALE 8053.98	40	155	199	243	375	530	608	722
FRANKLINVALE 8574.08	40	154	199	242	375	530	607	719
FRANKLINVALE 8835.62	40	154	198	242	374	530	606	779
FRANKLINVALE 9082.44	40	154	198	242	374	529	606	718
FRANKLINVALE 9517.19	40	153	199	242	374	530	607	718
FRANKLINVALE 10106.67	56	205	271	328	503	719	823	971
FRANKLINVALE 10730.88	56	205	271	323	501	717	821	971
FRANKLINVALE 11208.58	56	205	271	321	500	716	821	970
FRANKLINVALE 11664.60	56	205	270	321	499	715	819	968

FRANKLINVALE 12100.87	56	205	270	321	499	715	819	969
FRANKLINVALE 12535.39	56	205	270	321	498	714	819	968
FRANKLINVALE 12942.11	56	205	270	321	498	714	818	966
FRANKLINVALE 13360.25	56	204	269	321	496	713	816	966
FRANKLINVALE 13811.20	55	204	269	321	496	711	816	965
FRANKLINVALE 14284.28	55	204	269	321	495	711	815	963
FRANKLINVALE 14763.33	55	203	268	320	493	708	813	962
FRANKLINVALE 15237.53	55	203	267	320	491	708	811	960
FRANKLINVALE 15711.66	55	203	267	320	489	707	811	960
FRANKLINVALE 16175.25	69	245	324	393	577	848	978	1170
FRANKLINVALE 16638.88	69	245	323	393	575	846	976	1167
FRANKLINVALE 16953.78	69	245	323	393	575	847	976	1167
FRANKLINVALE 17032.00	84	343	448	915	938	1564	978	1167
FRANKLINVALE 17184.33	69	245	323	393	575	847	976	1167
FRANKLINVALE 17531.85	69	245	323	392	574	846	975	1167
FRANKLINVALE 17949.53	69	245	322	392	574	844	974	1164
FRANKLINVALE 18368.20	69	244	321	390	572	842	971	1163
FRANKLINVALE 19176.70	69	244	320	389	572	779	852	955
FRANKLINVALE 19937.44	69	245	320	389	573	778	857	1198
GOOD 10137.50	12	15	18	23	41	63	73	85
GOOD 10375.00	11	15	18	23	41	62	73	84
GOOD 10590.00	11	15	18	23	41	62	73	85
GOOD 10815.00	11	15	18	23	41	62	73	85
GOOD 11130.00	11	17	22	28	54	81	121	109
GOOD 11480.00	11	17	22	27	53	80	121	108
GOOD 11785.00	10	17	22	27	53	79	119	107
GOOD 11982.50	10	19	24	28	58	86	130	115
GOOD 12032.00	10	19	24	28	58	86	129	115
GOOD 12099.50	10	19	24	28	58	86	129	116
GOOD 12290.00	11	24	32	37	82	118	137	159
GOOD 12552.50	11	23	31	37	81	117	137	159
GOOD 12807.50	10	24	31	37	80	117	138	157
GOOD 13105.00	11	27	36	43	92	135	159	182
GOOD 13375.00	11	27	35	43	92	135	160	181
GOOD 13575.00	10	27	36	42	92	135	160	182
GOOD 13915.00	10	27	35	42	89	130	154	176
GOOD 14175.00	11	28	37	44	90	128	148	165
GOOD 14235.00	11	28	36	44	88	125	143	161
GOOD 14320.00	11	28	36	43	85	122	140	158
GOOD 14465.00	11	28	36	43	85	121	138	156
GOOD 14565.00	11	28	36	43	84	119	138	155
GOOD 14595.00	11	28	36	43	84	120	138	155
GOOD 14625.00	11	28	36	43	84	120	138	155
GOOD 14685.00	11	28	35	42	84	120	138	155
GOOD 14815.00	11	28	35	42	84	120	138	155
GOOD 14900.00	11	29	37	44	88	120	138	155
GOOD 14913.00	11	29	37	44	88	120	138	165
GOOD 14925.00	11	29	37	44	88	120	138	155
GOOD 14952.50	11	29	37	44	88	120	138	155
GOOD 15162.50	11	29	37	44	87	120	138	155
GOOD 15597.50	11	29	37	43	86	120	138	155
GOOD 16010.00	11	29	37	42	85	120	138	155
GOOD 16265.00	11	29	37	42	86	120	138	155
GOOD 16440.00	11	29	37	42	86	120	138	155
GOOD 16625.00	11	29	36	42	85	120	138	155
HWAY LEFT 85.00	2	6	9	9	17	25	69	34
HWAY LEFT 230.00	2	6	9	14	48	61	67	110
HWAY LEFT 300.00	2	6	9	14	48	61	66	111
HWAY LEFT 350.00	2	6	13	14	48	61	66	111
IRON 10137.00	1	1	2	2	5	8	10	11
IRON 10418.50	1	1	2	2	5	8	9	11
IRON 10644.00	1	1	2	2	5	8	9	11
IRON 10863.00	1	1	2	2	5	8	9	10
IRON 11211.50	1	2	3	3	8	12	14	16
IRON 11593.50	4	7	9	12	28	44	95	59
IRON 11779.50	4	7	9	12	27	43	94	57

IRON 11923.00	3	7	9	12	28	43	93	57
IRON 12193.50	7	15	20	25	59	90	105	121
IRON 12476.50	7	15	20	25	59	91	105	122
IRON 12641.00	7	15	20	25	59	92	106	122
IRON 12810.25	7	15	20	25	58	92	106	123
IRON 13114.75	7	15	20	25	58	90	106	121
IRON 13516.50	7	17	22	27	65	97	154	130
IRON 13936.50	7	17	22	27	64	96	152	130
IRON 14281.50	9	25	32	40	91	138	161	184
IRON 14630.50	9	25	32	40	91	138	161	184
IRON 14972.00	9	25	32	40	91	138	161	184
IRON 15273.00	9	25	31	39	89	135	157	182
IRON 15553.50	10	26	33	41	92	141	174	188
IRON 15793.50	10	26	33	41	92	141	175	186
IRON 16042.75	10	26	32	41	92	141	175	185
IRON 16354.25	10	26	33	41	91	139	173	181
IRON 16668.50	10	26	33	41	90	138	173	175
IRON 16960.00	11	30	36	45	99	151	217	186
IRON 17214.50	14	39	47	58	125	190	216	230
IRON 17482.00	14	39	47	58	125	190	216	230
IRON 17756.00	14	39	47	58	125	190	216	230
IRON 17957.50	14	39	47	58	125	190	216	230
IRON 18093.50	14	39	47	58	125	190	216	230
IRON 18209.50	14	39	47	58	125	190	216	230
IRON 18313.00	14	39	47	58	125	190	216	230
IRON 18375.00	14	39	47	58	125	190	216	230
IRON 18484.00	14	39	47	58	125	190	216	230
MIHI 11389.00	8	11	15	18	40	65	74	86
MIHI 11588.00	8	11	14	17	39	60	69	79
MIHI 11838.00	8	11	14	17	39	60	69	78
MIHI 12031.00	8	11	14	17	39	61	69	77
MIHI 12162.00	13	16	21	25	57	61	69	77
MIHI 12357.50	13	16	21	25	57	61	69	77
MIHI 12557.50	13	17	21	26	58	61	69	77
MIHI 12697.00	13	17	21	26	58	61	69	77
MIHI 12842.50	13	17	21	26	58	61	69	77
MIHI 13021.00	13	17	21	25	57	61	69	77
MIHI_LINK1 15.00	0	0	0	0	0	0	0	0
PURGA 672.90	21	83	106	130	203	286	315	394
PURGA 1629.05	20	83	106	129	202	285	314	393
PURGA 2449.15	44	83	106	129	201	285	313	391
PURGA 2996.06	151	229	291	364	551	840	885	1107
PURGA 3175.85	181	228	291	354	551	800	883	1110
PURGA 3924.06	339	339	339	353	549	795	876	1102
PURGA 4753.46	343	343	343	353	548	790	873	1097
PURGA 5239.53	274	274	289	352	548	788	867	1093
PURGA 5706.76	190	227	290	352	547	768	845	1091
PURGA 6194.88	193	227	290	352	546	763	845	1087
PURGA 6724.26	171	227	289	352	546	762	840	1087
PURGA 7244.66	171	226	288	352	545	762	838	1086
PURGA 7718.59	170	226	286	351	545	762	838	1083
PURGA 8197.92	168	225	286	351	544	762	835	1081
PURGA 8714.52	167	225	286	351	544	761	832	1080
PURGA 9747.02	151	265	336	418	636	896	956	1253
PURGA 10751.71	137	261	335	417	635	895	952	1251
PURGA 11166.55	135	260	334	416	634	894	951	1248
PURGA 11563.04	134	259	333	415	634	893	949	1244
PURGA 12072.24	134	257	333	415	633	891	945	1243
PURGA 12574.79	148	256	333	414	633	891	946	1242
PURGA 12796.29	314	403	359	414	633	891	946	1241
PURGA 13043.95	137	256	333	414	633	891	946	1240
PURGA 13425.37	133	256	332	414	633	890	945	1240
PURGA 13818.94	133	256	331	414	632	890	942	1240
PURGA 14264.46	132	255	331	414	632	890	943	1240
PURGA 14629.61	132	255	330	414	632	890	943	1239
PURGA 15053.80	132	255	330	413	632	889	942	1236

PURGA 15639.79	130	254	330	411	627	884	934	1228
PURGA 16267.20	128	250	325	410	623	881	929	1223
PURGA 16866.56	128	250	324	411	623	881	930	1222
PURGA 17498.04	127	249	322	404	621	880	929	1196
PURGA 17983.50	114	246	318	394	621	879	926	1312
PURGA 18385.25	114	246	318	387	618	878	927	1278
PURGA 18935.86	113	282	363	430	686	993	1033	1360
PURGA 19586.24	112	282	363	421	674	980	1017	1307
PURGA 19940.56	122	288	374	438	665	971	1011	1299
PURGA 20452.56	107	281	362	415	657	964	1004	1291
PURGA 21320.56	106	281	361	411	649	948	998	1581
PURGA 22015.28	103	281	359	405	638	933	993	1821
PURGA_2 160.50	37	147	186	225	355	506	555	703
PURGA_2 397.50	36	147	186	225	355	506	554	701
PURGA_2 634.50	36	147	186	225	355	505	554	702
PURGA_2 871.50	36	147	186	225	355	505	554	702
PURGA_2 1108.50	36	147	186	225	355	505	554	702
PURGA_2 1345.50	36	147	186	225	355	505	554	702
PURGA_2 1582.50	36	147	185	225	355	505	554	702
PURGA_2 1819.50	36	147	185	225	355	504	554	701
PURGA_2 2056.50	36	147	185	225	355	504	554	701
PURGA_2 2293.50	36	147	185	225	355	505	553	703
PURGA_2 2530.50	36	147	185	225	354	513	557	713
PURGA_2 2767.50	36	147	185	225	354	525	582	777
PURGA_2 2888.00	36	147	185	237	353	1393	1111	1457
PURGA_2 3000.13	36	147	185	232	353	717	766	794
PURGA_2 3220.38	36	147	185	227	353	661	665	824
PURGA_2 3440.63	36	147	185	225	353	559	626	793
PURGA_2 3660.88	36	147	185	225	352	555	634	771
PURGA_2 3881.13	36	147	185	225	352	554	608	742
PURGA_2 4101.38	36	147	185	225	352	534	596	731
PURGA_2 4321.63	36	147	185	225	352	530	581	713
PURGA_2 4541.88	36	147	185	225	352	526	580	711
RAILBRIDGE9 10.00	0	0	0	0	0	0	0	0
RAILNORTH 949.50	4	17	22	25	35	38	40	50
RAILNORTH 1214.98	8	19	23	26	35	38	40	50
RAILNORTH 1399.96	8	19	23	26	35	38	40	50
RAILNORTH 1400.00	8	19	23	26	35	38	40	50
RAILNORTH 1453.14	8	19	23	26	35	38	40	50
RAILNORTH 1810.66	8	19	23	26	35	38	40	50
RAILNORTH 2354.05	0	0	0	0	0	0	3	11
RAILNORTH 2973.38	0	0	0	0	0	0	2	10
RAILNORTH 3574.97	0	0	0	0	0	0	2	8
RAILNORTH 4040.64	0	0	0	0	0	0	2	8
RAILNORTH 4333.07	0	0	0	0	1	1	3	10
RAILNORTH 4469.57	0	0	0	0	1	2	5	12
RAILNORTH 4820.00	18	57	71	85	136	198	228	265
RAILNORTH 7127.50	0	1	1	1	1	2	2	2
RAILNORTH 7689.00	0	1	1	1	1	2	2	2
RAILNORTH 8410.64	0	1	1	1	1	2	2	2
RAILNORTH 8909.14	1	1	1	1	1	2	2	2
RAILNORTH 9149.17	1	1	1	1	1	2	2	2
RAILNORTH 9520.53	0	1	1	1	1	2	2	2
RAILNORTH 9781.72	0	1	1	1	1	2	2	2
RAILNORTH 10084.36	0	1	1	1	1	2	2	2
RAILNORTH 10586.55	0	1	1	1	1	2	2	2
RAILNORTH 11087.73	0	1	1	1	1	1	2	2
RAILNORTH 11379.68	1	1	1	1	1	1	2	2
RAILNORTH 11671.50	1	1	1	1	1	1	1	2
RAILNORTH 12176.50	0	0	0	0	0	1	1	2
RAILNORTH 12929.00	0	0	0	0	0	1	1	2
RAILNORTH 13668.00	0	0	0	0	0	1	1	2
RAILNORTH 14248.00	0	0	0	0	0	1	1	3
RAILNORTH 14678.00	0	0	0	0	0	0	0	1
RAILNORTH 14783.00	0	0	0	0	0	0	0	1
RAILNORTH 14848.00	0	0	0	0	0	0	0	1

RAILNORTH 15543.00	0	0	0	0	0	0	0	0
RAILSOUTH 949.50	10	39	49	60	102	163	192	229
RAILSOUTH 1215.00	10	39	49	60	101	163	192	228
RAILSOUTH 1453.16	10	38	49	60	101	163	193	227
RAILSOUTH 1810.66	10	38	49	60	101	163	193	227
RAILSOUTH 2354.05	19	57	71	86	136	201	229	267
RAILSOUTH 2973.38	18	57	71	85	136	201	229	266
RAILSOUTH 3574.97	18	57	71	85	136	201	229	265
RAILSOUTH 4040.64	18	57	71	85	136	200	229	265
RAILSOUTH 4333.07	18	57	71	85	136	200	228	264
RAILSOUTH 4469.57	18	57	71	85	136	199	228	263
RAILSOUTH 7127.50	31	110	139	168	268	382	437	510
RAILSOUTH 7689.00	31	110	139	168	266	383	437	563
RAILSOUTH 8178.00	29	105	137	168	269	400	476	2130
RAILSOUTH 8556.64	94	309	416	495	981	1051	1559	2316
RAILSOUTH 8909.14	94	311	420	495	983	1051	1467	2397
RAILSOUTH 9149.17	94	311	411	496	1026	1051	1487	2447
RAILSOUTH 9520.53	94	309	562	547	1026	1051	1405	2450
RAILSOUTH 9781.72	94	309	1651	3094	4577	4321	4141	4450
RAILSOUTH 10084.36	94	309	530	581	1157	1051	1431	2502
RAILSOUTH 10586.55	94	309	562	581	1116	1147	1718	2762
RAILSOUTH 11087.73	94	309	721	727	1219	1161	1397	2708
RAILSOUTH 11379.68	94	309	630	640	1470	1268	1683	2733
RAILSOUTH 11671.77	94	309	571	832	1956	1585	2240	2785
RAILSOUTH 12063.27	94	309	561	859	1956	1684	2149	2803
RAILSOUTH 12276.50	78	168	245	424	979	856	1218	1449
RAILSOUTH 12400.00	101	168	227	314	452	514	1011	1436
RAILSOUTH 12939.00	78	168	231	333	632	556	664	1088
RAILSOUTH 13668.00	78	168	331	358	453	480	701	1188
RAILSOUTH 14248.00	50	62	79	78	88	88	102	620
RAILSOUTH 14678.00	50	62	75	76	84	86	92	620
RAILSOUTH 14763.00	50	62	74	76	84	86	92	616
RAILSOUTH 14848.00	50	62	74	75	84	86	92	612
RAILSOUTH 15543.00	50	61	69	72	82	85	90	572
REEDY 1135.50	6	8	10	13	27	42	48	58
REEDY 1406.50	6	8	10	13	27	40	46	55
REEDY 1768.50	6	8	10	13	26	39	44	53
REEDY 2067.00	6	8	10	12	25	38	43	51
SAND 10160.00	5	11	14	17	36	56	64	75
SAND 10420.00	5	11	14	17	37	55	63	74
SAND 10720.00	5	12	15	18	40	59	66	79
SAND 10980.00	5	13	16	19	42	62	73	83
SAND 11051.00	5	13	16	19	42	62	73	82
SAND 11151.00	5	13	16	19	42	61	73	82
SAND 11379.00	5	13	16	19	41	62	73	82
SAND 11529.00	6	14	17	20	48	89	104	105
SAND 11650.00	6	14	17	20	43	65	75	86
SAND 11879.00	6	15	19	22	48	71	83	96
SAND 12009.00	6	15	19	22	48	71	84	96
SAND 12070.00	7	16	19	23	49	73	91	98
SAND 12280.00	6	16	19	23	49	73	92	98
SAND 12565.00	6	16	19	23	49	72	92	98
SAND 12855.00	7	17	21	25	53	79	95	106
SAND 13170.00	7	17	21	25	53	79	95	105
SAND 13570.00	7	18	22	26	55	81	114	109
SAND 14020.00	8	21	26	31	66	97	129	130
SAND 14420.00	8	21	26	31	65	97	126	129
SAND 14660.00	8	21	26	31	65	97	126	129
SAND 14720.00	8	21	26	31	65	97	126	129
SAND 14780.00	8	21	26	31	65	97	126	129
SAND 15020.00	8	21	26	31	65	97	126	129
SAND 15420.00	8	21	26	31	65	97	126	129
SAND 15806.00	8	21	26	31	65	97	126	129
SAND 16178.00	8	21	26	31	65	97	126	129
SAND 16542.50	8	21	26	31	65	97	126	129
SAND 16899.50	8	21	26	31	65	97	126	129

SAND 17256.50	8	21	26	31	65	97	126	129
SAND 17654.17	8	21	26	31	65	97	126	129
SAND 18092.50	8	21	26	31	65	97	126	129
SAND 18530.83	8	21	26	31	65	97	126	129
SAND 18972.86	8	21	26	31	65	97	126	129
SAND 19418.57	8	21	26	31	65	97	126	129
SAND 19864.29	8	21	26	31	65	97	126	129
SAND 20310.00	8	21	26	31	65	97	126	129
SAND 20755.71	8	21	26	31	65	97	126	129
SAND 21201.43	8	21	26	31	65	97	126	129
SAND 21647.14	8	21	26	31	65	97	126	129
SAND 22070.00	8	21	26	31	65	97	126	129
SAND 22470.00	8	21	26	31	65	97	126	129
SAND 22870.00	8	21	26	31	65	97	126	129
SAND 23205.00	8	21	26	31	65	97	126	129
SAND 23475.00	8	21	26	31	65	97	126	129
SAND 23755.00	8	21	26	31	65	97	126	129
SCH 10170.00	3	8	10	13	29	44	48	59
SCH 10570.00	3	8	10	13	29	44	47	59
SCH 10805.00	3	8	10	13	28	44	47	59
SCH 10960.00	3	8	10	13	28	44	47	59
SCH 11246.40	5	16	19	24	52	80	84	108
SCH 11496.40	5	17	20	25	53	82	86	112
SCH 11748.50	5	17	20	25	53	82	86	112
SCH 11907.00	5	17	20	25	53	82	86	111
SCH 12047.00	5	17	20	25	53	82	86	111
SCH 12227.00	7	20	24	29	62	96	101	129
SCH 12361.00	7	20	24	29	62	96	100	124
SCH 12449.00	7	20	24	29	63	96	100	122
SCH 12634.20	6	20	24	29	63	96	99	118
SCH 12932.80	6	20	24	29	62	95	99	112
SCH 13134.50	7	21	26	31	66	95	99	112
SCH 13403.75	7	21	26	31	66	95	99	112
SCH 13677.75	7	21	25	31	65	95	99	112
SCH 13757.30	7	21	25	31	65	95	99	112
SCH 13864.60	7	21	25	31	65	95	99	112
SIX 9795.00	7	21	27	33	72	95	99	112
SIX 10185.00	7	21	26	32	72	111	128	150
SIX 10337.50	7	21	26	32	72	111	128	149
SIX 10377.00	7	21	26	32	73	111	128	149
SIX 10420.00	7	21	26	32	72	111	128	149
SIX 10690.00	7	21	26	32	72	112	129	149
SIX 11137.50	8	22	27	34	75	117	149	148
SIX 11462.50	9	25	31	38	84	129	153	158
SIX 11620.00	11	31	39	47	104	156	180	201
SIX 11720.00	11	31	39	47	104	156	179	201
SIX 11785.00	11	31	39	54	104	155	179	200
SIX 11835.00	11	32	39	47	103	155	179	199
SIX 11940.00	11	32	39	47	102	155	178	195
SIX 12240.00	11	32	39	47	102	155	176	192
SIX 12720.00	13	35	44	52	113	172	183	220
SIX 13295.00	15	40	50	60	128	196	205	256
SIX 13832.50	15	40	49	59	126	190	198	248
SIX 14257.50	14	40	49	59	122	186	192	239
SIX 14635.00	14	39	49	58	123	185	189	234
SIX 14985.00	14	40	50	60	124	182	196	232
SIX 15370.00	14	41	53	63	115	169	183	222
SIX 15740.00	13	41	52	62	111	164	179	219
SIX 16090.00	12	43	55	65	112	165	182	222
SIX 16370.00	12	43	54	65	111	165	182	222
SIX 16595.00	13	44	57	68	113	167	183	227
SIX 16930.00	13	45	58	69	115	169	184	229
SIX 17205.00	13	45	58	69	115	169	183	229
SIX 17400.00	13	46	59	70	116	169	185	230
SIX 17730.00	13	46	59	70	116	169	185	230
SIX 18100.00	13	46	59	70	116	168	185	229

SIX 18495.00	13	47	60	72	118	169	188	229
SIX 18845.00	13	47	60	72	118	168	186	224
SIX 19070.00	13	47	60	71	118	167	186	223
SIX 19270.00	13	48	63	74	122	169	194	231
SIX 19510.00	13	48	63	74	122	169	193	230
SIX 19720.00	13	48	62	72	122	168	193	229
SIX 19850.00	14	49	64	74	124	170	197	234
SIX 19935.00	15	49	64	74	124	169	197	233
SIX 20070.00	17	49	63	73	124	169	196	232
SIX 20150.00	18	51	64	74	125	171	198	235
SIX 20197.50	19	58	64	73	125	171	198	235
SMALL 1114.00	7	10	11	13	21	30	35	41
SMALL 1242.50	7	9	11	13	21	30	34	40
SMALL 1333.00	7	9	11	13	21	30	33	39
SMALL 1539.50	7	9	10	12	20	29	33	38
SMALL 1779.00	10	13	15	18	33	48	55	64
SMALL 1939.00	10	13	15	19	32	47	53	62
SMALL 2059.00	10	13	15	19	35	45	54	61
WARRILL 516.72	171	485	715	863	1425	1790	1839	2189
WARRILL 1728.77	171	485	715	863	1425	1790	1839	2189
WARRILL 2434.10	170	483	715	958	1402	1851	1894	2122
WARRILL 2966.30	170	483	715	859	1296	1922	1944	2092
WARRILL 3493.49	170	482	714	858	1288	1883	1882	2072
WARRILL 3590.99	171	482	714	858	1288	1877	1902	2073
WARRILL 4231.19	171	482	714	858	1288	1904	1906	2100
WARRILL 4788.90	169	483	827	859	1288	3212	3304	3395
WARRILL 5597.98	188	533	804	999	1503	2197	2261	2569
WARRILL 6402.07	187	533	804	999	1503	2196	2172	2535
WARRILL 6759.17	187	533	804	999	1503	2219	2192	2534
WARRILL 7121.27	187	533	804	999	1503	2201	2185	2518
WARRILL 7822.70	187	533	803	999	1503	2193	2183	2516
WARRILL 9205.55	185	528	780	1169	1584	2226	2358	2555
WARRILL 10419.36	185	528	769	1149	1528	2199	2291	2523
WARRILL 11260.87	185	527	769	1110	1505	2141	2212	2517
WARRILL 11589.99	185	527	769	1108	1505	2142	2215	2517
WARRILL 11956.24	184	527	769	1106	1505	2140	2215	2517
WARRILL 12625.38	184	527	768	1088	1504	2091	2169	2517
WARRILL 13199.09	184	527	768	1053	1504	2073	2160	2516
WARRILL 13588.18	183	527	768	1051	1504	2074	2153	2516
WARRILL 13933.74	183	526	768	1050	1503	2075	2149	2516
WARRILL 14685.00	183	526	768	1047	1504	2075	2153	2516
WARRILL 15464.29	182	525	767	1036	1503	2076	2155	2516
WARRILL 16008.97	186	539	782	1084	1570	2194	2271	2798
WARRILL 16755.14	183	537	779	1027	1570	2186	2258	2797
WARRILL 17710.47	183	537	779	1025	1570	2184	2261	2798
WARRILL 18471.75	186	545	787	1042	1618	2263	2341	3009
WARRILL 18939.93	185	545	786	1033	1618	2259	2342	3010
WARRILL 19446.27	185	544	786	1028	1618	2262	2342	3011
WARRILL 19953.37	184	544	786	1025	1618	2266	2341	3010
WARRILL 20436.06	184	544	786	1025	1618	2410	2537	3011
WARRILL 20836.16	184	544	786	1024	1618	2291	2502	3011
WARRILL 21408.97	184	543	786	1024	1618	2267	2426	3013
WARRILL 22522.48	184	543	786	1024	1618	2267	2804	3427
WARRILL 23449.07	186	546	792	1042	1670	2329	2371	3183
WARRILL 23914.04	185	545	792	1042	1670	2297	2313	2969
WARRILL 24353.37	185	545	792	1042	1670	2285	2302	2959
WARRILL 24814.29	185	545	792	1042	1669	2281	2300	2955
WARRILL 25379.28	185	545	792	1042	1670	2274	2298	2949
WARRILL 25720.00	185	545	804	1048	1682	2273	2298	3137
WARRILL 25974.68	185	545	793	1041	1670	2273	2297	2944
WARRILL 26456.35	185	545	792	1042	1669	2270	2293	2937
WARRILL 27004.35	185	545	792	1041	1668	2268	2288	2929
WARRILL 27594.35	185	544	791	1041	1668	2266	2286	2914
WARRILL 28180.35	185	544	791	1041	1669	2264	2284	2909
WARRILL 28869.85	185	545	792	1043	1673	2268	2286	2911
WARRILL 29550.85	185	545	792	1043	1675	2261	2277	2877

WARRILL 30006.85	185	545	792	1043	1675	2253	2268	2667
WARRILL 30525.35	185	546	793	1043	1677	2191	2199	2529
WARRILL 31029.85	209	629	847	1255	2134	2691	2899	3880
WARRILL 31349.85	209	629	847	1253	2133	2685	2891	3872
WARRILL 31774.85	209	629	848	1249	2132	2672	2873	3854
WARRILL 32153.85	209	630	850	1248	2134	2666	2866	3847
WARRILL 32459.35	209	630	850	1246	2133	2659	2855	3833
WARRILL 32942.35	209	630	851	1243	2131	2646	2831	3815
WARRILL 33555.35	209	627	858	1233	2126	2621	2789	3789
WARRILL-BOONAH 881.95	34	123	166	204	291	418	484	571
WARRILL-BOONAH 2267.55	34	123	166	205	291	418	483	570
WARRILL-BOONAH 3078.10	34	123	166	205	291	418	483	569
WARRILL-BOONAH 3392.50	34	123	166	204	291	442	500	569
WARRILL-BOONAH 3950.52	34	123	166	204	291	418	483	570
WARRILL-BOONAH 5122.33	34	123	166	204	291	419	484	570
WARRILL-BOONAH 6096.17	34	123	166	204	290	431	484	570
WARRILL-BOONAH 6871.93	34	123	166	204	291	435	484	570
WARRILL-BOONAH 7759.10	34	123	166	204	291	423	484	570
WARRILL-BOONAH 8660.16	34	123	166	204	291	431	484	571
WARRILL-BOONAH 9855.94	34	123	166	204	291	418	484	570
WARRILL-BOONAH 11335.75	34	123	166	204	291	421	483	570
WARRILL-BOONAH 12618.46	34	123	166	204	290	418	482	568
WARRILL-BOONAH 13821.96	34	123	166	204	291	418	482	568
WARRILL-BOONAH 14671.40	34	123	166	204	291	418	482	568
WARRILL-BOONAH 15431.91	34	123	166	204	291	418	482	568
WARRILL-BOONAH 15989.89	34	123	166	204	291	418	482	568
WARRILL-BOONAH 16606.35	34	123	166	204	290	418	482	568
WARRILL-BOONAH 17763.03	34	123	166	204	290	418	482	568
WARRILL-BOONAH 18604.66	35	123	166	208	292	440	483	569
WARRILL-BOONAH 19171.36	63	239	353	430	608	906	1021	1198
WARRILL-BOONAH 19451.64	63	430	700	846	1102	1703	1547	1701
WARRILL-BOONAH 20226.62	173	516	709	860	1418	1808	1914	2227
WARRILL-BOONAH 21731.54	173	515	704	856	1416	1818	1890	2219
WARRILL-BOONAH 22767.29	173	515	705	856	1415	1819	1890	2213
WARRILL-BOONAH 23556.68	173	515	703	855	1410	1804	1928	2214
WARRILL-BOONAH 24590.68	173	515	703	855	1409	1801	1893	2211
WARRILL-BOONAH 25718.40	175	537	742	934	1549	1981	2096	2472
WARRILL-BOONAH 26310.71	174	508	726	877	1479	1866	1917	2277
WARRILL-BOONAH 27226.09	172	485	715	863	1425	1791	1840	2189
WARRILL-BOONAH 28624.97	172	485	715	863	1425	1791	1840	2189
WARRILL-BOONAH 29954.24	171	485	715	863	1425	1791	1839	2189
WARRILL-BOONAH 30805.00	171	485	715	863	1425	1790	1839	2189
WESTBREM1 10.00	16	142	190	293	531	583	982	1384
WESTBREM2 10.00	28	106	236	236	367	394	578	627
WESTBREM3 10.00	0	0	0	0	0	0	6	10
WESTERN 247.00	14	56	70	85	137	201	233	280
WESTERN 671.50	14	56	70	85	137	201	232	279
WESTERN 859.00	14	56	70	85	144	201	232	279
WESTERN 5374.44	18	57	71	85	136	195	224	260
WESTERN 5906.90	18	57	71	85	136	196	224	261
WESTERN 6517.88	31	112	141	170	269	384	439	512
WESTERN 6898.85	31	112	141	170	269	384	439	511
WOOG 10225.00	36	112	139	166	296	436	496	581
WOOG 10690.00	36	112	138	166	295	435	496	580
WOOG 11040.00	36	112	138	166	295	435	495	580
WOOG 11340.00	36	112	138	166	295	434	494	580
WOOG 11780.00	36	111	138	166	294	432	493	579
WOOG 12080.00	36	110	138	165	293	431	491	576
WOOG 12375.00	35	110	138	165	293	430	490	574
WOOG 12775.00	36	116	146	176	299	443	504	593
WOOG 13000.00	36	116	146	175	298	442	503	592
WOOG 13160.00	36	117	147	176	299	442	505	592
WOOG 13380.00	36	117	147	176	298	439	503	591
WOOG 13530.00	36	117	147	176	297	438	501	590
WOOG 13595.00	36	117	146	176	297	438	501	589
WOOG 13720.00	36	116	146	176	297	438	500	588

WOOG 13897.50	36	116	146	176	297	438	500	587
WOOG 14032.50	36	116	146	176	297	438	500	587
WOOG 14085.00	36	116	146	176	297	438	500	587
WOOG 14140.00	36	116	146	176	297	438	500	587
WOOG 14315.00	36	116	146	175	297	438	500	586
WOOG 14620.00	36	116	146	175	295	435	499	585
WOOG 14820.00	36	116	146	175	295	435	498	585
WOOG 14900.00	36	116	146	175	295	435	498	585
WOOG 15000.00	36	118	148	178	299	436	498	586
WOOG 15100.00	36	118	148	178	299	436	498	586
WOOG 15190.00	36	118	148	178	299	436	497	585
WOOG 15265.00	36	118	148	178	299	436	497	585
WOOG 15335.00	36	118	148	178	299	436	496	585
WOOG 15420.00	36	118	148	178	299	436	496	583
WOOG 15495.00	36	118	148	178	299	436	496	582
WOOG 15560.00	36	118	148	178	299	436	495	581
WOOG 15660.00	36	118	148	178	298	435	495	578
WOOG 15760.00	36	118	148	178	298	435	494	577
WOOG 15820.00	36	118	149	179	299	434	495	576
WOOG 15850.00	36	118	149	179	299	434	495	576
WOOG 15910.00	36	118	149	179	299	433	494	575
WOOG 15975.00	36	118	149	179	298	431	493	573
WOOG 16000.00	36	118	149	179	298	431	492	572
WOOG 16067.50	36	118	149	179	297	431	491	572
WOOG 16137.50	36	118	149	179	297	430	489	569
WOOG 16212.50	36	118	149	179	297	430	489	569
WOOG 16357.50	36	118	149	179	297	430	489	568
WOOG 16520.00	36	118	149	178	295	426	485	560
WOOG 16650.00	36	118	149	178	294	423	482	555
WOOG 16775.00	36	118	149	178	293	421	478	550
WOOG 16875.00	36	118	148	178	292	419	476	544
WOOG 16975.00	36	118	148	178	292	419	476	544
WOOG 17087.50	36	118	148	178	291	419	476	541
WOOG 17200.00	36	118	149	178	291	418	476	541
WOOG 17292.50	36	118	149	177	291	419	475	540
WOOG 17340.00	36	120	153	183	297	422	475	545
WOOG 17405.00	36	120	154	183	299	421	475	544
WOOG 17450.00	36	120	155	183	292	421	803	544
WOOG 17480.00	36	120	154	182	296	420	475	544
WOOG 17525.00	36	120	153	182	297	420	474	544
WOOG 17565.00	36	120	153	182	295	418	474	543
WOOG 17590.00	36	120	153	182	293	417	473	542
WOOG 17607.50	36	120	153	182	293	417	473	542
WOOG 17682.50	36	120	153	182	295	417	473	542
WOOG 17755.00	36	120	153	182	295	435	514	541
WOOG 17770.00	36	120	153	182	295	492	658	560
WOOG 17865.00	36	120	152	181	295	419	473	540
WOOG 17955.00	36	120	152	181	295	418	472	540
WOOG 18105.00	36	120	152	181	295	417	472	540
WOOG 18375.00	36	120	152	180	295	417	475	542
WOOG 18625.00	36	120	152	179	295	416	475	542
WOOG 18825.00	36	120	152	178	295	416	475	541
WOOG 18987.50	36	120	151	177	295	416	474	540

Appendix H Maximum Average Velocities – Design

Appendix H Maximum Average Velocity - Design

Flowpath/Chainage	Velocity (m/s) for ARI							
	2 Years	5 Years	10 Years	20 Years	50 Years	100 Years	200 Years	500 Years
BNE 964170.00 Velocity	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7
BNE 965390.00 Velocity	1.0	1.2	1.4	1.5	1.7	1.7	1.9	1.9
BNE 966610.00 Velocity	0.8	1.1	1.5	1.7	1.8	2.0	2.1	2.2
BNE 967010.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.7	1.9	1.9
BNE 967410.00 Velocity	0.5	0.7	1.0	1.2	1.4	1.6	1.7	1.7
BNE 968600.00 Velocity	0.5	0.8	1.1	1.3	1.5	1.7	1.8	1.9
BNE 969790.00 Velocity	0.6	0.9	1.2	1.5	1.7	1.9	2.0	2.1
BNE 970475.00 Velocity	0.6	0.9	1.2	1.5	1.7	1.9	2.0	2.1
BNE 971160.00 Velocity	0.6	0.9	1.2	1.5	1.8	1.9	2.0	2.1
BNE 971710.00 Velocity	0.7	1.0	1.3	1.5	1.7	1.9	2.0	2.0
BNE 972260.00 Velocity	1.1	1.2	1.6	1.8	1.7	1.9	2.0	2.0
BNE 972760.00 Velocity	0.5	0.7	1.0	1.1	1.3	1.5	1.6	1.6
BNE 973260.00 Velocity	0.4	0.6	0.8	0.9	1.1	1.2	1.3	1.3
BNE 973920.00 Velocity	0.5	0.7	1.0	1.1	1.3	1.4	1.5	1.6
BNE 974580.00 Velocity	0.7	1.0	1.3	1.5	1.7	1.8	1.9	1.9
BNE 975300.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.7	1.9	1.9
BNE 976020.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.7	1.8	1.9
BNE 976385.00 Velocity	0.7	1.0	1.1	1.2	1.3	1.4	1.4	1.4
BNE 976750.00 Velocity	0.9	1.2	1.2	1.3	1.3	1.5	1.5	1.5
BNE 977515.00 Velocity	0.8	1.1	1.2	1.3	1.4	1.4	1.5	1.5
BNE 978280.00 Velocity	0.7	1.1	1.4	1.6	1.9	2.0	2.0	2.0
BNE 978893.50 Velocity	0.7	1.0	1.2	1.3	1.5	1.6	1.6	1.7
BNE 979507.00 Velocity	0.7	0.9	1.1	1.1	1.3	1.3	1.4	1.4
BNE 979511.00 Velocity	0.7	0.9	1.0	1.1	1.3	1.3	1.4	1.4
BNE 979515.00 Velocity	0.7	0.9	1.0	1.1	1.3	1.3	1.4	1.4
BNE 979522.50 Velocity	0.7	1.0	1.1	1.2	1.3	1.4	1.4	1.4
BNE 979530.00 Velocity	0.8	1.1	1.2	1.3	1.4	1.5	1.5	1.5
BNE 979930.00 Velocity	0.8	1.0	1.1	1.2	1.3	1.3	1.4	1.4
BNE 980330.00 Velocity	0.8	1.2	1.4	1.3	1.2	1.2	1.3	1.3
BNE 980995.00 Velocity	0.6	0.9	1.1	1.3	1.4	1.4	1.5	1.5
BNE 981660.00 Velocity	0.5	0.9	1.2	1.4	1.7	1.8	1.9	1.9
BNE 982060.00 Velocity	0.5	0.8	1.2	1.4	1.6	1.7	1.8	1.8
BNE 982460.00 Velocity	0.5	0.8	1.1	1.3	1.6	1.7	1.8	1.8
BNE 983310.00 Velocity	0.6	0.9	1.1	1.3	1.5	1.6	1.7	1.7
BNE 984160.00 Velocity	0.6	0.9	1.1	1.2	1.5	1.5	1.6	1.6
BNE 984710.00 Velocity	0.7	0.9	1.2	1.3	1.6	1.6	1.7	1.7
BNE 985260.00 Velocity	0.7	1.0	1.3	1.4	1.7	1.8	1.8	1.9
BNE 985260.00 Velocity	0.7	1.0	1.3	1.4	1.7	1.8	1.8	1.9
BNE 985870.00 Velocity	0.7	1.0	1.3	1.5	1.8	1.9	1.9	2.0
BNE 986480.00 Velocity	0.6	1.0	1.4	1.6	1.9	2.0	2.1	2.1
BNE 987220.00 Velocity	0.5	0.9	1.2	1.4	1.6	1.7	1.7	1.7
BNE 987960.00 Velocity	0.4	0.8	1.0	1.2	1.5	1.5	1.8	1.6
BNE 988060.00 Velocity	0.6	1.0	1.3	1.4	2.5	2.0	2.3	1.9
BNE 988160.00 Velocity	0.8	1.4	1.7	1.9	2.7	2.7	3.1	2.4
BNE 988165.00 Velocity	3.5	4.0	4.0	4.1	8.4	4.7	7.9	4.7
BNE 988170.00 Velocity	1.1	1.4	1.7	2.0	2.6	2.7	3.0	2.4
BNE 988265.00 Velocity	0.9	1.2	1.4	1.6	2.9	2.9	2.5	2.1
BNE 988360.00 Velocity	0.8	1.0	1.5	1.6	2.2	2.3	2.1	1.9
BNE 989030.00 Velocity	0.7	0.9	1.0	1.1	1.4	1.5	1.4	1.4
BNE 989700.00 Velocity	0.7	0.8	0.9	1.0	1.1	1.2	1.2	1.2
BNE 990200.00 Velocity	0.7	0.8	1.0	1.1	1.4	1.4	1.5	1.5
BNE 990700.00 Velocity	0.6	0.9	1.2	1.4	1.7	1.9	1.9	2.0
BNE 990730.00 Velocity	0.6	0.9	1.2	1.4	1.8	1.9	1.9	2.0
BNE 990760.00 Velocity	0.6	0.9	1.3	1.5	1.8	2.0	2.0	2.1
BNE 991235.00 Velocity	0.5	0.7	0.9	1.1	1.3	1.4	1.4	1.5
BNE 991710.00 Velocity	0.5	0.6	0.8	0.9	1.0	1.1	1.1	1.2
BNE 992065.00 Velocity	0.5	0.6	0.8	0.8	1.0	1.1	1.1	1.1
BNE 992420.00 Velocity	0.5	0.6	0.8	0.8	1.0	1.1	1.1	1.1

BNE 992435.00 Velocity	0.5	0.6	0.7	0.8	1.0	1.1	1.1	1.1
BNE 992450.00 Velocity	0.5	0.6	0.8	0.8	1.0	1.1	1.1	1.1
BNE 992460.00 Velocity	1.4	1.4	1.8	1.9	1.3	1.3	1.4	1.4
BNE 992470.00 Velocity	0.6	0.6	0.8	0.8	1.0	1.1	1.1	1.1
BNE 992570.00 Velocity	0.6	0.7	0.9	1.0	1.2	1.3	1.3	1.3
BNE 992670.00 Velocity	0.7	0.9	1.1	1.2	1.5	1.6	1.6	1.6
BNE 993215.00 Velocity	0.7	1.0	1.3	1.4	1.7	1.8	1.8	1.9
BNE 993760.00 Velocity	0.7	1.1	1.5	1.7	2.0	2.1	2.1	2.2
BNE 994260.00 Velocity	0.8	1.0	1.2	1.3	1.5	1.6	1.6	1.7
BNE 994760.00 Velocity	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.3
BNE 994760.00 Velocity	0.8	0.9	1.0	1.1	1.2	1.3	1.3	1.3
BNE 995225.00 Velocity	0.7	0.9	1.1	1.2	1.5	1.5	1.6	1.6
BNE 995690.00 Velocity	0.7	0.9	1.3	1.5	1.8	2.0	2.0	2.1
BNE 996335.00 Velocity	0.7	1.0	1.3	1.5	1.7	1.8	1.9	1.9
BNE 996980.00 Velocity	0.8	1.1	1.3	1.5	1.7	1.7	1.8	1.8
BNE 996980.00 Velocity	0.8	1.1	1.3	1.5	1.7	1.7	1.8	1.8
BNE 997720.00 Velocity	0.6	0.8	0.9	1.1	1.2	1.3	1.3	1.3
BNE 998460.00 Velocity	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0
BNE 998460.00 Velocity	0.5	0.6	0.7	0.8	0.9	1.0	1.0	1.0
BNE 998810.00 Velocity	0.6	0.8	1.0	1.1	1.2	1.3	1.3	1.4
BNE 999160.00 Velocity	0.7	1.1	1.4	1.7	1.8	2.0	2.0	2.1
BNE 999580.00 Velocity	0.5	0.8	1.1	1.3	1.5	1.7	1.7	1.7
BNE 1000000.00 Velocity	0.4	0.7	0.9	1.1	1.3	1.4	1.4	1.5
BNE 1000142.50 Velocity	0.5	0.8	1.1	1.2	1.4	1.6	1.6	1.6
BNE 1000285.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.8	1.8	1.9
BNE 1000285.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.8	1.8	1.9
BNE 1000530.00 Velocity	0.6	0.9	1.2	1.4	1.7	1.9	1.9	2.0
BNE 1000775.00 Velocity	0.6	0.9	1.2	1.4	1.7	2.0	2.0	2.1
BNE 1001045.00 Velocity	0.6	0.9	1.1	1.3	1.4	1.6	1.6	1.7
BNE 1001315.00 Velocity	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.4
BNE 1001315.00 Velocity	0.7	0.9	1.0	1.1	1.2	1.3	1.4	1.4
BNE 1001590.00 Velocity	0.7	1.0	1.2	1.4	1.6	1.7	1.8	1.8
BNE 1001865.00 Velocity	0.7	1.1	1.6	1.9	2.2	2.5	2.5	2.7
BNE 1002107.50 Velocity	0.7	1.1	1.6	1.9	2.2	2.4	2.5	2.6
BNE 1002350.00 Velocity	0.7	1.2	1.6	1.9	2.2	2.4	2.4	2.5
BNE 1002567.50 Velocity	0.7	1.0	1.4	1.6	1.9	2.1	2.1	2.2
BNE 1002785.00 Velocity	0.6	0.9	1.2	1.4	1.7	1.8	1.9	2.0
BNE 1003030.00 Velocity	0.6	1.0	1.3	1.6	1.9	2.1	2.1	2.2
BNE 1003275.00 Velocity	0.6	1.1	1.5	1.8	2.1	2.3	2.4	2.5
BNE 1003525.00 Velocity	0.6	1.0	1.4	1.6	1.9	2.1	2.2	2.2
BNE 1003775.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.9	1.9	2.0
BNE 1004037.50 Velocity	0.6	1.0	1.5	1.7	2.0	2.2	2.3	2.4
BNE 1004300.00 Velocity	0.6	1.1	1.7	2.0	2.4	2.7	2.8	2.9
BNE 1004555.00 Velocity	0.6	1.0	1.4	1.7	2.0	2.2	2.3	2.4
BNE 1004810.00 Velocity	0.5	0.9	1.2	1.4	1.7	1.9	1.9	2.0
BNE 1005067.50 Velocity	0.6	0.9	1.3	1.5	1.6	1.8	1.9	1.9
BNE 1005325.00 Velocity	0.6	1.0	1.3	1.5	1.6	1.7	1.8	1.8
BNE 1005325.00 Velocity	0.6	1.0	1.3	1.5	1.6	1.7	1.8	1.8
BNE 1005597.50 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1005870.00 Velocity	0.7	1.2	1.6	1.7	1.9	2.1	2.1	2.2
BNE 1005870.00 Velocity	1.2	1.6	1.8	1.9	1.9	2.0	2.1	2.1
BNE 1006085.00 Velocity	0.9	1.4	1.6	1.7	1.7	1.9	1.9	1.9
BNE 1006300.00 Velocity	0.8	1.2	1.5	1.6	1.7	1.7	1.8	1.8
BNE 1006300.00 Velocity	0.8	1.2	1.5	1.6	1.7	1.7	1.8	1.8
BNE 1006605.00 Velocity	0.8	1.2	1.5	1.6	1.6	1.7	1.7	1.7
BNE 1006910.00 Velocity	0.7	1.2	1.4	1.5	1.5	1.6	1.7	1.7
BNE 1007160.00 Velocity	0.8	1.2	1.3	1.4	1.4	1.5	1.5	1.5
BNE 1007410.00 Velocity	0.8	1.2	1.2	1.3	1.3	1.4	1.4	1.4
BNE 1007665.00 Velocity	0.9	1.3	1.5	1.5	1.5	1.7	1.7	1.7
BNE 1007920.00 Velocity	1.0	1.5	1.8	2.0	2.0	2.1	2.1	2.2
BNE 1008057.50 Velocity	0.9	1.4	1.7	1.8	1.9	2.0	2.0	2.0
BNE 1008195.00 Velocity	0.8	1.3	1.6	1.7	1.8	1.8	1.9	1.9
BNE 1008195.00 Velocity	0.8	1.3	1.6	1.7	1.8	1.8	1.9	1.9
BNE 1008320.00 Velocity	0.7	1.2	1.5	1.6	1.7	1.8	1.9	1.9
BNE 1008445.00 Velocity	0.7	1.1	1.4	1.6	1.7	1.8	1.8	1.9
BNE 1008685.00 Velocity	0.7	1.1	1.4	1.6	1.7	1.8	1.8	1.9

BNE 1008925.00 Velocity	0.7	1.1	1.4	1.6	1.7	1.8	1.8	1.9
BNE 1008925.00 Velocity	0.7	1.1	1.4	1.6	1.7	1.8	1.8	1.9
BNE 1009162.50 Velocity	0.7	1.1	1.4	1.6	1.7	1.7	1.8	1.8
BNE 1009400.00 Velocity	0.7	1.1	1.4	1.6	1.7	1.7	1.7	1.8
BNE 1009560.00 Velocity	0.7	1.1	1.4	1.6	1.6	1.7	1.8	1.8
BNE 1009720.00 Velocity	0.7	1.1	1.4	1.5	1.6	1.7	1.8	1.8
BNE 1009720.00 Velocity	0.7	1.1	1.4	1.5	1.6	1.7	1.8	1.8
BNE 1010105.00 Velocity	0.7	1.2	1.5	1.7	1.8	1.9	1.9	2.0
BNE 1010490.00 Velocity	0.8	1.3	1.7	1.9	2.0	2.1	2.2	2.2
BNE 1010607.50 Velocity	0.7	1.2	1.6	1.8	1.9	2.0	2.1	2.2
BNE 1010725.00 Velocity	0.6	1.1	1.5	1.6	1.8	1.9	2.0	2.1
BNE 1010852.50 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	2.0	2.1
BNE 1010980.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1011245.00 Velocity	0.7	1.1	1.4	1.5	1.6	1.7	1.7	1.8
BNE 1011510.00 Velocity	0.7	1.0	1.3	1.4	1.5	1.6	1.6	1.7
BNE 1011510.00 Velocity	0.7	1.0	1.3	1.4	1.5	1.6	1.6	1.7
BNE 1011745.00 Velocity	0.7	1.0	1.3	1.3	1.3	1.4	1.4	1.4
BNE 1011980.00 Velocity	0.7	1.0	1.2	1.3	1.3	1.4	1.4	1.4
BNE 1012227.50 Velocity	0.7	1.0	1.2	1.2	1.2	1.3	1.3	1.3
BNE 1012475.00 Velocity	0.7	1.0	1.2	1.2	1.2	1.3	1.3	1.3
BNE 1012475.00 Velocity	0.7	1.0	1.2	1.2	1.2	1.3	1.3	1.3
BNE 1012705.00 Velocity	0.7	1.0	1.3	1.4	1.4	1.4	1.5	1.5
BNE 1012935.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.1
BNE 1013190.00 Velocity	0.7	1.1	1.3	1.5	1.6	1.7	1.7	1.8
BNE 1013445.00 Velocity	0.6	1.0	1.3	1.4	1.5	1.6	1.6	1.6
BNE 1013562.50 Velocity	0.7	1.1	1.4	1.5	1.6	1.7	1.7	1.7
BNE 1013680.00 Velocity	0.7	1.2	1.5	1.6	1.7	1.8	1.8	1.8
BNE 1013680.00 Velocity	0.7	1.2	1.5	1.6	1.7	1.8	1.8	1.8
BNE 1013795.00 Velocity	0.8	1.2	1.6	1.7	1.8	1.9	2.0	2.0
BNE 1013910.00 Velocity	0.9	1.3	1.7	1.8	2.0	2.1	2.1	2.2
BNE 1014110.00 Velocity	0.8	1.3	1.6	1.8	1.9	2.1	2.1	2.2
BNE 1014310.00 Velocity	0.7	1.2	1.6	1.8	1.9	2.0	2.1	2.2
BNE 1014460.00 Velocity	0.8	1.3	1.6	1.8	1.9	2.0	2.1	2.2
BNE 1014610.00 Velocity	0.8	1.3	1.6	1.8	1.9	2.0	2.1	2.2
BNE 1014610.00 Velocity	0.8	1.3	1.6	1.8	1.9	2.0	2.1	2.2
BNE 1014850.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.6	1.7	1.8
BNE 1015090.00 Velocity	0.4	0.8	1.0	1.2	1.3	1.4	1.4	1.5
BNE 1015325.00 Velocity	0.5	0.9	1.2	1.3	1.4	1.5	1.6	1.7
BNE 1015560.00 Velocity	0.6	1.0	1.3	1.5	1.6	1.7	1.7	1.8
BNE 1015705.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.6	1.7	1.7
BNE 1015850.00 Velocity	0.6	1.0	1.3	1.4	1.5	1.6	1.6	1.6
BNE 1015850.00 Velocity	0.6	1.0	1.3	1.4	1.5	1.6	1.6	1.6
BNE 1015995.00 Velocity	0.6	0.9	1.2	1.4	1.4	1.5	1.5	1.6
BNE 1016140.00 Velocity	0.6	0.9	1.2	1.3	1.4	1.4	1.5	1.5
BNE 1016390.00 Velocity	0.7	1.0	1.2	1.3	1.3	1.4	1.4	1.4
BNE 1016640.00 Velocity	0.8	1.1	1.2	1.3	1.3	1.3	1.3	1.4
BNE 1016640.00 Velocity	0.8	1.1	1.2	1.3	1.3	1.3	1.3	1.4
BNE 1016885.00 Velocity	0.9	1.2	1.5	1.6	1.7	1.7	1.7	1.8
BNE 1017130.00 Velocity	0.9	1.4	1.9	2.1	2.3	2.5	2.6	2.7
BNE 1017130.00 Velocity	0.9	1.4	1.9	2.1	2.3	2.5	2.6	2.7
BNE 1017370.00 Velocity	0.8	1.3	1.6	1.8	2.0	2.1	2.2	2.3
BNE 1017610.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1017610.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1017765.00 Velocity	0.7	1.1	1.5	1.7	1.8	2.0	2.0	2.1
BNE 1017920.00 Velocity	0.7	1.2	1.6	1.8	1.9	2.1	2.1	2.3
BNE 1018060.00 Velocity	0.6	1.1	1.3	1.5	1.6	1.7	1.7	1.8
BNE 1018200.00 Velocity	0.6	0.9	1.2	1.3	1.4	1.4	1.5	1.5
BNE 1018462.50 Velocity	0.6	1.0	1.3	1.4	1.5	1.6	1.7	1.7
BNE 1018725.00 Velocity	0.6	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1018910.00 Velocity	0.6	1.0	1.4	1.5	1.7	1.8	1.9	1.9
BNE 1019095.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.8	1.8	1.9
BNE 1019292.50 Velocity	0.6	0.9	1.2	1.4	1.5	1.6	1.6	1.7
BNE 1019490.00 Velocity	0.6	0.9	1.1	1.2	1.4	1.4	1.5	1.5
BNE 1019490.00 Velocity	0.6	0.9	1.1	1.2	1.4	1.4	1.5	1.5
BNE 1019677.50 Velocity	0.6	0.9	1.2	1.4	1.5	1.6	1.6	1.7
BNE 1019865.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.8	1.8	1.9

BNE 1019990.00 Velocity	0.6	0.8	1.1	1.2	1.3	1.4	1.4	1.5
BNE 1020115.00 Velocity	0.5	0.7	0.9	1.0	1.1	1.1	1.1	1.2
BNE 1020320.00 Velocity	0.5	0.6	0.8	0.8	0.9	1.0	1.0	1.0
BNE 1020525.00 Velocity	0.4	0.6	0.7	0.7	0.8	0.8	0.9	0.9
BNE 1020525.00 Velocity	0.4	0.6	0.7	0.7	0.8	0.8	0.9	0.9
BNE 1020677.50 Velocity	0.4	0.6	0.8	0.9	1.0	1.0	1.0	1.1
BNE 1020830.00 Velocity	0.4	0.7	0.9	1.1	1.2	1.3	1.3	1.3
BNE 1020962.50 Velocity	0.5	0.8	1.1	1.2	1.4	1.5	1.5	1.6
BNE 1021095.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.7	1.8	1.9
BNE 1021317.00 Velocity	0.6	1.0	1.2	1.4	1.6	1.6	1.7	1.8
BNE 1021539.00 Velocity	0.6	0.9	1.2	1.3	1.5	1.6	1.6	1.7
BNE 1021627.00 Velocity	0.6	0.9	1.1	1.2	1.4	1.5	1.5	1.6
BNE 1021715.00 Velocity	0.6	0.8	1.1	1.2	1.3	1.4	1.4	1.5
BNE 1021805.00 Velocity	0.5	0.8	1.0	1.2	1.3	1.4	1.4	1.5
BNE 1021895.00 Velocity	0.5	0.8	1.0	1.1	1.3	1.4	1.4	1.5
BNE 1022000.00 Velocity	0.5	0.8	1.1	1.2	1.4	1.5	1.5	1.6
BNE 1022105.00 Velocity	0.5	0.9	1.2	1.3	1.5	1.6	1.7	1.8
BNE 1022340.00 Velocity	0.5	0.9	1.1	1.3	1.5	1.6	1.6	1.7
BNE 1022575.00 Velocity	0.6	0.9	1.1	1.3	1.4	1.5	1.6	1.7
BNE 1022575.00 Velocity	0.6	0.9	1.1	1.3	1.4	1.5	1.6	1.6
BNE 1022807.50 Velocity	0.6	1.0	1.3	1.5	1.6	1.7	1.8	1.8
BNE 1023040.00 Velocity	0.6	1.1	1.5	1.7	1.9	1.9	2.0	2.0
BNE 1023305.00 Velocity	0.6	1.1	1.5	1.6	1.9	2.0	2.0	2.1
BNE 1023570.00 Velocity	0.6	1.1	1.4	1.6	1.9	2.0	2.1	2.1
BNE 1023825.00 Velocity	0.6	1.1	1.4	1.5	1.8	1.9	2.0	2.0
BNE 1024080.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.8	1.9	1.9
BNE 1024080.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.8	1.9	1.9
BNE 1024321.50 Velocity	0.6	1.0	1.3	1.4	1.6	1.7	1.8	1.8
BNE 1024563.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.6	1.7	1.7
BNE 1024563.00 Velocity	0.7	1.0	1.3	1.4	1.6	1.6	1.7	1.7
BNE 1024816.50 Velocity	0.6	0.9	1.2	1.3	1.5	1.6	1.6	1.7
BNE 1025070.00 Velocity	0.6	0.9	1.1	1.3	1.4	1.5	1.6	1.6
BNE 1025215.00 Velocity	0.6	0.9	1.2	1.4	1.5	1.6	1.7	1.7
BNE 1025360.00 Velocity	0.6	1.0	1.3	1.5	1.6	1.7	1.8	1.8
BNE 1025475.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	1.9	2.0
BNE 1025590.00 Velocity	0.7	1.1	1.5	1.7	2.0	2.1	2.1	2.2
BNE 1025590.00 Velocity	0.7	1.1	1.5	1.7	2.0	2.1	2.1	2.2
BNE 1025880.00 Velocity	0.7	1.1	1.4	1.6	1.8	1.9	2.0	2.1
BNE 1026170.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.8	1.9	2.0
BNE 1026425.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.7	1.8	1.9
BNE 1026680.00 Velocity	0.6	1.0	1.2	1.4	1.6	1.7	1.7	1.8
BNE 1026790.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.7	1.8	1.8
BNE 1026900.00 Velocity	0.6	1.0	1.3	1.4	1.6	1.7	1.8	1.9
BNE 1027030.00 Velocity	0.6	1.0	1.3	1.5	1.7	1.9	1.9	2.0
BNE 1027160.00 Velocity	0.6	1.0	1.4	1.6	1.9	2.0	2.1	2.2
BNE 1027420.00 Velocity	0.6	0.9	1.2	1.4	1.6	1.7	1.8	1.8
BNE 1027680.00 Velocity	0.6	0.9	1.1	1.2	1.4	1.5	1.5	1.6
BNE 1027930.00 Velocity	0.6	0.8	1.1	1.2	1.3	1.4	1.5	1.5
BNE 1028180.00 Velocity	0.6	0.8	1.0	1.1	1.3	1.4	1.4	1.5
BNE 1028292.56 Velocity	0.6	0.9	1.1	1.2	1.4	1.5	1.5	1.6
BNE 1028405.13 Velocity	0.6	0.9	1.2	1.3	1.5	1.6	1.6	1.7
BNE 1028405.13 Velocity	0.6	0.9	1.2	1.3	1.5	1.6	1.6	1.7
BNE 1028542.56 Velocity	0.6	1.0	1.3	1.4	1.6	1.7	1.8	1.9
BNE 1028680.00 Velocity	0.7	1.0	1.4	1.5	1.8	1.9	2.0	2.1
BREM 1000000.00 Velocity	0.7	1.3	1.5	1.6	1.8	1.8	1.8	1.8
BREM 1000350.00 Velocity	0.8	1.2	1.4	1.5	1.7	1.7	1.8	1.8
BREM 1000700.00 Velocity	1.1	1.2	1.3	1.4	1.6	1.7	1.7	1.7
BREM 1000910.00 Velocity	1.0	1.0	1.1	1.1	1.3	1.3	1.3	1.3
BREM 1001120.00 Velocity	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
BREM 1001410.00 Velocity	1.1	1.2	1.2	1.3	1.4	1.5	1.5	1.5
BREM 1001700.00 Velocity	1.4	1.8	2.0	2.1	2.4	2.4	2.4	2.5
BREM 1002000.00 Velocity	1.3	1.7	1.8	2.0	2.2	2.3	2.3	2.3
BREM 1002300.00 Velocity	1.2	1.5	1.7	1.9	2.1	2.2	2.2	2.2
BREM 1002500.00 Velocity	1.4	1.8	2.0	2.1	2.4	2.5	2.5	2.5
BREM 1002700.00 Velocity	1.7	2.2	2.3	2.5	2.8	2.9	2.9	2.9
BREM 1002950.00 Velocity	1.7	2.0	2.1	2.2	2.5	2.6	2.6	2.6

BREM 1003200.00 Velocity	1.6	1.9	1.9	2.0	2.2	2.4	2.4	2.4
BREM 1003200.00 Velocity	1.6	1.9	1.9	2.0	2.2	2.4	2.4	2.4
BREM 1003450.00 Velocity	2.2	2.4	2.4	2.4	2.5	2.5	2.5	2.4
BREM 1003700.00 Velocity	3.8	3.9	3.9	4.0	3.9	3.9	3.8	3.7
BREM 1003770.00 Velocity	3.1	3.2	3.2	3.2	3.3	3.2	3.1	3.1
BREM 1003840.00 Velocity	2.6	2.7	2.7	2.7	2.8	2.7	2.7	2.6
BREM 1003840.00 Velocity	2.6	2.7	2.7	2.7	2.8	2.7	2.7	2.6
BREM 1003995.00 Velocity	1.9	2.0	2.1	2.1	2.1	2.2	2.2	2.2
BREM 1004150.00 Velocity	1.5	1.7	1.7	1.7	1.9	2.1	2.1	2.1
BREM 1004235.00 Velocity	1.6	1.8	1.9	1.9	2.1	2.3	2.3	2.3
BREM 1004320.00 Velocity	1.7	2.0	2.0	2.1	2.4	2.5	2.6	2.6
BREM 1004320.00 Velocity	1.7	2.0	2.0	2.1	2.2	2.3	2.3	2.4
BREM 1004455.00 Velocity	2.0	2.3	2.3	2.4	2.7	2.7	2.8	2.8
BREM 1004590.00 Velocity	2.5	2.7	2.7	2.9	3.3	3.3	3.4	3.5
BREM 1004600.00 Velocity	2.9	2.9	3.1	3.1	3.2	3.3	3.3	3.4
BREM 1004610.00 Velocity	2.6	2.7	3.0	3.3	3.7	3.7	3.8	3.9
BREM 1004655.00 Velocity	2.5	2.6	2.8	2.8	2.9	3.0	3.0	3.0
BREM 1004700.00 Velocity	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.6
BREM 1004700.00 Velocity	2.5	2.5	2.6	2.7	2.7	2.8	2.8	2.8
BREM 1004920.00 Velocity	1.6	1.9	2.1	2.1	2.2	2.2	2.3	2.3
BREM 1005140.00 Velocity	1.2	1.5	1.7	1.9	2.2	2.3	2.3	2.3
BREM 1005330.00 Velocity	1.3	1.7	1.9	2.1	2.5	2.6	2.6	2.6
BREM 1005520.00 Velocity	1.5	1.9	2.2	2.5	3.0	3.1	3.1	3.1
BREM 1005630.00 Velocity	1.4	1.7	1.9	2.1	2.4	2.5	2.6	2.6
BREM 1005740.00 Velocity	1.3	1.5	1.7	1.8	2.1	2.1	2.2	2.2
BREM 1005915.00 Velocity	1.7	2.0	2.2	2.4	2.7	2.8	2.8	2.9
BREM 1006090.00 Velocity	2.4	2.8	3.2	3.5	3.9	4.1	4.1	4.2
BREM 1006170.00 Velocity	1.5	1.8	2.0	2.2	2.5	2.6	2.6	2.6
BREM 1006250.00 Velocity	1.1	1.3	1.5	1.6	1.8	1.9	1.9	1.9
BREM 1006370.00 Velocity	1.5	1.7	1.8	2.0	2.3	2.4	2.4	2.4
BREM 1006490.00 Velocity	2.3	2.4	2.5	2.7	3.0	3.2	3.2	3.2
BREM 1006500.00 Velocity	2.4	2.6	2.7	2.8	3.2	3.4	3.4	3.4
BREM 1006510.00 Velocity	2.3	2.5	2.5	2.7	3.1	3.2	3.2	3.2
BREM 1006645.00 Velocity	2.1	2.4	2.3	2.4	2.5	2.5	2.5	2.6
BREM 1006780.00 Velocity	2.0	2.3	2.3	2.3	2.4	2.3	2.3	2.3
BREM 1007110.00 Velocity	2.0	2.3	2.3	2.3	2.5	2.6	2.6	2.7
BREM 1007440.00 Velocity	2.1	2.4	2.6	2.8	3.4	3.5	3.5	3.5
BREM 1007570.00 Velocity	1.6	2.0	2.2	2.5	2.9	3.0	3.0	3.0
BREM 1007700.00 Velocity	1.2	1.8	2.0	2.2	2.5	2.6	2.6	2.6
BREM 1007850.00 Velocity	1.4	1.8	2.0	2.2	2.5	2.6	2.6	2.6
BREM 1008000.00 Velocity	1.6	1.8	2.0	2.2	2.5	2.6	2.6	2.7
BREM 1008000.00 Velocity	1.6	1.8	2.0	2.2	2.5	2.6	2.6	2.6
BREM 1008195.00 Velocity	1.7	1.9	2.1	2.3	2.5	2.6	2.6	2.7
BREM 1008390.00 Velocity	1.8	2.1	2.3	2.4	2.6	2.7	2.7	2.8
BREM 1008400.00 Velocity	1.9	2.2	2.4	2.6	2.7	2.8	2.8	2.8
BREM 1008410.00 Velocity	1.9	2.1	2.3	2.5	2.7	2.7	2.8	2.8
BREM 1008415.00 Velocity	1.6	2.0	2.2	2.4	2.7	2.7	2.7	2.8
BREM 1008420.00 Velocity	1.4	1.9	2.1	2.3	2.7	2.7	2.7	2.8
BREM 1008540.00 Velocity	1.5	2.0	2.2	2.4	2.8	2.9	2.9	2.9
BREM 1008660.00 Velocity	1.7	2.2	2.4	2.6	3.0	3.0	3.1	3.1
BREM 1008935.00 Velocity	1.4	1.9	2.0	2.2	2.6	2.7	2.7	2.7
BREM 1009210.00 Velocity	1.2	1.6	1.8	2.0	2.4	2.4	2.4	2.5
BREM 1009442.50 Velocity	1.0	1.4	1.6	1.8	2.2	2.2	2.3	2.3
BREM 1009675.00 Velocity	0.9	1.2	1.4	1.6	2.0	2.1	2.1	2.1
BREM 1009675.00 Velocity	0.9	1.2	1.4	1.6	2.0	2.1	2.1	2.1
BREM 1009765.50 Velocity	1.0	1.4	1.6	1.8	2.2	2.3	2.3	2.3
BREM 1009856.00 Velocity	1.2	1.6	1.8	1.9	2.4	2.4	2.5	2.5
BREM 1009856.00 Velocity	1.2	1.6	1.8	1.9	2.4	2.4	2.5	2.5
BREM 1009938.00 Velocity	1.5	1.9	2.0	2.1	2.6	2.7	2.7	2.7
BREM 1010020.00 Velocity	1.9	2.2	2.3	2.4	2.9	3.0	3.0	3.0
BREM 1010150.00 Velocity	1.4	1.8	1.9	2.0	2.3	2.4	2.4	2.4
BREM 1010280.00 Velocity	1.1	1.5	1.6	1.7	2.0	2.0	2.0	2.0
BREM 1010490.00 Velocity	1.0	1.4	1.6	1.7	2.1	2.1	2.1	2.1
BREM 1010700.00 Velocity	1.0	1.4	1.6	1.8	2.2	2.2	2.3	2.3
BREM 1010795.00 Velocity	1.2	1.6	1.8	2.0	2.4	2.5	2.5	2.5
BREM 1010890.00 Velocity	1.4	1.9	2.0	2.2	2.7	2.8	2.8	2.8

