Perthville Floodplain Management Study

PROJECT NO. 3308
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EXECUTIVE SUMMARY

The Perthville Floodplain Management Study was commissioned by Bathurst City Council in order to review flooding behaviour at Perthville and identify measures to reduce potential damages due to future floods.

Hydrology

Hydrological analysis of the Queen Charlottes Vale Creek catchment was carried out using the RAFTS-XP rainfall/runoff model. Modelling undertaken indicates that the peak 1990 flood flow was around 250 m$^3$/s. This is lower than the predicted 100 Year ARI peak flow of 320 m$^3$/s. The 1990 flood is considered to have been approximately equivalent to a 60 Year ARI flood.

Hydraulics

Hydraulic analysis was carried out using the EXTRAN-XP unsteady state hydraulic model. The model was initially calibrated against flood debris marks surveyed after the 1990 flood. The calibrated model was then used to estimate the 5, 10, 20, 50 and 100 Year ARI design flood levels using the previously computed critical duration design storm hydrographs as input to the model. The resulting 100 Year ARI design flood levels were up to 0.3 metres higher than the 1990 flood levels.

Under the design flood levels a total of 25 houses would be subject to overfloor flooding during a 100 Year ARI flood. The average annual damages due to flooding at Perthville was assessed to be $22,000 per annum.

Flood Mitigation Options

A range of structural and non-structural mitigation options were assessed. The effect of creek clearing, deepening and widening, widening of the Bridge Street crossing, provision of bypass floodways and the construction of a permanent flood protection levee were assessed using the EXTRAN-XP hydraulic model. The results of the modelling are shown in Figures 6 to 12. It was found that a levee scheme could only be implemented if waterway improvements were also undertaken to prevent increases in flood levels occurring in the non-levee protected areas.

An alternative non-structural mitigation approach consisting of a combined voluntary purchase and house raising scheme was developed for comparison with the structural approach. Preliminary costs were estimated for all options and an economic evaluation carried out based on pre and post-works annual average flood damages.
The preferred structural mitigation scheme which consists of creek clearing and deepening, the widening of the Bridge Street crossing and a permanent levee gives a benefit/cost ratio of 0.15. In comparison, the benefit cost/ratio for the alternative non-structural mitigation scheme was calculated to be 0.10.

Responses received from a survey questionnaire indicated that structural mitigation measures were favoured by the community in comparison to non-structural measures.

Recommended Flood Mitigation Measures

The following structural mitigation measures are recommended for implementation to provide 100 Year ARI protection for all existing and future development at Perthville.

(i) Carry out stream clearing and deepening of Queen Charlottes Vale Creek extending from approximately 600 metres upstream of the Bridge Street bridge to approximately 700 metres downstream of the bridge. The estimated cost of these works is $150,000.

(ii) Carry out widening of the Bridge Street bridge to effectively double the span of the bridge to more than double the existing waterway area at an estimated cost of $360,000.

(iii) Construct a permanent levee on the eastern side of the Queen Charlottes Vale Creek following the completion of the creek clearing, deepening and bridge widening works at an estimated cost of $710,000. The final alignment, extent and freeboard provision for the levee would be determined at the time of detailed design.

The staging of works would be such that the waterway improvement works would be completed prior to the construction of the permanent levee. The period over which the works would be carried out would depend on the availability of government funding.

The next step in the floodplain management process in accordance with the NSW State Government's Flood Policy is the preparation of the Floodplain Management Plan. The implementation of the Plan would then follow as the final stage of the floodplain management process.
1.0 INTRODUCTION

This report has been prepared by Willing & Partners Pty Ltd for Bathurst City Council to present the results and findings of the Perthville Floodplain Management Study. It represents the second stage of the management process in the development of a plan to deal with flood liable land in accordance with the NSW Floodplain Development Manual.

The objective of the study was to review flooding behaviour at Perthville and to recommend measures to reduce potential damages due to future floods.

Severe flooding at Perthville was most recently experienced in August 1990 when flooding from the Queen Charlottes Vale Creek (Vale Creek) resulted in approximately 19 houses experiencing overfloor flooding.

The principal tasks covered within the study are summarised as follows:

(i) a review of flooding behaviour at Perthville including the estimation of design flood flows and design flood levels;
(ii) identification and assessment of all available flood mitigation options including structural and non-structural alternatives;
(iii) estimation of damages resulting from flooding both for existing conditions and following the implementation of the alternative floodplain mitigation works;
(iv) carry out an economic evaluation of the alternative floodplain mitigation works, and
(v) propose a draft implementation strategy for the staging of works to reflect the relative benefits of the preferred floodplain mitigation measures.
2.0 DATA SOURCES

2.1 Survey

Ground based survey was undertaken by Bathurst City Council of the Queen Charlottes Vale Creek floodplain at Perthville and extending downstream from Perthville to the confluence with the Macquarie River. The ground survey data obtained was subsequently used for the assembly of the hydraulic floodplain model.

2.2 Maps and Plans

The Queen Charlottes Vale Creek catchment was defined with the aid of 10,000 scale orthophotomaps with contours specified at 4 metre intervals. Bathurst City Council supplied cadastral maps of the village of Perthville itself.

2.3 Rainfall Data

Design rainfall data for the catchment was obtained from the 1987 edition of Australian Rainfall and Runoff (Reference 1).

2.4 Previous Reports

Flooding of Perthville was previously reviewed during the Computer Based Floodplain Model (CBFM) study (Reference 2) and the subsequent Bathurst Floodplain Management Plan (Reference 3) prepared in 1992/93 for Bathurst City Council. The hydrologic and hydraulic models used in the present study were developed during the CBFM study.

A report prepared by Bathurst City Council in November 1993 (Reference 4) recommended that the present Floodplain Management Study be carried out to ensure that additional issues not fully covered in earlier reports be taken into account and that the community at Perthville be fully involved in the formulation of the preferred floodplain management plan.
3.0 HYDROLOGICAL MODELLING

3.1 RAFTS-XP Rainfall/Runoff Model

Hydrologic analysis of the Macquarie River catchment upstream of Bathurst was previously carried out during the CBFM study (Reference 2). The rainfall runoff model used during the CBFM study was the RAFTS-XP model (Reference 5).

The RAFTS-XP model simulates runoff hydrographs at defined points throughout a watershed for a given set of catchment conditions and specific rainfall events. The watershed is divided into a number of subcatchments from which runoff hydrographs are produced and routed through a network of storages including reservoirs and retarding basins, channels and/or pipes to analyse flood mitigation and drainage strategies or to provide hydrographs for detailed hydraulic modelling of drainage systems.

