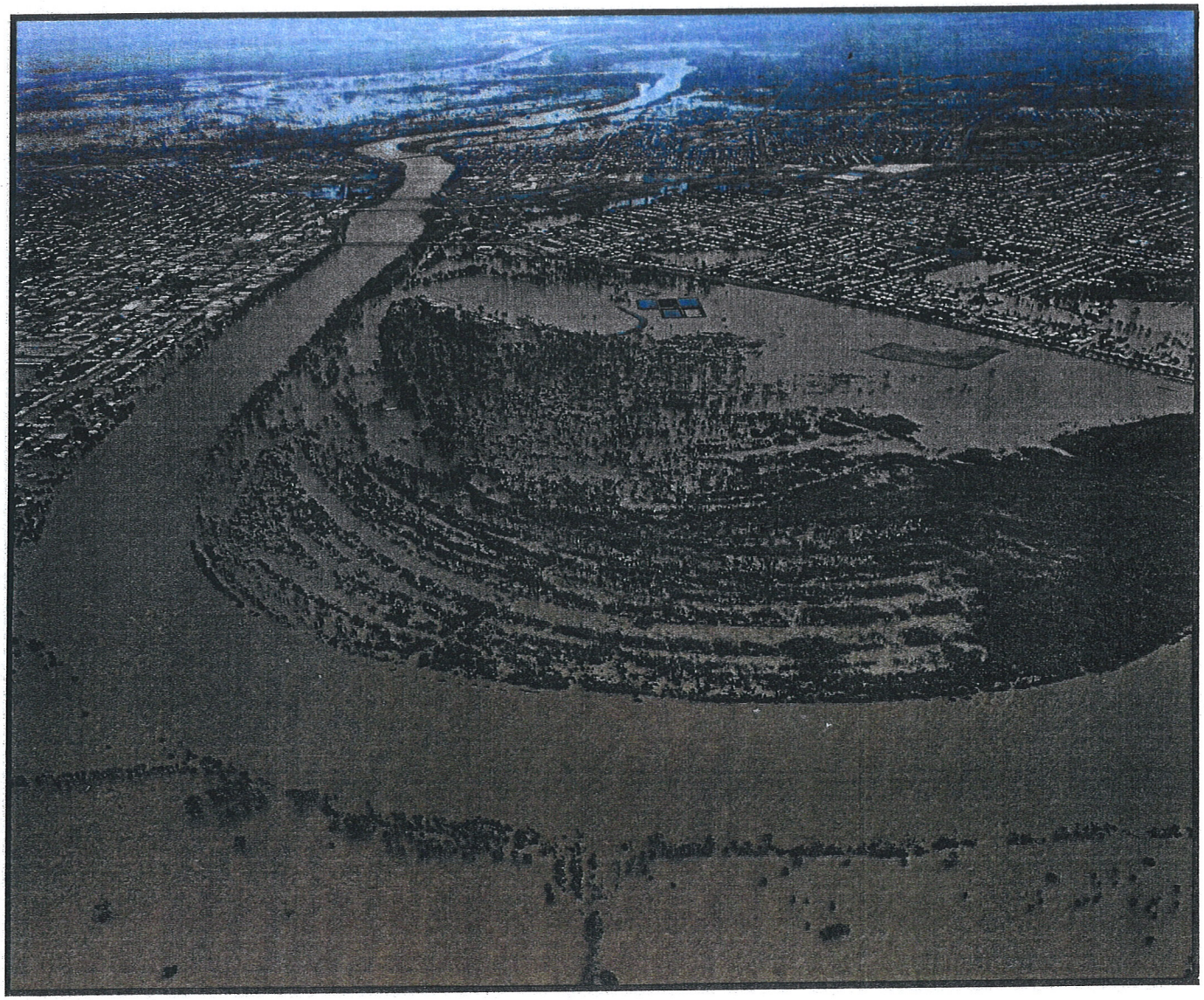
WATER RESOURCES COMMISSION



ROCKHAMPTON FLOOD MANAGEMENT STUDY

PHASE 2 REPORT

VOLUME 1
EXECUTIVE SUMMARY

CAMP SCOTT FURPHY PTY LTD
ACN 004 939 548

NOVEMBER 1992

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PREFACE

The Rockhampton Flood Management Study was an outcome of the January 1991 flooding at Rockhampton. This flood caused major economic and social problems in the Rockhampton area. Homes and businesses were flooded and the city was isolated from the rest of Queensland for 12 days. Communities right along the Queensland coast were affected by this severing of the coastal road and rail links.

The three levels of Government – local, state and federal – then agreed that a study was needed to allow better management of the Fitzroy River flooding at Rockhampton. The Water Resources Commission then arranged for this study and a Steering Committee, comprising the main authorities concerned with the flooded areas near Rockhampton, was formed. This Steering Committee, which provided direction during the study, consisted of representatives from the following bodies:

QDPI – Water Resources Commission
Rockhampton City Council
Livingstone Shire Council
Fitzroy Shire Council
Department of Transport
Queensland Railways
Commonwealth Department of Primary Industries and Energy

Consultant – Camp Scott Furphy Pty Ltd – was engaged to carry out this study.

The consultant considered recent Fitzroy River flow records, along with the historical flood levels since 1859, to assess the likely frequency of different flood levels at Rockhampton. The economic losses of the 1991 flood were assessed. These two aspects in combination then allowed assessment of the likely annual damages from flooding at Rockhampton. The effects of the existing major works in the flooded area were reviewed, while the social and environmental impacts of flooding were also considered.

From a whole range of possible flood mitigation options, the consultant has recommended a number of both structural and non-structural measures to best reduce the impacts of flooding at Rockhampton. The structural measures recommended are those with the highest benefit to cost advantage, whilst having acceptable hydraulic impacts. The non-structural measures recommended are those areas which need improving, based on the experiences gained from the 1991 flood.

The consultant regularly referred their findings back to the Steering Committee during the course of the study. They have also held public meetings and displays to allow input from the general public and to keep them informed. This report is the final outcome of the consultants extensive studies and its findings are endorsed by the Steering Committee. This study now allows a better understanding of the mechanisms and likely occurrence of flooding at Rockhampton, the damages flooding causes and recommends ways to better manage this flooding.

Nevertheless, the release of this study report does not imply any immediate commitment by the various authorities to carry out the recommended measures. These bodies each have ongoing work commitments, responsibilities and financial constraints which may restrict what action they take here. A statement by the Department of Transport on how they determine priorities for road works is contained in the main report.

Each authority will, no doubt, give due consideration to the study's detailed findings and recommendations in their planning and control of future works in these flood affected areas. Readers of this report should be aware, though, that it is still up to each authority to determine what measures it takes to reduce these flooding problems and for the timing of these measures.

M B McKenna
Regional Manager
Water Resources Commission
ROCKHAMPTON

&

Chairman
Rockhampton Flood Management Study
Steering Committee

ROCKHAMPTON FLOOD MANAGEMENT STUDY

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ROCKHAMPTON FLOOD MANAGEMENT STUDY

PHASE 2

EXECUTIVE SUMMARY

INTRODUCTION

Rockhampton, the largest urban centre in Central Queensland, is built adjacent to the Fitzroy River. The Fitzroy River basin is one of the largest on the east coast of Australia, with a catchment area above Rockhampton of about 140,000 km^2.

