SECTION 3

3. OPTIONS FOR FLOOD MITIGATION

3.1 INTRODUCTION

As discussed in the Phase 1 Report, flood damages may be divided into direct damages ie. those caused by the physical contact with floodwaters, and indirect damages. The latter being those damages consequent to, but not directly caused by floodwater.

In the case of Rockhampton, it was established that a significant proportion of the damage in the 1991 flood was caused by indirect losses which resulted from the closure of road, rail and air links effectively isolating the city for nearly 2 weeks.

Whilst most of the flood mitigation options considered address direct damages, some of the works considered at Yeppen Crossing, and to a lesser extent at Rockhampton Airport, are aimed primarily at reducing indirect losses, by reducing closure times of the major transport links.

In order to put the flood mitigation options considered in this section into perspective, it is worth recalling here the magnitude of flood damages under current conditions, the distribution of direct flood damages throughout the flood liable area, and the relative scale of direct and indirect flood damages, so that flood mitigation works can be concentrated where they will be of greatest benefit. The following summary given in Tables 3-1 and 3-2 is drawn from various tables in the Phase 1 Report.

TABLE 3-1

Summary of Flood Damages

	Damage Type	Mean Annual Damage $ million
A	Direct Flood Damage	
	Residential	0.2
	Commercial	0.8
	Public Sector	1.0
	Total	2.0
B	Indirect Flood Damage	3.2
	TOTAL	5.2

It should be emphasised that the cost of doing nothing to reduce flood damages may well not be the cheapest option, and it costs an average of $5.2 million each and every year ie. the long term average taking account of the range of flood magnitudes and their associated probabilities. Whilst this cost does not fall totally on the Local Authorities or State Government, it is a cost to the Australian economy. The cost of implementing flood mitigation works should be viewed in this context and in regard to the reduction of this average flood damage cost.

TABLE 3-2

Distribution of Direct Flood Damages

Zone No.	Location	Mean Annual Damage ($,000's)				% of Total
		Residential	Commercial	Approx Public Sector	Total	
	South of River					
10	Crescent Lagoon	9.2	60.3	37.8	107.3	9
11	Gladstone Road	5.7	225	28.8	259.5	23
12	Port Curtis	12.6	38.1	28.8	79.5	7
13	Central CBD	13.1	138	10.0	161.1	14
14	Lower CBD	36.8	189	10.0	235.8	21
15	Depot Hill	8.2	20.4	10.0	38.6	3
16	D/s Barrage	5.4	6.9	9.2	21.5	2
17	Pink Lily	9.4	1.4	10.0	20.8	2
18	U/s Barrage	0.8	4.3	7.0	12.1	1
	North of River					
20	D/s Barrage	3.5	13.5	8.5	25.5	2
21/22	Splitters Creek	21.6	13.4	15.0	50.0	4
23	Moores Creek	7.0	26.1	25.0	58.1	5
24/25	Lakes Creek Road	26.9	32.3	8	67.2	6
	TOTAL	160	769	208	1,137.0	100

Note: Public Sector Costs are based on RCC costs as only the urban area is considered herein.
MAD costs for RCC based on total cost of $1.52 million for 1991 flood and weighted average of residential and commercial MAD of 13.7% of 1991 damages.

Table 3-2 shows the approximate distribution of mean annual damage (MAD) throughout the urban area. It is clear from these values that the highest priority areas in terms of reducing flood damage costs are in the Gladstone Road/Lower Dawson Road area, and the lower part of the CBD, which together account for some 44% of MAD. The Central CBD accounts for a further 14% of MAD but is at risk to only rare floods.

In the case of Rockhampton, there is no easy solution to flooding, and because of its location, it will never be possible to eliminate flooding. The consideration of a wide range of flood mitigation options in the Phase 1 Report discounted several options including those which could reduce flood damages by means of reducing the peak flood flows, whether by storage or diversion. Hence, flood mitigation in Rockhampton must deal with the full natural flow of the Fitzroy River during flood.

In order to put the practical range of options considered herein in perspective, it is instructive to first consider two extreme scenarios, neither of which are regarded as being desirable or acceptable:

- firstly, to eliminate flows in the floodway to the south of the city by means of constructing levee banks along both banks from upstream of the city to well downstream. The effect of this would be to raise flood levels in the river considerably, at high cost. The consequences of overtopping if and when the design flood is exceeded would be considerable. The cost of such a scheme would be high, although this has not been considered in detail. Basically constraining the river to run between raised banks would not be considered a wise course of action;

- the opposite end of the spectrum of possible measures is the construction of a major floodway to the south of the city. This would need to carry about 50% of the total river flow in order to be effective in reducing flooding. The cost would be high, of the order of $200 million. Modelling, see Section 2.7.8, has shown this to be impractical.

Neither of the above are considered to be practical, nor do they offer least cost or high benefit-cost ratio solutions. The more practicable options fall generally within these two extremes.

The bulk of the flooding of the high risk areas arises from the flood flow 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 areas subject to flooding from the immediate vicinity. This suggests that reduction in flood flows and/or levels in the floodway is likely to provide the most appropriate means of reducing the flooding problems in Rockhampton.