BREM 1011105.00 Velocity	1.4	1.8	1.8	2.0	2.3	2.3	2.3	2.4
BREM 1011320.00 Velocity	1.4	1.7	1.7	1.8	2.0	2.0	2.0	2.0
BREM 1011510.00 Velocity	1.4	1.9	1.9	2.1	2.4	2.4	2.5	2.5
BREM 1011700.00 Velocity	1.5	2.1	2.3	2.5	3.1	3.2	3.3	3.3
BREM 1011745.00 Velocity	1.5	2.1	2.3	2.6	3.2	3.2	3.3	3.3
BREM 1011790.00 Velocity	1.6	2.2	2.3	2.6	3.2	3.2	3.3	3.3
BREM 1011800.00 Velocity	1.6	2.2	2.4	2.7	3.3	3.4	3.4	3.4
BREM 1011810.00 Velocity	1.6	2.2	2.3	2.6	3.2	3.3	3.3	3.4
BREM 1011930.00 Velocity	1.2	1.7	1.9	2.1	2.6	2.6	2.7	2.7
BREM 1012050.00 Velocity	1.0	1.4	1.5	1.7	2.1	2.2	2.2	2.2
BREM 1012060.00 Velocity	1.1	1.5	1.6	1.8	2.2	2.3	2.3	2.3
BREM 1012070.00 Velocity	1.0	1.4	1.5	1.7	2.1	2.2	2.2	2.3
BREM 1012135.00 Velocity	1.2	1.6	1.8	2.0	2.4	2.5	2.5	2.5
BREM 1012200.00 Velocity	1.4	1.9	2.0	2.3	2.8	2.8	2.9	2.9
BREM 1012535.00 Velocity	1.1	1.4	1.5	1.6	2.0	2.1	2.1	2.2
BREM 1012870.00 Velocity	0.8	1.1	1.1	1.3	1.6	1.7	1.7	1.7
BREM 1013125.00 Velocity	1.0	1.3	1.4	1.5	1.8	1.9	1.9	1.9
BREM 1013380.00 Velocity	1.3	1.8	1.8	1.9	2.2	2.2	2.2	2.3
BREM 1013540.00 Velocity	1.3	1.7	1.7	1.8	2.0	2.1	2.1	2.1
BREM 1013700.00 Velocity	1.4	1.6	1.7	1.7	1.9	1.9	1.9	2.0
BREM 1013960.00 Velocity	1.4	1.8	1.8	1.9	2.3	2.3	2.3	2.4
BREM 1014220.00 Velocity	1.5	2.0	2.1	2.3	2.8	2.9	2.9	3.0
BREM 1014430.00 Velocity	1.4	1.9	2.0	2.2	2.8	2.8	2.9	2.9
BREM 1014640.00 Velocity	1.3	1.8	1.9	2.2	2.7	2.8	2.8	2.8
BREM 1014910.00 Velocity	1.3	1.9	2.0	2.3	2.9	2.9	3.0	3.0
BREM 1015180.00 Velocity	1.4	2.1	2.2	2.5	3.1	3.1	3.1	3.2
BREM 1015312.50 Velocity	1.4	1.9	2.0	2.2	2.7	2.7	2.7	2.8
BREM 1015445.00 Velocity	1.3	1.8	1.8	2.0	2.4	2.4	2.4	2.5
BREM 1015445.00 Velocity	1.3	1.8	1.8	2.0	2.4	2.4	2.4	2.5
BREM 1015577.50 Velocity	1.3	1.7	1.7	1.9	2.1	2.1	2.2	2.2
BREM 1015710.00 Velocity	1.2	1.6	1.6	1.7	1.9	1.9	2.0	2.0
BREM 1015910.00 Velocity	1.2	1.6	1.6	1.8	2.0	2.1	2.1	2.1
BREM 1016110.00 Velocity	1.2	1.6	1.7	1.9	2.2	2.2	2.3	2.4
BREM 1016110.00 Velocity	1.2	1.6	1.7	1.9	2.2	2.2	2.3	2.4
BREM 1016310.00 Velocity	1.1	1.6	1.7	2.0	2.3	2.4	2.4	2.5
BREM 1016510.00 Velocity	1.1	1.6	1.7	2.0	2.5	2.5	2.6	2.6
BREM 1016795.00 Velocity	1.1	1.6	1.7	1.9	2.4	2.4	2.4	2.5
BREM 1017080.00 Velocity	1.1	1.6	1.6	1.8	2.3	2.3	2.4	2.4
BREM 1017415.00 Velocity	1.1	1.5	1.5	1.7	2.1	2.1	2.1	2.2
BREM 1017750.00 Velocity	1.1	1.4	1.4	1.6	1.9	1.9	2.0	2.0
BREM 1017945.00 Velocity	1.2	1.6	1.7	1.8	2.0	2.0	2.1	2.1
BREM 1018140.00 Velocity	1.4	1.9	2.0	2.1	2.2	2.2	2.2	2.2
BREM 1018230.00 Velocity	1.3	1.8	1.9	2.0	2.2	2.2	2.2	2.2
BREM 1018320.00 Velocity	1.2	1.7	1.8	1.9	2.2	2.2	2.2	2.3
BREM 1018320.00 Velocity	1.2	1.7	1.8	1.9	2.2	2.2	2.2	2.3
BREM 1018410.00 Velocity	1.1	1.6	1.7	1.9	2.3	2.3	2.3	2.3
BREM 1018500.00 Velocity	1.1	1.6	1.6	1.9	2.3	2.4	2.4	2.4
BREM 1018565.00 Velocity	1.1	1.6	1.7	2.0	2.4	2.5	2.5	2.5
BREM 1018630.00 Velocity	1.2	1.7	1.8	2.1	2.6	2.6	2.6	2.7
BREM 1018630.00 Velocity	1.2	1.7	1.8	2.1	2.6	2.6	2.6	2.7
BREM 1018695.00 Velocity	1.3	1.8	1.9	2.2	2.7	2.7	2.8	2.8
BREM 1018760.00 Velocity	1.4	1.9	2.0	2.3	2.9	2.9	3.0	3.0
BREM 1018955.00 Velocity	1.3	1.6	1.7	1.9	2.3	2.3	2.3	2.3
BREM 1019150.00 Velocity	1.2	1.4	1.4	1.6	1.9	1.9	1.9	1.9
BREM 1019365.00 Velocity	1.2	1.5	1.6	1.8	2.2	2.2	2.2	2.2
BREM 1019580.00 Velocity	1.2	1.7	1.8	2.1	2.6	2.6	2.6	2.6
BREM 1019790.00 Velocity	1.4	1.9	1.9	2.2	2.7	2.8	2.7	2.7
BREM 1020000.00 Velocity	1.6	2.0	2.1	2.3	2.7	2.7	2.7	2.8
BREM 1020000.00 Velocity	1.6	2.0	2.1	2.3	2.7	2.7	2.7	2.8
BREM 1020225.00 Velocity	1.3	1.5	1.5	1.6	1.6	1.5	1.6	1.6
BREM 1020450.00 Velocity	1.2	1.3	1.3	1.3	1.2	1.1	1.1	1.1
BREM 1020450.00 Velocity	1.2	1.4	1.5	1.5	1.4	1.4	1.3	1.3
BREM 1020525.00 Velocity	1.3	1.5	1.5	1.6	1.5	1.5	1.4	1.4
BREM 1020600.00 Velocity	1.3	1.6	1.6	1.7	1.6	1.6	1.5	1.5
BREM 1020600.00 Velocity	1.3	1.6	1.6	1.7	1.6	1.6	1.6	1.5
BREM 1020760.00 Velocity	1.4	1.7	1.8	1.9	2.0	1.9	1.9	1.9

BREM 1020920.00 Velocity	1.6	2.1	2.2	2.4	2.7	2.7	2.7	2.6
BREM 1021190.00 Velocity	1.4	1.9	2.0	2.2	2.5	2.6	2.6	2.6
BREM 1021460.00 Velocity	1.3	1.8	1.8	2.1	2.6	2.6	2.7	2.7
BREM 1021880.00 Velocity	1.3	1.8	1.9	2.2	2.6	2.7	2.7	2.7
BREM 1022300.00 Velocity	1.4	1.9	2.0	2.4	2.8	2.8	2.8	2.8
BREM 1022625.00 Velocity	1.3	1.8	1.9	2.1	2.3	2.3	2.3	2.3
BREM 1022950.00 Velocity	1.2	1.6	1.7	1.9	2.1	2.0	2.0	2.0
BREM 1023220.00 Velocity	1.2	1.7	1.8	2.0	2.2	2.2	2.2	2.2
BREM 1023490.00 Velocity	1.2	1.7	1.8	2.1	2.7	2.7	2.8	2.8
BREM 1023500.00 Velocity	1.2	1.8	1.9	2.2	2.8	2.8	2.9	2.9
BREM 1023510.00 Velocity	1.2	1.7	1.8	2.2	2.7	2.7	2.8	2.8
BREM 1023690.00 Velocity	1.1	1.5	1.6	1.9	2.4	2.4	2.5	2.5
BREM 1023870.00 Velocity	1.0	1.4	1.5	1.7	2.1	2.2	2.2	2.2
BREM 1024045.00 Velocity	1.1	1.5	1.6	1.9	2.4	2.4	2.4	2.5
BREM 1024220.00 Velocity	1.2	1.8	1.9	2.1	2.7	2.7	2.7	2.8
BREM 1024370.00 Velocity	1.2	1.7	1.8	2.1	2.4	2.5	2.5	2.5
BREM 1024520.00 Velocity	1.2	1.6	1.8	2.0	2.3	2.4	2.3	2.3
BREM 1024635.00 Velocity	1.0	1.5	1.6	1.8	2.2	2.2	2.2	2.2
BREM 1024750.00 Velocity	0.9	1.4	1.4	1.7	2.1	2.1	2.1	2.1
BREM 1025025.00 Velocity	0.9	1.3	1.4	1.7	2.1	2.1	2.1	2.1
BREM 1025300.00 Velocity	0.9	1.3	1.4	1.6	2.1	2.1	2.1	2.2
BREM 1025485.00 Velocity	1.0	1.4	1.5	1.8	2.2	2.2	2.2	2.3
BREM 1025670.00 Velocity	1.2	1.6	1.8	2.0	2.4	2.4	2.4	2.4
BREM 1025795.00 Velocity	1.1	1.6	1.7	2.0	2.4	2.4	2.5	2.5
BREM 1025920.00 Velocity	1.0	1.5	1.6	2.0	2.5	2.5	2.6	2.6
BREM 1026035.00 Velocity	1.0	1.4	1.5	1.8	2.3	2.3	2.4	2.4
BREM 1026150.00 Velocity	0.9	1.3	1.5	1.7	2.2	2.2	2.2	2.2
BREM 1026355.00 Velocity	0.9	1.4	1.5	1.8	2.4	2.4	2.4	2.4
BREM 1026560.00 Velocity	1.0	1.5	1.6	2.0	2.6	2.6	2.7	2.7
BREM 1026830.00 Velocity	1.0	1.5	1.6	2.0	2.6	2.6	2.6	2.7
BREM 1027100.00 Velocity	1.0	1.5	1.6	2.0	2.6	2.6	2.6	2.7
BREM 1027370.00 Velocity	1.0	1.4	1.6	1.9	2.5	2.5	2.5	2.6
BREM 1027640.00 Velocity	0.9	1.4	1.5	1.8	2.4	2.4	2.5	2.6
BREM 1027740.00 Velocity	0.9	1.4	1.5	1.9	2.5	2.5	2.6	2.7
BREM 1027840.00 Velocity	0.9	1.4	1.5	1.9	2.6	2.6	2.7	2.8
BREM 1028015.00 Velocity	1.0	1.5	1.7	2.0	2.7	2.7	2.8	2.9
BREM 1028190.00 Velocity	1.1	1.6	1.8	2.2	2.9	2.9	3.0	3.1
BREM 1028190.00 Velocity	1.1	1.6	1.8	2.2	2.9	2.9	3.0	3.1
BREM 1028340.00 Velocity	1.1	1.5	1.7	2.0	2.7	2.7	2.8	2.9
BREM 1028490.00 Velocity	1.1	1.5	1.6	1.9	2.6	2.6	2.6	2.7
BREMER 0.00 Velocity	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BREMER 182.40 Velocity	0.7	0.9	1.0	1.0	1.0	1.1	1.1	1.4
BREMER 364.80 Velocity	1.1	1.2	1.1	1.2	1.5	1.8	2.6	4.5
BREMER 989.17 Velocity	0.8	1.0	1.1	1.1	1.2	1.3	1.3	1.2
BREMER 1613.53 Velocity	0.6	1.1	1.2	1.3	1.3	1.4	1.4	1.4
BREMER 1910.60 Velocity	0.5	0.6	0.6	0.7	0.7	0.7	0.8	0.7
BREMER 2207.67 Velocity	0.3	0.4	0.4	0.5	0.6	0.6	0.6	0.6
BREMER 2339.84 Velocity	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7
BREMER 2472.00 Velocity	0.9	0.9	0.9	0.9	1.0	1.2	1.2	1.1
BREMER 2482.00 Velocity	1.6	1.7	1.7	1.8	1.8	2.0	1.9	2.0
BREMER 2492.00 Velocity	0.9	0.9	0.9	0.9	1.1	1.2	1.2	1.1
BREMER 2507.43 Velocity	0.9	0.9	0.9	0.9	1.1	1.2	1.3	1.1
BREMER 2522.86 Velocity	0.9	0.9	0.9	0.9	1.1	1.2	1.3	1.1
BREMER 2785.83 Velocity	0.9	1.0	1.0	1.0	1.1	1.3	1.2	1.2
BREMER 3048.80 Velocity	1.0	1.1	1.0	1.1	1.4	1.4	1.5	1.3
BREMER 3314.30 Velocity	0.9	1.0	0.9	1.0	1.2	1.3	1.3	1.2
BREMER 3579.79 Velocity	0.9	0.9	0.9	0.9	1.2	1.3	1.4	1.3
BREMER 3848.74 Velocity	0.9	0.9	0.9	0.9	1.1	1.1	1.2	1.1
BREMER 4117.69 Velocity	1.0	1.1	1.0	1.1	1.1	1.2	1.2	1.2
BREMER 4388.20 Velocity	0.9	1.1	1.0	1.0	1.2	1.2	1.3	1.2
BREMER 4658.71 Velocity	1.0	1.2	1.0	1.1	1.3	1.3	1.3	1.3
BREMER 5062.58 Velocity	0.7	0.9	0.8	0.8	0.9	1.0	1.0	0.9
BREMER 5466.45 Velocity	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
BREMER 5801.86 Velocity	0.6	0.8	0.8	0.8	0.8	0.9	0.9	0.9
BREMER 6137.27 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BREMER 6520.13 Velocity	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8

BREMER 6902.98 Velocity	0.8	0.8	0.9	0.9	1.0	1.0	0.9	0.9
BREMER 7249.99 Velocity	0.8	0.8	0.7	0.8	0.7	0.7	0.6	0.6
BREMER 7597.00 Velocity	0.8	0.8	0.8	0.8	0.7	0.7	0.7	0.7
BREMER 7597.00 Velocity	0.8	0.8	0.8	0.8	0.7	0.8	0.8	0.9
BREMER 7913.23 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BREMER 8229.47 Velocity	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BREMER 8617.83 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BREMER 9006.19 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BREMER 9395.10 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.8	1.0
BREMER 9784.00 Velocity	0.8	1.1	1.1	1.0	1.1	9.0	8.3	9.5
BREMER 9794.00 Velocity	1.2	2.6	3.1	3.5	3.7	5.3	157.4	195.2
BREMER 9804.00 Velocity	0.8	1.2	1.2	1.3	1.3	6.8	5.9	7.4
BREMER 9870.00 Velocity	0.8	0.9	1.0	1.0	1.1	1.1	1.8	5.3
BREMER 9936.00 Velocity	1.0	1.0	1.0	1.0	1.1	1.6	1.7	2.8
BREMER 9936.00 Velocity	1.0	1.0	1.0	1.0	1.0	1.6	1.7	2.8
BREMER 10163.50 Velocity	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.0
BREMER 10391.00 Velocity	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
BREMER 10391.00 Velocity	0.9	0.9	0.9	0.9	0.9	1.0	1.0	0.9
BREMER 10391.25 Velocity	0.9	0.9	0.9	0.9	0.9	1.0	1.0	0.9
BREMER 10391.51 Velocity	0.9	0.9	0.9	0.9	0.9	1.0	1.0	0.9
BREMER 10642.58 Velocity	0.6	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BREMER 10893.66 Velocity	0.4	1.0	1.1	1.1	1.2	1.2	1.2	1.1
BREMER 10893.66 Velocity	0.8	1.2	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 11104.67 Velocity	0.8	1.2	1.3	1.3	1.4	1.4	1.4	1.4
BREMER 11315.68 Velocity	1.1	1.3	1.4	1.4	1.5	1.5	1.5	1.5
BREMER 11396.65 Velocity	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4
BREMER 11477.63 Velocity	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
BREMER 11482.63 Velocity	2.9	3.1	3.3	3.4	3.5	3.5	3.5	3.5
BREMER 11487.63 Velocity	1.8	2.1	2.2	2.3	2.4	2.4	2.4	2.4
BREMER 11681.07 Velocity	1.3	1.4	1.5	1.6	1.7	1.7	1.7	1.7
BREMER 11874.52 Velocity	1.1	1.1	1.2	1.2	1.3	1.3	1.4	1.4
BREMER 12052.72 Velocity	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4
BREMER 12230.92 Velocity	1.2	1.4	1.4	1.4	1.4	1.4	1.5	1.5
BREMER 12462.76 Velocity	1.4	1.5	1.6	1.6	1.6	1.6	1.7	1.7
BREMER 12694.60 Velocity	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0
BREMER 12981.75 Velocity	1.7	1.8	1.8	1.9	2.0	2.0	2.0	2.0
BREMER 13268.91 Velocity	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1
BREMER 13569.55 Velocity	1.4	1.4	1.4	1.4	1.4	1.6	1.6	1.5
BREMER 13870.20 Velocity	1.0	1.1	1.1	1.1	1.1	1.3	1.3	1.2
BREMER 14130.01 Velocity	1.1	1.3	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 14389.82 Velocity	1.3	1.5	1.6	1.6	1.6	1.6	1.6	1.6
BREMER 14394.91 Velocity	1.3	1.5	1.6	1.6	1.6	1.6	1.6	1.6
BREMER 14400.00 Velocity	1.3	1.5	1.6	1.6	1.6	1.6	1.6	1.6
BREMER 14410.00 Velocity	1.5	2.9	3.0	3.0	3.0	3.0	3.0	3.0
BREMER 14420.00 Velocity	1.4	1.6	1.6	1.6	1.6	1.6	1.6	1.6
BREMER 14625.61 Velocity	0.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 14831.22 Velocity	0.6	0.9	0.9	1.0	1.0	1.1	1.1	1.1
BREMER 14945.61 Velocity	0.9	1.3	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 15060.00 Velocity	1.8	2.5	2.5	2.5	2.5	2.5	2.5	2.5
BREMER 15070.00 Velocity	2.1	3.6	3.6	3.6	3.6	3.7	3.7	3.6
BREMER 15080.00 Velocity	1.8	2.8	2.7	2.8	2.8	2.8	2.7	2.6
BREMER 15195.94 Velocity	2.1	2.9	2.9	2.9	2.9	2.9	2.9	2.9
BREMER 15311.88 Velocity	2.4	3.4	3.7	3.7	3.7	3.7	3.8	3.8
BREMER 15529.86 Velocity	2.0	2.6	2.6	2.6	2.6	2.7	2.7	2.7
BREMER 15747.83 Velocity	2.0	2.1	2.1	2.1	2.1	2.2	2.2	2.2
BREMER 16044.13 Velocity	1.7	1.8	1.8	1.8	1.9	1.9	1.9	1.9
BREMER 16340.42 Velocity	1.9	1.9	1.9	1.9	1.9	2.2	2.2	1.9
BREMER 16523.32 Velocity	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4
BREMER 16706.22 Velocity	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2
BREMER 16963.97 Velocity	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6
BREMER 17221.72 Velocity	2.1	2.5	2.5	2.5	2.5	2.5	2.5	2.5
BREMER 17577.40 Velocity	1.6	1.9	1.9	2.0	2.0	2.0	2.0	2.0
BREMER 17933.08 Velocity	1.3	1.6	1.7	1.7	1.8	1.8	1.8	1.8
BREMER 18165.94 Velocity	1.2	1.5	1.5	1.5	1.6	1.6	1.6	1.5
BREMER 18398.80 Velocity	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
BREMER 18724.87 Velocity	1.5	1.7	1.7	1.7	1.8	1.8	1.8	1.7

BREMER 19050.94 Velocity	2.0	2.3	2.5	2.5	2.7	2.7	2.7	2.5
BREMER 19205.47 Velocity	1.4	1.4	1.5	1.5	1.6	1.6	1.6	1.5
BREMER 19360.00 Velocity	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1
BREMER 19370.00 Velocity	2.1	2.6	2.6	2.6	2.6	2.6	2.5	2.2
BREMER 19380.00 Velocity	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 19399.74 Velocity	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 19419.49 Velocity	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 19952.52 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
BREMER 20485.54 Velocity	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
BREMER 20681.11 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	0.9
BREMER 20876.67 Velocity	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 21221.26 Velocity	0.9	1.3	1.3	1.3	1.3	1.3	1.3	1.4
BREMER 21565.85 Velocity	0.9	1.5	1.6	1.8	1.9	1.9	1.9	2.0
BREMER 21708.59 Velocity	1.0	1.3	1.4	1.4	1.5	1.5	1.5	1.5
BREMER 21851.32 Velocity	1.1	1.3	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 22130.95 Velocity	0.8	1.0	1.0	1.0	1.1	1.1	1.1	1.1
BREMER 22410.57 Velocity	0.7	0.8	0.9	0.9	0.9	0.9	1.0	1.0
BREMER 22670.96 Velocity	0.8	1.0	1.1	1.1	1.1	1.2	1.2	1.2
BREMER 22931.36 Velocity	1.0	1.4	1.5	1.5	1.5	1.5	1.5	1.6
BREMER 23153.61 Velocity	1.0	1.3	1.4	1.5	1.5	1.5	1.5	1.6
BREMER 23375.87 Velocity	1.0	1.3	1.4	1.5	1.5	1.6	1.6	1.6
BREMER 23672.13 Velocity	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8
BREMER 23968.39 Velocity	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6
BREMER 24176.44 Velocity	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.8
BREMER 24384.48 Velocity	0.8	1.0	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 24637.92 Velocity	0.8	1.0	1.1	1.1	1.1	1.2	1.2	1.2
BREMER 24891.36 Velocity	0.8	1.0	1.1	1.2	1.2	1.2	1.3	1.3
BREMER 25131.42 Velocity	0.9	1.1	1.2	1.2	1.3	1.3	1.3	1.3
BREMER 25371.48 Velocity	1.1	1.3	1.3	1.3	1.3	1.3	1.4	1.4
BREMER 25626.87 Velocity	0.8	1.1	1.1	1.1	1.2	1.2	1.2	1.2
BREMER 25882.25 Velocity	0.6	0.9	1.0	1.0	1.1	1.1	1.1	1.1
BREMER 26073.64 Velocity	0.7	1.0	1.1	1.1	1.1	1.1	1.1	1.1
BREMER 26265.02 Velocity	0.8	1.1	1.1	1.1	1.1	1.1	1.2	1.2
BREMER 26303.28 Velocity	0.9	1.1	1.2	1.2	1.2	1.2	1.2	1.2
BREMER 26341.55 Velocity	1.0	1.2	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 26557.59 Velocity	1.0	1.3	1.3	1.3	1.4	1.4	1.4	1.4
BREMER 26773.64 Velocity	0.9	1.4	1.4	1.4	1.5	1.5	1.5	1.5
BREMER 26914.87 Velocity	0.8	1.1	1.1	1.1	1.1	1.1	1.2	1.2
BREMER 27056.11 Velocity	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BREMER 27227.41 Velocity	0.8	1.0	1.0	1.0	1.1	1.0	1.1	1.1
BREMER 27398.71 Velocity	0.8	1.1	1.2	1.2	1.2	1.2	1.2	1.2
BREMER 27494.98 Velocity	1.0	1.3	1.3	1.3	1.3	1.3	1.4	1.3
BREMER 27591.25 Velocity	1.1	1.5	1.5	1.6	1.6	1.6	1.6	1.6
BREMER 27715.24 Velocity	1.0	1.4	1.5	1.5	1.5	1.5	1.5	1.5
BREMER 27839.23 Velocity	0.9	1.3	1.4	1.4	1.5	1.4	1.5	1.5
BREMER 27945.54 Velocity	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
BREMER 28051.84 Velocity	0.9	1.1	1.1	1.1	1.1	1.0	1.1	1.1
BREMER 28194.94 Velocity	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 28338.03 Velocity	1.2	1.7	1.7	1.8	1.8	1.8	1.8	1.8
BREMER 28603.16 Velocity	0.6	0.9	0.9	1.0	1.0	1.0	1.0	1.0
BREMER 28868.29 Velocity	0.4	0.6	0.6	0.6	0.7	0.7	0.7	0.7
BREMER 28997.60 Velocity	0.6	0.8	0.8	0.9	0.9	0.9	0.9	0.9
BREMER 29126.92 Velocity	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
BREMER 29299.46 Velocity	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
BREMER 29472.00 Velocity	1.9	1.9	1.9	1.8	1.8	1.8	1.8	1.8
BREMER 29493.50 Velocity	1.8	1.8	1.7	1.7	1.7	1.7	1.7	1.7
BREMER 29515.00 Velocity	1.7	1.7	1.7	1.6	1.6	2.1	1.6	1.7
BREMER 29525.00 Velocity	2.0	5.2	2.1	2.1	2.1	2.0	2.2	2.1
BREMER 29535.00 Velocity	1.7	1.7	1.7	1.6	1.6	2.6	1.6	1.7
BREMER 29556.50 Velocity	1.7	1.7	1.7	1.6	1.6	1.7	1.6	1.7
BREMER 29578.00 Velocity	1.7	1.8	1.7	1.6	1.6	2.0	1.6	1.7
BREMER 29734.50 Velocity	1.9	1.9	1.8	1.8	1.8	1.9	1.8	1.9
BREMER 29891.00 Velocity	2.1	2.1	2.1	2.1	2.1	2.2	2.1	2.2
BREMER 29991.00 Velocity	1.0	1.0	0.9	0.9	0.9	1.0	0.9	1.0
BREMER 30091.00 Velocity	0.6	0.7	0.6	0.6	0.6	0.6	0.6	0.7
BREMER 30441.00 Velocity	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7

BREMER 30791.00 Velocity	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.7
BREMER-BOONAHNEW 9869.00 Velocity	0.7	1.0	1.1	1.2	1.5	1.8	1.9	2.0
BREMER-BOONAHNEW 10167.71 Velocity	0.9	1.4	1.6	1.6	1.8	2.0	2.1	2.1
BREMER-BOONAHNEW 10466.43 Velocity	1.5	2.5	2.7	2.8	2.9	3.0	3.0	3.1
BREMER-BOONAHNEW 11191.71 Velocity	1.2	1.4	1.4	1.5	1.7	2.0	2.0	2.0
BREMER-BOONAHNEW 11917.00 Velocity	0.9	1.2	1.1	1.2	1.2	1.2	1.1	1.2
BREMER-BOONAHNEW 11927.00 Velocity	2.7	3.3	3.5	3.6	3.7	3.9	3.9	3.9
BREMER-BOONAHNEW 11937.00 Velocity	1.3	1.7	1.9	1.9	2.0	2.1	2.1	2.1
BREMER-BOONAHNEW 12218.50 Velocity	2.0	2.6	2.7	2.7	2.7	2.8	2.9	2.8
BREMER-BOONAHNEW 12500.00 Velocity	1.9	2.4	2.5	2.5	2.7	2.7	2.8	2.8
BREMER-BOONAHNEW 12952.70 Velocity	1.7	1.9	1.9	1.9	1.9	1.9	1.9	2.0
BREMER-BOONAHNEW 13405.41 Velocity	2.0	2.3	2.3	2.3	2.3	2.4	2.4	2.3
BREMER-BOONAHNEW 13667.81 Velocity	1.5	1.6	1.5	1.7	2.1	1.9	2.1	1.9
BREMER-BOONAHNEW 13930.22 Velocity	1.2	1.3	1.2	1.3	1.5	1.4	1.5	1.4
BREMER-BOONAHNEW 13934.22 Velocity	2.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4
BREMER-BOONAHNEW 13938.22 Velocity	1.4	1.8	1.8	1.8	1.9	1.9	1.8	1.9
BREMER-BOONAHNEW 14163.44 Velocity	1.7	2.0	2.0	2.0	2.1	2.4	2.3	2.3
BREMER-BOONAHNEW 14388.66 Velocity	2.3	2.4	2.4	2.4	2.5	3.3	3.6	3.4
BREMER-BOONAHNEW 14918.01 Velocity	0.9	1.2	1.2	1.3	1.5	1.7	1.7	1.8
BREMER-BOONAHNEW 15447.36 Velocity	0.6	0.8	0.9	1.0	1.3	1.4	1.5	1.6
BREMER-BOONAHNEW 15976.71 Velocity	0.3	0.5	0.5	0.6	0.8	1.0	1.0	1.0
BREMER-BOONAHNEW 16506.06 Velocity	0.2	0.4	0.5	0.6	0.8	1.0	1.0	1.0
BREMER-BOONAHNEW 16512.06 Velocity	2.9	3.6	3.9	3.9	3.9	3.9	3.9	3.9
BREMER-BOONAHNEW 16518.06 Velocity	0.5	0.9	0.9	1.1	1.3	1.7	1.8	1.9
BREMER-BOONAHNEW 17342.28 Velocity	0.8	1.3	1.3	1.4	1.6	1.8	1.9	1.9
BREMER-BOONAHNEW 18166.50 Velocity	1.8	2.7	2.8	2.8	2.8	2.9	2.9	2.9
BREMER-BOONAHNEW 18630.11 Velocity	1.8	2.7	2.7	2.7	2.8	2.9	2.9	2.9
BREMER-BOONAHNEW 19093.71 Velocity	1.9	2.6	2.6	2.6	2.8	3.0	3.1	3.1
BREMER-BOONAHNEW 19908.51 Velocity	0.4	0.5	0.5	0.6	0.8	0.9	1.0	1.0
BREMER-BOONAHNEW 20723.30 Velocity	0.2	0.3	0.3	0.3	0.5	0.6	0.6	0.6
BREMER-BOONAHNEW 21357.51 Velocity	0.4	0.5	0.5	0.6	0.7	0.8	0.9	0.9
BREMER-BOONAHNEW 21991.71 Velocity	1.2	1.6	1.7	1.7	1.8	1.8	1.8	1.9
BREMER-BOONAHNEW 22910.31 Velocity	1.4	1.7	1.7	1.8	2.0	2.2	2.2	2.3
BREMER-BOONAHNEW 23828.91 Velocity	1.4	1.7	1.7	1.7	2.0	2.2	2.3	2.3
BREMER-BOONAHNEW 24164.46 Velocity	0.8	1.1	1.1	1.2	1.4	1.5	1.6	1.6
BREMER-BOONAHNEW 24500.00 Velocity	0.6	0.9	0.9	0.9	1.0	1.2	1.2	1.3
BREMER-BOONAHNEW 24523.35 Velocity	0.6	0.9	0.9	0.9	1.0	1.2	1.2	1.3
BREMER-BOONAHNEW 24546.71 Velocity	0.6	0.9	0.9	0.9	1.0	1.2	1.2	1.8
BREMER-BOONAHNEW 24551.71 Velocity	2.6	2.6	2.6	2.6	2.6	4.9	2.6	2.6
BREMER-BOONAHNEW 24556.71 Velocity	0.6	0.9	0.9	0.9	1.1	1.2	1.2	2.1
BREMER-BOONAHNEW 24578.35 Velocity	0.6	0.9	0.9	1.0	1.1	1.2	1.3	1.3
BREMER-BOONAHNEW 24600.00 Velocity	0.6	1.0	1.0	1.0	1.1	1.2	1.3	1.9
BREMER-BOONAHNEW 25550.36 Velocity	0.6	0.9	1.0	1.0	1.1	1.2	1.2	1.2
BREMER-BOONAHNEW 26500.72 Velocity	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1
BREMER-BOONAHNEW 27042.52 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
BREMER-BOONAHNEW 27584.32 Velocity	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
BREMER-BOONAHNEW 28398.66 Velocity	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.7
BREMER-BOONAHNEW 29213.00 Velocity	0.4	0.7	0.7	0.8	0.9	0.9	0.8	0.8
BREMLINKBRANCH1 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BREMLINKBRANCH1 5.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BREMLINKBRANCH1 10.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BREMLINKBRANCH2 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
BREMLINKBRANCH2 25.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
BREMLINKBRANCH2 50.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.0
BUND 10000.00 Velocity	2.1	3.0	3.2	3.3	3.8	4.8	4.3	4.6
BUND 10153.75 Velocity	2.0	2.9	3.0	3.1	3.6	4.6	4.1	4.4
BUND 10307.50 Velocity	2.0	2.7	2.8	3.0	3.5	4.5	4.0	4.2
BUND 10461.25 Velocity	1.6	2.2	2.4	2.5	2.9	3.8	3.4	3.6
BUND 10615.00 Velocity	1.4	1.9	2.1	2.2	2.5	3.3	2.9	3.1
BUND 10861.25 Velocity	1.4	2.0	2.2	2.3	2.6	3.3	3.0	3.1
BUND 11107.50 Velocity	1.5	2.2	2.3	2.4	2.6	3.4	3.0	3.2
BUND 11353.75 Velocity	1.6	2.3	2.4	2.4	2.7	3.7	3.1	3.3
BUND 11600.00 Velocity	1.9	2.9	3.0	3.0	3.3	4.3	3.9	4.1
BUND 11784.17 Velocity	1.9	3.0	3.1	3.2	3.7	4.5	4.6	4.5
BUND 11968.33 Velocity	1.7	2.7	2.9	3.1	3.8	5.0	4.8	4.6
BUND 12152.50 Velocity	1.7	2.7	2.9	3.1	3.7	5.0	4.8	4.5

BUND 12336.67 Velocity	1.7	2.6	2.8	3.0	3.6	4.9	4.7	4.4
BUND 12520.83 Velocity	1.6	2.5	2.7	2.8	3.4	4.5	4.4	4.2
BUND 12705.00 Velocity	1.5	2.4	2.5	2.7	3.2	4.2	4.1	3.9
BUND 12935.00 Velocity	2.1	2.9	3.2	3.4	4.0	4.7	4.8	4.7
BUND 13165.00 Velocity	2.7	3.9	4.2	4.4	5.2	5.8	5.9	5.8
BUND 13358.75 Velocity	3.0	3.9	4.2	4.4	5.2	5.5	5.7	5.6
BUND 13552.50 Velocity	3.0	3.9	4.2	4.4	5.1	5.4	5.5	5.5
BUND 13746.25 Velocity	2.8	3.7	3.9	4.1	4.7	5.0	5.0	5.1
BUND 13940.00 Velocity	2.4	3.5	3.6	3.8	4.3	4.7	4.6	4.7
BUND 14078.75 Velocity	2.4	3.2	3.4	3.6	4.0	4.4	4.3	4.4
BUND 14217.50 Velocity	2.2	3.1	3.2	3.4	3.8	4.1	4.1	4.1
BUND 14356.25 Velocity	2.0	3.1	3.3	3.5	4.0	4.3	4.3	4.3
BUND 14495.00 Velocity	1.9	3.1	3.4	3.6	4.2	4.5	4.5	4.6
BUND 14635.00 Velocity	1.6	2.5	2.7	2.9	3.4	3.6	3.6	3.6
BUND 14775.00 Velocity	1.4	2.1	2.2	2.4	2.8	3.2	3.4	3.2
BUND 14915.00 Velocity	1.5	2.2	2.3	2.5	2.9	3.3	3.5	3.2
BUND 15055.00 Velocity	1.6	2.3	2.5	2.6	2.9	3.3	3.5	3.3
BUND 15216.25 Velocity	1.6	2.0	2.2	2.3	2.7	3.2	3.4	3.0
BUND 15377.50 Velocity	1.6	1.8	2.0	2.1	2.5	3.0	3.2	2.8
BUND 15538.75 Velocity	1.9	1.9	2.0	2.1	2.5	3.1	3.0	2.8
BUND 15700.00 Velocity	2.5	2.6	2.8	3.0	3.4	3.5	3.6	3.4
BUND 15873.75 Velocity	2.6	3.2	3.3	3.5	4.0	4.1	4.1	4.2
BUND 16047.50 Velocity	2.3	3.0	3.1	3.3	3.7	3.9	4.0	4.0
BUND 16221.25 Velocity	2.0	2.7	2.9	3.0	3.3	3.5	3.5	3.6
BUND 16395.00 Velocity	1.7	2.5	2.6	2.7	3.0	3.1	3.1	3.2
BUND 16521.25 Velocity	1.6	2.5	2.7	2.8	3.0	3.2	3.2	3.3
BUND 16647.50 Velocity	1.4	2.5	2.7	2.8	3.1	3.3	3.3	3.4
BUND 16773.75 Velocity	1.6	2.8	2.9	3.1	3.4	3.6	3.6	3.7
BUND 16900.00 Velocity	1.8	3.0	3.2	3.4	3.7	3.9	4.0	4.0
BUND 17057.50 Velocity	1.9	2.9	3.0	3.1	3.3	3.4	3.6	3.6
BUND 17215.00 Velocity	1.9	2.8	2.8	2.9	3.1	3.1	3.2	3.2
BUND 17372.50 Velocity	2.1	3.1	3.2	3.2	3.4	3.4	3.6	3.5
BUND 17530.00 Velocity	2.4	3.5	3.6	3.6	3.7	3.8	3.9	3.9
BUND 17707.50 Velocity	2.0	2.8	3.0	3.0	3.2	3.3	3.4	3.3
BUND 17885.00 Velocity	1.7	2.4	2.5	2.6	2.7	2.8	2.9	2.9
BUND 18096.25 Velocity	1.7	2.5	2.6	2.7	2.8	2.9	2.9	3.0
BUND 18307.50 Velocity	1.8	2.6	2.7	2.8	2.9	3.0	3.0	3.0
BUND 18518.75 Velocity	1.8	2.7	2.9	3.0	3.0	3.1	3.1	3.1
BUND 18730.00 Velocity	1.8	2.8	3.0	3.1	3.1	8.7	9.7	4.1
BUND 18740.00 Velocity	2.6	3.8	4.0	4.2	4.8	5.8	4.8	5.8
BUND 18750.00 Velocity	2.7	4.1	4.4	4.6	5.2	5.2	5.3	5.3
BUND 18882.50 Velocity	2.5	3.8	4.1	4.3	4.8	4.9	4.9	4.9
BUND 19015.00 Velocity	2.3	3.6	3.8	4.1	4.6	4.6	4.6	4.6
BUND 19147.50 Velocity	2.3	3.5	3.8	4.0	4.4	4.5	4.5	4.5
BUND 19280.00 Velocity	2.2	3.5	3.7	3.9	4.3	4.4	4.6	4.3
BUND 19410.00 Velocity	2.0	3.1	3.4	3.5	3.9	3.9	4.1	3.9
BUND 19540.00 Velocity	1.8	2.9	3.1	3.3	3.5	3.5	3.7	3.5
BUND 19670.00 Velocity	1.8	2.7	2.9	3.0	3.2	3.2	3.3	3.2
BUND 19800.00 Velocity	1.8	2.5	2.7	2.8	2.9	2.9	2.9	2.9
BUND 19960.00 Velocity	1.9	2.5	2.6	2.7	3.0	3.0	3.0	3.0
BUND 20120.00 Velocity	1.9	2.6	2.6	2.7	3.0	3.0	3.0	3.1
BUND 20280.00 Velocity	1.6	2.4	2.5	2.6	3.0	3.0	3.6	3.4
BUND 20440.00 Velocity	1.6	2.4	2.5	2.7	3.1	3.1	3.6	3.7
BUND 20672.50 Velocity	1.8	2.6	2.7	2.9	3.1	3.1	3.1	3.2
BUND 20905.00 Velocity	1.8	2.4	2.6	2.7	2.8	2.9	2.9	3.0
BUND 21137.50 Velocity	1.9	2.7	2.9	3.0	3.1	3.2	3.2	3.3
BUND 21370.00 Velocity	2.0	3.1	3.4	3.5	3.6	3.6	3.7	3.7
BUND 21557.50 Velocity	1.9	2.7	2.9	3.0	3.1	3.2	3.3	3.3
BUND 21745.00 Velocity	1.8	2.3	2.5	2.6	2.8	2.9	2.9	2.9
BUND 21932.50 Velocity	2.2	2.3	2.3	2.4	2.8	3.1	3.3	3.0
BUND 22120.00 Velocity	3.8	3.8	3.8	4.6	6.5	6.7	6.6	6.1
BUND 22120.00 Velocity	2.1	2.6	2.6	2.6	2.7	2.7	2.8	2.7
BUND 22286.25 Velocity	2.1	2.6	2.6	2.6	2.7	2.7	2.7	2.7
BUND 22452.50 Velocity	2.1	2.8	2.8	2.9	2.9	3.0	3.0	3.0
BUND 22618.75 Velocity	1.8	2.7	2.8	2.9	3.0	3.2	3.1	3.2
BUND 22785.00 Velocity	1.6	2.6	2.8	3.0	3.4	3.6	3.6	3.6

BUND 22967.50 Velocity	1.5	2.4	2.6	2.8	3.1	3.4	3.2	3.3
BUND 23150.00 Velocity	1.4	2.2	2.4	2.5	2.8	3.0	3.0	3.0
BUND 23332.50 Velocity	1.2	1.9	2.1	2.2	2.4	2.6	2.5	2.6
BUND 23515.00 Velocity	1.1	1.7	1.8	1.9	2.0	2.1	2.1	2.1
BUND 23668.75 Velocity	1.4	2.1	2.2	2.2	2.4	2.5	2.5	2.5
BUND 23822.50 Velocity	1.7	2.7	2.7	2.7	2.9	3.0	3.0	3.0
BUND 23976.25 Velocity	2.1	3.3	3.4	3.4	3.6	3.7	3.7	3.7
BUND 24130.00 Velocity	2.9	4.5	4.6	4.7	4.9	4.9	5.0	4.9
BUND 24287.50 Velocity	2.8	3.9	4.0	4.1	4.3	4.4	4.4	4.3
BUND 24445.00 Velocity	2.6	3.5	3.6	3.6	3.8	3.9	4.0	3.8
BUND 24602.50 Velocity	2.0	2.6	2.6	2.6	2.9	2.9	3.0	2.8
BUND 24760.00 Velocity	1.7	2.1	2.1	2.2	2.4	2.5	2.6	2.3
BUND 24917.50 Velocity	1.3	1.9	2.0	2.0	2.3	2.5	2.6	2.4
BUND 25075.00 Velocity	1.1	1.8	1.8	1.8	2.1	2.4	2.4	2.3
BUND 25201.25 Velocity	1.0	1.6	1.6	1.7	1.9	2.2	2.1	2.1
BUND 25327.50 Velocity	0.9	1.5	1.5	1.5	1.7	2.0	1.9	1.9
BUND 25453.75 Velocity	1.0	1.2	1.2	1.2	1.2	1.3	1.2	1.3
BUND 25580.00 Velocity	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
BUND 25590.00 Velocity	3.2	3.3	3.3	3.3	3.5	3.5	3.5	3.3
BUND 25600.00 Velocity	2.4	3.1	3.1	3.3	3.4	3.1	3.6	3.6
BUND 25835.00 Velocity	2.1	2.8	2.8	2.8	2.8	2.8	2.7	2.7
BUND 26070.00 Velocity	1.9	2.7	2.6	2.7	2.7	2.7	2.7	2.6
BUND 26305.00 Velocity	2.3	3.1	3.1	3.3	3.4	3.2	3.2	3.5
BUND 26540.00 Velocity	2.7	3.7	3.8	3.9	4.2	4.4	4.3	4.6
BUND 26660.00 Velocity	1.6	2.1	1.9	2.5	2.5	2.4	3.5	4.1
BUND 26780.00 Velocity	1.1	1.5	1.3	1.6	1.6	1.6	2.3	2.6
BUND 27030.00 Velocity	1.1	1.4	1.5	1.5	1.8	1.9	1.9	1.9
BUND 27280.00 Velocity	0.8	1.5	1.6	1.7	2.0	2.2	2.2	2.2
BUND 27330.00 Velocity	0.8	1.5	1.7	1.7	2.1	2.2	2.2	2.2
BUND 27380.00 Velocity	0.8	1.6	1.7	1.7	2.1	2.2	2.3	2.2
BUND 27390.00 Velocity	1.0	2.0	2.6	2.8	2.9	3.0	2.9	3.0
BUND 27400.00 Velocity	0.8	1.6	1.8	1.9	2.3	2.5	2.5	2.5
BUND 27527.50 Velocity	0.8	1.7	1.9	2.0	2.5	2.7	2.7	7.4
BUND 27655.00 Velocity	0.9	2.5	2.4	2.5	2.7	4.2	2.9	179.5
BUND 27665.00 Velocity	1.3	3.3	3.2	3.3	3.3	3.9	3.3	3.9
BUND 27675.00 Velocity	2.4	4.2	4.3	4.2	4.3	4.6	4.4	5.4
BUND 27842.50 Velocity	2.3	2.7	2.8	2.7	2.8	2.8	2.9	2.8
BUND 28010.00 Velocity	2.2	2.7	2.7	2.8	2.8	2.8	2.9	2.8
BUND 28180.00 Velocity	1.6	2.0	2.0	2.0	2.0	2.0	2.1	2.0
BUND 28350.00 Velocity	1.2	1.5	1.6	1.6	1.6	1.7	1.6	1.6
BUND 28350.00 Velocity	1.2	1.5	1.6	1.6	1.6	1.7	1.6	1.6
BUND 28415.00 Velocity	1.1	1.4	1.4	1.5	1.5	1.7	1.5	1.5
BUND 28480.00 Velocity	0.9	1.3	1.3	1.3	1.3	1.4	1.3	1.3
BUND 28510.00 Velocity	1.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4
BUND 28530.00 Velocity	1.1	2.1	2.2	2.2	2.2	2.3	2.2	2.2
BUND 28545.00 Velocity	1.3	2.1	2.2	2.2	2.2	2.2	2.2	2.2
BUND 28560.00 Velocity	1.5	2.1	2.2	2.2	2.2	2.2	2.2	2.2
BUND 28595.00 Velocity	1.6	2.1	2.1	2.1	2.2	2.2	2.2	2.1
BUND 28630.00 Velocity	1.6	2.0	2.1	2.1	2.1	2.1	2.1	2.1
BUND 28630.00 Velocity	1.9	2.1	2.2	2.2	2.3	2.3	2.3	2.3
BUND 28782.50 Velocity	1.5	1.6	1.6	1.6	1.8	1.7	1.9	1.7
BUND 28935.00 Velocity	1.5	1.5	1.5	1.6	1.7	1.6	1.6	1.6
BUND 29087.50 Velocity	1.4	1.4	1.4	1.5	1.4	1.5	1.5	1.5
BUND 29240.00 Velocity	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.2
BUND 29395.00 Velocity	0.9	0.8	0.8	0.9	0.8	0.8	1.0	0.8
BUND 29550.00 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.7
BUND 29730.00 Velocity	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.6
BUND 29910.00 Velocity	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.6
BUND 30062.50 Velocity	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7
BUND 30215.00 Velocity	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7
BUND 30367.50 Velocity	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.8
BUND 30520.00 Velocity	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.0
BUND 30730.00 Velocity	0.8	0.9	0.9	1.0	1.0	1.1	1.1	0.9
BUND 30940.00 Velocity	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2
BUND 31150.00 Velocity	0.6	1.0	1.1	1.2	1.3	1.3	1.4	1.4
BUND 31360.00 Velocity	0.7	1.2	1.4	1.5	1.6	1.6	1.7	1.7

BUND 31495.00 Velocity	0.6	0.9	1.0	1.0	1.1	1.1	1.1	1.1
BUND 31630.00 Velocity	0.8	0.8	0.8	0.9	1.0	1.0	1.0	0.9
BUND 31805.00 Velocity	0.7	0.8	0.8	0.8	0.8	0.9	0.9	0.8
BUND 31980.00 Velocity	1.0	1.0	1.0	1.1	1.0	1.3	1.4	1.0
BUND 31990.00 Velocity	2.7	1.4	1.7	2.7	1.8	1.9	2.7	1.9
BUND 32000.00 Velocity	0.9	0.9	0.9	1.0	0.9	1.4	1.4	0.9
BUND 32075.00 Velocity	0.6	0.8	0.8	0.8	0.9	0.9	0.9	0.9
BUND 32150.00 Velocity	0.7	1.0	1.1	1.2	1.2	1.3	1.3	1.4
BUND 32250.00 Velocity	0.8	1.1	1.2	1.2	1.2	1.2	1.2	1.2
BUND 32350.00 Velocity	1.0	1.1	1.2	1.2	1.2	1.3	1.3	1.3
BUND 32360.00 Velocity	1.3	1.4	1.5	1.5	2.1	2.3	2.3	2.3
BUND 32370.00 Velocity	1.0	1.2	1.2	1.2	1.2	1.3	1.3	1.3
BUND 32522.50 Velocity	0.7	0.9	1.0	1.0	1.1	1.1	1.1	1.2
BUND 32675.00 Velocity	0.5	0.8	0.9	0.9	1.1	1.2	1.2	1.3
BUND 32827.50 Velocity	0.6	0.9	1.0	1.1	1.2	1.3	1.3	1.5
BUND 32980.00 Velocity	0.8	1.2	1.2	1.2	1.4	1.5	1.5	1.7
BUND 33150.00 Velocity	0.9	1.2	1.3	1.3	1.6	1.7	1.7	1.9
BUND 33320.00 Velocity	0.9	1.2	1.4	1.5	1.8	2.0	2.0	2.3
BUND 33490.00 Velocity	0.6	0.8	0.8	0.8	0.9	1.0	1.0	1.1
BUND 33660.00 Velocity	0.4	0.6	0.6	0.6	0.6	0.7	0.7	0.7
BUND 33830.00 Velocity	0.5	0.5	0.5	0.6	0.7	0.7	0.7	0.8
BUND 34000.00 Velocity	0.7	0.6	0.5	0.6	0.7	0.8	0.8	0.8
BUND 34000.00 Velocity	0.5	0.5	0.5	0.6	0.7	0.8	0.8	0.9
BUND 34130.00 Velocity	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6
BUND 34260.00 Velocity	0.9	0.9	0.9	0.9	0.9	1.0	1.0	0.9
BUND 34282.50 Velocity	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
BUND 34305.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5
BUND 34325.00 Velocity	0.6	2.3	2.4	2.4	2.4	2.4	2.4	2.4
BUND 34345.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.5
BUND 34370.00 Velocity	0.4	0.6	0.6	0.7	0.8	0.8	0.8	0.8
BUND 34395.00 Velocity	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.6
BUND 34577.50 Velocity	0.7	1.0	1.1	1.2	1.4	1.5	1.6	1.8
BUND 34760.00 Velocity	1.5	1.6	1.6	1.6	1.7	1.7	1.6	1.8
BUND 34905.00 Velocity	0.7	1.0	1.1	1.2	1.3	1.3	1.3	1.5
BUND 35050.00 Velocity	1.4	1.6	1.6	1.6	1.7	1.8	1.8	1.7
BUND 35075.00 Velocity	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BUND 35100.00 Velocity	1.2	1.2	1.3	1.3	1.4	1.4	1.3	1.5
BUND 35110.00 Velocity	1.2	1.3	1.7	1.8	2.0	2.1	2.1	2.3
BUND 35120.00 Velocity	3.2	3.4	3.4	3.5	3.7	3.8	3.6	4.1
BUND 35320.00 Velocity	0.7	0.9	0.9	0.9	0.9	1.0	1.0	1.1
BUND 35520.00 Velocity	0.7	1.0	2.3	2.2	2.3	2.3	1.9	1.9
BUND 35530.00 Velocity	1.2	3.6	3.5	3.2	3.7	3.6	3.6	3.7
BUND 35540.00 Velocity	1.6	1.7	2.4	2.4	2.6	2.5	1.8	2.0
BUND 35635.00 Velocity	0.8	1.1	1.1	1.2	1.3	1.4	1.5	1.6
BUND 35730.00 Velocity	1.9	2.1	2.2	2.2	2.4	2.6	2.6	2.5
BUND 35867.50 Velocity	0.8	0.9	0.9	1.0	1.1	1.1	1.1	1.0
BUND 36005.00 Velocity	0.7	0.8	0.8	0.9	2.3	1.0	1.0	0.9
BUND 36015.00 Velocity	1.2	1.3	1.5	1.8	2.2	3.9	2.2	3.9
BUND 36025.00 Velocity	2.2	2.4	2.5	2.7	2.7	2.8	2.6	2.9
BUND 36161.25 Velocity	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0
BUND 36297.50 Velocity	1.9	2.1	2.2	2.4	2.6	2.7	2.5	2.9
BUND 36433.75 Velocity	0.9	1.0	1.1	1.1	1.1	1.1	1.1	1.2
BUND 36570.00 Velocity	2.0	2.5	2.7	2.9	3.2	3.5	3.4	3.2
BUND 36705.00 Velocity	0.9	1.0	1.1	1.1	1.3	1.3	1.4	1.4
BUND 36840.00 Velocity	1.6	1.9	2.1	2.3	2.8	3.3	3.5	2.4
BUND 36975.00 Velocity	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.0
BUND 37110.00 Velocity	1.2	1.4	1.6	1.8	2.2	2.5	2.6	2.1
BUND 37310.00 Velocity	0.5	0.6	0.6	0.7	0.8	0.9	0.9	0.9
BUND 37510.00 Velocity	1.0	1.1	1.1	1.2	1.2	1.4	2.2	1.4
BUND 37710.00 Velocity	0.6	0.8	0.8	0.9	1.0	1.1	1.1	1.1
BUND 37910.00 Velocity	0.9	1.1	1.2	1.2	1.3	1.4	3.7	1.4
BUND 37910.00 Velocity	1.2	1.3	1.3	1.4	1.4	1.5	2.4	1.5
BUND 38095.00 Velocity	0.9	1.0	1.0	1.0	1.2	1.2	1.2	1.2
BUND 38280.00 Velocity	0.8	0.9	0.9	0.9	1.0	1.1	1.1	1.1
BUND 38501.25 Velocity	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9
BUND 38722.50 Velocity	0.6	0.7	0.7	0.8	0.8	0.8	0.8	0.8

BUND 38943.75 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
BUND 39165.00 Velocity	1.0	1.1	1.1	1.1	1.2	1.2	1.3	1.2
BUND 39355.83 Velocity	0.8	1.1	1.1	1.1	1.2	1.2	1.2	1.2
BUND 39546.67 Velocity	0.6	1.0	1.0	1.0	1.1	1.2	1.2	1.2
BUND 39737.50 Velocity	0.6	0.9	0.9	0.9	1.1	1.1	1.1	1.1
BUND 39928.33 Velocity	0.5	0.8	0.8	0.8	1.0	1.0	1.0	1.0
BUND 40119.17 Velocity	0.4	0.7	0.7	0.8	0.9	1.0	1.0	1.0
BUND 40310.00 Velocity	0.4	0.7	0.7	0.7	0.9	0.9	0.9	0.9
BUND 40490.00 Velocity	0.4	0.7	0.7	0.8	0.9	1.0	1.0	1.0
BUND 40670.00 Velocity	0.5	0.8	0.8	0.8	1.0	1.0	1.0	1.0
BUND 40850.00 Velocity	0.7	1.0	1.0	1.0	1.2	1.2	1.2	1.2
BUND 41030.00 Velocity	1.8	2.2	1.7	1.9	1.5	1.5	1.5	1.5
BUND 41039.52 Velocity	3.1	3.0	2.9	2.5	1.5	1.5	1.6	1.5
BUND 41049.04 Velocity	13.4	11.9	10.6	6.7	1.6	1.5	1.6	1.5
BUND# 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	14.6	22.9	7.1
DEEB 10000.00 Velocity	0.2	0.3	0.3	0.3	0.4	0.6	0.6	0.7
DEEB 10157.50 Velocity	0.3	0.4	0.5	0.5	0.7	0.8	0.9	0.9
DEEB 10315.00 Velocity	0.6	0.9	0.9	1.0	1.4	1.5	1.6	1.7
DEEB 10451.75 Velocity	0.6	0.9	0.9	1.0	1.3	1.5	1.5	1.6
DEEB 10588.50 Velocity	0.6	0.9	0.9	1.0	1.2	1.4	1.5	1.6
DEEB 10725.25 Velocity	0.4	0.6	0.7	0.7	1.0	1.1	1.1	1.2
DEEB 10862.00 Velocity	0.3	0.5	0.5	0.6	0.8	0.9	0.9	1.0
DEEB 11001.50 Velocity	0.2	0.4	0.4	0.5	0.6	0.7	0.7	0.8
DEEB 11141.00 Velocity	0.2	0.3	0.4	0.4	0.5	0.6	0.6	0.7
DEEB 11297.00 Velocity	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8
DEEB 11453.00 Velocity	0.4	0.6	0.6	0.6	0.8	1.0	1.0	1.1
DEEB 11645.00 Velocity	0.5	0.7	0.7	0.7	0.9	1.1	1.1	1.1
DEEB 11837.00 Velocity	0.6	0.8	0.9	0.9	1.0	1.1	1.1	1.2
DEEB 11974.00 Velocity	0.8	1.0	1.1	1.1	1.3	1.4	1.4	1.5
DEEB 12111.00 Velocity	1.1	1.4	1.5	1.6	1.9	2.0	2.0	2.1
DEEB 12244.00 Velocity	0.9	1.3	1.4	1.5	1.8	1.9	2.0	2.0
DEEB 12377.00 Velocity	0.8	1.2	1.3	1.4	1.7	1.9	1.9	2.0
DEEB 12510.00 Velocity	0.7	1.1	1.1	1.2	1.5	1.7	1.8	1.9
DEEB 12643.00 Velocity	0.7	1.1	1.2	1.2	1.6	1.8	1.9	2.0
DEEB 12785.00 Velocity	0.4	0.8	0.8	0.9	1.3	1.6	1.7	1.8
DEEB 12927.00 Velocity	0.3	0.5	0.6	0.7	1.0	1.3	1.4	1.5
DEEB 12937.00 Velocity	2.3	2.4	2.4	2.4	2.9	2.9	2.9	3.0
DEEB 12947.00 Velocity	0.6	0.9	1.0	1.1	1.4	1.6	1.7	1.9
DEEB 13056.00 Velocity	0.7	1.0	1.1	1.1	1.3	1.5	1.6	1.7
DEEB 13165.00 Velocity	1.0	1.2	1.2	1.2	1.3	1.4	1.5	1.5
DEEB 13230.00 Velocity	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.5
DEEB 13295.00 Velocity	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
DEEB 13441.00 Velocity	0.2	0.2	0.3	0.3	0.4	0.5	0.5	0.5
DEEB 13587.00 Velocity	0.5	0.8	0.8	0.9	1.1	1.2	1.2	1.3
DEEB 13737.50 Velocity	0.4	0.6	0.7	0.7	0.9	1.0	1.1	1.1
DEEB 13888.00 Velocity	0.3	0.5	0.6	0.6	0.8	0.9	1.0	1.0
DEEB 13905.00 Velocity	1.9	2.6	2.7	2.8	3.5	3.9	4.1	4.4
DEEB 13922.00 Velocity	0.4	0.8	0.8	0.9	1.2	1.5	1.6	1.8
DEEB 14061.50 Velocity	0.4	0.7	0.8	0.9	1.2	1.4	1.5	1.6
DEEB 14201.00 Velocity	0.5	0.7	0.8	0.8	1.1	1.3	1.3	1.4
DEEB 14343.50 Velocity	0.4	0.7	0.8	0.8	1.0	1.2	1.2	1.3
DEEB 14486.00 Velocity	0.4	0.7	0.8	0.8	1.0	1.1	1.2	1.3
DEEB 14628.50 Velocity	0.4	0.6	0.6	0.7	0.8	0.8	0.8	0.9
DEEB 14771.00 Velocity	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6
DEEB 14875.00 Velocity	0.5	0.7	0.7	0.7	0.8	0.9	0.9	0.9
DEEB 14979.00 Velocity	0.7	1.0	1.1	1.1	1.4	1.5	1.6	1.7
DEEB 15069.00 Velocity	0.7	1.0	1.1	1.2	1.3	1.5	1.5	1.6
DEEB 15159.00 Velocity	0.7	1.0	1.1	1.2	1.3	1.4	1.5	1.5
DEEB 15247.50 Velocity	0.3	0.4	0.4	0.4	0.6	0.6	0.7	0.7
DEEB 15336.00 Velocity	0.2	0.2	0.3	0.3	0.4	0.4	0.4	0.5
DEEB 15509.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6
DEEB 15682.00 Velocity	0.5	0.8	0.9	0.9	1.1	1.1	1.1	1.1
DEEB 15682.00 Velocity	0.5	0.8	0.9	0.9	1.1	1.1	1.1	1.1
DEEB 15793.00 Velocity	0.6	0.8	0.8	0.9	1.0	1.0	1.0	1.0
DEEB 15904.00 Velocity	0.6	0.8	0.8	0.8	0.8	0.8	0.9	0.8
DEEB 15969.50 Velocity	0.5	0.6	0.7	0.7	0.7	0.7	0.8	0.7

DEEB 16035.00 Velocity	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7
DEEB 16035.00 Velocity	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.7
DEEB 16077.50 Velocity	0.3	0.4	0.5	0.5	0.6	0.6	0.7	0.7
DEEB 16120.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6
DEEB 16167.50 Velocity	0.4	0.5	0.6	0.6	0.8	0.9	0.9	0.9
DEEB 16215.00 Velocity	0.6	0.9	1.0	1.1	1.4	1.6	1.8	1.7
DEEB 16215.00 Velocity	0.7	1.1	1.2	1.3	1.7	1.9	1.8	2.0
DEEB 16259.00 Velocity	0.6	0.9	1.0	1.1	1.3	1.4	1.4	1.5
DEEB 16303.00 Velocity	0.6	0.8	0.9	0.9	1.1	1.1	1.2	1.2
DEEB 16321.50 Velocity	0.6	0.9	1.0	1.0	1.2	1.2	1.3	1.3
DEEB 16340.00 Velocity	0.7	1.1	1.1	1.2	1.3	1.4	2.1	1.4
DEEB 16474.50 Velocity	0.5	0.9	0.9	1.0	1.2	1.3	1.3	1.3
DEEB 16609.00 Velocity	0.4	0.8	0.8	0.9	1.1	1.2	1.2	1.2
DEEB 16622.00 Velocity	0.4	0.7	0.8	0.8	1.1	1.2	1.2	1.2
DEEB 16635.00 Velocity	0.4	0.7	0.8	0.8	1.0	1.2	1.4	1.3
DEEB 16635.00 Velocity	0.4	0.7	0.8	0.8	1.0	1.2	1.4	1.3
DEEB 16744.50 Velocity	0.4	0.8	0.9	1.0	1.3	1.5	1.6	1.6
DEEB 16854.00 Velocity	0.5	1.1	1.2	1.3	1.7	2.1	2.2	2.2
DEEB 16907.00 Velocity	0.5	0.8	0.9	0.9	1.2	1.3	1.4	1.4
DEEB 16960.00 Velocity	0.4	0.7	0.7	0.8	0.9	1.0	1.0	1.0
DEEB 16960.00 Velocity	0.4	0.7	0.7	0.8	0.9	1.0	1.0	1.0
DEEB 17012.00 Velocity	0.3	0.5	0.5	0.5	0.7	0.7	0.7	0.7
DEEB 17064.00 Velocity	0.2	0.4	0.4	0.4	0.5	0.5	0.6	0.5
DEEB 17064.00 Velocity	0.3	0.4	0.5	0.5	0.7	0.7	0.7	0.7
DEEB 17072.00 Velocity	1.8	2.0	2.0	2.0	2.6	2.9	2.7	2.9
DEEB 17080.00 Velocity	0.3	0.6	0.7	0.7	1.2	1.3	1.1	1.2
DEEB 17198.50 Velocity	0.5	0.7	0.7	0.8	0.9	1.0	1.0	1.0
DEEB 17317.00 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.1	1.0
DEEB 17463.00 Velocity	0.6	0.8	0.8	0.8	0.8	0.9	0.9	0.9
DEEB 17609.00 Velocity	0.5	0.7	0.7	0.7	0.7	0.8	0.9	0.9
DEEB 17653.00 Velocity	0.5	0.9	0.9	0.9	0.9	1.1	1.1	1.1
DEEB 17697.00 Velocity	0.6	1.2	1.2	1.2	1.2	1.4	1.5	1.5
DEEB 17697.00 Velocity	0.6	1.2	1.2	1.2	1.2	1.4	1.5	1.5
DEEB 17708.00 Velocity	3.4	3.4	3.4	3.4	3.4	3.8	3.8	3.8
DEEB 17717.00 Velocity	1.0	1.3	1.3	1.3	1.4	1.4	1.4	1.4
DEEB 17809.50 Velocity	0.6	0.9	0.9	0.9	1.1	1.1	1.2	1.1
DEEB 17902.00 Velocity	0.4	0.7	0.7	0.8	1.0	1.0	1.0	1.0
DEEB 17923.00 Velocity	2.5	2.7	2.7	2.6	2.8	2.8	2.9	2.9
DEEB 17927.00 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.2	0.9
DEEB 18132.00 Velocity	0.4	0.7	0.7	0.8	0.9	1.0	1.0	1.0
DEEB 18337.00 Velocity	0.4	0.7	0.8	0.8	1.1	1.2	1.2	1.3
DEEB 18347.00 Velocity	0.6	1.4	1.5	1.5	1.6	1.7	1.6	1.6
DEEB 18357.00 Velocity	0.3	0.5	0.6	0.6	0.8	0.9	0.9	1.0
DEEB 18417.50 Velocity	0.4	0.7	0.7	0.7	1.0	1.1	1.1	1.2
DEEB 18478.00 Velocity	0.6	0.8	0.8	0.9	1.2	1.4	1.4	1.4
DEEB 18491.00 Velocity	6.7	5.1	5.0	3.9	4.1	4.4	4.4	4.5
DEEB 18502.00 Velocity	1.0	1.4	1.5	1.5	2.0	2.1	2.1	2.3
DEEB 18586.00 Velocity	1.0	1.4	1.5	1.5	1.7	1.8	1.8	1.8
DEEB 18670.00 Velocity	1.2	1.5	1.5	1.6	1.7	1.7	1.7	1.7
DEEB 18670.00 Velocity	1.2	1.5	1.5	1.6	1.7	1.7	1.7	1.7
DEEB 18732.50 Velocity	1.0	1.3	1.3	1.3	1.4	1.5	1.4	1.4
DEEB 18795.00 Velocity	0.9	1.1	1.1	1.1	1.2	1.2	1.2	1.2
DEEB 18865.50 Velocity	1.0	1.3	1.3	1.4	1.5	1.5	1.5	1.5
DEEB 18936.00 Velocity	1.1	1.6	1.6	1.7	1.9	2.0	2.0	2.0
DEEB 19024.00 Velocity	0.8	1.3	1.3	1.4	1.7	1.9	1.9	1.9
DEEB 19112.00 Velocity	0.6	1.0	1.1	1.2	1.5	1.7	1.7	1.8
DEEB 19122.00 Velocity	2.2	2.2	2.2	2.2	2.2	2.8	2.8	3.0
DEEB 19132.00 Velocity	0.7	1.1	1.1	1.2	1.5	1.7	1.7	1.8
DEEB 19189.50 Velocity	0.9	1.3	1.4	1.5	1.8	1.9	2.0	2.0
DEEB 19247.00 Velocity	1.4	1.9	1.9	2.0	2.4	2.4	2.4	2.4
DEEB 19247.00 Velocity	1.4	1.9	1.9	2.0	2.4	2.4	2.4	2.4
DEEB 19324.00 Velocity	1.3	1.8	1.7	2.0	2.4	2.4	2.4	2.5
DEEB 19401.00 Velocity	1.2	1.7	1.6	1.9	2.4	2.6	2.5	2.6
DEEB 19469.00 Velocity	1.2	1.6	1.5	1.8	2.2	2.3	2.3	2.4
DEEB 19537.00 Velocity	1.3	1.4	1.5	1.8	2.1	2.2	2.2	2.2
DEEB 19572.00 Velocity	1.1	1.3	1.4	1.8	2.2	2.3	2.3	2.4

DEEB 19607.00 Velocity	1.0	1.2	1.2	1.7	2.2	2.4	2.4	2.5
DEEB 19654.50 Velocity	0.8	1.0	1.0	1.3	1.6	1.8	1.8	1.8
DEEB 19702.00 Velocity	0.7	0.8	0.9	1.1	1.3	1.4	1.4	1.5
DEEB 19764.50 Velocity	0.5	0.6	0.7	0.9	1.2	1.3	1.3	1.3
DEEB 19827.00 Velocity	0.4	0.5	0.5	0.7	1.0	1.2	1.2	1.2
DEEB 19837.00 Velocity	1.2	1.4	1.5	2.2	2.7	3.1	3.0	3.1
DEEB 19847.00 Velocity	0.4	0.5	0.6	0.8	1.1	1.2	1.2	1.3
DEEB 19879.50 Velocity	0.5	0.5	0.6	0.8	1.0	1.2	1.1	1.2
DEEB 19912.00 Velocity	0.5	0.6	0.6	0.9	1.0	1.1	1.1	1.1
FRANKLINVALE 0.00 Velocity	1.3	1.6	1.6	1.6	1.8	1.8	1.8	1.8
FRANKLINVALE 212.98 Velocity	1.4	1.7	1.7	1.7	1.8	1.9	1.9	1.9
FRANKLINVALE 425.97 Velocity	1.6	2.0	2.0	2.0	2.1	2.1	2.2	2.2
FRANKLINVALE 655.82 Velocity	1.6	2.1	2.1	2.1	2.2	2.2	2.2	2.3
FRANKLINVALE 885.68 Velocity	1.7	2.3	2.3	2.3	2.3	2.4	2.5	2.4
FRANKLINVALE 1125.48 Velocity	1.7	2.4	2.4	2.4	2.4	2.5	2.6	2.5
FRANKLINVALE 1365.29 Velocity	1.8	2.5	2.7	2.8	3.2	3.5	3.5	3.5
FRANKLINVALE 1567.12 Velocity	1.7	2.5	2.7	2.7	2.8	2.9	2.9	3.0
FRANKLINVALE 1768.94 Velocity	1.7	2.6	2.7	2.7	2.8	2.8	2.8	2.9
FRANKLINVALE 2010.40 Velocity	1.2	1.7	1.8	1.8	1.9	2.5	2.5	1.9
FRANKLINVALE 2251.85 Velocity	1.4	1.3	2.2	2.2	2.2	2.5	2.4	2.4
FRANKLINVALE 2476.41 Velocity	0.7	0.9	0.9	1.0	1.2	1.4	1.5	1.6
FRANKLINVALE 2700.97 Velocity	0.8	1.1	1.2	1.2	1.5	1.8	1.9	2.1
FRANKLINVALE 2848.49 Velocity	1.1	1.4	1.4	1.5	1.6	1.8	1.9	2.0
FRANKLINVALE 2996.01 Velocity	1.2	1.5	1.5	1.5	1.8	1.9	1.9	1.8
FRANKLINVALE 3272.45 Velocity	0.9	1.2	1.2	1.3	1.5	1.8	1.9	1.6
FRANKLINVALE 3548.88 Velocity	0.8	1.0	1.1	1.2	1.2	1.5	1.5	1.4
FRANKLINVALE 3805.40 Velocity	1.0	1.1	1.1	1.1	1.2	1.4	1.5	1.3
FRANKLINVALE 4061.92 Velocity	1.4	1.5	1.5	1.5	1.6	1.7	1.8	1.6
FRANKLINVALE 4255.61 Velocity	1.1	1.3	1.3	1.4	1.4	1.5	1.7	1.5
FRANKLINVALE 4449.29 Velocity	1.0	1.3	1.3	1.3	1.5	1.5	1.5	1.5
FRANKLINVALE 4641.44 Velocity	1.2	1.6	1.6	1.6	1.7	1.7	1.7	1.7
FRANKLINVALE 4833.58 Velocity	1.6	1.9	1.9	1.9	2.1	2.2	2.1	2.2
FRANKLINVALE 4973.05 Velocity	1.5	1.6	1.6	1.7	1.9	2.0	2.1	1.9
FRANKLINVALE 5112.51 Velocity	1.3	1.4	1.5	1.5	1.7	1.9	1.9	1.8
FRANKLINVALE 5366.76 Velocity	1.4	1.6	1.6	1.6	1.7	1.8	1.8	1.7
FRANKLINVALE 5621.00 Velocity	1.6	1.8	1.8	1.9	1.9	2.0	2.1	2.0
FRANKLINVALE 5623.00 Velocity	2.3	3.0	3.1	3.2	3.3	3.3	3.3	3.3
FRANKLINVALE 5626.00 Velocity	1.6	1.8	1.9	1.9	2.0	2.1	2.1	2.0
FRANKLINVALE 5829.16 Velocity	1.4	1.7	1.8	1.8	1.9	2.0	2.0	1.9
FRANKLINVALE 6032.32 Velocity	1.3	1.7	1.8	1.8	1.8	1.9	2.1	1.8
FRANKLINVALE 6251.44 Velocity	1.1	1.5	1.5	1.5	1.6	1.8	1.9	1.7
FRANKLINVALE 6470.57 Velocity	0.9	1.5	1.5	1.5	1.8	1.9	1.8	1.9
FRANKLINVALE 6721.82 Velocity	0.9	1.1	1.1	1.2	1.3	1.5	1.5	1.4
FRANKLINVALE 6973.07 Velocity	1.0	1.1	1.1	1.2	1.3	1.6	1.5	1.4
FRANKLINVALE 7109.93 Velocity	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.4
FRANKLINVALE 7246.79 Velocity	0.9	1.2	1.2	1.2	1.2	1.3	1.6	1.3
FRANKLINVALE 7387.69 Velocity	1.0	1.2	1.2	1.2	1.3	1.3	1.3	1.3
FRANKLINVALE 7528.59 Velocity	1.1	1.3	1.3	1.3	1.4	1.5	1.5	1.5
FRANKLINVALE 7657.85 Velocity	0.9	1.0	1.0	1.1	1.3	1.4	1.4	1.3
FRANKLINVALE 7787.11 Velocity	0.7	0.9	0.9	1.0	1.2	1.2	1.2	1.2
FRANKLINVALE 8053.98 Velocity	0.9	1.0	1.0	1.0	1.2	1.2	1.2	1.2
FRANKLINVALE 8320.85 Velocity	1.2	1.3	1.3	1.4	1.5	1.6	1.6	1.6
FRANKLINVALE 8574.08 Velocity	1.0	1.0	1.0	1.1	1.2	1.3	1.3	1.2
FRANKLINVALE 8827.31 Velocity	0.8	0.8	0.8	0.8	0.8	0.9	0.9	1.0
FRANKLINVALE 8835.62 Velocity	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
FRANKLINVALE 8843.31 Velocity	1.3	1.7	1.7	1.7	1.8	1.8	1.8	1.8
FRANKLINVALE 9082.44 Velocity	1.2	1.4	1.4	1.4	1.4	1.4	1.4	1.4
FRANKLINVALE 9321.57 Velocity	1.1	1.3	1.3	1.3	1.3	1.3	1.3	1.3
FRANKLINVALE 9517.19 Velocity	1.0	1.3	1.3	1.3	1.3	1.3	1.3	1.3
FRANKLINVALE 9712.81 Velocity	1.0	1.4	1.4	1.4	1.5	1.5	1.5	1.6
FRANKLINVALE 10106.67 Velocity	1.0	1.3	1.3	1.3	1.4	1.5	1.6	1.4
FRANKLINVALE 10500.52 Velocity	0.8	1.0	1.1	1.1	1.2	1.3	1.3	1.3
FRANKLINVALE 10730.88 Velocity	0.9	1.2	1.2	1.3	1.3	1.3	1.3	1.3
FRANKLINVALE 10961.24 Velocity	0.9	1.4	1.5	1.6	1.6	1.6	1.7	1.6
FRANKLINVALE 11208.58 Velocity	1.0	1.2	1.2	1.2	1.3	1.4	1.4	1.3
FRANKLINVALE 11455.91 Velocity	1.1	1.2	1.2	1.2	1.4	1.5	1.6	1.4