The Fitzroy River at Rockhampton and adjacent areas and townships have been subjected to flooding on many occasions as a result of heavy rainfalls in the Fitzroy River basin. The worst flood since records commenced in 1859 was in 1918, when the river level at Rockhampton reached 10.11 m on the City flood gauge (8.65 m AHD). The second highest peak was 9.4 m gauge height (7.95 m AHD) in 1954. Rockhampton again suffered major flooding in January 1991 due to heavy rainfalls associated with Cyclone Joy. The peak flood level on this occasion reached 9.30 m gauge height (7.85 m AHD), but due to changes in the floodplain characteristics in recent years this level cannot be compared directly with that of previous major floods. In river discharge terms, both the 1991 and 1954 floods had peak flows of about 15,000 m^3/s at Yaamba compared to about 18,000 m^3/s in 1918.

Major flood flows cause flooding from Yaamba to downstream of Rockhampton including significant flooding of the lower lying parts of Rockhampton. A major flood breakout occurs upstream of Rockhampton at Pink Lily which results in significant flow in the floodplain which flows to the south of the city. These floodplain flows can result in the closure of Rockhampton Airport, the Bruce and Capricorn Highways and the North Coast Railway. Also the Bruce Highway and the North Coast Railway can be cut by floodwaters at the Alligator Creek crossing near Yaamba, some 30 km north of Rockhampton. In the 1991 flood, all of these links were cut for about two weeks, effectively isolating Rockhampton for this period.

This disruption to all major traffic routes in and out of Rockhampton results in large indirect flood losses not only in Rockhampton but throughout the Queensland Coast. Significant direct flood damages resulted in the 1991 flood from about 160 properties being inundated above floor level, with a further 1200 properties being flooded to below floor level.

This Study was commissioned, following the 1991 flood, to consider all aspects of current flood management and options for future flood management in order to make recommendations aimed at reducing the impact, both tangible and intangible, of future floods.

The Study has been funded under the Federal Water Resources Assistance Program (FWRAP) and the study reports have been prepared to facilitate application for further FWRAP funding for the recommended works.

The Phase 1 Report, released in April 1992 comprised:

- Study of Fitzroy River flood characteristics;
- Flood damage assessment;
- Appraisal of options for flood management;
- Recommendations in regard to future flood management;
- Community consultation.

The current report on Phase 2 comprises detailed investigation of those options identified in Phase 1 as having sufficient merit to warrant more detailed study.

A brief summary of the studies carried out, the recommendations of non-structural flood management measures which can be implemented immediately, and structural flood mitigation works are given in this Executive Summary.

The recommended measures provide the opportunity for substantial reduction in the economic and social costs of flooding in Rockhampton. The recommended works are capable of providing these improvements with minimal adverse impact.

It is anticipated that, providing the works recommended herein secure community support, application for funding of the structural works may be made under the Federal Water Resources Assistance Program (FWRAP). It is the responsibility of the Local Authorities to make such application for funding, in the first instance to the Water Resources Commission. Applications close on 15 December each year and if supported by both State and Federal Government may be included in the budget for commencement of the following year. It should be noted that such applications are assessed on their merits, cost-effectiveness and priority relative to other State projects.

COMMUNITY CONSULTATION

Public displays to summarise the findings and recommendations of the Phase 1 Report were prepared in late April 1992 and the reports were made available in local libraries. Three public meetings were held in early May 1992 to explain the findings of Phase 1 and to elicit feedback from the community. These meetings were attended by a total of 53 residents whose response was generally positive. Two written submissions were subsequently received in regard to proposed flood mitigation works.

There was general support for the proposed non-structural measures, namely upgrading of the flood warning system, the installation of flood markers, provision of a recorded telephone service, flood preparedness leaflets/telephone directory entries.

There was general agreement that further consideration to upgrading the flood immunity of the Yeppen Crossing was warranted.

There was concern expressed in regard to levees, particularly property resumption impacts and flood level impact upstream. The positive effect on property values within the protected area and the potential for development of land currently liable to flooding were recognised.

Fairybower/Gracemere residents were vocal in their adverse reaction against levees both around Port Curtis/Depot Hill and the airport. Their view was that they had been disadvantaged by previous works eg. the Fitzroy River Barrage and Yeppen crossing and did not want to be further disadvantaged. Furthermore they are against contributing (by way of rates/charges) to any works which will disadvantage them.

HYDRAULIC MODEL STUDIES

Model Calibration and Validation

A major component of the Phase 2 Study was the hydraulic model study. This comprised setting up of the computer model MIKE II to simulate floods in the Fitzroy River from Yaamba to the ocean together with the associated floodplain in the Rockhampton area. The model was calibrated using the 1991 and 1988 floods, the only floods which are representative of current conditions. Agreement between observed flood levels for these events and those estimated from the model were generally within ±0.2 m and within ±0.15 m at key locations. This degree of agreement is regarded as being satisfactory considering the known limitations of some of the topographic information utilised in the model, and the difficulty of accurately recording flood levels under very bad conditions.

It was concluded that the fitted model adequately represented floods of 9,400 m^3/s (1988) and 14,200 m^3/s (1991) representing annual exceedance probabilities (AEP's) of 8.5% and 2% respectively. Floodplain flows in the 1988 flood were within 14% of measured flows, and bridge flows at Yeppen for the 1991 flood were in very close agreement with those estimated from measured levels and velocities.

The model was then run, without further amendment to its parameters, with the recorded flood hydrographs for 1983, 1978, 1954 and 1918, in order to validate the model, satisfactory model performance for these events indicating the robustness of the model over a range of floods. The only modification made to the model for these validations runs was the removal of the Fitzroy River barrage in the runs for pre-barrage conditions (1954 and 1918). The model represented existing conditions in all other aspects. At the Rockhampton flood gauge, differences between observed and modelled flood levels for these events were in the range of +0.06 m and -0.21 m, whilst at Yaamba, flood levels were overestimated by up to 0.28 m and 0.23 m for the 1954 and 1918 floods but underestimated by up to 0.6 m from the 1983 flood. These discrepancies are believed to relate to changes in cross section which are known to have occurred over the period of record. As the model has been set up to represent current conditions in the river and the floodplain as closely as possible, it could not be expected to reproduce levels in conditions different from those presently existing. It was concluded that, subject to the limitations outlined above, the model performed satisfactorily over a wide range of floods.

Following from the above, it was concluded the model could be utilised with acceptable confidence in the estimation of flood levels for a range of design floods for current conditions, and for consideration of the effectiveness and impact of a range of flood mitigation options.

Design Floods

Following completion of the calibration/validation stage, the hydraulic model was used to simulate water levels resulting from a range of design floods from 5% AEP (20 year ARI) to 0.1% AEP (1,000 year ARI).

The peak flow at Yaamba together with the resulting distribution of flows between the river and the floodplain are given in Table A.

TABLE A

Summary of Peak Discharges in Design Runs

Flow Path	Location	Peak Discharge (m^3/s) for AEP of					
		5%	2%	1%	0.5%	0.2%	0.1%
Fitzroy River	Yaamba	11,500	14,200	16,400	19,000	22,500	24,000
	Barrage	9,150	10,250	11,100	12,100	13,400	14,000
Floodplain	Breakout at Pink Lily	2,435	4,130	5,600	7,400	9,810	10,850
	Yeppen Crossing						
	– bridge flow	2,100	2,500	2,650	2,670	2,675	2,680
	– overflow	200	1,410	2,600	4,420	6,920	7,920
	– total	2,300	3,910	5,250	7,090	9,595	10,600
Note: the difference between flow at the Barrage and breakout flow at Pink Lily is return flow via Lion Creek.							