The options considered are discussed in the following paragraphs. The findings of the hydraulic model study are drawn upon in determining the impact of various options on flood levels (as discussed in section 2.7); costs given in the Phase 1 Report are updated and refined; and social/environmental impacts are discussed .

Options are initially considered separately and then in various combinations. Finally, recommendations are made in regard to preferred options. The options considered generally give protection to the 1% AEP flood level, except for upgrading of Yeppen Crossing where this is considered impractical. The worth of providing protection against more extreme floods is considered for the preferred options only.

The results from the hydraulic model studies of the options considered have already been outlined in Section 2.7. Figures in this section further summarise this information as well as adding costs and other considerations. In order to highlight the economics, hydraulic and other impacts of the various schemes, a number of diagrams have been included to emphasis the most salient points in order to try to simplify consideration of the options.

3.2 LEVEES

3.2.1 General

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. There a many examples of successful levee schemes in Australia and overseas.

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

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

Cost estimates for levee schemes have been revised and refined on the following basis, but are still regarded as preliminary pending geotechnical investigation and final route selection. The basis for cost estimation assumed the following:

- side slopes of 1 vertical to 4 horizontal, with 4 m crest width. Passing lanes of 6 m crest width were allowed every 250 m allow passing of maintenance vehicles, whilst the former allows use of other than first grade materials for construction. A 4 m crest width is regarded as a minimum, 6 m is preferable but at additional cost. The provision of passing lanes is an appropriate compromise in this regard;

- a freeboard of 0.6 m above design flood level over and above making allowance for any increase in flood levels caused by the levee itself;

- generally the 1% AEP flood has been defined as the design flood. Whilst the freeboard allowance does not strictly give protection above the design flood as it allows for subsidence of the crest, and wave action, in practice some further protection is provided in this way. Spillway sections would be designed to overflow at the design flood level;

- alignment accommodated by easement thereby minimising land acquisition costs;

A higher level of protection may be provided at relatively low cost as the difference in level between the 1% AEP flood and the 0.1% AEP flood is only of the order of 1 m. This is considered where appropriate after the primary consideration of options.

The following paragraphs discuss the individual levee schemes considered. Their location is shown in Figures 3–1 to 3–3. A summary of schemes, their costs and impacts are given in Figure 3–4.

Cost estimates are given in Appendix G, which also gives revised flood damage reduction figures derived by re-running the ANUFLOOD model developed in Phase 1 with the revised flood height/probability curve derived from the design runs of the hydraulic model.

3.2.2 Protection of Port Curtis, Depot Hill and the lower CBD

As outlined in the Phase 1 Report, it would be possible to protect the whole of Port Curtis, Depot Hill and the lower CBD by a single levee. Alternatively, separate schemes could protect i) Port Curtis, ii) Depot Hill and the lower CBD. As the Phase 1 Study showed a combined levee to be the most economic solution, a separate Port Curtis levee has not been considered further. Consideration in Phase 2 has been limited to 2 schemes, namely the single levee protecting all the areas named above, and a second scheme excluding protection to Port Curtis.

A levee protecting Port Curtis, Depot Hill and the CBD would eliminate all flooding in these frequently flooded areas up to the selected design flood, which would be at least 1% AEP, and would eliminate flooding along Lower Dawson Road to the same limit.

Further consideration has been given to the alignment of these levees, as shown in Figure 3–1. These alignments will minimise disruption to existing landowners whilst providing maximum protection to the flood protection area. The alignments have not, however, been finalised.

The revised cost of these schemes are as follows, breakdowns for which are given in Appendix G:

- Depot Hill – Lower CBD only (Option A1) to 1% AEP flood level plus freeboard, cost $5.7 million.

- Lower Dawson Road – Port Curtis – Depot Hill – CBD (Option A2) to 1% AEP plus freeboard, cost $6.9 million.

Option A1 would reduce mean annual damage (MAD) by $300,000 p.a., which has a net present value (NPV) of $5.8 m at 5% discount rate, reducing to $4.3 million at 7% discount rate. The benefit-cost ratio (BCR) of this scheme is thus 1.01 at 5%, (0.75 at 7%) assuming all construction costs are in year 1 and ignoring maintenance costs.

Option A2 is considerably more attractive in economic terms. Construction cost has been estimated to be $6.9 million, with a reduction in MAD of $0.49 million. This gives an NPV of $9.3 m at 5% discount rate ($6.9 million at 7%) and corresponding BCR of 1.33 (1.0), which is high for a flood protection scheme.

As well as the economic advantages of this scheme, the social benefits would be high as they would greatly reduce the risk of flooding in the protected areas, and also encourage further development in these areas.

As discussed in Section 2.7, construction of the Depot Hill/lower CBD levee would have very little effect on flood levels, but the Port Curtis part of the combined levee would have a substantial effect as it closes off a significant flow path. The result of the above would be to raise levels in the floodway by 0.9 m downstream of the Yeppen crossing for a 1% AEP flood and by 0.4 m on the upstream side of Yeppen, and about 0.15 m at Fairybower Road. As these increases are not likely to be acceptable, the overall performance in combination with other options was considered. This is discussed in Section 3.6.