FRANKLINVALE 11664.60 Velocity	1.1	1.2	1.2	1.2	1.3	1.5	1.5	1.4
FRANKLINVALE 11873.29 Velocity	1.0	1.2	1.2	1.2	1.3	1.9	2.1	1.5
FRANKLINVALE 12100.87 Velocity	1.1	1.1	1.1	1.1	1.3	1.4	1.5	1.3
FRANKLINVALE 12328.45 Velocity	1.2	1.3	1.3	1.4	1.6	1.7	1.7	1.6
FRANKLINVALE 12535.39 Velocity	0.8	1.0	1.0	1.0	1.3	1.3	1.5	1.3
FRANKLINVALE 12742.32 Velocity	0.8	1.2	1.2	1.3	1.3	1.3	1.3	1.3
FRANKLINVALE 12942.11 Velocity	0.6	0.7	0.8	0.8	0.9	0.9	0.9	1.0
FRANKLINVALE 13141.89 Velocity	0.8	0.9	0.9	1.2	1.3	1.9	1.9	1.3
FRANKLINVALE 13360.25 Velocity	0.7	0.8	0.8	0.9	1.0	1.1	1.1	1.0
FRANKLINVALE 13578.62 Velocity	0.9	0.9	0.9	1.0	1.3	1.3	1.4	1.2
FRANKLINVALE 13811.20 Velocity	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.1
FRANKLINVALE 14043.78 Velocity	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
FRANKLINVALE 14284.28 Velocity	1.0	1.1	1.1	1.1	1.1	1.1	1.2	1.1
FRANKLINVALE 14524.77 Velocity	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FRANKLINVALE 14763.33 Velocity	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.8
FRANKLINVALE 15001.90 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
FRANKLINVALE 15237.53 Velocity	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.8
FRANKLINVALE 15473.17 Velocity	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
FRANKLINVALE 15711.66 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
FRANKLINVALE 15950.15 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
FRANKLINVALE 16175.25 Velocity	0.9	0.9	0.9	0.9	1.1	1.2	1.2	1.1
FRANKLINVALE 16400.35 Velocity	1.0	1.0	1.0	1.0	1.1	1.4	1.4	1.2
FRANKLINVALE 16638.88 Velocity	0.5	0.7	0.8	0.8	0.9	1.0	1.0	1.1
FRANKLINVALE 16877.42 Velocity	0.4	0.6	0.7	0.7	0.8	1.0	1.0	1.1
FRANKLINVALE 16953.78 Velocity	0.6	0.6	0.7	0.8	0.8	1.0	1.0	1.1
FRANKLINVALE 17030.13 Velocity	2.3	2.3	2.3	1.2	2.4	1.6	1.9	1.7
FRANKLINVALE 17032.00 Velocity	2.2	3.5	3.5	3.1	3.8	3.5	2.6	2.9
FRANKLINVALE 17033.13 Velocity	2.8	2.9	3.2	1.4	2.9	1.8	1.8	2.0
FRANKLINVALE 17184.33 Velocity	0.9	1.0	1.0	1.0	1.2	1.5	1.5	1.1
FRANKLINVALE 17335.54 Velocity	0.9	1.0	1.0	1.0	1.1	1.4	1.3	1.1
FRANKLINVALE 17531.85 Velocity	0.9	1.0	0.9	1.0	1.0	1.2	1.2	1.0
FRANKLINVALE 17728.16 Velocity	0.9	0.9	0.9	0.9	1.2	1.5	1.6	1.1
FRANKLINVALE 17949.53 Velocity	0.9	0.9	0.9	0.9	1.0	1.1	1.1	1.0
FRANKLINVALE 18170.90 Velocity	0.9	0.9	0.9	0.9	1.2	1.6	1.9	1.0
FRANKLINVALE 18368.20 Velocity	0.9	1.0	1.0	1.0	1.2	1.4	1.4	1.2
FRANKLINVALE 18565.51 Velocity	2.4	2.9	2.4	2.6	4.2	5.0	5.0	3.8
FRANKLINVALE 18565.51 Velocity	1.0	1.3	1.2	1.2	1.7	2.2	2.0	1.6
FRANKLINVALE 19176.70 Velocity	0.9	1.1	1.1	1.1	1.1	1.1	1.2	1.2
FRANKLINVALE 19787.88 Velocity	1.2	1.4	1.2	1.4	2.0	2.0	2.2	2.1
FRANKLINVALE 19787.88 Velocity	0.9	1.1	1.1	1.1	1.1	1.1	1.1	1.1
FRANKLINVALE 19937.44 Velocity	0.8	0.7	0.8	0.8	0.7	0.8	0.9	1.0
FRANKLINVALE 20087.00 Velocity	0.7	0.6	0.7	0.6	0.6	0.7	0.8	0.9
GOOD 10000.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GOOD 10137.50 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.2
GOOD 10275.00 Velocity	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5
GOOD 10375.00 Velocity	0.7	0.7	0.8	0.8	1.0	1.1	1.1	1.2
GOOD 10475.00 Velocity	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.7
GOOD 10590.00 Velocity	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.1
GOOD 10705.00 Velocity	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6
GOOD 10815.00 Velocity	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
GOOD 10925.00 Velocity	0.8	0.9	0.9	0.9	0.9	0.9	1.0	0.9
GOOD 11130.00 Velocity	0.8	0.9	0.9	1.0	1.2	1.3	1.3	1.4
GOOD 11335.00 Velocity	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.5
GOOD 11480.00 Velocity	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9
GOOD 11625.00 Velocity	0.6	0.7	0.7	0.7	0.6	0.6	0.6	0.6
GOOD 11785.00 Velocity	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
GOOD 11945.00 Velocity	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.5
GOOD 11982.50 Velocity	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
GOOD 12020.00 Velocity	0.7	0.8	0.8	0.8	0.6	0.6	0.7	0.6
GOOD 12032.00 Velocity	1.7	2.7	3.8	4.2	4.8	4.8	4.8	4.8
GOOD 12044.00 Velocity	0.9	1.1	1.2	1.3	1.2	1.3	1.4	1.3
GOOD 12099.50 Velocity	0.8	0.8	0.8	0.8	0.9	0.9	1.1	1.0
GOOD 12155.00 Velocity	0.6	0.6	0.6	0.5	0.5	0.6	0.7	0.6
GOOD 12290.00 Velocity	0.6	0.7	0.7	0.8	0.9	1.0	1.1	1.1
GOOD 12425.00 Velocity	0.5	0.5	0.6	0.6	0.8	0.9	0.9	1.0
GOOD 12552.50 Velocity	0.6	0.6	0.7	0.7	0.9	1.0	1.0	1.1

GOOD 12680.00 Velocity	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
GOOD 12807.50 Velocity	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.7
GOOD 12935.00 Velocity	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5
GOOD 13105.00 Velocity	0.3	0.4	0.4	0.4	0.6	0.6	0.7	0.7
GOOD 13275.00 Velocity	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
GOOD 13375.00 Velocity	0.3	0.4	0.4	0.4	0.6	0.7	0.8	0.8
GOOD 13475.00 Velocity	0.3	0.3	0.3	0.3	0.5	0.5	0.6	0.6
GOOD 13575.00 Velocity	0.3	0.4	0.5	0.5	0.7	0.8	0.9	0.9
GOOD 13675.00 Velocity	0.4	0.6	0.6	0.7	0.8	0.9	0.9	0.9
GOOD 13915.00 Velocity	0.6	0.8	0.9	0.9	1.0	1.0	1.1	1.0
GOOD 14155.00 Velocity	1.1	1.1	1.1	1.0	0.9	0.8	0.8	0.8
GOOD 14175.00 Velocity	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.7
GOOD 14195.00 Velocity	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
GOOD 14235.00 Velocity	1.6	1.6	1.7	1.7	2.2	2.7	2.9	3.1
GOOD 14265.00 Velocity	0.3	0.3	0.3	0.4	0.4	0.3	0.4	0.3
GOOD 14320.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5
GOOD 14375.00 Velocity	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
GOOD 14465.00 Velocity	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
GOOD 14555.00 Velocity	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5
GOOD 14565.00 Velocity	0.4	0.5	0.5	0.5	0.7	0.5	0.9	0.8
GOOD 14575.00 Velocity	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
GOOD 14595.00 Velocity	2.3	3.1	3.1	3.2	3.6	4.0	4.0	4.2
GOOD 14615.00 Velocity	0.5	0.6	0.6	0.7	0.6	0.6	0.6	0.6
GOOD 14625.00 Velocity	0.7	0.9	0.9	0.9	1.0	0.9	1.0	0.9
GOOD 14635.00 Velocity	0.9	1.0	1.0	1.1	1.1	1.0	1.0	0.9
GOOD 14685.00 Velocity	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.7
GOOD 14735.00 Velocity	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4
GOOD 14815.00 Velocity	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5
GOOD 14895.00 Velocity	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.3
GOOD 14900.00 Velocity	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
GOOD 14905.00 Velocity	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.4
GOOD 14913.00 Velocity	1.8	4.2	4.6	4.8	4.9	4.9	4.9	4.9
GOOD 14920.00 Velocity	0.5	0.7	0.7	0.8	0.8	0.9	0.9	0.8
GOOD 14925.00 Velocity	0.6	0.9	0.9	1.0	1.1	1.2	1.2	1.2
GOOD 14930.00 Velocity	0.6	0.9	0.9	1.0	1.1	1.2	1.2	1.1
GOOD 14952.50 Velocity	0.6	0.8	0.8	0.9	1.0	1.1	1.2	1.1
GOOD 14975.00 Velocity	0.5	0.6	0.7	0.7	0.9	1.0	1.0	1.0
GOOD 15162.50 Velocity	0.5	0.7	0.7	0.7	0.9	1.0	1.0	1.0
GOOD 15350.00 Velocity	0.6	0.6	0.6	0.6	0.7	0.7	0.8	0.7
GOOD 15597.50 Velocity	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.0
GOOD 15845.00 Velocity	0.6	0.7	0.7	0.8	0.9	1.0	1.1	0.9
GOOD 16010.00 Velocity	0.6	0.9	0.9	1.0	1.2	1.3	1.4	1.3
GOOD 16175.00 Velocity	0.5	0.7	0.8	0.8	1.0	1.1	1.3	1.1
GOOD 16265.00 Velocity	0.6	0.9	1.0	1.1	1.4	1.5	1.7	1.6
GOOD 16355.00 Velocity	0.6	0.8	0.9	1.0	1.3	1.4	1.7	1.3
GOOD 16440.00 Velocity	0.8	1.2	1.2	1.3	1.6	1.7	1.9	1.7
GOOD 16525.00 Velocity	0.9	1.2	1.2	1.2	1.4	1.5	1.7	1.4
GOOD 16625.00 Velocity	1.5	1.8	1.6	1.4	1.6	1.8	2.2	1.8
GOOD 16725.00 Velocity	2.4	2.6	1.7	1.3	1.6	1.8	2.5	1.9
HWAY LEFT 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HWAY LEFT 85.00 Velocity	0.2	0.2	0.3	0.3	0.3	0.4	0.5	0.4
HWAY LEFT 170.00 Velocity	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.2
HWAY LEFT 170.00 Velocity	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.2
HWAY LEFT 230.00 Velocity	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.2
HWAY LEFT 290.00 Velocity	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.3
HWAY LEFT 300.00 Velocity	1.1	1.6	1.9	1.9	2.3	2.5	3.3	3.2
HWAY LEFT 310.00 Velocity	0.5	0.6	0.6	0.6	0.7	0.8	1.1	0.7
HWAY LEFT 350.00 Velocity	0.5	0.6	0.6	0.6	0.8	1.0	1.8	0.7
HWAY LEFT 390.00 Velocity	1.6	1.3	1.6	1.6	1.3	1.5	6.4	1.3
IRON 10000.00 Velocity	0.3	0.5	0.5	0.6	0.9	1.1	1.1	1.2
IRON 10137.00 Velocity	0.2	0.4	0.4	0.5	0.7	0.9	0.9	1.0
IRON 10274.00 Velocity	0.1	0.3	0.3	0.4	0.6	0.7	0.7	0.8
IRON 10418.50 Velocity	0.1	0.3	0.3	0.4	0.6	0.8	0.8	0.8
IRON 10563.00 Velocity	0.1	0.3	0.4	0.5	0.7	0.8	0.8	0.9
IRON 10644.00 Velocity	0.1	0.3	0.4	0.5	0.7	0.9	0.9	1.0
IRON 10725.00 Velocity	0.2	0.4	0.5	0.5	0.8	0.9	1.0	1.0

IRON 10863.00 Velocity	0.2	0.3	0.4	0.4	0.6	0.7	0.8	0.8
IRON 11001.00 Velocity	0.3	0.4	0.4	0.4	0.6	0.7	0.8	0.8
IRON 11211.50 Velocity	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.5
IRON 11422.00 Velocity	0.2	0.3	0.3	0.4	0.5	0.6	0.8	0.7
IRON 11593.50 Velocity	0.3	0.4	0.5	0.5	0.8	0.9	1.2	1.0
IRON 11765.00 Velocity	0.3	0.4	0.5	0.5	0.7	0.8	1.2	0.9
IRON 11779.50 Velocity	0.3	0.4	0.4	0.5	0.6	0.7	1.1	0.8
IRON 11794.00 Velocity	0.3	0.3	0.4	0.4	0.6	0.7	1.0	0.8
IRON 11923.00 Velocity	0.3	0.3	0.4	0.4	0.5	0.6	1.0	0.6
IRON 12052.00 Velocity	0.4	0.5	0.5	0.6	0.8	0.8	1.1	0.9
IRON 12193.50 Velocity	0.6	0.8	0.8	0.9	1.2	1.3	1.4	1.4
IRON 12335.00 Velocity	0.6	0.9	0.9	1.0	1.3	1.4	1.5	1.5
IRON 12476.50 Velocity	0.6	0.8	0.9	1.0	1.3	1.4	1.4	1.4
IRON 12618.00 Velocity	0.5	0.8	0.9	0.9	1.2	1.3	1.4	1.5
IRON 12641.00 Velocity	1.2	1.3	1.7	1.6	3.0	3.5	3.6	3.8
IRON 12658.00 Velocity	0.5	0.8	0.9	1.0	1.3	1.6	1.7	1.8
IRON 12810.25 Velocity	0.4	0.6	0.7	0.7	1.0	1.2	1.3	1.3
IRON 12962.50 Velocity	0.3	0.5	0.5	0.6	0.8	0.9	1.0	1.0
IRON 13114.75 Velocity	0.3	0.4	0.5	0.5	0.7	0.9	0.9	1.0
IRON 13267.00 Velocity	0.3	0.4	0.5	0.5	0.7	0.9	0.9	0.9
IRON 13516.50 Velocity	0.4	0.5	0.5	0.7	0.8	0.9	1.1	1.0
IRON 13766.00 Velocity	0.3	0.5	0.5	0.5	0.8	0.9	1.1	1.0
IRON 13936.50 Velocity	0.3	0.5	0.5	0.6	0.8	0.9	1.1	1.0
IRON 14107.00 Velocity	0.4	0.6	0.7	0.7	0.9	1.0	1.2	1.1
IRON 14281.50 Velocity	0.5	0.8	0.8	0.9	1.1	1.2	1.3	1.3
IRON 14456.00 Velocity	0.6	0.8	0.9	0.9	1.1	1.3	1.3	1.4
IRON 14630.50 Velocity	0.6	0.9	1.0	1.0	1.3	1.5	1.6	1.6
IRON 14805.00 Velocity	0.7	1.0	1.0	1.1	1.5	1.8	1.9	2.0
IRON 14972.00 Velocity	0.2	0.3	0.4	0.4	0.6	0.8	0.8	0.8
IRON 15139.00 Velocity	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.5
IRON 15273.00 Velocity	0.2	0.3	0.3	0.4	0.5	0.6	0.6	0.7
IRON 15407.00 Velocity	0.3	0.5	0.5	0.6	0.8	1.0	1.1	1.1
IRON 15553.50 Velocity	0.4	0.6	0.7	0.7	1.0	1.2	1.3	1.3
IRON 15700.00 Velocity	0.6	0.8	0.9	0.9	1.2	1.4	1.5	1.5
IRON 15793.50 Velocity	0.6	0.8	0.9	0.9	1.2	1.4	1.4	1.4
IRON 15887.00 Velocity	0.6	0.9	0.9	1.0	1.2	1.3	1.3	1.3
IRON 16042.75 Velocity	0.7	0.9	0.9	1.0	1.2	1.3	1.3	1.3
IRON 16198.50 Velocity	0.7	0.9	0.9	1.0	1.1	1.2	1.3	1.2
IRON 16354.25 Velocity	0.8	1.0	1.1	1.1	1.3	1.5	1.5	1.5
IRON 16510.00 Velocity	1.0	1.3	1.3	1.4	1.7	1.8	1.9	1.9
IRON 16668.50 Velocity	0.9	1.2	1.2	1.3	1.4	1.6	1.6	1.5
IRON 16827.00 Velocity	0.8	1.1	1.2	1.2	1.4	1.4	1.6	1.4
IRON 16960.00 Velocity	0.5	0.7	0.8	0.8	1.1	1.2	1.5	1.2
IRON 17093.00 Velocity	0.4	0.6	0.6	0.7	1.0	1.1	1.3	1.1
IRON 17214.50 Velocity	0.5	0.8	0.9	0.9	1.2	1.4	1.4	1.4
IRON 17336.00 Velocity	0.7	1.0	1.1	1.1	1.4	1.6	1.7	1.6
IRON 17482.00 Velocity	0.6	0.9	1.0	1.0	1.3	1.5	1.6	1.5
IRON 17628.00 Velocity	0.6	0.8	0.9	0.9	1.2	1.4	1.4	1.4
IRON 17756.00 Velocity	0.8	1.1	1.2	1.3	1.5	1.7	1.8	1.7
IRON 17884.00 Velocity	1.4	1.8	1.7	1.9	2.1	2.3	2.3	2.3
IRON 17957.50 Velocity	1.4	1.7	1.7	1.7	1.8	1.9	2.0	2.0
IRON 18031.00 Velocity	1.3	1.6	1.6	1.6	1.8	1.9	1.9	1.8
IRON 18093.50 Velocity	1.0	1.1	1.2	1.2	1.3	1.4	1.3	1.3
IRON 18156.00 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
IRON 18209.50 Velocity	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1
IRON 18263.00 Velocity	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3
IRON 18313.00 Velocity	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
IRON 18363.00 Velocity	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0
IRON 18375.00 Velocity	2.7	6.0	5.4	6.3	6.3	6.3	6.3	6.3
IRON 18384.00 Velocity	1.0	1.4	1.4	1.9	2.3	2.6	2.6	2.6
IRON 18484.00 Velocity	0.2	0.4	0.4	0.7	0.9	1.1	1.2	1.1
IRON 18584.00 Velocity	0.1	0.3	0.2	0.4	0.6	0.7	0.7	0.7
MIHI 11310.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MIHI 11389.00 Velocity	0.8	0.9	0.9	1.0	1.1	1.2	1.2	1.2
MIHI 11468.00 Velocity	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
MIHI 11588.00 Velocity	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9

MIHI 11708.00 Velocity	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
MIHI 11838.00 Velocity	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.1
MIHI 11968.00 Velocity	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.6
MIHI 12031.00 Velocity	0.7	0.8	0.9	0.9	1.1	1.3	1.3	1.3
MIHI 12094.00 Velocity	0.8	0.8	0.9	1.0	1.2	1.4	1.4	1.4
MIHI 12094.00 Velocity	0.8	0.8	0.9	1.0	1.2	1.4	1.4	1.4
MIHI 12162.00 Velocity	1.0	1.0	1.1	1.2	1.4	1.6	1.7	1.6
MIHI 12230.00 Velocity	1.0	1.1	1.1	1.2	1.4	1.6	1.8	1.6
MIHI 12357.50 Velocity	1.0	1.1	1.2	1.2	1.6	1.7	1.8	1.7
MIHI 12485.00 Velocity	1.1	1.2	1.3	1.4	1.8	1.9	2.1	1.9
MIHI 12557.50 Velocity	1.1	1.2	1.2	1.2	1.6	1.7	1.8	1.7
MIHI 12630.00 Velocity	1.1	1.1	1.1	1.1	1.4	1.5	1.6	1.5
MIHI 12697.00 Velocity	1.2	1.3	1.3	1.3	1.7	1.8	1.9	1.8
MIHI 12764.00 Velocity	1.4	1.5	1.6	1.6	2.1	2.5	2.5	2.4
MIHI 12842.50 Velocity	1.1	1.3	1.3	1.4	1.9	2.3	2.4	2.2
MIHI 12921.00 Velocity	0.9	1.1	1.2	1.2	1.8	2.2	2.3	2.0
MIHI 13021.00 Velocity	0.2	0.3	0.3	0.4	0.7	0.9	1.0	0.8
MIHI 13121.00 Velocity	0.1	0.2	0.2	0.2	0.4	0.6	0.6	0.5
PURGA 0.00 Velocity	0.5	0.7	0.8	0.9	1.4	1.6	1.6	1.4
PURGA 672.90 Velocity	0.6	0.9	0.9	1.0	1.1	1.2	1.3	1.4
PURGA 1345.80 Velocity	0.8	1.0	1.1	1.1	1.3	1.4	1.4	1.5
PURGA 1629.05 Velocity	0.9	1.2	1.3	1.3	1.4	1.5	1.5	1.6
PURGA 1912.30 Velocity	7.2	7.2	7.2	7.2	1.8	2.0	2.0	2.0
PURGA 2449.15 Velocity	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.8
PURGA 2986.00 Velocity	0.5	0.5	0.5	0.5	0.5	0.7	0.5	0.5
PURGA 2986.00 Velocity	0.5	0.9	0.9	0.9	1.1	1.3	1.3	1.3
PURGA 2996.06 Velocity	0.9	1.4	1.0	1.1	1.6	1.4	1.4	1.5
PURGA 3006.00 Velocity	0.5	0.9	0.9	1.0	1.1	1.3	1.3	1.3
PURGA 3175.85 Velocity	0.6	0.8	0.9	0.9	1.0	1.2	1.2	1.3
PURGA 3345.71 Velocity	1.2	1.4	1.4	1.5	1.0	1.1	1.1	1.2
PURGA 3924.06 Velocity	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.4
PURGA 4502.41 Velocity	1.8	2.0	1.9	2.0	1.7	1.7	1.7	1.7
PURGA 4753.46 Velocity	1.9	2.0	1.9	1.9	1.7	1.7	1.7	1.7
PURGA 5004.51 Velocity	2.0	2.2	2.0	2.0	1.8	1.8	1.8	1.8
PURGA 5239.53 Velocity	1.9	2.0	2.0	1.8	1.4	1.4	1.4	1.4
PURGA 5474.54 Velocity	1.7	1.9	1.8	1.6	1.5	1.5	1.4	1.4
PURGA 5706.76 Velocity	1.3	1.5	1.5	1.5	1.5	1.5	1.5	1.5
PURGA 5938.99 Velocity	1.8	2.1	2.5	2.7	2.7	2.7	2.7	2.7
PURGA 6194.88 Velocity	1.5	1.8	1.8	1.8	1.8	1.8	1.8	1.9
PURGA 6450.77 Velocity	1.4	1.9	1.9	1.9	1.9	1.9	1.9	2.0
PURGA 6724.26 Velocity	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7
PURGA 6997.75 Velocity	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PURGA 7244.66 Velocity	1.1	1.1	1.1	1.2	1.2	1.2	1.3	1.4
PURGA 7491.57 Velocity	1.0	1.1	1.1	1.0	1.0	1.2	1.2	1.3
PURGA 7718.59 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.3
PURGA 7945.62 Velocity	0.8	0.8	0.8	0.8	1.0	1.1	1.1	1.2
PURGA 8197.92 Velocity	0.9	0.9	0.9	1.0	1.1	1.1	1.2	1.2
PURGA 8450.21 Velocity	1.5	2.0	1.5	1.5	1.5	1.5	1.5	1.5
PURGA 8714.52 Velocity	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2
PURGA 8978.82 Velocity	2.2	2.2	2.2	2.2	2.2	2.1	2.2	2.0
PURGA 9747.02 Velocity	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
PURGA 10515.22 Velocity	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7
PURGA 10751.71 Velocity	1.4	1.4	1.4	1.4	1.5	1.5	1.5	1.5
PURGA 10988.20 Velocity	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
PURGA 11166.55 Velocity	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
PURGA 11344.89 Velocity	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
PURGA 11563.04 Velocity	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA 11781.18 Velocity	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8
PURGA 12072.24 Velocity	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1
PURGA 12363.30 Velocity	2.4	2.5	2.5	2.5	2.6	2.5	2.5	2.5
PURGA 12574.79 Velocity	2.1	2.1	2.3	2.4	2.4	2.2	2.2	2.0
PURGA 12786.29 Velocity	1.6	3.4	3.4	3.4	3.4	3.4	3.3	3.3
PURGA 12796.29 Velocity	4.5	5.4	5.0	5.0	5.0	5.0	5.0	5.0
PURGA 12806.29 Velocity	1.6	4.2	4.2	4.2	4.2	4.2	4.0	4.2
PURGA 13043.95 Velocity	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1
PURGA 13281.62 Velocity	2.6	2.7	2.7	2.7	2.7	2.7	2.7	2.7

PURGA 13425.37 Velocity	2.4	2.7	2.7	2.7	2.7	2.7	2.7	2.7
PURGA 13569.12 Velocity	2.3	2.8	2.8	2.8	2.8	2.8	2.8	2.8
PURGA 13818.94 Velocity	2.4	2.9	2.9	2.9	2.9	2.9	2.9	2.9
PURGA 14068.76 Velocity	2.4	2.9	3.0	3.0	3.0	3.1	3.1	3.1
PURGA 14264.46 Velocity	1.9	1.9	1.9	1.9	2.0	2.1	2.2	2.3
PURGA 14460.16 Velocity	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9
PURGA 14629.61 Velocity	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA 14799.07 Velocity	2.7	3.2	3.3	3.3	3.3	3.3	3.3	3.3
PURGA 15053.80 Velocity	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3
PURGA 15308.54 Velocity	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA 15639.79 Velocity	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8
PURGA 15971.04 Velocity	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
PURGA 16267.20 Velocity	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.7
PURGA 16563.37 Velocity	1.7	1.7	1.7	1.8	1.9	2.2	2.3	2.6
PURGA 16866.56 Velocity	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
PURGA 17169.76 Velocity	2.4	2.5	2.7	2.7	2.8	2.7	2.7	2.6
PURGA 17498.04 Velocity	2.9	2.9	2.9	2.9	2.7	1.8	1.9	1.5
PURGA 17826.32 Velocity	4.2	4.2	4.2	4.2	3.8	1.7	1.8	1.0
PURGA 17826.32 Velocity	1.6	1.6	1.6	1.6	1.4	1.2	1.1	1.0
PURGA 17983.50 Velocity	1.6	1.6	1.6	1.6	1.3	1.1	1.1	1.1
PURGA 18140.67 Velocity	2.1	2.1	2.2	2.3	2.3	2.3	2.1	1.7
PURGA 18385.25 Velocity	1.7	1.7	1.8	1.9	1.9	1.9	1.7	1.3
PURGA 18629.82 Velocity	1.4	1.6	1.6	1.7	1.7	1.7	1.6	1.3
PURGA 18935.86 Velocity	1.7	1.9	1.9	2.0	2.0	2.0	2.0	2.0
PURGA 19241.91 Velocity	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.4
PURGA 19586.24 Velocity	1.8	1.8	1.8	1.9	1.8	1.9	2.0	1.9
PURGA 19930.56 Velocity	1.5	1.5	1.5	1.6	1.5	4.5	1.7	4.3
PURGA 19940.56 Velocity	2.8	2.8	2.8	2.9	2.6	2.9	3.0	3.1
PURGA 19950.56 Velocity	1.6	1.6	1.6	1.6	1.9	5.1	2.3	5.0
PURGA 20452.56 Velocity	1.4	1.4	1.5	1.5	1.6	1.8	1.8	1.7
PURGA 20954.56 Velocity	1.4	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA 20954.56 Velocity	1.4	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA 21320.56 Velocity	1.6	1.9	1.8	1.9	2.0	2.0	2.0	2.1
PURGA 21686.56 Velocity	1.9	2.1	1.9	2.1	2.2	2.3	2.3	2.3
PURGA 21686.56 Velocity	1.9	2.1	1.9	2.1	2.2	2.3	2.3	2.3
PURGA 22015.28 Velocity	1.2	1.2	1.2	1.3	1.4	1.4	1.4	1.4
PURGA 22344.00 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
PURGA_2 42.00 Velocity	1.7	2.4	2.6	2.7	3.0	3.0	3.0	3.0
PURGA_2 160.50 Velocity	1.7	2.4	2.6	2.7	3.0	3.0	3.0	3.0
PURGA_2 279.00 Velocity	1.8	2.4	2.6	2.7	3.0	3.0	3.0	3.0
PURGA_2 397.50 Velocity	1.8	2.4	2.6	2.8	2.9	2.9	3.0	3.0
PURGA_2 516.00 Velocity	1.8	2.5	2.6	2.8	2.9	2.9	3.0	3.0
PURGA_2 634.50 Velocity	1.8	2.5	2.6	2.8	2.9	2.9	3.0	3.0
PURGA_2 753.00 Velocity	1.8	2.5	2.6	2.8	2.9	2.9	3.0	2.9
PURGA_2 871.50 Velocity	1.8	2.5	2.7	2.8	2.9	2.9	3.0	2.9
PURGA_2 990.00 Velocity	1.8	2.5	2.7	2.8	2.9	2.9	2.9	2.9
PURGA_2 1108.50 Velocity	1.8	2.5	2.7	2.8	2.9	2.9	2.9	2.9
PURGA_2 1227.00 Velocity	1.8	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1345.50 Velocity	1.8	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1464.00 Velocity	1.9	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1582.50 Velocity	1.9	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1701.00 Velocity	1.9	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1819.50 Velocity	1.9	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 1938.00 Velocity	1.9	2.6	2.7	2.8	2.8	2.9	2.9	2.9
PURGA_2 2056.50 Velocity	1.9	2.6	2.7	2.7	2.8	2.9	2.9	3.0
PURGA_2 2175.00 Velocity	1.9	2.6	2.7	2.7	2.8	2.8	2.8	2.9
PURGA_2 2293.50 Velocity	1.9	2.6	2.7	2.7	2.8	2.9	2.8	3.0
PURGA_2 2412.00 Velocity	1.9	2.6	2.7	2.7	2.7	2.8	2.8	2.9
PURGA_2 2530.50 Velocity	1.9	2.6	2.7	2.8	2.9	2.9	3.0	3.0
PURGA_2 2649.00 Velocity	1.9	2.6	2.7	3.0	3.3	3.3	3.4	3.3
PURGA_2 2767.50 Velocity	1.8	2.5	2.8	3.4	3.9	3.9	3.9	3.9
PURGA_2 2886.00 Velocity	1.8	2.5	2.9	4.0	4.8	4.8	4.8	4.8
PURGA_2 2888.00 Velocity	3.0	4.3	4.3	7.1	7.5	19.6	15.6	20.5
PURGA_2 2890.00 Velocity	2.2	4.0	4.4	4.9	5.3	7.4	6.0	8.0
PURGA_2 3000.13 Velocity	1.9	2.3	2.3	2.7	2.7	3.6	3.7	3.6
PURGA_2 3110.25 Velocity	1.7	1.8	1.8	1.8	1.9	2.2	2.3	2.3

PURGA_2 3220.38 Velocity	1.6	1.8	1.8	1.8	1.9	2.0	2.0	2.1
PURGA_2 3330.50 Velocity	1.6	1.9	1.9	1.9	1.9	2.1	2.0	2.0
PURGA_2 3440.63 Velocity	1.5	1.9	1.9	1.9	2.0	2.0	2.0	2.0
PURGA_2 3550.75 Velocity	1.5	2.0	2.0	2.0	2.1	2.1	2.1	2.1
PURGA_2 3660.88 Velocity	1.5	2.0	2.1	2.1	2.1	2.1	2.1	2.1
PURGA_2 3771.00 Velocity	1.5	2.2	2.2	2.2	2.2	2.3	2.3	2.2
PURGA_2 3881.13 Velocity	1.5	2.2	2.2	2.2	2.2	2.3	2.3	2.3
PURGA_2 3991.25 Velocity	1.5	2.2	2.3	2.3	2.4	2.4	2.4	2.4
PURGA_2 4101.38 Velocity	1.5	2.3	2.4	2.4	2.4	2.4	2.4	2.4
PURGA_2 4211.50 Velocity	1.4	2.3	2.5	2.6	2.7	2.7	2.7	2.7
PURGA_2 4321.63 Velocity	1.4	2.4	2.6	2.7	2.9	2.9	2.9	3.0
PURGA_2 4431.75 Velocity	1.3	2.4	2.7	2.9	3.5	3.7	3.7	3.7
PURGA_2 4541.88 Velocity	1.2	2.5	2.8	3.2	4.0	4.5	4.6	4.6
PURGA_2 4652.00 Velocity	1.0	2.6	3.1	3.5	4.7	6.2	6.8	7.5
RAILNORTH 869.00 Velocity	0.1	0.3	0.4	0.4	0.5	0.5	0.5	0.6
RAILNORTH 949.50 Velocity	0.2	0.5	0.6	0.7	0.7	0.8	0.8	0.8
RAILNORTH 1030.00 Velocity	0.6	1.5	1.7	1.7	1.8	1.9	1.9	1.9
RAILNORTH 1030.00 Velocity	1.3	1.7	1.8	1.8	1.8	1.9	1.9	1.9
RAILNORTH 1214.98 Velocity	0.8	1.0	1.1	1.1	1.2	1.3	1.3	1.3
RAILNORTH 1399.96 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1399.96 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1399.96 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1400.00 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1400.00 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1400.00 Velocity	0.5	0.7	0.8	0.8	0.9	0.9	1.0	1.0
RAILNORTH 1453.14 Velocity	0.7	0.9	0.9	1.0	1.1	1.1	1.1	1.1
RAILNORTH 1506.31 Velocity	0.9	1.0	1.1	1.2	1.4	1.4	1.5	1.4
RAILNORTH 1810.66 Velocity	1.7	1.9	1.9	1.9	2.2	2.2	2.1	2.1
RAILNORTH 2115.00 Velocity	0.0	0.4	0.7	0.9	1.4	2.1	3.2	3.0
RAILNORTH 2354.05 Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5
RAILNORTH 2593.10 Velocity	0.0	0.0	0.0	0.0	0.1	0.2	0.5	0.7
RAILNORTH 2973.38 Velocity	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.5
RAILNORTH 3353.67 Velocity	0.0	0.0	0.2	0.2	0.3	0.4	0.5	0.6
RAILNORTH 3574.97 Velocity	0.1	0.1	0.2	0.2	0.3	0.4	0.6	0.6
RAILNORTH 3796.28 Velocity	0.1	0.1	0.2	0.2	0.3	0.3	0.6	0.8
RAILNORTH 4040.64 Velocity	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.3
RAILNORTH 4285.00 Velocity	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
RAILNORTH 4285.00 Velocity	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
RAILNORTH 4333.07 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
RAILNORTH 4381.13 Velocity	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
RAILNORTH 4469.57 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
RAILNORTH 4558.00 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
RAILNORTH 4558.00 Velocity	1.5	2.0	2.1	2.2	2.6	2.9	3.1	3.2
RAILNORTH 4820.00 Velocity	1.2	1.5	1.6	1.7	1.9	2.1	2.1	2.0
RAILNORTH 5082.00 Velocity	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.5
RAILNORTH 6909.00 Velocity	0.1	0.4	0.4	0.4	0.5	0.5	0.5	0.5
RAILNORTH 7127.50 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 7346.00 Velocity	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
RAILNORTH 7346.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
RAILNORTH 7689.00 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 8032.00 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 8032.00 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 8410.64 Velocity	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2
RAILNORTH 8789.28 Velocity	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
RAILNORTH 8909.14 Velocity	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
RAILNORTH 9029.00 Velocity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
RAILNORTH 9029.00 Velocity	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3
RAILNORTH 9149.17 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
RAILNORTH 9269.34 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 9520.53 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 9771.72 Velocity	0.1	0.4	0.3	0.3	0.3	0.3	0.4	0.4
RAILNORTH 9781.72 Velocity	0.1	0.5	0.4	0.4	0.5	0.5	0.5	0.5
RAILNORTH 9791.72 Velocity	0.1	1.0	0.7	0.6	0.8	0.9	0.9	0.8
RAILNORTH 10084.36 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 10377.00 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH 10377.00 Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1

RAILNORTH	10586.55	Velocity	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
RAILNORTH	10796.10	Velocity	0.1	0.4	0.5	0.4	0.4	0.3	0.3	0.3
RAILNORTH	11087.73	Velocity	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
RAILNORTH	11379.36	Velocity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
RAILNORTH	11379.68	Velocity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
RAILNORTH	11380.00	Velocity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
RAILNORTH	11380.00	Velocity	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.5
RAILNORTH	11671.50	Velocity	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
RAILNORTH	11963.00	Velocity	0.0	0.2	1.6	2.0	2.7	2.9	3.9	3.2
RAILNORTH	12176.50	Velocity	0.0	0.0	0.0	0.0	0.6	0.5	0.5	0.5
RAILNORTH	12390.00	Velocity	0.0	0.0	0.0	0.0	0.8	0.6	0.7	0.7
RAILNORTH	12929.00	Velocity	0.0	0.0	0.0	0.0	0.2	0.4	0.5	0.5
RAILNORTH	13468.00	Velocity	0.0	0.0	0.0	0.0	0.2	0.9	0.9	1.0
RAILNORTH	13468.00	Velocity	0.0	0.0	0.0	0.0	0.2	0.5	0.5	0.6
RAILNORTH	13668.00	Velocity	0.0	0.0	0.0	0.0	0.3	0.5	0.5	0.5
RAILNORTH	13868.00	Velocity	0.2	0.2	0.2	0.2	0.5	0.8	0.8	0.7
RAILNORTH	13868.00	Velocity	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4
RAILNORTH	14248.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
RAILNORTH	14628.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
RAILNORTH	14678.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
RAILNORTH	14728.00	Velocity	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.5
RAILNORTH	14728.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
RAILNORTH	14783.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAILNORTH	14838.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
RAILNORTH	14848.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
RAILNORTH	14858.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
RAILNORTH	15543.00	Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RAILSOUTH	869.00	Velocity	0.3	0.8	0.8	1.0	1.4	2.0	2.3	2.5
RAILSOUTH	949.50	Velocity	0.4	0.8	0.9	1.1	1.5	2.2	2.5	2.8
RAILSOUTH	1030.00	Velocity	0.6	1.0	1.1	1.2	1.6	2.4	2.7	3.0
RAILSOUTH	1030.00	Velocity	0.5	1.0	1.1	1.2	1.6	2.4	2.7	3.0
RAILSOUTH	1215.00	Velocity	0.8	1.0	1.0	1.1	1.3	1.7	1.8	1.8
RAILSOUTH	1400.00	Velocity	1.6	1.7	1.8	1.8	1.9	2.2	2.2	1.9
RAILSOUTH	1400.00	Velocity	1.6	1.7	1.8	1.8	1.9	2.1	2.2	1.9
RAILSOUTH	1453.16	Velocity	1.4	1.7	1.7	1.7	1.9	2.2	2.3	2.2
RAILSOUTH	1506.31	Velocity	1.3	2.4	2.9	3.5	5.6	8.0	8.0	8.0
RAILSOUTH	1810.66	Velocity	1.0	2.0	2.5	3.0	4.8	7.1	7.2	7.2
RAILSOUTH	2115.00	Velocity	0.9	1.8	2.2	2.6	4.2	6.4	7.1	7.7
RAILSOUTH	2115.00	Velocity	1.6	2.6	3.2	3.8	5.7	7.9	8.5	8.9
RAILSOUTH	2354.05	Velocity	1.2	1.5	1.6	1.8	2.0	2.4	3.1	2.6
RAILSOUTH	2593.10	Velocity	1.1	1.1	1.1	1.1	1.6	1.7	2.0	1.6
RAILSOUTH	2973.38	Velocity	1.0	1.2	1.3	1.3	1.5	1.6	1.6	1.7
RAILSOUTH	3353.67	Velocity	1.1	1.4	1.5	1.6	1.8	2.0	2.0	2.0
RAILSOUTH	3574.97	Velocity	1.1	1.5	1.6	1.7	2.1	2.5	2.6	2.6
RAILSOUTH	3796.28	Velocity	1.2	1.6	1.7	1.8	2.5	3.5	3.9	4.4
RAILSOUTH	4040.64	Velocity	0.9	1.4	1.6	1.7	2.3	2.9	3.1	3.3
RAILSOUTH	4285.00	Velocity	0.7	1.3	1.5	1.6	2.1	2.5	2.6	2.7
RAILSOUTH	4285.00	Velocity	0.7	1.3	1.5	1.6	2.1	2.5	2.6	2.7
RAILSOUTH	4333.07	Velocity	0.7	1.3	1.5	1.5	2.1	2.4	2.5	2.7
RAILSOUTH	4381.13	Velocity	0.6	1.3	1.4	1.5	2.0	2.4	2.5	2.6
RAILSOUTH	4469.57	Velocity	0.9	1.4	1.4	1.4	1.6	1.6	1.7	1.7
RAILSOUTH	4558.00	Velocity	1.5	1.8	1.8	1.8	2.0	2.6	3.7	2.7
RAILSOUTH	6909.00	Velocity	1.0	1.4	1.7	2.1	3.1	4.2	4.6	5.2
RAILSOUTH	7127.50	Velocity	1.1	1.8	2.3	2.7	4.0	5.0	5.4	6.0
RAILSOUTH	7346.00	Velocity	1.4	2.8	3.4	3.9	5.5	6.4	6.6	7.0
RAILSOUTH	7346.00	Velocity	1.4	2.8	3.4	3.9	5.5	6.4	6.6	7.3
RAILSOUTH	7689.00	Velocity	1.6	1.6	1.6	1.6	2.0	2.5	2.6	2.4
RAILSOUTH	8032.00	Velocity	5.2	5.2	5.2	5.2	5.5	5.8	5.9	5.4
RAILSOUTH	8032.00	Velocity	0.9	1.0	1.0	1.0	1.2	1.5	1.4	1.3
RAILSOUTH	8178.00	Velocity	0.7	0.8	0.8	0.9	1.2	1.4	1.4	1.3
RAILSOUTH	8324.00	Velocity	0.6	0.7	0.7	0.8	1.2	1.4	1.4	1.4
RAILSOUTH	8324.00	Velocity	0.9	0.9	0.9	1.0	1.1	1.1	1.2	1.3
RAILSOUTH	8556.64	Velocity	1.0	1.0	1.0	1.1	1.3	1.5	2.0	2.3
RAILSOUTH	8789.28	Velocity	1.2	1.5	1.9	2.2	4.1	4.4	5.5	7.1
RAILSOUTH	8909.14	Velocity	1.3	1.6	2.0	2.3	4.2	4.6	5.8	7.6
RAILSOUTH	9029.00	Velocity	1.5	1.7	2.0	2.4	4.4	4.7	5.9	7.9

RAILSOUTH 9029.00 Velocity	1.5	1.7	2.0	2.4	4.4	4.7	5.9	7.9
RAILSOUTH 9149.17 Velocity	1.5	1.8	2.1	2.5	4.8	5.0	6.2	8.6
RAILSOUTH 9269.34 Velocity	1.5	1.9	2.2	2.6	5.0	5.2	6.5	9.1
RAILSOUTH 9520.53 Velocity	1.4	1.9	3.0	3.0	5.0	5.2	6.6	9.2
RAILSOUTH 9771.72 Velocity	1.4	2.0	3.1	6.3	7.6	7.8	7.0	9.3
RAILSOUTH 9781.72 Velocity	1.5	1.7	8.1	12.9	19.1	18.0	17.2	19.5
RAILSOUTH 9791.72 Velocity	1.4	2.0	3.2	9.6	16.2	15.8	13.0	13.4
RAILSOUTH 10084.36 Velocity	1.1	1.7	2.6	3.0	5.3	4.9	6.1	10.2
RAILSOUTH 10377.00 Velocity	0.9	1.4	2.1	2.3	4.8	4.7	5.5	9.5
RAILSOUTH 10377.00 Velocity	0.9	1.4	2.3	2.4	4.8	4.7	5.8	9.7
RAILSOUTH 10586.55 Velocity	1.1	1.7	2.8	2.9	5.1	5.7	7.1	11.3
RAILSOUTH 10796.10 Velocity	1.3	2.0	3.7	3.9	6.1	6.8	8.0	13.2
RAILSOUTH 11087.73 Velocity	1.3	2.0	4.3	4.3	6.7	7.1	8.1	13.8
RAILSOUTH 11379.36 Velocity	1.3	2.0	3.6	3.7	8.7	8.0	9.9	14.5
RAILSOUTH 11379.68 Velocity	1.3	2.0	3.6	3.6	8.9	8.0	8.4	14.5
RAILSOUTH 11380.00 Velocity	1.3	2.0	3.6	3.7	8.7	8.0	9.8	14.5
RAILSOUTH 11380.00 Velocity	1.3	2.0	3.1	4.5	10.2	9.1	11.2	14.7
RAILSOUTH 11671.77 Velocity	1.4	2.4	4.1	5.7	12.6	10.8	12.8	15.0
RAILSOUTH 11963.54 Velocity	1.6	3.0	4.6	7.1	13.4	12.5	13.7	15.4
RAILSOUTH 12063.27 Velocity	1.2	1.3	1.9	2.6	4.2	3.8	4.6	3.7
RAILSOUTH 12163.00 Velocity	1.3	1.4	1.4	1.5	2.2	2.0	2.2	2.1
RAILSOUTH 12163.00 Velocity	1.3	1.3	1.3	1.5	1.6	1.7	1.7	1.7
RAILSOUTH 12276.50 Velocity	1.2	1.3	1.2	1.4	1.8	1.7	1.8	1.7
RAILSOUTH 12390.00 Velocity	2.6	1.8	2.4	2.5	2.0	2.6	2.6	2.6
RAILSOUTH 12400.00 Velocity	3.7	4.2	3.7	4.2	4.4	4.6	4.6	4.6
RAILSOUTH 12410.00 Velocity	3.2	1.7	3.1	3.2	3.3	3.8	5.4	6.0
RAILSOUTH 12939.00 Velocity	1.1	1.4	2.0	2.8	4.3	4.0	4.1	4.3
RAILSOUTH 13468.00 Velocity	1.1	1.4	2.5	2.5	3.2	3.1	3.5	3.4
RAILSOUTH 13468.00 Velocity	1.1	1.4	2.5	2.5	3.2	3.1	3.5	3.4
RAILSOUTH 13668.00 Velocity	1.6	2.0	3.7	3.8	4.4	4.5	5.0	5.0
RAILSOUTH 13868.00 Velocity	5.2	5.2	6.0	6.3	7.6	7.9	10.4	9.3
RAILSOUTH 13868.00 Velocity	1.3	1.3	1.8	1.9	1.9	1.9	2.1	3.2
RAILSOUTH 14248.00 Velocity	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.6
RAILSOUTH 14628.00 Velocity	1.0	1.0	1.2	1.2	1.2	1.2	1.3	1.2
RAILSOUTH 14628.00 Velocity	1.0	1.0	1.2	1.2	1.2	1.2	1.2	1.2
RAILSOUTH 14678.00 Velocity	1.0	1.1	1.2	1.2	1.2	1.2	1.2	1.2
RAILSOUTH 14728.00 Velocity	1.0	1.1	1.2	1.2	1.3	1.2	1.3	1.2
RAILSOUTH 14728.00 Velocity	1.0	1.1	1.2	1.2	1.3	1.2	1.3	1.2
RAILSOUTH 14783.00 Velocity	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.2
RAILSOUTH 14838.00 Velocity	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.3
RAILSOUTH 14848.00 Velocity	1.2	1.2	1.3	1.4	1.4	1.4	1.4	1.4
RAILSOUTH 14858.00 Velocity	1.1	1.2	1.3	1.3	1.3	1.3	1.3	1.3
RAILSOUTH 15543.00 Velocity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.6
RAILSOUTH 16228.00 Velocity	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4
REEDY 1000.00 Velocity	0.8	0.9	1.0	1.1	1.3	1.6	1.6	1.7
REEDY 1135.50 Velocity	0.7	0.8	0.8	0.9	1.1	1.3	1.4	1.5
REEDY 1271.00 Velocity	0.6	0.7	0.7	0.8	1.0	1.1	1.2	1.3
REEDY 1406.50 Velocity	0.6	0.7	0.7	0.8	1.0	1.1	1.1	1.2
REEDY 1542.00 Velocity	0.5	0.6	0.6	0.7	0.9	1.1	1.1	1.1
REEDY 1542.00 Velocity	0.5	0.6	0.6	0.7	0.9	1.1	1.1	1.1
REEDY 1768.50 Velocity	0.5	0.6	0.6	0.7	0.9	1.0	1.0	1.1
REEDY 1995.00 Velocity	0.7	0.7	0.7	0.7	0.8	0.9	0.9	1.0
REEDY 1995.00 Velocity	0.7	0.7	0.7	0.7	0.8	0.9	0.9	1.0
REEDY 2067.00 Velocity	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0
REEDY 2139.00 Velocity	0.5	0.6	0.6	0.7	0.8	1.0	1.1	1.1
SAND 10000.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SAND 10160.00 Velocity	0.4	0.6	0.6	0.7	0.8	0.8	0.8	0.8
SAND 10320.00 Velocity	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
SAND 10420.00 Velocity	0.5	0.6	0.6	0.7	0.8	1.0	1.0	1.0
SAND 10520.00 Velocity	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.6
SAND 10720.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8
SAND 10920.00 Velocity	0.5	0.6	0.6	0.6	0.4	0.4	0.4	0.4
SAND 10980.00 Velocity	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
SAND 11040.00 Velocity	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SAND 11051.00 Velocity	1.9	2.6	2.8	2.9	2.9	2.9	2.9	2.9
SAND 11062.00 Velocity	0.6	0.9	1.0	1.0	1.3	1.3	1.4	1.4

SAND 11151.00 Velocity	0.6	0.8	0.8	0.8	1.1	1.1	1.2	1.2
SAND 11240.00 Velocity	0.4	0.5	0.5	0.5	0.6	0.6	0.7	0.7
SAND 11379.00 Velocity	0.5	0.6	0.6	0.7	1.0	1.0	1.1	1.1
SAND 11518.00 Velocity	0.4	0.5	0.5	0.4	0.4	0.6	0.7	0.7
SAND 11529.00 Velocity	1.7	2.3	2.5	2.7	2.8	2.8	2.9	3.2
SAND 11540.00 Velocity	0.6	0.8	0.8	0.8	1.1	1.5	1.4	1.3
SAND 11650.00 Velocity	0.6	0.8	0.8	0.8	0.9	0.9	0.9	1.0
SAND 11760.00 Velocity	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6
SAND 11879.00 Velocity	0.7	0.9	1.0	1.0	1.1	1.1	1.1	1.1
SAND 11998.00 Velocity	0.6	0.7	0.8	0.8	0.8	0.9	0.9	1.0
SAND 12009.00 Velocity	1.5	2.1	2.2	2.3	3.0	3.4	3.5	3.6
SAND 12020.00 Velocity	0.7	0.9	0.9	1.0	1.3	1.5	1.5	1.6
SAND 12070.00 Velocity	0.7	0.8	0.9	0.9	1.2	1.4	1.4	1.5
SAND 12120.00 Velocity	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0
SAND 12280.00 Velocity	0.7	0.8	0.8	0.9	1.1	1.2	1.2	1.2
SAND 12440.00 Velocity	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.9
SAND 12565.00 Velocity	0.8	1.0	1.0	1.1	1.3	1.4	1.4	1.4
SAND 12690.00 Velocity	0.7	0.8	0.8	0.9	1.1	1.3	1.3	1.4
SAND 12855.00 Velocity	0.7	1.0	1.1	1.2	1.6	1.8	1.8	1.9
SAND 13020.00 Velocity	0.6	0.7	0.7	0.8	1.0	1.2	1.3	1.4
SAND 13170.00 Velocity	0.5	0.7	0.7	0.8	1.0	1.2	1.2	1.2
SAND 13320.00 Velocity	0.4	0.4	0.4	0.5	0.6	0.7	0.7	0.7
SAND 13570.00 Velocity	0.4	0.5	0.6	0.6	0.8	0.9	1.0	1.0
SAND 13820.00 Velocity	0.4	0.5	0.5	0.5	0.7	0.8	0.8	0.8
SAND 14020.00 Velocity	0.5	0.6	0.7	0.7	0.9	1.0	1.0	1.1
SAND 14220.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
SAND 14420.00 Velocity	0.6	0.7	0.7	0.7	0.9	1.0	1.0	1.1
SAND 14620.00 Velocity	0.7	0.8	0.8	0.8	0.8	0.9	1.2	1.0
SAND 14660.00 Velocity	0.2	0.4	0.4	0.5	0.8	1.0	1.4	1.0
SAND 14700.00 Velocity	0.1	0.2	0.2	0.2	0.4	0.5	1.2	0.6
SAND 14720.00 Velocity	0.2	0.3	0.4	0.4	0.9	1.3	2.3	1.8
SAND 14740.00 Velocity	0.1	0.2	0.3	0.3	0.5	0.6	1.3	0.8
SAND 14780.00 Velocity	0.2	0.4	0.4	0.5	0.8	1.0	1.5	1.1
SAND 14820.00 Velocity	0.7	0.7	0.8	0.8	1.0	1.2	1.6	1.3
SAND 15020.00 Velocity	0.9	0.9	0.9	1.0	1.2	1.2	1.5	1.3
SAND 15220.00 Velocity	0.9	0.9	0.9	0.9	1.0	1.1	1.3	1.1
SAND 15420.00 Velocity	0.9	1.0	1.0	1.1	1.3	1.4	1.5	1.4
SAND 15620.00 Velocity	0.8	1.0	1.0	1.1	1.5	1.6	1.7	1.6
SAND 15620.00 Velocity	0.8	1.0	1.0	1.1	1.4	1.5	1.6	1.5
SAND 15806.00 Velocity	0.7	0.9	0.9	1.0	1.2	1.3	1.5	1.4
SAND 15992.00 Velocity	0.6	0.8	0.8	0.9	1.1	1.2	1.4	1.3
SAND 16178.00 Velocity	0.6	0.8	0.8	0.8	1.0	1.1	1.3	1.2
SAND 16364.00 Velocity	0.5	0.7	0.7	0.8	0.9	1.0	1.2	1.1
SAND 16542.50 Velocity	0.5	0.7	0.8	0.8	0.9	1.0	1.2	1.0
SAND 16721.00 Velocity	0.5	0.7	0.8	0.8	0.9	1.0	1.2	1.0
SAND 16899.50 Velocity	0.5	0.8	0.8	0.8	0.9	1.0	1.1	1.1
SAND 17078.00 Velocity	0.5	0.8	0.8	0.9	1.0	1.1	1.2	1.1
SAND 17256.50 Velocity	0.6	0.8	0.9	0.9	1.0	1.1	1.2	1.1
SAND 17435.00 Velocity	0.6	0.9	0.9	1.0	1.2	1.3	1.4	1.3
SAND 17654.17 Velocity	0.5	0.7	0.7	0.8	1.0	1.1	1.3	1.2
SAND 17873.33 Velocity	0.4	0.5	0.6	0.6	0.8	1.0	1.2	1.1
SAND 18092.50 Velocity	0.3	0.5	0.5	0.5	0.7	0.9	1.2	1.0
SAND 18311.67 Velocity	0.3	0.4	0.5	0.5	0.7	0.8	1.2	0.9
SAND 18530.83 Velocity	0.3	0.4	0.4	0.4	0.6	0.7	1.1	0.8
SAND 18750.00 Velocity	0.2	0.3	0.4	0.4	0.5	0.6	1.0	0.7
SAND 18972.86 Velocity	0.2	0.3	0.4	0.4	0.5	0.6	0.9	0.6
SAND 19195.71 Velocity	0.2	0.3	0.4	0.4	0.5	0.6	1.0	0.6
SAND 19418.57 Velocity	0.2	0.3	0.4	0.4	0.5	0.6	1.0	0.6
SAND 19641.43 Velocity	0.3	0.4	0.4	0.4	0.5	0.6	1.0	0.6
SAND 19864.29 Velocity	0.3	0.4	0.4	0.4	0.5	0.6	1.0	0.7
SAND 20087.14 Velocity	0.4	0.4	0.4	0.4	0.6	0.6	1.0	0.7
SAND 20310.00 Velocity	0.4	0.4	0.4	0.4	0.6	0.6	1.0	0.7
SAND 20532.86 Velocity	0.5	0.5	0.5	0.5	0.6	0.7	1.0	0.7
SAND 20755.71 Velocity	0.5	0.5	0.5	0.5	0.6	0.7	1.0	0.7
SAND 20978.57 Velocity	0.6	0.6	0.6	0.6	0.6	0.7	1.0	0.7
SAND 21201.43 Velocity	0.6	0.6	0.6	0.6	0.6	0.7	0.9	0.7

SAND 21424.29 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.7
SAND 21647.14 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6
SAND 21870.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.9	0.6
SAND 22070.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.9	0.6
SAND 22270.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.8	0.6
SAND 22470.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.9	0.6
SAND 22670.00 Velocity	0.6	0.6	0.6	0.6	0.6	0.6	0.9	0.6
SAND 22870.00 Velocity	0.7	0.7	0.7	0.7	0.7	0.7	1.0	0.7
SAND 23070.00 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	1.1	0.8
SAND 23070.00 Velocity	0.8	0.8	0.8	0.8	0.8	0.8	1.1	0.8
SAND 23205.00 Velocity	0.9	0.9	0.9	0.9	0.9	0.9	1.1	0.9
SAND 23340.00 Velocity	0.9	0.9	0.9	0.9	0.9	0.9	1.1	0.9
SAND 23475.00 Velocity	1.0	1.0	1.0	1.0	1.0	1.0	1.4	1.0
SAND 23610.00 Velocity	1.2	1.2	1.2	1.2	1.2	1.2	2.2	1.2
SAND 23755.00 Velocity	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.1
SAND 23900.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
SCH 10000.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCH 10170.00 Velocity	0.5	0.7	0.8	0.9	1.1	1.3	1.3	1.4
SCH 10340.00 Velocity	0.3	0.5	0.5	0.6	0.7	0.8	0.8	0.8
SCH 10570.00 Velocity	0.4	0.8	0.9	0.9	1.2	1.3	1.3	1.4
SCH 10800.00 Velocity	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3
SCH 10805.00 Velocity	2.5	2.5	2.5	2.5	2.5	2.5	2.6	2.8
SCH 10810.00 Velocity	0.6	0.8	0.9	0.9	1.2	1.3	1.4	1.4
SCH 10960.00 Velocity	0.3	0.4	0.4	0.5	0.5	0.6	0.8	0.6
SCH 11110.00 Velocity	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SCH 11246.40 Velocity	0.3	0.4	0.5	0.5	0.6	0.7	0.6	0.7
SCH 11382.80 Velocity	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4
SCH 11496.40 Velocity	0.4	0.6	0.7	0.7	0.8	0.8	0.8	0.8
SCH 11610.00 Velocity	0.8	1.1	1.2	1.2	1.5	1.6	1.6	1.7
SCH 11748.50 Velocity	0.5	0.8	0.9	0.9	1.0	1.1	1.1	1.1
SCH 11887.00 Velocity	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.5
SCH 11907.00 Velocity	1.7	2.5	2.6	2.8	3.6	4.2	4.2	4.6
SCH 11927.00 Velocity	0.3	0.4	0.4	0.5	0.6	0.8	0.8	0.9
SCH 12047.00 Velocity	0.4	0.5	0.6	0.6	0.8	1.0	1.0	1.0
SCH 12167.00 Velocity	0.4	0.6	0.6	0.6	0.9	1.0	1.0	1.0
SCH 12227.00 Velocity	0.6	0.8	0.8	0.9	1.0	1.1	1.1	1.1
SCH 12287.00 Velocity	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.8
SCH 12361.00 Velocity	0.5	0.7	0.7	0.8	0.9	0.9	0.9	1.0
SCH 12435.00 Velocity	0.2	0.4	0.4	0.5	0.6	0.7	0.7	0.7
SCH 12449.00 Velocity	1.2	1.2	1.3	1.4	2.1	2.6	2.7	3.9
SCH 12462.80 Velocity	0.3	0.6	0.7	0.7	0.9	1.1	1.1	1.2
SCH 12634.20 Velocity	0.5	0.7	0.8	0.8	1.0	1.2	1.2	1.2
SCH 12805.60 Velocity	0.5	0.7	0.7	0.7	0.8	0.9	0.9	0.9
SCH 12932.80 Velocity	0.2	0.3	0.4	0.4	0.6	0.7	0.8	0.8
SCH 13060.00 Velocity	0.1	0.2	0.2	0.3	0.4	0.6	0.6	0.6
SCH 13060.00 Velocity	0.1	0.2	0.2	0.3	0.4	0.6	0.6	0.6
SCH 13134.50 Velocity	0.2	0.3	0.4	0.4	0.7	0.8	1.0	0.8
SCH 13209.00 Velocity	0.7	0.9	1.0	1.0	1.2	1.3	1.5	1.3
SCH 13403.75 Velocity	0.7	1.0	1.0	1.0	1.2	1.3	1.5	1.3
SCH 13598.50 Velocity	0.8	1.0	1.0	1.1	1.3	1.3	1.5	1.3
SCH 13677.75 Velocity	0.9	1.2	1.1	1.2	1.4	1.6	1.8	1.6
SCH 13757.00 Velocity	1.0	1.4	1.3	1.4	1.7	1.9	2.3	1.9
SCH 13757.30 Velocity	1.0	1.4	1.3	1.4	1.7	1.9	2.3	1.9
SCH 13757.61 Velocity	1.0	1.4	1.3	1.4	1.7	1.9	2.3	1.9
SCH 13757.61 Velocity	1.0	1.4	1.3	1.4	1.7	1.9	2.3	1.9
SCH 13864.80 Velocity	0.7	1.1	0.9	1.0	1.3	1.6	2.3	1.6
SCH 13972.00 Velocity	0.5	1.0	0.7	0.8	1.1	1.4	2.3	1.4
SCH_LK1 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
SCH_LK1 15.00 Velocity	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0
SCH_LK1 30.00 Velocity	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
SCH_LK2 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCH_LK2 25.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SCH_LK2 50.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SIX 9530.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SIX 9795.00 Velocity	0.8	1.1	1.1	1.2	1.4	1.5	1.6	1.6
SIX 10060.00 Velocity	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.7

SIX 10185.00 Velocity	0.8	1.0	1.0	1.0	1.2	1.3	1.4	1.4
SIX 10310.00 Velocity	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
SIX 10337.50 Velocity	0.7	0.8	0.9	0.9	0.9	1.1	1.1	1.1
SIX 10365.00 Velocity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
SIX 10377.00 Velocity	1.3	1.4	1.4	1.5	1.6	1.9	2.2	2.5
SIX 10380.00 Velocity	0.8	0.9	0.9	0.9	1.1	1.3	1.3	1.3
SIX 10420.00 Velocity	0.8	0.9	0.9	1.0	1.2	1.4	1.4	1.4
SIX 10460.00 Velocity	0.6	0.7	0.7	0.7	1.0	1.2	1.2	1.2
SIX 10690.00 Velocity	0.7	0.8	0.8	0.9	1.1	1.2	1.2	1.3
SIX 10920.00 Velocity	0.4	0.5	0.5	0.5	0.6	0.7	0.7	0.7
SIX 11137.50 Velocity	0.8	0.8	0.9	1.0	1.2	1.3	1.4	1.3
SIX 11355.00 Velocity	0.7	0.7	0.7	0.7	0.7	0.8	1.1	1.1
SIX 11462.50 Velocity	0.9	0.9	0.9	0.9	0.9	1.0	1.1	1.1
SIX 11570.00 Velocity	0.8	0.8	0.8	0.8	0.7	0.7	0.6	0.6
SIX 11620.00 Velocity	0.9	0.9	0.9	0.9	1.0	1.0	1.0	1.0
SIX 11670.00 Velocity	0.7	0.7	0.8	0.8	0.8	0.7	0.7	0.7
SIX 11720.00 Velocity	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7
SIX 11770.00 Velocity	0.2	0.2	0.2	0.2	0.3	0.4	0.4	0.4
SIX 11785.00 Velocity	1.1	2.1	2.2	2.3	2.4	2.5	2.4	2.5
SIX 11800.00 Velocity	0.2	0.3	0.3	0.3	0.4	0.5	0.5	0.5
SIX 11835.00 Velocity	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.6
SIX 11870.00 Velocity	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.7
SIX 11940.00 Velocity	0.8	0.8	0.9	0.9	1.1	1.1	1.2	1.1
SIX 12010.00 Velocity	0.9	0.9	0.9	1.0	1.0	0.9	1.0	0.9
SIX 12240.00 Velocity	0.8	0.9	0.9	0.9	0.9	1.0	1.1	1.1
SIX 12470.00 Velocity	0.6	0.7	0.7	0.7	0.8	0.9	1.0	1.0
SIX 12720.00 Velocity	0.6	0.6	0.6	0.7	0.7	0.8	0.9	0.9
SIX 12970.00 Velocity	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.5
SIX 13295.00 Velocity	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8
SIX 13620.00 Velocity	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
SIX 13832.50 Velocity	0.6	0.7	0.7	0.7	0.8	0.8	0.9	0.9
SIX 14045.00 Velocity	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
SIX 14257.50 Velocity	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6
SIX 14470.00 Velocity	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
SIX 14635.00 Velocity	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
SIX 14800.00 Velocity	0.7	0.8	0.8	0.7	0.8	0.8	0.8	0.8
SIX 14985.00 Velocity	0.5	0.6	0.6	0.5	0.5	0.6	0.6	0.6
SIX 15170.00 Velocity	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
SIX 15370.00 Velocity	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
SIX 15570.00 Velocity	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.3
SIX 15740.00 Velocity	0.1	0.2	0.2	0.2	0.3	0.4	0.4	0.4
SIX 15910.00 Velocity	0.1	0.2	0.2	0.2	0.3	0.3	0.4	0.4
SIX 16090.00 Velocity	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.6
SIX 16270.00 Velocity	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8
SIX 16370.00 Velocity	0.9	1.1	1.1	1.1	1.1	1.2	1.1	1.1
SIX 16470.00 Velocity	0.9	1.4	1.5	1.7	2.1	2.2	2.2	2.2
SIX 16595.00 Velocity	0.8	1.1	1.2	1.2	1.4	1.5	1.5	1.6
SIX 16720.00 Velocity	0.6	0.8	0.8	0.8	1.0	1.0	1.1	1.1
SIX 16930.00 Velocity	0.6	0.7	0.7	0.7	0.8	0.9	0.9	1.0
SIX 17140.00 Velocity	0.5	0.5	0.6	0.6	0.6	0.6	0.7	0.7
SIX 17205.00 Velocity	0.5	0.7	0.7	0.7	0.8	0.9	1.0	1.0
SIX 17270.00 Velocity	0.5	0.7	0.8	0.8	1.1	1.2	1.3	1.4
SIX 17400.00 Velocity	0.6	0.8	0.9	0.9	1.1	1.3	1.4	1.5
SIX 17530.00 Velocity	0.7	0.8	0.8	0.8	1.0	1.2	1.3	1.4
SIX 17730.00 Velocity	0.7	0.8	0.9	0.9	1.1	1.3	1.3	1.4
SIX 17930.00 Velocity	0.7	0.8	0.8	0.8	1.0	1.1	1.1	1.1
SIX 18100.00 Velocity	0.8	1.0	1.0	1.0	1.2	1.3	1.3	1.3
SIX 18270.00 Velocity	1.1	1.1	1.1	1.1	1.2	1.3	1.3	1.3
SIX 18495.00 Velocity	1.0	1.0	1.1	1.1	1.2	1.2	1.3	1.2
SIX 18720.00 Velocity	1.0	1.1	1.0	1.1	1.0	1.0	1.0	1.0
SIX 18845.00 Velocity	1.0	1.1	1.1	1.1	1.3	1.3	1.3	1.3
SIX 18970.00 Velocity	0.9	1.1	1.1	1.1	1.4	1.4	1.5	1.4
SIX 19070.00 Velocity	0.9	1.0	1.1	1.1	1.1	1.2	1.2	1.1
SIX 19170.00 Velocity	0.7	0.9	0.9	0.9	0.9	0.9	0.9	0.8
SIX 19270.00 Velocity	0.9	1.1	1.1	1.1	1.1	1.1	1.2	1.2
SIX 19370.00 Velocity	0.9	1.1	1.2	1.2	1.4	1.4	1.4	1.4