Comparison of this distribution of flows between the river and the floodplain with those from the previous model studies (Table 13–1 of the Phase 1 Report) shows these to be consistent with the two physical models but with substantially greater floodplain flow than the 1987 mathematical model.

Table B summarises the peak flood levels at key locations in the river and the floodplain for the range of flows considered. Levels for floods more extreme than 1% AEP should be regarded as tentative as they may exceed the levels of topographic information.

TABLE B

Summary of Peak Flood Levels for Design Runs

Location	Peak Flood Levels (m AHD) for AEP of					
	5%	2%	1%	0.5%	0.2%	0.1%
Yaamba	17.11	17.93	18.52	19.14	19.88	20.18
Barrage	8.93	9.49	9.91	10.35	10.90	11.13
City Flood Gauge	7.37	7.84	8.21	8.59	9.04	9.23
u/s Yeppen Crossing	8.06	8.64	9.00	9.32	9.67	9.83
Airport (Terminal)	8.64	9.61	10.15	10.64	11.20	11.43
Note: Levels for floods of AEP < 1% are tentative.						

The flood levels obtained from the design runs were utilised to produce flood maps for existing conditions as outlined in a subsequent paragraph.

The model was then modified to simulate the resulting flood levels with a wide range of flood mitigation options, as outlined below.

FLOOD MITIGATION OPTIONS

The report describes a wide range of flood mitigation options in detail together with their impact on flood levels. The range of flood mitigation options considered was:

- levee construction: Port Curtis - Depot Hill - Lower CBD and Depot Hill - Lower CBD only;
- levee construction: airport including the effect of the proposed runway extension;
- levee construction: Splitters Creek;
- improving flood immunity of the Yeppen Crossing, together with lessening the impact on upstream flood levels;
- reduction in floodplain flows by raising breakout control levels in the Pink Lily area;
- construction of a major floodway to the south of the city, either in whole or in part;
- impact of Commonage Landfill;
- lowering the elevated section of the Capricorn Highway.

These options were considered firstly on an individual basis, and then in various combinations. A summary of the cost, benefit cost ratios where appropriate, and flood level impacts of the various schemes are given in the accompanying Figures.

Only the first four options given above were beneficial in substantially reducing flood damages and/or levels. A summary of the recommended options is given in a subsequent paragraph.

The cost of the various flood mitigation options should be compared with the 'do nothing' cost which has been estimated (see Phase 1 Report) to be $5.2 million per annum. This is the long term damage cost averaged over the range of flood probabilities.

The bulk of the flood damages in Rockhampton result from flows in the Pink Lily–Yeppen–Gavial Creek Floodway, with only the lower part of Quay Street and relatively minor flooding on the north bank of the river resulting directly from river levels exceeding bankfull in the immediate vicinity. This suggests that reduction in flood levels in the areas subject to flooding from the floodway is likely to provide the most appropriate means of reducing the flooding problems in Rockhampton.

Levee Construction

The most appropriate means of reducing flood damages in the main flood liable areas such as Port Curtis and Depot Hill is to protect them from flooding by the construction of levees.

Levees are low earth embankments built to exclude flood waters. They have advantages and disadvantages which should be clearly understood by the community in deciding whether to proceed with any proposed levees.

Levees are often the most economically attractive form of protection to flood liable areas. They exclude all flood waters from the protected area for all floods up to some selected design flood. Their chief disadvantage results from this limitation in that they may overtop in some flood greater than that for which they are designed, unless designed to protect against probable maximum flood. This overtopping may be accompanied by failure of the levee. Subsequent damage in these circumstances is made all the worse because of the expectation of protection. This impact is minimised by good design which incorporates spillway sections in the levees to allow controlled overtopping in the event of extreme flood together with good construction practices and an appropriate level of maintenance. This allows time for evacuation and prevents catastrophic failure.

Levee construction should be accompanied by a community education and awareness program to ensure that the benefits and limitations of levees are realised.

Other negative impacts are the effects on flood levels elsewhere in the floodplain, and problems with internal drainage which requires storage, and in extreme cases may require pumped outlets to be provided.

In spite of these problems, which as stated above may be minimised by appropriate design and by community education, levees can provide a high level of community benefit.

For example, by preventing flooding over the full range of floods up to the design flood, significant reduction in flood damages can accrue. Furthermore, any land protected by the levee which was previously undeveloped because of its flood liable nature, may become available for development. Property values tend to rise due to rezoning and subsequent development of vacant land, and also values of existing property may increase due to the lowered flood risk. As property values rise, and/or land is developed, Council rates income increases. In Rockhampton, where there is little development potential close to the business district, this could be a substantial benefit, which has not been included in the benefit–cost analysis.

A summary of advantages and disadvantages of levee schemes is given below.

Advantages	Disadvantages	Overcome by
Reduction in mean annual flood damage Reduction in social impacts of flooding Improved property values Scope for additional development	Failure due to overtopping False sense of security Increase in flood levels elsewhere	Design/maintenance Education/warning Compensatory works if increase unacceptable

The above are taken into account in regard to the various options considered.

A levee to protect Depot Hill and the CBD alone would offer substantial benefits in terms of reduction in flood damages and would have a negligible impact on flood levels. This would, however, be to the detriment of the Port Curtis community whose already high sense of isolation would be worsened. The Port Curtis area could be protected within a combined levee one end of which would be near the Yeppen Crossing and the other along Quay Street. This levee would have substantial economic benefits, but if constructed on its own would cause significant increase in flood levels upstream of 0.9 m downstream of Yeppen Crossing for 1% AEP flood, by 0.4 m on the upstream side of Yeppen Crossing and by 0.15 m at Fairybower Road. However, these negative impacts can be obviated by carrying out these works in conjunction with the proposed upgrading of the Yeppen Crossing (see below). With protection to 1% AEP flood level, the cost of this option is $7.4 million, with reduction in mean annual damages (MAD) of $0.49 million and a benefit–cost ratio (BCR) of 1.25 at 5% discount rate (0.93 at 7%). Raising the level of protection to 0.5% AEP, at a cost of $8.85 million would increase the BCR to 1.43 (1.05) as damage reduction would be substantially increased to $0.63 million. However, the latter is not recommended as this would have a negative impact on flood levels in the floodplain.

LEVEE OPTIONS

Option	Description	Table J-1
A1	Levee Depot Hill, Lower CBD	

Cost: $5.7 million (to 1% AEP)
Reduction MAD: $0.30 m p.a.
BCR: 1.07 (0.75) **NPV:** $5.8 m ($4.3 m)
Impact on levels:
Minimal as not flow path.
Eliminates flooding to design level in area protected which suffers from high frequency flooding. Port Curtis still in floodway.

Option	Description	Table J-2
A2	Levee Port Curtis – Depot Hill – Lower CBD	

Cost: $6.9 million (to 1% AEP)
Reduction MAD: $0.49 m p.a.
BCR: 1.35 (1.0) **NPV:** $9.3 m ($6.9 m)
Impact on levels:
u/s Yeppen Crossing +0.30 m, +0.42 m at 2%, 1% AEP.
d/s Yeppen Crossing +0.61 m, +0.90 m at 2%, 1% AEP.
Eliminates flooding to design level in protected area which suffers high frequency flooding.
Impact on levels too great as a stand alone measure – needs to be combined with other measures.