A levee to protect Depot Hill and the CBD would offer substantially economic benefits, but would have only a marginal impact on flood levels. However, this would be disadvantageous to the residents of Port Curtis whose current sense of isolation from the community would be heightened. Flood hazard at Port Curtis would remain high as it is as present. There is, therefore, a significant social cost in excluding Port Curtis should a levee be constructed to protect Depot Hill and the CBD.

If constructed, the Port Curtis to CBD levee would commence on the city side of the Yeppen crossing. It would be tied into higher ground along and adjacent to Blackall Street.. The levee would then be built along the southern side of Blackall Street to its junction with Lower Dawson Road. A section of Lower Dawson Road from Yeppen bridge to the Blackall Street/Jellicoe Street junction would be ramped to tie in with the levee crest, with a ramp down on the city side. This would be a fairly flat grade. If this option were built in conjunction with raising the road level across the Yeppen Crossing, this ramp would be less marked on the southern side. The levee would then be constructed along the southern edge of Jellicoe Street to the railway crossing. The railway crossing will have to be raised from the Yeppen bridge to the levee crest level at Jellicoe Street, and regraded towards Port Curtis junction. Alternatively, this section could be left at its existing level and fitted with flood gates but this would not be preferred. The levee would be built along the southern edge of Jellicoe Street to near the junction with the Old Burnett Highway, where it would divert to the south so that it could cross the Old Burnett Highway and pass on the floodway side of Hastings Deering Pty Ltd. The levee would then turn northwards past the last house in Port Curtis (along the Old Bruce Highway) and pass to the east of Depot Hill. The route in this section has not been determined but would be as far to the east as possible in order to maximise the area available for storage of internal drainage (or for development). The levee would then pass close to Gavial Creek (between the sewage treatment works and the creek), turn along the right bank of the river, terminating near Derby Street. There is generally sufficient room for this section of levee, although where space is restricted short sections of retaining wall may be required. These details would be determined at the design stage. Flood valves will need to be provided on all drainage outlets along the levee route, to prevent backflow up the drainage lines. They would prevent the flooding of a large part of Allenstown which currently can be flooded by backwater from the main drain. At least two spillway sections would be incorporated into the levee, probably one on the river side upstream of the Gavial Creek Junction, and one on the opposite side between Depot Hill and Gavial Creek. This would allow controlled flooding to occur in the event of the levee being overtopped in an extreme flood and thereby enable water to accumulate behind the levee to prevent failure if the entire levee overtops. It should be noted that even in such an extreme situation flood, damages would be no worse than under existing conditions.

A separate levee for Depot Hill/lower CBD would need to start in the Port Curtis Junction area and would need to include local raising of the highway and railway and be tied into higher ground next to the highway to avoid overflow into the Allenstown area.

3.2.3 Protection of Rockhampton Airport

As discussed in the Phase 1 Report, the protection of Rockhampton Airport would require levees. In order to protect the road access to and from the airport, the levees should be extended to encompass the adjacent residential areas. The indicative preferred location is shown in Figure 3–2.

The levee has only been shown for the protection of the existing airport, as no details are available about the extension being considered. The preferred option is to tie the levee to high ground to the south of the airport and to build the levee on the western side of the runways and then close to the southern bank of Lion Creek, passing behind the residential properties and terminating along the river bank upstream of the barrage. This would provide considerable protection to the adjacent residential areas as well as maintaining the airport in operational order for the 1% AEP flood (or higher).

This would however have a negative impact on flood levels on the small number of houses in the floodplain. Levels along Nine Mile Road would be increased by a maximum of 0.3 m for 2% AEP, and 0.56 m for 1% AEP, so the houses adjacent to the proposed levee would need to be raised. The increase in flood level along the Rockhampton–Ridgelands Road would be 0.06 m for 2% AEP and 0.12 m for 1% AEP, which is regarded as being acceptable.

In this way the airport could be protected to 1% AEP or higher. Protection to 1% AEP would require a levee about 2.75 m high (including allowing 0.6 m freeboard and for local increase in flood level) along the boundary adjacent to Lion Creek.

The estimated cost given in the Phase 1 Report included protection of the proposed extended runways. In regard to protection of the existing airport, the revised cost is $4.3 million, a breakdown of which is given in Appendix G. Using the approximate reduction in MAD of $102,000 p.a. given in Table 14–1 of the Phase 1 Report, the NPV at 5% is $1.94 million and at 7% is $1.43 million, giving BCR of 0.45 and 0.33 respectively. Thus this scheme is not viable in purely economic terms, but may be justifiable in terms of reduction in social impacts which would result from being able to maintain the airport in operation condition in a 1% AEP flood.

3.2.4 Protection of other areas

Levees along the north bank of the Fitzroy River in the Splitters Creek area was briefly investigated. The Splitters Creek levee has some merit in regard to closing off a minor flow path, so that this area would be limited to flood storage (ie. low velocity) flooding.

The breakout could be closed off by a partial levee as shown on Figure 3–3 for a cost of about $140,000 (see Appendix G for details). This would not prevent flooding in the Splitters Creek area but would limit this to backwater flooding. Full levee protection requiring a floodgate across Splitters Creek would present practical difficulties resulting from its proximity to the barrage and has not been considered in detail. Assuming the reduction in MAD to be a third of that from the total protection this would give a BCR of about 1.2 at 5% discount rate (0.9 at 7%).