SIX 19510.00 Velocity	1.0	1.3	1.3	1.3	1.4	1.5	1.5	1.5
SIX 19650.00 Velocity	0.9	1.1	1.2	1.2	1.3	1.3	1.3	1.2
SIX 19720.00 Velocity	0.9	1.2	1.2	1.3	1.4	1.5	1.5	1.5
SIX 19790.00 Velocity	0.7	1.0	1.1	1.1	1.3	1.4	1.4	1.4
SIX 19850.00 Velocity	1.4	2.0	2.0	2.1	2.4	2.5	2.6	2.6
SIX 19870.00 Velocity	1.0	1.5	1.5	1.6	1.8	1.9	1.9	1.9
SIX 19935.00 Velocity	1.0	1.3	1.4	1.3	1.6	1.7	1.7	1.8
SIX 20000.00 Velocity	0.8	1.0	1.0	1.0	1.2	1.3	1.3	1.3
SIX 20070.00 Velocity	0.9	1.3	1.4	1.2	1.5	1.6	1.6	1.7
SIX 20140.00 Velocity	0.8	1.2	1.0	1.1	1.3	1.4	1.5	1.4
SIX 20150.00 Velocity	2.1	2.6	2.8	1.8	2.4	2.6	2.7	2.9
SIX 20160.00 Velocity	1.0	1.7	1.6	1.2	1.6	1.7	1.8	1.8
SIX 20197.50 Velocity	1.5	2.6	2.4	1.6	1.9	2.0	2.1	2.2
SIX 20235.00 Velocity	3.3	4.2	4.3	2.5	2.2	2.4	2.4	2.5
SMALL 1000.00 Velocity	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.0
SMALL 1114.00 Velocity	0.8	0.8	0.8	0.9	0.9	0.9	1.0	1.0
SMALL 1228.00 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
SMALL 1242.50 Velocity	0.9	1.0	1.0	1.0	1.1	1.1	1.1	1.1
SMALL 1257.00 Velocity	1.0	1.0	1.1	1.1	1.2	1.3	1.3	1.3
SMALL 1333.00 Velocity	1.0	1.1	1.1	1.1	1.2	1.3	1.3	1.4
SMALL 1409.00 Velocity	1.0	1.1	1.1	1.2	1.3	1.4	1.4	1.4
SMALL 1539.50 Velocity	0.8	0.8	0.9	0.9	0.9	1.0	1.0	1.0
SMALL 1670.00 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.1	1.1
SMALL 1670.00 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.1	1.1
SMALL 1779.00 Velocity	0.9	0.9	1.0	1.0	1.1	1.3	1.3	1.3
SMALL 1888.00 Velocity	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.9
SMALL 1939.00 Velocity	0.8	0.8	0.8	0.9	1.0	1.1	1.2	1.1
SMALL 1990.00 Velocity	0.7	0.8	0.8	0.8	0.9	1.0	1.1	1.0
SMALL 1990.00 Velocity	0.7	0.8	0.8	0.8	0.9	1.0	1.1	1.0
SMALL 2059.00 Velocity	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.7
SMALL 2128.00 Velocity	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5
WARRILL 0.00 Velocity	1.1	1.8	2.5	2.9	4.2	4.9	5.0	5.5
WARRILL 516.72 Velocity	1.3	2.1	3.0	3.5	5.3	6.3	6.5	7.3
WARRILL 1033.45 Velocity	1.8	2.6	3.7	4.5	7.2	9.0	9.2	10.9
WARRILL 1728.77 Velocity	1.0	1.3	1.2	1.2	1.3	1.5	1.6	1.7
WARRILL 2424.10 Velocity	0.7	1.0	1.2	0.7	0.8	0.8	1.2	1.2
WARRILL 2434.10 Velocity	0.9	1.5	0.7	0.8	3.8	0.9	3.9	4.0
WARRILL 2444.10 Velocity	0.7	1.0	1.2	0.7	0.8	0.8	1.2	1.2
WARRILL 2966.30 Velocity	0.5	0.6	0.6	0.7	0.8	0.9	0.9	0.9
WARRILL 3488.49 Velocity	0.6	0.7	0.7	0.7	0.7	0.8	0.8	0.8
WARRILL 3498.49 Velocity	0.6	0.8	1.0	1.2	1.6	2.1	2.1	2.2
WARRILL 3590.99 Velocity	0.6	0.8	1.0	1.2	1.6	2.0	2.1	2.2
WARRILL 3683.49 Velocity	0.6	0.8	1.0	1.2	1.6	2.0	2.1	2.2
WARRILL 4231.19 Velocity	0.4	0.7	0.8	0.9	1.1	1.5	1.5	1.7
WARRILL 4778.90 Velocity	1.4	1.2	0.8	0.8	0.9	2.1	2.1	2.1
WARRILL 4798.90 Velocity	1.6	1.2	0.8	0.8	1.1	2.7	2.7	2.8
WARRILL 5597.98 Velocity	0.8	0.9	0.9	1.0	1.4	1.9	1.9	2.1
WARRILL 6397.07 Velocity	0.5	0.6	0.9	1.0	1.4	1.9	1.9	2.1
WARRILL 6402.07 Velocity	0.5	0.7	0.9	1.0	1.4	1.9	1.9	2.1
WARRILL 6407.07 Velocity	0.5	0.7	0.9	1.0	1.4	1.9	1.9	2.1
WARRILL 6759.17 Velocity	0.4	0.7	1.0	1.1	1.5	2.0	2.0	2.2
WARRILL 7111.27 Velocity	0.4	0.8	1.0	1.2	1.6	2.1	2.1	2.3
WARRILL 7121.27 Velocity	7.3	7.3	7.3	7.3	7.3	7.3	7.3	7.3
WARRILL 7131.27 Velocity	1.0	1.5	1.6	1.8	2.3	2.9	2.9	3.2
WARRILL 7822.70 Velocity	0.7	0.9	0.9	0.8	0.9	1.0	1.1	1.1
WARRILL 8514.13 Velocity	0.7	0.7	0.6	0.6	0.6	0.7	0.7	0.6
WARRILL 9205.55 Velocity	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.8
WARRILL 9896.98 Velocity	0.7	0.7	0.7	0.7	0.8	0.9	1.0	1.0
WARRILL 10419.36 Velocity	0.7	0.7	0.7	0.7	0.7	0.9	0.9	1.0
WARRILL 10941.75 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	1.0
WARRILL 11260.87 Velocity	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0
WARRILL 11579.99 Velocity	0.8	0.8	0.8	1.0	1.1	1.3	1.3	1.4
WARRILL 11589.99 Velocity	2.3	2.5	2.4	2.4	4.0	4.2	4.2	4.3
WARRILL 11599.99 Velocity	0.8	0.8	0.8	1.1	1.3	1.7	1.7	1.9
WARRILL 11956.24 Velocity	0.8	0.8	0.8	0.8	0.9	1.1	1.1	1.2
WARRILL 12312.49 Velocity	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9

WARRILL 12625.38 Velocity	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8
WARRILL 12938.26 Velocity	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
WARRILL 13199.09 Velocity	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9
WARRILL 13459.92 Velocity	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
WARRILL 13588.18 Velocity	1.0	1.1	1.0	1.0	1.0	1.1	1.1	1.2
WARRILL 13716.44 Velocity	1.3	1.4	1.3	1.3	1.2	1.3	1.3	1.4
WARRILL 13933.74 Velocity	1.1	1.1	1.1	1.1	1.0	1.2	1.2	1.3
WARRILL 14151.04 Velocity	1.0	1.0	1.0	1.0	0.9	1.1	1.1	1.2
WARRILL 14685.00 Velocity	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.1
WARRILL 15218.95 Velocity	1.1	1.1	1.0	1.0	0.9	0.9	0.9	1.0
WARRILL 15464.29 Velocity	1.0	1.0	1.0	1.0	0.8	1.0	1.1	1.2
WARRILL 15709.63 Velocity	1.0	1.0	1.0	0.9	1.1	1.4	1.5	1.6
WARRILL 16008.97 Velocity	0.9	0.9	0.9	0.9	1.1	1.3	1.3	1.1
WARRILL 16308.32 Velocity	1.0	0.8	0.8	0.8	1.1	1.2	1.2	1.0
WARRILL 16755.14 Velocity	0.9	0.9	0.8	0.9	0.9	1.0	1.0	1.0
WARRILL 17201.96 Velocity	1.0	1.0	1.2	1.3	1.7	2.1	2.2	2.5
WARRILL 17710.47 Velocity	1.0	1.0	0.9	1.0	1.2	1.5	1.5	1.8
WARRILL 18218.98 Velocity	1.0	1.0	1.0	1.0	0.9	1.2	1.2	1.4
WARRILL 18471.75 Velocity	1.0	1.1	1.1	1.1	1.2	1.3	1.4	1.2
WARRILL 18724.52 Velocity	1.0	1.1	1.1	1.1	1.3	1.4	1.4	1.3
WARRILL 18939.93 Velocity	0.9	0.9	1.0	1.0	1.1	1.2	1.2	1.1
WARRILL 19155.35 Velocity	0.8	0.8	0.9	0.9	1.0	1.1	1.1	1.1
WARRILL 19446.27 Velocity	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.3
WARRILL 19737.18 Velocity	1.2	1.2	1.2	1.2	1.3	1.4	1.4	1.6
WARRILL 19953.37 Velocity	1.1	1.2	1.2	1.2	1.3	1.4	1.4	1.6
WARRILL 20169.55 Velocity	1.1	1.1	1.1	1.1	1.3	1.4	1.4	1.7
WARRILL 20436.06 Velocity	0.9	1.0	1.0	1.1	1.4	1.9	2.0	2.3
WARRILL 20702.56 Velocity	0.8	1.2	1.4	1.6	2.1	2.8	3.0	3.6
WARRILL 20836.16 Velocity	0.8	0.9	1.0	1.1	1.4	2.0	2.1	2.3
WARRILL 20969.75 Velocity	0.8	1.0	1.0	1.0	1.0	1.4	1.5	1.6
WARRILL 21408.97 Velocity	0.9	1.0	1.0	1.2	1.5	1.9	2.1	2.4
WARRILL 21848.19 Velocity	1.0	1.2	1.5	1.9	2.7	3.6	3.9	4.4
WARRILL 22522.48 Velocity	1.0	0.9	0.9	1.0	1.3	1.6	2.1	2.4
WARRILL 23196.78 Velocity	1.0	0.9	0.9	0.9	0.9	1.1	1.1	1.3
WARRILL 23449.07 Velocity	1.1	0.9	0.9	0.9	1.0	1.1	1.2	1.4
WARRILL 23701.37 Velocity	1.4	0.9	0.8	0.7	0.9	1.1	1.2	1.4
WARRILL 23701.37 Velocity	0.6	0.7	0.7	0.7	0.9	1.1	1.1	1.3
WARRILL 23914.04 Velocity	0.6	0.7	0.7	0.7	1.0	1.2	1.1	1.3
WARRILL 24126.72 Velocity	0.6	0.7	0.7	0.7	1.0	1.2	1.2	1.3
WARRILL 24353.37 Velocity	0.7	0.9	0.9	1.0	1.5	1.7	1.7	1.8
WARRILL 24580.02 Velocity	1.0	1.2	1.4	1.7	2.6	2.9	3.0	3.1
WARRILL 24814.29 Velocity	1.1	1.1	1.2	1.5	2.1	2.4	2.3	2.4
WARRILL 25048.56 Velocity	1.2	1.2	1.2	1.3	1.8	2.0	1.9	2.0
WARRILL 25379.28 Velocity	1.0	1.1	1.3	1.6	2.3	2.4	2.5	2.5
WARRILL 25710.00 Velocity	0.9	1.4	1.8	2.1	3.1	3.6	3.6	4.3
WARRILL 25720.00 Velocity	2.5	2.5	2.5	2.5	3.4	4.0	4.5	5.1
WARRILL 25730.00 Velocity	1.2	1.4	1.8	2.2	3.1	3.7	3.8	5.1
WARRILL 25974.68 Velocity	0.9	1.3	1.6	1.9	2.4	2.7	2.8	3.0
WARRILL 26219.35 Velocity	1.0	1.2	1.5	1.6	2.0	2.2	2.3	2.3
WARRILL 26456.35 Velocity	0.9	1.2	1.5	1.7	2.0	2.1	2.2	2.3
WARRILL 26693.35 Velocity	1.2	1.2	1.5	1.7	2.0	2.1	2.1	2.2
WARRILL 27004.35 Velocity	1.0	1.3	1.5	1.7	2.0	2.1	2.2	2.2
WARRILL 27315.35 Velocity	1.0	1.3	1.4	1.7	2.1	2.3	2.3	2.4
WARRILL 27594.35 Velocity	1.0	1.1	1.2	1.4	1.9	2.1	2.1	2.2
WARRILL 27873.35 Velocity	0.9	1.0	1.1	1.2	1.7	1.9	1.9	2.1
WARRILL 28180.35 Velocity	0.9	1.2	1.3	1.5	1.9	2.2	2.2	2.4
WARRILL 28487.35 Velocity	0.9	1.4	1.6	1.8	2.4	2.5	2.6	2.7
WARRILL 28869.85 Velocity	0.9	1.2	1.3	1.4	1.9	1.9	2.0	2.1
WARRILL 29252.35 Velocity	0.9	1.1	1.1	1.2	1.5	1.6	1.7	1.7
WARRILL 29550.85 Velocity	1.0	1.1	1.1	1.1	1.4	1.5	1.6	1.6
WARRILL 29849.35 Velocity	1.6	1.6	1.6	1.6	1.7	1.8	1.9	1.8
WARRILL 29849.35 Velocity	1.3	1.3	1.3	1.3	1.4	1.5	1.5	1.6
WARRILL 30006.85 Velocity	1.2	1.4	1.4	1.4	1.7	1.9	2.0	2.0
WARRILL 30164.35 Velocity	1.3	1.8	2.0	2.0	2.4	2.7	2.9	2.9
WARRILL 30164.35 Velocity	1.3	1.8	2.0	2.0	2.4	2.7	2.9	2.9
WARRILL 30525.35 Velocity	1.0	1.5	1.6	1.7	2.0	2.3	2.4	2.4

WARRILL 30886.35 Velocity	0.9	1.3	1.4	1.4	1.7	1.9	2.1	2.1
WARRILL 30886.35 Velocity	0.9	1.4	1.5	1.6	2.2	2.5	2.7	2.9
WARRILL 31029.85 Velocity	0.9	1.3	1.4	1.5	1.9	2.2	2.3	2.4
WARRILL 31173.35 Velocity	1.0	1.2	1.3	1.4	1.7	1.9	2.0	2.1
WARRILL 31349.85 Velocity	0.8	1.2	1.2	1.2	1.5	1.7	1.8	1.8
WARRILL 31526.35 Velocity	0.9	1.2	1.2	1.2	1.3	1.5	1.6	1.6
WARRILL 31774.85 Velocity	0.8	1.2	1.2	1.2	1.4	1.6	1.7	1.7
WARRILL 32023.35 Velocity	0.8	1.2	1.2	1.3	1.6	1.8	1.9	1.9
WARRILL 32153.85 Velocity	0.9	1.3	1.4	1.4	1.8	2.1	2.2	2.2
WARRILL 32284.35 Velocity	1.1	1.6	1.7	1.7	2.1	2.4	2.6	2.6
WARRILL 32459.35 Velocity	1.1	1.6	1.7	1.7	2.0	2.2	2.3	2.3
WARRILL 32634.35 Velocity	1.1	1.6	1.8	1.8	1.9	2.0	2.1	2.1
WARRILL 32942.35 Velocity	1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.2
WARRILL 33250.35 Velocity	1.5	1.5	1.5	1.5	1.4	1.3	1.2	1.2
WARRILL 33555.35 Velocity	1.7	1.7	1.7	1.7	1.3	1.0	1.0	1.0
WARRILL 33860.35 Velocity	2.0	2.0	2.0	1.9	1.4	1.5	1.6	1.6
WARRILL-BOONAH 0.00 Velocity	1.5	2.5	2.8	3.0	3.2	3.5	3.6	3.7
WARRILL-BOONAH 881.95 Velocity	1.8	2.8	3.2	3.4	3.8	4.3	4.5	4.8
WARRILL-BOONAH 1763.90 Velocity	2.4	3.3	3.7	4.0	4.5	5.7	6.2	6.8
WARRILL-BOONAH 2267.55 Velocity	2.6	3.7	4.0	4.3	4.5	5.6	6.1	6.6
WARRILL-BOONAH 2771.21 Velocity	2.8	4.1	4.4	4.7	4.7	5.5	5.9	6.4
WARRILL-BOONAH 3078.10 Velocity	2.0	2.8	3.0	3.3	3.3	3.5	3.4	3.6
WARRILL-BOONAH 3385.00 Velocity	1.5	2.2	2.3	2.5	2.6	2.8	2.6	2.9
WARRILL-BOONAH 3392.50 Velocity	2.7	3.7	3.9	4.0	4.2	5.9	5.9	6.0
WARRILL-BOONAH 3400.00 Velocity	2.6	4.4	4.7	4.9	5.2	6.0	5.9	6.1
WARRILL-BOONAH 3950.52 Velocity	3.0	4.6	5.0	5.3	6.1	7.1	7.5	8.1
WARRILL-BOONAH 4501.05 Velocity	3.9	4.8	5.4	5.8	7.3	9.6	10.6	12.0
WARRILL-BOONAH 5122.33 Velocity	2.3	3.5	3.9	4.2	5.1	6.3	6.9	7.6
WARRILL-BOONAH 5743.62 Velocity	1.7	2.8	3.1	3.3	3.9	4.7	5.1	5.6
WARRILL-BOONAH 6096.17 Velocity	1.7	2.9	3.3	3.5	4.2	5.0	5.4	5.9
WARRILL-BOONAH 6448.72 Velocity	1.8	3.1	3.5	3.8	4.5	5.4	5.8	6.3
WARRILL-BOONAH 6871.93 Velocity	1.6	2.7	3.1	3.4	3.8	4.6	4.8	5.1
WARRILL-BOONAH 7295.14 Velocity	1.5	2.5	2.8	3.1	3.4	3.8	4.1	4.3
WARRILL-BOONAH 7759.10 Velocity	2.0	3.2	3.5	3.8	4.2	5.1	5.4	5.8
WARRILL-BOONAH 8223.07 Velocity	3.1	4.3	4.8	5.1	5.6	7.3	7.9	8.9
WARRILL-BOONAH 8660.16 Velocity	2.8	4.2	4.6	4.8	5.4	6.7	7.0	7.7
WARRILL-BOONAH 9097.24 Velocity	2.5	4.1	4.4	4.6	5.1	5.9	6.3	6.9
WARRILL-BOONAH 9855.94 Velocity	2.3	3.8	4.2	4.5	5.0	5.8	6.3	7.0
WARRILL-BOONAH 10614.64 Velocity	2.2	3.6	4.0	4.3	4.9	5.9	6.4	7.1
WARRILL-BOONAH 11335.75 Velocity	2.4	3.7	3.9	4.0	4.2	4.8	4.7	4.8
WARRILL-BOONAH 12056.87 Velocity	2.6	4.0	3.9	3.9	4.0	4.1	4.0	4.1
WARRILL-BOONAH 12618.46 Velocity	2.4	3.8	3.9	4.0	4.1	4.3	4.4	4.6
WARRILL-BOONAH 13180.04 Velocity	2.2	3.7	4.0	4.3	4.9	5.6	6.1	6.7
WARRILL-BOONAH 13821.96 Velocity	2.2	3.6	4.0	4.3	4.9	5.7	6.2	6.7
WARRILL-BOONAH 14463.88 Velocity	2.1	3.6	3.9	4.2	4.9	5.9	6.3	6.7
WARRILL-BOONAH 14671.40 Velocity	2.7	4.5	4.9	5.2	5.8	6.6	6.9	7.2
WARRILL-BOONAH 14878.92 Velocity	3.9	6.1	6.5	6.8	7.2	7.5	7.6	7.7
WARRILL-BOONAH 15431.91 Velocity	2.6	3.8	4.2	4.4	4.7	5.1	5.2	5.3
WARRILL-BOONAH 15984.89 Velocity	1.9	2.7	3.1	3.2	3.5	3.9	4.0	4.1
WARRILL-BOONAH 15989.89 Velocity	3.2	4.4	4.7	4.9	5.3	5.7	5.8	6.0
WARRILL-BOONAH 15994.89 Velocity	2.7	4.2	4.5	4.8	5.4	6.6	7.2	7.9
WARRILL-BOONAH 16606.35 Velocity	2.4	3.7	4.1	4.4	5.0	6.3	7.0	7.7
WARRILL-BOONAH 17217.81 Velocity	2.1	3.3	3.8	4.1	4.7	6.1	6.7	7.6
WARRILL-BOONAH 17763.03 Velocity	1.9	2.9	3.3	3.7	4.4	5.1	5.3	5.5
WARRILL-BOONAH 18308.24 Velocity	1.7	2.5	2.9	3.4	4.2	4.9	4.9	4.8
WARRILL-BOONAH 18604.66 Velocity	1.9	2.1	2.3	2.7	3.2	3.9	3.8	3.7
WARRILL-BOONAH 18901.08 Velocity	2.3	2.7	3.0	3.3	3.9	4.7	4.7	4.8
WARRILL-BOONAH 19171.36 Velocity	2.3	3.1	3.5	4.0	4.9	5.9	5.9	6.1
WARRILL-BOONAH 19441.64 Velocity	2.3	4.1	5.2	5.6	6.2	6.5	7.0	7.8
WARRILL-BOONAH 19451.64 Velocity	2.2	4.1	5.1	5.4	5.4	5.2	5.4	5.3
WARRILL-BOONAH 19461.64 Velocity	2.3	3.6	4.1	4.1	4.1	4.1	4.1	4.2
WARRILL-BOONAH 20226.62 Velocity	3.9	4.7	5.1	5.3	5.3	5.4	5.3	5.3
WARRILL-BOONAH 20991.60 Velocity	4.2	5.4	6.2	6.8	7.7	8.2	8.2	8.2
WARRILL-BOONAH 21731.54 Velocity	3.4	4.8	5.6	6.2	7.0	7.6	7.7	7.9
WARRILL-BOONAH 22471.48 Velocity	2.9	4.3	5.1	5.7	6.5	7.1	7.5	7.9
WARRILL-BOONAH 22767.29 Velocity	2.8	3.6	3.6	3.9	4.2	4.2	4.3	4.2

WARRILL-BOONAH 23063.09 Velocity	2.7	3.3	3.2	3.3	3.3	3.5	3.6	3.4
WARRILL-BOONAH 23556.68 Velocity	3.0	3.6	3.6	3.8	4.0	4.1	4.1	4.1
WARRILL-BOONAH 24050.26 Velocity	3.2	4.2	5.0	5.5	6.1	6.6	6.9	7.3
WARRILL-BOONAH 24590.68 Velocity	3.4	4.3	5.1	5.6	6.2	6.8	7.0	7.3
WARRILL-BOONAH 25131.10 Velocity	3.5	4.8	5.5	6.2	7.1	8.0	8.1	8.1
WARRILL-BOONAH 25718.40 Velocity	2.6	2.9	2.8	3.1	3.5	3.7	3.6	3.4
WARRILL-BOONAH 26305.71 Velocity	2.1	2.4	2.4	2.6	2.8	2.8	2.8	2.8
WARRILL-BOONAH 26310.71 Velocity	3.2	3.6	5.0	5.0	5.0	5.0	5.0	5.2
WARRILL-BOONAH 26315.71 Velocity	2.3	2.4	2.6	2.7	3.2	3.4	3.6	3.2
WARRILL-BOONAH 27226.09 Velocity	2.5	2.8	2.8	3.0	3.3	3.5	3.5	3.2
WARRILL-BOONAH 28136.46 Velocity	3.1	3.7	4.0	4.4	5.7	6.1	6.2	6.5
WARRILL-BOONAH 28624.97 Velocity	2.8	3.1	3.1	3.3	4.2	4.7	4.8	4.9
WARRILL-BOONAH 29113.49 Velocity	2.6	2.7	2.7	2.8	3.7	4.2	4.3	4.0
WARRILL-BOONAH 29954.24 Velocity	1.8	1.8	2.3	2.6	3.7	4.2	4.2	4.6
WARRILL-BOONAH 30795.00 Velocity	1.1	1.8	2.5	2.8	4.2	4.9	5.0	5.5
WARRILL-BOONAH 30805.00 Velocity	1.1	1.8	2.5	2.9	4.2	4.9	5.0	5.5
WARRILL-BOONAH 30815.00 Velocity	1.1	1.8	2.5	2.9	4.2	4.9	5.0	5.5
WESTBREM1 0.00 Velocity	0.0	0.1	0.1	0.2	0.3	0.3	0.5	0.7
WESTBREM1 10.00 Velocity	1.2	2.1	2.3	2.6	2.9	3.0	3.4	3.6
WESTBREM1 20.00 Velocity	0.0	0.1	0.1	0.2	0.3	0.3	0.4	0.5
WESTBREM2 0.00 Velocity	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
WESTBREM2 10.00 Velocity	1.4	1.9	2.3	2.3	2.4	2.5	2.6	2.6
WESTBREM2 20.00 Velocity	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
WESTBREM3 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WESTBREM3 10.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.0
WESTBREM3 20.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WESTERN 0.00 Velocity	1.8	2.5	2.6	2.7	3.0	3.2	3.2	3.3
WESTERN 247.00 Velocity	1.7	2.5	2.6	2.7	2.9	3.2	3.2	3.4
WESTERN 494.00 Velocity	1.7	2.4	2.5	2.6	2.9	3.2	3.3	3.5
WESTERN 671.50 Velocity	0.7	1.5	1.6	1.8	2.2	2.8	3.0	3.4
WESTERN 849.00 Velocity	0.5	1.1	1.2	1.3	1.8	2.5	2.8	3.2
WESTERN 859.00 Velocity	0.6	1.2	1.4	1.6	2.2	2.9	3.2	3.7
WESTERN 869.00 Velocity	0.5	1.1	1.2	1.4	1.8	2.5	2.8	3.3
WESTERN 5082.00 Velocity	1.1	1.3	1.3	1.4	1.6	1.7	1.8	1.9
WESTERN 5374.44 Velocity	1.1	1.3	1.4	1.5	1.6	1.8	1.9	2.0
WESTERN 5666.88 Velocity	1.0	1.4	1.5	1.5	1.7	1.9	2.0	2.2
WESTERN 5906.90 Velocity	0.9	1.0	1.1	1.1	1.3	1.5	1.5	1.6
WESTERN 6146.92 Velocity	1.0	1.1	1.2	1.2	1.4	1.6	1.6	1.7
WESTERN 6517.88 Velocity	1.0	1.5	1.7	1.9	2.1	2.3	2.4	2.4
WESTERN 6888.85 Velocity	1.0	1.4	1.7	2.0	2.2	2.4	2.5	2.5
WESTERN 6898.85 Velocity	1.2	1.5	1.8	2.7	3.9	4.3	4.4	4.4
WESTERN 6909.00 Velocity	1.0	1.4	1.7	2.1	3.1	4.2	4.7	5.2
WOOG 10000.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG 10225.00 Velocity	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.9
WOOG 10450.00 Velocity	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
WOOG 10690.00 Velocity	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3
WOOG 10930.00 Velocity	0.3	0.5	0.5	0.5	0.6	0.7	0.7	0.8
WOOG 11040.00 Velocity	0.8	1.1	1.1	1.2	1.4	1.6	1.6	1.7
WOOG 11150.00 Velocity	0.5	0.6	0.6	0.6	0.7	0.8	0.9	0.9
WOOG 11340.00 Velocity	0.7	1.0	1.0	1.1	1.3	1.5	1.6	1.7
WOOG 11530.00 Velocity	0.5	0.7	0.7	0.7	0.9	1.1	1.1	1.2
WOOG 11780.00 Velocity	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.2
WOOG 12030.00 Velocity	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.4
WOOG 12080.00 Velocity	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9
WOOG 12130.00 Velocity	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8
WOOG 12375.00 Velocity	0.7	0.8	0.8	0.9	1.0	1.0	1.1	1.1
WOOG 12620.00 Velocity	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.7
WOOG 12775.00 Velocity	0.7	0.9	0.9	1.0	1.1	1.2	1.3	1.3
WOOG 12930.00 Velocity	0.3	0.4	0.4	0.4	0.5	0.6	0.6	0.6
WOOG 13000.00 Velocity	0.6	0.8	0.9	0.9	1.0	1.1	1.2	1.2
WOOG 13070.00 Velocity	0.4	0.5	0.6	0.6	0.7	0.7	0.7	0.7
WOOG 13160.00 Velocity	0.5	0.7	0.8	0.8	0.9	1.0	1.0	1.0
WOOG 13250.00 Velocity	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
WOOG 13380.00 Velocity	0.5	0.6	0.6	0.7	0.8	0.8	0.9	0.9
WOOG 13510.00 Velocity	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.5
WOOG 13530.00 Velocity	0.6	0.7	0.7	0.8	0.9	1.0	1.0	1.1

WOOG 13550.00 Velocity	0.5	0.6	0.6	0.6	0.7	0.8	0.8	0.9
WOOG 13595.00 Velocity	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9
WOOG 13640.00 Velocity	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
WOOG 13720.00 Velocity	0.7	0.8	0.8	0.8	0.9	0.9	0.9	1.0
WOOG 13800.00 Velocity	0.5	0.8	0.8	0.9	1.1	1.3	1.3	1.4
WOOG 13800.00 Velocity	0.5	0.8	0.8	0.9	1.1	1.3	1.3	1.4
WOOG 13897.50 Velocity	0.7	0.9	1.0	1.1	1.3	1.5	1.6	1.7
WOOG 13995.00 Velocity	0.9	1.2	1.2	1.3	1.6	1.9	2.0	2.1
WOOG 13995.00 Velocity	0.9	1.2	1.2	1.3	1.6	1.9	2.0	2.1
WOOG 14032.50 Velocity	1.3	1.4	1.5	1.5	1.8	2.0	2.1	2.3
WOOG 14070.00 Velocity	2.0	2.0	2.0	2.0	2.1	2.2	2.3	2.4
WOOG 14085.00 Velocity	1.4	1.7	1.8	1.8	2.2	2.6	2.7	2.9
WOOG 14100.00 Velocity	1.1	1.5	1.7	1.8	2.5	3.1	3.3	3.6
WOOG 14140.00 Velocity	1.1	1.4	1.5	1.6	2.1	2.4	2.5	2.7
WOOG 14180.00 Velocity	1.1	1.3	1.4	1.5	1.8	2.0	2.1	2.2
WOOG 14180.00 Velocity	1.1	1.3	1.4	1.5	1.8	2.0	2.1	2.2
WOOG 14315.00 Velocity	1.0	1.2	1.3	1.3	1.4	1.4	1.5	1.5
WOOG 14450.00 Velocity	0.9	1.1	1.1	1.1	1.2	1.2	1.3	1.3
WOOG 14620.00 Velocity	0.9	1.1	1.1	1.2	1.2	1.3	1.3	1.3
WOOG 14790.00 Velocity	0.9	1.0	1.1	1.2	1.5	1.8	1.9	2.0
WOOG 14820.00 Velocity	0.8	1.1	1.2	1.3	1.7	2.0	2.1	2.3
WOOG 14850.00 Velocity	0.7	1.2	1.3	1.4	1.8	2.2	2.4	2.6
WOOG 14900.00 Velocity	0.6	0.8	0.8	0.9	1.1	1.3	1.4	1.5
WOOG 14950.00 Velocity	0.5	0.6	0.6	0.7	0.8	0.9	1.0	1.0
WOOG 15000.00 Velocity	0.7	0.8	0.8	0.9	1.1	1.2	1.2	1.3
WOOG 15050.00 Velocity	0.8	1.0	1.1	1.2	1.5	1.6	1.6	1.6
WOOG 15100.00 Velocity	0.7	0.8	0.8	0.8	1.1	1.2	1.2	1.3
WOOG 15150.00 Velocity	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.1
WOOG 15150.00 Velocity	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.1
WOOG 15190.00 Velocity	0.4	0.6	0.7	0.7	0.9	1.0	1.1	1.1
WOOG 15230.00 Velocity	0.4	0.7	0.7	0.8	1.0	1.1	1.2	1.2
WOOG 15265.00 Velocity	0.6	1.0	1.1	1.2	1.4	1.7	1.7	1.8
WOOG 15300.00 Velocity	2.2	2.3	2.3	2.4	2.8	3.2	3.3	3.4
WOOG 15335.00 Velocity	0.7	0.9	0.9	1.0	1.3	1.5	1.5	1.6
WOOG 15370.00 Velocity	0.4	0.6	0.6	0.6	0.8	1.0	1.0	1.0
WOOG 15420.00 Velocity	0.5	0.6	0.7	0.7	0.9	1.1	1.1	1.1
WOOG 15470.00 Velocity	0.6	0.7	0.7	0.8	1.0	1.2	1.2	1.2
WOOG 15495.00 Velocity	0.7	0.9	0.9	1.0	1.2	1.4	1.5	1.5
WOOG 15520.00 Velocity	1.0	1.2	1.3	1.4	1.6	1.8	1.9	1.9
WOOG 15560.00 Velocity	1.0	1.2	1.3	1.3	1.4	1.4	1.4	1.5
WOOG 15600.00 Velocity	1.0	1.2	1.2	1.3	1.3	1.3	1.3	1.3
WOOG 15660.00 Velocity	0.8	0.9	0.9	0.9	1.1	1.2	1.2	1.2
WOOG 15720.00 Velocity	0.8	0.8	0.8	0.8	1.0	1.2	1.3	1.3
WOOG 15760.00 Velocity	1.0	1.0	1.0	1.1	1.3	1.4	1.4	1.4
WOOG 15800.00 Velocity	1.7	1.8	1.8	1.9	2.0	2.0	2.1	2.1
WOOG 15820.00 Velocity	0.8	1.2	1.3	1.4	1.5	1.6	1.6	1.6
WOOG 15840.00 Velocity	0.6	0.9	1.0	1.1	1.3	1.4	1.4	1.4
WOOG 15850.00 Velocity	1.5	2.5	2.5	2.5	2.6	2.7	3.1	3.6
WOOG 15860.00 Velocity	0.6	0.9	0.9	1.0	1.1	1.2	1.2	1.2
WOOG 15910.00 Velocity	0.6	1.0	1.0	1.0	1.1	1.1	1.1	1.1
WOOG 15960.00 Velocity	0.7	1.1	1.1	1.2	1.2	1.2	1.2	1.2
WOOG 15975.00 Velocity	0.6	0.9	1.0	1.0	1.0	1.0	1.0	1.0
WOOG 15990.00 Velocity	0.5	0.8	0.8	0.9	0.9	0.9	0.9	0.9
WOOG 16000.00 Velocity	0.7	1.0	1.0	1.0	1.1	1.1	1.1	1.1
WOOG 16010.00 Velocity	1.0	1.3	1.3	1.4	1.6	1.8	1.8	1.9
WOOG 16067.50 Velocity	1.0	1.4	1.4	1.5	1.5	1.5	1.5	1.5
WOOG 16125.00 Velocity	1.0	1.5	1.6	1.7	1.7	1.7	1.7	1.8
WOOG 16137.50 Velocity	0.9	1.2	1.3	1.3	1.4	1.4	1.4	1.4
WOOG 16150.00 Velocity	0.8	1.0	1.1	1.1	1.3	1.5	1.5	1.6
WOOG 16212.50 Velocity	1.0	1.3	1.4	1.4	1.7	2.0	2.1	2.2
WOOG 16275.00 Velocity	1.6	1.9	2.0	2.0	2.5	3.0	3.2	3.4
WOOG 16357.50 Velocity	1.2	1.4	1.4	1.5	1.6	1.6	1.6	1.6
WOOG 16440.00 Velocity	1.0	1.1	1.1	1.1	1.2	1.3	1.3	1.2
WOOG 16520.00 Velocity	0.7	1.0	1.0	1.1	1.1	1.2	1.2	1.2
WOOG 16600.00 Velocity	0.6	0.9	1.0	1.0	1.1	1.2	1.3	1.3
WOOG 16650.00 Velocity	0.7	0.9	0.9	0.9	1.0	1.0	1.0	1.0

WOOG 16700.00 Velocity	0.8	0.9	0.9	0.9	1.0	1.0	1.0	0.9
WOOG 16775.00 Velocity	0.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1
WOOG 16850.00 Velocity	0.9	1.4	1.5	1.5	1.6	1.6	1.6	1.6
WOOG 16875.00 Velocity	1.0	1.5	1.6	1.6	1.6	1.6	1.7	1.6
WOOG 16900.00 Velocity	1.2	1.6	1.7	1.7	1.8	1.8	1.8	1.8
WOOG 16975.00 Velocity	1.0	1.5	1.6	1.6	1.8	1.8	1.9	1.9
WOOG 17050.00 Velocity	0.9	1.5	1.6	1.6	1.9	2.0	2.1	2.2
WOOG 17087.50 Velocity	0.9	1.3	1.4	1.5	1.7	1.8	1.8	1.9
WOOG 17125.00 Velocity	0.9	1.2	1.3	1.3	1.5	1.6	1.6	1.7
WOOG 17200.00 Velocity	0.8	1.2	1.3	1.3	1.5	1.6	1.6	1.6
WOOG 17275.00 Velocity	0.8	1.1	1.2	1.3	1.5	1.7	1.7	1.7
WOOG 17292.50 Velocity	0.7	1.0	1.1	1.1	1.2	1.3	1.3	1.3
WOOG 17310.00 Velocity	0.6	0.9	0.9	0.9	1.0	1.0	1.1	1.0
WOOG 17340.00 Velocity	3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
WOOG 17370.00 Velocity	1.4	1.7	1.7	1.8	1.9	2.0	2.1	2.1
WOOG 17405.00 Velocity	0.9	1.3	1.4	1.4	1.7	1.9	2.0	2.0
WOOG 17440.00 Velocity	0.7	1.1	1.2	1.2	2.9	1.7	1.9	1.9
WOOG 17450.00 Velocity	1.1	1.4	1.4	1.5	1.7	1.9	5.6	2.1
WOOG 17460.00 Velocity	0.6	0.8	0.9	0.9	1.8	1.0	1.2	1.0
WOOG 17480.00 Velocity	0.6	0.9	1.0	1.0	1.1	1.2	1.2	1.2
WOOG 17500.00 Velocity	0.7	1.0	1.1	1.1	1.7	1.5	1.6	1.6
WOOG 17525.00 Velocity	0.7	1.0	1.1	1.1	1.4	1.5	1.5	1.5
WOOG 17550.00 Velocity	0.7	1.0	1.0	1.1	1.4	1.5	1.5	1.5
WOOG 17565.00 Velocity	0.9	1.1	1.2	1.2	1.4	1.5	1.7	1.5
WOOG 17580.00 Velocity	1.9	2.0	1.9	1.9	1.7	1.7	2.2	1.7
WOOG 17590.00 Velocity	0.8	1.1	1.2	1.2	1.4	1.5	2.0	1.6
WOOG 17600.00 Velocity	0.6	0.9	1.0	1.0	1.3	1.5	1.7	1.7
WOOG 17607.50 Velocity	0.4	0.7	0.8	0.8	1.1	1.3	1.4	1.5
WOOG 17615.00 Velocity	0.3	0.6	0.7	0.7	1.0	1.1	1.2	1.3
WOOG 17682.50 Velocity	0.5	0.8	0.9	0.9	1.1	1.2	1.3	1.3
WOOG 17750.00 Velocity	0.7	1.1	1.2	1.2	1.3	1.5	1.5	1.4
WOOG 17755.00 Velocity	0.7	1.1	1.2	1.2	1.4	1.5	1.5	1.5
WOOG 17760.00 Velocity	0.6	1.0	1.1	1.1	1.4	1.5	1.5	1.5
WOOG 17770.00 Velocity	1.2	1.7	1.7	1.8	1.8	1.8	2.4	1.8
WOOG 17780.00 Velocity	0.8	1.2	1.3	1.3	1.4	1.4	1.6	1.4
WOOG 17865.00 Velocity	0.8	1.3	1.4	1.4	1.4	1.4	1.7	1.4
WOOG 17950.00 Velocity	0.8	1.4	1.5	1.5	1.5	1.6	1.6	1.6
WOOG 17955.00 Velocity	0.8	1.3	1.5	1.5	1.6	1.7	1.7	1.7
WOOG 17960.00 Velocity	0.8	1.3	1.5	1.5	2.0	2.2	2.2	2.3
WOOG 18105.00 Velocity	0.8	1.3	1.4	1.4	1.8	2.0	2.0	2.0
WOOG 18250.00 Velocity	0.8	1.3	1.4	1.4	1.7	1.8	1.8	1.8
WOOG 18250.00 Velocity	0.8	1.3	1.4	1.4	1.7	1.8	1.8	1.8
WOOG 18375.00 Velocity	0.8	1.3	1.4	1.5	1.8	2.0	2.0	2.1
WOOG 18500.00 Velocity	0.8	1.3	1.5	1.5	2.0	2.3	2.4	2.4
WOOG 18625.00 Velocity	0.6	1.2	1.3	1.4	1.9	2.2	2.3	2.4
WOOG 18750.00 Velocity	0.5	1.1	1.2	1.2	1.7	2.1	2.2	2.3
WOOG 18825.00 Velocity	0.8	1.5	1.5	1.6	2.2	2.5	2.6	2.6
WOOG 18900.00 Velocity	1.7	2.3	2.2	2.4	2.9	3.1	3.2	3.1
WOOG 18987.50 Velocity	0.1	0.2	0.2	0.3	0.5	0.6	0.6	0.7
WOOG 19075.00 Velocity	0.0	0.1	0.1	0.2	0.2	0.3	0.3	0.4
WOOG_LK1 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG_LK1 15.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG_LK1 30.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG_LK2 0.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG_LK2 15.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WOOG_LK2 30.00 Velocity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix I

Initial Investigation of Channel Change in the Brisbane River – Bremer River Confluence Area

Appendix I

Initial Investigation of Channel Change in the Brisbane River – Bremer River Confluence Area

I.1 Introduction

The re-calibration of the MIKE 11 hydraulic model (Sargent Consulting 2006) has shown that calibration with the 1974 and 1996 floods produce different values of hydraulic roughness, generally with the 1974 flood requiring higher values of roughness to replicate historic flood levels.

All of the model runs have used the currently available river cross-sections. For the Brisbane River these were based on surveyed cross-sections provided by Brisbane City Council downstream from chainage 1000km (upstream of Kholo Bridge) to the river mouth. These cross-sections are understood to have been surveyed in 1998. Cross-sections upstream were based on information supplied by DNRW (SKM 2000).

For the Bremer River and other tributaries, cross section information was based on a mix of surveyed cross-sections, and levels taken from 0.5m and 5m contour maps (SKM 2000).

One of the main causes of the calibration anomaly referred to above is thought to be due to increases in river channel capacity between 1974 and 1996 events, as a result of erosion caused by the 1974 flood and by extraction of sand and gravel by dredging of the river bed.

If these events have had significant impact on the channel capacity over this period, it means that the model overestimates the actual cross-section geometry in 1974, and that if the model had the correct geometry, the flood levels would be replicated with lower hydraulic roughness. If it were possible to identify and quantify these changes, it would be possible to run the model with more appropriate cross-section geometry, and a replication of flood levels achieved using the roughness values more closely resembling those obtained from fitting the 1996 event.

A full investigation of this issue is outside the scope of the current commission, but an initial, simplistic assessment has been made just for the confluence area of the Brisbane and Bremer Rivers in order to determine whether there is evidence of the river cross-section having increased since 1974.

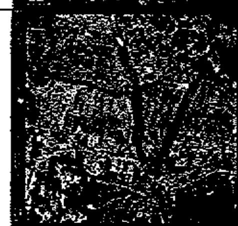
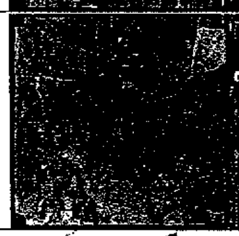
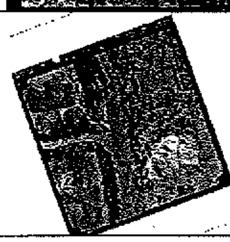
There were no earlier river cross-sections available for comparison so this initial investigation was limited primarily to aerial photography interpretation together with some information regarding dredging activities.

The following paragraphs outline the work carried out in this brief investigation, its results, and recommendations for further work.

I.2 Historic Aerial Photography

Aerial photographs over Ipswich are held by Ipswich City Council in its GIS. Scanned aerial photographs were extracted from the GIS for the dates shown in Table I1, which also shows the photographic scale and a thumbnail sized copy of the photography:

Table I1 Aerial Photography Used

Date	Scale	Thumbnail
27 July 1955	1:24,000	
22 February 1968	1:12,500	
17 May 1970	1:25,000	
18 November 1972	1:10,000	
21 August 1978	1:25,000	
14 April 1989	1:5,000	

In addition, 2002 digitised photography was available as part of Council's GIS and this was used as the mapping base.

These photographs were rotated where necessary to correct their orientation then input into MapInfo GIS as raster images. The images were geo-registered by defining coordinates for identifiable points in the historic photographs from the 2002 photography.

This enabled superimposition of the photographs to the same scale and map projection. From this the channel width was estimated at a number of model cross-section locations, and the channel boundary as shown in the photograph was mapped. This process has errors due to both inaccuracies in the geo-referencing of individual photographs; due to shadow effects; estimation of the channel bank where there is overhanging vegetation; and limits from the resolution of the scanned photographs.

Figure I1 shows graphs of cross-section widths measured as outlined above over time; **Figure I2** shows the MIKE 11 cross-section locations; and **Figures I3** to **I5** show channel locations and widths over time at various locations.

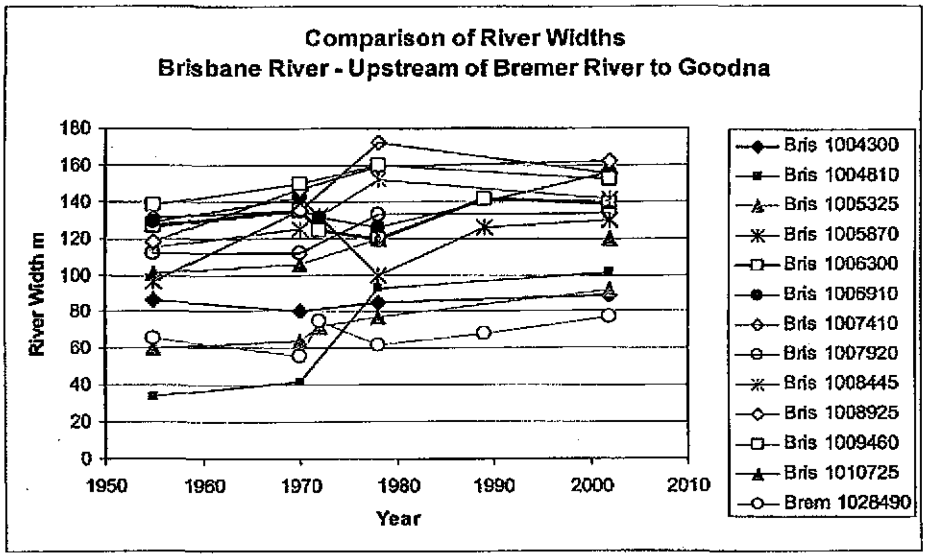


Figure I1 Comparison of River Widths

Figure I1 shows a general increasing trend in cross-section width since 1955, although this varies considerably between cross-sections. The largest change seems to occur between 1970 and 1978 suggesting that the 1974 flood was a major influence.

The variability is caused mainly by the errors in map registration and in determining the exact bank location. Variation in water level between photographs is a minor issue as the banks are generally steep within the main river channel.

The comparison of historic channel widths in **Figures I3** to **I5** is also instructive. **Figure I3** shows the Brisbane River island upstream (north) of the Bremer River confluence. The following can be seen from this figure:

- There is little or no change in the size of the island or in the width of the main channel to the east of the island over the period 1955-1972;

- There is a significant reduction change in the size of the island and increase in the width of the main channel to the east of the island over the period 1972 - 2002; and

- Most of the changes referred to above are apparent by 1978.

Figure I4 shows the Brisbane River - Bremer River confluence. The following can be seen from this figure:

- There is little or no change in the boundary of the point bar on the north bank of the confluence over the period 1955-1972;

- There is a significant reduction in the size of the point bar over the period 1972 - 2002; and

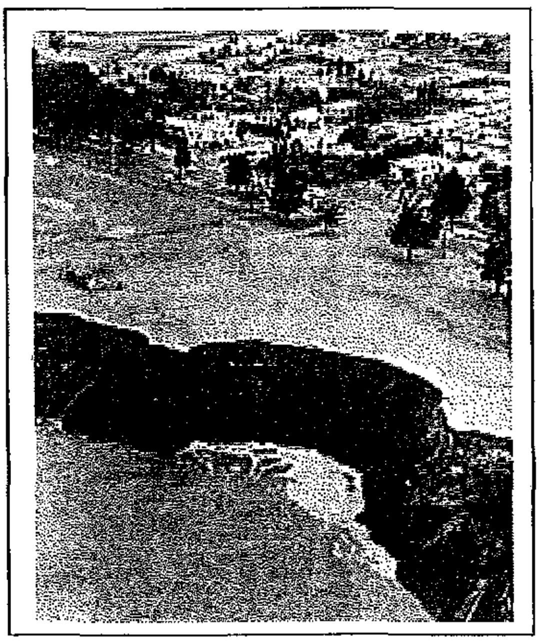
- Most of the changes referred to above are apparent by 1978.

Figure I5 shows the Brisbane River island downstream (north east) of the Six Mile Creek confluence. The following can be seen from this figure:

- There is some reduction in size of this island between 1955 and 1970; and

- This island is absent from all photographs from 1978 onwards.

All of the above indicate that there has been significant widening throughout this reach over the period for which aerial photography was available, with the greatest activity being between 1972 and 1978.



The aftermath of the flood: Severe erosion of the banks of the Brisbane River at Goodna

Brisbane *Sunday Sun*

Photograph reproduced from Bureau of Meteorology (1974)

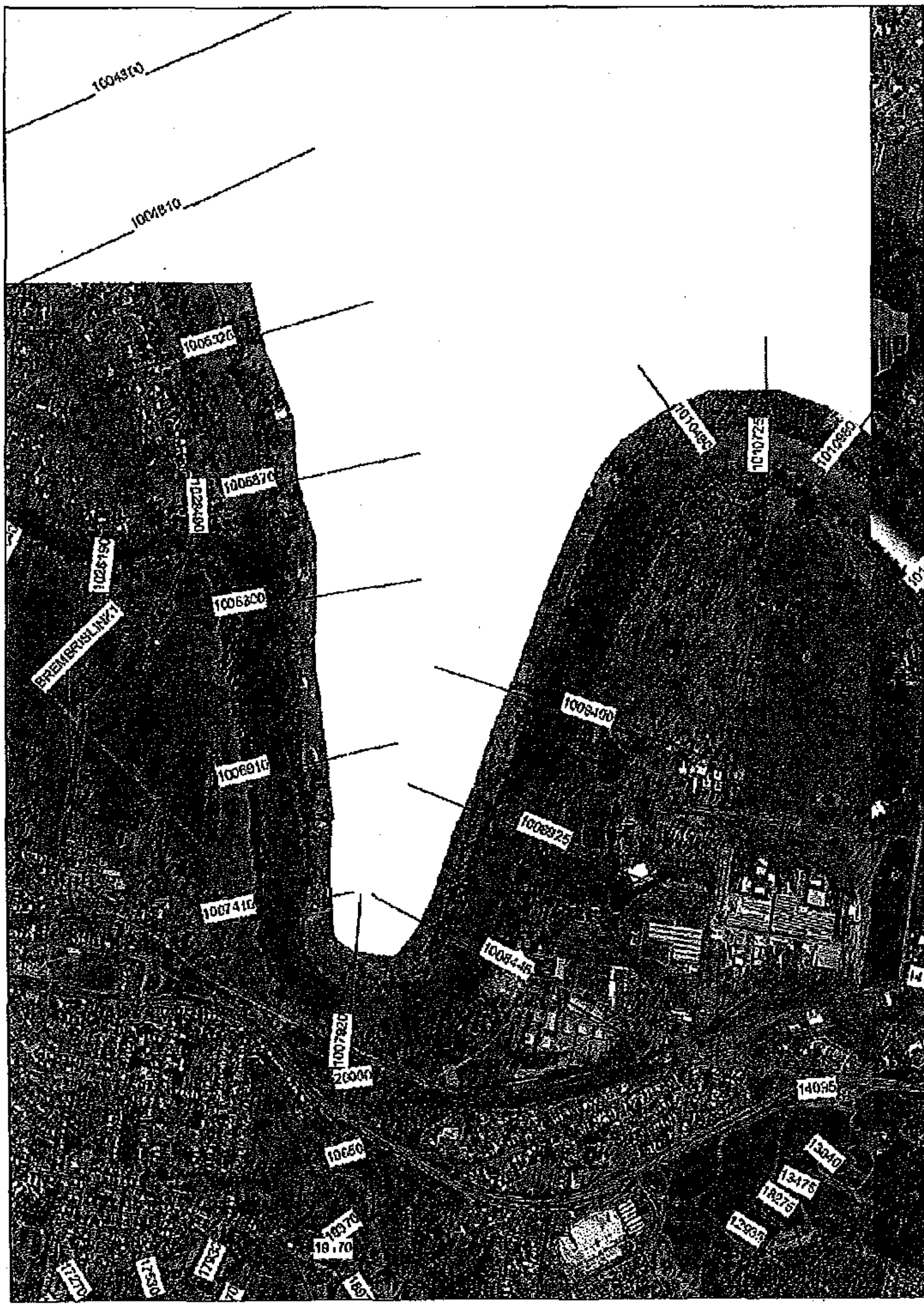


Figure I2 Cross –Section Locations

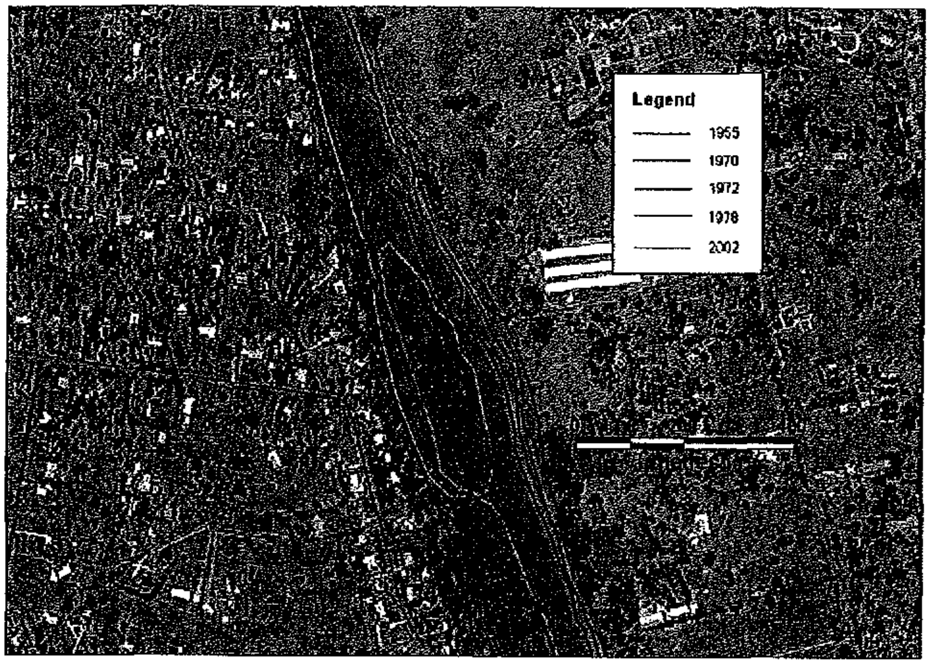


Figure I3 **Brisbane River – Island North of Bremer River Confluence**

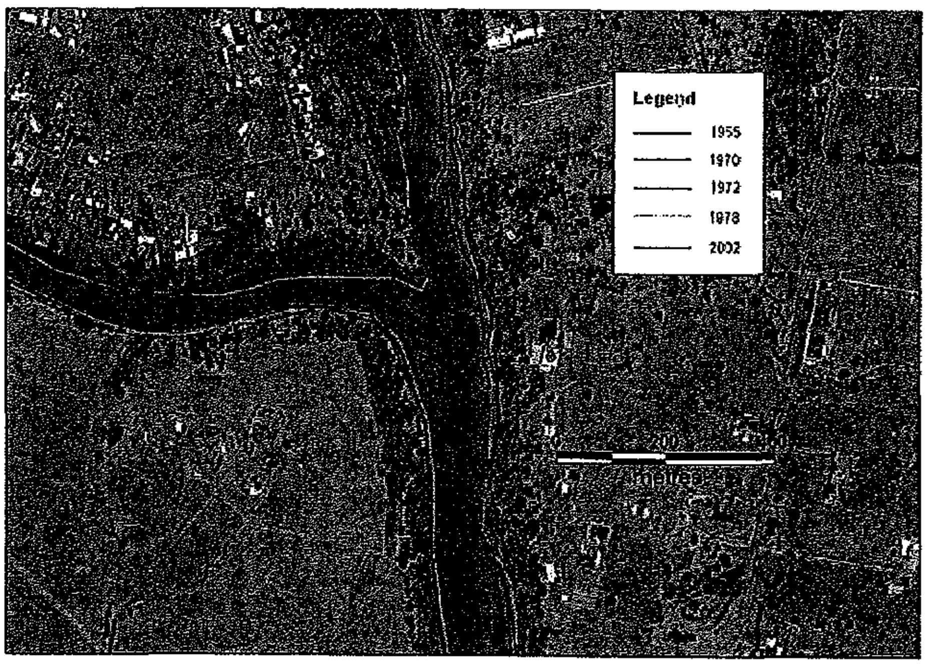


Figure I4 **Brisbane River – Bremer River Confluence**

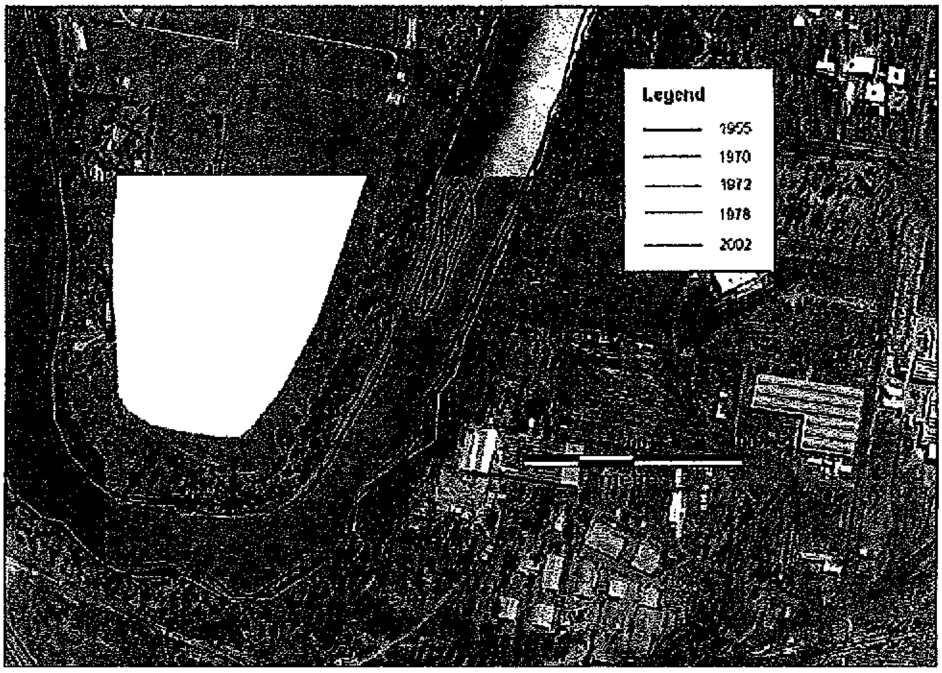


Figure I5 **Brisbane River – Island North East of Six Mile Creek Confluence**

I.3 Dredging

Dredging of the Brisbane River bar was first undertaken in the 1870s for navigational purposes (O'Flynn & Thornton 1990) and the river was subsequently straightened and deepened further.

Dredging for the extraction of sand and gravel for building and construction aggregates is understood to have commenced about 1900 (O'Flynn & Thornton 1990) and reached a peak in the early 1970s. Anecdotal evidence suggests that a significant increase may have occurred subsequent to the Second World War (Stock & Neller 1990). Some 12 million cubic metres of material is understood to have been extracted between 1900 and 1970. Annual production rates for 1976 to 1990 are given in **Figure I6.**

These figures show a peak extraction in 1976/7 with a gradual decline though the 1980s. Unfortunately, no details are available for annual extraction volumes prior to this date. Dredging in the Brisbane River, except for navigation purposes, ceased in 1998.

Extraction was not limited to the lower Brisbane River and extended upstream to Karana Downs and into the Bremer River. In addition to river dredging, extraction from bank deposits occurred at a number of locations including Priors Pocket, Colleges Crossing, Karana Downs and Sapling Pocket. **Figure I7** shows dredges working in the vicinity of the Brisbane River/ Bremer River junction in 1972.

Figure I8 shows a longitudinal bed profile along the Brisbane River from about 15km upstream of Kholo Bridge to the Brisbane River bar. In the absence of intervention this would be a smooth curve.

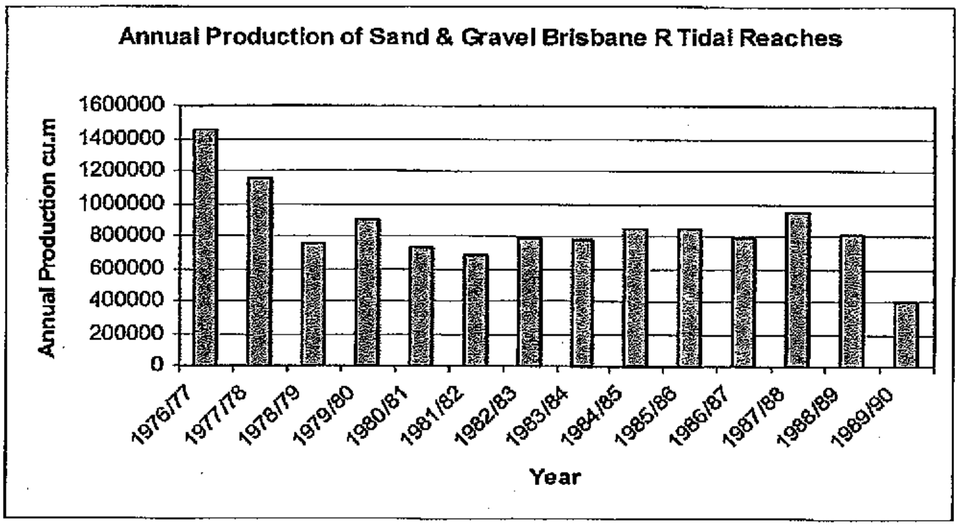


Figure I6 Sand & Gravel Extraction from Brisbane River 1976 – 1990
Source: O'Flynn & Thornton (1990)

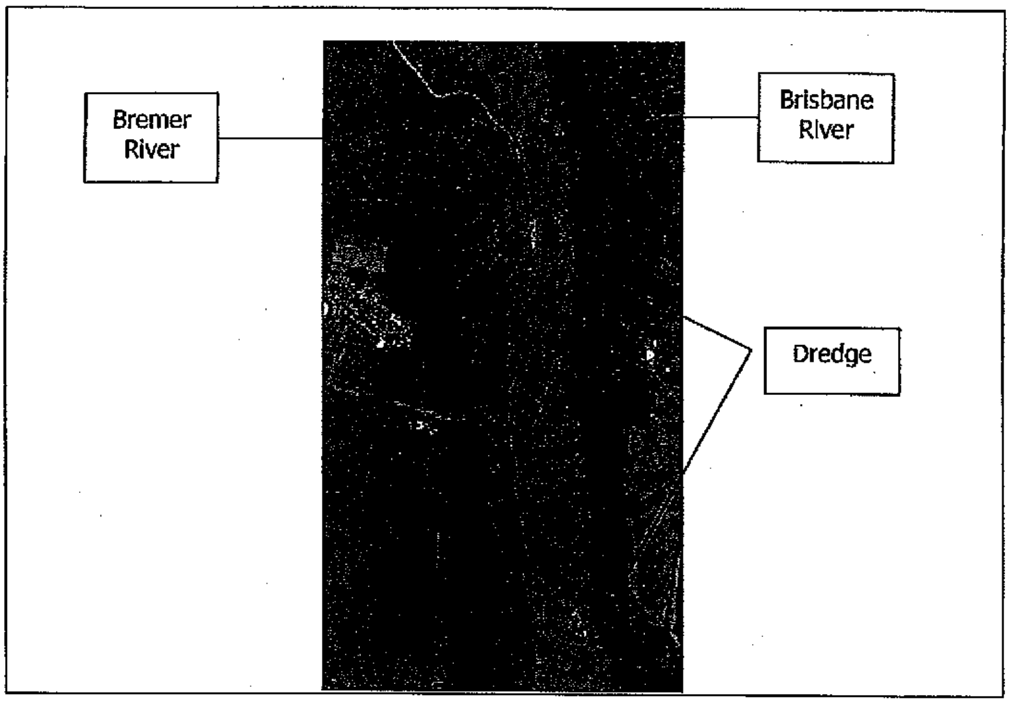


Figure I7 Dredges working in the Moggill Reach November 1972

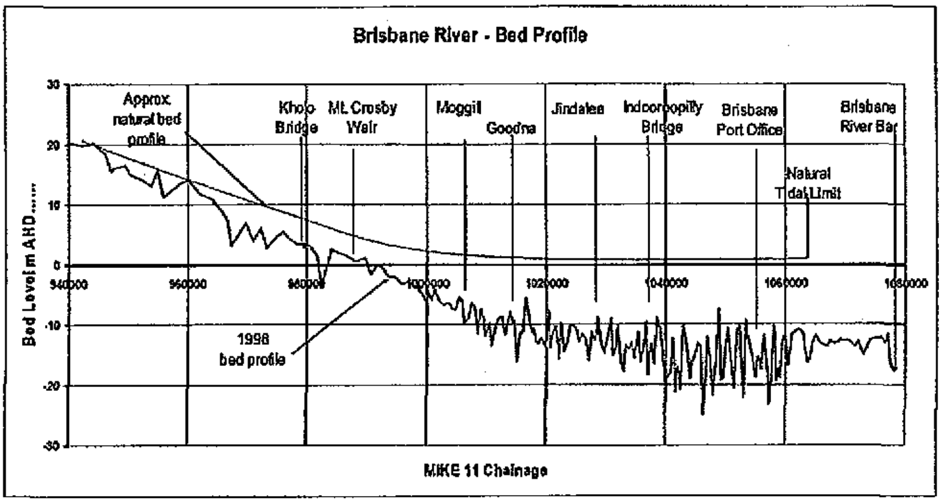


Figure I8 Longitudinal Bed Profile Brisbane River

Referring to **Figure I8**, the chaotic nature of the bed profile from Moggill downstream is probably mainly as a result of the dredging operations.

Indicative of the scale of bed lowering is the upstream movement of the tidal limit which was naturally at about 16km AMTD (Healthy Waterways webpage) but is now at 90km AMTD at Mount Crosby Weir. An approximate natural bed profile is shown in **Figure I8,** which shows that the river bed has been lowered by about 5m to 10m between Mount Crosby and Moggill; about 10m at Moggill and Goodna; and increasing to about 15m at Indooroopilly and further downstream. Unfortunately, no timeline can be applied to this bed degradation, but it appears likely that the bulk of it has occurred in the period 1945 to 1998. There will still be changes following the cessation of dredging in 1998 as both upstream and downstream erosion initiated by the extraction continue to work through the system.

As the peak of extraction was in the 1970s, it is possible that a significant amount of the bed degradation occurred subsequent to the 1974 flood.

In the mid-1970s, there were calls to close down the dredging operations because of bank stability problems and noise (O'Flynn & Thornton 1990) which led to more stringent conditions being applied to extraction permits. Further anecdotal evidence (A. Underwood pers. com.) indicates deepening by dredging and the disappearance of an old training wall since 1974.

I.4 Discussion

This limited investigation has shown:

- At least for the Brisbane River from about 1.5km upstream of the Bremer River confluence to about 5km downstream, there is evidence of increasing river width since about 1970, with the bulk of the increase occurring between 1970 and 1978;
- There is compelling evidence that dredging operations in the Brisbane River and Bremer River have significantly lowered the river bed levels by about 5m to 10m

between Mount Crosby and the Bremer River confluence and about 10m from the confluence downstream;

- The disappearance of the island downstream of the Six Mile Creek confluence between 1970 and 1978 probably from sand extraction is further evidence of channel widening/deepening; and

- There is weaker evidence that a significant amount of this bed degradation took place in the mid to late 1970s.

Channel widening can result directly from attrition by floodwaters; bank slumping as a result of rapid drawdown in the flood recession phase; and as a consequence of channel deepening.

It is considered likely that the observed increase in channel cross-section in the subject reach is a consequence of both the lowering of the river bed for sand/gravel extraction and of the 1974 flood, but it is not possible to quantify the relative impacts of these causes, or to estimate the river geometry prior to the 1974 flood.

The smaller increases in channel width observed at some cross-sections since 1978 are probably due to the ongoing dredging and to erosion initiated by dredging.

In order to see if the indicated degree of channel widening and deepening would account for the apparent change in roughness required to replicate the historic floods, a pre-1974 cross-section was estimated for Ch. 1010725 which is one of the cross sections showing a moderate change and in which the Manning's n value of .028 from fitting the 1996 event, which is already on the low side of typical values, needed to be reduced to 0.017 in order to fit the 1974 flood, which is a very low value recognised as being unrealistic.

In order to estimate the pre-1974 cross-section, the width at the water line (assumed 0m AHD) was decreased to that measured from the 1970 aerial photography, and the bed level increased to -2m AHD. This is shown in **Figure I9**.

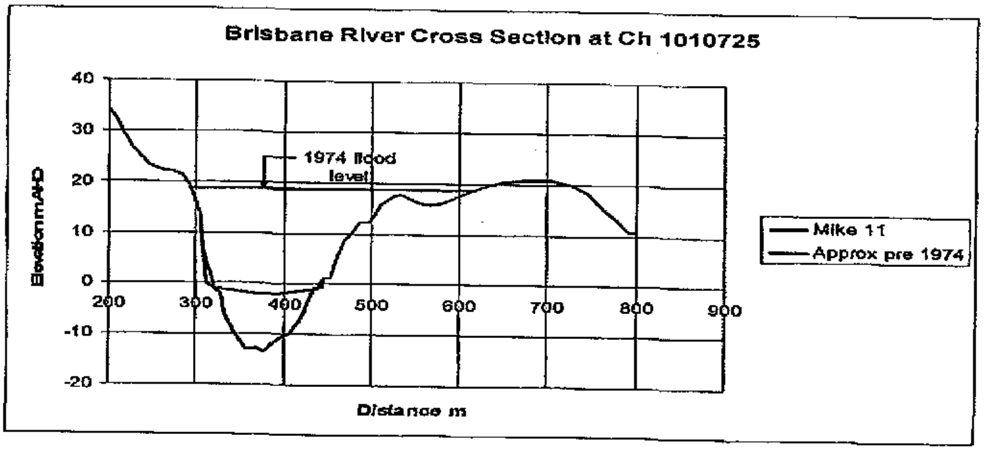


Figure I9 Cross- Section at Ch 1010725

The conveyance of the revised cross section was computed and found to be 0.58 of the original cross-section, compared to the change in roughness of 0.6m. Hence, other things being equal, specifically flow and water surface slope, this change in cross section would reasonably replicate the 1974 flood level using the same roughness as used to fit the 1996 event.

I.5 Conclusions

Taking account of the above, it was concluded that there has been significant river channel widening and deepening of the Brisbane River, between 1.5km upstream and 5km downstream of the Bremer River confluence, since about 1970 and that most of this has occurred between 1970 and 1978. As this period includes the 1974 flood, and was also the peak period of dredging activity, it was concluded that the increase in channel capacity over that period is due largely to both of these causes, but it has not been possible to identify the relative impacts.