Option	Description	Table J-3
A3	Levee – Rockhampton Airport	

Cost: $4.3 (to 1% AEP)
Reduction MAD: $2.1 m p.a
BCR: 0.45 (0.33) **NPV:** $1.94 m ($1.44 m)
Impact on levels:
Increases levels along Lion Creek (outside levee) by max of 0.37 m at 2% AEP, 0.58 m at 1% AEP.
Reduces levels u/s Yeppen by 0.04 m, 0.08 m for 2%, 1% AEP.
Increase levels city reach of river by 0.03 m, 0.05 m for 2% AEP, 1% AEP.
Major benefit – keeps airport open to 1% AEP for emergency relief.

Option	Description	Table J-4
A4	Levee – Airport with proposed runway extension	

Details not available, modelled approximately, little change from A3.

Note: NPV at 5% (7%)

Option	Description	Table J-5
A5	Splitters Creek	

Cost: $140,000 (to 1% AEP)
Reduction MAD: $9,000 p.a.
BCR: approx 1.2 (0.9)
Impact on levels:
Negligible – eliminates minor flood path.

Option	Description
A6	Moores Creek

Impact on levels:
Negligible as flood storage only.

Option	Description
A7	Lakes Creek Road

Impact on levels:
Increases flood levels negligible as flood storage only.

Options shaded thus are carried forward for further consideration.

Summary of Levee Options

The proposed levee around Rockhampton Airport would ensure flood free operation to 1% AEP flood and provide protection to the adjacent residential area. This would increase flood levels along Nine Mile Road and the Rockhampton-Ridgelands Road by 0.56 m and 0.12 m respectively in 1% AEP but would result in a small decrease in flood levels downstream of the airport. A few houses outside the levee, within the floodway would need to be raised. The estimated cost of these works is $4.3 million, for protection to 1% AEP flood level, with MAD reduction of $0.1 million and BCR of 0.45 at 5% (0.33 at 7%). Increasing the level of protection to 0.5% AEP would increase the cost to $5.6 million. The justification of these works would be in regard to maintaining operation of the airport during major floods.

A small levee to prevent the breakout from the Fitzroy River into Splitters Creek was also considered. A levee alone, without flood gates on Splitters Creek would not eliminate backwater flooding from the river but would stop the higher velocity overflow occurring. This would cost $0.14 million and has a bcr of about 1.2 (0.9).

Upgrading of Yeppen Crossing

As discussed in the Phase 1 Report (section 13.5), the highway and railway crossings, of the Fitzroy River floodplain to the South of Rockhampton, known as the 'Yeppen Crossing' were reconstructed in the 1980's. The design flood immunity of the crossing is 8.5% AEP (12 year ARI). The actual performance of the crossing in the 1988 and 1991 floods is consistent with the design criteria and the anticipated average duration of closure of 0.58 days per year. Notwithstanding the above, it is clear that the indirect losses caused by closure of this crossing are high and could be substantially reduced by further upgrading of the flood immunity of the crossing.

It was apparent from the investigation of individual options for Yeppen Crossing that only those combining an increase in waterway area with an increase in embankment height would be able to improve the flood immunity of the crossing without negative impact on flood levels.

The existing bridge and embankment structures across the floodplain at Yeppen comprise 4 road and 4 rail bridges. These structures cause significant afflux during major floods. Although reduction in afflux would be beneficial to flood levels in the Fairybower area and to a lesser degree at the airport, flood damages in these areas alone are not sufficient to warrant works to reduce afflux by increasing bridge waterway area. Also simply raising the embankments without increasing waterway area has a negative impact on upstream levels but very small reduction to submergence times.

However, the combination of increased waterway area and raised embankment height offers significant reduction in submergence time together with some improvement in flood levels. The options considered in this regard (B5 and B7) would both maintain flood free conditions for 2% AEP flood (eg. the 1991 flood) with time of submergence for 1% AEP being reduced from about 12.7 days under existing conditions to 6.8 days for Option B5 and 8 days for Option B7.

Under Option B5, each of the bridges would be doubled in length, and the embankment would be raised so as to give constant road and rail heights across the entire length of the crossing. It is emphasised that, whilst doubling of bridging length is shown by the hydraulic model studies to be appropriate, this should not be taken as final design dimensions of these structures. The individual bridges will need to be designed to ensure that they meet design criteria for velocity and afflux. This is outside the scope of the current study.

The cost of upgrading as outlined above has been estimated to be $16.5 million on the basis of existing carriageway width. No allowance has been made for widening to four lanes as has been recommended in the recent Rockhampton Transport Study.

Option B7 represents a lower cost alternative in which the additional waterway area would be obtained by excavating an average of 2 m from upstream of the highway bridges through to downstream of the railway bridges. The hydraulic model runs showed this to be almost as beneficial as doubling bridge length, in conjunction with raising embankments. An initial consideration of the structural implications of this has shown this to be feasible. In the case of the highway bridge, DOT have indicated that no bridge strengthening would be required, but in the case of the railway bridges the pile caps would be exposed, requiring some structural works and possibility the installation of some additional piles. However, detailed structural calculations in this regard, are outside the scope of the study. It would also be necessary to provide some protection works in the lowered sections in order to prevent continuing erosion. Gabions/reno mattresses would be suitable in this regard. This option could have a relatively high maintenance cost, as small floods may cause siltation in the lowered section. This tendency would be minimised by limiting the slope of the downstream ramp. As floodplain flows occur only on a frequency of 1 year in 7 on average, this should not be a major problem. The lowered sections would be drained to Scrubby Creek to prevent permanent water below the bridges. The cost of this option, at $13.0 million, offers substantial saving over Option B5. This cost includes for bridge strengthening measures expected to be sufficient.

However, the Department of Transport have indicated that this option would be unacceptable, hence it has been excluded from the recommended options.

The preferred option would produce a flood free crossing at 2% AEP with reduced times of submergence of 6.8 days at 1% AEP. The average annual closure time would be reduced to 0.15 days per annum. These times vary slightly when these measures are combined with others.

Mean annual damage costs for the Yeppen Crossing which relate primarily to indirect losses resulting from disruption to business operation was estimated to be $1.75 million p.a., although accuracy of this estimate is not high, as explained in the Phase 1 Report. Upgrading the crossing as outlined above, would reduce MAD to $0.45 million p.a. representing a benefit of $1.3 million p.a.. This has a net present value of $24.7 million at 5% discount rate and hence a BCR of 1.50. Corresponding values at 7% are $18.2 million with BCR of 1.1.

As well as this scheme having a reasonable high benefit-cost ratio (greater than 1) it would also have a significant social impact as it would not only greatly reduce the disruption to the movement of persons and goods into and out of Rockhampton during floods, but would also significantly improve the sense of isolation caused by the closure of the major crossings.