Phase 1 studies had shown levee protection of other areas such as Lakes Creek Road and the Moores Creek area to be not cost-effective and these were not pursued in Phase 2. However, as the bulk of flooding in these areas is by backwater from the river, it would require only the provision of flood gates on the major creeks and stormwater drains to given some measure of flood protection (to about 2% AEP). This has been included as a low priority item in the recommended works summarised in section 5.

3.3 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 flood is consistent with this design criterion. The average time of submergence was estimated to be 0.58 days per year. As the 1988 flood was the fourth highest since discharge records begin in 1914 it is apparent that had the current floodplain conditions existed throughout this century only the major floods of 1918, 1954 and 1991 would have caused closure. The hydraulic model has shown that times of submergence for these floods would have been 15, 12.5 and 11.5 days respectively ie. a total of 39 days in 78 years or an average of 0.50 days per year. Thus on this basis also the crossing is performing as designed.

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. A statement from the Department of Transport in regard to their position concerning this upgrading proposal is given in Appendix L.

A summary of the options considered in regard to upgrading of Yeppen crossing are given in Figure 3–5. The hydraulic impacts of these options have been outlined in Section 2.7.

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. Hence, only these combinations are considered further here.

This paragraph will only consider options for improvement of the flood immunity and flood level impact of Yeppen Crossing and not combinations of the above plus other possible schemes. Such combinations are considered in section 3.6.

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. Average closure time would be reduced to 0.15 days per annum.

Under Option B5, each of the bridges would be doubled in length to double the bridge waterway area, 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.

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 a substantial saving over Option B5. This cost includes for bridge strengthening measures expected to be sufficient. However, this is an inferior solution which would result in increased maintenance.

Estimates given in section 8 of the Phase 1 Report in relation to the 1991 flood show direct damage to the combined Yeppen crossing of $1.2 million and indirect damage resulting from road and rail traffic delays of about $5 million, giving a total of about $6.2 million. In addition to the above, the closure of this route is one of the main causes of indirect losses to the commercial/industrial sector. Assuming these losses are in proportion to the traffic delay losses for north and south links (ie. 75% of the total), this would result in an indirect loss of about $22 million (using the adopted value of $32 million for indirect losses to the commercial/industrial sector given in Table 8-11 of the Phase 1 Report). On the above basis, which is only approximate, the total losses caused by the closure of the crossing in the 1991 flood were about $28 million. Assuming, further, that the damages are proportional to the time of submergence, this gives a total damage of cost of about $2.5 million per day of closure.

The preferred options B5 and B7 would produce a flood free crossing at 2% AEP with reduced times of submergence of 6.8 and 8 days at 1% AEP. These times vary slightly when these measures are combined with others. The damage values and times of submergence were used to estimate a damage probability curve as given in Figure 3-6.

Times of submergence (TOS) for the range of design floods (5% AEP to 0.1% AEP) together with the existing design of zero TOS at 12.5% AEP (as per the current design and as evidenced by the 1988 flood) were used to prepare a curve relating TOS to event probability (Figure 13-6 a). From this a damage/probability curve was derived assuming that indirect losses caused by the crossing being closed are proportional to closure time. This may be conservative for short duration of closure but is considered to be reasonable for the longer durations. It should be noted that for the purposes of this report TOS is defined as the time for which there is flow across the road. This is not necessarily the time of closure.

The area under this curve was integrated to estimate the mean annual damage. This was estimated to be $1.75 million to $2.1 million depending on the curve adopted from Figure 3-6. The higher value relates to the TOS given by the design runs but this is based as the shape and hence duration of the design hydrographs which are based only on observed hydrographs for the 1991 flood (which was used for AEP to 1%) and 1918 used for more extreme floods. The lower value relates to an interpolated curve given in Figure 3-6 which may be more realistic. This above figures compare to $1.6 m. used in Phase 1, when extrapolation to the more extreme floods was not available.

The reduction of MAD by Options B5 and B7 is shown in Figures 3-6. These are very similar, the residual MAD being $0.45 million and $0.43 million respectively. The latter should be reduced to reflect the increased maintenance cost of say $0.1 million per annum. On this basis, the reduction in MAD is $1.3 million for Option B5 and $1.18 million for Option B7.

Net present value (NPV) of Option B5 is thus, $24.3 million at 5% discount rate ($18.2 million at 7%), with BCR of 1.50 (1.10). The corresponding NPV for Option B7 is $22.4 million ($16.5 million) and BCR of 1.72 (1.27). Thus even accounting for increased maintenance, Option B7 has a preferable BCR.

As well as these schemes, particularly B7, being justifiable economically, they would also have a significant social impact as these schemes 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.

The Department of Transport subsequently advised that Option B7 involving lowering of the bridge inverts would not be acceptable.

3.4 CONTROL OF PINK LILY BREAKOUT

The necessity for works to stabilise the right bank of the Fitzroy River in the breakout section at Pink Lily has been discussed in detail in the Phase 1 Report. The level at which the banks should be stabilised was to be considered as part of the hydraulic modelling studies in Phase 2.