The RAFTS-XP model is able to directly export hydrographs to the EXTRAN-XP flood routing model which was the adopted hydraulic model for the study.

The adopted subcatchment layout for the RAFTS-XP model is shown on Figure 1. The total catchment area of the Queen Charlottes Vale Creek to Perthville is approximately 30,000 hectares.

3.2 Model Calibration

The RAFTS-XP model of the Macquarie River catchment upstream of Bathurst was calibrated to the August 1990 flood. Streamflow records for gauges located at Bathurst, Oberon Dam and Ben Chiefly Dam combined with rainfall pluviometer data at Oberon Dam were used to calibrate the model.

Rainfall infiltration was modelled using the Australian Representative Basin Model (ARBM). The ARBM model was selected because of its ability to model antecedent wetness conditions, soil moisture conditions during storm events and baseflows. Modelling the 1990 event involved the establishment of representative initial soil moisture conditions prior to the August 1990 flood. This was achieved by modelling rainfall and runoff for the month leading up to the August 1990 flood. The soil moisture conditions and streamflows at the end of the month long simulation were adopted as the initial conditions for modelling of the flood event.
An excellent calibration of the August 1990 flood was achieved at all 3 gauged points in the Macquarie River catchment. The peak flow modelled at Perthville was 252 m$^3$/s. A detailed description of the calibration procedure and results is given in the CBFM report.

3.3 Design Flood Flows

The calibrated RAFTS-XP rainfall/runoff model was used to develop the design flood hydrographs for the Queen Charlottes Vale Creek. Rainfall intensity-frequency-duration (IFD) data was derived from the 1987 edition of Australian Rainfall and Runoff (Reference 1).

A range of storm durations were tested to enable the critical storm duration to be identified. The critical duration was found to be 18 hours at Perthville. The computed design flood frequency curve for Perthville is given in Figure 2.

The design flood modelling indicates that the August 1990 flood was approximately equivalent to a 60 Year ARI flood. The estimated 100 Year ARI peak flow at Perthville of 320 m$^3$/s is higher than the August 1990 peak flow of 252 m$^3$/s.

It should be noted that the calibration of the RAFTS-XP model was based on streamflow records at Bathurst on the Macquarie River. The Vale Creek catchment is currently an ungauged catchment and design flows at Perthville should therefore be viewed as guideline values subject to review as gauged records become available. The installation of a flow measurement station upstream of Perthville at Georges Plain in the near future should provide over time a flood frequency curve for the Queen Charlottes Vale Creek against which the computed design floods can be tested.
4.0 HYDRAULICS

4.1 EXTRAN-XP Model

Hydraulic modelling at Perthville was previously carried out using the EXTRAN-XP model (Reference 6) during the CBFM study.

EXTRAN-XP is a dynamic flow routing model for gradually varied unsteady flow. It routes inflow hydrographs through an open channel and/or closed conduit system and computes the time history of flows and heads throughout a system.

EXTRAN-XP can be used to model natural channels through the use of non-uniform HEC-2 formatted cross sections, trapezoidal or parabolic open channels or a range of closed conduit sections incorporating any number of orifices, weirs and pumps. EXTRAN-XP is one of very few models capable of modelling networks consisting of loops, multiple outlets with differing boundary conditions, and negative or zero flow conditions.

4.2 Vale Creek Floodplain Model

The EXTRAN-XP model of the Vale Creek floodplain was assembled using detailed ground survey data collected at Perthville which enabled the floodplain to be divided into a series of "cells" bounded by cross sections at approximately 150 m intervals. Downstream of Perthville the floodplain was divided into "cells" by a series of regularly spaced cross sections at approximately 600-800 m intervals.

The cross section data obtained from the ground survey was supplemented by detailed information of all major bridges and culverts on the Vale Creek supplied by Council. The modelling of the Bridge Street bridge at Perthville comprised modelling of the waterway opening as a closed conduit in conjunction with a road cross section to model possible overtopping of the road.

The EXTRAN-XP model node layout at Perthville is shown in Figure 3. Water surface levels are calculated at each node in the model.
4.3 Hydraulic Model Calibration

The EXTRAN-XP model at Perthville was calibrated against the August 1990 flood. A total of nine surveyed debris marks were available against which to calibrate the model. Flood level marks in a number of houses flooded were also used to calibrate the model. The locations of the debris marks at Perthville are shown in Figure 4.

Channel and floodplain roughness values were initially based on field assessments of the Vale Creek and the floodplain overbank areas. These roughness values were subsequently adjusted during the August 1990 flood calibration process until acceptable calibrations were achieved against the surveyed levels of the flood debris marks.

The results of the hydraulic model calibration at Perthville are presented in Table 1. It should be noted, as discussed in the CBFM report, that the expected accuracy of surveyed debris marks as an indication of peak flood levels is to within ±0.25 m.

Almost all of the predicted peak flood levels at Perthville were within ±0.15 m of the surveyed debris mark levels. In view of the expected accuracy of the debris marks as indicators of peak flood levels and the adoption of a hydrograph at Perthville which was unable to be tested against gauged flows, the level of model calibration was considered very good and the model calibration was accepted.

4.4 Design Flood Levels

The calibrated Vale Creek EXTRAN-XP model was used to estimate the 5, 10, 20, 50, and 100 Year ARI design flood levels and also a flood profile for an extreme flood.

The design flow hydrographs which were directly input into the hydraulic model were estimated using the RAFTS-XP rainfall/runoff model. The computed design flood levels are given in Table 2. The approximate 100 Year ARI flood extents are shown in Figure 5.