YEPPEN CROSSING

Option	Description	Table J-6
B1	Double bridge width	

Impact on levels:
Reduces flood level u/s of crossing by 0.27 m for 2% AEP, 0.29 for 1% AEP.
Reduces flood levels Airport, Fairybower Road by 0.08, 0.14 m respectively for both 2% and 1% AEP.
Reduces levels Depot Hill by 0.06 m, 0.1 m for 2% and 1% AEP.
TOS: 9.75 d, 11.95 d (current 11.6, 12.7 d)

Option	Description	Table J-9
B5	Combine B1 + B4	

Cost: $16.5 million
Reduction MAD: $1.3 m p.a.
Flood Free at 2% AEP

NPV: $24.7 m ($18.2 m)
BCR: 1.50 (1.10)
Impact on levels:
Reduces flood level u/s crossing by 0.17 m, 0.05 m for 2%, 1% AEP.
Reduces flood levels Airport by 0.05 m, 0.02 m for 2%, 1% AEP.
Reduces flood level Fairybower Road by 0.09 m, 0.02 m.
Reduces level at Depot Hill by 0.08 m, 0.15 m.
TOS: 0 at 2% AEP, 6.8 d at 1% AEP

Option	Description	Table J-8
B4	Raise road/rail to bridge level	

Impact on levels:
Increases flood u/s of crossing by 0.38 m for 2% AEP, 0.31 m for 1% AEP.
Increases level Fairybower Road by 0.23 m, 0.19 m for 2% AEP, 1% AEP.
Reduces level Depot Hill by 0.04 m, 0.06 m for 2%, 1% AEP
TOS: 7.67 d, 9.63 d for 2%, 1% AEP

Option	Description	Table J-11
B7	Combine B6 + B4	

Cost: $13.0 million
Reduction MAD: $1.28 m p.a
Flood Free at 2% AEP

NPV: $24.3 m ($17.9 m)
BCR: 1.87 (1.38)
Impact on levels:
Increases flood level u/s of crossing by 0.01 m for 2% AEP, 0.27 m for 1% AEP.
Increases flood level Airport by 0 for 2% AEP, 0.09 m for 1% AEP.
Increases flood level Fairybower by 0, 0.16 m for 2%, 1% AEP.
TOS: 0 for 2% AEP, 8.d for 1% AEP

Option	Description	Table J-10
B6	Increase waterway area by lowering invert by 2 m	

Impact on levels:
Reduces level u/s of crossing by 0.21 m for 2% AEP, 0.22 m for 1% AEP.
Reduces level Fairybower Road by 0.11 m 2% and 1% AEP.
Reduces level Depot Hill by 0.03 m, 0.05 m for 2%, 1% AEP
TOS: 10.1 d, 11.4 d for 2%, 1% AEP

Options shaded thus are carried forward for further consideration.

Note: NPV at 5% (7%) **Summary of Flood Mitigation Options – Yeppen Crossing**

a) Options with Port Curtis – Depot Hill – CBD Levee

Option	Description	Table J-30
C8	(B5a + A2) Yeppen upgrade + levee Port Curtis to CBD	

Cost: $23.9 m
Reduction MAD: $1.77 m
NPV: $33.6 m ($24.8 m)
BCR: 1.40 (1.04)

Yeppen flood free at 2% AEP Port Curtis, Depot Hill, Lower CBD flood free to 1% AEP

Impact on levels:
Flood level u/s Yeppen reduced by 0.28 m at 2% AEP and 0.02 lower at 1% AEP. Levels at airport reduced by 0.09 m at 2% AEP, and 0.02 m at 1% AEP.
Levels at Fairybower Road reduced by 0.15 for 2% AEP and by 0.02 m at 1% AEP.
TOS zero 2% AEP, 6.5 days at 1% AEP.
THIS OPTION PROVIDES PROTECTION TO GREATEST FREQUENTLY FLOODED AREA AND RESULTS IN REDUCTION IN LEVEL U/S OF YEPPEN AT 1% AND 2% AEP.

Option	Description	Table J-31
C9	(C8 + A3 + A5) ie. as C8 + Levee Airport + Spitters Creek	

Cost: $28.4 million
Reduction MAD: $1.88 m p.a.
NPV: $35.7 m ($26.3 m)
BCR: 1.26 (0.93)

Yeppen flood free at 2% AEP Airport, Port Curtis, Depot Hill, CBD flood free to 1% AEP

Impact on levels:
Flood level u/s Yeppen reduced by 0.33 m at 2% AEP compared with existing and 0.09 m at 1% AEP compared to existing. Raises level Nine Mile road by 0.11 m, 0.18 m for 2% AEP, 1% AEP.
Level at Fairybower Road reduced by 0.25 m, 0.17 m for 2%, 1% AEP. Small increase in level in river Pink Lily – Barrage, reduction d/s of barrage of 0.02 m, 0.05 m at City gauge for 2%, 1% AEP.
TOS zero 2% AEP, 3.5 days at 1% AEP.
THIS OPTION PROVIDES PROTECTION TO AIRPORT AND SPLITTERS CREEK AREA AS WELL AS PORT CURTIS – CBD – SMALL REDUCTION IN LEVEL U/S YEPPEN AT 2% AEP, BUT INCREASE OF 0.17 M AT 1% AEP.

Option	Description	Table J-32
C10	as C9 + Raise Pink Lily Breakout by 1.25 m	

Yeppen flood free at 2% AEP Airport, Port Curtis, Depot Hill, CBD flood free to 1% AEP.

Impact on levels:
Breakout level at Pink Lily offsets increased levels at Fairybower, Yeppen caused by levee, at expense of raising river levels by 0.02 m, 0.01 m at Yaamba, 0.44 m, 0.27 m near WTW (2%, 1% AEP) 0.28, 0.16 at Barrage, 0.12 m, 0.02 m at City Flood Gauge.
Reduction at Fairybower Road 0.44 m, 0.18 m, and at Yeppen Crossing 0.40 m, 0.01 m for 2%, 1% AEP.
TOS zero 2% AEP, 5.4 days 1% AEP.

Option	Description	Table J-9a
B5a	as B5 + removal of bridge on Old Burnett Highway & disused railway embankment	

Yeppen TOS 0 for 2% AEP, 3.0 d 1% AEP

Impact on levels:
Flood level u/s Yeppen Crossing reduced by 0.34 m for 2% AEP, and by 0.16 m for 1 % AEP. Respective reductions Fairybower Road 0.18 m, 0.09 m.
Levels in City reach reduced by 0.04, 0.05 m for 2%, 1% AEP.
Levels at Airport reduced by 0.11 m, 0.05 m.
Levels at Depot Hill reduced by 0.13 m, 0.25 m for 2% , 1% AEP.
Yeppen Crossing flood free at 2% AEP
TOS: 3.0 d for 1% AEP

Preferred Options

Note: NPV at 5% (7%)

NOTE: The above options relate to increasing waterway area of Yeppen bridges by doubling the bridge length.

b) Options with Depot Hill – CBD Levee only (ie. excluding Port Curtis)

Option	Description	Table J-28
C6	(B5 + A1) Yeppen upgrade + levee Depot Hill to CBD	

Cost: $22.2 million
Reduction MAD: $1.62 m
NPV: $30.8 m ($22.7 m)
BCR: 1.38 (1.02)

Yeppen flood free at 2% AEP Depot Hill, Lower CBD flood free to 1% AEP

Impact on levels:
Improved flood level impacts compared to C8 at expense of not protecting Port Curtis area. Levels u/s Yeppen reduced by 0.16 m for 2% AEP compared to existing, and by 0.07 m at 1% AEP.
Reduction at Airport 0.05 m at 2% AEP, 0.01 m at 1% AEP.
Reduction at Fairybower Road 0.09 m 2% AEP, 0.03 m at 1% AEP. TOS zero 2% AEP, 6.9 days at 1% AEP.
REDUCED IMPACT U/S YEPPEN COMPARED TO OPTION C8, BUT AT EXPENSE OF NOT PROTECTING PORT CURTIS.