For a given river level the breakout at Pink Lily controls the flow of water in the floodplain. Hence raising or lowering the control level would alter the distribution of flows between the river and the floodplain. A number of options were investigated in regard to varying this control to offset the impact of existing structures and of those being considered in the current study. These options are summarised in Figure 3-7.

It was found that a minor raising of control levels of, say, 1 m throughout the breakout zone was ineffectual (Option D1). The banks at Pink Lily could be raised so as to eliminate overflow for 2% AEP (Option D2) and this would cause the existing Yeppen crossing to remain open even at 1% AEP. However, this would have a major impact on flood levels and hence flood damages in the city area, where levels would be raised by about 0.5 m. At the barrage, levels would be raised by 1.1 m for 2% AEP and 2.3 m for 1% AEP, with similar increases to upstream of Pink Lily. Even flood levels at Yaamba would be raised by 0.11 m for 2% AEP, and by 0.15 m at 1% AEP. These increases were regarded as unacceptably high, and this option was not pursued. A compromise raising of 2.5 m (Option D3) was also briefly investigated.

Whilst none of the above were found to be acceptable on their own, the lower degrees of raising in the 1 m to 2.5 m range were thought to be of possible use in combination with other measures. If such a scheme were to be promoted, it would probably be a combination of raising the control level and reducing the length of the overflow path to ensure damaging overtopping did not occur. Lowering of the control level was not considered as it is not practical and would worsen levels in the lower floodplain. Increasing floodway capacity by means of a major channel is considered in the following paragraph.

As none of these options are considered to be worthwhile, except possibly in conjunction with other measures, it is recommended that the banks at Pink Lily be stabilised at their current levels.

3.5 MISCELLANEOUS OPTIONS

3.5.1 Major Improvements to Floodway Capacity

The option of a major floodway to the south of the city was briefly investigated using the hydraulic model. This option had been discounted in Phase 1 due to limited effectiveness, high cost and high environmental impact. It was, however, given further consideration in Phase 2 as a result of having been raised in the Community Consultation process.

A summary of the findings are given in Figure 3-8. Even with a channel with 1,000 m base width and a further 1,000 m width in the right overbank area once a depth of 3 m was reached, such a channel would only carry 3,500 m^3/s in a 2% AEP flood and 4,600 m^3/s in a 1% AEP flood. This general channel shape was used so that a potential benefit of such a scheme could be to provide levee protection, or allow filling of the left bank area, ie. the area between the channel and the city. However, even with a channel of this size, levels through the city reach would be increased by 0.3 m at 1% AEP, thereby rendering the proposal ineffectual. Due to the lack of hydraulic performance this was not considered further. As such a scheme would be of very high cost, would also cause severe environmental damage and involve resumption of a substantial land area, it was concluded that this did not warrant further consideration.

3.5.2 Minor Improvement to Floodway Capacity

The old Burnett Highway bridge across Scrubby Creek and the associated causeway across the Yeppen floodplain is still in existence close to the downstream side of the new Yeppen railway crossing.

Also the disused railway embankment adjacent to the Old Bruce Highway between Port Curtis and Roopes bridge is still mainly intact. Both of these structures impede the passage of floodwaters. Whether there is any benefit in removal of these structures was considered using the hydraulic model. This was found to have only a marginal impact on flood levels (Option F3) on its own, but subsequently was found to be effective in partly offsetting the increase in flood levels caused by the levees around Port Curtis being considered.

The cost of these works was estimated to be $500,000.

A partial floodway was also considered in relation to the above, by means of excavating a channel from downstream of Yeppen Crossing to discharge downstream of Gavial Creek. However, because of flat grades and the wide nature of the floodplain, this was found to have very little impact on flood levels and was not considered further.

3.5.3 Effect of Commonage Landfill

The effect of the Commonage Landfill was investigated using the hydraulic model. As the flow in the adjacent overbank section was very small, the impact on flood levels of increasing the size of the landfill was found to be insignificant.

However, the environmental concerns in regard to the presence of the landfill in the floodplain, as expressed in the Phase 1 Report are reiterated.

3.5.4 Lowering of the Capricorn Highway

Whilst a high level of flood immunity for the Capricorn Highway between Gracemere and the Bruce Highway is not a high priority due to the existence of an alternative flood free route, the question had been raised during the Community Consultation Phase of the impact on flood levels of this section of the Capricorn Highway being of the order of 1 m above surrounding ground level in places.

The effect of this was investigated in the model by lowering the relevant sections by 1 m (Option M3). This was found to have virtually no impact on peak flood levels, so action in this regard is not warranted.

3.6 COMBINATIONS OF OPTIONS

Consideration of the individual flood mitigation options in the sections above has demonstrated that upgrading the Yeppen Crossing by both raising embankment height to improve flood immunity and increasing bridge waterway area to counteract the increase in water levels which would otherwise occur, is the most cost effective means of reducing indirect damages.

Further hydraulic model runs were carried out with a range of combined options in order to determine whether the negative impact of the proposed levee schemes could be offset by the other measures under consideration. These combinations are summarised in Figures 3–9 and 3–10.