The extreme flood was assumed to be an event 6 times the magnitude of a 100 Year ARI event which would place it in the range between a 10,000 Yr ARI flood and the probable maximum flood (PMF). The resulting extreme flood levels given in Table 2 are indicative only. Extensive modification of the hydraulic model by extending all floodplain cross sections beyond the 100 Year ARI flood fringe would be required if more accurate extreme flood levels are required.
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Notes: 1. Node locations are shown on Figure 3.
5.0 FLOOD MITIGATION OPTIONS

5.1 Available Strategies

Possible measures for reducing the social disruption and damage caused by flooding within the study area include both structural and non-structural options. Structural measures are designed to reduce the incidence or impact of flooding on developed areas by physically modifying flood behaviour. They commonly include the following works which are described briefly as follows:

- **retarding basins** are used to collect and temporarily store runoff for release at a controlled rate. The storage of runoff leads to a reduction in peak discharges and flood levels downstream;

- **by-pass floodways** which are channels, either natural or man-made which convey a portion of the floodwaters in order to decrease the flow in the main channel below the diversion. They may also modify the local flooding behaviour at the diversion and decrease flood levels for some distance upstream of the diversion;

- **channel or waterway improvements** to increase the discharge capacity of a waterway. This may be achieved by enlarging the waterway and by clearing the waterway area of obstructions of flows such as scrub and fallen trees. An increased flow capacity in the main channel can reduce flood levels on the floodplain; and

- **levees** are a further form of flood protection. The main limitation of levees is that they rarely provide complete protection against all floods and can lead to increases in flood levels elsewhere on the floodplain and can be visually intrusive.

Non-structural measures are designed to modify existing or proposed development to reduce the impact of flooding. This can be achieved by the following means:

- **voluntary purchase** of flood affected properties. This involves the physical removal of the building from the floodplain and may be appropriate in certain high hazard areas of the floodplain where it is uneconomic to mitigate the flood hazard using structural mitigation measures;
• flood proofing of buildings by raising floor levels or house raising can be a viable option particularly for residential properties;

• the use of zoning, development and building controls as a means of ensuring that new development is subject to minimal risk of flood damage; and

• the implementation of a flood warning system and associated, evacuation plans and better public information all contribute to lessening the impact of flood damage on the community.

The primary aim of this study was to examine the range of alternative measures to provide 100 Year ARI flood protection for all existing buildings at Perthville. A series of structural mitigation options have been investigated. These are discussed in the following sections.

5.2 Structural Measures

5.2.1 Retarding Basin

The Queen Charlottes Vale Creek has a catchment area upstream of Perthville of approximately 30,000 hectares. The total volume of floodwaters passing down the creek during the critical 18 hour duration 100 Year ARI design storm is approximately 17 million m$^3$. The 100 Year ARI peak flow is 320 m$^3$/s.

An "on-line" retarding basin located a short distance upstream of Perthville would require a storage volume of approximately 3 million m$^3$ to reduce the peak 100 Year ARI flood flows at Perthville by 25%.

A retarding basin of this size with the required spillway outlet structures is likely to cost around $5 million. The high cost associated with constructing a retarding basin far outweighs the benefits which would result from reduced flood damages at Perthville. The retarding basin option was therefore considered not to be a cost-effective option.
5.2.3 Waterway Improvements

A number of waterway improvement measures to the Vale Creek were considered separately and in combination. These measures included:

(i) stream clearing works along the creek bed and bank areas extending from approximately 300 metres downstream of North Street to approximately 600 metres upstream of the Bridge Street bridge;
(ii) deepening of the creek bed by an average depth of approximately 1 metre extending as for the stream clearing works to provide additional waterway area for the conveyance of flood flows;
(iii) widening of the creek by approximately 10 metres to provide further additional waterway area, and
(iv) widening of the Bridge Street bridge structure to double its present waterway area.

The calibrated EXTRAN-XP hydraulic model was used to compute the effect on 100 Year ARI flood levels of the above works. The resulting effect on 100 Year ARI flood levels are shown in Figures 5 to 9. The implementation of all the proposed waterway improvement measures would provide 100 Year ARI protection for all but 4 existing houses at Perthville. Reductions in 100 Year ARI flood levels of up to 0.8 metres would be expected to occur under these circumstances.

A further option which was modelled was the use of Perth Street as a bypass floodway by lowering the road by up to 2 metres. The resulting effect on 100 Year ARI flood levels is shown on Figure 10. Reductions in flood levels of around 0.3 metres could be expected to result from implementing this measure.

Stream clearing works would involve the following measures to be undertaken:

(i) Clearing of all dense vegetation located within the waterway area;
(ii) Desnagging the creek bed and the removal of all flow obstacles such as dead trees, car bodies etc;
(iii) Retain existing healthy aesthetic trees while pruning any lower branch intrusions into the waterway area;
(iv) Smoothing of creek bends to avoid abrupt changes in flow direction.
Creek clearing, deepening and/or widening should be carried out such that the creek waterway retains an acceptable degree of erosion resistance. Creek clearing for example should be carried out selectively leaving sufficient trees and vegetation to ensure a stable environment. Those healthy trees of most value to the environment should be retained.

5.2.4 Levee

Almost all houses at Perthville currently subject to 100 Year ARI flooding are located on the east bank of the Queen Charlottes Vale Creek. The construction of a permanent levee to provide 100 Year ARI flood protection for all the buildings on the east bank of the creek currently subject to flooding was also modelled using the calibrated hydraulic model.

The levee would extend from the north side of North Street to approximately 600 metres upstream of the Bridge Street bridge. An indicative alignment is shown on Figure 11. The final alignment of any proposed levee would not be decided until detailed design was undertaken. The final alignment of any proposed permanent levee would attempt to minimize disruption to existing and future development and maximize the waterway area available for the conveyance of floodwaters.

The average height of the proposed levee to provide 100 Year ARI flood protection is approximately 1 metre with a maximum height of 1.5 metres. A permanent levee would also require a freeboard allowance above the 100 Year ARI flood level. Permanent levees constructed as part of NSW Government funded floodplain management schemes normally require a 1 metre freeboard above the 100 Year ARI flood level. A permanent levee at Perthville constructed under these arrangements would have an average height of 2 metres and be as high as 2.5 metres in some places.

The construction of the permanent levee would lead to increased flood levels elsewhere on the floodplain as shown on Figure 11. The levee would not be acceptable unless waterway improvements were carried out prior to the construction of the levee. Stream clearing, deepening and upgrading the existing bridge structure at Bridge Street would enable flood levels following the construction of the permanent levee to remain at or below existing flood levels on the western bank of the creek as shown on Figure 12.
The construction of a permanent levee in conjunction with the stream clearing, deepening and bridge widening waterway improvement works would provide in excess of 100 Year ARI protection for all existing buildings at Perthville. The preferred composite levee and waterway improvement works scheme is shown in Figure 13.

5.3 Non-Structural Improvement Options

There are approximately 25 existing houses at Perthville which would be subject to overfloor flooding in the event of a 100 Year ARI flood. Only a small number of these properties would possibly be suitable for cost-effective house raising. The remaining houses subject to 100 Year ARI overfloor flooding would be nominated for inclusion in a voluntary purchase scheme comprising non-structural measures only.