Option	Description	Table J-29
C7	(C6 + A3 + A5) – as C3 + levee Airport & Spitters Creek	

Cost: $26.7 million
Reduction MAD: $1.73 m
NPVE: $32.9 m ($24.2 m)
BCR: 1.23 (0.91)

Yeppen flood free at 2% AEP Airport, Depot Hill, Lower CBD flood free to 1% AEP

Impact on levels:
U/s Yeppen flood level reduced by 0.20 m at 2% AEP 0.13 m at 1% AEP and at Fairybower Road by 0.18 m, 0.19 m respectively.
Raises level Nine Mile Road by 0.11 m, 0.19 m for 2%, 1% AEP.
TOS zero at 2% AEP, 6.4 days at 1% AEP.
BENEFICIAL U/S YEPPEN AND FAIRYBOWER AREA, PREVENTS FLOODING 1% AEP TO AIRPORT, DEPOT HILL, CBD, BUT NOT PORT CURTIS.

'Do Nothing' Case
Cost: MAD of $5.2 million per year Closure Frequency Yeppen Crossing 8.5% (12 year ARI) Flooding Frequency Port Curtis – Depot Hill – Lower CBD 8% – 10 % AEP (10 – 12 year ARI)

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Summary of Combined Flood Mitigation Options

The contribution to reduction in damages and isolation due to the currently planned upgrade of the Alligator Creek crossing near Yaamba is recognised.

Summary of Recommended Options

The recommended structural flood mitigation schemes are therefore:

Priority 1 • Levee to protect lower Dawson Road, Port Curtis, Depot Hill and the lower CBD against floods up to 1% AEP together with upgrading Yeppen Crossing to 2% AEP flood immunity. The combined cost of these works has been estimated to be $24 million. These works would greatly reduce direct flood damages in the most flood liable areas of Rockhampton, and greatly reduce indirect damages due to the closure of the southern approach routes. This scheme also has high social as well as economic benefit.

Priority 2 • Levee to protect Rockhampton Airport. This would cost $4.3 million with protection to 1% AEP flood level. This would have to be justified on the basis of greatly improved flood immunity to the Airport from about 5% AEP to 1% AEP.

Priority 3 • Splitters Creek levee, cost $0.14 million and a BCR of 1.2.

Priority 4 • Flood gates on Splitters Creek, Moores Creek, Frenchmans Creek, Thozet Creek and flood valves yon stormwater drainage outlets, approximate cost $2.5 million.

FLOOD MAPPING

Flood maps showing the extent of flooding for a range of flood levels, on a probability basis, are a necessary pre-requisite to the development of planning controls for flood liable land. The delineation of the flood liable area into high and low hazard categories is a further aid in the development of planning controls.

A flood map has been prepared at a scale of 1:10,000 to show the extent of inundation in 2%, 1% and 0.5 % AEP floods.

The extent of the maps has been limited to the areas for which contour plans are available. These do not, therefore, cover the whole of Rockhampton City nor any of the flood liable parts of Livingstone and Fitzroy Shires. Predictions of flood levels are available for the latter areas from the hydraulic model.

The flood maps, however, are of a low level of accuracy because of significant anomalies between the observed flood inundation extent in 1991 (2% AEP) and that determined by available contour information.

Whilst the 2% AEP flood line is believed to be reasonably accurate, the 1% and 0.5% AEP events are regarded as indicative only. They should not be used, therefore, to determine whether or not a particular block is flood liable at 1% AEP. The flood maps have been marked to clearly display this limitation.

The accuracy of the maps is also dependant upon the accuracy of the modelled flood levels. This is expected to be of the order of ±0.2 m at the 1% AEP level. The extent of such variation on the ground can be substantial where gradients are low.

If the works recommended in this study are constructed, the necessity for improving the accuracy of the flood maps will diminish, because most of the areas where there is some doubt as to the extent of flooding will be protected by the various mitigation measures.

However, should the recommended works not proceed, it is recommended that the accuracy of the flood maps be improved by actually establishing on the ground, the 1% AEP levels determined from the hydraulic model. This should be done prior to final adoption of the flood maps.

Prior to adoption of the maps for planning purposes, we recommend that the maps be issued in draft form for public comment. This will enable any minor anomalies in relation the 1991 flood extent to be identified and resolved. The maps could then be adopted as interim documents until they can be refined as discussed above.

In addition to the flood inundation map, a flood hazard map has been prepared. This categorises the flood liable area of Rockhampton into floodway, flood storage and flood fringe areas which are each sub-divided into low hazard and high hazard areas. This map is subject to similar limitations regarding accuracy as the flood inundation map, and should be regarded as preliminary.

It is recommended that the development guidelines given in the NSW Floodplain Development Manual be adopted in regard to planning and the consideration of development applications in the flood liable areas of Rockhampton City, and where applicable to the adjacent flood liable parts of the Fitzroy Shire and Livingstone Shire.

It is also recommended that no new residential, commercial or industrial development be permitted in designated floodways.

The primary requirement in regard to new residential dwellings where they are permitted is for a minimum habitable floor level of 0.5 m above the design flood (1% AEP). It is recommended that this level be adopted. The same criteria should apply to access roads within any new areas of development, where these are permitted in flood fringe and flood storage areas.

SUMMARY OF RECOMMENDATIONS

This section summarises the recommendations made in Phases 1 and 2 of the study for improvement of flood management in Rockhampton. The latter incorporates both the structural flood mitigation options discussed above and the non-structural measures recommended in the Phase 1 Report. The consideration of a combination of such measures is in line with the guidelines given for works to be funded under the Federal Water Resources Assistance Program (FWRAP).

This section also briefly addresses possible funding for these works.

It is recommended that those items of the relatively low cost non-structural measures identified as being of first priority be implemented by Rockhampton City Council, Fitzroy Shire Council and Livingstone Shire Council as appropriate, as soon as possible and prior to awaiting the outcome of any funding application, as although these do not give any physical protection against flooding they will ensure that damages are minimised should another major flood occur prior to the construction of the flood mitigation works.

The estimated total cost of the recommended works is about $32 million. Of this, the very important non-structural works would cost about $0.3 million, and it is recommended that these be carried out as soon as possible. The structural works have been designated at four priority levels and it is recommended that these priorities be used in phasing the works according to budget constraints. A summary of these items is given in Table C and recommendations are outlined in more detail in the following paragraphs.

Non-Structural Measures

The following is a summary of the non-structural measures which were recommended in the Phase 1 Report, which should be consulted for further detail. These are measures recommended for immediate implementation.

a) Formulation and adoption of a floodplain management policy to be formalised by the adoption of appropriate planning instruments. The flood inundation map and flood hazard map produced as part of this study provide the basis for these controls. For the preparation of the floodplain management policy allow $30,000;

b) Upgrading of the flood warning system:
   - installation of telephone telemetry at the Rockhampton flood warning gauge, cost $20,000;
   - installation of a new river level station with telephone telemetry at Pink Lily to provide information regarding floodplain flows, cost $15,000;
   - installation of rainfall recorders at existing river level stations equipped with telephone telemetry (Riverslea, The Gap, Neerkol Creek) cost 3 @ $1,000 ie. $3,000;
   - installation of a water level and a rainfall recorder with telephone telemetry in the Alligator Creek catchment, cost $16,000.