Of the levee schemes considered, the Port Curtis – Depot Hill – CBD levee is very beneficial in terms of reducing flood damages. Together with the option of lowering the bridge inverts, this would cause increase in flood levels immediately upstream of the Yeppen Crossing in a 1% AEP flood but not in the Fairybower Road area. Protecting the smaller area of Depot Hill and the lower CBD only avoids this problem but to the detriment of the residents of Port Curtis. In the option with bridge duplication, no such increase in level would occur. The proposed levee around the airport is believed to be beneficial, if not justifiable on purely economic terms, due to its enabling the airport to continue operation during a 1% AEP flood (or possibly higher). Construction of this levee would result in flood levels being increased close to the airport but reduced downstream.

Therefore the following (Options C8/C9) are put forward for final consideration:

- Construction of a levee from Port Curtis – Depot Hill – Quay Street, together with upgrading of Yeppen Crossing, removal of the Old Burnett Highway bridge and the disused railway embankment adjacent to the Old Bruce Highway, levee protection of the existing airport and the adjacent residential area, and levee protection to prevent breakout from the river in the Splitters Creek area.

The cost of the total combined scheme is estimated to be $23.9 million if the airport and Splitters Creek levees are excluded or $28.2 million with these included (Option C9). Overall BCR for these alternatives are 1.40, 1.26 at 5% discount reducing to 1.04, 0.93 for 7% discount rate.

The preferred option should be compared to the cost of the 'do nothing' option. If no flood mitigation works are constructed, even though there may be no flood and hence no flood damages for some years, the long term average damage cost has been estimated to be $5.2 million per annum, together with significant social disruption during and after each major flood. Floods occur in a random sequence, so the fact that a major flood has occurred recently is no guarantee that there will not be a flood of similar or greater magnitude in the near future.

As the preferred schemes would substantially reduce the long term average flood damage, and also substantially reduce the social impacts of flooding they are recommended for implementation. Possible funding of such works is discussed in Section 5.

In the above combinations the levee components are based on protection against 1% AEP flood. Costs and benefits associated with the recommended levees were then considered for a range of higher levels in order to determine the most appropriate level of protection.

In regard to the CBD levee, the cost differential between protection to 1% AEP and 0.5% AEP is about $1.45 million ie. a total cost of $8.35 million. The benefits however, increase considerably as the MAD reduction is improved significantly from $0.49 million to $0.63 million. The BCR at this level is increased to 1.43 at 5%, 1.05 at 7%, compared to 1.35 (1.0) respectively at 1% AEP. However, a levee giving protection to 0.5% would have some adverse impact on flood levels, for example raising the level upstream of Yeppen Crossing by 0.2 m to 0.3 m depending on whether the airport levee is also constructed.

Further increase in protection level beyond 0.5% AEP would result in a significant cost increase in order to prevent direct breakout from the river in the city area (which first occurs between 0.5% AEP and 0.2% AEP). This would require construction of a retaining wall along Quay Street to at least the Fitzroy Street bridge. MAD reduction would rise to $0.77 million, and the estimated capital cost would be $10.1 million. This would give a BCR of 1.45 at 5% and 1.07 at 7% discount rate. Such a levee would also have a significant impact on flood levels in the floodplain for floods in excess of the 1% AEP event.

It is apparent on the basis of the above that protection to levels higher than 1% AEP flood have marginally beneficial BCR's at higher initial cost. Levees to 0.5% AEP would keep out a flood greater than the 1918 flood, which is a reasonably high degree of protection. However, as protection above the 1% AEP level starts to have a negative impact on flood levels in the floodplain for events between 1% AEP and levee overtopping, it is recommended that protection should be limited to the 1% AEP flood.

In regard to the airport levee, the additional cost of raising from 1% AEP flood level to 0.5% AEP flood level would be $1.3 million, raising the cost to $5.6 million. Further raising to the 0.2% AEP level would incur a substantial cost increase to $7.4 million. As this levee cannot be justified even to 1% AEP on economic grounds, a decision to raise the levee to above 1% AEP level would need to be based on disaster relief considerations, as the need for an operational airport could become more important as flood magnitude increases. However, again as increasing protection above 1% AEP causes detrimental impact on flood levels, this is not recommended.

The Yeppen Crossing upgrade has been based on maintaining flood free access at 2% AEP, as that is the maximum which can be practically achieved without major cost over and above that already considered. This is because providing a greater level of immunity would require raising of the deck level of the existing bridges, as well as any new works. This has not been considered.

3.7 EXTREME FLOODS

The operation of the preferred scheme under floods more extreme than the design flood was considered to ensure that the works would not be detrimental under such circumstances.

The hydraulic model was run with the 0.1% AEP flood assuming that the levees were not overtopped, with the following results compared to the corresponding values for existing floodplain conditions:

- peak levels in the Pink Lily to barrage reach would be increased by up to 0.29 m;
- peak levels in the city reach would be reduced by 0.09 m at the flood gauge;
- peak levels in the upper part of the floodway ie. Pink Lily to Nine Mile road would be up to 0.45 m higher than under existing conditions, and up to 0.59 m along Lion Creek;
- peak level at Fairybower Road raised by only 0.02 m;
- peak level upstream of Yeppen Crossing would be raised by 0.39 m, and by a maximum of 0.56 m downstream.