Although only a single cross-section was checked, it appears that the scale of cross-section change since prior to the 1974 flood is commensurate with that required to account for the apparent anomaly in model calibration.

It would be possible, by applying similar techniques throughout the whole model, to develop estimated cross sections applicable in 1974. These could then be tested with the 1996 calibration roughnesses, and should result in smaller discrepancies. This would, in turn, reduce the uncertainty in the current model.

I.6 Recommendations

If it is decided that a significant reduction in model uncertainty is warranted, the most appropriate way of doing this is to estimate a set of model cross-sections for 1974.

This will require application of the techniques used in this initial investigation through the entire model area.

The use of other approaches such as tidal calibration would be useful in confirming, and possibly refining, the low flow roughness values and the tidal zone, but will not enable quantification of cross-sectional changes.

The analysis of aerial photography should be extended to the overall model and should also look for shortening of the river length by straightening and/or by meander cut-off.

Further effort should be made to locate earlier cross-section information from Council records, and for the tidal reaches from historic Admiralty hydrographic charts.

If possible, dredging records should be obtained from the various companies involved to show annual volumes extracted from each location.

Other anecdotal evidence, for example, relating to bank stability and erosion, should also be collated and reviewed in order to provide further evidence in respect of the river widening/deepening process.

This process would comprise the following steps:

- Obtain historic aerial photography for the whole model area covering the period from 1972 (or 1970) to present. The 1972 photography is preferable as this is to a larger scale than 1970;

- Review for large scale changes such as river shortening and meander cutoff and re-compute cross-section chainages for 1972 (or 1970) if significant change is found to have occurred;

- Geo-reference the aerial photography for at least 1972 (or 1970) and measure cross-section widths for that date. Alternatively scale directly from photographs, but this will be less accurate in both measurement and in locating cross-sections;

- Review any historic cross-section information available from surveyed cross-sections or hydrographic charts;

- Combine river width and cross-section information to estimate 1972 (or 1970) cross-sections, taking account of any relevant anecdotal evidence;

- Modify MIKE 11 model to run with 1972 (or 1970) cross-sections and re-calibrate to the 1974 flood levels, with a view to obtaining a set of roughness values which are compatible with those used to calibrate the 1996 flood;

- Re-run MIKE 11 design flow events using revised roughness values; and

- Report on the above.

I.7 References

BUREAU OF METEOROLOGY (1974) *Brisbane Floods January 1974*

O'FLYNN M & THORNTON M (1990) *Sand, Gravel and Coal Resources of the Brisbane River and Adjacent Areas* in *The Brisbane River - A Source Book for the Future* Australian Littoral Society

SARGENT CONSULTING (2006) *Ipswich Rivers Flood Study Rationalisation Project Phase 3 Re-estimation of Design Flood Levels – Hydraulic Model Calibration Report* prepared for Ipswich Rivers Improvement Trust and Ipswich City Council

SINCLAIR KNIGHT MERZ (2000) *Ipswich Rivers Flood Study Phase 1 & Phase 2 - Final Report* prepared for Ipswich Rivers Improvement Trust in association with Ipswich City Council

STOCK E & NELLER RJ (1990) *Geomorphic Transitions and The Brisbane River* in *The Brisbane River – A Source Book for the Future* Australian Littoral Society

Queensland Government
Department of Emergency Services

DOTARS
DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

City of Ipswich

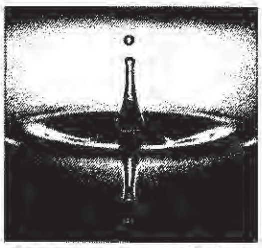
Ipswich City Council

Natural Disaster Mitigation Program

Planning Study for Flood Mitigation at Ripley

Final Report

December 2010



Sargent Consulting

Sargent Consulting
ABN 74 424 370 508
PO Box 561
HAMILTON
Queensland 4007
Tel 0419 311160
Fax 07 31619869
Email dms@sargentconsulting.com.au

Job No 08002

Ipswich City Council
Natural Disaster Mitigation Program

Planning Study for Flood Mitigation at Ripley

Draft Report

Executive Summary

Introduction

Ipswich City Council (ICC) has obtained funding through the Natural Disaster Mitigation Programme (NDMP) to undertake a Planning Study for Flood Mitigation at Ripley. The Planning Study has been overseen and directed by the Study Advisory Group (SAG), with Sargent Consulting providing project management services and specialist services in respect of hydrology and hydraulics. Design and cost estimation components have been undertaken by ICC personnel. In the period between the Draft Report being submitted and this Final Report being completed, some of the recommended works have been completed.

Background

Flooding from heavy rain on the catchment of an unnamed tributary of Bundamba Creek which flows through Ripley township, results in frequent flooding of parts of the urban area of Ripley and flooding of Ripley Road, which has a current flood immunity of less than 50% AEP (2 year ARI).

The current population at risk from direct flooding is approximately 120 at 2 year ARI. The population flooded at 100 year ARI is approximately 2400. In addition, it has been estimated that a further 600 people are at risk and inconvenience from flooding of Ripley Road.

The frequency of property flooding and road closure is considered to be too high, resulting in this part of the community facing community disruption and personal/community distress on a frequent basis, resulting in inequitable impacts on the residents of Ripley. Some residents are fearful of flooding whenever it rains.

Due to the small size of the catchment, there is little or no warning time available. The frequency of flooding of the most severely impacted properties has an adverse impact on property prices.

The frequent closure of Ripley Road restricts emergency access to properties south of Ripley. This impact will worsen as the regional growth area south of the current Ripley Township is developed.

Review of Relevant Reports

A review of relevant reports was undertaken to ensure that all relevant considerations were taken into account. This review was used as a tool in developing the planning strategy for the current project. The review is presented in the report.

Hydrology

In order to fully investigate the hydraulic of the drainage system in Ripley, a more detailed hydraulic model was required, and hence a new XP-RAFTS model was developed to provide the required inputs to the hydraulic model. This is described in the body of the report.

Hydraulic Model

A detailed HEC-RAS model was set up to represent flows in the existing open drain through Ripley. This included all of the culvert crossings, the footbridges and the individual house access crossings.

The model was established initially for existing conditions and subsequently amended to enable a range of flood mitigation options to be tested.

Existing Flood Immunity

From the hydraulic model runs for it was determined that the current flood immunity is as follows:

- *The trafficable flood immunity of Ripley Road through Ripley Township is less than 2 year ARI;*
- *There is one property (444 Ripley Road) which has a flood immunity against over floor flooding of less than 2 year ARI, and two properties (446 and 448 Ripley Road) with an over floor flooding immunity of 20 year ARI; and*
- *There is one house access crossing (430 Ripley Road) with a trafficable flood immunity of less than 2 year ARI, two (440 AND 442 Ripley Road) with a trafficable flood immunity of 5 year ARI, and six properties (424, 426-428, 432, 440, 446 and 448 Ripley Road) with a trafficable flood immunity of 10 year ARI.*

Design Flood Immunity

From the literature review, the Study Advisory Group (SAG) determined that the principal design criteria to be adopted were:

- *No over floor flooding of houses in 100 year ARI event;*
- *Ripley Road to be trafficable in a 10 year ARI event; and*
- *House access crossings to be trafficable in a 10 year event.*

Flood Mitigation

A number of flood mitigation options were considered with the objective of raising the flood immunity in Ripley to meet the design criteria.

Options to address stormwater drainage issues in Clarke Street were considered outside of the NDRM study and are reported upon elsewhere.

The options considered were as follows:

1. *Do nothing (RR1).*
2. *Upgrade existing Ripley Road drain on its existing alignment (RR2).*
3. *Upgrade drainage capacity by means of a new drain along the western side of Ripley Road (RR3).*
4. *Reduce peak flows in Ripley Drain by construction of a retarding basin at the low point on the west side of Ripley Road (RR4).*

Given the very low flood immunity under current conditions, the "do nothing" option was rejected.

Conclusions

The following conclusions were reached as a result of this study:

- *The trafficable flood immunity of Ripley Road through Ripley Township is less than 2 year ARI;*
- *There is one property which has a flood immunity against over floor flooding of less than 2 year ARI, and two properties with an over floor flooding immunity of 20 year ARI; and*

- *There is one house access crossing with a trafficable flood immunity of less than 2 year ARI, two with a trafficable flood immunity of 5 year ARI, and six properties with a trafficable flood immunity of 10 year ARI.*

As a consequence of this low existing flood immunity, the "do nothing" scenario was untenable and flood mitigation works are required.

Recommendations

Having considered a range of flood mitigation options from: a hydraulic performance perspective; costs; and public safety, it was concluded that the most appropriate flood mitigation option is the construction of a new relief drain on the western side of Ripley Road, to the west of the road reserve.

This option is recommended for implementation and design plans have been prepared. The overall scheme comprises the following elements:

- *A new culvert (2 no 1800 x 1200mm RCBC) under Ripley Road upstream of 448 Ripley Road which diverts the upstream flow to the west of Ripley Road thereby relieving flooding to the properties between 448 Ripley Road and Scotts Road;*
- *A new grass lined open drain to the west of Ripley Road (4m wide invert, 1 in 4 batters) from upstream of No 457 Ripley Road to downstream to a point opposite No 420 Ripley Road. The drain will be constructed on land to be acquired for this purpose;*
- *A new culvert (2400 x 1200 RCBC) under Ripley Road to convey the drain flow to the existing drain in Scotts Park;*
- *A connector section of grass lined open drain to connect the downstream end of the new drain to the existing culvert under Ripley Road;*
- *Access crossings of the new drain as required;*
- *Removal of the footbridges in Scotts Park, adjacent to Scotts Road, and adjacent to Michels Street; and*
- *Reconstruction of all of the house access crossings along the existing drain.*

As full funding for this scheme is not currently available, interim works are recommended which can be constructed at the time of other upgrading works along Ripley Road.

These comprise:

- *the new 2400 x 1800 culvert under Ripley Road; and*
- *The raising of the carriageway of Ripley Road to 46.8m between Scotts Road and Michels Street; and*
- *The raising of the carriageway of Ripley Road to 47.1m at the sag point north of Ripley township together with the replacement of the existing culvert at this location with 2 no 1200mm dia RCP.*

These interim works will improve the flood immunity of Ripley Road in the vicinity of the culvert crossing and of particular low points along Ripley Road.

1. Introduction

Ipswich City Council (ICC) has obtained funding through the Natural Disaster Mitigation Programme (NDMP) to undertake a Planning Study for Flood Mitigation at Ripley. The Planning Study has been overseen and directed by the Study Advisory Group (SAG), with Sargent Consulting providing project management services and specialist services in respect of hydrology and hydraulics. Design and cost estimation components have been undertaken by ICC personnel.

Ripley is a small township lying south east of the Ipswich CBD. Its location within Ipswich City is shown in **Figure 1** and **Figure 2** its layout at a larger scale.

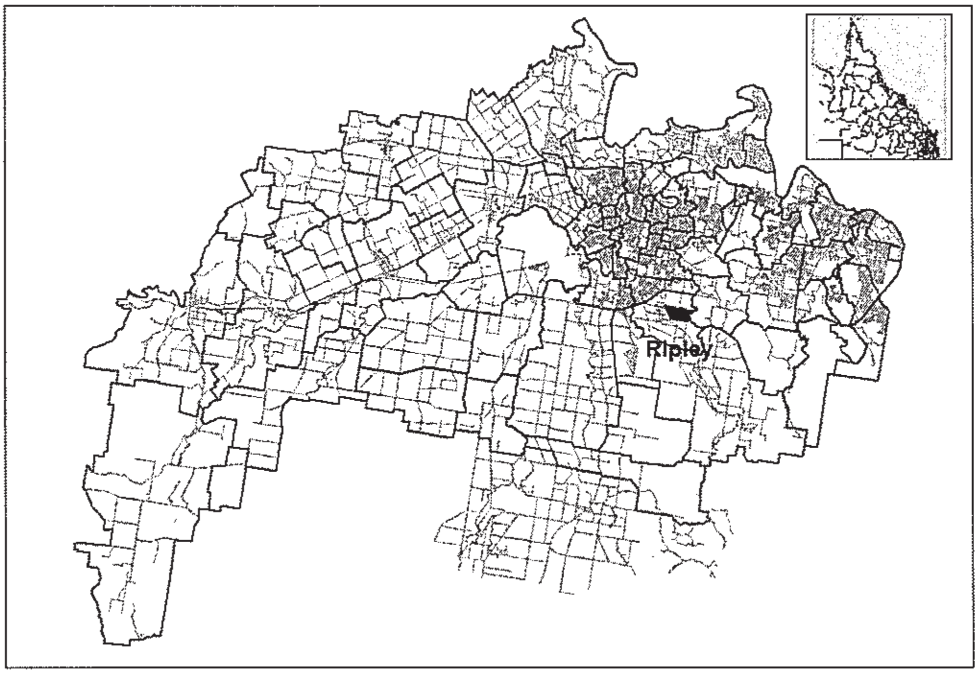


Figure 1 Location Plan

1.1. Background

Flooding from heavy rain on the catchment of an unnamed tributary of Bundamba Creek which flows through Ripley township, results in frequent flooding of parts of the urban area of Ripley and flooding of Ripley Road, which has a current flood immunity of less than 50% AEP (2 year ARI).

The current population at risk from direct flooding is approximately 120 at 2 year ARI. The population flooded at 100 year ARI is approximately 2400. In addition, it has been estimated that a further 600 people are at risk and inconvenience from flooding of Ripley Road.

The frequency of property flooding and road closure is considered to be too high, resulting in this part of the community facing community disruption and personal/community distress on a frequent basis, resulting in inequitable impacts on the residents of Ripley. Some residents are fearful of flooding whenever it rains.

Due to the small size of the catchment, there is little or no warning time available. The frequency of flooding of the most severely impacted properties has an adverse impact on property prices.

The frequent closure of Ripley Road restricts emergency access to properties south of Ripley. This impact will worsen as the regional growth area south of the current Ripley Township is developed.

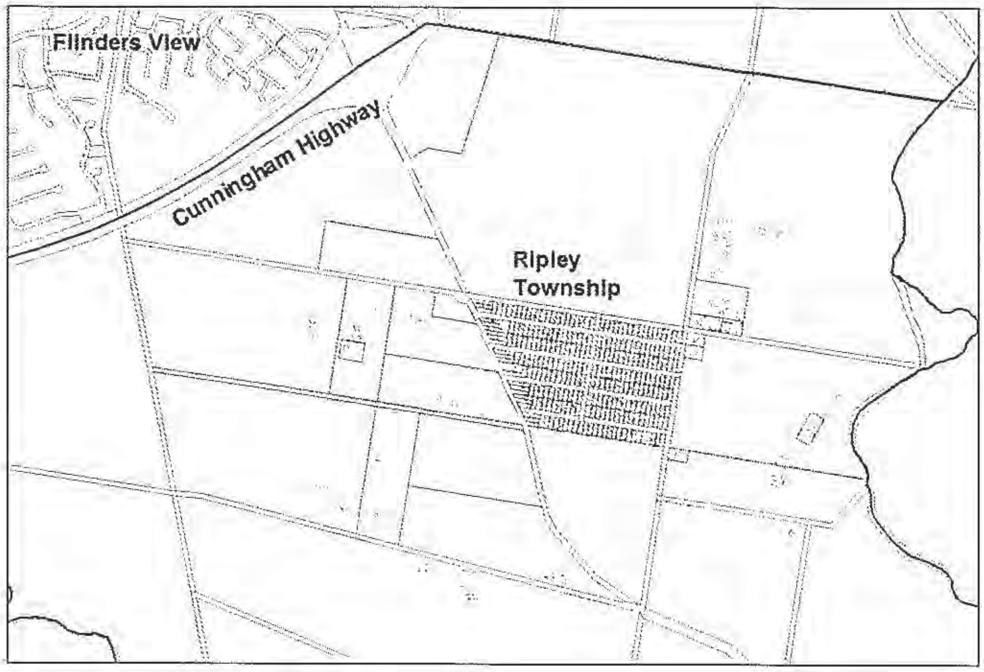


Figure 2 Map of Ripley

1.2. Planning Study Strategy

As determined by the SAG, the Planning Study will:

- Take account of legislation, planning and design requirements and guidelines as identified in the Literature Review, namely:

  Queensland Legislation
  - Integrated Planning Act (1997)
  - Environmental Protection (Water) Policy (1997)
  - SPP 1/03 Mitigating the Adverse Impacts of Floods, Bushfires and Landslides

  Australian & Queensland Guidelines
  - Queensland Urban Drainage Manual (QUDM) 2007 edition
  - Water Sensitive Urban Design Guidelines (Healthy Waterways 2006)
  - ANZECC Water Quality Guidelines

Ipswich City Council Requirements
- ICC Corporate Plan
- Ipswich Planning Scheme
- Ipswich Master Drainage Strategy
- Urban Stormwater Quality Plan
- Ripley Valley Structure Plan.

- Address all of the identified stormwater drainage issues in Ripley Township.

- Be cognisant of the flooding issues downstream in the urban areas of Bundamba and Blackstone and consider the potential of the planned works to provide improvements downstream.

- Develop a range of optional treatments and solutions which are workable and economic.

- Undertake stakeholder consultation in respect of identified options.

- Comply with the requirements of potential funding agencies.

- Document the preferred option.

- Prepare a Planning Report describing all of the above.

2. Review of Relevant Reports

A review of relevant reports was undertaken to ensure that all relevant considerations were taken into account. This review was used as a tool in developing the planning strategy for the current project. It is presented in **Appendix A** in tabular form for ease of reference and is divided into the following categories:

- Flood Mitigation and Drainage Strategy, General;

- Ripley Valley Master Plan; and

- Ripley Flood Mitigation and Drainage, Specific.

The main findings of this review were:

a) *Flood Mitigation and Drainage Strategy, General*
These strategic planning documents set the broad guidelines for stormwater and drainage planning in Ipswich, including compliance requirements. These have been taken into account in developing the flood mitigation measures considered in this report, and the subsequent recommendations

b) *Ripley Valley Master Plan*
Ripley Township is within the area covered by the Ripley Valley Master Plan which sets out the planning requirements for this major urban development. The most relevant items from this plan are:

Flood management is to:
- Result in no increase in peak flow downstream of Ripley Valley catchment;
- Result in no increase in pre-development peak flows from 1 year event up;
- Ensure design runoff depth capture rates defined;

- Result in no loss of floodplain storage;
- Ensure compliance with SPP 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslides;
- include detention basins and WSUD measures (includes sub-regional detention basins G4 and F4 at Ripley);
- Ensure detention basins incorporate water quality treatment;
- Ensure regional detention storage in Bundamba Creek;
- Ensure that existing watercourses are maintained for stormwater conveyance, especially in upper reaches where no 100 year ARI inundation extent has been defined; and
- Meet the following water quality targets: 80% reduction in sediment load; 60% reduction in phosphorus load; 45% reduction in Nitrogen load; and 90% reduction in gross pollution load.

c) *Ripley Flood Mitigation and Drainage, Specific Recommendations*:
Short Term
- Piped drainage in Michel St.
- Divert upstream runoff into a second stormwater collection channel to be constructed on the western side of Ripley Rd via new pipe crossing under road, to reduce flow in main drain.
- Maintain existing drainage corridor in its natural condition.
- Instigate a water quality monitoring program.

Long Term
- Construct detention basin on western side of Ripley Road to maintain existing Q_{50} flows under future ultimate catchment conditions.
- Upgrade Ripley Road to Q_{50} flood immunity by raising roadway by 1m and increasing cross drainage capacity opposite Clarke Street.

3. Hydrology

SKM (1999) prepared an XP-RAFTS model for the Ripley Valley catchment from upstream of Ripley to the junction with Bundamba Creek. This model comprised a total of 36 sub areas of which the upstream 11 sub areas covered the area of Ripley Township.

In order to fully investigate the hydraulic of the drainage system in Ripley, a more detailed hydraulic model was required, and hence a new XP-RAFTS model was developed to provide the required inputs to the hydraulic model. The layout of this model showing catchment delineation and model nodes is given in **Figure 3**.

Flows in the range of 2 years to 100 year ARI were estimated for the following scenarios:

- Existing development;
- Ultimate development in current Ripley Township area (i.e to the east of Ripley Road); and
- Ultimate development in current Ripley Township area and in the catchment to the west of Ripley Road.

Modelling was undertaken using the following rainfall losses:

- Undeveloped areas, initial loss 20mm, continuing loss 2.5mm/hr; and
- Urban areas, initial loss 2mm, continuing loss 2.5mm/hr.

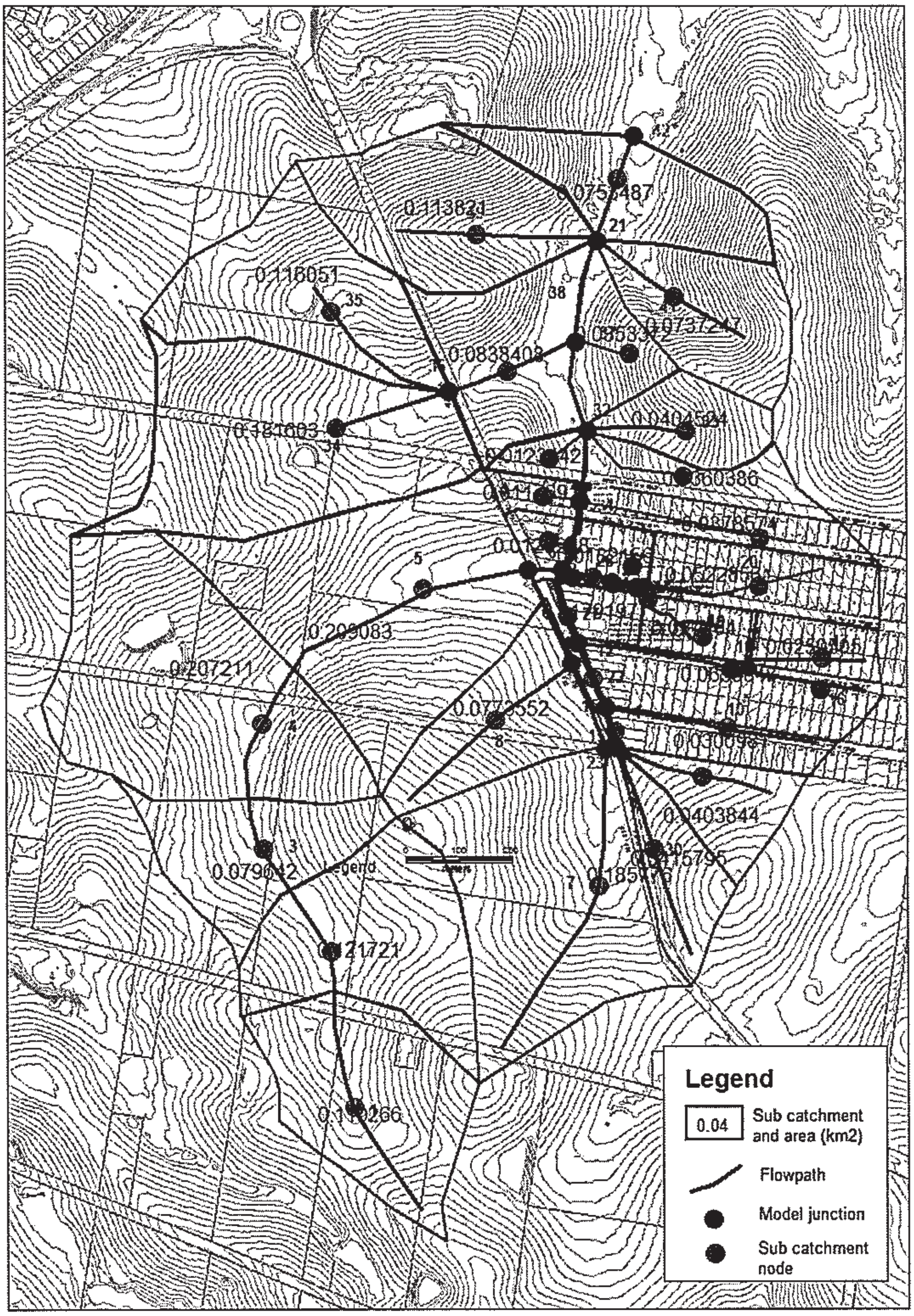


Figure 3 Ripley XP-RAFTS Model Layout

Preliminary runs showed that the critical storm durations are 30 minutes and 60 minutes for the various sub areas for all ARIs. As the design criteria used were 10 year ARI for local drainage and flood immunity for Ripley Road, and 100 year ARI for house inundation, results are presented only for these scenarios.

A summary of peak flows is given in **Table 1**, and the modelled peak flows are given in **Appendix B**.

Table 1 Peak Flows – Summary

Location	RAFTS Node	HECRAS chainage m	Peak Flow (m3/s) for ARI Existing Conditions					Peak Flow (m3/s) for ARI Ultimate Conditions		
			2 yr ARI	5 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI
Ripley Rd u/s Scotts Rd	23	1222	1.8	3.2	4.0	6.7	8.1	11.6	14.9	17.0
Scotts Rd	14		2.3	3.0	3.5	4.6	5.3	3.9	5.2	5.8
Ripley Rd d/s Scotts Rd	15	1138	2.8	4.7	5.9	9.6	11.6	15.6	20.0	22.6
Ripley Rd u/s Michels St	12	1020	3.4	5.8	7.3	12.2	14.7	17.5	22.7	25.8
Ripley Rd d/s Michels St	27	962	3.5	6.0	7.5	12.5	15.1	17.7	23.1	26.2
Small area W of Ripley Rd	8		0.7	1.3	1.6	2.6	3.1	4.0	5.2	5.9
Main area W of Ripley Rd	5		5.0	8.4	10.4	17.2	20.3	18.9	26.5	30.4
Clarke St area	26		6.6	8.6	9.7	13.1	14.9	11.3	14.6	16.5
Ripley Drain Clarke St-Falvey St	31	738	9.6	14.0	17.1	28.5	34.1	41.1	56.0	63.8
Ripley Drain d/s Monterea Rd	32	578	10.3	15.8	19.3	30.9	36.8	42.9	58.7	66.8
N area W of Ripley Rd	36		2.4	4.2	5.3	8.9	10.7	15.4	19.7	22.3
D/s of Ripley Township	21	212	14.0	23.1	28.4	45.6	54.0	55.0	75.7	86.2

4. Hydraulic Model

A detailed HEC-RAS model was set up to represent flows in the existing open drain through Ripley. This included all of the culvert crossings, the footbridges and the individual house access crossings.

The model was established initially for existing conditions and subsequently amended to enable a range of flood mitigation options to be tested. This paragraph outlines the existing situation modelling, and the next section outlines the flood mitigation options investigated. A layout diagram for the overall model is given in **Figure 4**, and **Figure 5** gives more detail of the township part of the model.

The main drain through Ripley Township is to the east of Ripley Road. There is also a partly formed table drain to the west of Ripley Road and a culvert under Ripley Road which carries flow from the main western catchment to the main drain.

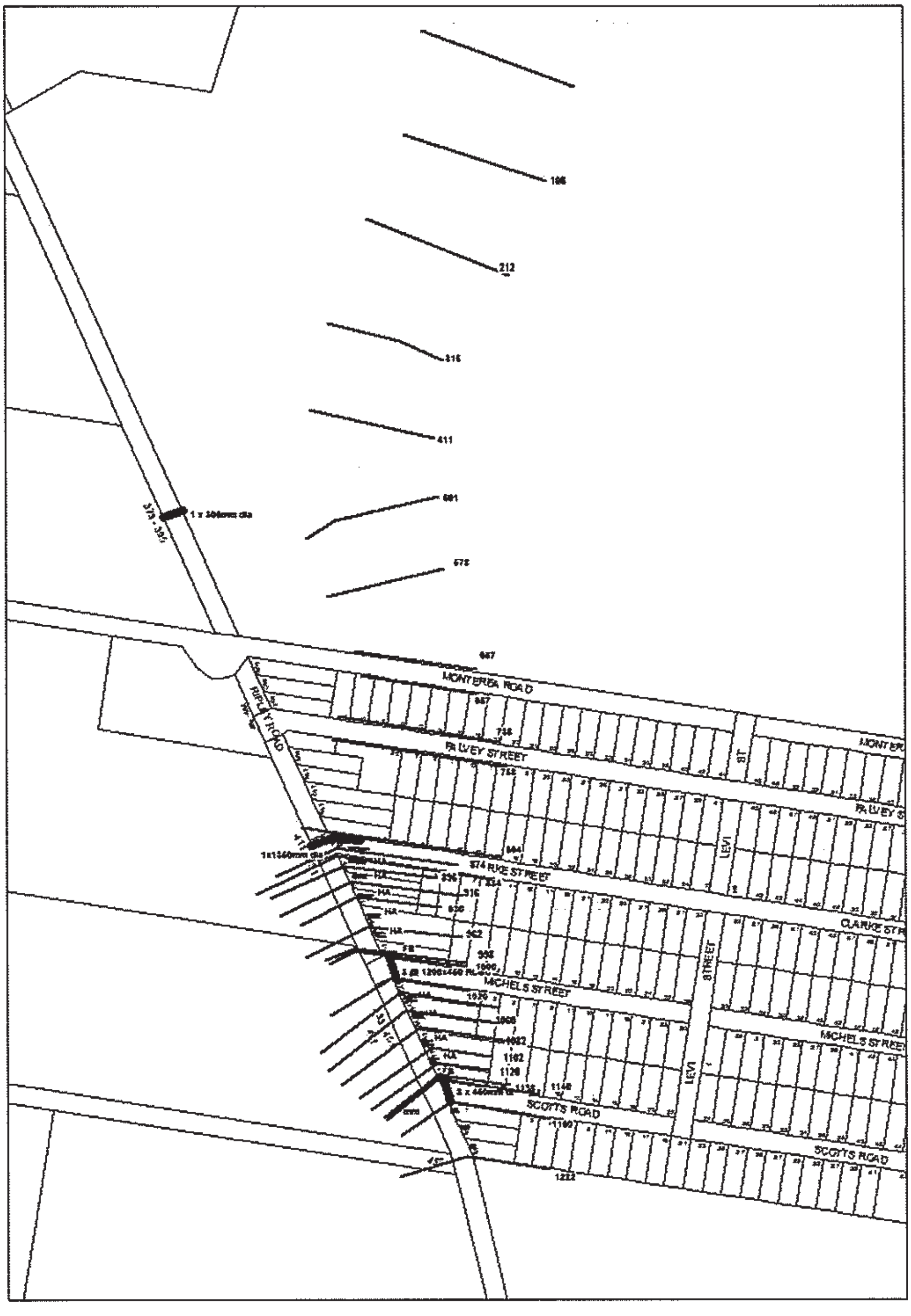


Figure 4 HEC-RAS Model for Existing Conditions – Overall Model

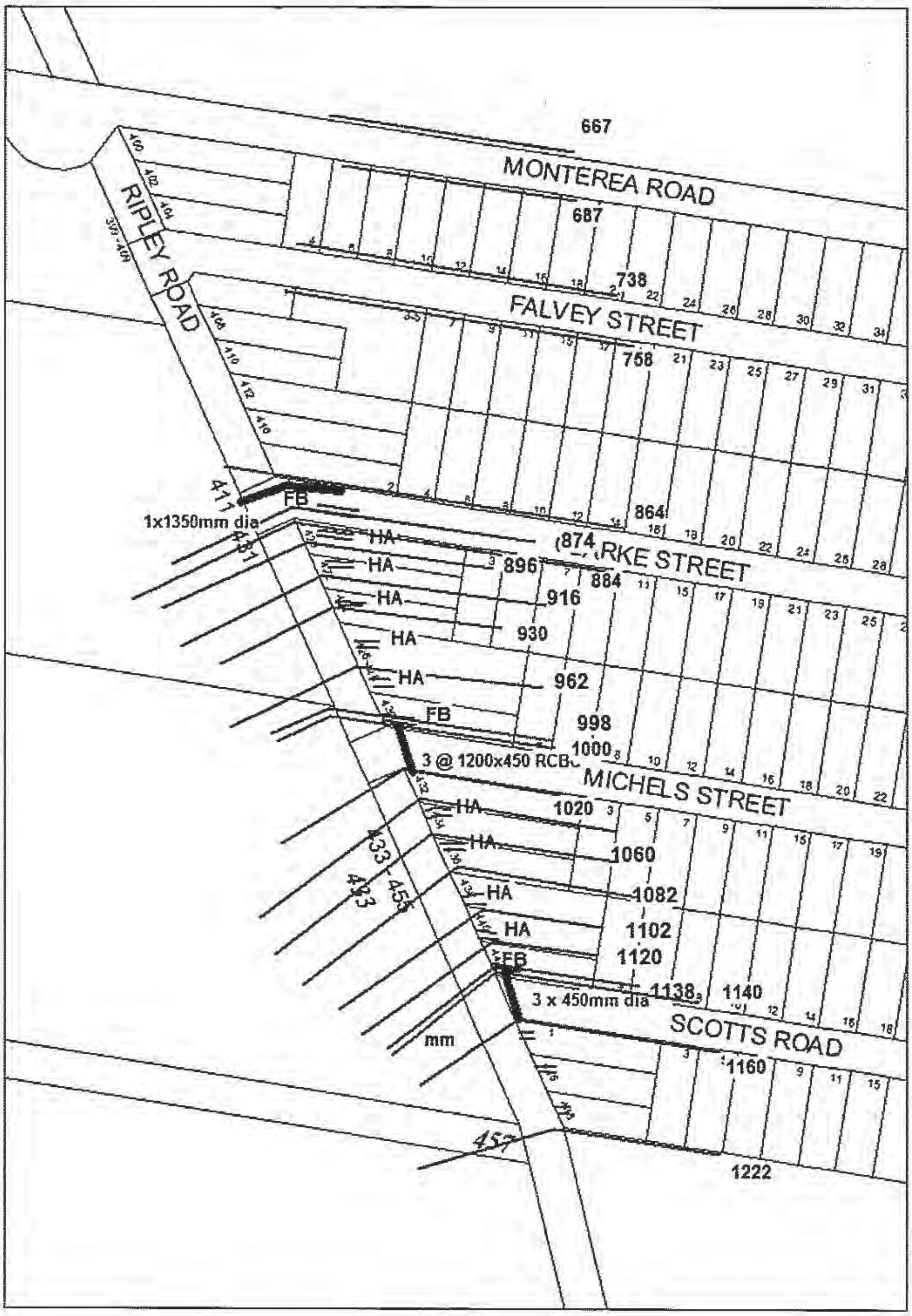


Figure 5 **HEC-RAS Model for Existing Conditions - Ripley Township Detail**

4.1 Design Flood Immunity

From the literature review and SAG discussions, it was determined that the principal design criteria to be adopted were:

- No over floor flooding of houses in 100 year ARI event;
- Ripley Road to be trafficable in a 10 year ARI event; and
- House access crossings to be trafficable in a 10 year event.

4.2 Existing Flood Immunity

The model was used to estimate the existing flood immunity of Ripley Road and the houses along Ripley Road. The outcomes from this are shown in **Figure 6** and details are given in **Appendix C.**

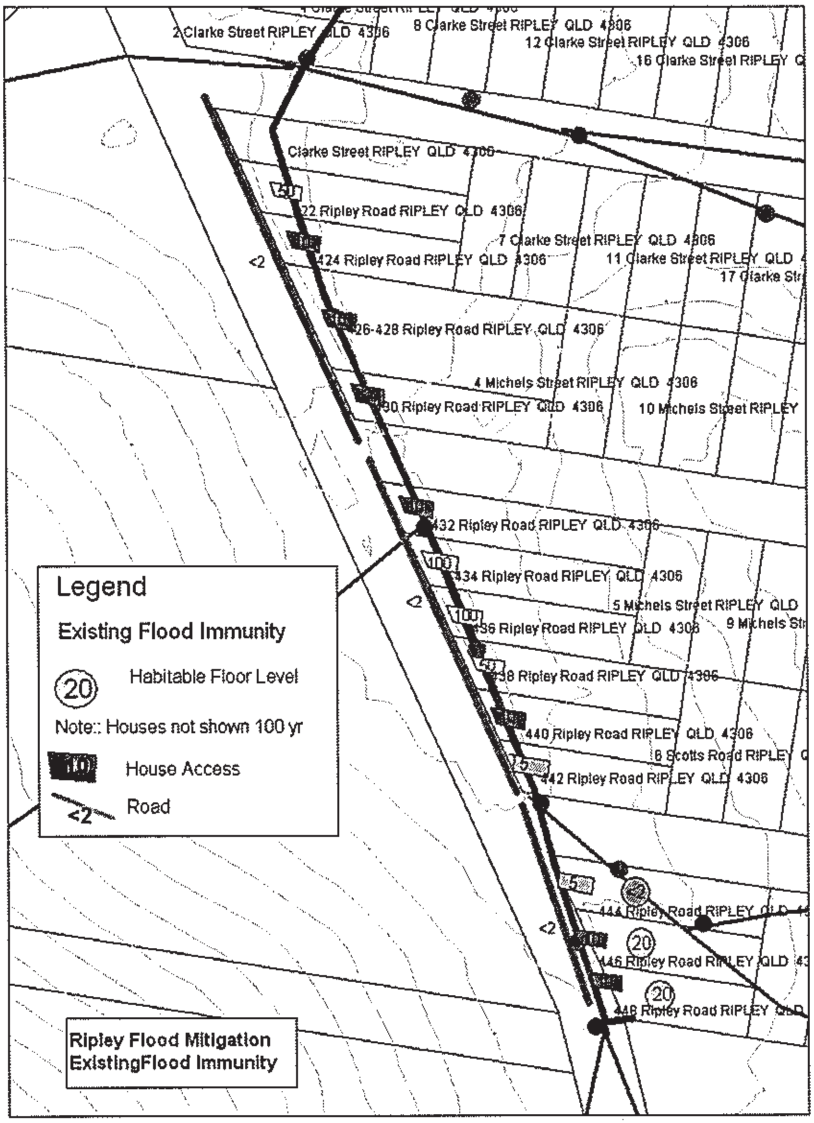


Figure 6 **Existing Flood Immunity**

The following were determined from these model runs:

- The trafficable flood immunity of Ripley Road through Ripley Township is less than 2 year ARI;
- There is one property (444 Ripley Road) which has a flood immunity against over floor flooding of less than 2 year ARI, and two properties (446 and 448 Ripley Road) with an over floor flooding immunity of 20 year ARI; and
- There is one house access crossing (430 Ripley Road) with a trafficable flood immunity of less than 2 year ARI, two (440 AND 442 Ripley Road) with a trafficable flood immunity of 5 year ARI, and six properties (424, 426-428, 432, 440, 446 and 448 Ripley Road) with a trafficable flood immunity of 10 year ARI.

Detailed results from this model run are given in **Appendix C**.

It can be seen from these results that the current flood immunity is below the design criteria at various locations in respect of all three nominate criteria, i.e. over floor flooding, road trafficability and house access trafficability.

Consequently, a number of flood mitigation options were considered as outlined in **Section 5** hereof.

5. Flood Mitigation

A number of flood mitigation options were considered with the objective of raising the flood immunity in Ripley to meet the design criteria.

These options were modelled by modifying the hydraulic model to emulate the proposed option and determining the resulting flood immunity. In the case of retarding basin storage on the western catchment, the performance of the retarding basin was modelled by modifying the XP-RAFTS model.

This section outlines the range of options considered. Further details including cost estimates and model results are given in **Appendix D** hereof.

Options to address stormwater drainage issues in Clarke Street were considered outside of the NDRM study and are reported upon elsewhere.

The options considered were as follows:

1. Do nothing (RR1).
2. Upgrade existing Ripley Road drain on its existing alignment (RR2).
3. Upgrade drainage capacity by means of a new drain along the western side of Ripley Road (RR3).
4. Reduce peak flows in Ripley Drain by construction of a retarding basin at the low point on the west side of Ripley Road (RR4).

Given the very low flood immunity under current conditions, the "do nothing" option was rejected.

A new culvert comprising 2 no. 1200mm diameter pipes is also required, together with raising the road a maximum of 300mm to 47.1m AHD at a second sag point to the north of Ripley. This is a component of all of the options considered.

a) Upgrading of Existing Drain

Upgrading of the existing Ripley Road drain was found to be possible, but required widening of the invert from 2m to 4m, regrading along the entire length from upstream of Scotts Road to Scotts Park, including the construction of new culverts under Scotts Road and Michels Road and the reconstruction of all 12 house access crossings.

This would result in the following flood immunity of houses, house access and Ripley Road:

- All houses would have 100 year ARI immunity against over floor flooding;
- House access crossings would have 20 year ARI or higher flood immunity (3 @ 20 year, 2 @ 50 year, remainder at 100 year or higher); and
- Ripley Road would have a flood immunity of 10 year ARI. This requires:
    - Replacement of the existing culverts at the Scotts Road/Ripley Road intersection with a 3 cell culvert of 1800mm x 1200mm RCBC;
    - Replacement of the existing culverts at the Michels Road/Ripley Road intersection with a 3 cell culvert of 1800mm x 1200mm RCBC;
    - Between 436 and 438 Ripley Road, the flood immunity of the roadway will still be 2 years only with the drainage works alone, requiring some 60m of road to be raised a maximum of about 300mm to provide the 10 year immunity.

The additional flow capacity is provided by regrading the drain from its upstream end outside 448 Ripley Road to Clarke Road and widening the concrete lined invert from 2m (1.5m upstream of Scotts Road) to 4m throughout. There is room to do this within the existing drainage easement, by steepening of the batters. Downstream of Scotts Road this may require some trees to be removed. Upstream of Scotts Road the easement width is narrower and detail survey is required to confirm that there is sufficient room for the proposed reconstruction.

In addition the house access crossings will all have to be reconstructed, at their existing levels but with great flow capacity. The proposed 4m wide invert will accommodate 2 cell culverts of 1800mm width. Culvert depth will vary from 600mm upstream of Scotts Road to 900mm between Scotts Road and Michels Street, and 1200mm downstream of Scotts Road.

The 2 existing footbridges will need to be removed for reconstruction but should be able to be re-used.

A number of sub-options comprising replacement of culverts and house access crossings only were considered but were found to be ineffective without the widening and deepening of the drain itself. Hence, these sub-options were discounted from any further consideration.

b) New Relief Drain West of Ripley Road

Constructing a new relief drain to the west of Ripley Road was previously recommended in SKM (1999). This option has been modified from that originally proposed and includes the following elements

- A new culvert under Ripley Road upstream of 448 Ripley Road diverts the upstream flow to the west of Ripley Road;
- A new open drain to the west of Ripley Road from upstream of No 457 downstream to a point opposite No 420;
- A new culvert under Ripley Road to convey the drain flow to the existing drain in Scotts Park;
- A connector drain to connect the downstream end of the new drain to the existing culvert under Ripley Road to the existing drain in Scotts Park;
- Access crossings of the new drain as required;
- Removal of the Scotts Park footbridge; and
- Reconstruction of all of the house access crossings along the existing drain; and
- Raising of the road crown level to 46.8m AHD between Scotts Road and Michels Street.

A number of variations of this option were considered, with the new western drain within the road reserve, and on acquired land west of the road reserve; with and without interceptor drains to carry runoff from Scotts Road and Michels Street under Ripley Road to the new drain, (and in the latter case the filling of the existing drain). Details of these sub-options are given in **Appendix D**. The preferred option as presented in this paragraph was found to be the least cost solution and also preferable on public safety grounds. An outline of the preferred option is given in **Figure 7**.

As full funding for this scheme is not currently available, interim works were considered which could be constructed at the time of other upgrading works along Ripley Road. These comprised: the new 2400 x 1200 culvert under Ripley Road and the raising sag points in Ripley Road as follows:

C) Flood Mitigation Storage West of Ripley Road

Construction of a retarding basin in the flow path to the west of Ripley Road to reduce the flows in Ripley Road drain was investigated, but was found to be insufficient to obviate the need for works similar to those in Options RR2 and RR3, as this would only reduce existing flows marginally downstream from Scotts Park, and hence would have a marginal impact on the flood levels upstream of Clarke St.

A retarding basin at this location and a second retarding basin further north will be required when the catchments upstream of these locations are developed for residential development. These works do not however, form part of the current project.

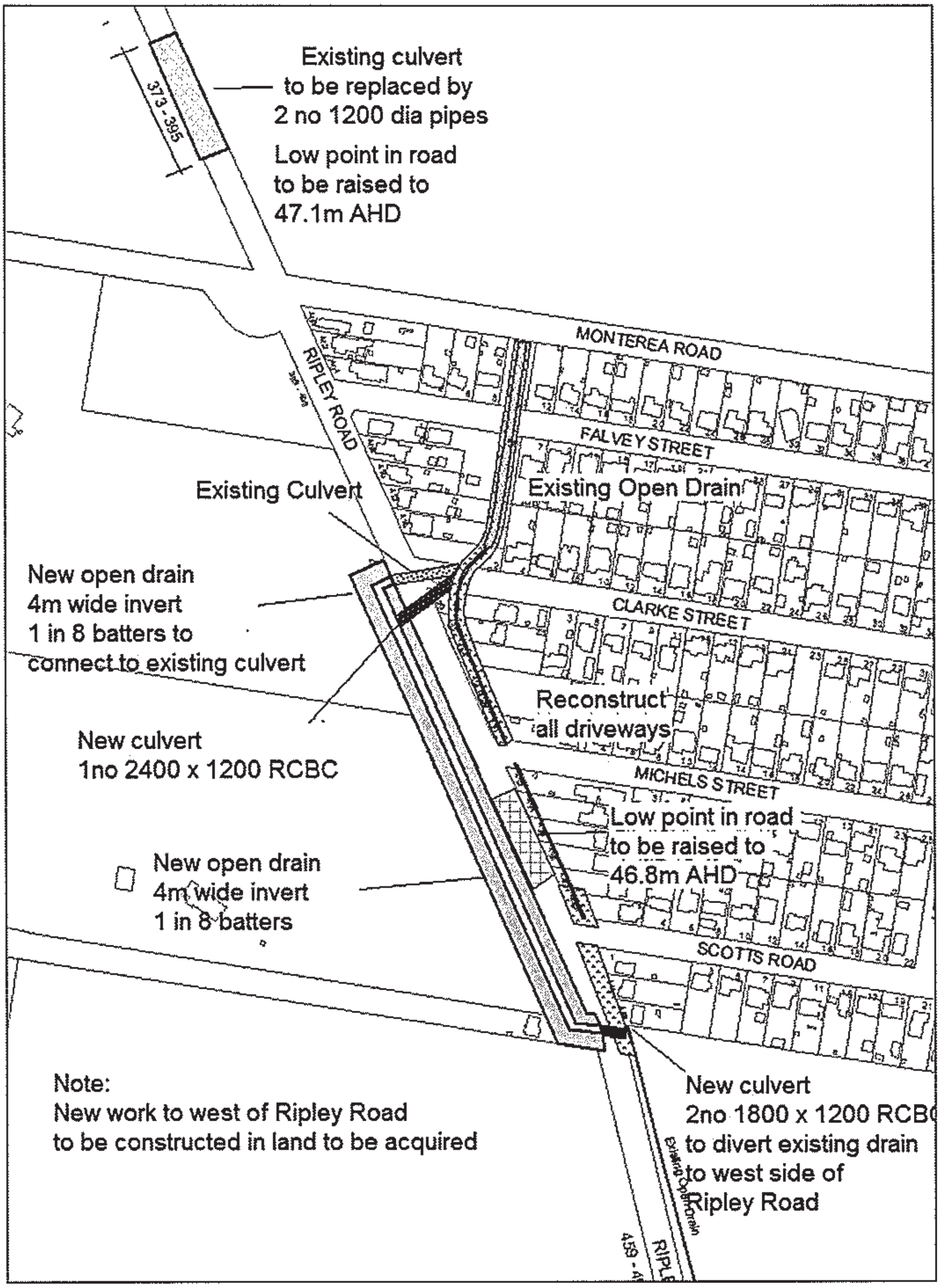


Figure 7 New Drain West of Ripley Road – Preferred Layout

6. Conclusions and Recommendations

6.1 Conclusions

The following conclusions were reached as a result of this study:

- The trafficable flood immunity of Ripley Road through Ripley Township is less than 2 year ARI;
- There is one property which has a flood immunity against over floor flooding of less than 2 year ARI, and two properties with an over floor flooding immunity of 20 year ARI; and
- There is one house access crossing with a trafficable flood immunity of less than 2 year ARI, two with a trafficable flood immunity of 5 year ARI, and six properties with a trafficable flood immunity of 10 year ARI.

As a consequence of this low existing flood immunity, the "do nothing" scenario was untenable and flood mitigation works are required.

The review of relevant literature and Council policy resulted in the following design criteria being adopted for the flood mitigation works:

- No over floor flooding of houses in 100 year ARI event;
- Ripley Road to be trafficable in a 10 year ARI event; and
- House access crossings to be trafficable in a 10 year event.

6.2 Recommendations

Having considered a range of flood mitigation options from: a hydraulic performance perspective; costs; and public safety, it was concluded that the most appropriate flood mitigation option is the construction of a new relief drain on the western side of Ripley Road, to the west of the road reserve.

This option is recommended for implementation and design plans have been prepared. The overall scheme comprises the following elements:

- A new culvert (2 no 1800 x 1200mm RCBC) under Ripley Road upstream of 448 Ripley Road which diverts the upstream flow to the west of Ripley Road thereby relieving flooding to the properties between 448 Ripley Road and Scotts Road;
- A new grass lined open drain to the west of Ripley Road (4m wide invert, 1 in 4 batters) from upstream of No 457 Ripley Road to downstream to a point opposite No 420 Ripley Road. The drain will be constructed on land to be acquired for this purpose;
- A new culvert (2400 x 1200 RCBC) under Ripley Road to convey the drain flow to the existing drain in Scotts Park;
- A connector section of grass lined open drain to connect the downstream end of the new drain to the existing culvert under Ripley Road;

- Access crossings of the new drain as required;
- Removal of the footbridges in Scotts Park, adjacent to Scotts Road, and adjacent to Michels Street; and
- Reconstruction of all of the house access crossings along the existing drain.

As full funding for this scheme is not currently available, interim works are recommended which can be constructed at the time of other upgrading works along Ripley Road.

These comprise:

- the new 2400 x 1800 culvert under Ripley Road; and
- The raising of the carriageway of Ripley Road to 46.8m between Scotts Road and Michels Street; and
- The raising of the carriageway of Ripley Road to 47.1m at the sag point north of Ripley township together with the replacement of the existing culvert at this location with 2 no 1200mm dia RCP.

These interim works will improve the flood immunity of Ripley Road in the vicinity of the culvert crossing and of particular low points along Ripley Road.

7. References

HALLIBURTON KBR (2002a) *Local Storm Flood Mapping - Final Report* prepared for Ipswich City Council

HALLIBURTON KBR (2002b) *Ipswich Rivers Flood Study Phase 3 - Final Report* prepared for Ipswich City Council

INSTITUTION OF ENGINEERS AUSTRALIA (1987 and updates) *Australian Rainfall and Runoff – A Guide to Flood Estimation*

JWP (2007) *Consistency of Floodway Warning across South East Queensland* prepared for South East Queensland Disaster Management Advisory Group

SINCLAIR KNIGHT MERZ (1999) *Ripley Area Catchment Management Plan* prepared for Ipswich City Council

SINCLAIR KNIGHT MERZ (2000) *Ipswich Rivers Flood Study Phase 1 & Phase 2 - Final Report* prepared for Ipswich Rivers Improvement Trust in association with Ipswich City Council

Appendices

Appendix A Review of Relevant Reports

This paper summarises the findings a brief review of existing reports and associated documents relevant to the current Planning Study for Flood Mitigation Storage at Ripley. This review will be used as a tool in developing the planning strategy for the current project. It is presented in tabular form for ease of reference and is divided into the following categories:

- Flood Mitigation and Drainage Strategy, General;
- Ripley Valley Master Plan; and
- Ripley Flood Mitigation and Drainage, Specific.

a) Flood Mitigation and Drainage Strategy, General

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Stormwater Management Scoping Strategy	PPK (1998)	Documents, in broad terms, the then current situation regarding stormwater drainage problems throughout Ipswich, and presents a suggested approach to the development of a master strategy for future action.	ICC has adopted the Queensland Urban Drainage Manual (QUDM) for drainage design – drainage in new developments to comply with QUDM (note QUDM revised in 2007) (Executive Summary & 2.3). ICC required to develop and implement a water quality environmental plan under the *Environmental Protection (Water) Policy 1997* (Executive Summary). The *Integrated Planning Act 1997* requires Councils to develop management strategies for stormwater on a catchment by catchment basis and to implement a pricing policy to meet the associated costs. (Section 1). Flooding due to drainage inadequacies distinguished from creek and river flooding, with the former more localised in extent and of shorter duration (Section 1). Section 2.2 lists common drainage problems in Ipswich. Stormwater remediation works where subsidy/loan is sought require Planning Reports DLG Bulletin No 6/10 DRA 1986 and Bulletin 84/20 Appendix B (1984) list requirements (included in Appendix D to this document (2.5).

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Stormwater Management Scoping Strategy (contd.)	PPK (1998)	Documents, in broad terms, the then current situation regarding stormwater drainage problems throughout Ipswich, and presents a suggested approach to the development of a master strategy for future action.	Hierarchy of reports: Master Stormwater Management Strategy is the umbrella under which there may be Stormwater Management Plans for each catchment (5.5) *(and presumably but not stated Planning Reports in relation to implementation of specific strategies under the above).* The Master Stormwater Management Strategy will need to identify potential areas involving policy decisions, and prioritisation linked to Financial Management Strategy (5.2). Notes that Ripley Township is one of the areas identified as having drainage problems (3.9.2).
Ipswich Master Drainage Strategy (Draft)	PPK (1998)	Establishes a framework to ensure: • Minimisation of adverse flooding; • Appropriate levels of service; • Protection of environmental values; • Financial planning; and • Compliance with legislation.	QUDM levels of service applicable to new developments (essentially major/minor 100/10). Interim standard for relief drainage for existing developments (essentially major/minor 10/2) (Section 3.3). Environmental guidelines e.g. *ANZECC Water Quality Guidelines for Fresh and Marine Waters* and *Brisbane River/Moreton Bay Wastewater Management Study* to be used to identify objectives for each catchment (3.4). Strategy Framework giving hierarchy (5.1) – catchment management plans -> stormwater management plans -> Local Stormwater Management Plans (5.2). Requirements for the above (5.3, -5.6). Sub-catchment ranking procedure (Appendix B).

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Strategy for Preparation of a Total Management Plan for Flooding and Drainage Services	Cardno & Davies (1998)	Proposes development of TMP through: • TMP documentation • Floodplain Management Strategy • Mast Drainage Planning • Stormwater Quality Management Plans • Specific Environmental Management Plans	Specific requirements for Flooding and Drainage Sub Plans • Customer Service. • Quality Management. • Financial Management. • Environmental Coordination. • Human Resource Development. • Risk Management. • Asset Evaluation. • Maintenance Management. • Information Management. • Planning Overview. • Project Management Overview. • Performance Assessment.
Design Selection and Siting of SQIDS – Planning Process Report	Brown & Root (2000)	Developed a Planning process for the section of appropriate sites for SQIDS in Ipswich and selection of SQID types at specific sites	Performance criteria based on: • Legislative requirements e.g. EPP (Water). • Guidelines e.g. ANZECC, WHO. • Regional water quality strategies eg SE Qld Regional Water Quality Strategy. • Locally determined environmental values. • Sites considered in Ripley Valley (B11) immediately d/s of Ripley Township and sites B8-B10 further downstream – nominated the following as being appropriate treatment: litter racks (B11 only), extended detention basin, sediment trap, constructed wetland (Fig 4.8, Tables 6.3-6.5).
Jacaranda Street Catchment Stormwater Management Strategy	PPK (2002)	An example of a Stormwater Management Strategy at the catchment level	Adopted Interim Drainage standard of 10 year ARI for major event and 2 year ARI for minor event.

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Scoping Study for Infrastructure Charging Schedule for Waterways	JWP (2003)	Summarises planning framework, and the place of waterway management planning. Outlines principles for infrastructure charging. Recommends process integration and development of infrastructure charges for priority development and redevelopment areas.	Framework for hierarchy of Corporate Plan, Planning Scheme, Urban Stormwater Management Plans, Waterway Management Plans (section 2). Focus is on major waterways rather than drainage infrastructure. Identifies Urban Stormwater Quality Plan as the driver for waterway management activities Same hierarchy as identified in Master Drainage Strategy. Outlines broad principles for Priority Infrastructure Plan (PIP) and Infrastructure Charges Schedule (ICS).
Bundamba Creek Flood Mitigation Project Stage 1 (Final report and Addendum Report)	JWP (2004 & 2005)	Development of a flood mitigation strategy for the lower reaches of Bundamba Creek. Hydrological modelling using RAFTS for whole catchment – hydraulic modelling for lower reaches only. Addendum report provided concept level design.	Hydrological modelling of limited use for current study as too coarse scale. Lists legislative framework for flood mitigation works.
Ipswich Rivers Flood Study Phase 2 Final Report	SKM (2000)	Catchment wide modelling using RAFTS and MIKE 11.	Hydrologic and hydraulic modelling at too coarse a scale to be of use to current study. Includes flood levels for Bundamba Ck at Ripley but not Ripley Drainage.

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Ipswich Rivers Flood Study Local Storm Flooding	KBR (2000)	Catchment wide modelling using RAFTS and MIKE 11 but for local storms only.	Hydrologic and hydraulic modelling at too coarse a scale to be of use to current study. Includes flood levels for Bundamba Ck at Ripley but not Ripley Drainage.
Ipswich Rivers Flood Study Phase 3 Re-estimation of Design Flows	Sargent Consulting (2006)	Re-estimation of design flows using RAFTS model with new CRC-FORGE rainfalls.	Hydrologic modelling at too coarse a scale to be of use to current study. Includes flood levels for Bundamba Ck at Ripley but not Ripley Drainage.
Ipswich Rivers Flood Study Phase 3 Re-estimation of Design Flood Levels	Sargent Consulting (2006)	Re-estimation of design flood levels using MIKE 11 model.	Hydraulic modelling at too coarse a scale to be of use to current study. Includes flood levels for Bundamba Ck at Ripley but not Ripley Drainage.
The Future in Balance	SEQ Catchments (2006)	Integrated Natural Resource Management Plan for SE Queensland.	Broad overview of threats to natural resources including water resources and waterways.
WSUD Technical Guidelines	Healthy Waterways (2006)		
WSUD Engineering Guidelines: Stormwater (Draft)	Brisbane City Council (2005)		

b) Ripley Valley Structure Plan

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Ripley Valley Structure Plan (Extract) 10 Strategies	Ripley Valley Master Planning Group 2007	Strategies for integrated water cycle management (including stormwater management) for Ripley Valley Development Area.	Promotes Water Sensitive Urban Design (WSUD) includes integrating stormwater treatment into the landscape, protecting water quality, reducing runoff volume and peak flows. Urban stormwater drainage design to incorporate overland flow paths to be designed according to QUDM and ICC Guidelines. Stormwater runoff to be treated in accordance with SEQ WSUD Technical Guidelines and BCC Guidelines, currently considered to provide best practice advice (available from Healthy Waterways web site). Riparian corridor protection to comply with local and/or state government requirements. Cardno (Dec 2006) Flooding report used to provide flood extent information Flood management: no increase in peak flow downstream of Ripley Valley catchment. no increase in pre-development peak flows from 1 year event up. design runoff depth capture rates defined. no loss of floodplain storage. compliance with SPP 1/03 Mitigating the Adverse Impacts of Flood, Bushfire and Landslides. to include detention basins and WSUD measures **(fig 10.1.3 shows sub-regional detention basins G4 and F4 at Ripley).** **detention basins to incorporate WQ treatment.** regional detention storage in Bundamba Creek. existing watercourses to be maintained for stormwater conveyance, especially in upper reaches where no 100 year ARI inundation extent has been defined. WQ targets, 80% reduction in sediment load, 60% reduction in phosphorus load, 45% reduction in Nitrogen load and 90% reduction in gross pollution load.

Ripley Flood Mitigation and Drainage, Specific

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Ripley Area Catchment Management Plan	SKM (1999)	Stormwater Management Plan for drainage through Ripley. Includes hydrology and hydraulics for trunk drainage through Ripley Township and downstream to Bundamba Creek junction. Recommends flood mitigation storage and remedial works for local drainage issues.	Comments on existing Ripley Township drainage: • No piped drainage. • Many of the properties are below road level and cannot discharge roof water to the road. • A sag in Michels St overtops the kerb and results in property flooding between Michels St and Clarke St. (AU to check if footpath has been raised) • Open channel along east side of Ripley Road is encroached by a number of driveway crossings which increase water levels. • Runoff from rural area to W and SW of Ripley conveyed under road to the open channel. Hydrology: • RAFTS model used to compute flows 36 sub areas in all – 11 at downstream of Ripley Township; cross checked with Rational Model estimates; variable initial loss rates used; storms of 45 minutes to 2 hour duration (1 hr critical at Ripley) and 2 to 100 year ARI modelled for existing and ultimate land use; significant increase from existing to ultimate conditions. Hydraulics: • Design standard adopted: minor drainage 2 year ARI; major drainage 20 year ARI (existing), 100 year ARI (new or upgraded); minor roads 2 year ARI (existing), 10 year ARI (new or upgraded); major roads 20 year ARI (existing), 50 year ARI (new or upgraded). • HEC-RAS model used has 17 cross-sections in all of which only 6 are within Ripley Township.

Document Title	Author, Date	Summary of Contents	Items relevant to Current Study
Ripley Area Catchment Management Plan (contd.)	SKM (1999)		Recommendations: *Short Term* • Piped drainage in Michel St. • Divert upstream runoff into a second stormwater collection channel to be constructed on the western side of Ripley Rd via new pipe crossing under road, to reduce flow in main drain. • Maintain existing drainage corridor in its natural condition. • Instigate a water quality monitoring program. *Long Term* • Construct detention basin on western side of Ripley Road to maintain existing Q_{50} flows under future ultimate catchment conditions. • Upgrade Ripley Road to Q_{50} flood immunity by raising roadway by 1m and increasing cross drainage capacity opposite Clarke Street.
Clark St Ripley (Memo)	Paul Wilke ICC (2008)		Flooding in Clarke St 9th January 2008 • Stormwater running through back yards of 11,17 and 19 Clark St. • Internal flooding of No 17 Clark St. • Existing (private) pipe under yards of 15 & 17 – doesn't discharge to road. • The yards of these properties are too low to drain to the road. • Best means of routing an outlet to the road would be via the driveway of No 11. • Pipe would have to be at some depth to allow gravity drainage. • If pipe constructed could also add gully pits.
Complaints received			• 17 Clarke St (2007) advising 600 x 300 RCBC backs up in heavy rain. • Inlet near intersection of Ripley Rd & Scotts Rd was blocked (2008). • General request via Councillor to interview local residents. • Properties along Ripley Road upstream of Scotts Road are flooded from drain

Appendix B XP-RAFTS

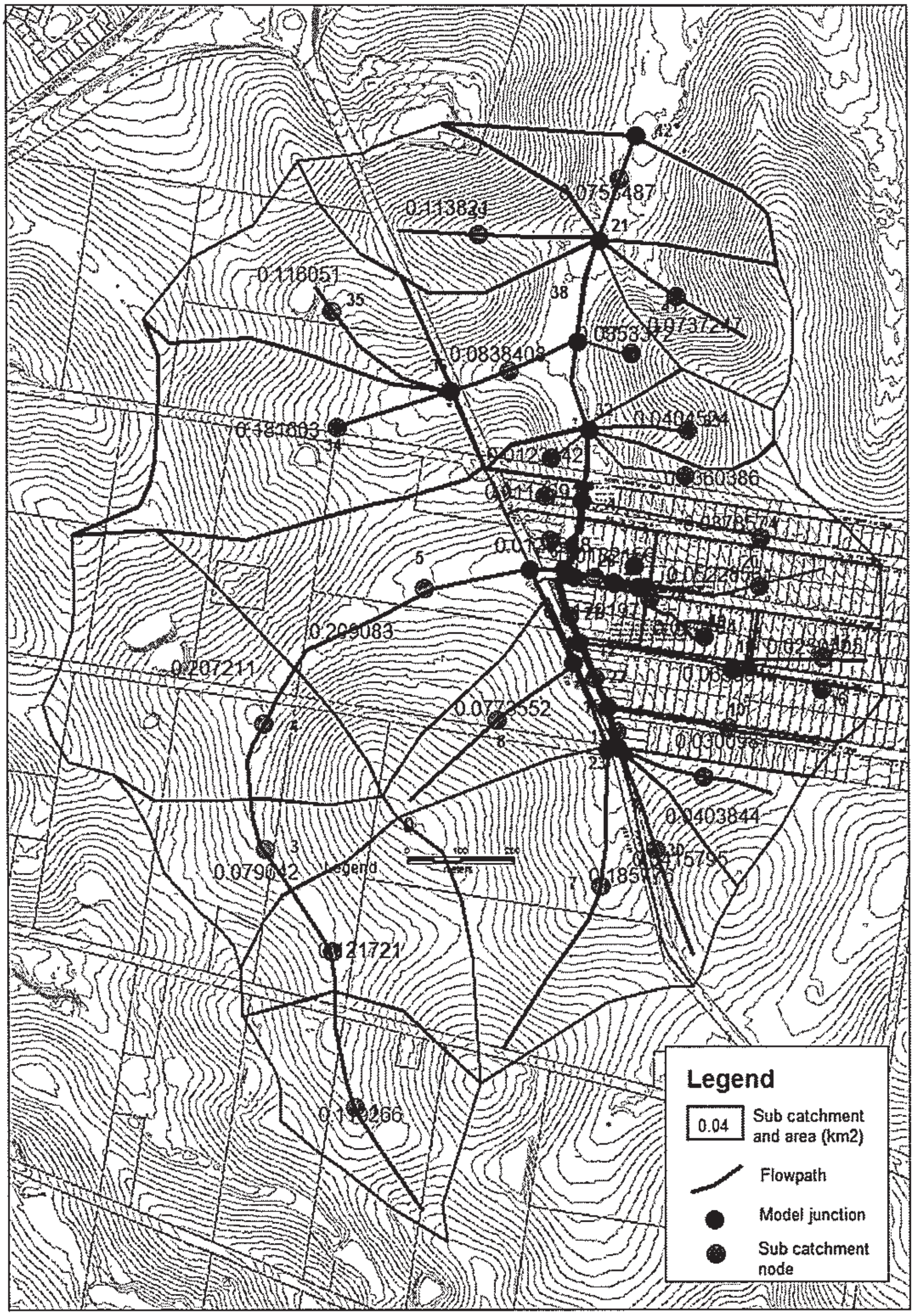


Figure B1 XP-RAFTS Model Layout

Table B1 Peak Flows – Summary

Location	RAFTS Node	HECRAS chainage m	Peak Flow (m3/s) for ARI Existing Conditions					Peak Flow (m3/s) for ARI Ultimate Conditions		
			2 yr ARI	5 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI
Ripley Rd u/s Scotts Rd	23	1222	1.8	3.2	4.0	6.7	8.1	11.6	14.9	17.0
Scotts Rd	14		2.3	3.0	3.5	4.6	5.3	3.9	5.2	5.8
Ripley Rd d/s Scotts Rd	15	1138	2.8	4.7	5.9	9.6	11.6	15.6	20.0	22.6
Ripley Rd u/s Michels St	12	1020	3.4	5.8	7.3	12.2	14.7	17.5	22.7	25.8
Ripley Rd d/s Michels St	27	962	3.5	6.0	7.5	12.5	15.1	17.7	23.1	26.2
Small area W of Ripley Rd	8		0.7	1.3	1.6	2.6	3.1	4.0	5.2	5.9
Main area W of Ripley Rd	5		5.0	8.4	10.4	17.2	20.3	18.9	26.5	30.4
Clarke St area	26		6.6	8.6	9.7	13.1	14.9	11.3	14.6	16.5
Ripley Drain Clarke St-Falvey St	31	738	9.6	14.0	17.1	28.5	34.1	41.1	56.0	63.8
Ripley Drain d/s Monterea Rd	32	578	10.3	15.8	19.3	30.9	36.8	42.9	58.7	66.8
N area W of Ripley Rd	36		2.4	4.2	5.3	8.9	10.7	15.4	19.7	22.3
D/s of Ripley Township	21	212	14.0	23.1	28.4	45.6	54.0	55.0	75.7	86.2

Table B2 Peak Flows – Existing Conditions

RAFTS Node	HECRAS X-S	10 year ARI		100 year ARI	
		30 min	60 min	30 min	60 min
1		1.4	2.1	3.2	4.2
2		2.4	3.9	5.8	7.9
3		3.1	4.9	7.0	9.7
4		4.8	7.8	11.0	15.0
5	738	6.3	10.0	14.0	19.0
6	864	13.0	17.0	26.0	34.0
7		2.1	3.1	4.9	**6.4**
8		1.1	1.6	2.5	3.2
9		0.6	0.9	1.3	**1.7**
10		1.6	1.5	2.3	2.3
11		1.6	1.6	2.3	2.3
12	div 210	6.1	5.9	8.9	8.9
13	1222	0.1	0.1	0.1	0.1
14	1140	0.7	0.6	1.0	1.0
15		1.6	1.6	2.3	2.4
16		3.4	3.3	4.8	4.9
17		1.3	1.3	1.9	1.9
18		4.7	4.6	6.7	6.8
19		1.1	1.0	1.5	1.6
20		2.8	2.7	3.9	4.0
21	212	21.0	30.0	44.0	58.0
22	div	1.7	1.7	2.4	2.5
23	div 420	3.4	4.8	7.5	9.7
24		1.1	1.1	1.6	1.6
25		3.8	3.7	5.5	5.6
26	874	4.1	4.1	6.0	6.2
27	962	6.4	6.2	9.3	9.4
28	div	4.4	6.3	9.5	12.0
29		2.0	1.9	2.8	2.9
30		0.9	1.3	2.0	**2.5**
31	738	13.0	18.0	27.0	35.0
32	578	15.0	19.0	29.0	38.0
33		1.7	2.3	3.4	4.3
34		2.1	3.1	4.8	6.3
35		1.6	2.3	3.6	4.7
36		3.7	5.4	8.4	11.0
37	411	19.0	26.0	40.0	53.0
38	315	19.0	27.0	40.0	53.0
39		1.6	2.3	3.6	4.6
41		1.3	1.9	2.8	3.5
42	0	22.0	30.0	45.0	59.0
43		0.6	0.6	0.9	0.9

Table B3 Peak Flows – With Retarding Basin

Ripley _ Planning Report for Flood Mitigation Storage
RAFTS model setup
With diversion to west side Ripley Rd

Rafts Node	HECRAS X-S	100 year ARI Existing conditions 1 *1350 pipe outlet				100 year ARI Ultimate conditions 1 *1350 pipe outlet
		30min	60 min	90 min	2hr	60 min
1		3.79	4.69	4.13	3.73	8.72
2		6.98	8.80	7.89	7.15	14.20
3		8.44	11.02	10.27	9.37	16.98
4		13.35	17.15	16.35	14.90	24.16
5 Basin in	738	25.10	32.69	31.34	28.84	47.76
Basin out		18.91	26.45	25.65	23.76	20.26
Max WL		47.41	47.69	47.66	47.59	48.90
6	864	19.10	29.42	30.39	28.38	24.84
7		5.80	7.20	6.43		13.52
8		2.90	3.48	2.95		5.89
9		3.29	3.10	2.21	2.00	3.62
10		1.86	1.89	1.25	1.18	1.90
11		5.19	5.05	3.49	3.21	5.56
12	div 210	5.82	5.87	4.13	3.96	6.41
13	1222	0.10	0.10	0.07	0.06	0.10
14	1140	5.41	5.36	3.70	3.47	5.88
15		5.45	5.41	3.73	3.51	5.93
16		1.70	1.71	1.23	1.12	2.14
17		2.66	2.72	1.80	1.68	2.73
18		4.32	4.41	3.03	2.81	4.88
19		5.62	5.80	4.52	4.12	6.36
20		4.66	4.75	3.11	2.89	4.78
21	212	37.10	44.51	38.78	36.96	54.48
22	1082	5.82	5.87	4.13	3.96	6.4
23	div 420	7.30	9.03	8.21	7.39	16.67
24		10.23	11.27	8.50	7.83	11.80
25		14.69	15.09	11.05	10.09	4.78
26	874	14.78	15.21	11.24	10.27	15.70
27	962	6.24	6.31	4.87	4.4	6.86
28		9.37	11.73	10.62	9.57	19.15
30		2.46	2.70	2.44	1.85	3.64
31	738	19.10	29.43	30.40	28.39	24.87
32	578	22.51	30.17	31.56	29.62	28.11
33		4.02	4.80	3.85	3.46	7.23
34		5.71	7.00	6.21	5.53	12.88
35		4.21	5.14	4.51	4.09	9.35
36		9.92	12.13	10.72	9.61	22.23
37	411	30.40	36.90	35.80	34.01	48.28
38	315	31.02	37.69	36.04	34.38	48.95
39		4.19	5.06	4.33	3.98	8.68
41		3.24	3.85	3.13	2.83	5.89
42	0	37.10	44.51	38.78	36.96	54.48

Note: It will be a condition of development in the catchment to the west of Ripley Road that the post-development discharge does not exceed the pre-development discharge, and the retarding basin will be required to provide this mitigation.