Annual maintenance and operation on the above, allow $20,000. It is possible that some of the cost of the above upgrading could be met by the Bureau of Meteorology.

c) Installation of permanent flood markers throughout the urban area and the floodplain to show the 1991 flood level, allow $25,000 (1,000 markers @ $25);

d) Establishment of a recorded message telephone service for flood warnings at the Local Emergency Operations Centre (LEOC), cost approximately $30,000. The warning messages should be frequently updated and should contain information on levels at Tartrus, Riverslea, The Gap, Yaamba, and the new floodway reference gauge as well as Rockhampton. The message should repeat so that information missed on the first pass may be reheard. Multiple telephone lines should be provided;

e) Instigation of a programme of raising community flood awareness and preparedness, by means of:

i) making the flood maps available for sale to the public;
ii) preparation of a flood awareness pamphlet;
iii) inclusion of a flood awareness page in the local telephone directory;
iv) encouragement to local business operators to prepare flood action plans;
v) establishment of the LEOC as a single point of contact;
vi) raising media awareness of their role in flood warning dissemination;
vii) improvement to road closure reporting (RACQ/LEOC).

The costs of preparation of the community flood awareness material would be approximately $25,000.

The total cost of these measures outlined above would be $163,000 plus annual maintenance costs of about $30,000. The improvement in flood warnings and the way in which the community can relate the warnings to their own circumstances would be expected to result in a substantial reduction in direct flood damages. If this results in only a 10% reduction in actual damage, this is worth of the order of $200,000 p.a. (mean annual direct damage approximately $2 m) so this expenditure is clearly worthwhile. These measures are further summarised in Table C.

The Phase 1 report also contained a recommendation in regard to a pilot study of the feasibility of flood proofing commercial premises in Rockhampton. This may be supported by local business groups. The aim of such a study would be to look at the practicalities of flood proofing a small number of existing buildings of a range of types and industry types, together with a detailed examination of the damage reduction such measures would produce in order to enable evaluation of the cost effectiveness of this approach. There is very little detailed information in this regard, hence support for a pilot study would be very worthwhile. The cost of this study would be about $40,000. Business operators should also be encouraged to prepare flood contingency plans, or flood action plans, so that they can minimise damage and disruption caused by any future floods.

Whilst the responsibility for flood forecasting lies with the Bureau of Meteorology, there would be merit in establishing a flood forecasting model for the lower Fitzroy River which would be operated locally. This could be developed from the MIKE II model set up for the current study and would allow the operators of the LEOC to have improved information of a more detailed nature than that provided by the bureau. The cost of developing this model would be about $50,000 plus $30,000 for computer software and hardware. It is recommended that consideration be given to developing this system.

Structural Measures

The following structural measures are recommended. The priority of each component is shown. Should the works be constructed in a phased manner, the order of construction should follow the priority rating. A phased approach will allow the highest level of benefits to be achieved early during the works programme. Works of Priority 1 to 4 may be convesidgned, for example, as a 4 year work programme. This timing must be determined by Local Authority in regard to the bridges and also in regard to possible funding.

As discussed in Section 3, the recommended works comprise the following, a summary of which is given in Table C.

a) **Priority 1**

- upgrading Yeppen crossing by raising embankment height to bridge height for the full width of the floodplain crossing, together with doubling the bridge waterway area by increasing bridge length to about 840 m from the existing 420 m. The estimated cost of these works is $16.5 million.

  These works would raise the flood immunity of the southern road and rail approaches to Rockhampton to above 2% AEP, with significantly reduced closure times for more extreme floods.

  The damage reduction has been estimated to be about $ 1.3 million per annum on a long term average basis, with a benefit-cost ratio of 1.5, 1.87 for these alternatives assuming a 5% discount rate (1.1, 1.4 for 7%).

- Construction of a levee to protect the lower Dawson Road/Gladstone Road, Port Curtis, Depot Hill areas and the lower part of the CBD. This would extend from Blackall Street to the north of Yeppen Yeppen Lagoon along Jellicoe Street to Port Curtis, across to Depot Hill, to near the Gavial Creek junction with the Fitzroy River, then along Quay Street to Derby Street. If protection were provided to 1% AEP, the cost would be about $6.9 million, with a BCR of 1.35 at 5% (1.0 at 7%). Raising the level of protection to 0.5% AEP would increase the total cost to $8.35 million with a BCR of 1.43 (1.05), and to 0.2% AEP the cost would be $10.1 million with a BCR of 1.45 (1.06). However, raising the level of protection above 1% AEP would adversely impact on flood levels elsewhere in the floodplain for floods more severe than 1% AEP, so 1% AEP is recommended as the basis of design.

- Removal of the bridge/causeway along the section of the Old Burnett Highway between Jellicoe Street and the new Bruce Highway, together with removal of the disused railway embankment adjacent to the Old Bruce Highway between Port Curtis and Roopes Bridge at a cost of approximately $0.5 million.

The latter measure is necessary to help offset the adverse impact of flood levels caused by the proposed levee. The measures outlined above should be regarded as a total package and should preferably be constructed concurrently. If phasing is necessary due to financial constraints, the Yeppen Crossing upgrade should be regarded as being the highest priority.

This scheme will have a very high positive social impact. It will allow complete protection from flooding (apart from local runoff) for the areas within the levee up to at least 1% AEP with consequent reduction of the trauma effects of isolation during flooding. The community awareness programme should include discussion of the limits of flood protection but this should be balanced against the benefits. This scheme will also allow development within the protected areas, although sufficient area should be retained for storage of local flood waters, and should result in a rise in property values. It is considered that there is little or no negative environmental impact of these works.

The proposed upgrading of Yeppen Crossing will also have a substantial positive social impact as it will significantly reduce the frequency of closure of the southern road and rail approach to Rockhampton, with consequent reduction in disruption to social and business activity. The proposed scheme is considered to have negligible environmental impacts.

b) **Priority 2**

At a slightly lower priority, construction of a levee to protect Rockhampton Airport, and the adjacent residential areas is recommended. One end of this levee would be near the Barrage. It would then pass close to Lion Creek, around the airport and then to higher ground near Denham Street (Extended). This would cause a significant increase in flood levels in that part of the floodplain between Pink Lily and Lion Creek. This is a maximum of 0.3 m at 2% AEP and 0.6 m at 1% AEP. A small number of houses along Nine Mile Road may need to be raised to compensate for this effect. The increase in level along the Rockhampton–Ridgelands Road is 0.05 m at 2% AEP and 0.12 m at 1% AEP, which is regarded as being acceptable.

Social impact will be positive overall with the protection of the airport and the adjacent residential areas, although it will be negative for the small number of houses where flood levels are adversely effected. However, as these houses are within a current floodway, their lot is not significantly worsened. The cost of raising these houses should be considered as part of the scheme. Land use controls should be utilised to prevent additional development in the floodway as discussed in section 4.

The cost of this levee system, with protection to 1% AEP is estimated to be $4.3 million rising to $5.6 million at 0.5% AEP and $7.1 million at 0.2% AEP. The direct benefits are relatively low with BCR at 1% AEP at only about 0.45 at 5% (0.33 at 7%). However, a significant intangible benefit would be obtained from keeping the airport open to traffic during such circumstances by allowing emergency and flood relief services to operate far more effectively than is currently possible. The recommended level of protection is 1% AEP due to the adverse impact on flood levels which would occur with a higher degree of protection.

c) **Priority 3**

- The construction of a levee to prevent direct overflow from the Fitzroy River into Splitters Creek. The levee would extend from near Limestone Creek to near Splitters Creek. The purpose of this levee is to prevent the direct overflow and hence reduce flood hazard. The cost would be $0.14 million but the tangible benefits would be small. The social impact would be positive as a result of reduction in flood hazard.