A combined voluntary purchase/house raising scheme is an alternative to the previously described structural scheme. The economic and social merits of the two alternative schemes are discussed in the following sections.
6.0 ECONOMIC ASSESSMENT OF MITIGATION OPTIONS

6.1 Cost of Structural Options

Preliminary cost estimates for each of the previously described structural mitigation options were prepared. These estimates are detailed in Appendix C. The estimated total cost of each of the options are summarised in Table 3. The preliminary cost estimates would be refined during the detailed design phase.

<table>
<thead>
<tr>
<th>Structural Mitigation Measure</th>
<th>Capital Cost ($</th>
<th>Maintenance Cost ($/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Creek clearing</td>
<td>40,000</td>
<td>1,200</td>
</tr>
<tr>
<td>2. Creek deepening</td>
<td>110,000</td>
<td>2,000</td>
</tr>
<tr>
<td>3. Creek widening</td>
<td>780,000</td>
<td>6,800</td>
</tr>
<tr>
<td>4. Widen Bridge Street bridge</td>
<td>360,000</td>
<td>3,100</td>
</tr>
<tr>
<td>5. Permanent Levee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 metre freeboard provided)</td>
<td>1,050,000</td>
<td>6,500</td>
</tr>
<tr>
<td>6. Permanent Levee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(300 mm freeboard provided)</td>
<td>710,000</td>
<td>4,200</td>
</tr>
</tbody>
</table>

Notes: 1. Maintenance costs have been assumed to represent 1%-3% of estimated total construction costs.
2. An allowance for land acquisition has been included within the levee costing.

Maintenance costs would be highest for creek clearing and deepening works due to the continual nature of the sediment transport and deposition processes. Maintenance costs were consequently assumed to represent 3% of the estimated total capital costs for these works. Maintenance costs for levees are likely to be lower in comparison and were assumed to represent 1% of the estimated total construction cost consistent with assumptions made in the CBFM report.
It may be possible to achieve some savings in capital costs for the permanent levee by using material excavated during creek deepening and/or widening for levee embankment formation depending on the quality of the material excavated during creek deepening and widening.

6.2 Cost of Non-Structural Options

The following assumptions were adopted for the preliminary cost assessment of the voluntary house purchase and house raising scheme:

(i) an average cost of $20,000 per residential building was applied to weatherboard and fibro clad buildings for the purpose of raising these buildings to 500 mm above the 100 Year ARI flood level, and

(ii) an average voluntary purchase price of $70,000 per flood prone dwelling was applied to those properties nominated for voluntary purchase.

A summary of the costs associated with a non-structural scheme are given in Table 4.

Table 4
Preliminary Cost Estimates for Non-Structural Mitigation Options

<table>
<thead>
<tr>
<th>Street</th>
<th>No. of Houses Flooded in 100 Year ARI flood</th>
<th>Voluntary Purchase $</th>
<th>House Raising $</th>
<th>Total ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apsley Street</td>
<td>2</td>
<td>140,000</td>
<td>-</td>
<td>140,000</td>
</tr>
<tr>
<td>Bathurst Street</td>
<td>10</td>
<td>630,000</td>
<td>20,000</td>
<td>650,000</td>
</tr>
<tr>
<td>Bridge Street</td>
<td>7</td>
<td>420,000</td>
<td>20,000</td>
<td>440,000</td>
</tr>
<tr>
<td>Vale Road</td>
<td>1</td>
<td>-</td>
<td>20,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Perth Street</td>
<td>5</td>
<td>280,000</td>
<td>20,000</td>
<td>300,000</td>
</tr>
</tbody>
</table>

**TOTAL** 25 1,470,000 80,000 1,550,000
6.3 Flood Damage Estimates

Flood damage estimates were prepared using the methods and assumptions described in Appendix A. Damages were computed for existing conditions and following the implementation of selected flood mitigation options.

Bathurst City Council carried out a floor level survey of a total of 49 buildings at Perthville which enabled the threshold and degree of overfloor flooding for each building to be defined. The ground surface level at each property was based on natural surface levels obtained during the ground survey carried out at the start of the study.

The results of the flood damages analysis are summarised in Table 5 for each of the assessed design floods. The average annual damages (AAD) are also given in Table 5.

6.4 Benefit Cost Analysis

The economic viability of the flood mitigation options was assessed using a benefit/cost analysis of each scheme. The results of the benefit cost analysis are presented in Table 6.

Assuming a discount rate of 7% and a design life period of 50 Years, the benefit/cost ratio of the two schemes are as follows:

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Benefit/Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>0.15</td>
</tr>
<tr>
<td>(levee (300mm freeboard) + stream clearing, deepening &amp; widening + bridge widening works)</td>
<td>0.15</td>
</tr>
<tr>
<td>Non-structural</td>
<td>0.10</td>
</tr>
<tr>
<td>(house raising + voluntary purchase)</td>
<td>0.10</td>
</tr>
</tbody>
</table>

A structural scheme is therefore, favoured over a non-structural scheme based on economic considerations. The benefit/cost ratio for the structural mitigation scheme does not take into account any increases in property values which may occur for those properties protected the permanent levee.
<table>
<thead>
<tr>
<th>Design Flood ARI (Years)</th>
<th>Existing Conditions</th>
<th>Post Structural Works</th>
<th>Post Voluntary Purchase/House Raising</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Damage ($)</td>
<td>No. of Buildings (*)</td>
<td>Total Damage ($)</td>
</tr>
<tr>
<td>5</td>
<td>12,000</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>10</td>
<td>46,000</td>
<td>3</td>
<td>3,000</td>
</tr>
<tr>
<td>20</td>
<td>128,000</td>
<td>11</td>
<td>4,000</td>
</tr>
<tr>
<td>50</td>
<td>209,000</td>
<td>15</td>
<td>6,000</td>
</tr>
<tr>
<td>100</td>
<td>340,000</td>
<td>27</td>
<td>9,000</td>
</tr>
<tr>
<td>Extreme</td>
<td>1,170,000</td>
<td>&gt;50</td>
<td>1,170,000</td>
</tr>
</tbody>
</table>