Appendix C HEC-RAS Model – Existing Conditions

Ripley Flood Mitigation HEC-RAS Model
Existing Conditions

Ripley Drain

Location	River Station	Q (m3/s) 2 yr ARI	Q (m3/s) 5 yr ARI	Q (m3/s) 10 yr ARI	Q (m3/s) 50 yr ARI	Q (m3/s) 100 yr ARI	W.S. Elevation (m) 2 yr ARI	W.S. Elevation (m) 5 yr ARI	W.S. Elevation (m) 10 yr ARI	W.S. Elevation (m) 50 yr ARI	W.S. Elevation (m) 100 yr ARI	Road Flood Level (m AHD)	Flood Immunity (Years) at trafficable depth (250mm)	House Access Flood Level (m AHD)	Flood Immunity at 250mm depth (Years)	House Flood Immunity (Years) assume 300mm AGL
u/s 448 RipleyRd	1222	1.8	3.2	4.0	6.7	8.1	48.4	48.6	48.5	48.8	48.6	48.2	<2			
448 Ripley Road access	1215	1.8	3.2	4.0	6.7	8.1	48.4	48.6	48.5	48.8	48.6	48.3	<2	48.3	10	20
448 Ripley Rd	1212	1.8	3.2	4.0	6.7	8.1	48.2	48.4	48.4	48.8	48.5	48.4	5			
446 Ripley Rd	1195	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	47.8	<2			20
446 Ripley Road access	1190	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	47.8	<2	48.03	10	
446 Ripley Rd	1185	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	47.8	<2			
444 Ripley Rd	1175	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	48.0	<2			
444 Ripley Road access	1170	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	48.0	<2	47.9	5	<2
444 Ripley Rd	1165	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	48.0	<2	47.6	<2	
u/s Scotts Road	1160	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	47.6	<2			
Scotts Rd culverts	1150	1.8	3.2	4.0	6.7	8.1	48.1	48.2	48.2	48.8	48.3	48.0	<2			
d/s Scotts Road	1140	1.8	3.2	4.0	6.7	8.1	47.3	47.7	47.9	48.8	47.6	47.5	>2<5			
Footbridge d/s Scotts Rd	1139	1.8	3.2	4.0	6.7	8.1	47.3	47.7	47.9	48.8	47.6	47.5	>2<5			
442 Ripley Rd	1138	2.4	4.7	5.9	9.6	11.6	47.2	47.3	47.3	47.4	47.4	46.8	<2	47.1	10	100
440 Ripley Rd	1120	2.4	4.7	5.9	9.6	11.6	46.7	46.8	46.8	46.9	46.9	46.3	2	47	100	100
438 Ripley Rd access	1111	2.4	4.7	5.9	9.6	11.6	46.7	46.8	46.8	46.9	46.9	45.6	<2	46.6	50	100
438 Ripley Rd	1102	2.4	4.7	5.9	9.6	11.6	46.3	46.3	46.4	46.5	46.6	46.3	2			
438 Ripley Rd access	1092	2.4	4.7	5.9	9.6	11.6	46.3	46.3	46.4	46.5	46.6	46.3	2			
436 Ripley Rd	1082	3.0	4.9	6.2	9.9	12.0	46.2	46.3	46.3	46.3	46.4	46.0	<2			
436 Ripley Rd access	1071	3.0	4.9	6.2	9.9	12.0	46.2	46.3	46.3	46.3	46.4	46.0	<2	46.5	100	100
434 Ripley Rd	1060	3.0	4.9	6.2	9.9	12.0	46.3	46.3	46.4	46.4	46.4	46.0	<2	46.2	100	
434 Ripley Rd access	1048	3.0	4.9	6.2	9.9	12.0	46.3	46.3	46.4	46.4	46.4	46.0	<2			
432 Ripley Rd	1036	3.0	4.9	6.2	9.9	12.0	46.3	46.4	46.4	46.5	46.5	46.0	<2	46.2	10	100
u/s Michels St	1020	3.4	5.8	7.3	12.2	14.7	46.3	46.3	46.4	46.5	46.5	46.0	<2			
Michels St culverts	1010	3.4	5.8	7.3	12.2	14.7	46.3	46.3	46.4	46.5	46.5	46.0	<2			
d/s Michels St	1000	3.4	5.8	7.3	12.2	14.7	46.1	46.1	46.2	46.2	46.2	46.0	<2			
Michels St footbridge	999	3.4	5.8	7.3	12.2	14.7	46.1	46.1	46.2	46.2	46.2	46.0	<2			
Michels St footbridge	998	3.4	5.8	7.3	12.2	14.7	46.0	46.0	46.0	46.0	46.0	46.0	<2			
430 Ripley Rd access	980	3.4	5.8	7.3	12.2	14.7	46.0	46.0	46.0	46.0	46.0	46.0	<2	45.7	<2	100
426-428 Ripley Rd	962	3.5	6.0	7.5	12.5	15.1	45.6	45.6	45.5	45.8	45.9	45.9	<2			
426-428 Ripley Rd acces	946	3.5	6.0	7.5	12.5	15.1	45.6	45.6	45.5	45.8	45.9	45.9	<2	45.4	10	100
424 Ripley Rd	930	3.5	6.0	7.5	12.5	15.1	45.2	45.2	45.2	45.4	45.4	45.4	<2			
424 Ripley Rd access	923	3.5	6.0	7.5	12.5	15.1	45.2	45.2	45.2	45.4	45.4	45.4	<2	45	10	
422 Ripley Rd	916	3.5	6.0	7.5	12.5	15.1	45.1	45.2	45.2	45.2	45.4	45.4	<2			
422 Ripley Rd access	906	3.5	6.0	7.5	12.5	15.1	45.1	45.2	45.2	45.2	45.4	45.4	<2	44.9	50	100
1 Clarke St	896	3.5	6.0	7.5	12.5	15.1	45.1	45.2	45.2	45.3	45.4	45.4	<2			
1 Clarke St access	890	3.5	6.0	7.5	12.5	15.1	45.1	45.2	45.2	45.3	45.4	45.4	<2			100
u/s Clarke St	884	3.5	6.0	7.5	12.5	15.1	44.7	44.8	44.9	45.0	45.2	45.6	100	44.8	100	
Scottts Park	880	3.5	6.0	7.5	12.5	15.1	44.4	44.7	44.9	45.0	45.1	44.5	>2<5			
Scotts Park footbridge	876	3.5	6.0	7.5	12.5	15.1	44.4	44.7	44.9	45.0	45.1	44.5	>2<5			
2 Clarke St	864	9.4	14.0	17.1	28.5	34.1	44.4	44.5	44.6	44.9	45.0	44.5	5	45.8	100	
4 Clarke St												45.3				100
416 Ripley Rd														46.2		100
412 Ripley Rd														46.5		100
410 Ripley Rd														47.2		100
3-5 Falvey St	758	9.6	14.0	17.1	28.5	34.1	43.8	44.0	44.0	44.5	44.6	>45	>100	44.5	10	100
7 Falvey St														44.5	10	100
10 Falvey St	738	9.6	14.0	17.1	28.5	34.1	43.6	43.8	43.9	44.2	44.4	>45	>100			100
14 Falvey St	687	9.6	14.0	17.1	28.5	34.1	43.2	43.4	43.5	43.7	43.8	44.0	>100			100
d/s Monterea Road	667	9.6	14.0	17.1	28.5	34.1	43.1	43.3	43.4	43.4	43.5	>44	>100			
	578	10.3	15.8	19.3	30.9	36.8	42.8	42.9	43.0	43.0	43.1	43.0	50			
	501	10.3	15.8	19.3	30.9	36.8	42.3	42.5	42.5	42.7	42.8	43.0	>100			
	411	11.8	19.7	24.4	39.9	47.5	42.1	42.2	42.3	42.4	42.5	42.5	>100			
	315	12.1	20.0	24.8	40.3	48.0	41.4	41.5	41.6	41.7	41.8	>42	>100			
	212	14.0	23.1	28.4	45.6	54.0	40.3	40.4	40.5	40.7	40.8	>41	>100			
	108	14.0	23.1	28.4	45.6	54.0	39.6	40.0	39.8	40.0	40.1	40.2	>100			
D/s boundary	0	14.0	23.1	28.4	45.6	54.0	38.7	38.6	38.7	38.8	38.9	>39	>100			

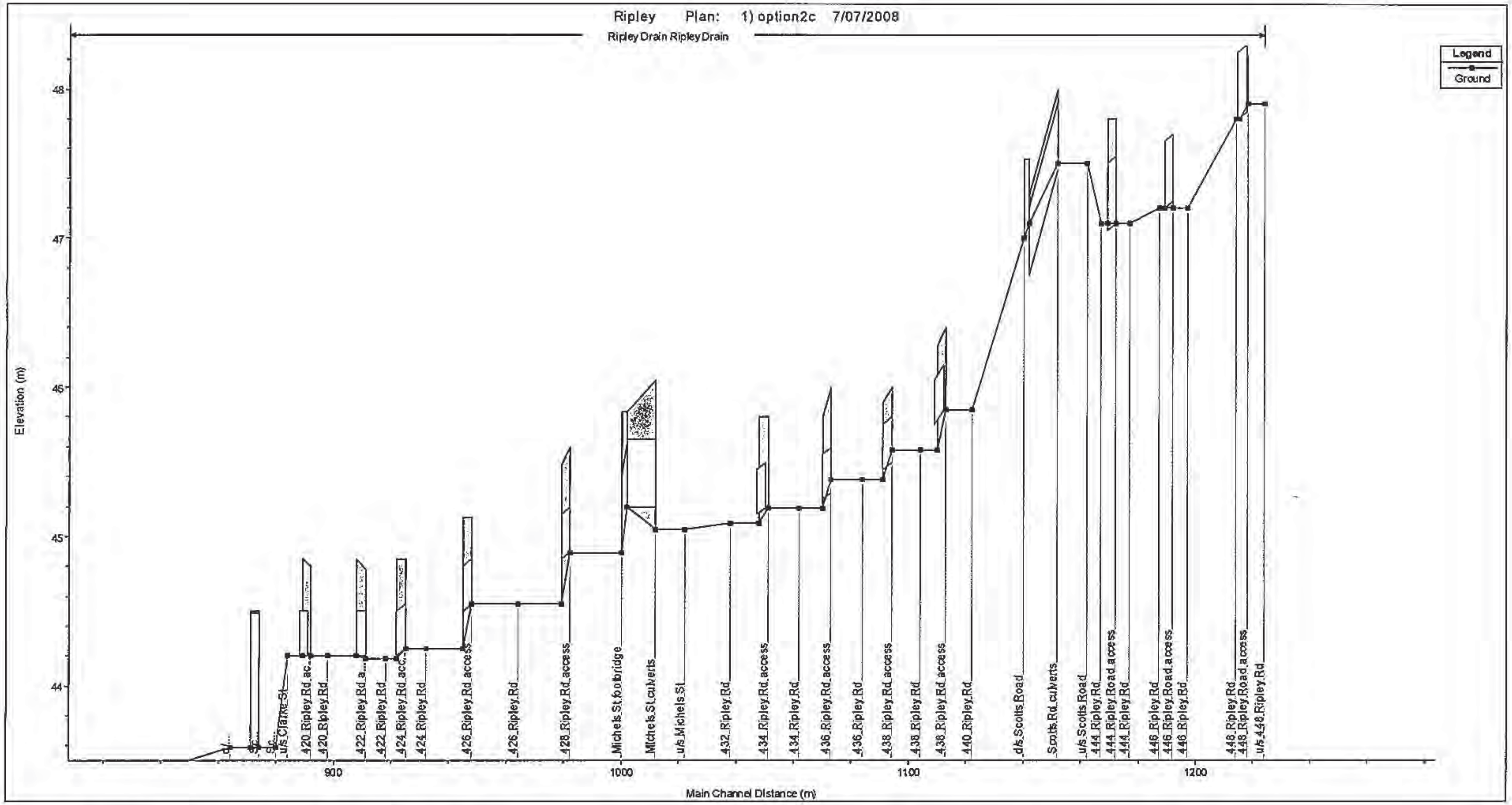


Figure 3 Ripley Drain Longitudinal Profile – Existing

Appendix D Flood Mitigation Options

This Appendix outlines the options considered in respect of flood mitigation at Ripley.

Options to address stormwater drainage issues in Clarke Street were considered outside of the NDRM study and are reported upon elsewhere.

Cost estimation for these options was undertaken by ICC.

A total of four options were considered, as follows:

5. Do nothing.
6. Upgrade existing Ripley Road drain on its existing alignment.
7. Upgrade drainage capacity by means of a new drain along the western side of Ripley Road.
8. Reduce peak flows in Ripley Drain by construction of a retarding basin at the low point on the west side of Ripley Road.

These are outlined below.

D.1. Option RR1 - Do Nothing

Section 4.1 of the Main Report and Figure 6 show the existing flood immunity of Ripley Road and the adjacent properties. The main points in this regard are:

- There are 3 houses subject to over floor flooding, the worst (444 Ripley Road) with a <2 year ARI flood immunity, and 2 (446 and 448 Ripley Road) have a 20 year ARI flood immunity;
- Ripley Road is untrafficable to light vehicles in a 2 year ARI flood event; and
- Of the 13 house access crossings, 1 is untrafficable at 2 year ARI, 1 is trafficable up to 5 year ARI, 6 to 10 year ARI and the remainder at 50 year ARI or higher.

Due to the very low flood immunities, doing nothing is not a viable option. It is included here for completeness and to indicate the benefits from the other options.

D.2 Option RR2 - Upgrade Ripley Road Drain

Option RR2 comprises:

- Upgrading the existing open drain within the existing drainage easement by widening its invert, regrading and deepening;
- Rebuilding all of the house access crossings (12);
- Replacing the culverts at the intersections of Ripley Road with Scotts Road and Michels Street with larger culverts; and
- Minor road raising (or edging).

The components of this option are shown in **Figure D1**.

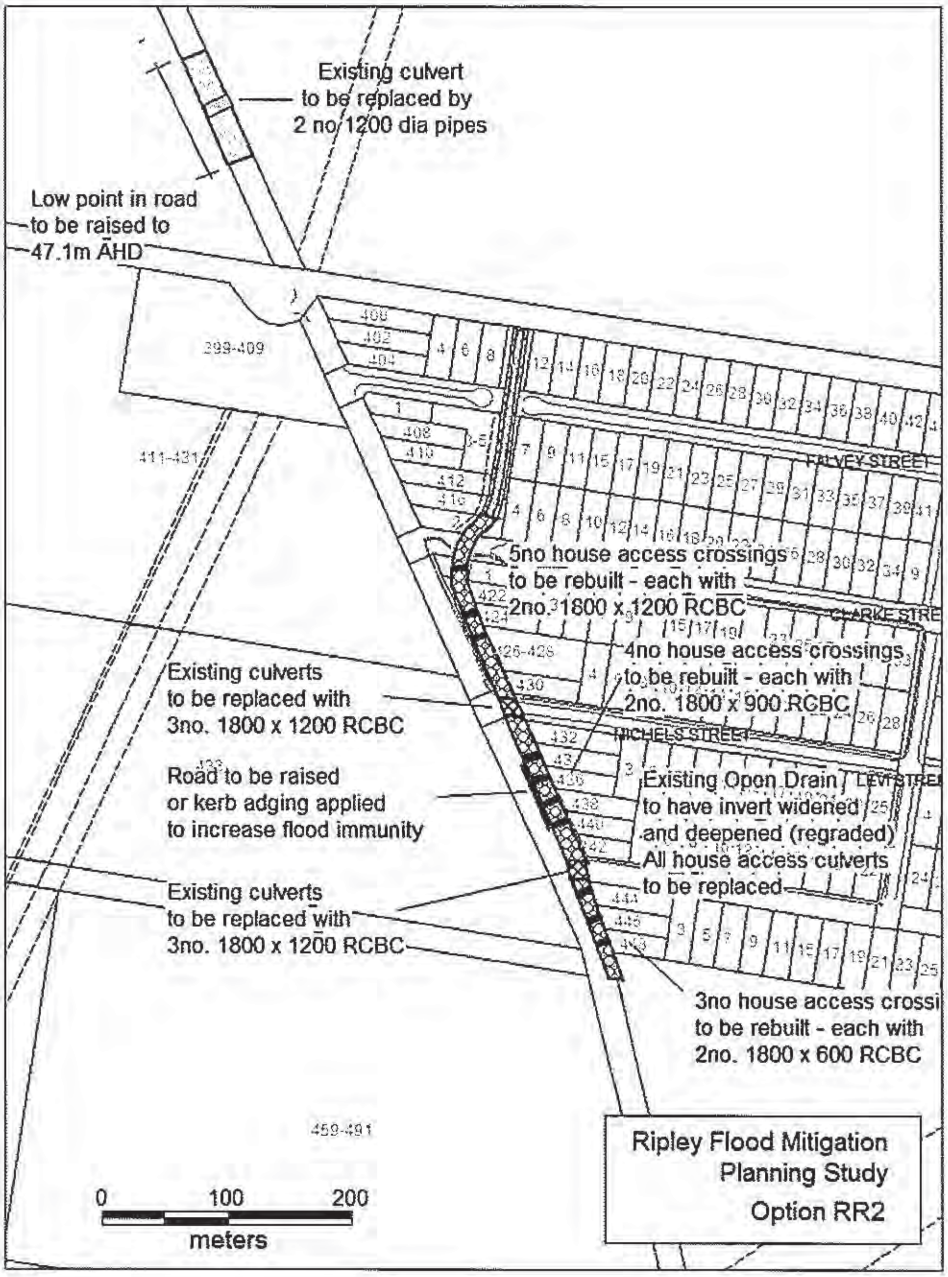


Figure D1 Option RR2

The construction of these components will increase the flood immunity of houses, house access and Ripley Road as follows:

- All houses will have 100 year ARI immunity against over floor flooding;
- House access crossings will have 20 year ARI or higher flood immunity (3 @ 20 year, 2 @ 50 year, remainder at 100 year or higher); and
- Ripley Road will have a flood immunity of 10 year ARI. This requires:
  - Replacement of the existing culverts at the Scotts Road/Ripley Road intersection with a 3 cell culvert of 1800mm x 1200mm RCBC;
  - Replacement of the existing culverts at the Michels Road/Ripley Road intersection with a 3 cell culvert of 1800mm x 1200mm RCBC;
  - Between 436 and 438 Ripley Road, the flood immunity of the roadway will still be 2 years only with the drainage works alone, requiring some 60m of road to be raised a maximum of about 300mm to provide the 10 year immunity.

The additional flow capacity is provided by regrading the drain from its upstream end outside 448 Ripley Road to Clarke Road and widening the concrete lined invert from 2m (1.5m upstream of Scotts Road) to 4m throughout. There is room to do this within the existing drainage easement, by steepening of the batters. Downstream of Scotts Road this may require some trees to be removed. Upstream of Scotts Road the easement width is narrower and detail survey is required to confirm that there is sufficient room for the proposed reconstruction.

In addition the house access crossings will all have to be reconstructed, at their existing levels but with great flow capacity. The proposed 4m wide invert will accommodate 2 cell culverts of 1800mm width. Culvert depth will vary from 600mm upstream of Scotts Road to 900mm between Scotts Road and Michels Street, and 1200mm downstream of Scotts Road.

The 2 existing footbridges will need to be removed for reconstruction but should be able to be re-used.

A new culvert comprising 2 no. 1200mm diameter pipes is also required, together with raising the road a maximum of 300mm to 47.1m AHD, is required at a second sag point to the north of Ripley, as shown in **Figure D1**. The longitudinal profile for this option is shown in **Figures D2**.

A number of sub-options comprising replacement of culverts and house access crossings only were considered but were found to be ineffective without the widening and deepening of the drain itself. Hence, these sub-options were discounted from any further consideration.

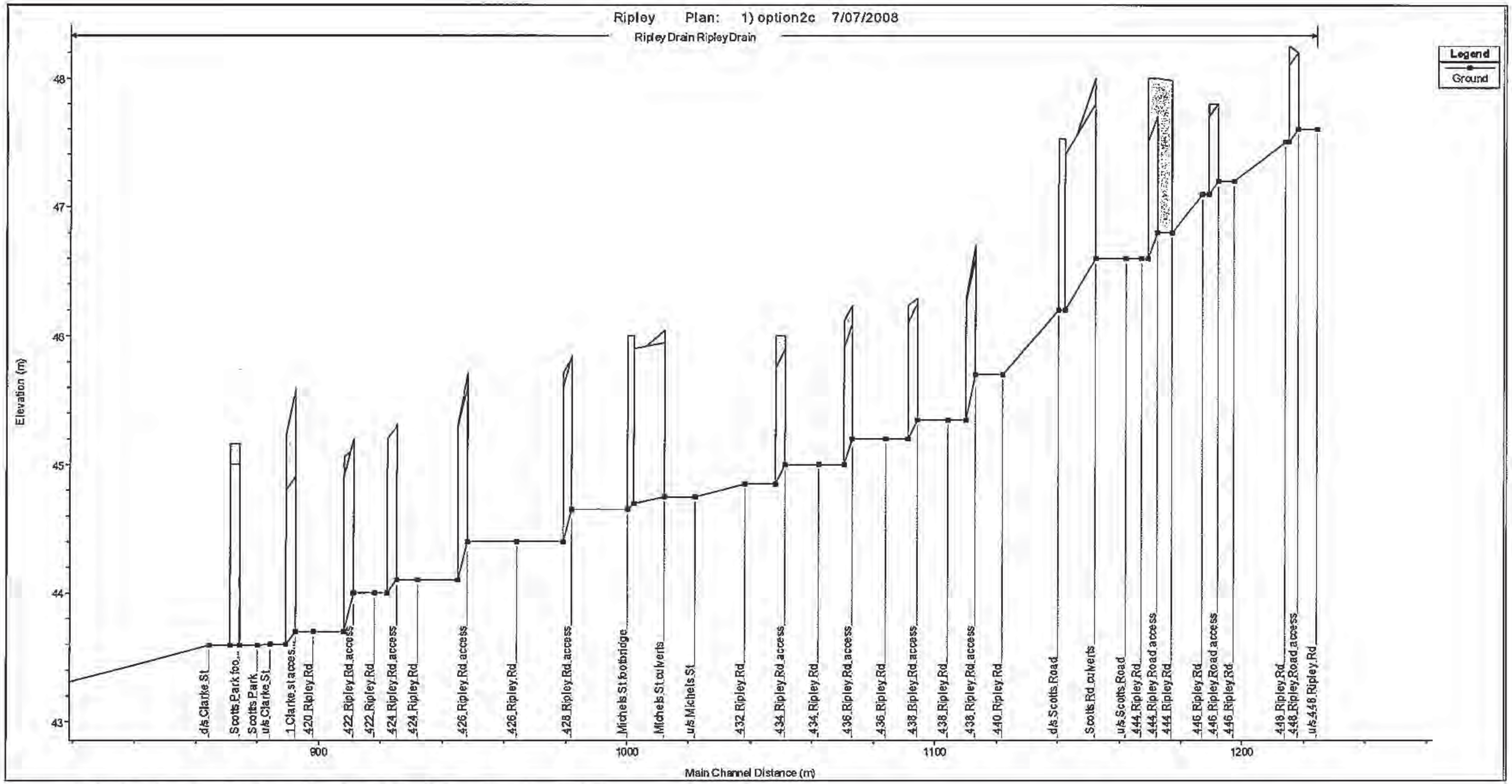


Figure D2 Ripley Drain Longitudinal Profile – Option RR2

D.3 Option RR3 - New Drain West of Ripley Road

In this option, the flow from upstream of 448 Ripley Road is diverted via a new culvert under Ripley Road, to a new open drain on the west side of the road, which then flows back into the exist drain through Scotts Park via a new culvert.

Three sub-options were considered, namely RR3a, RR3b and RR3c. In Option RR3a, the drain is constructed within the road reserve, whereas in Option RR3b, land is acquired for the drain. Sub option RR3c is similar to RR3b, but with the local street drainage being conveyed to the new drain, thereby allowing refilling of the existing drain on the east side of Ripley Road.

Details of these options are given in **Figures D3, D4** and **D5**.

D.3.1 Option RR3a

In order to construct the new drain within the existing road reserve it will be limited to an 8m top width, which will necessitate concrete lining in order to have sufficient carrying capacity. This will have steep batters of 1.5v:1h.

This will also require the relocation of significant Telstra infrastructure, 7 power poles and a bus shelter, and the replacement of two existing culverts under house access roads (433 and 459-491 Ripley Road).

The new drain from opposite Scotts Road to opposite Michels Street, and the enlarged drain from opposite Michels Street to opposite Clark Street will have a 4m wide concrete lined invert and batters and 8m top width.

Although this diversion will significantly reduce the flows in the existing open drain, it will still be necessary to reconstruct 4 of the house access crossings (between Michels St and Scotts Road) to reduce their impedance of the flow. These will comprise single cell culverts of 1800mm width, with depths varying from 450mm to 600mm.

The necessity and cost of relocating the Telstra and other infrastructure, and the public safety aspects of having a concrete lined drain within the road reserve may well render this option unworkable.

A new culvert comprising 2 no. 1200mm diameter pipes is also required, together with raising the road a maximum of 300mm to 47.1m AHD, is required at a second sag point to the north of Ripley, as shown in **Figure D3**.

D.3.2 Option RR3b

In this case the drain is constructed adjacent to the road reserve in acquired land, and can have a wider footprint. The drain has a 4m invert width and 1 in 8 batters and can be grass lined. The footprint could be reduced by steepening the batter to a maximum of 1 in 4.

There is an existing Telstra cable or optic fibre about 10m west of the fence line which would either need to be relocated further to the west, or the drain constructed west of this infrastructure.

Other elements of this option, i.e. the new culvert under Ripley Road, the reconstruction of four house access crossings, and the culvert further north are the same as required for Option RR3a.

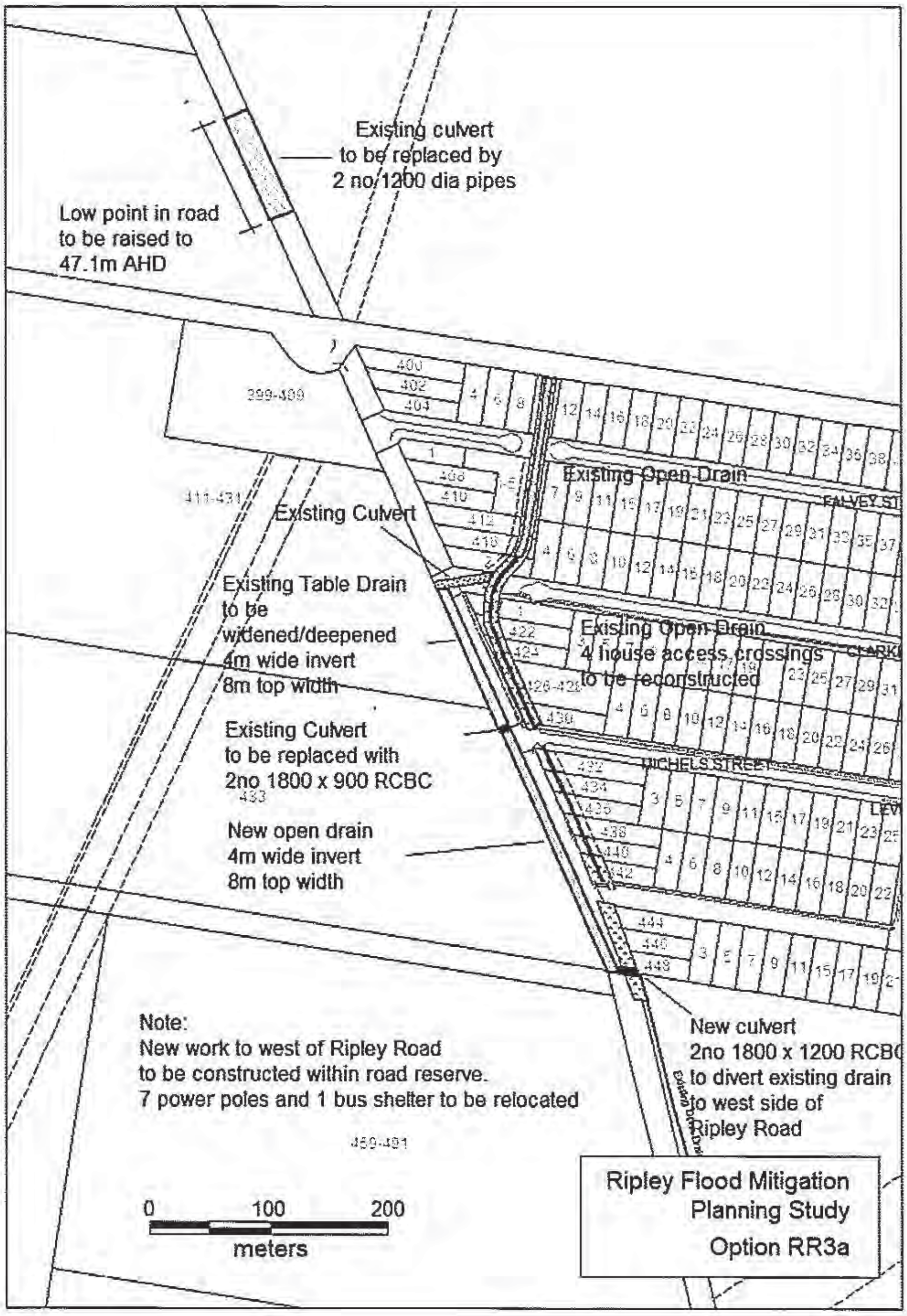


Figure D3 Option RR3a

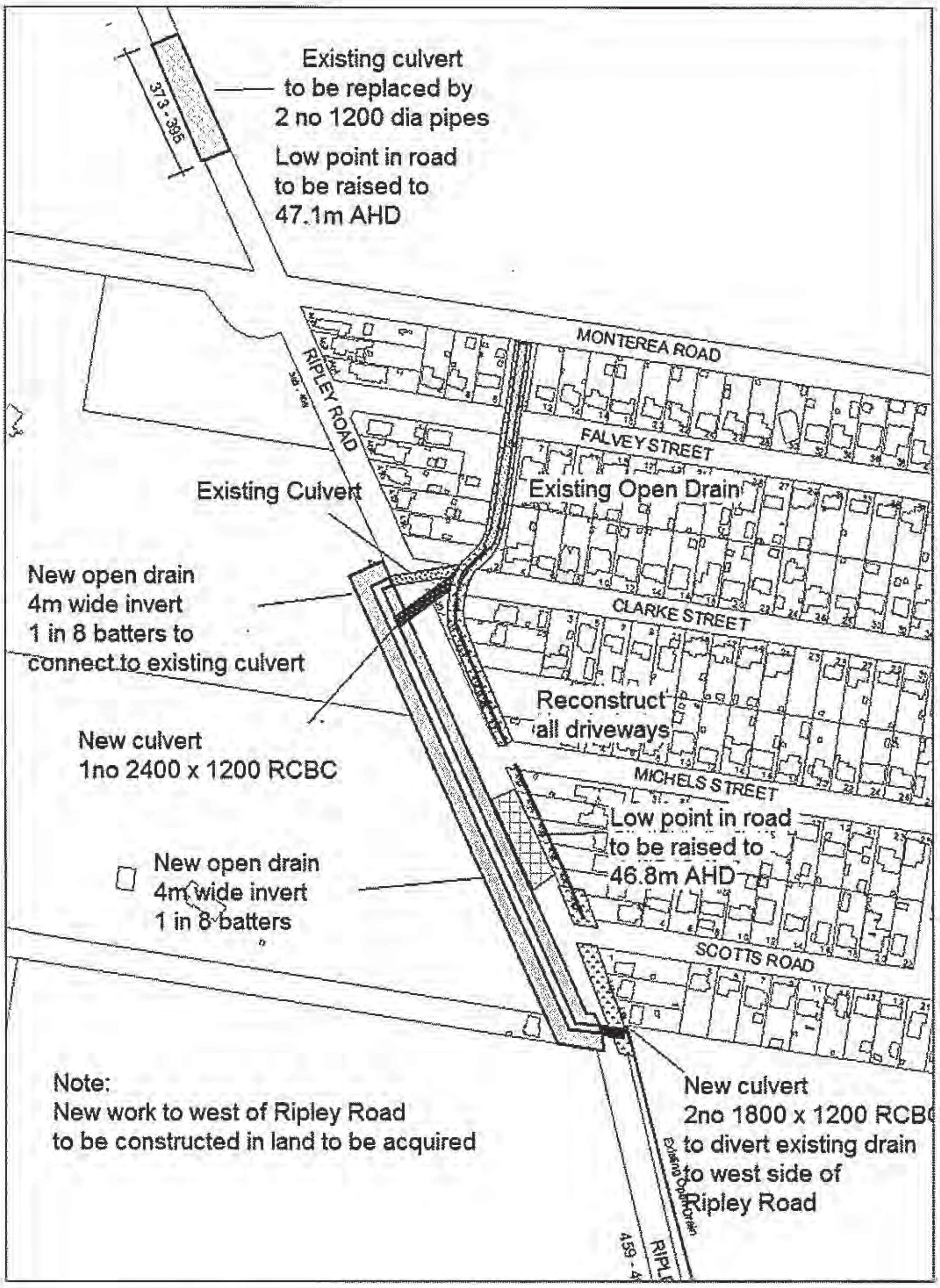


Figure D4 Option RR3b

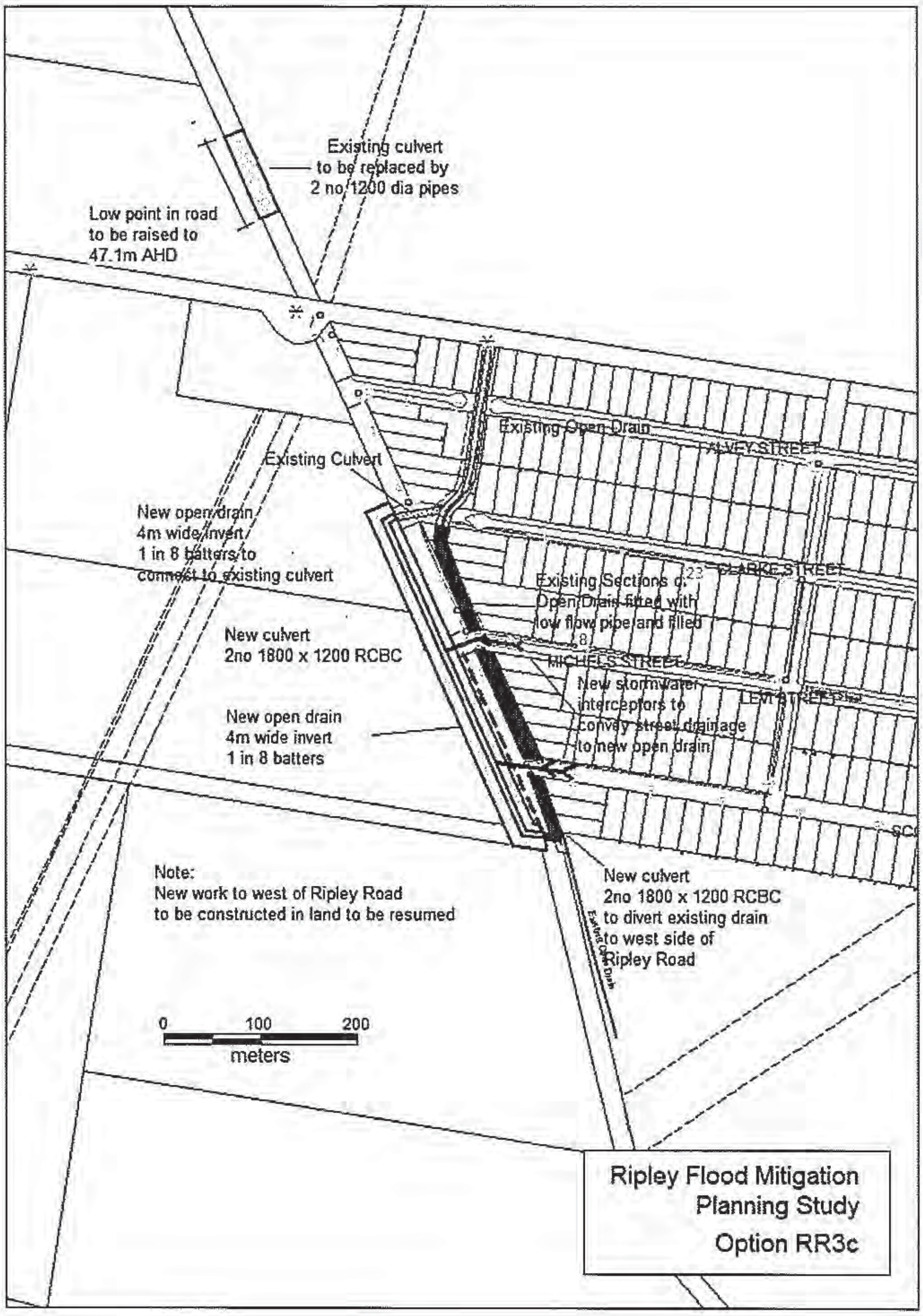


Figure D5 Option RR3c

D.3.3 Option RR3c

Option RR3c is similar to RR3b except that it allows removal of the house access crossings and filling of the existing drain on the east side of Ripley Road between Scotts Road and Clarke Street. Removal of the house access crossings is one of the recommendations of the recent Ripley Road Safety Audit.

This option requires the stormwater drainage from Scotts Road and Michels Street to be intercepted before it reaches Ripley Road and conveyed under Ripley Road to discharge into the new drain. Details of these interception requirements have not yet been determined.

Also, if this option were implemented, it is recommended that the refilling of the indicated sections of the existing open drain would contain a low flow pipe to convey infiltrated flow and shallow groundwater flow.

This option provides the greatest level of public safety of any of the RR2 and RR3 options as it removes the open drain from the vicinity of the houses along the east of Ripley Road, and obviates the need for the house access drain crossings in order to enter the houses.

D.4 Option RR4

Construction of a retarding basin in the flow path to the west of Ripley Road to reduce the flows in Ripley Road drain was investigated, but was found to be insufficient to obviate the need for works similar to those in Options RR2 and RR3, as this would only reduce existing flows marginally downstream from Scotts Park, and hence would have a marginal impact on the flood levels upstream of Clarke St.

A retarding basin at this location and a second retarding basin further north will be required when the catchments upstream of these locations are developed for residential development.

Figure D6 gives an outline of the works which will be required. These works do not however, form part of the current project.

D.5 Discussion

Of the options considered, only Options RR2 and RR3 provide solutions to the current flooding issues.

Both of these are able to provide the required flood immunity of 10 year ARI for Ripley Road and 100 year ARI to over floor flooding of houses.

Option RR2 requires the widening of the drain invert and deepening of the drain together with new culverts at the Scotts Road and Michels Street intersections with Ripley Road.

Option RR2 requires reconstruction of all 12 of the house access crossings, whilst options RR3a and RR3b require reconstruction of only 4 of the crossings with smaller culverts than required for Option RR2.

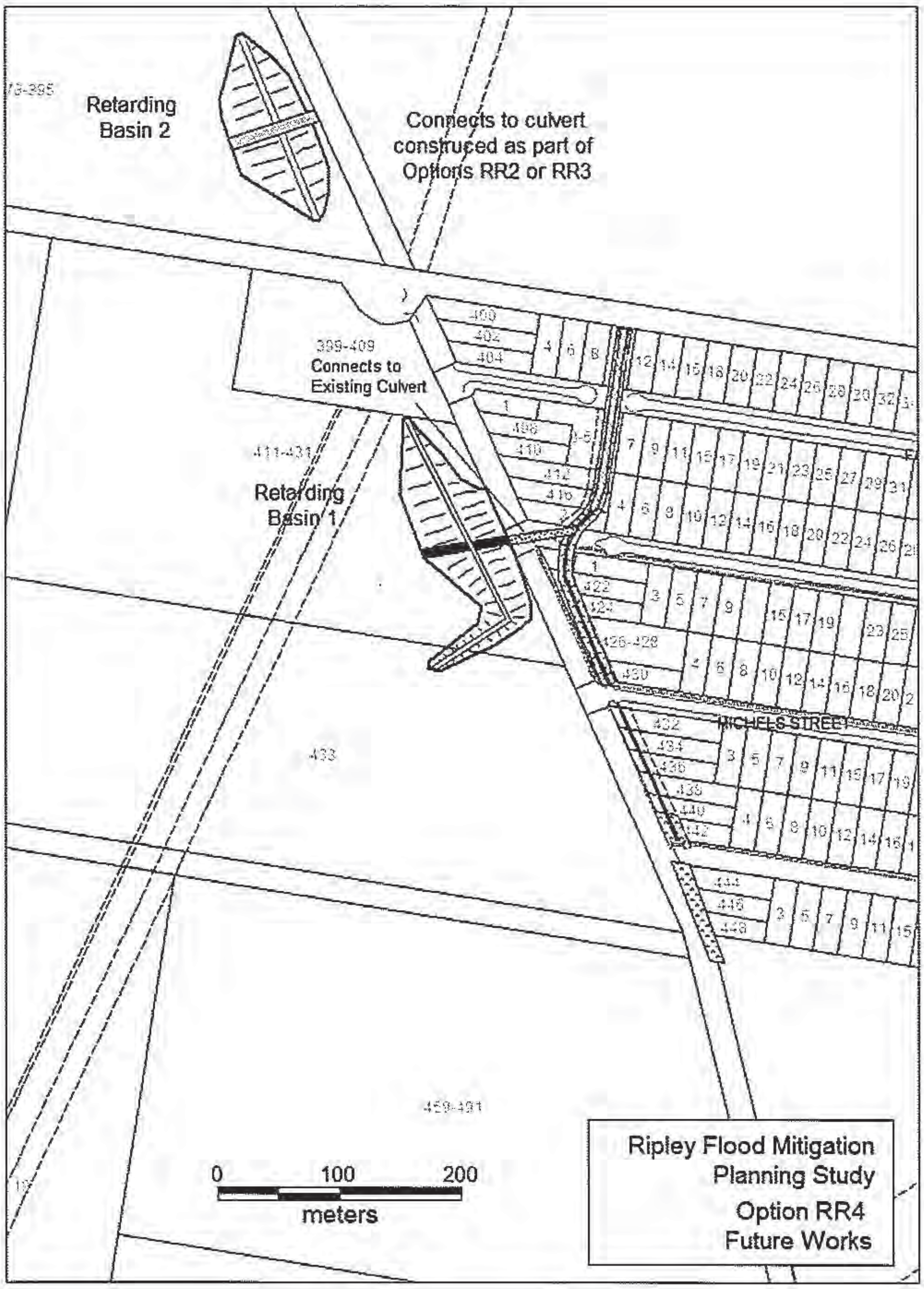


Figure D6 Option RR4 – Future Works – Retarding Basins

Option RR3 (all sub-options) requires two new culverts under Ripley Road together with the construction of a new drain along the west side of Ripley Road. Three sub options were considered, Option RR3a within the road reserve, which required the drain to be concrete lined, Option RR3b in acquired land which could be grass lined, and RR3c which is similar to RR3b except that all local street drainage is conveyed to the new drain, allowing parts of the existing open drain to be refilled and obviating the need for house access drain crossings.

Option RR3a necessitates the relocation of significant Telstra cabling, 7 power poles and a bus shelter. The necessity and cost of relocating this infrastructure, and the public safety aspects of having a concrete lined drain within the road reserve may well render this option unworkable.

Table D1 lists the major items in each of Options RR2, RR3a, RR3b and RR3c as an aid to cost estimation. The estimated costs are given in **Table D2**, from which it can be seen that option RR3b has the lowest estimated cost at $1.8million. **Tables D3** and **D4** summarise the results from the hydraulic model runs.

As well as being the least cost option, Option RR3b is considered to be the most practical and has the highest public safety as the new drain is not within the road reserve and would be fenced off; and the hazard resulting from the house access crossings reduced as recommended in the recent Ripley Road Safety Audit. Hence, it was decided by the SAG that the preferred option was RR3b.

As full funding for this scheme is not currently available, interim works were considered which could be constructed at the time of other upgrading works along Ripley Road. These comprised: the new 2400 x 1800 culvert under Ripley Road and the rebuilding of 4 house access crossings.

Table D1   Major Items in Options RR2, RR3a, RR3b and RR3c

Item	Quantity	Unit	Option			
			RR2	RR3a	RR3b	RR3c
New culvert under Ripley Road 1800 x 1200 RCBC	2	No		■	■	■
temporary table drain connection	1	Item		■	■	■
Concrete lined drain in west road reserve including relocation of Telstra, Ergon and other infrastructure	400	lin m.		■		
Resume land for drain construction	1	Ha			■	■
Grass lined drain west of road reserve	400	lin m.			■	■
New culvert under Ripley Road	2	No		■	■	■
Connect to existing culvert	1	Item		■	■	■
Reconstruct culvert at Scotts Rd Ripley Rd intersection 1800 x 1200 RCBC	1	No	■			
Reconstruct culvert at Michels St Ripley Rd intersection 1800 x 1200 RCBC	1	No	■			
Widen/deepen existing open drain	400	lin m.	■			
Reconstruct house access crossings with 2 no 1800 RCBC (heights vary)	12	No	■			
Reconstruct house access crossings with 1 no 1800 RCBC (heights vary)	4	No		■	■	
Remove house crossings/ fill existing drain including low flow pipe	400	lin m.				■
Stormwater street drainage interceptors	2	No				■

Table D2 Cost Estimates

Description	Qty	Unit	Rate	Option RR2	RR3a	RR3b	RR3c
New culvert under Ripley Rd (east to west)(2/1800x1200 RCBC)	1	No					
Temporary table drain connection	200	m					
Raise sag point between Michels St and Scotts Rd	60	m					
Concrete lined drain in west road reserve	400	m					
Resume land for drain construction							
Grass lined drain west of road reserve	400	m					
Upgrade access to 433 Ripley Rd with 2/1800x1200 RCBC	1	No					
Connect to existing culvert inlet at Clarke St		Item					
Reconstruct culvert at intersection of Scotts Rd and Ripley Rd (3/1800x1200 RCBC)	1	No					
Reconstruct culvert at intersection of Michels St and Ripley Rd (3/1800x1200 RCBC)	1	No					
Widen/deepen existing open drain	350	m					
Reconstruct house access crossings with 2/1800x (varies 600-1200)	12	No	$ 31,000				
Reconstruct house access crossings with 1/1800x (varies 450-600)	4	No	$ 20,000				
Remove house crossings, fill existing drain and provide a low flow pipe	400	m					
Stormwater street drainage interceptors	2	No					
Timber footbridges (option 2&3c -> remove)							
Relocate power poles along western side of Ripley Rd	7	No	$ 30,000				
Relocate bus shelter							
Telstra infrastructure alterations							
Water infrastructure alterations							
Sewerage infrastructure alterations							
Guardrail	varies	m	$ 200				
Weldmesh fencing	varies	m	$ 60				
Resume easement for services that are to be relocated		Item					
Duplicate drain line at Clarke St (in 1200 dia.)							
Modifications to infrastructure in park at end of Clarke St incl. new footbridge		Item					
New culvert under Ripley Rd (west to east)(1/1800x1200 RCBC)	1	No					
All figures have been based on 20% contingency except for the costs associated with obtaining easements/land.			**Totals**	**$ 2,005,000**	**$ 2,232,000**	**$ 1,908,000**	**$ 2,053,000**

Table D3 Hydraulic model Results Summary – Option RR2

Ripley Flood Mitigation HEC-RAS Model
Option 2c - as Option 2b but culverts instead of bridges for house access (Channel base widened from 2m to 4m - batters steepened - top width unaltered) plus regraded to deepen
Existing Flows
Ripley Drain

Location	River Station	Changes	Q (m3/s) 2 yr ARI	5 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI	W.S. Elevation (m) 2 yr ARI	5 yr ARI	10 yr ARI	50 yr ARI	100 yr ARI	Road Flood Level (m AHD)	Flood Immunity (Years) at trafficable depth (250mm)	House Access Flood Level (m AHD)	Flood Immunity at 250mm depth (Years)	Property Floor Level (m AHD) assumes 300mm agl	House Flood Immunity (Years) assume 300mm AGL
u/s 448 RipleyRd	1222		1.8	3.2	4.0	6.7	8.1	48.09	48.32	48.28	48.19	48.37	48.2	100				
448 Ripley Road access	1215	bridge	1.8	3.2	4.0	6.7	8.1	48.09	48.32	48.28	48.19	48.37	48.3	100	48.3	100	48.65	100
448 Ripley Rd	1212		1.8	3.2	4.0	6.7	8.1	47.7	47.82	47.95	48.12	48.2	48.4	100				
446 Ripley Rd	1195		1.8	3.2	4.0	6.7	8.1	47.69	47.88	47.92	47.99	47.96	47.8	100			48.33	100
446 Ripley Road access	1190	bridge	1.8	3.2	4.0	6.7	8.1	47.69	47.88	47.92	47.99	47.96	47.8	100	47.8	100		
446 Ripley Rd	1185		1.8	3.2	4.0	6.7	8.1	47.3	47.48	47.54	47.88	47.81	47.8	100				
444 Ripley Rd	1175		1.8	3.2	4.0	6.7	8.1	47.27	47.49	47.61	47.9	47.85	48.0	100				
444 Ripley Road access	1170	bridge	1.8	3.2	4.0	6.7	8.1	47.27	47.49	47.61	47.9	47.85	48.0	100	48	100	48.1	100
444 Ripley Rd	1165		1.8	3.2	4.0	6.7	8.1	46.77	46.87	46.93	47.39	47.51	48.0	100				
u/s Scotts Road	1160		1.8	3.2	4.0	6.7	8.1	46.97	47.15	47.25	47.52	47.66	47.6	100				
Scotts Rd culverts	1150	6no 1800x750 RCBC	1.8	3.2	4.0	6.7	8.1	46.97	47.15	47.25	47.52	47.66	48.0	100				
d/s Scotts Road	1140		1.8	3.2	4.0	6.7	8.1	46.32	46.39	46.42	46.53	46.58	47.5	100				
Footbridge d/s Scotts Rd	1139	raise soffit to 47.53	1.8	3.2	4.0	6.7	8.1	46.32	46.39	46.42	46.53	46.58	47.5	100				
442 Ripley Rd	1138		2.4	4.7	5.9	9.6	11.6	46.32	46.63	46.73	46.84	46.89	46.8	100	47.1	100	48.2	100
440 Ripley Rd	1120		2.4	4.7	5.9	9.6	11.6	46.3	46.65	46.73	46.84	46.87	46.3	2	47	100	47.7	100
438 Ripley Rd access	1111	bridge	2.4	4.7	5.9	9.6	11.6	46.3	46.65	46.73	46.84	46.87	45.6	<2	46.6	100	47.2	100
438 Ripley Rd	1102		2.4	4.7	5.9	9.6	11.6	45.95	46.27	46.4	46.45	46.46	46.3	100				
438 Ripley Rd access	1092	bridge	2.4	4.7	5.9	9.6	11.6	45.95	46.27	46.4	46.45	46.46	46.3	100				
436 Ripley Rd	1082		3.0	4.9	6.2	9.9	12.0	45.88	46.13	46.35	46.41	46.42	46.0	5				
436 Ripley Rd access	1071	bridge	3.0	4.9	6.2	9.9	12.0	45.88	46.13	46.35	46.41	46.42	46.0	5	46.5	100	47.3	100
434 Ripley Rd	1060		3.0	4.9	6.2	9.9	12.0	45.68	45.96	46.11	46.27	46.29	46.0	50	46.2	50	no house	
434 Ripley Rd access	1048	bridge	3.0	4.9	6.2	9.9	12.0	45.68	45.96	46.11	46.27	46.29	46.0	50				
432 Ripley Rd	1036		3.0	4.9	6.2	9.9	12.0	45.44	45.8	45.98	46.26	46.32	46.0	50	46.2	100	48.55	100
u/s Michels St	1020		3.4	5.8	7.3	12.2	14.7	45.44	45.79	45.97	46.23	46.27	46.0	50				
Michels St culverts	1010	6no 1800x900 RCBC	3.4	5.8	7.3	12.2	14.7	45.44	45.79	45.97	46.23	46.27	46.0	50				
d/s Michels St	1000		3.4	5.8	7.3	12.2	14.7	45.43	45.76	45.92	46.11	46.15	46.0	100				
Michels St footbridge	999	raise soffit to 46.0	3.4	5.8	7.3	12.2	14.7	45.43	45.76	45.92	46.11	46.15	46.0	100				
Michels St footbridge	998	raise soffit to 46.0	3.4	5.8	7.3	12.2	14.7	45.4	45.74	45.9	46.05	46.06	46.0	100				
430 Ripley Rd access	980	bridge	3.4	5.8	7.3	12.2	14.7	45.4	45.74	45.9	46.05	46.06	46.0	100	45.7	20	47.2	100
426-428 Ripley Rd	962		3.5	6.0	7.5	12.5	15.1	45.14	45.48	45.64	45.9	45.94	45.9	100				
426-428 Ripley Rd acces	946	bridge	3.5	6.0	7.5	12.5	15.1	45.14	45.48	45.64	45.9	45.94	45.9	100	45.4	50	46.3	100
424 Ripley Rd	930		3.5	6.0	7.5	12.5	15.1	44.88	45.27	45.42	45.58	45.59	45.4	100				
424 Ripley Rd access	923	bridge	3.5	6.0	7.5	12.5	15.1	44.88	45.27	45.42	45.58	45.59	45.4	100	45	20	no house	
422 Ripley Rd	916		3.5	6.0	7.5	12.5	15.1	44.78	45.12	45.28	45.6	45.62	45.4	100				
422 Ripley Rd access	906	bridge	3.5	6.0	7.5	12.5	15.1	44.78	45.12	45.28	45.6	45.62	45.4	100	44.9	20	45.6	100
1 Clarke St	896		3.5	6.0	7.5	12.5	15.1	44.47	44.82	45	45.6	45.62	45.4	100				
1 Clarke St access	890	bridge	3.5	6.0	7.5	12.5	15.1	44.47	44.82	45	45.6	45.62	45.4	100			46.4	100
u/s Clarke St	884		3.5	6.0	7.5	12.5	15.1	44.25	44.4	44.47	44.76	44.86	45.6	100	44.8	100		
Scottts Park	880		3.5	6.0	7.5	12.5	15.1	44.26	44.43	44.51	44.81	44.92	44.5	20				
Scotts Park footbridge	876	raise soffit to 45.0	3.5	6.0	7.5	12.5	15.1	44.26	44.43	44.51	44.81	44.92	44.5	20				
2 Clarke St	864		9.4	14.0	17.1	28.5	34.1	44.26	44.42	44.5	44.8	44.91	44.5	20	45.8	100	no house	
4 Clarke St																	45.9	100
416 Ripley Rd															46.2		46.5	100
412 Ripley Rd															46.5		45.77	100
410 Ripley Rd															47.2		46.2	100
3-5 Falvey St	758		9.6	14.0	17.1	28.5	34.1	43.47	43.62	43.73	44.07	44.23	>45		44.5	100	45.18	100
7 Falvey St								43.47	43.62	43.73	44.07	44.23	>45		44.5	100	45.7	100
10 Falvey St	738		9.6	14.0	17.1	28.5	34.1	43.3	43.45	43.55	43.83	43.95	>45				44.9	100
14 Falvey St	687		9.6	14.0	17.1	28.5	34.1	43.17	43.29	43.28	43.34	43.38	44.0				44.9	100
d/s Monterea Road	667		9.6	14.0	17.1	28.5	34.1	43.12	43.28	43.36	43.44	43.51	>44					
	578		10.3	15.8	19.3	30.9	36.8	42.8	42.92	42.97	43.02	43.07	43.0					
	501		10.3	15.8	19.3	30.9	36.8	42.34	42.46	42.52	42.69	42.76	43.0					
	411		11.8	19.7	24.4	39.9	47.5	42.05	42.19	42.26	42.44	42.51	42.5					
	315		12.1	20.0	24.8	40.3	48.0	41.43	41.52	41.57	41.69	41.75	>42					
	212		14.0	23.1	28.4	45.6	54.0	40.25	40.4	40.46	40.66	40.75	>41					
	108		14.0	23.1	28.4	45.6	54.0	39.63	40.02	39.84	40.04	40.11	40.2					
D/s boundary	0		14.0	23.1	28.4	45.6	54.0	38.66	38.55	38.7	38.83	38.89	>39					

Table D4 Hydraulic model Results Summary – Option RR3 (Final)

Option RR3b final
Ripley Drain

Ult flows

Location	River Station	Q (m3/s) 10 yr ARI	Q (m3/s) 100 yr ARI	W.S. Elevation 10 yr ARI	W.S. Elevation 100 yr ARI	Road Level (m AHD)	Flood Immunity (Years) at trafficable depth (250mm)	Mitigation Required	House Access Flood Level (m AHD)	Flood Immunity at 250mm depth (Years)	Property Ground Level adj house (m AHD)	Property Floor Level (m AHD) assumes 300mm agl	Flood Immunity (Years)
u/s 448 RipleyRd	1222	0.07	0.1	47.96	48	48.2	100						
448 Ripley Road access	1215	0.07	0.1	47.96	48	48.3	100		48.3	100	48.35	48.65	100
448 Ripley Rd	1212	0.07	0.1	47.85	47.86	48.4	100						
446 Ripley Rd	1195	0.07	0.1	47.62	47.66	47.8	100				48.03	48.33	100
446 Ripley Road access	1190	0.07	0.1	47.62	47.66	47.8	100		48.03	100			
446 Ripley Rd	1185	0.07	0.1	47.62	47.65	47.8	100						
444 Ripley Rd	1175	0.07	0.1	47.62	47.65	48.0	100						
444 Ripley Road access	1170	0.07	0.1	47.62	47.65	48.0	100		47.9	50	47.8	48.1	50
444 Ripley Rd	1165	0.07	0.1	47.62	47.65	48.0	100		47.6	50			
u/s Scotts Road	1160	0.07	0.1	47.62	47.65	47.6	10						
Scotts Rd culverts	1150	0.07	0.1	47.62	47.65	48.0	100						
d/s Scotts Road	1140	0.07	0.1	47.13	47.16	47.5	100						
Footbridge d/s Scotts Rd	1139	1.6	2.4	47.13	47.16	47.5	100						
442 Ripley Rd	1138	1.6	2.4	47.13	47.16	46.8	<10	raise road to 47.1	47.1	100	47.9	48.2	100
440 Ripley Rd	1120	1.6	2.4	46.52	46.6	46.3	10	raise road to 46.8	47	100	47.4	47.7	100
438 Ripley Rd access	1111	1.6	2.4	46.52	46.6	45.6	10	raise road to 46.7	46.6	100	46.9	47.2	100
438 Ripley Rd	1102	1.6	2.4	46.18	46.26	46.3	100						
438 Ripley Rd access	1092	1.6	2.4	46.18	46.26	46.3	100						
436 Ripley Rd	1082	1.6	2.4	46.1	46.23	46.0	100						
436 Ripley Rd access	1071	1.6	2.4	46.1	46.23	46.0	100		46.5	100	47	47.3	100
434 Ripley Rd	1060	1.6	2.4	46.09	46.23	46.0	10		46.2	100	47.54	no house	
434 Ripley Rd access	1048	1.6	2.4	46.09	46.23	46.0	10						
432 Ripley Rd	1036	1.6	2.4	46.02	46.23	46.0	10		46.2	100	48.25	48.55	100
u/s Michels St	1020	1.6	2.4	46.02	46.22	46.0	10						
Michels St culverts	1010	1.6	2.4	46.02	46.22	46.0	10						
d/s Michels St	1000	1.6	2.4	45.93	46.03	46.0	100						
Michels St footbridge	999	1.6	2.4	45.93	46.03	46.0	100						
Michels St footbridge	998	1.6	2.4	45.9	45.96	46.0	100						
430 Ripley Rd access	980	5.9	8.9	45.9	45.96	45.5	<10		45.7	10	46.9	47.2	100
426-428 Ripley Rd	962	5.9	8.9	45.68	45.74	45.5	100						
426-428 Ripley Rd acces	946	5.9	8.9	45.68	45.74	45.5	100		45.4	100	46	46.3	100
424 Ripley Rd	930	5.9	8.9	45.28	45.36	45.0	<10	AISE ROAD TO 45.3					
424 Ripley Rd access	923	5.9	8.9	45.28	45.36	45.0	<10	AISE ROAD TO 45	45	100	45.1	no house	
422 Ripley Rd	916	5.9	8.9	45.22	45.29	45.0	<10	AISE ROAD TO 45.3					
422 Ripley Rd access	906	5.9	8.9	45.22	45.29	45.0	<10	AISE ROAD TO 45	44.9	100	45.3	45.6	100
1 Clarke St	896	5.9	8.9	45.2	45.29	45.0	<10	AISE ROAD TO 45.3					
1 Clarke St access	890	5.9	8.9	45.2	45.29	45.0	<10	AISE ROAD TO 45.3			46.1	46.4	100
u/s Clarke St	884	5.9	8.9	44.72	44.82	45.6	100		44.8	100			
Scotts Park	880	5.9	8.9	44.48	44.73	44.5	100						
Scotts Park footbridge	876	5.9	8.9	44.48	44.73	44.5	100						
2 Clarke St	864	6.2	9.4	44.48	44.73	44.5	100		45.8	100	44.9	no house	
4 Clarke St		6.2	9.4			45.3					45.6	45.9	100
416 Ripley Rd		6.2	9.4						46.2		46.2	46.5	100
412 Ripley Rd		6.2	9.4						46.5		45.47	45.77	100
410 Ripley Rd		6.2	9.4						47.2		45.9	46.2	100
3-5 Falvey St	758	17	34	43.51	43.74	44.63	>100		44.5	100	44.88	45.18	100
7 Falvey St			34						44.5	10	45.4	45.7	100
10 Falvey St	738	17	34	43.92	44.29	44.63	>100				44.6	44.9	100
14 Falvey St	687	17	34	43.46	43.8	44.63	>100				44.6	44.9	100
d/s Monterea Road	667	17	34	43.2	43.46	44.63	>100						
	578	18	35	42.76	42.94	43.0	>100						
	501	18	35	42.43	42.62	43.0	>100						
	411	19	35	42.06	42.28	42.5	>100						
	315	26	53	41.64	41.83	>42	>100						
	212	26	53	40.4	40.65	>41	>100						
	108	26	53	39.75	40.08	40.2	>100						
D/s boundary	0	30	59	38.62	38.84	>39	>100						
Western Drain													
Diversion_sth	413.18	3.1	6.4	48.37	48.45	48.3	10						
Diversion_sth	382.85	3.1	6.4	46.84	47.7	48.27	100						
Diversion_sth	380.27	3.1	6.4	46.84	47.68	48.28	100						
Diversion_sth	375	Culvert	Culvert										
Diversion_sth	370.52	3.1	6.4	46.23	46.5	48.19	100						
Diversion	366.77	4.8	9.7	46.2	46.5	48.3	100						
Diversion	272.5	4.8	9.7	45.62	46.17	46.88	100						
Diversion	162.5	4.8	9.7	45.43	46.1	46.27	100						
Diversion	161.86	4.8	9.7	45.4	46.04	46.27	100						
Diversion	155	Culvert	9.7										
Diversion	150	4.8	21	45.31	46.08	46.26	100						
Diversion	149.54	6.3	21	45.33	46.08	46.26	100						
Diversion	52.04	6.3	21	45.28	46.01	45.28	10						
Diversion	50	6.3	21	45.28	46.01	45.28	10						
Diversion	45	Culvert	21										
Diversion	6.62	6.3	21	44.15	46.01								
Diversion	0	6.3	21	44.15	46.01								
southern_culvert	69.12	2.2	4.2	48.33	48.5	48.3	10						
southern_culvert	58.82	2.2	4.2	47.73	48.56	48.3	100						
southern_culvert	58.36	2.2	4.2	45.02	48.6	48.3	100						
southern_culvert	37.5	Culvert	4.2										
southern_culvert	17.66	2.2	4.2	46.25	46.54	48.3	100						
southern_culvert	12.5	2.2	4.2	46.3	46.63	48.3	100						
southern_culvert	0	2.2	4.2	46.29	46.62	46.3	100						
Existing_culvert	45	10	10	46.4	46.4								
Existing_culvert	42	10	19	46.33	46.33								
Existing_culvert	21	Culvert	19										
Existing_culvert	1	10	19	44.85	44.85								
Existing_culvert	0	10	19	44.68	44.68								

City of Ipswich

Thagoona Catchments Flood Study

and

Flood Risk Management Plan

BRIEF for Quotation RFQ #10-11-XXX

Issued for Procurement – August 2010

Table of Contents

1. INTRODUCTION

The Ipswich region is undergoing significant change. The South East Queensland Regional Plan identifies a number of large-scale greenfield development areas which will support some of the population growth in South East Queensland.

A number of these development areas are located in the Thagoona area (as identified in the 2006 Ipswich Planning Scheme).

Land within the catchments has been identified as suitable for the development in the Ipswich City Planning Scheme. Council is taking an active role in the planning for the study area in conjunction with developers. In order to facilitate acceptable planning outcomes, it is important to accurately define the various constraints impacting the land.

There are also existing flood risks in the catchment, specifically in the currently developed areas. The management of these risks will also be a focus of this study.

A primary objective of the study is to increase the resilience to flooding of the Thagoona community. This will be achieved through the following tasks:

1) Define the existing catchments and the drainage & flooding behavior, flood risk and constraints of the study area
2) Define the direction, location and hazard for all overland flow paths in the urbanised areas
3) Identify resilience opportunities
4) Identify the impacts of proposed developments on drainage and flooding (quantity and quality).
5) Identify flood risk management best practice, regulation and opportunities for the study area
6) Identify the potential impacts on water quality and aquatic ecology within the study area
7) Establish integrated water management objectives and design parameters for the study area
8) Identify flood risk management measures to achieve the objectives including mapping flood levels suitable for development control and capacity building of the local volunteer resources
9) In association with Council, establish a flood risk management strategy for the study area (strategies, devices, timing, cost etc)
10) Gain agreement on this conceptual design of the flood risk management strategy from Council
11) Document findings within an agreed timeframe.

This study is aimed at meeting these purposes, specifically defining the extent of flooding impacts and flood risk management within the catchment. As well, the study is focused on developing resilience and mitigation measures which can be incorporated into development proposals and future stormwater / flooding infrastructure works among other related Councils interests.

A primary objective is the development of a Flood Risk Management Plan which will provide the basis for Council's ongoing response to flood management issues in the study area.

2. STUDY AREA

There are three catchments in the study area, namely Yarrow Road, Thagoona and Thagoona East catchments as shown in Figure 1. All three catchments are crossed by Karrabin-Rosewood Road and the Ipswich-Rosewood railway line. As well, all three catchments drain to directly to the Bremer River.

The planning scheme as it relates to this catchment is shown in Figure 2.