- The stabilisation of control levels at Pink Lily was investigated as described in Sections 2.7 and 3.4, whereupon it was determined that no alteration to the control levels could be justified. However, as discussed in the Phase 1 Report, section 13.4.3, it would be advisable to stabilise the outer bank of the Pink Lily meander so that the breakout threshold level does not reduce with time. It is not possible to estimate direct flood mitigation benefits from this measure. Hence these stabilisation works are included as a low priority item at an estimated cost of $900,000 on the basis of battering the existing bank, placement of a rockfill toe and revegetation of the banks.

d) Priority 4

Priority 4 items are those which should be undertaken in the longer term. These are measures to reduce flooding in flood fringe areas and comprise the fitting of flood gates on creeks and flood valves on stormwater drainage outlets to prevent backwater flooding. These will not prevent flooding in the relevant drainage areas when local flooding is coincident with river flooding, but will prevent river floodwater backing up these systems to between 2% AEP and 1% AEP level at which adjacent bank sections would start to overtop. Further long term measures to improve the immunity would be to raise the north bank levels by means of low levees. These have not been costed at this time.

These items have not been costed in detail, a sum of $500,000 has been allowed for floodgates for each major creek on the north bank ie. Splitters Creek, Moores Creek, Frenchmans Creek and Thozet Creek, and a further $500,000 in total for similar control on piped stormwater drainage outlets.

In addition to the capital costs outlined above, the Local Authorities and Government Departments responsible for the above works would need to meet maintenance costs. These costs are difficult to establish and a nominal cost of $100,000 per annum for Priority 1 works, $50,000 per annum for Priority 2 and Priority 3 works and $100,000 for Priority 4 works should be allowed. These would be substantially reduced if there is spare capacity in the existing maintenance labour force.

Other Issues Requiring Action

This paragraph lists other issues raised in this report which require further investigation or action for their resolution. Due to budgetary and time constraints it was not possible to include the following in Phase 2, but all of the items listed warrant further study.

- Estimation of probable maximum flood;
- Scrubby Creek Diversion;
- Development of a geographic information system for counter disaster planning and operation;
- Detailed investigation of erosion and siltation in the lower Fitzroy River;
- Investigation of leachate from operational and closed landfills in the Fitzroy River floodplain and subsequent remediation if warranted.

TABLE C

Summary of Proposed Works Programme

PRIORITY 1 MEASURES	
NON-STRUCTURAL	
• Floodplain Management Policy	$30,000
• Upgrading of flood warning system	$53,000
• Installation of Flood Markers	$25,000
• Recorded message service	$30,000
• Community awareness programme	$25,000
SUB-TOTAL	$163,000
CAPITAL WORKS	
• Upgrade Yeppen Crossing to increase embankment height to that of the bridges, plus increase waterway area by increasing bridging length to 840 m (BCR 1.5)	$16.5 m
• Construction of levee from Blackall Street to Quay Street protecting Lower Dawson Road, Port Curtis, Depot Hill and the lower CBD (BCR 1.25)	$6.9 m
• Removal of disused railway embankment adjacent to Old Bruce Highway (material may be used in levee works) Demolition and removal of bridge/causeway on Old Burnett Highway	$0.5 m
SUB-TOTAL	$23.9 m
TOTAL PRIORITY 1	$24.063 m

PRIORITY 2 MEASURES	
NON STRUCTURAL	
• Development of Flood Forecasting model	$80,000
• Commercial Flood Proofing Pilot Study	$40,000
SUB-TOTAL	$120,000
CAPITAL WORKS	
• Construction of levee to protect airport extending from Savage Street to Denham Street Extd (BCR 0.45)	$4.3 m
TOTAL PRIORITY 2	$4.42 m

PRIORITY 3 MEASURES	
• Construction of levee to prevent overflow from River to Splitters Creek (BCR approximately 0.7)	$0.14 m
• Bank stabilisation works at Pink Lily	$0.9 m
TOTAL PRIORITY 3	$1.04 m

PRIORITY 4 MEASURES	
• Flood gates on Splitters Creek, Moores Creek, Frenchmans Creek and Thozet Creek	$2.0 m
• Flood valves on stormwater drainage outfalls	$0.5 m
TOTAL PRIORITY 4	$2.5 m

OVERALL TOTAL RECOMMENDED WORKS	**$32.023 m**
Note: BCRs at 5% discount rate.	

FUNDING OF WORKS

In recent years flood mitigation works have been eligible for funding under the Federal Water Resources Assistance Program (FWRAP). From 1993/94 flood mitigation works and measures are expected to be eligible for funding under the National Landcare Program (NLP) which will integrate FWRAP and other programs.

In Queensland, it is the responsibility of the relevant Local Authority to apply for funding under the program to the State Government in the first instance through the Water Resources Commission, customarily by December each year. The State Government will integrate and prioritise applications and submit those programs it supports as part of a Partnership Agreement with the Commonwealth Government. Notification of successful applications is made following the Federal Budget each August.

Under this scheme funding is as follows:

- Federal Government 40%
- State Government 40%
- Local Government 20%

It should be noted that NLP funds are limited, and that submissions for funding are considered on their merits and cost-effectiveness and also on the basis of priority with other state projects as this program is placing increasing emphasis on well integrated land and water resource management projects and non-structural flood mitigation measures. However, due to the magnitude of flood damages in the recent flood and the isolation of a city of the size of Rockhampton which results from such floods, it may be expected that the chances of a support by the State would be high, but would of course depend on the State's priorities in the particular year. Criteria for Commonwealth support under the new NLP may evolve from those under FWRAP with increasing emphasis on Commonwealth funds being used to stimulate micro-economic reform or improvements in procedures and perceptions of natural resource management issues. Consequently, successful projects would need to engender new local and regional financing schemes and viable, beneficial, community-based flood management strategies.

Thus if funding were obtained under NLP for all the first priority works, the Local Authority Contribution would be expected to be $4.8 million. However, if only the levee works and the non-structural works were funded in this way, for example, this would reduce to $1.5 million.

Whilst the proposed upgrading at Yeppen principally relates to flood mitigation in respect of reduction of indirect damages, it would be expected that part of the upgrading costs would be met by the Department of Transport. This would be the subject of negotiation between relevant Government Departments and Local Authorities. A statement from the Department of Transport setting out their position in regard to funding these works is given in Volume 3 (Appendix L).

In regard to the airport levee, Rockhampton Airport is owned by Rockhampton City Council but is administered as a separate entity. Thus the costs attributable to protection of the airport will need to be separated from those for protection of the adjacent residential areas, so that the costs of protection of the airport are not a direct cost on ratepayers. As for the Yeppen crossing, the distribution of costs will need to be negotiated should the scheme proceed.

Also the Bureau of Meteorology may contribute to funding of the flood warning system upgrade. Local business groups may be willing to fund the proposed flood proofing pilot study.

The priorities listed above should be followed in developing a phased programme of works to match Local Authority and funding agency budgets.

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