AAD  $21,700  $1,900  $8,600

Notes: 1. * refers to the total number of buildings for which the flood level exceeds the surveyed floor level of the building.
2. Structural works includes the construction of a permanent levee, creek clearing, deepening and bridge widening works.
<table>
<thead>
<tr>
<th>Mitigation Measure Description</th>
<th>Design Life (Years)</th>
<th>AAD Prevented ($)</th>
<th>Annual Maintenance ($)</th>
<th>Net Benefit ($)</th>
<th>Net Present Worth Benefits $ Discount Rate</th>
<th>Estimated Capital Cost ($)</th>
<th>Net Present Worth Capital Cost $ Discount Rate</th>
<th>Benefit Cost Ratio Discount Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary Purchase/ House Raising</td>
<td>30</td>
<td>16,800</td>
<td>8,600</td>
<td>8,200</td>
<td>142,000 102,000 77,000</td>
<td>1,550,000 1,257,000 1,089,000</td>
<td>953,000</td>
<td>0.11 0.09 0.08</td>
</tr>
<tr>
<td>Levee + Associated Waterway Improvement</td>
<td>50</td>
<td>19,800</td>
<td>10,500</td>
<td>9,300</td>
<td>161,000 115,000 88,000</td>
<td>1,220,000 990,000 857,000</td>
<td>750,000</td>
<td>0.16 0.13 0.12</td>
</tr>
<tr>
<td>Works</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td>228,000 133,000 93,000</td>
<td></td>
<td>750,000</td>
<td>0.23 0.16 0.12</td>
</tr>
</tbody>
</table>

Notes: 1. Maintenance costs for structural mitigation works have been assumed to represent 1-3% of estimated total construction costs.
2. Capital costs of mitigation measures assumed to be incurred over a 10 Year period.
3. Levee cost assumes 300 mm of freeboard provided.
7.0 SOCIAL ASSESSMENT

The NSW Floodplain Development Manual requires that representatives of the community and particularly the owners of the flood liable land be involved in the preparation and review of the management plan. The following community consultation activities were undertaken during the preparation of the Perthville Floodplain Management Study:

(i) a detailed questionnaire was distributed to residents living on the floodplain at Perthville to gain their views on floodplain management, and
(ii) a public meeting was held at Perthville at which floodplain mitigation measures were discussed.

7.1 Questionnaire

A copy of the questionnaire distributed to residents is presented in Appendix B. Questionnaires were distributed to 45 addresses representing owners and occupiers of dwellings on the floodplain. A total of 18 completed questionnaires were returned giving a response rate of 40%.

The questionnaire responses to the various flood mitigation measures which were listed for consideration are summarised as follows:

<table>
<thead>
<tr>
<th>Measure</th>
<th>In Favour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth levees</td>
<td>61%</td>
</tr>
<tr>
<td>Concrete wall levees</td>
<td>11%</td>
</tr>
<tr>
<td>Creek clearing of excessive vegetation</td>
<td>88%</td>
</tr>
<tr>
<td>Creek widening and/or deepening</td>
<td>88%</td>
</tr>
<tr>
<td>Increasing capacity of Bridge Street bridge</td>
<td>55%</td>
</tr>
<tr>
<td>Voluntary sale schemes</td>
<td>17%</td>
</tr>
<tr>
<td>House raising schemes</td>
<td>22%</td>
</tr>
<tr>
<td>Other flood proofing of individual properties</td>
<td>33%</td>
</tr>
<tr>
<td>Zoning controls</td>
<td>11%</td>
</tr>
<tr>
<td>Building controls</td>
<td>22%</td>
</tr>
</tbody>
</table>

Of the 18 questionnaires received only 6 indicated their house had been flooded above their floor level during the 1990 flood. Approximately 45% of responses indicated that they had received prior warning that the 1990 flood was about to occur.

19
The survey responses which were received would appear to indicate that the community favours a structural mitigation approach. The preferred structural options in order of greatest support were:

1. Creek clearing
2. Creek widening and/or deepening
3. Earth levees
4. Increasing the capacity of the Bridge Street bridge

7.2 Public Meeting

A public meeting was held on Thursday, 21 July 1994 to discuss floodplain management options with the Perthville community. Structural and non-structural options were described to those present at the meeting.

A number of residents at the meeting reported experiencing higher depths of overfloor flooding during the 1990 flood than indicated by the EXTRAN-XP model. As a consequence, a number of floor levels were re-surveyed by Bathurst City Council. Depths of overfloor flooding were also obtained where known. The model was subsequently re-calibrated in response to the additional flooding data collected by Council.
8.0 FLOODPLAIN MITIGATION STRATEGY

8.1 Preferred Mitigation Scheme

The objective of the study was to recommend measures to reduce potential damages at Perthville due to future flooding. The hydrological and hydraulic analysis carried out as part of this study enabled a wide range of structural mitigation options to be assessed. Based on the mitigation measures investigated in this study, it is recommended that the preferred approach to floodplain management at Perthville should consist of structural mitigation measures.

The following structural mitigation measures are recommended for implementation to provide 100 Year ARI flood protection for the residents of Perthville:

(i) Carry out stream clearing and deepening of Queen Charlottes Vale Creek extending from approximately 600 metres upstream of the Bridge Street bridge to approximately 700 metres downstream of the bridge. The estimated cost of these works is $150,000.
(ii) Carry out widening of the Bridge Street bridge to double its present waterway width at an estimated cost of $360,000.
(iii) Construct a permanent levee on the eastern bank of the Queen Charlottes Vale Creek following the completion of the creek clearing, deepening and bridge widening works at an estimated cost of $710,000. The final alignment, extent and freeboard provision for the levee would be determined during the detailed design phase.

It should be noted that Bathurst City Council will shortly commence improving the flood warning system for Perthville by installing a combined river height and rainfall recording station at Georges Plains. The station shall form part of an upgraded flood warning system for the Macquarie River catchment upstream of Bathurst. All recording stations will be connected via a telemetry system to a base station located at Bathurst where rainfall and streamflow data can be monitored continuously. This system will increase the warning time of a flood and allow flood damages to be partly avoided by allowing residents time to lift household items off the floor and to remove valuable items from their homes.
8.2 Funding and Staging of Works

Floodplain management plans prepared in accordance with the NSW Floodplain Development Manual (Reference 7) have been successful in attracting 2:2:1 Federal: State: Local Government funding. Under this arrangement, Council's share in funding of flood mitigation works are 20% whilst the Federal and State Governments each contribute 40%. The timing and availability of funds cannot be predicted. Consequently the staging of works given below is an indicative program only. A possible sequence of events is:

<table>
<thead>
<tr>
<th>Year</th>
<th>Measure</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Creek clearing and deepening</td>
<td>150,000</td>
</tr>
<tr>
<td>2-5</td>
<td>Bridge Street bridge widening</td>
<td>360,000</td>
</tr>
<tr>
<td>5-10</td>
<td>Permanent levee construction</td>
<td>710,000</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>$1,220,000</td>
</tr>
</tbody>
</table>

Note: 1. Costs are 1994 estimates

8.3 Preparation of Floodplain Management Plan

The next step in the floodplain management process in accordance with the NSW State Government's Flood Policy is the preparation of the Floodplain Management Plan. The Plan preparation would include further consultation with the Perthville community most likely in the form of an additional public meeting. The implementation of the Plan would then follow as the final stage of the floodplain management process.
9.0 REFERENCES


2. WILLING & PARTNERS PTY LTD (June 1993), "Computer Based Floodplain Model Final Report", prepared for Bathurst City Council.