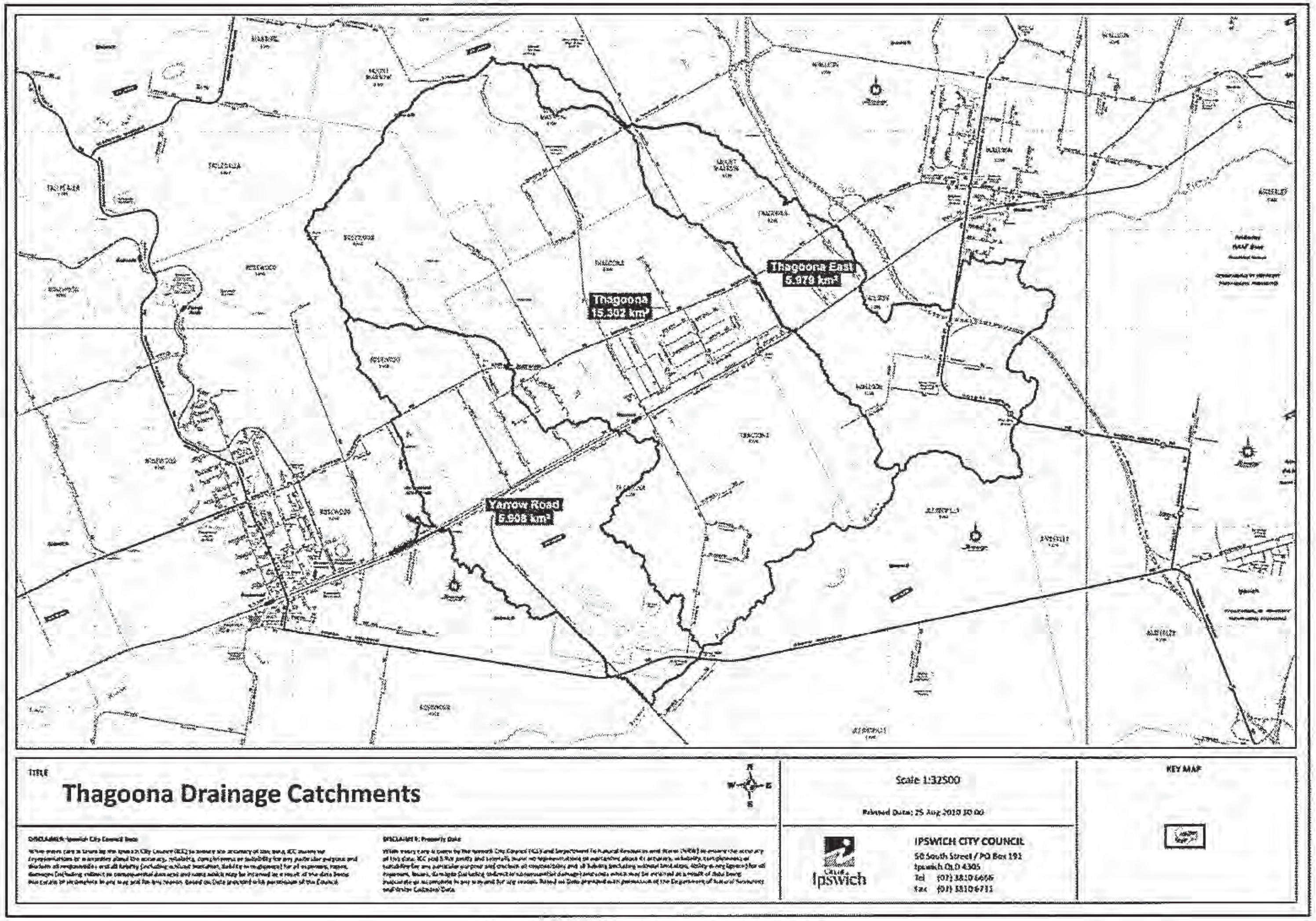


Figure 1: Thagoona Catchments

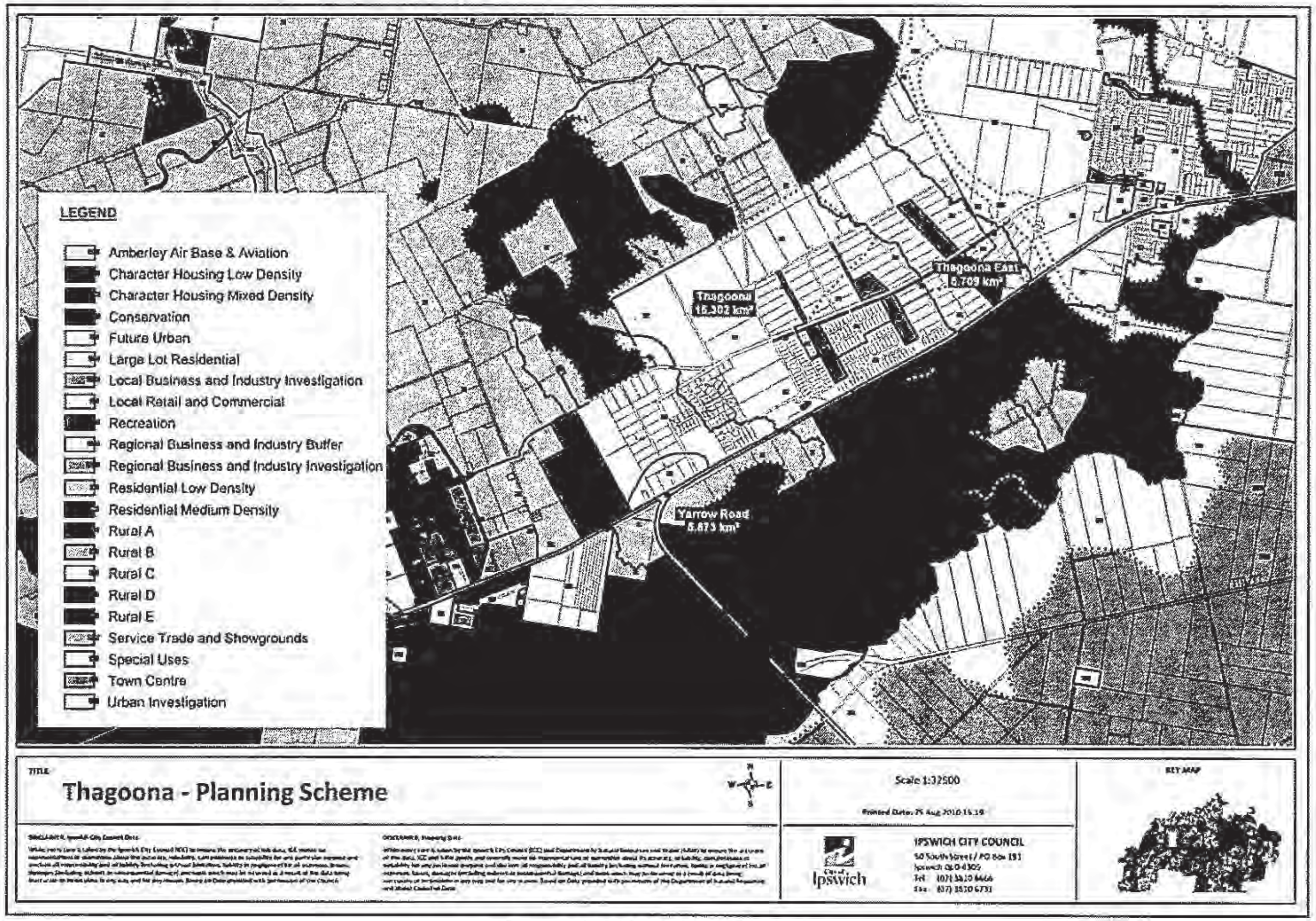


Figure 2: Planning Scheme

3. STUDY ELEMENTS

3.1. STUDY TASKS

The study will comprise of six (6) main tasks, each with numerous sub–tasks.

1. Data Compilation

- Meetings with Study Advisory Group.
- Data Collation (Existing Data)
- Site Inspections
- Rainfall Data for Flood Modeling
- Rainfall Data for Stormwater Management Modeling (MUSIC)
- Identification and Acquisition of Additional Data

2. Flood Study

- Define Flood Management Objectives
- Digital Terrain Model
- Resident Flood Survey
- Hydrological Modeling
- Hydraulic Modeling
- Calibration, Verification and Sensitivity of Models
- Community Briefing Session on Calibration / Verification of Flood Models
- Definition of Existing Flood Behavior
- Flood Risk Assessment
- Definition of Developed Case Flood Behavior (Unmitigated)

3. Water Sensitive Urban Design

- Define WSUD Objectives
- Water Conservation (Queensland Development Code, other regulations and Policies)
- Define Compliance Methods
- Stormwater Quality Modeling Overview
- Simulation of Existing and Developed (Unmitigated) Cases
-

4. Integrated Water Management Compliance

- Define Integrated Water Management Objectives and Compliance
- Flood Risk Management Objectives and Compliance
- Water Quality, Waterway Stability and Frequent Flow Management

5. Flood Risk Management

- Non-Structural (Flood Warning and Emergency Management)
- Non-Structural (Building Local Volunteer Capacity)
- Non-Structural (Development Control)
- Non-Structural (Increasing Community Resilience Pre and Post Flood Events)
- Resilience Measures
- Structural Measures / Drainage System Improvements
- Benefit / Cost Assessment of Measures
- Flood Risk Management Strategy

6. Documentation

- Meetings with Study Advisory Group
- Interim Report and Maps
- Final Report and Mapping
- Handover of Data

3.2. STUDY MANAGEMENT

The study will be managed by the Study Manager (the Engineering Services Principal Engineer, Hydraulics or nominated delegate). The Study Manager will be responsible, with the Consultant, for delivery of the project.

The study manager and consultant will be assisted by a small Study Advisory Group (SAG) which will be available to assist in facilitation and delivery of the Project.

The Study Advisory Group

The Study Advisory Group will be chaired by Engineering Services and consist of representatives from

- ICC Staff – Representatives from Engineering Services, Planning and Development, Health, Parks and Recreation and Risk Management
- Division Councilor(s) representing existing residents and ratepayers in the study area. The Chair of the Works Committee will also be invited to attend as available.
- SES Representative

Other representatives as considered appointed by the Study Manager.

The SAG will assist in the flow of information to existing ratepayers, assist and advise as appropriate to ensure that the study objectives are delivered, assist the integration of the study findings with Council's (development) objectives, assist to ensure that the study recommendations are achievable within known constraints and that the adopted delivery milestones are have a realistic timeframe.

The Consultant will attend all Study Advisory Group meetings (unless otherwise advised) and provide a presentation on the progress and findings of the study.

The consultant will provide the Study Manage with draft meeting minutes for discussion before circulation by the Study Manager. The consultant will indicate the number of SAG meetings allowed for in the quotation.

4. SCOPE OF WORK

The Consultant shall provide all services required to satisfy the objectives and true intent of the study. The services shall include, but not necessarily be limited to, the following tasks.

An indication of the scope of works for each stage is listed in the following sections.

4.1. DATA COMPILATION

4.1.1. Meetings with Study Advisory Group

The Consultant should use meetings of the Study Advisory Group as a resource for assisting in gathering and providing data for the study. In this respect the consultant needs to identify, at the initial Study Advisory Group meeting, data being collected and any data requests from the Study Advisory Group. The consultant should allow costing for preparation and attendance at five (5) SAG meetings.

4.1.2. Data Collation (Existing Data)

The Consultant is to collect, compile and assess all relevant data and previous studies in the study area. In addition, the Consultant is to identify and propose further data collection to Council if and as required.

The following information will be made available to the successful consultant:

- Ipswich City Council Planning Scheme and Maps (MapInfo)
- 2009 ALS data (.asc format in MGA94 Zone 56) [subject to availability within the timeframe of the study]
- 2007 photogrammetry (3D DXF format in MGA94 Zone 56)
- 2007 aerial photography (ecw format and seamless mosaic in MapInfo)
- Numerous MapInfo layers for area from Council (see images below)
- Information available on infrastructure and levels.
- ICC Waterway Healthy Strategy 2009

GIS_Bridges.TAB
GIS_Buildings.TAB
GIS_Detention_Basins.TAB
GIS_Easements.TAB
GIS_House_Numbers.TAB
GIS_Open_Drains.TAB
GIS_Open_Drains_Invert.TAB
GIS_Property_DCDB.TAB
GIS_Property_Survey.TAB
GIS_Railway_Lines.TAB
GIS_rivers.TAB
GIS_Road_Kerbs.TAB
GIS_Road_Medians.TAB
GIS_Road_Names.TAB
GIS_Roads_DCDB.TAB
GIS_Stormwater_Mains.TAB
GIS_Stormwater_Pits.TAB
GIS_Survey_Historic.TAB
GIS_Water_Fittings.TAB
GIS_Water_Mains.TAB
GIS_Water_Pump_Stations.TAB
GIS_Water_Reservoirs.TAB
GIS_Water_Structure.TAB

Overlay_Maps
!Overlay_Maker
!Overlay_Output
Character_Places
OV01_Bushfire_Risk_Area
OV02_Key_Resource_Areas
OV03_Mining_Buffer
OV04_Difficult_Topography
OV05_Flooding
OV06_Highway_Buffer
OV07A_Defence_Area_Control
OV07B_Operational_Airspace
OV07C_Anef
OV07D_Explosive_Storage
OV07D_Public_Safety_Area_Buffer
OV07D_Purga_Rifle_Range_Buffer
OV07E_Unexploded_Ordnance
OV08_Motor_Sport_Buffer
OV09_Wastewater_Treatment
OV10_Swanbank_Power_Station
OV11_Oil_Gas
OV12_Warrill_Creek_Water
OV13_High_Voltage_Electricity
OV14_Rail_Noise_Buffer

Table 1 MapInfo Table Listing

4.1.3. Development Planning

Developments are currently being delivered in the catchment. The developments are at various stages in planning, development application, approval and construction. Flood management and stormwater management features have been proposed for these sites and approved. The successful consultant must complete the following in consultation with Council:

- Review of planning scheme to understand extent proposed development (see previous task).
- Review the current state of development applications and approvals with Council to understand development extent, flood management and stormwater management within these developments. Relevant details of the proposed flood and stormwater management features will need to be obtained.
- Map the findings of the above activities for inclusion in the modeling and conceptual design.

4.1.4. Rainfall Data for Flood Modeling

The successful consultant is responsible for the collection of appropriate rainfall data to assist in the calibration and verification of the flood models.

There are some rainfall gauges in and around the catchment of the study area. There are rainfall gauges at least five pluviograph (ALERT) stations near the edges of the catchments.

4.1.5. Rainfall Data for Stormwater Management Modeling (MUSIC)

The BoM ALERT stations will be reviewed to identify a suitable length of rainfall for stormwater management modeling (MUSIC).

It is Council's preference to have a 10 year period of 6 minute rainfall which is representative of the long term rainfall average in the region of the site. If this is not possible, then a suitable substitute must be presented to Council with justification.

4.1.6. Acquisition of Additional Data

If, during the course of the study, it becomes necessary to acquire additional data, including survey, and it can be shown that the need could not have been reasonably anticipated prior to submission of quotations, the Consultant can submit to Council a brief outlining details of the data required, together with a firm quotation for the cost and timing of the work.

Following receipt of written approval by Council, the Consultant may undertake the additional data collection.

Council reserves the right to undertake any survey component in response to the Consultant's Brief.

4.1.7. Site Inspections

Site inspection(s) are to be completed by the consultant team to gain information for the Flood Study. The proposal should outline the objectives of the site inspection(s) and who will attend the site inspection(s). Relevant members of the Study Advisory Group may accompany the consultant team.

Importantly the site inspection needs to identify important ecosystems within the waterway which might be sensitive to changes in frequent flow. This will assist with assessing whether the frequent flow objective needs to be applied to these catchments.

4.2. FLOOD STUDY

4.2.1. Digital Terrain Model

A topographic survey and development of a Digital Terrain Model (DTM) using remote sensing data (i.e. 2007 photogrammetry and 2009 ALS) of the study area will be required to meet the study objectives.

The successful consultant will be responsible for developing the required DTM's from the supplied photogrammetry and ALS data.

Additional survey information of structures such as culverts and road levels will be provided by Council in 12d and MapInfo format.

4.2.2. Resident Flood Survey

The consultant will be responsible for consulting with the community to obtain historical flood data. Specifically, the recent events of November 2008 and May 2009 resulted in inundation of study area.

The objectives of this element are as follows:

- Ensure the community is informed of the study and its objectives
- Enable the community to provide input on historical flood behaviour and possible floodplain management measures
- Increase the knowledge of the SES volunteers in historical flooding behaviour
- Identify to the community that local councilor(s) will be the ongoing conduit between the community and the Study Advisory Group
- Provide an initial input from the community to the Study Advisory Group.

The proposal is to clearly describe how this survey will be carried out. The consultant is to manage the process including development of consultation material and collation of responses. However, the consultant will use SES resources (staff and vehicles) to carry out the face-to-face interviews of residents with flood level information.

Hence, the consultant costs should include the management of the process. Council will negotiate and agreed SES costs associated with the project directly with the SES.

Survey of the flood marks will be carried out by Council. Council will also bear the costs of distribution (e.g postage) of any consultation material.

The Consultant is required to communicate the results of the resident flood survey back to the community. The consultant is to provide details of how it is intended to undertake this communication. The final determination of the communication requirements will be determined in consultation with the Study Advisory Group.

4.2.3. Hydrological Modeling

A hydrologic model of the catchment will be created that will provide suitable inputs to the hydraulic model. The choice of hydrological model must be supported in the proposal.

Details of proposed calibration methodology must be provided. To assist in this process, ICC has undertaken the collection of flood information from historic data and in particular the most recent flood events.

As an additional check, the hydrologic model will also be checked against the Rational Method. The Consultant may propose additional optional calibration methods for consideration.

A joint calibration of the hydrological and hydraulic models will be required.

Flood Modeling will consider a wide range of events with average recurrence intervals (ARI) of 5, 20 and 100 years as well as the 500 years and the extreme event (i.e. PMF). In addition, a simulation of the 100 year ARI with increased rainfall estimates to represent potential climate change effects (due to the Enhanced Greenhouse Effect) is required to be modeled.

Modeling of other frequencies (e.g. 1 year ARI) will be required for water quality purposes and frequent flow analysis.

4.2.4. Hydraulic Modeling

Model Design and Selection

The Consultant shall nominate hydraulic modeling techniques and appropriate commercially available models to be used. The selection should be based on the hydraulic characteristics of the system, the boundary conditions and the requirements of the study. The hydraulic model(s) used need to be suitable for the type, nature and scale of the modelling. It is important that the design and layout of the models shall also be suitable for future testing of development proposals and floodplain measures.

Full two–dimensional (2D) or a combination of a 1D and full 2D modeling in a nested configuration is required. Numerous grid sizes may be required to adequately model the study area's hydraulic features.

An overview of the model selection and design process should be provided in the proposal, which should address in detail the following issues:

- The grid spacing of the model, its relationship to the topographical terrain and the ability to vary the grid pattern and size, to suit the hydraulics in situations such as flow through culvert, bridges, over road embankments, between buildings and over levees.
- The process used to link the 2D domain to the 1D network.
- The representation of the flow distribution along model boundaries (upstream and downstream).
- The simulation of the principal characteristics of the flow across/through road embankments. Where required it should be able to accurately calculate flow through a culvert or bridge and

the concurrent weir flow over an embankment. In this respect the model should be able to simulate pressure or orifice flow through the culvert or bridge.
- The representation of all flows in the drainage network.
- The ability of the model to represent overland flowpaths.
- Calibration of flood level and the realistic modeling of velocity magnitudes and direction.
- The quality and format of model output including the capability to present 1D results (levels, depths, velocities) in conjunction with 2D results (both in plan view and as in animations).

The concurrence of Council is required in relation to the selection and design of the models.

Model Development

The hydraulic model will be developed using the Digital Terrain Model and any other data collected. The proposal will describe the methodology to be used to develop the model including:

1) Model Geometry:
   a) bridge and culvert structures
   b) weirs
   c) culvert blockage
   d) floodplain embankments
   e) hydraulic roughness (2D and 1D)
   f) allowance for future infrastructure needs [eg ultimate road network, waterway and floodplain configurations]

2) Model Boundaries
   a) catchment inflows
   b) floodplain inflows
   c) downstream boundary conditions

3) Model Structure:
   a) 2D/1D interaction
   b) Eddy viscosity representation

Council will require that the Consultant provide for visual display of model findings. (In this regard it is advised that Council has an existing license for WaterRide).

4.2.5. Calibration of Models

There is likely to be limited historical flood information available within this study area. However, the recent flood events of January 2008 and May 2009 may provide good and recent flood data for the purposes of calibration and verification.

As described in previous sections, the consultant will be responsible for consulting with the community to obtain historical flood data. The methodology for this task is to be described in the proposal as part of the Resident Flood Survey.

The hydrological model and the hydraulic model should be calibrated to one event. A further event should be chosen during the study for verification.

A report on the modeling tasks up to the point of calibration / verification will be presented to the Study Advisory Group. This report will document all data collation, model development, model calibration and verification tasks to a standard suitable for the final report.

This stage in the study is a milestone and a hold point. The Study Advisory Group will review this report. The Project Manager will advise if further work is required on the calibration to improve the quality and/or whether the model is suitable for use in subsequent stages of the study. Any request for variation to payment will not be considered unless it can be demonstrated that the requirement for the additional work was not due to a lack of quality of the calibration, sub–standard work or the requirement of the Study Manager was could not reasonably have been anticipated.

4.2.6. Community Session on Calibration / Verification of Flood Models

Following acceptance of the model calibration and verification process, the consultant will organise and conduct, in association with the Division Councillor and other members of the Study Advisory Group, a community information session to present these interim findings. The session will provide the community with an opportunity to view the flood model calibration and verification results.

The objective of the community session is to:

- Obtain any additional community input into the model development / performance
- Inform the community of the model's performance in replicating actual flood events.
-
- The Consultant is to outline proposals to achieve this requirement.
-

4.2.7. Definition of Existing Flood Behavior

Design Events

For the purposes of this study, flood design floods shall include the 1, 5, 20 and 100 year ARI events. Additionally, the 500 year and an extreme event (representing an estimate of the Probable Maximum Flood) shall also be simulated.

In addition, the 100 year ARI with increased rainfall estimates to represent potential climate change effects (due to the Enhanced Greenhouse Effect) shall be simulated.

Hence, there are a total of seven (7) flood events to be finally simulated.

The Consultant shall modify the calibrated models as necessary to represent accurately the existing and developed catchment and floodplain conditions.

The Consultant shall establish the inputs to the models of design events, including:

- Design hydrographs

- Downstream boundary conditions .
- Boundary conditions are to be established following discussion with the Project Manager.

The modeling of design events shall be undertaken for a range of storm durations to ensure that the critical event(s) are identified over the full area of the hydraulic model. For consistency in tender comparisons, consultants are to assume three (3) critical durations are required.

Alternatively, the consultant can propose the development of a synthetic temporal pattern that envelope the short duration events within longer duration events. This would enable a single duration to be used. The consultant shall clearly nominate any such proposals in the submission.

The Consultant shall liaise with Council in relation to the definition of existing conditions, the selection of design inputs to the model and adoption of design results.

The consultant shall incorporate the requirements of Council's Development Guidelines, with sensitivity testing on the effect of blockage factors for closed conduits, bridges and culverts. This shall be carried out for the two (2) 100 year ARI events only.

Hence, a total of 21 design flood events are required (6 ARI events for 3 durations for existing catchment/floodplain states with blocked culverts for 100 year ARI).

The modeling results shall be checked using alternative methods, including checking of head losses at bridges and culverts by an alternative hydraulic method (e.g. HEC–RAS).

Maps of peak flood levels, flows, velocities, and depths (as an envelope of both durations) are to be provided for each of the six (6) ARI flood events. As well, maps of durations that results in the peak levels in the envelope are to be produced for the six (6) events.

Hence, as a minimum, a total of 36 flood maps are required as both A3 figures and in digital GIS format and to be displayed visually. [The consultant is required to undertake all necessary work, including additional simulations, leading to finalization of these maps, figures and visual presentations]

Modelling of the 1 year ARI storm allows assessment of the waterway stability objective (see Section 4.3.1).

Verification to Regional Flood Frequency Analysis

The peak flows at four (4) locations in the catchment derived from the hydraulic model results will be compared with the results from a Regional Flood Frequency analysis to be provided by Council. Any significant discrepancies (i.e. more than 20%) will need to be explored. Changes to the model may be required to meet the Regional Flood Frequency analysis results.

Sensitivity Analyses

Sensitivity analyses shall be carried out to assess the effects of changing model parameter values and design inputs on the results. The principal parameters are those simulating friction, energy and debris losses at culverts, bridges and other structures. These values shall be based on sound documented assumptions and agreed with Council prior to design event modeling work commencing.

For consistency in tender comparisons, tenderers are to assume ten (10) simulations of the 100 year ARI event are required to assess these sensitivities.

4.2.8. Flood Risk Assessment

Mapping of Flood Risk

Maps of Flood Risks (low, medium and high) should also be created [SCARM Report 73 (CSIRO, 2000) and EMA Manuals etc] based on:

- Velocity of flow and depth of inundation;
- Hazard;
- Ground and floor levels;
- Flood warning time and duration of flooding;
- Suitability of evacuation and access routes; and
- Emergency management during major floods.

Flood Hazard Categorisation

The Consultant should provide a description of the nature of flooding for the full range of potential floods in the study area. A flood hazard categorisation is to be carried out for the existing level of development, and areas identified for future development, in accordance with the classifications outlined in CSIRO SCARM National Guidelines and EMA Manuals. Flood hazard is to be assessed over the full range of assessed flood events.

Hence, a total of five (5) flood hazard maps are required as both A3 figures and in digital GIS format.

Flood Damages Assessment

A flood damages assessment is to be carried out that quantifies the total direct and indirect flood damages for the study area. Floor levels will either be surveyed (as an additional cost to this study) or based on assumptions from other data.

Identification of Existing Flooding Issues in Catchment

Based on the definition of existing flooding behavior and flood risk described above, the consultant will identify the existing flooding issues within the catchment. These will be described both qualitatively and quantitatively.

4.2.9. Definition of Developed Case Flood Behavior (Unmitigated)

There are numerous developments proposed in the catchment. The flood model (hydrological and hydraulic) is to be adapted to represent the catchment areas with full development (as per the planning scheme).

The development will be initially simulated without mitigation measures. Simulations are to be carried out for the same 21 design flood events for the existing case.

Impact maps of levels are to be produced for each event. As well, maps demonstrating the changes in peak flows, specifically downstream of the development site(s), are to be produced. Specific focus should fall on impacts to areas of high risk (existing case) identified in the flood risk assessment.

4.3. INTEGRATED WATER MANAGEMENT

4.3.1. Integrated Water Management Objectives

Council is proposing an innovative approach to managing and controlling the impact of development on the water quality, waterway stability and flood behaviour of the catchment. Previous attempts at development control and regulation have been focused on compliance at the outlet of the development site. A compliant solution under this approach can lead to adverse changes in flood and waterway behaviour at downstream locations (e.g. due to changes in flood peak timing). Objectives for the following are to be defined:

- Flood management
- Stormwater quality
- Waterways stability
- Frequent flow

Flood management objectives
The flood management of the catchment is to be focused on maintaining flood behaviour at a network of nodes throughout the catchment. The indicative number and locations of these nodes are shown in Figure 3.

The following parameters will be considered and assessed at the node locations for management of flooding.

- Peak flood levels
- Peak flood flows
- Duration of flood inundation
- Rate of floodwater rise
- Rate of floodwater recession
- Timing of flood peak
- Flood event volume

Stormwater quality, waterways stability and frequent flow objectives
The integrated water cycle management strategy for study area must be informed by the requirements of the downstream ecosystem and current legislative requirements. The requirements must be quantified in the form of WSUD objectives. Refer Section 4.3.3 for details.

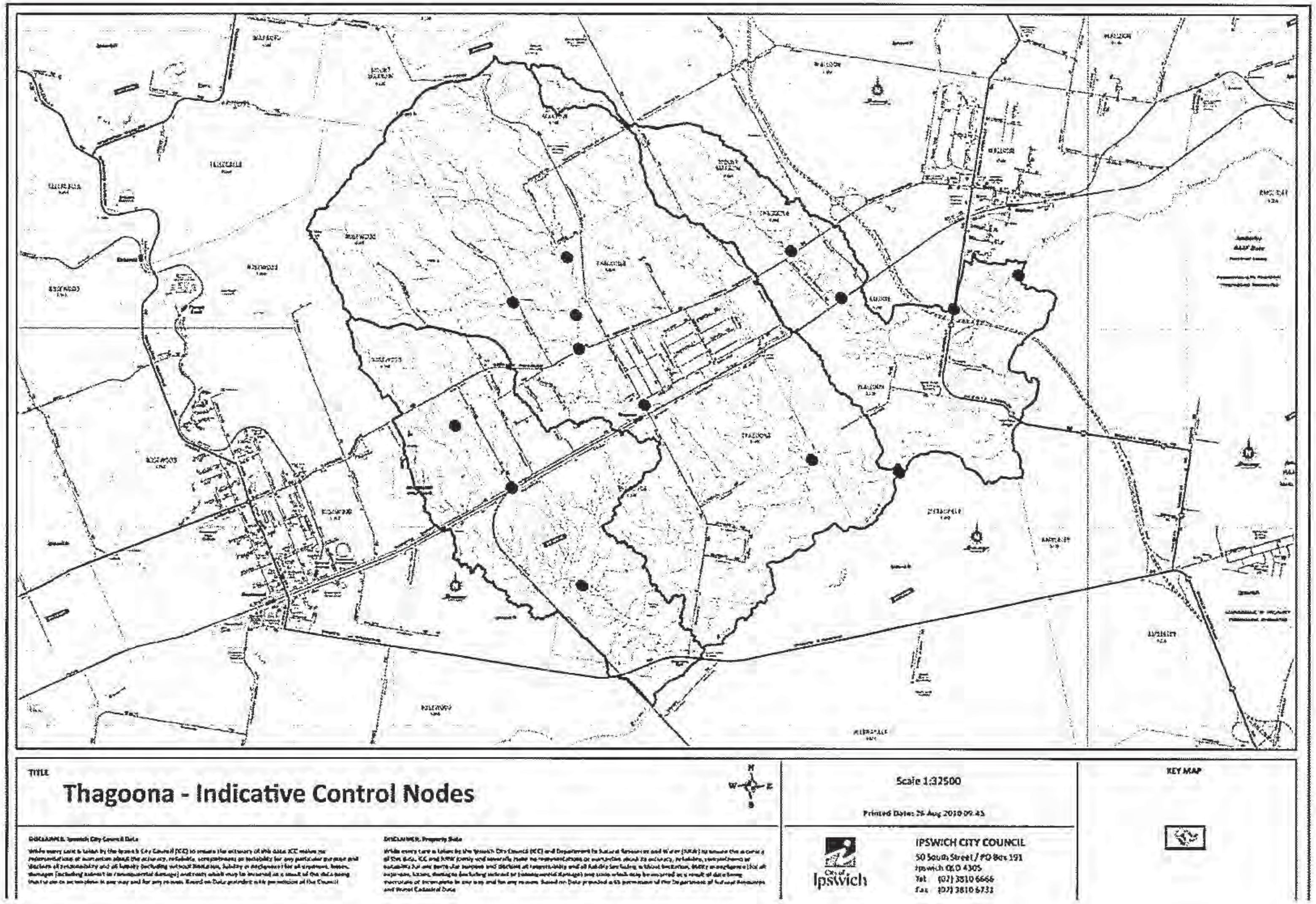


Figure 3: Indicative Control Nodes

4.3.2. Flood Risk Management Objectives and Compliance

The flood parameters listed above will form the basis of compliance for development assessments throughout the catchment. The compliance process will require setting of limits for these parameters at the nodes. The study will provide the basis and detail associated with the setting of these limits

Some of the limits will be based on the existing case values. This will be mainly true for the flooding parameters (e.g. peak levels, flows etc). Hence, for example, the study may recommend that for all development in the catchment (cumulatively):

- Peak flood levels cannot increase by more than 50mm above the existing case values;
- Peak flows cannot increase by more than 5% above the existing case values;
- Duration of flood inundation cannot increase by more than 5% above the existing case values at all 'whole' mAHD values (e.g. 4.0mAHD, 5.0mAHD, 6.0mAHD etc);

At an individual development scale, each development will be constrained to stricter limits in order to ensure that the cumulative minor increases listed above are achievable. It is envisaged that individual developments would be limited to increases that are approximately 20% of the cumulative increases listed above. Hence, for example, for an individual development:

- Peak flood levels cannot increase by more than 10mm above the existing case values;
- Peak flows cannot increase by more than 1% above the existing case values;
- Duration of flood inundation cannot increase by more than 1% above the existing case values at all 'whole' mAHD values (e.g. 4.0mAHD, 5.0mAHD, 6.0mAHD etc);

This study will consult with the SAG to confirm these limits and their practical application. ***However, most importantly, this study will provide a concept design of a regional (i.e. catchment-wide) solution that meets the cumulative limits set.*** This will require iterative sizing of elements to meet these objectives.

As well, following the mapping of flood risk in the catchment for the existing case, there is likely to be opportunities to reduce this existing risk through regional measures. These measures are also to be assessed as 'stretch targets' to improve the current risk profile.

Based on the above, it is expected that there will be a total of four (4) catchment scenarios to be defined for flood risk management:

(1) Existing Case
(2) Fully Developed unmitigated
(3) Fully Developed with mitigation to meet existing case parameters for flooding
(4) Fully Developed with mitigation to address and improve existing flood risk

4.3.3. Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance

Through its development approval process, Council has identified that a lack of suitable compliance (and reporting) requirements creates problems in the design and assessment of developer submissions. WSUD objectives for the catchment must be set for the catchment which consider the following:

- Implementation Guideline No 7 Water Sensitive Urban Design Objectives for Urban Stormwater Management (SEQ Regional Plan 2009–2031).
- Draft State Planning Policy for Healthy Waterways (DERM, 2009) and the associated Queensland Best Practice Environmental Management Guidelines – Urban Stormwater (DERM, 2009)
- Draft PIP (Stormwater) Guidelines
- EPA (Water) 2009 Water Quality Objectives

The guidelines specify the stormwater quality, waterway stability and frequent flow management objectives to be achieved by new urban development. With the release the new SEQ Regional Plan, the objectives are now mandatory.

This study must:
- assess the waterways and associated ecosystems to define whether all of the objectives apply (stormwater quality is mandatory)
- confirm whether the regional policy objectives are appropriate
- define a compliance methodology for each objective

The compliance methods must consider work that Council is currently undertaking in defining compliance methods and any information available through Water by Design, other Councils, the State Government or research organisations.

The intent is to define a simple transparent compliance approach for each WSUD objective that can be applied through the development assessment of the study area and the proposed development sites as it develops. The methods should define modeling software, parameter assumptions, post process management and reporting requirements (beyond this project).

The following points are provided to assist with understand the objectives and compliance.

<u>Stormwater quality</u>
It is expected the stormwater quality objectives two levels of objectives will be applied:
- Mandatory discharge criteria at the discharge point of the development sites. The criteria will be consistent with the SEQ Regional Plan (80/60/45) and may includemore stringent targets which can be readily achieved in Ipswich and deliver additional treatment for the protection of Bremer River.
- Comparison criteria at each of the nodes provided in Figure 3:
  - Total suspended solids load
  - Total phosphorus load
  - Total nitrogen load

  This will allow the assessment of the cumulative impact or improvement as a result or new development and retrofit.

Compliance with the stormwater quality management objectives must be illustrated through the use of the MUSIC software. Modeling must be undertaken in Version 4, which is expected to be available in mid September 2010. The MUSIC modeling shall be carried out in accordance with either the *Gold Coast City Council MUSIC Guidelines* or the *SEQ MUSIC Modeling Guideline* (under development by Water by Design).

Waterway stability
Given the current form of the waterways stability objective involves assessment of the 1yr ARI flow, the flood modeling will be used to assess potential changes in waterway stability. The waterway stability objectives will generally follow the flood management objective discussed above and consist of regional objectives at the nodes and individual development discharge objectives.

Frequent Flow
If the frequent flow objective is to apply to the watercourses in the study area, then suitable hydrologic indices must be derived at these nodes to allow assessment of any change in these indices as a result of new development. The consultant will need to determine whether there are discharge objectives for individual developments or regional objectives at the waterway nodes or a combination of both.

4.3.4. Water Quality, Waterway Stability and Frequent Flow Management

The WSUD objectives discussed above will be used to enforce WSUD on new development in the catchment. For the existing urban areas stormwater management retrofit opportunities must be identified conceptually. Suitable detail should be provided for these concepts to allow forward planning and budgeting to occur.

Stormwater quality modelling
To test the performance of the stormwater quality objectives for new development and retrofit in existing urban areas, MUSIC modeling is required as per below:

- Use local rainfall information
- Define pre–development pollutant loads and concentrations (for comparison purposes use both forest, rural residential and agriculture) at the nodes in Figure 3
- Define post–development unmitigated pollutant loads and concentrations at the nodes in Figure 3
- Define post–development mitigated pollutant loads and concentrations for following scenarios at the nodes in Figure 3
- SEQ Regional Plan Implementation Guideline No. 7 objectives (80/60/45)
- Stretch targets to provide a high level of protection to Bremer River (compensate for lack of treatment elsewhere)

This will be an iterative modeling process completed at the same time as the balance of all study actions.

4.4. FLOOD RISK MANAGEMENT

4.4.1. Non-Structural (Flood Warning and Emergency Management)

The Consultant is to assess the existing status of flood warning, emergency management and community preparedness / awareness and provide recommendations for improvements.

Identification of key evacuation routes and upgrade requirements, in terms of formation raising and major cross drainage upgrades to manage floods up to the extreme flood event is required; incorporation of key emergency routes in consultation with stakeholders.

Consultation with SAG is a key element in the provision of these recommendations and mapping.

4.4.2. Non-Structural (Building Local Volunteer Capacity)

The Consultant is to liaise with the local SES to identify opportunities to increase the capacity of services offered by the SES in association with flood risk management. Consultation with SAG is a key element in the provision of these recommendations.

4.4.3. Non-Structural (Development Control)

Identify the extent to which infill, new development and redevelopment may safely occur within the various land use areas under the Ipswich City Council Planning Scheme. Make recommendations regarding the adoption of appropriate resilience measures to be adopted in defined areas and incorporation in mapping of Flood Risk.

Consultation with SAG is a key element in the provision of these recommendations.

4.4.4. Non-Structural (Increasing Community Resilience)

The Consultant is to identify effective measures for increasing community resilience both pre and post flood events. Consultation with SAG is a key element in the provision of these recommendations.

4.4.5. Structural Measures / Drainage System Improvements

Any identified structural floodplain management measures should be assessed and incorporated into the mapping. For consistency in tender comparisons, consultants are to assume five (5) structural floodplain management measures are to be assessed for all five (5) flood events.

Consultation with SAG is a key element in the provision of these recommendations.

4.4.6. Benefit / Cost Assessment of Measures

A benefit-cost assessment for each measure is required. A life–cycle costing which identifies the capital costs and the long–term maintenance costs needs to be identified for each measure.

4.4.7. Flood Risk Management Strategy

Once the conceptual definition of the Flood Risk Management measures have occurred, the consultant will then establish the broad Flood Risk Management Strategy for the study area and the possible development sites. This will involve:

- Confirming conceptual sizes (and associated catchments)
- Identifying locations
- Integrating with flood storage, drainage and development intent.

It is anticipated a number of Flood Risk Management Strategy options will be considered. The consideration of these options will involve, but not be limited to the following:

- Considering development requirements;
- Considering existing vegetation constraints;
- Consideration of existing case risk mapping
- Predevelopment flow regimes;
- Erosion and Sediment Control planning
- Consider any local waterway management plan (if available during the study)
- Flood storage at source or end of pipe
- Integration of WSUD and flood risk management
- Parameters and criteria for ownership, public/private control of assets; whether local assets undertaken by the developer, private assets undertaken by individual property owners, regional assets undertaken by jointly by the developers and council etc.
- capital cost and the on–going operations and maintenance
- Presentation and discussion of options with the Study Advisory Group.

Following discussion with the SAG and agreement on the preferred elements of the strategy, the outcome will be an overall Flood Risk Management Strategy that meets the objectives of the study and supports the intended development.

4.5. DOCUMENTATION

4.5.1. Reporting and Mapping

The consultant shall provide progress reports at critical stages of the study process.

Whilst the format is not rigid, the report shall generally incorporate the items included in this brief along with others that may become apparent during the course of the study. The methodology and findings of the study shall be presented in sufficient detail to support the validity of the conclusions.

Five (5) hard copies of the draft report and an electronic copy compatible with Council's system shall be provided. After review of the draft report by the Study Advisory Group, the Consultant shall undertake any additional work necessary to achieve the final draft for approval by Council (again, allow for five (5) hard and one (1) electronic copies of the final draft report).

Following public exhibition, the consultant will meet with the Study Advisory Group and will be required to address any comments received from the exhibition period. For consistency in tender comparisons, tenderers are to assume 20 hours of work required to address these responses.

Any changes to the draft final report arising out of the public exhibition stage will be incorporated in the Final Report. Ten (10) copies of the final report and one (1) electronic copy will be required. The Consultant will provide visual computer based presentation of findings to the Study Advisory Group at each stage; particularly the flood simulations are required to be presented. The consultant will provide a copy of the visual presentations and any amendment required.

Printing of the final report shall not proceed without the written direction of Council.

The cost of all work associated with preparing all reports and presentations listed above shall be included in the Consultant's fee estimate.

4.5.2. Hand–over of Data

At the completion of the project the Consultant is required to hand–over all data files and provide details of the hardware and software requirements to run the models (documents in hard copy and soft copy, inclusive of hard and electronic raw data files).

The hydrologic and hydraulic software are not required in the hand–over. However, any software developed (including source) or acquired by the Consultant to interface or transfer data between the hydrologic model to the hydraulic model or to pre–process data into a format required for input to these models or post–process data to a required output format is to be supplied to Council as part of the study and Council will retain ownership of data files.

The Consultant is to provide the following documentation at hand–over:

- All gathered survey and aerial photographic data, including DTM model, in MapInfo (Vertical Mapper) format. All project files are to be submitted.

- All model data files, including input and output files. A logical directory structure including modeling log files should be provided [assumptions & treatments within the formal report are to be included]
- A copy of the report text compatible with MS Word and a copy of the report in Adobe pdf along with all figures.

Model data including; catchment and sub–catchment data (including plans), adopted design inflows, recorded flood levels, flow paths, major flood ways, development data and major infrastructures.

Complete model results including; flood heights, flow distributions, velocities, hazard and flood regulation lines for all design events.

All maps requested as listed in the Scope of Works provided in MapInfo format suitable for direct import to Council's GIS system. Each plan should contain as a minimum:

- cadastral boundaries
- significant roads and suburb/district names
- creek names
- overlaid on existing aerial photography.

Council will retain all intellectual property rights to the work undertaken by the Consultant for this project.

5. INFORMATION TO BE SUBMITTED IN PROPOSAL

5.1. METHODOLOGY

The Consultant's proposal for the study shall include the following information:

- A detailed proposal for managing and scoping the necessary surveying and aerial photography tasks
- A detailed proposed study methodology
- Details of the proposed hydraulic modeling system with justification for use in this study
- Details of the additional data collection proposed to be undertaken, and any other matters that the consultant sees as important.
-

5.2. CONSULTANT DETAILS

The proposal is to include details of the study team members experienced in flood studies (and component parts) similar to that outlined in this Specification, along with contact names and telephone numbers of clients.

Other information to be provided includes:

- Structure of the proposed study team, together with roles and responsibilities of team members, and **team member hours and rates for each major task in accordance with the table provided**
- **Brief** Curriculum Vitae of nominated team members including details of experience in **similar projects** and experience with the proposed models
- Details of any sub–consultants to be used, associated nominated staff and their experience
- Quality Assurance, Public Liability, Professional Indemnity Insurance details.
-
- Where the Consultant proposes to change staff undertaking work on the project, such changes must be preapproved by the Study Manager.
-

5.3. FEES

The principle to be observed is that the Consultant's proposal must identify with clarity, certainty and detail the scope of total payments to be made and received under the Contract.

The fee shall be on a lump sum basis to carry out all work required in completing the study in accordance with the specification. Payment is to be distributed over the duration of the project, with 10% of total fees retained until satisfactory completion of the final report.

A quotation for the project is to be presented and based on the identified activities, designated hourly rates for the nominated project team members and estimated time inputs for:

- Nominated members of the project team
- Support staff
- Sub–consultants

All costs, but particularly the unit costs for team members, are to be those, which currently apply. Cost items not identified in the proposal will not be allowed in the final contract. These charge–out rates shall also apply for any additional work.

A Draft Schedule of Prices and Rates is attached to the Brief for information. The consultant is required to submit a Schedule of Prices and Rates to truly reflect the work being undertaken and its cost components. The Schedule must at least include items which may be subjected to Variation as outlined in the brief and unit rates for staff undertaking the brief. The Schedule will be used to evaluate any variations to the brief which may be issued by Council. (Note that any variation must be authorized in writing by the Study Manager before being undertaken)

5.4. PROGRAM

The Consultant shall provide a program in the form of a 'time line' showing the major tasks of the study and the relationship between them. Also required are the timing, duration and completion dates of major tasks of the study.

5.5. QUALITY ASSURANCE AND INSURANCE

Details of the Consultant's Quality Assurance system and how this system will be applied to the study are to be provided in the proposal.

The successful consultant is required to hold no less than $5 million professional indemnity and $20 million public liability insurances, and certificates of currency should be provided with the proposal.

5.6. CONFIDENTIALITY

The subject matter and the nature of the outputs are sensitive and subject to a number of variables. As has been seen recently with flood some studies, the material and outcomes of these studies can be the subject of wide interpretation and debate. The consultant is to keep the study and findings confidential and is to deal through the Study Manager only. Language and expression in the report shall be soundly based and have due regard to community sensitivities.

6. SUBMISSION OF PROPOSALS

Proposals are to be submitted in a sealed envelope clearly marked "Thagoona Catchments Flood Study Quotation 10-11-052" and placed in the tender box located at Council Chambers, prior to 2:00 pm on Tuesday, 7th September 2010.

7. ASSESSMENT OF THE PROPOSAL

Council will assess the proposals received on the merits of the individual proposals.

As a guide only, Council will assign weightings for each of the following categories:

- Price
- Methodology
- Allocation and Experience of relevant staff
- Management Experience and QA

Table 1: Schedule of Prices and Rates (Excl of GST)

Brief Item	Description	Quantity & Rate	Amount ($)
4.1.	**DATA COMPILATION**		
4.1.1.	Meetings with Stakeholders		
4.1.2.	Data Collation (Existing Data)		
4.1.3.	Development Planning		
4.1.4.	Rainfall Data for Flood Modelling		
4.1.5.	Rainfall Data for Stormwater Management Modelling (MUSIC)		
4.1.6.	Acquisition of Additional Data		
4.1.7.	Site Inspections		
4.2.	**FLOOD STUDY**		
4.2.1.	Digital Terrain Model		
4.2.2.	Resident Flood Survey		
4.2.3.	Hydrological Modelling		
4.2.4.	Hydraulic Modelling		
4.2.5.	Calibration, Verification and Sensitivity of Models		
4.2.6.	Community Session on Calibration / Verification of Flood Models		
4.2.7.	Definition of Existing Flood Behaviour		
4.2.8.	Flood Risk Assessment		
4.2.9.	Definition of Developed Case Flood Behaviour (Unmitigated)		
4.3.	**INTEGRATED WATER MANAGEMENT**		
4.3.1.	Integrated Water Management Objectives		
4.3.2.	Flood Risk Management Objectives and Compliance		
4.3.3.	Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance		
4.3.4.	Water Quality, Waterway Stability and Frequent Flow Management		
4.4.	**FLOOD RISK MANAGEMENT**		
4.4.1.	Non-Structural (Flood Warning and Emergency Management)		
4.4.2.	Non-Structural (Building Local Volunteer Capacity)		
4.4.3.	Non-Structural (Development Control)		
4.4.4.	Non-Structural (Increasing Community Resilience)		
4.4.5.	Structural Measures / Drainage System Improvements		
4.4.6.	Benefit / Cost Assessment of Measures		
4.4.7.	Flood Risk Management Strategy		
4.5.	**DOCUMENTATION**		
4.5.1.	Reporting and Mapping		
4.5.2.	Hand–over of Data		
	Additional Items		
	TOTAL		
OPTIONAL/CONTINGENT ITEMS			
(Not included in Total Cost of Proposal – any to be identified by tenderer)			
	(a) Additional SAG Meeting (attendance and preparation)		

Table 2: Schedule of Time Allocations

Brief Item	Description	Team Member Time & Rate	Amount ($)
4.1.	**DATA COMPILATION**		
4.1.1.	Meetings with Stakeholders		
4.1.2.	Data Collation (Existing Data)		
4.1.3.	Development Planning		
4.1.4.	Rainfall Data for Flood Modelling		
4.1.5.	Rainfall Data for Stormwater Management Modelling (MUSIC)		
4.1.6.	Acquisition of Additional Data		
4.1.7.	Site Inspections		
4.2.	**FLOOD STUDY**		
4.2.1.	Digital Terrain Model		
4.2.2.	Resident Flood Survey		
4.2.3.	Hydrological Modelling		
4.2.4.	Hydraulic Modelling		
4.2.5.	Calibration, Verification and Sensitivity of Models		
4.2.6.	Community Session on Calibration / Verification of Flood Models		
4.2.7.	Definition of Existing Flood Behaviour		
4.2.8.	Flood Risk Assessment		
4.2.9.	Definition of Developed Case Flood Behaviour (Unmitigated)		
4.3.	**INTEGRATED WATER MANAGEMENT**		
4.3.1.	Integrated Water Management Objectives		
4.3.2.	Flood Risk Management Objectives and Compliance		
4.3.3.	Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance		
4.3.4.	Water Quality, Waterway Stability and Frequent Flow Management		
4.4.	**FLOOD RISK MANAGEMENT**		
4.4.1.	Non-Structural (Flood Warning and Emergency Management)		
4.4.2.	Non-Structural (Building Local Volunteer Capacity)		
4.4.3.	Non-Structural (Development Control)		
4.4.4.	Non-Structural (Increasing Community Resilience)		
4.4.5.	Structural Measures / Drainage System Improvements		
4.4.6.	Benefit / Cost Assessment of Measures		
4.4.7.	Flood Risk Management Strategy		
4.5.	**DOCUMENTATION**		
4.5.1.	Reporting and Mapping		
4.5.2.	Hand–over of Data		
	Additional Items		
	TOTAL		
OPTIONAL/CONTINGENT ITEMS			
(Not included in Total Cost of Proposal – any to be identified by tenderer)			
	(a) Additional SAG Meeting (attendance and preparation)		

City of Ipswich

Deebing Creek Catchment Flood Study

and

Flood Risk Management Plan

BRIEF for Quotation RFQ #10-11-XXX

Issued for Procurement – September 2010

Table of Contents

1. INTRODUCTION

The Ipswich region is undergoing significant change. The South East Queensland Regional Plan identifies a number of large-scale greenfield development areas which will support some of the population growth in South East Queensland.

A number of these development areas are located in the Deebing Creek catchment (as identified in the 2006 Ipswich Planning Scheme). Specifically, the proposed new township of Ripley Valley partially lies in the Deebing Creek catchment and floodplain. Ripley Valley will be home to over 120,000 people, housing 10% of South East Queensland's population growth over the next 20 years. An estimated 50,000 homes will be developed in the Ripley Valley at time of ultimate development.

Land within the catchments has been identified as suitable for the development in the Ipswich City Planning Scheme. Council is taking an active role in the planning for the study area in conjunction with developers. In order to facilitate acceptable planning outcomes, it is important to accurately define the various constraints impacting the land.

There are also existing flood risks in the catchment, specifically in the currently developed areas. The management of these risks will also be a focus of this study.

A primary objective of the study is to increase the resilience to flooding of the community within the Deebing Creek catchment. This will be achieved through the following tasks:

1) Define the existing catchments and the drainage & flooding behavior, flood risk and constraints of the study area
2) Define the direction, location and hazard for all overland flow paths in the urbanised areas
3) Identify resilience opportunities
4) Identify the impacts of proposed developments on drainage and flooding (quantity and quality).
5) Identify flood risk management best practice, regulation and opportunities for the study area
6) Identify the potential impacts on water quality and aquatic ecology within the study area
7) Establish integrated water management objectives and design parameters for the study area
8) Identify flood risk management measures to achieve the objectives including mapping flood levels suitable for development control and capacity building of the local volunteer resources
9) In association with Council, establish a flood risk management strategy for the study area (strategies, devices, timing, cost etc)
10) Gain agreement on this conceptual design of the flood risk management strategy from Council
11) Document findings within an agreed timeframe.

This study is aimed at meeting these purposes, specifically defining the extent of flooding impacts and flood risk management within the catchment. As well, the study is focused on developing resilience and mitigation measures which can be incorporated into development proposals and future stormwater / flooding infrastructure works among other related Councils interests.

A primary objective is the development of a Flood Risk Management Plan which will provide the basis for Council's ongoing response to flood management issues in the study area.

2. STUDY AREA

The catchment of Deebing Creek is shown in Figures 1 and 2. The catchment has two distinct areas. The downstream, northern area is largely developed. The upstream, southern area is largely undeveloped with a large portion of this area proposed for future development.

The catchment includes the smaller catchment of the Edward Street area (see Figure 1). The flood risk management of this sub-catchment has been assessed as part of a study commissioned by Council in 2009 (due for completion in October 2010).

The catchment drains to directly to the Bremer River.

The planning scheme as it relates to this catchment is shown in Figure 3.

Figure 1: Deebing Creek Catchment (Street Map Background)

Figure 2: Deebing Creek Catchment (Aerial Background)

Figure 3: Planning Scheme

3. STUDY ELEMENTS

3.1. STUDY TASKS

The study will comprise of six (6) main tasks, each with numerous sub–tasks.

1. Data Compilation

- Meetings with Study Advisory Group.
- Data Collation (Existing Data)
- Site Inspections
- Rainfall Data for Flood Modeling
- Rainfall Data for Stormwater Management Modeling (MUSIC)
- Identification and Acquisition of Additional Data

2. Flood Study

- Define Flood Management Objectives
- Digital Terrain Model
- Resident Flood Survey
- Hydrological Modeling
- Hydraulic Modeling
- Calibration, Verification and Sensitivity of Models
- Community Briefing Session on Calibration / Verification of Flood Models
- Definition of Existing Flood Behavior
- Flood Risk Assessment
- Definition of Developed Case Flood Behavior (Unmitigated)

3. Water Sensitive Urban Design

- Define WSUD Objectives
- Water Conservation (Queensland Development Code, other regulations and Policies)
- Define Compliance Methods
- Stormwater Quality Modeling Overview
- Simulation of Existing and Developed (Unmitigated) Cases
-

4. Integrated Water Management Compliance

- Define Integrated Water Management Objectives and Compliance
- Flood Risk Management Objectives and Compliance
- Water Quality, Waterway Stability and Frequent Flow Management

5. Flood Risk Management

- Non-Structural (Flood Warning and Emergency Management)
- Non-Structural (Building Local Volunteer Capacity)
- Non-Structural (Development Control)
- Non-Structural (Increasing Community Resilience Pre and Post Flood Events)
- Resilience Measures
- Structural Measures / Drainage System Improvements
- Benefit / Cost Assessment of Measures
- Flood Risk Management Strategy

6. Documentation

- Meetings with Study Advisory Group
- Interim Report and Maps
- Final Report and Mapping
- Handover of Data

3.2. STUDY MANAGEMENT

The study will be managed by the Study Manager (the Engineering Services Principal Engineer, Hydraulics or nominated delegate). The Study Manager will be responsible, with the Consultant, for delivery of the project.

The study manager and consultant will be assisted by a small Study Advisory Group (SAG) which will be available to assist in facilitation and delivery of the Project.

The Study Advisory Group

The Study Advisory Group will be chaired by Engineering Services and consist of representatives from

- ICC Staff – Representatives from Engineering Services, Planning and Development, Health, Parks and Recreation and Risk Management
- Division Councilor(s) representing existing residents and ratepayers in the study area. The Chair of the Works Committee will also be invited to attend as available.
- SES Representative

Other representatives as considered appointed by the Study Manager.

The SAG will assist in the flow of information to existing ratepayers, assist and advise as appropriate to ensure that the study objectives are delivered, assist the integration of the study findings with Council's (development) objectives, assist to ensure that the study recommendations are achievable within known constraints and that the adopted delivery milestones are have a realistic timeframe.

The Consultant will attend all Study Advisory Group meetings (unless otherwise advised) and provide a presentation on the progress and findings of the study.

The consultant will provide the Study Manage with draft meeting minutes for discussion before circulation by the Study Manager. The consultant will indicate the number of SAG meetings allowed for in the quotation.

4. SCOPE OF WORK

The Consultant shall provide all services required to satisfy the objectives and true intent of the study. The services shall include, but not necessarily be limited to, the following tasks.

An indication of the scope of works for each stage is listed in the following sections.

4.1. DATA COMPILATION

4.1.1. Meetings with Study Advisory Group

The Consultant should use meetings of the Study Advisory Group as a resource for assisting in gathering and providing data for the study. In this respect the consultant needs to identify, at the initial Study Advisory Group meeting, data being collected and any data requests from the Study Advisory Group. The consultant should allow costing for preparation and attendance at five (5) SAG meetings.

4.1.2. Data Collation (Existing Data)

The Consultant is to collect, compile and assess all relevant data and previous studies in the study area. In addition, the Consultant is to identify and propose further data collection to Council if and as required.

The following information will be made available to the successful consultant:

- Ipswich City Council Planning Scheme and Maps (MapInfo)
- 2009 ALS data (.asc format in MGA94 Zone 56) [subject to availability within the timeframe of the study]
- 2007 photogrammetry (3D DXF format in MGA94 Zone 56)
- 2007 aerial photography (ecw format and seamless mosaic in MapInfo)
- Numerous MapInfo layers for area from Council (see images below)
- Information available on infrastructure and levels.
- ICC Waterway Healthy Strategy 2009

GIS_Bridges.TAB	Overlay_Maps
GIS_Buildings.TAB	!Overlay_Maker
GIS_Detention_Basins.TAB	!Overlay_Output
GIS_Easements.TAB	Character_Places
GIS_House_Numbers.TAB	OV01_Bushfire_Risk_Area
GIS_Open_Drains.TAB	OV02_Key_Resource_Areas
GIS_Open_Drains_Invert.TAB	OV03_Mining_Buffer
GIS_Property_DCDB.TAB	OV04_Difficult_Topography
GIS_Property_Survey.TAB	OV05_Flooding
GIS_Railway_Lines.TAB	OV06_Highway_Buffer
GIS_rivers.TAB	OV07A_Defence_Area_Control
GIS_Road_Kerbs.TAB	OV07B_Operational_Airspace
GIS_Road_Medians.TAB	OV07C_Anef
GIS_Road_Names.TAB	OV07D_Explosive_Storage
GIS_Roads_DCDB.TAB	OV07D_Public_Safety_Area_Buffer
GIS_Stormwater_Mains.TAB	OV07D_Purga_Rifle_Range_Buffer
GIS_Stormwater_Pits.TAB	OV07E_Unexploded_Ordnance
GIS_Survey_Historic.TAB	OV08_Motor_Sport_Buffer
GIS_Water_Fittings.TAB	OV09_Wastewater_Treatment
GIS_Water_Mains.TAB	OV10_Swanbank_Power_Station
GIS_Water_Pump_Stations.TAB	OV11_Oil_Gas
GIS_Water_Reservoirs.TAB	OV12_Warrill_Creek_Water
GIS_Water_Structure.TAB	OV13_High_Voltage_Electricity
	OV14_Rail_Noise_Buffer

Table 1 MapInfo Table Listing

4.1.3. Development Planning

Developments are currently being delivered in the catchment. The developments are at various stages in planning, development application, approval and construction. Flood management and stormwater management features have been proposed for these sites and approved. The successful consultant must complete the following in consultation with Council:

- Review of planning scheme to understand extent proposed development (see previous task).
- Review the current state of development applications and approvals with Council to understand development extent, flood management and stormwater management within these developments. Relevant details of the proposed flood and stormwater management features will need to be obtained.
- Map the findings of the above activities for inclusion in the modeling and conceptual design.

4.1.4. Rainfall Data for Flood Modeling

The successful consultant is responsible for the collection of appropriate rainfall data to assist in the calibration and verification of the flood models.

There are some rainfall gauges in and around the catchment of the study area. There are rainfall gauges at least five pluviograph (ALERT) stations near the edges of the catchments.

4.1.5. Rainfall Data for Stormwater Management Modeling (MUSIC)

The BoM ALERT stations will be reviewed to identify a suitable length of rainfall for stormwater management modeling (MUSIC).

It is Council's preference to have a 10 year period of 6 minute rainfall which is representative of the long term rainfall average in the region of the site. If this is not possible, then a suitable substitute must be presented to Council with justification.

4.1.6. Acquisition of Additional Data

If, during the course of the study, it becomes necessary to acquire additional data, including survey, and it can be shown that the need could not have been reasonably anticipated prior to submission of quotations, the Consultant can submit to Council a brief outlining details of the data required, together with a firm quotation for the cost and timing of the work.

Following receipt of written approval by Council, the Consultant may undertake the additional data collection.

Council reserves the right to undertake any survey component in response to the Consultant's Brief.

4.1.7. Site Inspections

Site inspection(s) are to be completed by the consultant team to gain information for the Flood Study. The proposal should outline the objectives of the site inspection(s) and who will attend the site inspection(s). Relevant members of the Study Advisory Group may accompany the consultant team.

Importantly the site inspection needs to identify important ecosystems within the waterway which might be sensitive to changes in frequent flow. This will assist with assessing whether the frequent flow objective needs to be applied to these catchments.

4.2. FLOOD STUDY

4.2.1. Digital Terrain Model

A topographic survey and development of a Digital Terrain Model (DTM) using remote sensing data (i.e. 2007 photogrammetry and 2009 ALS) of the study area will be required to meet the study objectives.

The successful consultant will be responsible for developing the required DTM's from the supplied photogrammetry and ALS data.

Additional survey information of structures such as culverts and road levels will be provided by Council in 12d and MapInfo format.

4.2.2. Resident Flood Survey

The consultant will be responsible for consulting with the community to obtain historical flood data. Specifically, the recent events of November 2008 and May 2009 resulted in inundation of study area.

The objectives of this element are as follows:
- Ensure the community is informed of the study and its objectives
- Enable the community to provide input on historical flood behaviour and possible floodplain management measures
- Increase the knowledge of the SES volunteers in historical flooding behaviour
- Identify to the community that local councilor(s) will be the ongoing conduit between the community and the Study Advisory Group
- Provide an initial input from the community to the Study Advisory Group.

The proposal is to clearly describe how this survey will be carried out. The consultant is to manage the process including development of consultation material and collation of responses. However, the consultant will use SES resources (staff and vehicles) to carry out the face-to-face interviews of residents with flood level information.

Hence, the consultant costs should include the management of the process. Council will negotiate and agreed SES costs associated with the project directly with the SES.

Survey of the flood marks will be carried out by Council. Council will also bear the costs of distribution (e.g postage) of any consultation material.

The Consultant is required to communicate the results of the resident flood survey back to the community. The consultant is to provide details of how it is intended to undertake this communication. The final determination of the communication requirements will be determined in consultation with the Study Advisory Group.

4.2.3. Hydrological Modeling

A hydrologic model of the catchment will be created that will provide suitable inputs to the hydraulic model. The choice of hydrological model must be supported in the proposal.

Details of proposed calibration methodology must be provided. To assist in this process, ICC has undertaken the collection of flood information from historic data and in particular the most recent flood events.

As an additional check, the hydrologic model will also be checked against the Rational Method. The Consultant may propose additional optional calibration methods for consideration.

A joint calibration of the hydrological and hydraulic models will be required.

Flood Modeling will consider a wide range of events with average recurrence intervals (ARI) of 5, 20 and 100 years as well as the 500 years and the extreme event (i.e. PMF). In addition, a simulation of the 100 year ARI with increased rainfall estimates to represent potential climate change effects (due to the Enhanced Greenhouse Effect) is required to be modeled.

Modeling of other frequencies (e.g. 1 year ARI) will be required for water quality purposes and frequent flow analysis.

4.2.4. Hydraulic Modeling

Model Design and Selection

The Consultant shall nominate hydraulic modeling techniques and appropriate commercially available models to be used. The selection should be based on the hydraulic characteristics of the system, the boundary conditions and the requirements of the study. The hydraulic model(s) used need to be suitable for the type, nature and scale of the modelling. It is important that the design and layout of the models shall also be suitable for future testing of development proposals and floodplain measures.

Full two–dimensional (2D) or a combination of a 1D and full 2D modeling in a nested configuration is required. Numerous grid sizes may be required to adequately model the study area's hydraulic features.

An overview of the model selection and design process should be provided in the proposal, which should address in detail the following issues:

- The grid spacing of the model, its relationship to the topographical terrain and the ability to vary the grid pattern and size, to suit the hydraulics in situations such as flow through culvert, bridges, over road embankments, between buildings and over levees.
- The process used to link the 2D domain to the 1D network.
- The representation of the flow distribution along model boundaries (upstream and downstream).
- The simulation of the principal characteristics of the flow across/through road embankments. Where required it should be able to accurately calculate flow through a culvert or bridge and

the concurrent weir flow over an embankment. In this respect the model should be able to simulate pressure or orifice flow through the culvert or bridge.

- The representation of all flows in the drainage network.
- The ability of the model to represent overland flowpaths.
- Calibration of flood level and the realistic modeling of velocity magnitudes and direction.
- The quality and format of model output including the capability to present 1D results (levels, depths, velocities) in conjunction with 2D results (both in plan view and as in animations).

The concurrence of Council is required in relation to the selection and design of the models.

Model Development

The hydraulic model will be developed using the Digital Terrain Model and any other data collected. The proposal will describe the methodology to be used to develop the model including:

1) Model Geometry:
   a) bridge and culvert structures
   b) weirs
   c) culvert blockage
   d) floodplain embankments
   e) hydraulic roughness (2D and 1D)
   f) allowance for future infrastructure needs [eg ultimate road network, waterway and floodplain configurations]

2) Model Boundaries
   a) catchment inflows
   b) floodplain inflows
   c) downstream boundary conditions

3) Model Structure:
   a) 2D/1D interaction
   b) Eddy viscosity representation

Council will require that the Consultant provide for visual display of model findings. (In this regard it is advised that Council has an existing license for WaterRide).

4.2.5. Calibration of Models

There is likely to be limited historical flood information available within this study area. However, the recent flood events of November 2008 and May 2009 may provide good and recent flood data for the purposes of calibration and verification.

As described in previous sections, the consultant will be responsible for consulting with the community to obtain historical flood data. The methodology for this task is to be described in the proposal as part of the Resident Flood Survey.

The hydrological model and the hydraulic model should be calibrated to one event. A further event should be chosen during the study for verification.

A report on the modeling tasks up to the point of calibration / verification will be presented to the Study Advisory Group. This report will document all data collation, model development, model calibration and verification tasks to a standard suitable for the final report.

This stage in the study is a milestone and a hold point. The Study Advisory Group will review this report. The Project Manager will advise if further work is required on the calibration to improve the quality and/or whether the model is suitable for use in subsequent stages of the study. Any request for variation to payment will not be considered unless it can be demonstrated that the requirement for the additional work was not due to a lack of quality of the calibration, sub–standard work or the requirement of the Study Manager was could not reasonably have been anticipated.

4.2.6. Community Session on Calibration / Verification of Flood Models

Following acceptance of the model calibration and verification process, the consultant will organise and conduct, in association with the Division Councillor and other members of the Study Advisory Group, a community information session to present these interim findings. The session will provide the community with an opportunity to view the flood model calibration and verification results.

The objective of the community session is to:

- Obtain any additional community input into the model development / performance
- Inform the community of the model's performance in replicating actual flood events.
- The Consultant is to outline proposals to achieve this requirement.

4.2.7. Definition of Existing Flood Behavior

Design Events

For the purposes of this study, flood design floods shall include the 1, 5, 20 and 100 year ARI events. Additionally, the 500 year and an extreme event (representing an estimate of the Probable Maximum Flood) shall also be simulated.

In addition, the 100 year ARI with increased rainfall estimates to represent potential climate change effects (due to the Enhanced Greenhouse Effect) shall be simulated.

Hence, there are a total of seven (7) flood events to be finally simulated.

The Consultant shall modify the calibrated models as necessary to represent accurately the existing and developed catchment and floodplain conditions.

The Consultant shall establish the inputs to the models of design events, including:

- Design hydrographs
- Downstream boundary conditions .

- Boundary conditions are to be established following discussion with the Project Manager.

The modeling of design events shall be undertaken for a range of storm durations to ensure that the critical event(s) are identified over the full area of the hydraulic model. For consistency in tender comparisons, consultants are to assume three (3) critical durations are required.

Alternatively, the consultant can propose the development of a synthetic temporal pattern that envelope the short duration events within longer duration events. This would enable a single duration to be used. The consultant shall clearly nominate any such proposals in the submission.

The Consultant shall liaise with Council in relation to the definition of existing conditions, the selection of design inputs to the model and adoption of design results.

The consultant shall incorporate the requirements of Council's Development Guidelines, with sensitivity testing on the effect of blockage factors for closed conduits, bridges and culverts. This shall be carried out for the two (2) 100 year ARI events only.

Hence, a total of 21 design flood events are required (6 ARI events for 3 durations for existing catchment/floodplain states with blocked culverts for 100 year ARI).

The modeling results shall be checked using alternative methods, including checking of head losses at bridges and culverts by an alternative hydraulic method (e.g. HEC–RAS).

Maps of peak flood levels, flows, velocities, and depths (as an envelope of both durations) are to be provided for each of the six (6) ARI flood events. As well, maps of durations that results in the peak levels in the envelope are to be produced for the six (6) events.

Hence, as a minimum, a total of 36 flood maps are required as both A3 figures and in digital GIS format and to be displayed visually. [The consultant is required to undertake all necessary work, including additional simulations, leading to finalization of these maps, figures and visual presentations]

Modelling of the 1 year ARI storm allows assessment of the waterway stability objective (see Section 4.3.1).

Verification to Regional Flood Frequency Analysis

The peak flows at four (4) locations in the catchment derived from the hydraulic model results will be compared with the results from a Regional Flood Frequency analysis to be provided by Council. Any significant discrepancies (i.e. more than 20%) will need to be explored. Changes to the model may be required to meet the Regional Flood Frequency analysis results.

Sensitivity Analyses

Sensitivity analyses shall be carried out to assess the effects of changing model parameter values and design inputs on the results. The principal parameters are those simulating friction, energy and debris losses at culverts, bridges and other structures. These values shall be based on sound documented assumptions and agreed with Council prior to design event modeling work commencing.

For consistency in tender comparisons, tenderers are to assume ten (10) simulations of the 100 year ARI event are required to assess these sensitivities.

4.2.8. Flood Risk Assessment

Mapping of Flood Risk

Maps of Flood Risks (low, medium and high) should also be created [SCARM Report 73 (CSIRO, 2000) and EMA Manuals etc] based on:
- Velocity of flow and depth of inundation;
- Hazard;
- Ground and floor levels;
- Flood warning time and duration of flooding;
- Suitability of evacuation and access routes; and
- Emergency management during major floods.

Flood Hazard Categorisation

The Consultant should provide a description of the nature of flooding for the full range of potential floods in the study area. A flood hazard categorisation is to be carried out for the existing level of development, and areas identified for future development, in accordance with the classifications outlined in CSIRO SCARM National Guidelines and EMA Manuals. Flood hazard is to be assessed over the full range of assessed flood events.

Hence, a total of five (5) flood hazard maps are required as both A3 figures and in digital GIS format.

Flood Damages Assessment

A flood damages assessment is to be carried out that quantifies the total direct and indirect flood damages for the study area. Floor levels will either be surveyed (as an additional cost to this study) or based on assumptions from other data.

Identification of Existing Flooding Issues in Catchment

Based on the definition of existing flooding behavior and flood risk described above, the consultant will identify the existing flooding issues within the catchment. These will be described both qualitatively and quantitatively.

4.2.9. Definition of Developed Case Flood Behavior (Unmitigated)

There are numerous developments proposed in the catchment. The flood model (hydrological and hydraulic) is to be adapted to represent the catchment areas with full development (as per the planning scheme).

The development will be initially simulated without mitigation measures. Simulations are to be carried out for the same 21 design flood events for the existing case.

Impact maps of levels are to be produced for each event. As well, maps demonstrating the changes in peak flows, specifically downstream of the development site(s), are to be produced. Specific focus should fall on impacts to areas of high risk (existing case) identified in the flood risk assessment.

4.3. INTEGRATED WATER MANAGEMENT

4.3.1. Integrated Water Management Objectives

Council is proposing an innovative approach to managing and controlling the impact of development on the water quality, waterway stability and flood behaviour of the catchment. Previous attempts at development control and regulation have been focused on compliance at the outlet of the development site. A compliant solution under this approach can lead to adverse changes in flood and waterway behaviour at downstream locations (e.g. due to changes in flood peak timing). Objectives for the following are to be defined:

- Flood management
- Stormwater quality
- Waterways stability
- Frequent flow

Flood management objectives
The flood management of the catchment is to be focused on maintaining flood behaviour at a network of nodes throughout the catchment. The indicative number and locations of these nodes are shown in Figure 4.

The following parameters will be considered and assessed at the node locations for management of flooding.

- Peak flood levels
- Peak flood flows
- Duration of flood inundation
- Rate of floodwater rise
- Rate of floodwater recession
- Timing of flood peak
- Flood event volume

Stormwater quality, waterways stability and frequent flow objectives
The integrated water cycle management strategy for study area must be informed by the requirements of the downstream ecosystem and current legislative requirements. The requirements must be quantified in the form of WSUD objectives. Refer Section 4.3.3 for details.

Figure 4: Indicative Control Nodes

4.3.2. Flood Risk Management Objectives and Compliance

The flood parameters listed above will form the basis of compliance for development assessments throughout the catchment. The compliance process will require setting of limits for these parameters at the nodes. The study will provide the basis and detail associated with the setting of these limits

Some of the limits will be based on the existing case values. This will be mainly true for the flooding parameters (e.g. peak levels, flows etc). Hence, for example, the study may recommend that for all development in the catchment (cumulatively):

- Peak flood levels cannot increase by more than 50mm above the existing case values;
- Peak flows cannot increase by more than 5% above the existing case values;
- Duration of flood inundation cannot increase by more than 5% above the existing case values at all 'whole' mAHD values (e.g. 4.0mAHD, 5.0mAHD, 6.0mAHD etc);

At an individual development scale, each development will be constrained to stricter limits in order to ensure that the cumulative minor increases listed above are achievable. It is envisaged that individual developments would be limited to increases that are approximately 20% of the cumulative increases listed above. Hence, for example, for an individual development:

- Peak flood levels cannot increase by more than 10mm above the existing case values;
- Peak flows cannot increase by more than 1% above the existing case values;
- Duration of flood inundation cannot increase by more than 1% above the existing case values at all 'whole' mAHD values (e.g. 4.0mAHD, 5.0mAHD, 6.0mAHD etc);

This study will consult with the SAG to confirm these limits and their practical application. ***However, most importantly, this study will provide a concept design of a regional (i.e. catchment-wide) solution that meets the cumulative limits set.*** This will require iterative sizing of elements to meet these objectives.