These impacts whilst significant in the floodplain are in areas of low density of occupation and represent increases in flood depth but not increases in flood frequency. The above figures are conservative in that they assume that the levees are not overtopped in such an event. As the recommended level of protection is for 1% AEP, more extreme floods would cause the levees be overtopped, whereupon the peak levels would be reduced from those reported above.

As considerable devastation would occur in any event in a flood of this magnitude, the increase in damages which would result from the presence of the works as a result of increased flood levels would be small. On the contrary, the presence of the flood mitigation works would allow adequate time for evacuation prior to an extreme flood with consequent reduction in flood damages and social impact. Hence, it is believed that the presence of the works would be beneficial even when the design flood is exceeded.

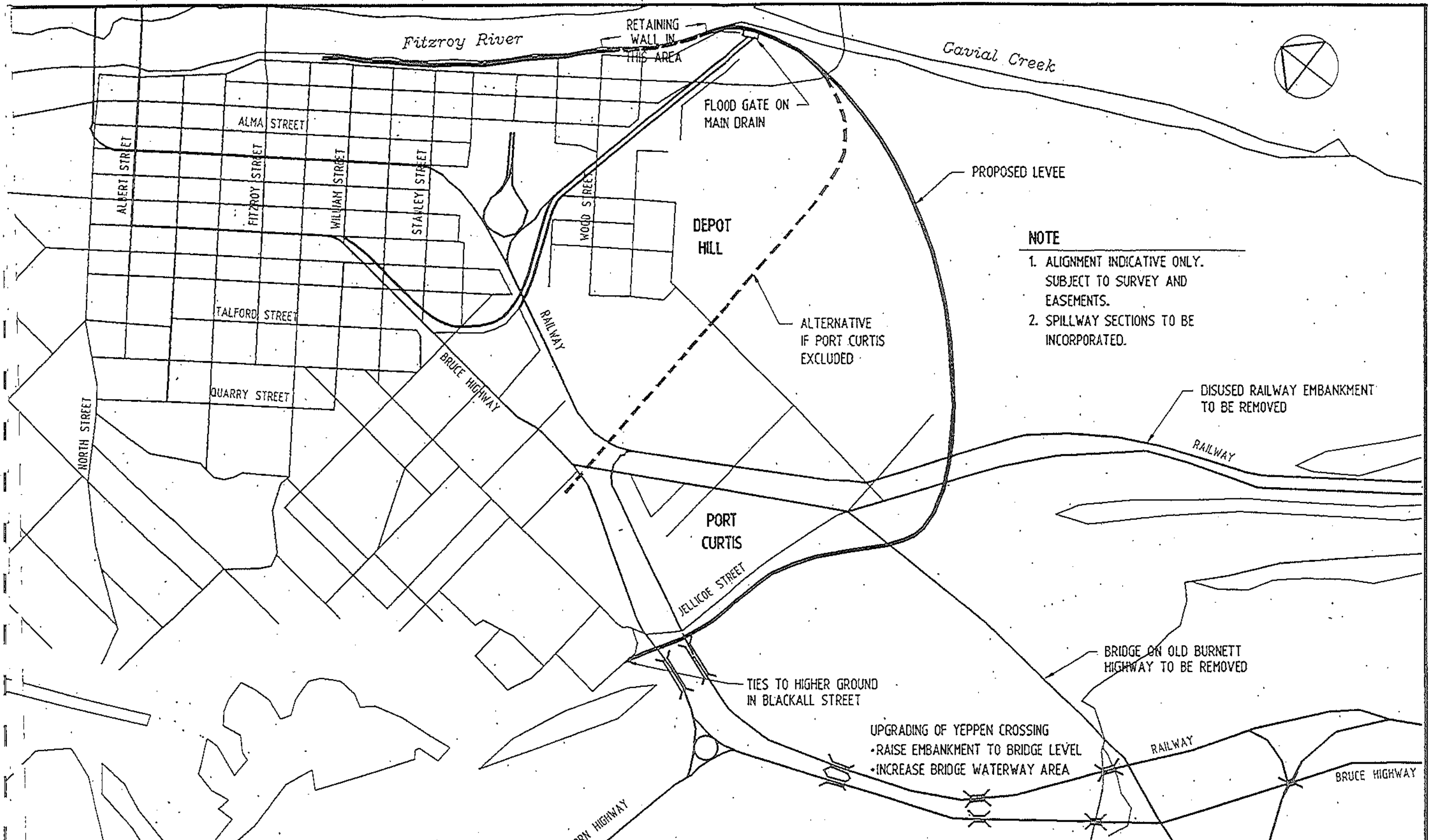
The effect on flood levels of 0.5% and 0.2% AEP floods for Options C8 and C9 were also considered. There are given in Tables J–30a and J–31 a (Volume 3).