4. CITY OF BATHURST (November 1993), "Floodplain Management Plan Report".


7. NEW SOUTH WALES GOVERNMENT (1986) "Floodplain Development Manual".
LEGEND

- MACQUARIE RIVER CATCHMENT BOUNDARY
- RAFTS - XP SUBCATCHMENT BOUNDARY
- WATERCOURSE
- CATCHMENT AREA UPSTREAM OF PERTHVILLE
- RAFTS - XP NODE NUMBER

CATCHMENT PLAN

FIGURE 1
PREDICTED PERTHVILLE FLOOD FREQUENCY CURVE

FIGURE 2
LOCATION OF SURVEYED DEBRIS MARKS
AUGUST 1990 FLOOD
FIGURE 4
LEGEND

- 673.37  100 YEAR ARI FLOOD LEVEL

- Approx. 100 Year ARI Flood Extents

- Area Subject to 100 Year ARI Inundation

100 Year ARI Flood Levels

Figure 5
LEGEND

-0.06 CHANGE IN FLOOD LEVEL

CREEK CLEARING WORKS
EFFECT ON 100 YEAR ARI FLOOD LEVELS
FIGURE 6
LEGEND

-0.33 CHANGE IN FLOOD LEVEL

COMBINED CREEK CLEARING AND BRIDGE WIDENING WORKS EFFECT ON 100 YEAR ARI FLOOD LEVELS

FIGURE 7
LEGEND
-0.79 CHANGE IN FLOOD LEVEL

COMBINED CREEK CLEARING, DEEPENING
AND WIDENING AND BRIDGE WIDENING WORKS
EFFECT ON 100 YEAR ARI FLOOD LEVELS
FIGURE 9
LEGEND

-0.07 CHANGE IN FLOOD LEVEL

PERMANENT LEVEE INDICATIVE ALIGNMENT

COMBINED PERMANENT LEVEE AND CREEK CLEARING, DEEPENING AND BRIDGE WIDENING WORKS EFFECT ON 100 YEAR ARI FLOOD LEVELS

FIGURE 12
APPENDIX A
FLOOD DAMAGES ASSESSMENT
A. FLOOD DAMAGES ASSESSMENT

A.1 Damage Categories

It is usual practice to divide flood damages into two major categories, direct and indirect. The latter is further subdivided into tangible and intangible damage components.

Flood damages can also be classified as 'actual' or 'potential'. Potential damage represents the situation where the damages are not mitigated, i.e. no allowance is made for items lifted or removed from properties to lessen flood damages. Actual damage is an estimate of the damages after action has been taken to reduce them. The difference between potential and actual damage is sometimes referred to as 'avoidable damage'.

A.1.1 Direct Damage

Direct damage results from the action of floodwaters together with associated sediment and debris. In broad terms, such losses include the direct impact of floods upon a range of man made structures. In this study the direct damages are those that would occur to buildings and their contents. The direct damages to other forms of the built environment such as roads, bridges and other aspects of infrastructure are termed as external damage within this study.

A.1.2 Indirect Damage

The tangible component of indirect damage results from the disruption caused by flooding. Tangible losses are capable of expression in direct monetary terms. It includes the cost of alternative accommodation for the residential sector and loss of trading profit for commercial enterprises and services, together with the additional costs of transport due to the destruction of bridges etc.

The improvement of flood warning times by the formulation of improved flood evacuation procedures or an upgraded flood warning system would have the potential to reduce the actual flood damages incurred.
The adopted residential stage damage estimates are shown in Table A.1. They represent 75% of the potential damage for an average sized residential dwelling. Indirect flood damages were determined as a percentage of direct damages in line with previous flood damage studies. The adopted figure for residential property was 5% which excludes the clean-up costs.

Clean-up costs for residential property were evaluated as a function of depth of flooding and the value of the time of those involved in the clean-up, which was taken as half the average weekly earnings. The equation for clean-up time was assumed as follows in line with previous studies:

\[
N = 5.5 \ln \left( \frac{d}{0.023} \right) \quad \text{B.1}
\]

where:
- \( N \) = number of man-days required to clean up the average property
- \( d \) = depth of flooding (m)

The value of the time of those involved in the clean-up operations was adopted as $300 per week, which gave clean-up costs:

\[
$\text{Clean-up} = 330 \ln(d/0.023) \quad \text{B.2}
\]

**Table A.1**

<table>
<thead>
<tr>
<th>Depth Overfloor Flooding (m)</th>
<th>Direct Damage ($).</th>
<th>Indirect Damage ($).</th>
<th>Clean-Up Costs ($).</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1</td>
<td>3,600</td>
<td>180</td>
<td>490</td>
</tr>
<tr>
<td>0.6</td>
<td>10,200</td>
<td>510</td>
<td>1,080</td>
</tr>
<tr>
<td>1.5</td>
<td>13,200</td>
<td>660</td>
<td>1,380</td>
</tr>
<tr>
<td>2.0</td>
<td>13,800</td>
<td>690</td>
<td>1,470</td>
</tr>
</tbody>
</table>
The usual flood damage estimation procedures are restricted to the estimation of direct damage to buildings and contents. Indirect damage, the other component of tangible loss, is more difficult to assess. The methods used in earlier studies in Australia assume indirect damage to be a set proportion of direct damage. For example, the indirect losses for the residential sector are then taken to be 5 to 15% of direct costs, and for the commercial sector 55%.

The remaining category of indirect damage is termed 'intangible' and is difficult, or impossible, to assess in real monetary terms. Major components of intangible damage would include stress and inconvenience experienced by the flood community. The most significant factor is the possibility of the loss of life.