As well, following the mapping of flood risk in the catchment for the existing case, there is likely to be opportunities to reduce this existing risk through regional measures. These measures are also to be assessed as 'stretch targets' to improve the current risk profile.

Based on the above, it is expected that there will be a total of four (4) catchment scenarios to be defined for flood risk management:

(1) Existing Case
(2) Fully Developed unmitigated
(3) Fully Developed with mitigation to meet existing case parameters for flooding
(4) Fully Developed with mitigation to address and improve existing flood risk

4.3.3. Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance

Through its development approval process, Council has identified that a lack of suitable compliance (and reporting) requirements creates problems in the design and assessment of developer submissions. WSUD objectives for the catchment must be set for the catchment which consider the following:

- Implementation Guideline No 7 Water Sensitive Urban Design Objectives for Urban Stormwater Management (SEQ Regional Plan 2009–2031).
- Draft State Planning Policy for Healthy Waterways (DERM, 2009) and the associated Queensland Best Practice Environmental Management Guidelines – Urban Stormwater (DERM, 2009)
- Draft PIP (Stormwater) Guidelines
- EPA (Water) 2009 Water Quality Objectives

The guidelines specify the stormwater quality, waterway stability and frequent flow management objectives to be achieved by new urban development. With the release the new SEQ Regional Plan, the objectives are now mandatory.

This study must:

- assess the waterways and associated ecosystems to define whether all of the objectives apply (stormwater quality is mandatory)
- confirm whether the regional policy objectives are appropriate
- define a compliance methodology for each objective

The compliance methods must consider work that Council is currently undertaking in defining compliance methods and any information available through Water by Design, other Councils, the State Government or research organisations.

The intent is to define a simple transparent compliance approach for each WSUD objective that can be applied through the development assessment of the study area and the proposed development sites as it develops. The methods should define modeling software, parameter assumptions, post process management and reporting requirements (beyond this project).

The following points are provided to assist with understand the objectives and compliance.

<u>Stormwater quality</u>
It is expected the stormwater quality objectives two levels of objectives will be applied:

- Mandatory discharge criteria at the discharge point of the development sites. The criteria will be consistent with the SEQ Regional Plan (80/60/45) and may includemore stringent targets which can be readily achieved in Ipswich and deliver additional treatment for the protection of Bremer River.
- Comparison criteria at each of the nodes provided in Figure 3:
  - Total suspended solids load
  - Total phosphorus load
  - Total nitrogen load

  This will allow the assessment of the cumulative impact or improvement as a result or new development and retrofit.

Compliance with the stormwater quality management objectives must be illustrated through the use of the MUSIC software. Modeling must be undertaken in Version 4, which is expected to be available in mid September 2010. The MUSIC modeling shall be carried out in accordance with either the *Gold Coast City Council MUSIC Guidelines* or the *SEQ MUSIC Modeling Guideline* (under development by Water by Design).

Waterway stability
Given the current form of the waterways stability objective involves assessment of the 1yr ARI flow, the flood modeling will be used to assess potential changes in waterway stability. The waterway stability objectives will generally follow the flood management objective discussed above and consist of regional objectives at the nodes and individual development discharge objectives.

Frequent Flow
If the frequent flow objective is to apply to the watercourses in the study area, then suitable hydrologic indices must be derived at these nodes to allow assessment of any change in these indices as a result of new development. The consultant will need to determine whether there are discharge objectives for individual developments or regional objectives at the waterway nodes or a combination of both.

4.3.4. Water Quality, Waterway Stability and Frequent Flow Management

The WSUD objectives discussed above will be used to enforce WSUD on new development in the catchment. For the existing urban areas stormwater management retrofit opportunities must be identified conceptually. Suitable detail should be provided for these concepts to allow forward planning and budgeting to occur.

Stormwater quality modelling
To test the performance of the stormwater quality objectives for new development and retrofit in existing urban areas, MUSIC modeling is required as per below:

- Use local rainfall information
- Define pre–development pollutant loads and concentrations (for comparison purposes use both forest, rural residential and agriculture) at the nodes in Figure 3
- Define post–development unmitigated pollutant loads and concentrations at the nodes in Figure 3
- Define post–development mitigated pollutant loads and concentrations for following scenarios at the nodes in Figure 3
- SEQ Regional Plan Implementation Guideline No. 7 objectives (80/60/45)
- Stretch targets to provide a high level of protection to Bremer River (compensate for lack of treatment elsewhere)

This will be an iterative modeling process completed at the same time as the balance of all study actions.

4.4. FLOOD RISK MANAGEMENT

4.4.1. Non-Structural (Flood Warning and Emergency Management)

The Consultant is to assess the existing status of flood warning, emergency management and community preparedness / awareness and provide recommendations for improvements.

Identification of key evacuation routes and upgrade requirements, in terms of formation raising and major cross drainage upgrades to manage floods up to the extreme flood event is required; incorporation of key emergency routes in consultation with stakeholders.

Consultation with SAG is a key element in the provision of these recommendations and mapping.

4.4.2. Non-Structural (Building Local Volunteer Capacity)

The Consultant is to liaise with the local SES to identify opportunities to increase the capacity of services offered by the SES in association with flood risk management. Consultation with SAG is a key element in the provision of these recommendations.

4.4.3. Non-Structural (Development Control)

Identify the extent to which infill, new development and redevelopment may safely occur within the various land use areas under the Ipswich City Council Planning Scheme. Make recommendations regarding the adoption of appropriate resilience measures to be adopted in defined areas and incorporation in mapping of Flood Risk.

Consultation with SAG is a key element in the provision of these recommendations.

4.4.4. Non-Structural (Increasing Community Resilience)

The Consultant is to identify effective measures for increasing community resilience both pre and post flood events. Consultation with SAG is a key element in the provision of these recommendations.

4.4.5. Structural Measures / Drainage System Improvements

Any identified structural floodplain management measures should be assessed and incorporated into the mapping. For consistency in tender comparisons, consultants are to assume five (5) structural floodplain management measures are to be assessed for all five (5) flood events.

Consultation with SAG is a key element in the provision of these recommendations.

4.4.6. Benefit / Cost Assessment of Measures

A benefit-cost assessment for each measure is required. A life–cycle costing which identifies the capital costs and the long–term maintenance costs needs to be identified for each measure.

4.4.7. Flood Risk Management Strategy

Once the conceptual definition of the Flood Risk Management measures have occurred, the consultant will then establish the broad Flood Risk Management Strategy for the study area and the possible development sites. This will involve:

- Confirming conceptual sizes (and associated catchments)
- Identifying locations
- Integrating with flood storage, drainage and development intent.

It is anticipated a number of Flood Risk Management Strategy options will be considered. The consideration of these options will involve, but not be limited to the following:

- Considering development requirements;
- Considering existing vegetation constraints;
- Consideration of existing case risk mapping
- Predevelopment flow regimes;
- Erosion and Sediment Control planning
- Consider any local waterway management plan (if available during the study)
- Flood storage at source or end of pipe
- Integration of WSUD and flood risk management
- Parameters and criteria for ownership, public/private control of assets; whether local assets undertaken by the developer, private assets undertaken by individual property owners, regional assets undertaken by jointly by the developers and council etc.
- capital cost and the on–going operations and maintenance
- Presentation and discussion of options with the Study Advisory Group.

Following discussion with the SAG and agreement on the preferred elements of the strategy, the outcome will be an overall Flood Risk Management Strategy that meets the objectives of the study and supports the intended development.

4.5. DOCUMENTATION

4.5.1. Reporting and Mapping

The consultant shall provide progress reports at critical stages of the study process.

Whilst the format is not rigid, the report shall generally incorporate the items included in this brief along with others that may become apparent during the course of the study. The methodology and findings of the study shall be presented in sufficient detail to support the validity of the conclusions.

Five (5) hard copies of the draft report and an electronic copy compatible with Council's system shall be provided. After review of the draft report by the Study Advisory Group, the Consultant shall undertake any additional work necessary to achieve the final draft for approval by Council (again, allow for five (5) hard and one (1) electronic copies of the final draft report).

Following public exhibition, the consultant will meet with the Study Advisory Group and will be required to address any comments received from the exhibition period. For consistency in tender comparisons, tenderers are to assume 20 hours of work required to address these responses.

Any changes to the draft final report arising out of the public exhibition stage will be incorporated in the Final Report. Ten (10) copies of the final report and one (1) electronic copy will be required. The Consultant will provide visual computer based presentation of findings to the Study Advisory Group at each stage; particularly the flood simulations are required to be presented. The consultant will provide a copy of the visual presentations and any amendment required.

Printing of the final report shall not proceed without the written direction of Council.

The cost of all work associated with preparing all reports and presentations listed above shall be included in the Consultant's fee estimate.

4.5.2. Hand–over of Data

At the completion of the project the Consultant is required to hand–over all data files and provide details of the hardware and software requirements to run the models (documents in hard copy and soft copy, inclusive of hard and electronic raw data files).

The hydrologic and hydraulic software are not required in the hand–over. However, any software developed (including source) or acquired by the Consultant to interface or transfer data between the hydrologic model to the hydraulic model or to pre–process data into a format required for input to these models or post–process data to a required output format is to be supplied to Council as part of the study and Council will retain ownership of data files.

The Consultant is to provide the following documentation at hand–over:

- All gathered survey and aerial photographic data, including DTM model, in MapInfo (Vertical Mapper) format. All project files are to be submitted.

- All model data files, including input and output files. A logical directory structure including modeling log files should be provided [assumptions & treatments within the formal report are to be included]
- A copy of the report text compatible with MS Word and a copy of the report in Adobe pdf along with all figures.

Model data including; catchment and sub–catchment data (including plans), adopted design inflows, recorded flood levels, flow paths, major flood ways, development data and major infrastructures.

Complete model results including; flood heights, flow distributions, velocities, hazard and flood regulation lines for all design events.

All maps requested as listed in the Scope of Works provided in MapInfo format suitable for direct import to Council's GIS system. Each plan should contain as a minimum:

- cadastral boundaries
- significant roads and suburb/district names
- creek names
- overlaid on existing aerial photography.

Council will retain all intellectual property rights to the work undertaken by the Consultant for this project.

5. INFORMATION TO BE SUBMITTED IN PROPOSAL

5.1. METHODOLOGY

The Consultant's proposal for the study shall include the following information:

- A detailed proposal for managing and scoping the necessary surveying and aerial photography tasks
- A detailed proposed study methodology
- Details of the proposed hydraulic modeling system with justification for use in this study
- Details of the additional data collection proposed to be undertaken, and any other matters that the consultant sees as important.
-

5.2. CONSULTANT DETAILS

The proposal is to include details of the study team members experienced in flood studies (and component parts) similar to that outlined in this Specification, along with contact names and telephone numbers of clients.

Other information to be provided includes:

- Structure of the proposed study team, together with roles and responsibilities of team members, and **team member hours and rates for each major task in accordance with the table provided**
- **Brief** Curriculum Vitae of nominated team members including details of experience in **similar projects** and experience with the proposed models
- Details of any sub–consultants to be used, associated nominated staff and their experience
- Quality Assurance, Public Liability, Professional Indemnity Insurance details.
-
- Where the Consultant proposes to change staff undertaking work on the project, such changes must be preapproved by the Study Manager.
-

5.3. FEES

The principle to be observed is that the Consultant's proposal must identify with clarity, certainty and detail the scope of total payments to be made and received under the Contract.

The fee shall be on a lump sum basis to carry out all work required in completing the study in accordance with the specification. Payment is to be distributed over the duration of the project, with 10% of total fees retained until satisfactory completion of the final report.

A quotation for the project is to be presented and based on the identified activities, designated hourly rates for the nominated project team members and estimated time inputs for:

- Nominated members of the project team
- Support staff
- Sub–consultants

All costs, but particularly the unit costs for team members, are to be those, which currently apply. Cost items not identified in the proposal will not be allowed in the final contract. These charge–out rates shall also apply for any additional work.

A Draft Schedule of Prices and Rates is attached to the Brief for information. The consultant is required to submit a Schedule of Prices and Rates to truly reflect the work being undertaken and its cost components. The Schedule must at least include items which may be subjected to Variation as outlined in the brief and unit rates for staff undertaking the brief. The Schedule will be used to evaluate any variations to the brief which may be issued by Council. (Note that any variation must be authorized in writing by the Study Manager before being undertaken)

5.4. PROGRAM

The Consultant shall provide a program in the form of a 'time line' showing the major tasks of the study and the relationship between them. Also required are the timing, duration and completion dates of major tasks of the study.

5.5. QUALITY ASSURANCE AND INSURANCE

Details of the Consultant's Quality Assurance system and how this system will be applied to the study are to be provided in the proposal.

The successful consultant is required to hold no less than $5 million professional indemnity and $20 million public liability insurances, and certificates of currency should be provided with the proposal.

5.6. CONFIDENTIALITY

The subject matter and the nature of the outputs are sensitive and subject to a number of variables. As has been seen recently with flood some studies, the material and outcomes of these studies can be the subject of wide interpretation and debate. The consultant is to keep the study and findings confidential and is to deal through the Study Manager only. Language and expression in the report shall be soundly based and have due regard to community sensitivities.

6. SUBMISSION OF PROPOSALS

Proposals are to be submitted in a sealed envelope clearly marked "Deebing Creek Catchment Flood Study Quotation 10-11-052" and placed in the tender box located at Council Chambers, prior to 2:00 pm on Tuesday, X[th] September 2010.

7. ASSESSMENT OF THE PROPOSAL

Council will assess the proposals received on the merits of the individual proposals.

As a guide only, Council will assign weightings for each of the following categories:

- Price
- Methodology
- Allocation and Experience of relevant staff
- Management Experience and QA

Table 1: Schedule of Prices and Rates (Excl of GST)

Brief Item	Description	Quantity & Rate	Amount ($)
4.1.	**DATA COMPILATION**		
4.1.1.	Meetings with Stakeholders		
4.1.2.	Data Collation (Existing Data)		
4.1.3.	Development Planning		
4.1.4.	Rainfall Data for Flood Modelling		
4.1.5.	Rainfall Data for Stormwater Management Modelling (MUSIC)		
4.1.6.	Acquisition of Additional Data		
4.1.7.	Site Inspections		
4.2.	**FLOOD STUDY**		
4.2.1.	Digital Terrain Model		
4.2.2.	Resident Flood Survey		
4.2.3.	Hydrological Modelling		
4.2.4.	Hydraulic Modelling		
4.2.5.	Calibration, Verification and Sensitivity of Models		
4.2.6.	Community Session on Calibration / Verification of Flood Models		
4.2.7.	Definition of Existing Flood Behaviour		
4.2.8.	Flood Risk Assessment		
4.2.9.	Definition of Developed Case Flood Behaviour (Unmitigated)		
4.3.	**INTEGRATED WATER MANAGEMENT**		
4.3.1.	Integrated Water Management Objectives		
4.3.2.	Flood Risk Management Objectives and Compliance		
4.3.3.	Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance		
4.3.4.	Water Quality, Waterway Stability and Frequent Flow Management		
4.4.	**FLOOD RISK MANAGEMENT**		
4.4.1.	Non-Structural (Flood Warning and Emergency Management)		
4.4.2.	Non-Structural (Building Local Volunteer Capacity)		
4.4.3.	Non-Structural (Development Control)		
4.4.4.	Non-Structural (Increasing Community Resilience)		
4.4.5.	Structural Measures / Drainage System Improvements		
4.4.6.	Benefit / Cost Assessment of Measures		
4.4.7.	Flood Risk Management Strategy		
4.5.	**DOCUMENTATION**		
4.5.1.	Reporting and Mapping		
4.5.2.	Hand–over of Data		
	Additional Items		
	TOTAL		
OPTIONAL/CONTINGENT ITEMS			
(Not included in Total Cost of Proposal – any to be identified by tenderer)			
	(a) Additional SAG Meeting (attendance and preparation)		

Table 2: Schedule of Time Allocations

Brief Item	Description	Team Member Time & Rate	Amount ($)
4.1.	**DATA COMPILATION**		
4.1.1.	Meetings with Stakeholders		
4.1.2.	Data Collation (Existing Data)		
4.1.3.	Development Planning		
4.1.4.	Rainfall Data for Flood Modelling		
4.1.5.	Rainfall Data for Stormwater Management Modelling (MUSIC)		
4.1.6.	Acquisition of Additional Data		
4.1.7.	Site Inspections		
4.2.	**FLOOD STUDY**		
4.2.1.	Digital Terrain Model		
4.2.2.	Resident Flood Survey		
4.2.3.	Hydrological Modelling		
4.2.4.	Hydraulic Modelling		
4.2.5.	Calibration, Verification and Sensitivity of Models		
4.2.6.	Community Session on Calibration / Verification of Flood Models		
4.2.7.	Definition of Existing Flood Behaviour		
4.2.8.	Flood Risk Assessment		
4.2.9.	Definition of Developed Case Flood Behaviour (Unmitigated)		
4.3.	**INTEGRATED WATER MANAGEMENT**		
4.3.1.	Integrated Water Management Objectives		
4.3.2.	Flood Risk Management Objectives and Compliance		
4.3.3.	Water Quality, Waterway Stability and Frequent Flow Objectives & Compliance		
4.3.4.	Water Quality, Waterway Stability and Frequent Flow Management		
4.4.	**FLOOD RISK MANAGEMENT**		
4.4.1.	Non-Structural (Flood Warning and Emergency Management)		
4.4.2.	Non-Structural (Building Local Volunteer Capacity)		
4.4.3.	Non-Structural (Development Control)		
4.4.4.	Non-Structural (Increasing Community Resilience)		
4.4.5.	Structural Measures / Drainage System Improvements		
4.4.6.	Benefit / Cost Assessment of Measures		
4.4.7.	Flood Risk Management Strategy		
4.5.	**DOCUMENTATION**		
4.5.1.	Reporting and Mapping		
4.5.2.	Hand–over of Data		
	Additional Items		
	TOTAL		
OPTIONAL/CONTINGENT ITEMS			
(Not included in Total Cost of Proposal – any to be identified by tenderer)			
	(a) Additional SAG Meeting (attendance and preparation)		

Hydraulic Issue	Explanation/elaboration	Relevant Legislation (Planning Scheme Code/SPP/EPA regulation etc) Trigger	Information to be requested/ to be clarified by proponent
Regional Modelling			
Modelling Parameters • **Stormwater Quantity/Hydraulic Parameters – assumptions and omissions**	• In the case of the existing flows detained on-site, it appears that the input parameters have been assumed, with flows and velocities having been calculated to suit a favourable modelling outcome- in other words, a set of parameters have been created to align with the 'desired' outcomes of the modelling results, rather than conventional modelling practice where the input values represent the existing case and solutions are developed based on the outcomes of the true-case modelling. • The design Q's adopted for each of the following cases: Residential (Q2), Commercial (Q10), Overland flow (Q100), and Roads (Q100) have not been justified in the Stormwater Quantity and Quality documentation provided within the Master plans • The modelling for the development has adopted the use of superseded flood inundation lines as a basis for meeting the densities adopted for Ripley Valley. • A velocity of 3m/s has been assumed for all pipe flow – what about the Time of concentration and	*Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code, Part 12, division 3, 12.4.4 (38)a* *Planning Scheme Policy 3- General Works* *Draft Urban Stormwater – Queensland Best Practice Environmental Management Guidelines (BPEM), 2009* *Environmental Protection (Water) Policy 2009 (EPP Water) State Planning Policy: Healthy Waters (SPP Healthy Waters)* *Sustainable Planning Act 2009* *Queensland Urban Drainage Manual NRW 2007* *Environmental Protection Act 1994* *Environmental Protection (Water) Policy 2009 – Schedule 1* *Queensland Water Quality Guidelines 2009* *South-east Queensland Regional Plan 2009-2031* *SEQ Healthy waterways 2006, Water Sensitive Urban Design- developing design objectives for WSUD in SEQ* *Ipswich Planning Scheme Part 15- 15.3.4.section 5 (l) - Functional Valley*	Please state clearly in the Flooding and Stormwater Quality reports the assumptions that have been taken into account prior to the modelling. Of particular importance is the A copy of the Model build files suitable for council to review are requested Please justify the use of the adopted design Q's Please clarify how the adoption of the superseded flood inundation lines is appropriate for this development over the newer flood inundation lines founded by the Bundamba Creek Flood Study (April 2007) Explain why a velocity of 3m/s has been assumed for all pipe flow, and how scouring arising from such velocities will be managed. Also, what is the influence of such high velocities to the Time of Concentration? Explore other calibration methodologies, and

	the scouring issues due to such high velocities? • Calibration of the modelling is solely based on the Rational Method- which, for a development of such size and complexity is not acceptable • no initial losses have been accounted for in the existing case in both the urban core, secondary urban centre east, and Binnies Road areas • There is no documentation of the alpha and beta parameters which would have been used in the model/ model setup • No evidence has been provided regarding sensitivity analysis (how to different sources of variation in the input parameters of the models yield various outcomes). As such, the robustness of the modeling can not be confirmed. • With regards to peak flows, there has been no determination of subsequent flows and of Qflows>Q100 • No details have been provided of the effects of attenuation on flood flows (flood attenuation)		provide a comparison of this prior to selection of the particular methodology upon which the modelling will be based Clarification of initial loss assumptions, including stating whether storage has been assumed as being at full capacity is required Provide the alpha and beta parameters for the model input. A sensitivity analysis is required of the modelling to confirm the outcome is indeed the best possible outcome for the development. Please explain why the runoff hydrographs adopted for all scenarios were the same, with the onus being on the detention basins to attenuate flood levels back to pre-existing conditions
• **Stormwater Quality Modelling Parameters** MUSIC Modelling	• The MUSIC Model has incorporated the use of the 'agricultural node' to represent undeveloped areas/conservation areas of the site, and assumed this land to be completely pervious.	*Draft Urban Stormwater – Queensland Best Practice Environmental Management Guidelines (BPEM), (2009) – Table 2.1b (Water Quality Objectives)* *Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code, Part 12, division 3, 12.4.4 (38)*	Please justify the use of the 'agricultural' node within the MUSIC model and why this is a better representative over, say the Forest node which would have given a better representation of the site's undeveloped areas.

AUS-IFD Rainfall Data MUSIC Model Files	• The MUSIC Modelling has not allowed for rainwater tanks (which are mandatory for all new houses) within the model. • With regards to rainfall – It appears that only one AUS-IFD rainfall curve has been used for the entire catchment area. Given the fact that rainfall patterns can vary within a catchment, the use of only 1 IFD curve to reflect the rainfall of the area is not acceptable. • Limited data regarding the MUSIC Modelling output files have been provided within the submitted documentation	*Ipswich Planning Scheme Policy 3- General Works* *Ipswich Planning Scheme Part 15- 15.3.4.section 5 (I) - Functional Valley* *Environmental Protection (Water) Policy 2009 (EPP Water)* *State Planning Policy: Healthy Waters (SPP Healthy Waters)* *Sustainable Planning Act 2009* *Queensland Urban Drainage Manual NRW 2007* *Environmental Protection Act 1994* *Environmental Protection (Water) Policy 2009 – Schedule 1* *Queensland Water Quality Guidelines 2009* *South-east Queensland Regional Plan 2009-2031* *SEQ Healthy waterways 2006, Water Sensitive Urban Design- developing design objectives for WSUD in SEQ*	Please justify the absence of rainwater tanks within the MUSIC Model Please clarify the approach for the use of the IFD data within the modelling Please provide details of the MUSIC Modelling files for review by council.
Sub-regional Modelling			
• **Detention Basins for Volume control and Stormwater Quality** Detention Basin Strategy	• The provided documents indicate that the Ripley Valley development will contain a number of sub-regional detention basins, with associated stormwater quality improvement devices (via Bioretention systems) for both volume control and stormwater quality treatment purposes. • The detention basins are to be located at the major inflow areas to Bundamba Creek	*Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code, Part 12, division 3, 12.4.4 (38)* *The major drainage system is designed based on the provisions of QUDM and Planning Scheme Policy 3- General Works* *Ipswich Planning Scheme Draft Traditional neighbourhood Design Code, Part 12.3.4.4.BB – non acceptance of increased flows unless part of an approved overall drainage master plan.* *Ipswich Planning Scheme Part 15- 15.3.4.section 5 (I) - Functional Valley* *State Planning Policy 01/03*	Please provide the details of the strategy adopted for Basins within the development, with emphasis on the following: • Demonstrate how the detention basins will be sufficient in meeting the WQO's as well as retaining storm flows without causing adverse effects downstream • Also, with regards to placing bioretention system filters within the basins, clarify as to whether filter media will be tested in-situ, taking into account the dispersive soils. • Demonstrate how the detention basins and WSUD measures within the systems will maintain the existing times of concentration within the sub-

Filling in of the Detention Basins	• Where filling in the detention basins is required, it is found that an increase in the peak flow rate at the point of discharge from the valley occurs due to this.	Hazard Analysis: *State Planning policy 01/03* *Queensland Urban Drainage Manual, 2nd edition 2008*	catchments Increased water flows should not leave a development site unless it is part of an overall approved drainage master plan. If the mitigation of increased flows can not be achieved, compensatory earthworks are required elsewhere within the development site to off-set the increase in flows. Please provide information with regards to the filling of the basins, including the timing of the filling (the phase it occurs at), the depth of filling, and the effects of the filling on peak flow levels downstream.
Hazard Analysis	• Since the development plans indicate the siting of the detention basin infrastructure within open space areas, a Hazards analysis should be considered. This has not been identified within the provided documentation		With regards to hazards and risks associated with the detention basins within the public open space areas, *Ipswich City Council's 'Information councils may request document' Planning Scheme Policy 2* stipulates that: 'If an application involving uses or works which have the potential for environmental harm, safety hazards or risks, information regarding – (a) a hazard vulnerability analysis (b) a hazard and operability (HAZOP) study or other qualitative risk analysis, and/or a quantitative risk assessment (c) that in accordance with the hazard or risk identified, appropriate ameliorative design and environmental management measures have been included in the proposed development in accordance with the relevant Australian Standards or legislation.
Consideration of upstream/adjacent catchment areas	• That sensitivity analysis has not been considered within the modelling, it is not known whether the modelling has addressed the impacts of drainage from foreshadowed developments upstream or surrounding the catchment areas.		The catchment plan should encompass the development itself plus any upstream catchments delivering runoff into the development site and extend sufficiently downstream to indicate a lawful point of discharge for any concentrated or modified flows leaving the site.

• Conservation Areas, Parks and Linear Parks: Green space usage for the siting of Stormwater Infrastructure Detention Basins	• The provided documents indicate that the Ripley Valley Development promotes biodiversity by utilising 50% of the development area as Green space. The Green space is to be used for sports fields/ recreational parks/ pedestrian and cycle paths. • Stormwater management measures including detention basins and wetlands are indicated as being accommodated within the open space areas and the primary corridor along Bundamba Creek will be subject to rehabilitation in accordance with the proposed Bundamba Creek Management Study. • Retention of natural features- e.g. Daly's Lagoon are in line with the Conservation interests of the site • Where detention basins have been sited within the recreational areas of the development site, it must be understood that the 'recreational areas' are designated as drainage reserves with the primary function of such area for drainage purposes.	*Ipswich Planning Scheme Traditional Neighbourhood Design Code, Part 12, Division 3, Table 12.3.4.4 section 35 (v)* *Ipswich Planning Scheme Part 15.3.3 section 6 (f)/g(g)conservation areas, section 8 (b) endangered veg 15.3.4 (i) parkland and linear open spaces (living valley) 15.3.4 section 6 Natural Valley (linear parks/ watercourse corridors/riparian veg/remnant veg/conservation)* *Ipswich Planning Scheme Part 15- 15.3.4 section 5 (I) - Functional Valley (Total water cycle management/SW management/regional approach to detention basins)* *Ipswich Planning Scheme Part 15 - 15.5.2 Conservation T1 zones* *Ipswich Planning Scheme Part 15 - 15.12.1 Recreational Zones and linear parks*	Where development is overlapping onto the conservation areas, please demonstrate how the conditions stipulated within section 15.5.2 are being met especially with regards to minimising soil erosion, landslip, and the siltation of watercourses, with avoidance of the modification of Riparian areas According to Council's experience is that a Riparian Buffer Zone allowance of a minimum of 100m would be necessary for the optimal functioning of the natural channel ecosystem, in light of waterway health stability, integration and sensitivity, security, and effectiveness in water quality and volume control Please clarify the natural features to be retained on-site Land below the 1 in 10 Average recurrence interval (ARI) is considered to represent a primary drainage function and is not to be included in any public parks infrastructure credit unless the land is stable, useable, and free from encumbrances to provide public recreation uses. Council will not accept the use of the open space areas and recreational zones for the siting of stormwater infrastructure as these areas will be used by council to mitigate issues downstream .Please provide the strategy with regards to how the detention basins which have been sited within the recreational zones been classified as being within drainage reserve areas?
• 1st Order streams and their importance	• The filling-in of first order streams as part of the 're-moulding' of the terrain of the entire development is not normally accepted by council.	*Vegetation Management Act 1999*	Retention of the catchments' first order streams is vital as a means for preserving ecological ecosystems in the area, and for aiding in water quality/soil erosivity, and Riparian vegetation/Bundamba Creek Rehabilitation measures, which is

Retention of First-Order Streams	• This is because first-order streams play an important role within aquatic ecosystems, due to their direct impact on higher order streams and rivers. These streams and their resident species, such as macro invertebrates, serve as sinks and processors of organic and inorganic matter regulating the flow of detritus and sediment into higher order systems. Excess sediment input from small streams to large rivers can reduce the depth of downstream river beds • First-order streams also help to reduce the number and severity of downstream flooding events by retaining water longer than terrestrial habitats • First-order streams are distinctive in that they are closely connected with adjacent terrestrial processes. Ecologically, they receive and are highly responsive to inputs of energy, sediments, nutrients and pollutants from the adjacent terrestrial environment.		fundamental to achieving a holistic best practice outcome. The first order streams and their accompanying riparian vegetation are required to be protected to maintain bank stability, water quality, aquatic habitat and wildlife habitat According to Council's experience is that a Riparian Buffer Zone allowance of a minimum of 100m would be necessary for the optimal functioning of the natural channel ecosystem, in light of waterway health stability, integration and sensitivity, security, and effectiveness in water quality and volume control As the most extreme impacts on headwater streams in Australia are probably wrought by urbanisation, the rehabilitation of urban headwaters needs to be reconciled with other management goals in such catchments. In non-urban catchments, substantial mitigation of human impacts on streams might be achieved by improved catchment management.
• **Riparian Zones and development within these areas**	• Aspects of the development will involve works undertaken within the Riparian Zone areas (such as cut and fill works associated with filling in the eroded gullies. It must be realised that removal of the riparian vegetation, especially within sites which harbour highly dispersive soils, such as Ripley Valley, increases the likelihood of significant impairments to the functioning of waterways downstream, due to over-	***Nature Conservation Act, 1992*** ***Environmental Protection Act, 1994*** ***Environmental Protection Policy (Water), 1997*** ***Fisheries Act, 1994*** ***Land Act, 1994*** ***Water Act, 2000*** *Vegetation Management Act 1999* *Sustainable Planning Act 2009*	Please provide details of the strategy adopted for the implementation of Riparian Zones within the Ripley Valley Development. Sound catchment management strategies, such as the implementation of riparian buffer strips, in-stream works, and better designed roads and drainage works (to help restore complex flow paths, increase residence times and shorten nutrient spirals) need to be considered for the development.

	sedimentation, turbidity, siltation and eutrophication (from the increase in nutrients in the stormwater flows). • A lack of vegetation also dramatically increases flood volumes		According to Council's experience is that a Riparian Buffer Zone allowance of a minimum of 100m would be necessary for the optimal functioning of the natural channel ecosystem, in light of waterway health stability, integration and sensitivity, security, and effectiveness in water quality and volume control
Stormwater Management Plan			

Stormwater Quality MUSIC Modelling	• The MUSIC Model has incorporated the use of the 'agricultural node' to represent undeveloped areas/conservation areas of the site, and assumed this land to be completely pervious.	• *Queensland Water Quality Guidelines 2009 'Guidelines for Urban Stormwater Quality' Table 8.2.2.(* NB: It is expected that the application of Best Practice designed stormwater treatment technologies configured in an appropriately sequenced treatment train will exceed the design objectives presented in 8.2.2)	Please justify the use of the 'agricultural' node within the MUSIC model and why this is a better representative over, say the Forest node which would have given a better representation of the site's undeveloped areas.
Bioretention Systems	• An issue arising from the placement of bioretention systems within the basins is the issue of the filter media getting clogged – which leads to poor infiltration and ponding/fouling • Also, if in-situ testing is not undertaken of the soils when selecting the filter media, there will be no demonstration of how well the filter media can perform • It is understood that both street level and distributed end of line measures (bioretention systems, on-line wetlands) will be considered for the development. The wetlands are being placed in the bioretention basins to recirculate flows and maintain water quality treatment (with underground storage tanks are also an option for maintaining water in the water bodies during low flow)	• *Ipswich City Council's Planning Scheme- Policy 3: General Works Table 2.3.1 – Stormwater Quality Water Quality Objectives* • *Department of Environment and Resources Management (DERM) Urban Stormwater – QLD BPEM Guidelines 2009* • *Environmental Protection Act 1994* • *Ipswich Planning Scheme Part 15- 15.3.4.section 5 (l) - Functional Valley* • *State Planning Policy: Healthy Waters (SPP Healthy Waters)* • *Sustainable Planning Act 2009* • *Queensland Urban Drainage Manual NRW 2007* • *Environmental Protection Act 1994*	Demonstrate how the bioretention system filters will be able to cope with the inflows from all design ARI's without compromising on the water quality objectives As mentioned above, a copy of the MUSIC Modelling files are required for review by council. Prior to the selection of the bioretention system filter media, please ensure that in-situ soil testing and analysis has been undertaken so that a selection can be made of the filter media which best suits the site's purposes, and is able to give optimal performance
On-line Wetland (see also Total Water Cycle- online wetland)	• The use of a wetland as part of an on-line water quality treatment infrastructure is not accepted by council.	• *Environmental Protection (Water) Policy 2009 – Schedule 1* • *Queensland Water Quality Guidelines 2009* • *South-east Queensland Regional Plan 2009-2031*	If a wetland is to be considered for the development, it must be off-line, maintain its minimal water levels, and accept only overland or sheet flows, not piped flows. Please reconfigure the modelling to reflect this.
Staging (see also Other Issue- Phasing)	• Staging will be carried out for the implementation of the water quantity/quality measures- with treatment measures progressively operational as development proceeds, with the incremental terracing of basins, treatment trains	• *SEQ Healthy waterways 2006, Water Sensitive Urban Design- developing design objectives for WSUD in SEQ*	Please clarify the staging schedule for the implementation of the stormwater quality infrastructure

Planting	and bioretention areas added as development comes online • With the bioretention systems- are the plants used within the filter areas native?		Please confirm as to whether native plants are used within the filter areas of the bioretention systems

Total Water Cycle			
• **Water balance**	• The submitted Hydraulics and hydrology documentation do not indicate whether a water balance has been carried out for the site. A water balance can be used to help manage water supply and predict where there may be water shortages. It is also used in irrigation, flood control and pollution control.	*Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code, Part 12, Division 3, section 12(iii) The Implementation of Total Water Cycle Management* *Ipswich Planning Scheme Part 15- 15.3.4.section 5 (I) - Functional Valley*	A water balance should be carried out for the development site to gather an understanding of the movements of water in all aspects so as to size and model the stormwater infrastructure and treatment trains effectively. It may also confirm the importance of retaining native riparian vegetation which helps reduce the amount of surface water runoff, and reduces rising groundwater levels due to the high evapotranspiration rates of mature trees.
• **Online Wetland**	• The implementation of on-line wetlands within detention basin's as part of stormwater quality treatment is not normally accepted by council The wetland will require a constant flow through it in order to maintain its natural bathymetry, and the reliance on underground storage tanks to facilitate this is not acceptable. The underground storage tanks pose difficulties for the layout of road network infrastructure. The wetland is also only able to accept incoming flows as sheetflow/overland flow, and not piped flows.		The wetland must be as part of an off-line system- the stormwater must not be discharged directly into the water bodies, with only major storm events able to reach the wetland via overland flow paths across vegetated surfaces. Stormwater management should be integrated into the urban landscape with neighbourhood scale systems incorporated in public space and linear multiple use corridors. This approach results in improved biodiversity and the health of the receiving waterways, and improved amenity and quality of urban areas.
• **Maintenance**	• High maintenance issues are associated with the implementation of stormwater infrastructure such as the terraced basins with bioretention systems and the online wetland. Maintenance Plans have only been provided for the bioretention system.		Council is concerned with maintenance requirements of such stormwater infrastructure, and it's obligation in the upkeep and eventual ownership of such devices. Please provide the maintenance details for the detention basins and wetland system for consideration.

• **Soil Erosivity** Total Suspended Solids	• A site visit revealed that the area has severely degraded/eroded natural gullies due to highly dispersive sandy soils within the area. • The site is characterised by stormwater passing as overland/sheet flows (which occur extensively throughout the site) with undefined water courses- not unlike an inland delta. In the event of urban development (and the filling in of the gullies and first-order streams), these undefined flow paths will become concentrated flows, which will be exacerbate the current problem of severe erosion of the gullies if not properly channelled and treated. • The sediment and suspended solids can become mobilised by stormwater as suspended solids from the erosion of exposed soil areas can affect receiving waterways physically through smothering aquatic flora and fauna. Sediments can also block stormwater systems leading to local flooding. Suspended solids may also be used as a transport medium for nutrients and heavy metals making their way into waterways, adversely affecting the biochemical homeostasis of the downstream aquatic and riparian ecosystems, if not adequately managed.	*Environmental Protection (Water Policy) 2009* *State Planning Policy (Healthy Waters)* *SEQ Regional Plan – Policy 11.4.1*	The preparation of a stringent Erosion Hazard Risk Assessment Report must be provided to show that the vulnerability of the Ripley Valley highly erosive soils has been taken into account in the planning process of the development. When land is developed, native vegetation is removed, imperviousness is added, and landform is changed – all of these processes change catchment hydrology. As such, cutting and filling should be minimised. Options such as the use of the existing eroded channels and gullies (rehabilitated, and planted out with riparian vegetation) for the conveyance of stormwater flows should be looked at, so as to minimise disturbance. Please revise the modelling and treatment train layout to include this as a possible solution. Use of the Revised Universal Soil Loss Equation (RUSLE) to calculate the predicted total soil loss from the site for the entire duration of the site disturbance is recommended. In order to manage the Total Suspended Solids (TSS) within the stormwater flows, it is necessary that the drainage be the first thing put into the development site and stabilised so that the disruption is minimal during construction and operations phases There is an inherent need for an integrated stormwater system which encompasses frequent flow control and volume control mechanisms. Note: There are three primary sources of sediment: - development phase - operational phase - destroying Riparian vegetation, which causes

			changes in the amount and velocity of flows, which exacerbates the amount of sediments flowing downstream
• **Management of Endangered Vegetation** **(Binnies Road Development)**	• Need to view the vegetation maps- an endangered species of tea tree is located along Binnies road- south of the site	*Vegetation Management Act 1999* *Environmental Protection Act 1994*	The proposed development must ensure that the endangered Tea tree's are not disturbed during the construction and operation processes. A vegetation management plan highlighting the conservation methodologies employed for the endangered flora is required by council
Other Issues to be clarified			
• **Resilience** Emergency/Disaster Mitigation	Flood management and public safety remain as fundamental objectives of stormwater system planning and design. Stormwater management measures for waterway health enhancement should in no way compromise these objectives As such, it is of paramount importance that stormwater management for the Ripley Development site follows a hierarchy of control mechanisms: Preservation Source Control Structural Control From the provided documentation, it is apparent that resilience and emergency/disaster mitigation issues have not been considered in depth.	*Draft Urban Stormwater – Queensland Best Practice Environmental Management (BPEM) Guidelines, Chp. 2, Fig. 2.3* *State Planning Policy 1/03: Mitigating the adverse impacts of Flood, Bushfire, and Landslide* *Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code, Part 12- Division 3 Table 12.3.4.3* *Ipswich Planning Scheme Part 15, Division 5, section 15.5.2)*	Please make amends to the report and modelling in light of emergency/disaster/and topography

Climate Change Allowances	• The documents have indicated that climate responsive design has been applied. This has not been considered for hydraulics, stormwater quality, or stormwater quantity. • The *Queensland Greenhouse Policy Framework14* acknowledges a growing scientific consensus that the enhanced greenhouse effect is changing the world's climate and that Queensland will be vulnerable to the effects of climate change. • Predicted changes are likely to include reductions in annual rainfall (increases in rainfall intensity), coastal erosion, rising sea levels, risk of bushfires, and flood risk and damage to transport infrastructure and low-lying human settlements. • These changes would have significant impacts on the nature and extent of natural hazards and, where practicable, should be considered when developing hazard mitigation strategies.	The *Queensland Greenhouse Policy Framework14.* Ipswich City Council *'Incorporation of Climate Change Impacts within the Ipswich Natural Disaster Risk Management Plan – Statement of Impacts', January 2010*	What is meant by 'climate responsive' design, and what strategy has been employed for this in terms of the water balance, water modelling, and the general hydraulic design for this development? Please clarify the strategy regarding how rainfall data has been adapted to synchronise with the changes wrought by climate change on perennial rainfall patterns, especially as the Australian Rainfall and Runoff Guidelines will be subject to change. This issue, if not considered, may affect the viability of the development assumptions In light of tailwater conditions- please justify how have they been set in line with upcoming changes to the climate-, and how has this been incorporated within the modelling?
• **Adaptation of the development to the terrain/environment**	• The extensive use of cut and fill measures through out the site to fill in existing gullies which are characterised by their highly dispersive soils is unnecessary and destructive to the natural environment of the site. • Disturbance of the dispersive soils will cause an increase in the rate of erosion occurring within the site and lead to severe problems downstream in terms of elevated Total Suspended Solids (TSS) levels, turbidity, and eventual siltation and eutrophication of	*Ipswich Planning Scheme Draft Traditional Neighbourhood Design Code Part 12 Division 3- Reconfiguration of a lot section 12 (x)* *Land Act 1994*	• Revise the need for cut and fill procedures within the natural gullies, and erosive riparian corridors, and instead opt for the option of implementing systems which mimic the inherent natural channel processes of the site, with possible rehabilitation by way of vegetated slopes and controlled velocities flowing into the natural channels as a 'natural engineered system'

	receiving waterways.		
• **Phasing/Staging of the development**	• The Master Plan/ SWMP/flooding report does not indicate how the stormwater infrastructure will be phased into the development. The current practice of putting in drainage systems as one of the last things to be completed as part of a development has led to the under sizing of infrastructure or the heavy reliance of high maintenance devices such as streetscape systems, which goes against the principles of sub-regional modelling.	*Ipswich Planning Scheme, Part 15- 15.3.6 Development sequencing*	It is suggested within the planning scheme that the development be phased according to fig 15.14 based on the existing commitments by council for a) development in the north-western/Deebing Creek Catchment b) the north-east Bundamba creek catchment

CONTENTS

1 Introduction

Ipswich City Council (Council) has engaged Kellogg Brown & Root Pty Ltd (KBR) to review two reports that examine drainage in Ripley Township within the Bundamba Creek catchment. This review will be a supplement to the Bundamba Creek Flood Study and Flood Risk Management Plan currently being prepared by KBR under the auspices of the Natural Disaster Mitigation Program.

The two reference reports are:

- Sargent Consulting (2010), *Planning Study for Flood Mitigation at Ripley*, report prepared for Ipswich City Council, Emergency Management Queensland and Department of Transport and Regional Services (referred to as the Sargent report).
- MPN Consulting Pty Ltd (2010), *Ripley Road Drainage Briefing for Council*, 3 November 2010, prepared for the reconfiguration of a lot associated with a development application (referred to as the MPN report).

2 Background

The Ripley Township is located on the eastern side of Ripley Road approximately 1.0 km to 1.6 km south east of its intersection with the Centenary Highway. The western portion of the town is bisected by a drainage reserve that eventually flows northwards to Bundamba Creek.

The principal design criteria set out by Sargent:

- no overfloor flooding of houses in a 100 year ARI flood event
- Ripley Road to be trafficable in a 10 year ARI flood event
- house access crossing to be trafficable in a 10 year ARI flood event.

Sargent determined the existing flooding exposure in Ripley Township as: one property has an overfloor flood immunity of less than 2 year ARI, another 2 properties have an overfloor flood immunity of 20 year ARI, and 9 house access driveway immunities range from 2 year to 10 year ARI. Ripley Road trafficable flood immunity (not defined) is less than a 2 Year Average Recurrence Interval (ARI)

Ripley township could be surrounded by low and medium density urbanisation as is likely under Council's planning scheme and if approved under the Urban Land Development Authority's (ULDA) charter. Under this ultimate development scenario, Sargent estimated the peak flow rate at the lower end of the township drain would increase from 34 cubic metres per second (m^3/s) to 64 m^3/s. MPN (2010) estimated the capacity of the drain at Clark Street at 28 m^3/s.

A locality map and local catchments are provided in Figure 1.

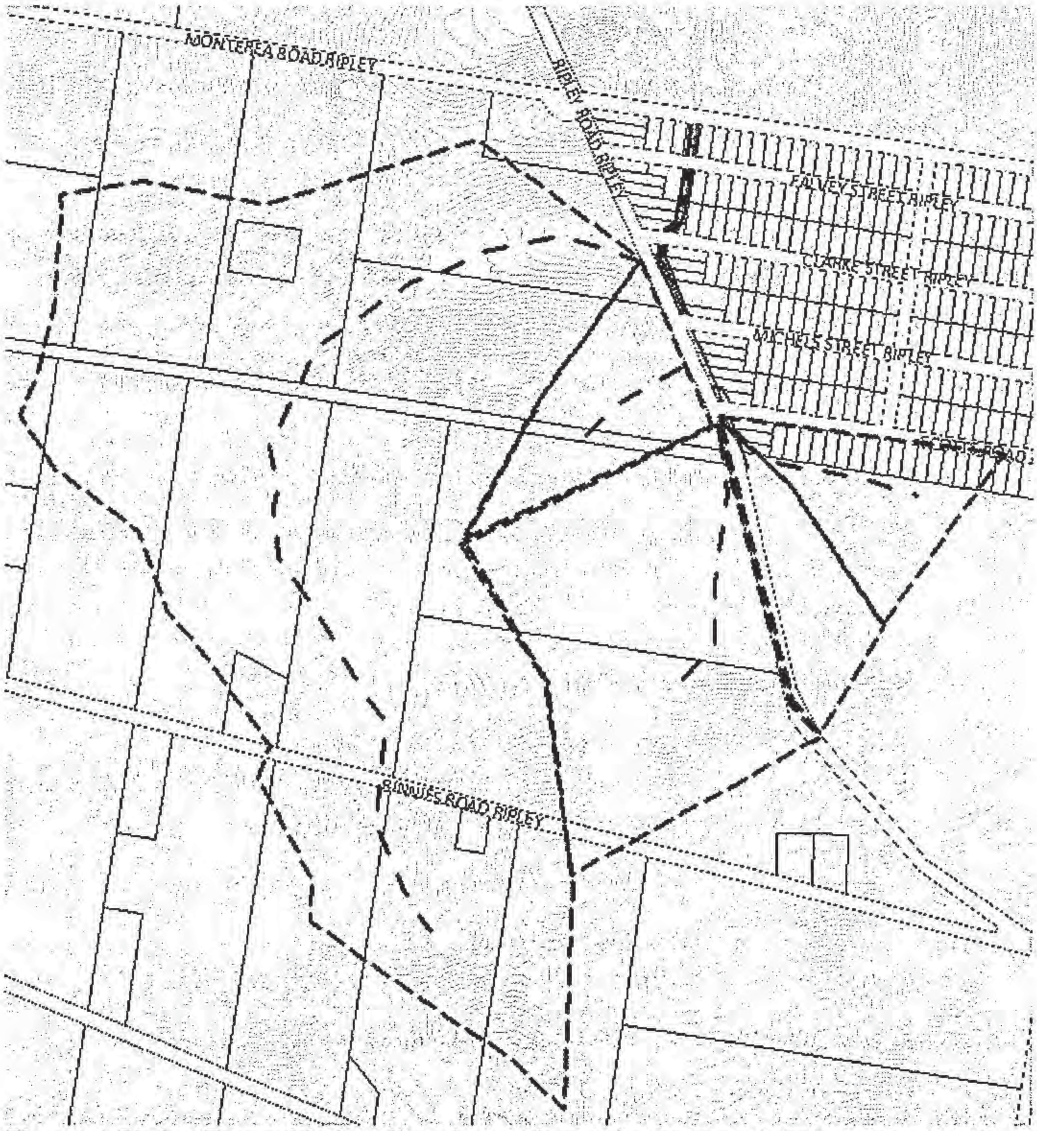


Figure 1 Ripley Township locality plan, sub-catchments and drainage network

3 Sargent Consulting study (2010)

Purpose of Sargent Report

The Sargent Consulting study (Sargent, 2010) was undertaken as part of the Natural Disaster Mitigation Program (NDMP) to identify flood mitigation opportunities and likely capital costs within the Ripley Township. This was a wide ranging study that included a review of relevant reports and the redefinition and development of the hydrologic and hydraulic characteristics of drainage upstream, within and through the Ripley Township.

Four mitigation strategies were considered:

1. Do nothing case (RR1).
2. Upgrade the existing Ripley Road drain on its current alignment (RR2).
3. Upgrade drainage capacity by means of a new drain along the western side of Ripley Road (RR3).
4. Reduce peak flows in Ripley drain by construction of a retarding basin at the low point on the west side of Ripley Road.

Sargent determined that:

- Ripley Road has less than a 2 year ARI trafficable flood immunity.
- One property has flood immunity against overfloor flooding of less than 2 years ARI with 2 properties having immunity of flooding at only 20 years ARI.
- The trafficable immunity of house crossings is poor with 1 house having less than 2 year ARI, 2 houses with less than 5 years ARI and 6 properties with 10 year ARI trafficable immunity.

Recommendations of Sargent report

A number of capital works were recommended including:

- diverting flood flows from the catchment south of Ripley Township and east of Ripley Road to the western side to relieve flooding on the eastern side
- provision of a new drain on the western side of Ripley Road within land acquired for that purpose
- provision of a detention on the western side of Ripley Road
- provision of a new culvert under Ripley Road
- raising sections of Ripley Road
- improving the existing drainage network, house crossings, removal of the bridge in Scotts Park.

Under ultimate development conditions, Sargent recommended that these works should be expanded to provide 100 year ARI immunity against overfloor flooding, house crossings would have a 20 year ARI immunity, and Ripley Road would be upgraded to 10 year ARI immunity. The report also recommended a new relief drain and flood mitigation storage on the western side of Ripley Road, such storage being incorporated within the western drain. This strategy is generally supported.

The recommended layout (Sargent Report Figure 7) is reproduced below.

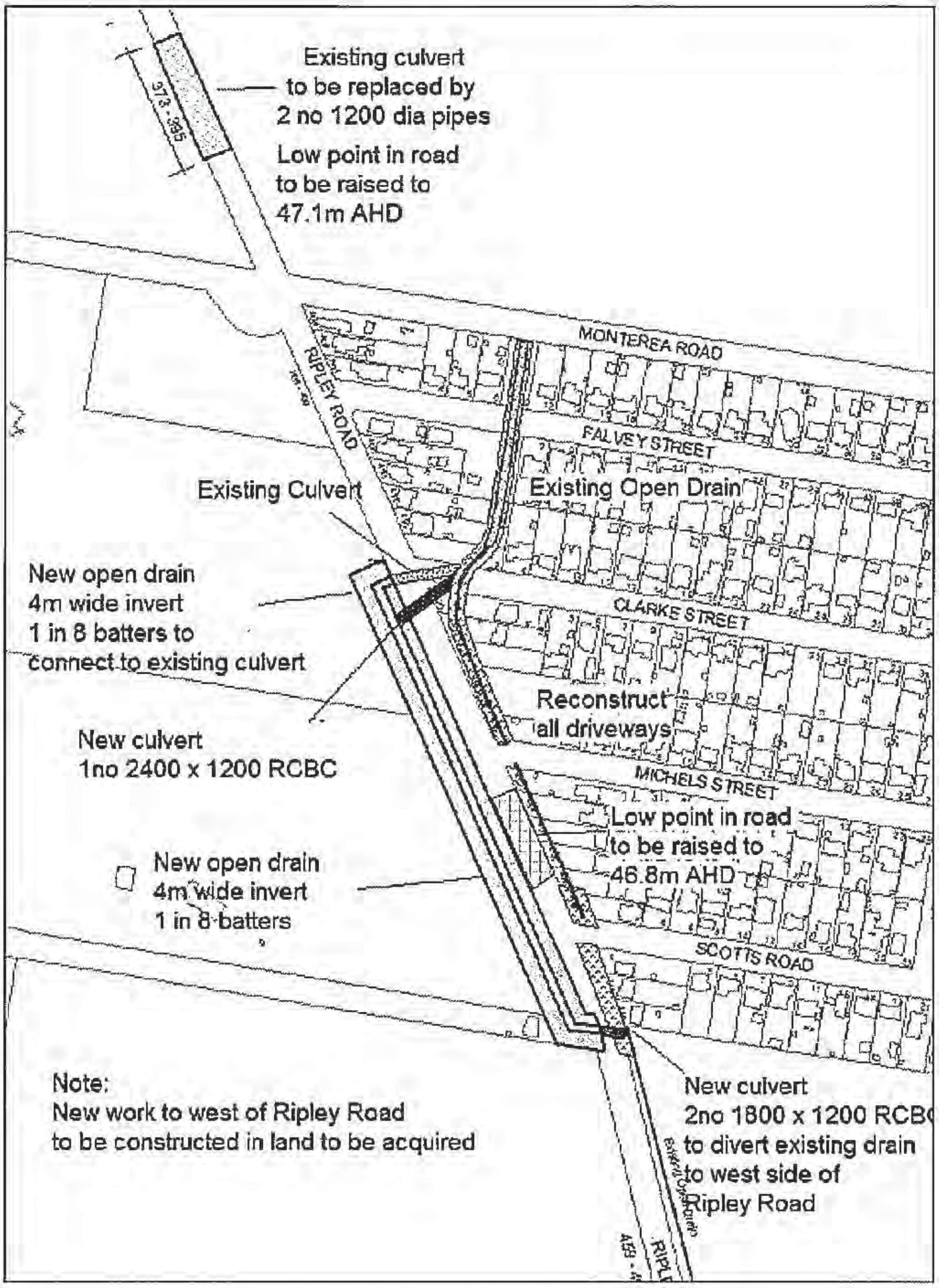


Figure 7 New Drain West of Ripley Road – Preferred Layout

Figure 1 Drainage works recommended by Sargent (Sargent, 2010 Figure 7)

This Sargent Report strategy has been generally supported with Council moving to increase drainage capacity under Ripley Road in 2009/2010.

Details of the configurations and costs as presented as Tables D1 and D2 in the Sargent report are included in Appendix A.

Comments on Sargent report

This report was prepared as a draft in May 2009 although not finalised until 2010. The report predates later considerations for upgrading Ripley Road and providing a service road for the existing township. As detailed in the report, the Planning Scheme suggests intensive urban development that will increase flow rates unless strict controls are enforced.

The overall strategy espoused in the Sargent report is sound but likely require modification with the imminent requirement to increase the traffic capacity and flood immunity of Ripley Road as a consequence of future development within the ULDA precinct. This is intimated in the MPN report (discussed below).

4 MPN Consulting study

Purpose of the MPN report

The MPN report identifies a proposed ultimate configuration of Ripley Road and servicing of the existing Ripley Township. The report investigated the potential for a half width upgrading of Ripley Road associated with a land development application with the ULDA on the basis that Ripley Road will have cross drainage designed to convey the 50 year ARI flood flows (giving the road comparable immunity), and longitudinal drainage designed for a 10 year ARI storm flows. The rationale and authority for these criteria are not stated.

The MPN report also considers other major culverts would be needed under Ripley Road between the Centenary Highway and Cunningham Highway.

Discussion of the MPN report

MPN state that half width road construction will involve raising Ripley Road to provide cover to services passing over culverts. MPN developed a DRAINS model (software developed by Watercom Pty Ltd) and determined that much of the existing drainage network did not have sufficient capacity and/or would not be capable of conveying the additional flows from new development. Table 1 details the capacity of the drainage system at various locations as determined by MPN. It should be noted that MPN do not include the basis for their recurrence interval flow estimates nor their assumptions regarding future development.

Table 1 Existing Drainage Capacities

Location	Capacity (m^3/s)	Capacity (ARI years)
Monteria Street	35	50 years
Clark Street	28	20 years
Michels Street	3.5	2 to 5 years
Scott Street	3.0	2 years
Drainage swale upstream of Scott Street	Not stated	1 year

Other information in the MPN report is primarily confined to a discussion of road, property and culvert levels. Hydrologic and hydraulic information that would support this discussion is not provided.

The MPN report identifies the cross culvert at the township as Culvert C and suggest that it's interim configuration should be a 2 cell 2400 mm x 1200 mm Reinforced Concrete Box Culvert (RCBC), the ultimate drainage requirement is identified as a 5 cell 2400 x 1200 RCBC.

MPN study recommendations

The MPN study made the following recommendations:

- Ripley Road must be raised above the existing formation to provide 50 year ARI flood immunity.
- Drainage under Ripley Road to convey flow from the west to the Ripley Township drain should comprise a 5 cell RCBC to cater for ultimate development.

Additionally MPN recommended that until the capacity of the downstream drain is improved and a detention storage provided upstream, the inlet to the new 5 cell RCBC should be choked.

Comments on MPN report

The MPN report does not provide any assumptions as to the state of development in the contributing catchments that would influence presented runoff rates, or other parameters used in hydrologic modelling. It is not known whether the flow rates presented for the main channel through Ripley Township are based on conservative or aggressive assumptions.

The raising of Ripley Road without compensating drainage works will cause increased inundation upstream of the upgraded Ripley Road, may adversely affect existing drainage patterns and is likely to limit the effectiveness of flood mitigation works proposed by Sargent.

Detention storage would need to be provided upstream of Ripley Road (on private property). The proposed choked culvert solution (until the downstream drainage capacity is improved as indicated in the MPN report) will require an additional 9000 m^2 of inundation caused directly by the detention requirement. MPN state this requirement does not cause "actionable damage" although the basis for that claim is not sourced..

Information on the ultimate configuration of Ripley Road is not provided and development of an overall road and drainage strategy based on the MPN report alone is not possible.

MPN recommendations for interim Ripley Road drainage works are provided in Appendix 2 of the MPN Report.

5 Discussion

Flow patterns

The topography of the area dictates the flow patterns. Flows from the south east, south west and from the west of the town must enter the township at its current location, this being the natural flow path. To relocate the flow path and divert flows around the township is not practical.

Flood immunity and public safety

The Sargent Report indentified that the existing flood immunities of some dwellings, house accesses and the roadway are inadequate and residents are either exposed directly to flooding or affected by its frequency. Public safety is also of concern as people could easily find themselves in dangerous situations with ready access to the open drainage network with numerous culvert crossings and a dangerous transition between the formed and natural channels at Monterea Road. It is considered the situation is serious and drainage improvements should be included in a works program as soon as practicable.

A number of drainage strategies have been developed by Sargent and with some additional works are likely to cost in excess of $2,000,000 based on Sargent's estimates. Ultimately, the drainage configuration adopted will depend on the development scenario adopted, the level of flood immunity required for roadwork, house driveways and buildings.

Development control

Land to the south and west of the Ripley Township will ultimately be developed in accordance with the provisions of the ULDA arrangements and Council's Planning Scheme for the area. Urbanisation will increase impervious areas, restrict the opportunities for rainfall interception and infiltration, and will increase runoff rates and flood volumes unless controlled. Uncontrolled development will worsen flooding downstream.

Sargent Consulting has recommended that post-development flows should not exceed the pre-development run-off rates for the 100 year ARI flood event.

It is well known that Australian Rainfall and Runoff (Engineers Australia, 1998) is being reviewed by Engineers Australia with inputs by the Bureau of Meteorology, universities and the engineering profession. Several seminars have been held to facilitate this review which is being funded by the Federal Department of Climate Change and Energy Efficiency[1].

There is considerable evidence that rainfall precipitation will increase during current planning horizons. The Queensland Office of Climate Change has indicated a 4°C rise

[1] Source Engineers Australia National Committee on Water Engineering http://www.ncwe.org.au/arr/index.html accessed 16 February 2011.

in temperature will occur by year 2100 and its Final Scientific Advisory Group report (Queensland,2010) the Scientific Advisory Group (SAG) notes on page 1:

a. *an increase in rainfall intensity is likely*

b. *the available scientific evidence indicates this increased rainfall intensity to be I the range 3-10% per degree of global warming*

c. *The SAG understand the preference for a single figure to a support further policy development.*

   More detailed analysis is required to firmly establish such a figure and this work will be undertaken as part of a review of Australian Rainfall and Runoff. This document will become the authoritative source of information on the issue when released in 2014. However, the SAG would consider a figure of a 5% increase in rainfall intensity per degree of global warming reasonable for policy development in the interim.

A series of seminars was held to explain the implications of the study which led to the Minister's statement of the 10 November 2010 (Appendix A) which applies to rivers that are not susceptible to sea level influences. The Queensland Government and the Local Government Association of Queensland is "encouraging Queensland councils to move away from 1 in 100 year flood planning and focus more on likely future increase in rainfall intensity brought about by climate change".

The Minister and the government are

> *... recommending that local governments adopt a climate change factor for increased rainfall intensity of 5 per cent per degree of global warming and incorporate this into local flood studies and planning schemes.*

If applied to each degree rise of global warming local authorities must plan for increases in rainfall intensity of at least 20% to the year 2100.

Work undertaken by Sargent Consulting (Sargent, 2010) in the Ipswich area indicated that once increased rainfall intensities are applied what might now be considered a 350 year ARI event will be considered a 100 year ARI event by year 2100. These estimate vary depending on the That being the case, KBR recommends that this proposition be extended so that pre-development flow rates are not exceeded for the full range of floods up to and including the 500 year ARI flood event so as to minimize the quantum of the residual risk to the Ripley Township and other future developments.

Assessment of floods up to the 500 year ARI flood is recommended as an interim measure until Engineers Australia and the Bureau of Meteorology revise the current methodology for determining rainfall intensity-frequency-duration (IFD) data and flood frequency analysis which form the basis for hydrologic assessments. This statement does not mean that Council should adopt the 500 year ARI flood event as its designated flood, but given future uncertainties, it should be aware of the implications of flood events larger than the planning horizon. The current IFD data is largely based on instrumental records of the 20th Century which non-instrumental records (such as newspaper reports, anecdotal, biological and paleo-evidence) suggests was a relatively benign period in South-East Queensland's flood history.

In addition, KBR not only endorses the comments made by the Minister for Climate Change and Sustainability, the Honourable Kate Jones on 10 November 2010 to increase peak rainfall intensities by 5% per degree Celsius rise on forecast temperature, but recommends that sensitivity tests be conducted for a 7% rise in rainfall intensity per degree Celsius. For a 4°C rise in temperature by year 2100, these represent 20% and 28% increases in rainfall intensity that should be incorporated into planning decisions. A sensitivity analysis shows that increases of 20% and 28% in rainfall precipitation would result in increases in rainfall intensity for a 30 minute time of concentration as follows.

Table 2 Impact of increase rainfall intensities

Rainfall frequency	Existing Rainfall (30 minute time of concentration) (mm/hour)	20% Rainfall Increase (mm/hour)	28% Rainfall Increase (mm/hour)
Q100	181	217	232
Q500	242	290	310

As part of its development of the Bundamba Creek Catchment Flood Risk Management Plan, KBR will be setting a series of peak flow rates and peak flood levels at significant control points for a range of recurrence intervals. These will be based on jointly calibrated hydrologic and hydraulic models.

KBR strongly recommends that development applications for land within the Ripley Township catchments provide evidence that these peak flow rates and peak flood levels will not be exceeded following development singly or in combination with other development. This may require alternate building construction techniques and land development philosophies that provide space for water, increase flood storage, and do not reduce times of concentration or critical storm durations within sub-catchments.

As development downstream is known to suffer overfloor flooding from regional flood events that will be worse when regional and local storms combine, it is essential opportunities are taken to provide additional detention facilities to reduce the likelihood and severity of downstream flooding.

Land development

Intensive land development in the Ripley Valley will increase pressures on the road network and could see Ripley Road being upgraded, initially through lane and shoulder widening and limited access classification, and ultimately to perhaps four lanes. Ripley Road is the most direct connection to Ipswich City Centre for much of Ripley Valley and provides a connection between the Centenary and Cunningham Highways. The need for space for the ultimate road configuration must be taken into account in all drainage/flooding considerations. The need for both road space and space for water may compromise drainage improvements proposed by Sargent and MPN.

Drainage strategies

The following factors and concepts should be addressed in any future drainage strategy:

Factors:

- the catchments surrounding the Ripley township will be urbanized
- urbanisation implies increased run-off rates and the potential to worsen flooding unless that additional run-off is controlled
- urbanization implies higher traffic volumes, a need to increase road capacity and improve road safety, perhaps by road duplication or service road separation
- higher road volumes will require increased immunity from flooding
- the capacity of the existing drainage system is limited and is unable to tolerate any increases in flow rates without significant works
- existing dwellings and driveways are severely prone to flooding
- the proposed ultimate width of the Ripley Road reserve will be determined by traffic and road considerations. Drainage reserve requirement are additional to the minimum road requirements.
- streams and drainage channels in the Deebing Creek catchment are susceptible to erosion, sediment transport and deposition in areas where downstream flooding might be a problem

Concepts:

- any drainage works should improve public safety and increase flood immunities for local dwellings, house and street access
- existing landowners and residents should not be disadvantaged by development, road and drainage works
- road and drainage works should provide synergies wherever possible
- drainage strategies should seek to retard flows upstream of the township, and discharge flows through the township in a safe manner in accordance with accepted/required standards
- development control strategies must aim to restrict post development flow rates to pre-development levels or less given the extent of downstream flooding
- drainage strategies should seek to minimise further erosion and sediment transport
- post development flows should have no adverse impact downstream.

Development of drainage strategies around Ripley Road and Ripley Township must be integrated with proposals for land development in the area and future road requirements. Ultimately proposed drainage works around Ripley Road can not be located with any confidence without input from road designers and adjacent landowners. The location and size of detention basins will depend on road widening requirements, the development aspirations of landowners and synergies that might be obtained by all parties acting in concert. Some works can and should be undertaken to improve public safety and amenity but the provision of new detention basins and drains beneath Ripley Road should not be undertaken in isolation.

There is an identifiable and urgent need to make space for the ultimate road configuration and to make space for the ultimate drainage and flood mitigation configuration.

Having outlined the above, the following works can be considered. Some works are additional to those proposed by Sargent and/or MPN.

A. Given that the dwellings and property driveways with the lowest immunity are 444, 446 and 448 Ripley Road, protect these properties by

   - constructing a common driveway from Scott Street to No 448 utilising part of the footpath and resuming some of the property frontages
   - constructing a solid fence (water barrier) along the southern boundary of 448 Ripley Road until higher ground is reached, extending that fence northwards on the outer side of the new common driveway to Scott Street
   - providing local drainage within the new common driveway.

B. Redirecting flows to and retarding flows on the western side of Ripley Road

   - providing a detention basin on the north western corner of the property immediately to the south of No 448
   - conveying outflow from that basin under Ripley Road to a new drain on the western side of Ripley Road
   - providing a detention basin on the south-western side of Ripley Road (these basins will work in concert to reduce the flow rate along the western side of Ripley Road)
   - providing improved detention facilities on the western side of the Ripley Road at the Clark Street intersection

C. Improving the discharge capacity and public safety through the Ripley Township by

   - upgrading cross drainage to the required capacity
   - reducing the flood hazard to pedestrians within the township particularly where bounding public open space and residential properties particularly between Michels Street and Clark Street
   - improving the through-park drain and facilities including the open drain south of Clark Street by seeking to reduce the flood depths between Clark Street and Monterea Road and reducing flow velocities as discharge transitions from the formed channel and is received by the "natural" creek system
   - where possible confining high velocity flows to fully enclosed or protected channels.

6 Conclusions

Existing drainage capacities within Ripley Township are inadequate with some dwellings at risk of overfloor flooding, others that lose driveway access more frequently than generally accepted and some drainage elements within the township likely to create a hazard during flood conditions. Drainage channels are constrained but scope exists to improve public safety and channel capacity.

The above problems are compounded by the sub-catchment drainage configuration and the drainage of Ripley Road.

Conceptual drainage strategies to improve drainage to Ripley Road and through the township are outlined in the reference reports and as amended above.

Drainage improvements and mitigation costs are likely to be in excess of $2,000,000.

Council's planning scheme and the Urban Land Development Authority contemplate urbanisation around the township that has the potential to increase stormwater discharges well beyond the capacity of the existing drainage system.

More extensive urbanisation coupled with higher traffic volumes will require the upgrading of Ripley Road for both traffic and drainage volume requirements.

Land required for drainage is likely to be additional to land required for roadworks.

Conceptual planning for the ultimate design of Ripley Road and drainage is needed to define the land needed for these works. This land needs to be protected now, so that it will be available when both these infrastructure assets need to be constructed.

7 Recommendations

Drainage through Ripley Township be given priority to address public safety and improve flood immunity to existing buildings and properties.

Conceptual planning be undertaken to determine the land requirements for the ultimate development of Ripley Road and the drainage works to ensure acceptable flood immunity throughout the catchment, and in particular through the Ripley Township.

Consultation be undertaken by Ipswich City Council with the Urban Land Development Authority, landowners, developers and other stakeholders so they understand the need for the land for both roadworks and drainage systems to be given priority over other land uses.

Once a combined land, road and drainage strategy has been approved, protect the land until it is purchased or acquired under the Community Infrastructure Designation of the Sustainable Planning Act 2009 and capital works commenced.

Special development criteria for drainage and flooding are formulated and applied to the undeveloped lands surrounding the Ripley Township.

8 References

Minister for Climate Change and Sustainability (the Honourable Kate Jones), *Flooding Study to help Councils plan for future risks*, Ministerial Statement 10 November 2010.

MPN Consulting Pty Ltd (2010), Ripley Road Drainage Briefing for Council, 3 November 2010, prepared for the reconfiguration of a lot associated with a development application.

Queensland Government (2010), *Increasing Queensland's resilience to inland flooding in a changing climate: Final Scientific Advisory Group (SAG) report - Derivation of a rainfall intensity figure to inform an effective interim policy approach to managing inland flooding risks in a changing climate,* A joint project of: Department of Environment and Resource Management, Department f Infrastructure and Planning, Local Government Association of Queensland, November 2010.

Queensland Government (2010), *Increasing Queensland's resilience to Inland Flooding in a Changing Climate: Final report of the inland flooding study*, prepared by Queensland's Office of Climate Change – Department of Environment and Resources Management, 2010.

Sargent Consulting (2009), Planning Study for Flood Mitigation at Ripley, draft report prepared under the Natural Disaster Mitigation Program (NDMP) for Ipswich City Council, Emergency Management Queensland and Department of Transport and Regional Services.

Sargent Consulting (2010??), "…….", prepared for Ipswich City Council (date)