The size of the death toll is heavily dependent on the length of the warning time, the efficiency of transmitting such a warning and, finally, upon the response of those at risk. For planning purposes this is compounded by the differing forms the flood could take.

A.2 Estimation Procedure

The computer model DAMAGE developed by Willing & Partners was used to calculate the expected cost of damage for a range of design floods. Properties were divided into residential and commercial/industrial categories. Damages were categorised into direct and indirect damages as previously defined.

A2.1 Residential Damages

The stage damages estimates for residential properties used in this study are given in Table A1.

The direct damages for residential properties were calculated as a function of the depth of flooding of the house for a typical property. The flood damages were derived from extensive studies carried out in Sydney after floods experienced in 1986. The residential stage damages used for this study are therefore based on actual damage and not potential damage. Previous studies have shown that actual damages may range between 40% and 90% of potential flood damages depending on the degree of preparedness of the residents. The actual damages experienced during the 1986 Sydney floods were considered to represent approximately 75% of the potential damage.
A2.2 Commercial/Industrial Damages

The adopted commercial/industrial stage-damage curves are in terms of potential damage due to the more complex nature of the commercial/industrial sector. These curves were also derived from extensive studies which followed the 1986 Sydney floods.

In common with other flood damage studies, indirect flood damages for the commercial/industrial sector were determined as 55% of the direct damages. The adopted depth dependant damages for industrial and commercial properties are given in Table A2.

Table A2
Average Direct Industrial and Commercial Damages

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Low Value</th>
<th>Medium Value</th>
<th>High Value</th>
<th>Low Value</th>
<th>Medium Value</th>
<th>High Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.25</td>
<td>1,910</td>
<td>5,730</td>
<td>17,170</td>
<td>6,040</td>
<td>18,130</td>
<td>54,380</td>
</tr>
<tr>
<td>0.75</td>
<td>4,770</td>
<td>14,310</td>
<td>42,930</td>
<td>14,630</td>
<td>43,890</td>
<td>131,650</td>
</tr>
<tr>
<td>1.25</td>
<td>7,160</td>
<td>21,470</td>
<td>64,400</td>
<td>22,260</td>
<td>66,780</td>
<td>200,340</td>
</tr>
<tr>
<td>1.75</td>
<td>7,950</td>
<td>23,850</td>
<td>71,550</td>
<td>24,650</td>
<td>73,940</td>
<td>221,805</td>
</tr>
<tr>
<td>≥2.0</td>
<td>8,430</td>
<td>25,280</td>
<td>75,850</td>
<td>26,240</td>
<td>78,710</td>
<td>236,115</td>
</tr>
</tbody>
</table>
A2.3 External Damages

External damages were evaluated as a function of depth of flooding above ground level for a typical developed property. The major component of external damage includes an allowance for damage to motor vehicles (eg. cars, caravans, boats and trailers). Other considerations include allowances for damage to infrastructure (eg. roads, bridges, drains) and damage to fences, gardens and lawns. The adopted depth dependant damages are shown in Table A3.

Table A3
Average Direct External Damages

<table>
<thead>
<tr>
<th>Depth over ground m</th>
<th>Damage $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>0.6</td>
<td>780</td>
</tr>
<tr>
<td>1.0</td>
<td>3,300</td>
</tr>
<tr>
<td>≥2.0</td>
<td>6,600</td>
</tr>
</tbody>
</table>

A.3 Property Data

Bathurst City Council provided floor level information for a total of 49 properties located within the flood affected and flood fringe areas at Perthville. A summary of the data provided is shown in Table A4.
<table>
<thead>
<tr>
<th>Street</th>
<th>No. of Residential Properties</th>
<th>No. Commercial/Industrial Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apsley Street</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Bathurst Street</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Bridge Street</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Perth Street</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Prince Street</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Rockley Street</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Vale Road</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX B
QUESTIONNAIRE
PART A - GENERAL INFORMATION ON THE FLOODPLAIN COMMUNITY

1. How long have you been a resident in Perthville?
   - Less than 1 year
   - 1 to 5 years
   - 5 to 10 years
   - More than 10 years

2. How long have you been a resident in this house in Perthville?
   - Less than 1 year
   - 1 to 5 years
   - 5 to 10 years
   - More than 10 years

3. How many people normally reside in your house?
   - 1
   - 2
   - 3
   - 4
   - More than 4

4. What is the main source of income to your household?
   - One or more people working
   - Retirement income other than pension
   - Pension or Special Benefits

5. Is your total yearly household income (that is the combined income of all those resident in the house)
   - Less than $20,000
   - $20,000 to $35,000
   - More than $35,000
6. Do you own (includes paying off) or rent your house?

☐ Own
☐ Rent

7. What is the main reason you chose to live in this location?

☐ Like the neighbourhood
☐ Like the house
☐ Close to the creek
☐ House cheaper
☐ Near relatives/friends
☐ Inherited House
☐ Other

PART B - FLOOD EXPERIENCE

8. Did you live in this house at the time of the 1990 flood?

☐ Yes
☐ No

If your answer is No go to Question 12.

9. Was your house flooded to above floor level in the 1990 flood?

☐ Yes
☐ No

10. Did you receive any warning that the 1990 flood was about to occur?

☐ Yes
☐ No
If Yes
- What was the source of the warning?

☐ Police
☐ SES
☐ Radio
☐ TV
☐ Neighbours of friends
☐ Other

- How long before your floor was flooded did you receive the warning?

☐ Less than 30 minutes
☐ 30 minutes to 1 hour
☐ 1 to 2 hours
☐ 2 to 4 hours
☐ 4 to 12 hours
☐ More than 12 hours

11. Were you evacuated from your house?

☐ Yes
☐ No

If Yes, for how long?

☐ Less than 6 hours
☐ 6 to 12 hours
☐ 12 to 24 hours
☐ 24 to 48 hours
☐ More than 48 hours

- Where did you stay?

☐ With friends or relatives
☐ In a motel/hotel paid for by Government Authorities
☐ In a motel/hotel that you paid for
☐ In community facilities (such as a church hall etc.)
☐ Other
PART C - ATTITUDES TO FLOODPLAIN MANAGEMENT MEASURES

12. Do you believe a levee around your area is desirable?

☐ Yes
☐ No

Do you have any comments on levees?

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

(Attach additional comments if so desired)

13. Do you favour widening and/or deepening of the Queen Charlottes Vale Creek as a flood mitigation measure?

☐ Yes
☐ No

Do you have any comment on creek widening and/or deepening?

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

(Attach additional comments if so desired)

14. Do you favour one or more of the measures on the list attached to this questionnaire?

Numbers of the measures supported (eg. 1, 3, 8)

..........................................................................................................................
..........................................................................................................................
..........................................................................................................................
..........................................................................................................................

(Attach additional comments if so desired)
FLOOD MITIGATION MEASURES (for Question 14)

1. Grassed earth levees
2. Concrete wall levees
3. Creek clearing of excessive vegetation
4. Creek widening and/or deepening
5. Increasing capacity of Bridge Street bridge
6. Voluntary sale schemes
7. House raising schemes (mainly for timber or fibro houses)
8. Other flood proofing of individual properties
9. Zoning controls
10. Building controls
APPENDIX C
PRELIMINARY COST ESTIMATES
<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>2.</td>
<td>Clearing and Disposal</td>
<td>m</td>
<td>1500</td>
<td>15.00</td>
<td>22,500</td>
</tr>
<tr>
<td>3.</td>
<td>Stabilisation</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td><strong>Sub Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>32,500</td>
</tr>
</tbody>
</table>

**Contract Sum**

- Contingencies -10% | 3,250

**Total Construction Cost**

- Survey & Design - 10% | 3,575
- Supervision - 5%      | 1,787

**TOTAL** | 41,112

**SAY** | $41,000
### Table C2
**Preliminary Cost Estimate - Creek Deepening**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>2.</td>
<td>Construction Survey</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>3.</td>
<td>Excavation &amp; Disposal</td>
<td>m³</td>
<td>25,000</td>
<td>2.00</td>
<td>50,000</td>
</tr>
<tr>
<td>4.</td>
<td>Stabilisation/Regrassing</td>
<td>m²</td>
<td>20,000</td>
<td>1.00</td>
<td>20,000</td>
</tr>
</tbody>
</table>

**Sub Total** 90,000

**Contract Sum**

- Contingencies -10% 9,000

**Total Construction Cost** 99,000

- Survey & Design - 10% 9,900
- Supervision - 5% 4,950

**TOTAL** 113,850

**SAY** $110,000
### Table C3

**Preliminary Cost Estimate - Creek Widening Works**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate $</th>
<th>Amount $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>2.</td>
<td>Construction Survey</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>3.</td>
<td>Excavation &amp; Disposal</td>
<td>m³</td>
<td>75,000</td>
<td>7.50</td>
<td>562,500</td>
</tr>
<tr>
<td>4.</td>
<td>Stabilisation/Regrassing</td>
<td>m²</td>
<td>45,000</td>
<td>1.00</td>
<td>45,000</td>
</tr>
</tbody>
</table>

Sub Total: 622,500

**Contract Sum**

Contingencies -10%: 62,250

Total Construction Cost: 684,750

Survey & Design - 10%: 68,475

Supervision - 5%: 34,238

**TOTAL**: 787,463

**SAY**: $780,000
### Table C4
Preliminary Cost Estimate - Bridge Street Bridge Widening

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate $</th>
<th>Amount $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Construction Survey</td>
<td>Item</td>
<td></td>
<td>5,000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Abutments</td>
<td>Item</td>
<td></td>
<td>90,000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Deck</td>
<td>Item</td>
<td></td>
<td>175,000</td>
<td></td>
</tr>
</tbody>
</table>

Sub Total | 280,000

**Contract Sum**
- Contingencies -10% | 28,000

Total Construction Cost | 308,000
- Survey & Design - 10% | 30,800
- Supervision - 5% | 15,400

**TOTAL** | 354,200

**SAY** | $360,000
Table C5
Preliminary Cost Estimate - Permanent Levee (1 metre freeboard provided)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate $</th>
<th>Amount $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>2.</td>
<td>Construction Survey</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>3.</td>
<td>Site Preparation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Clearing &amp; Grubbing</td>
<td>m²</td>
<td>16,500</td>
<td>7.90</td>
<td>130,350</td>
</tr>
<tr>
<td>3.2</td>
<td>Strip and Stockpile</td>
<td>m²</td>
<td>16,500</td>
<td>2.60</td>
<td>42,900</td>
</tr>
<tr>
<td>4.</td>
<td>Earthworks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Win, transport &amp; compact all fill,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>topsoiling &amp; regrassing</td>
<td>m³</td>
<td>17,600</td>
<td>17.30</td>
<td>304,480</td>
</tr>
<tr>
<td>5.</td>
<td>Internal Drainage Works</td>
<td>Item</td>
<td></td>
<td></td>
<td>100,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sub Total 592,730

Contract Sum
Contingencies -10% 59,273

Total Construction Cost 652,003
Survey & Design - 10% 65,200
Supervision - 5% 32,600

Sub Total 749,803

Land Acquisition 300,000

TOTAL 1,049,803

SAY $1,050,000
### Table C6
Preliminary Cost Estimate - Permanent Levee (300 mm freeboard provided)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Rate $</th>
<th>Amount $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Establishment</td>
<td>Item</td>
<td></td>
<td></td>
<td>10,000</td>
</tr>
<tr>
<td>2</td>
<td>Construction Survey</td>
<td>Item</td>
<td></td>
<td></td>
<td>5,000</td>
</tr>
<tr>
<td>3</td>
<td>Site Preparation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Clearing &amp; Grubbing</td>
<td>m²</td>
<td>11,000</td>
<td>7.90</td>
<td>86,900</td>
</tr>
<tr>
<td>3.2</td>
<td>Strip and Stockpile</td>
<td>m²</td>
<td>11,000</td>
<td>2.60</td>
<td>28,600</td>
</tr>
<tr>
<td>4</td>
<td>Earthworks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Win, transport &amp; compact all fill, topsoiling &amp; regrassing</td>
<td>m³</td>
<td>9,000</td>
<td>17.30</td>
<td>155,700</td>
</tr>
<tr>
<td>5</td>
<td>Internal Drainage Works</td>
<td>Item</td>
<td></td>
<td></td>
<td>100,000</td>
</tr>
</tbody>
</table>

Sub Total 386,200

**Contract Sum**

| Contingencies -10% | 38,620 |

Total Construction Cost 424,820
Survey & Design - 10% 42,482
Supervision - 5% 21,241

Sub Total 488,543

Land Acquisition 220,000

**TOTAL** 708,543

**SAY** $710,000