3.8 RECOMMENDATIONS

Having taking account of the costs, benefit cost–ratio (BCR), impact on flood levels and of social consequences of flooding and flood protection, it was concluded that the most beneficial works for flood mitigation in Rockhampton are:

- Upgrading of Yeppen Crossing to provide flood free passage to both the Bruce Highway and the North Coast Railway at 2% AEP and to reduce times of submergence for larger floods. This will significantly reduce indirect flood damages;
- Construction of a levee to protect Port Curtis, Depot Hill, and the more flood liable part of the CBD from floods up to 1% AEP. This will significantly reduce direct flood damages and social costs without negative impact on flood levels compared to existing conditions. This also requires the removal of disused rail embankments and a disused highway bridge;
- Construction of a levee to protect Rockhampton Airport and the adjacent residential areas. As well improving the flood immunity of the airport this will reduce direct damages to the adjacent residential area;
- Construction of a levee to prevent overflow from the river in the Splitters Creek area.

These proposals have a marked positive social impact in regard to those members of the community who will be protected by the levees. However, a small number of persons outside the levees, particularly those in the area between the Rockhampton–Ridgelands Road and Lion Creek, and to a lesser extent those in the Fairybower area will suffer a negative impact because levels in any given flood will be increased, although the frequency of flooding will be unaffected. The impact on the latter groups will be offset to some degree by the proposed upgrading of the flood warning network which will enable, for the first time, forecasting of levels in the floodplain. All residents and businesses will benefit significantly from the marked reduction in social and business disruption resulting from improving the flood immunity of the Yeppen Crossing.



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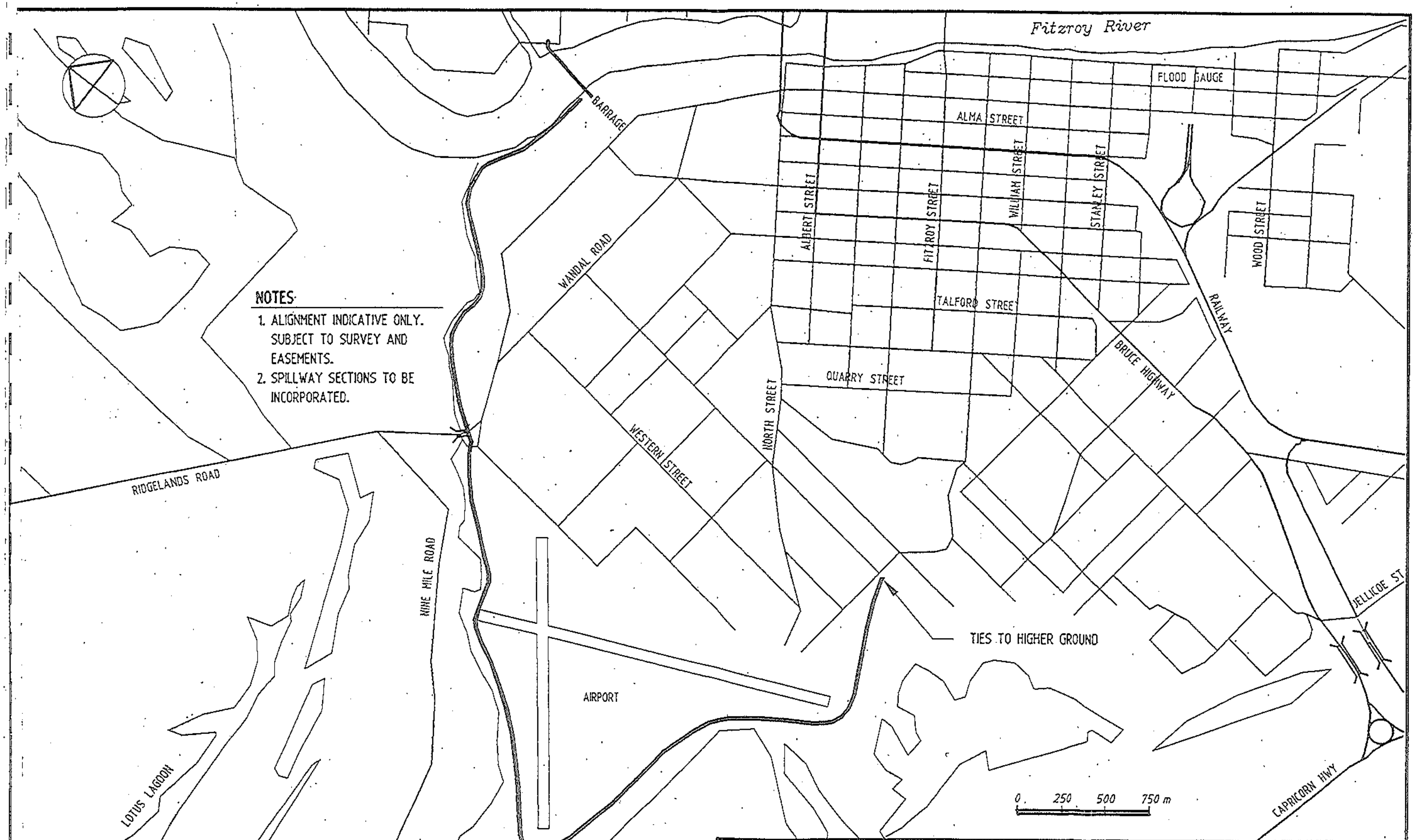
ROCKHAMPTON FLOOD MANAGEMENT STUDY
OUTLINE OF LEVEE SCHEMES - 1
PORT CURTIS - DEPOT HILL - CBD

FIGURE 3-1



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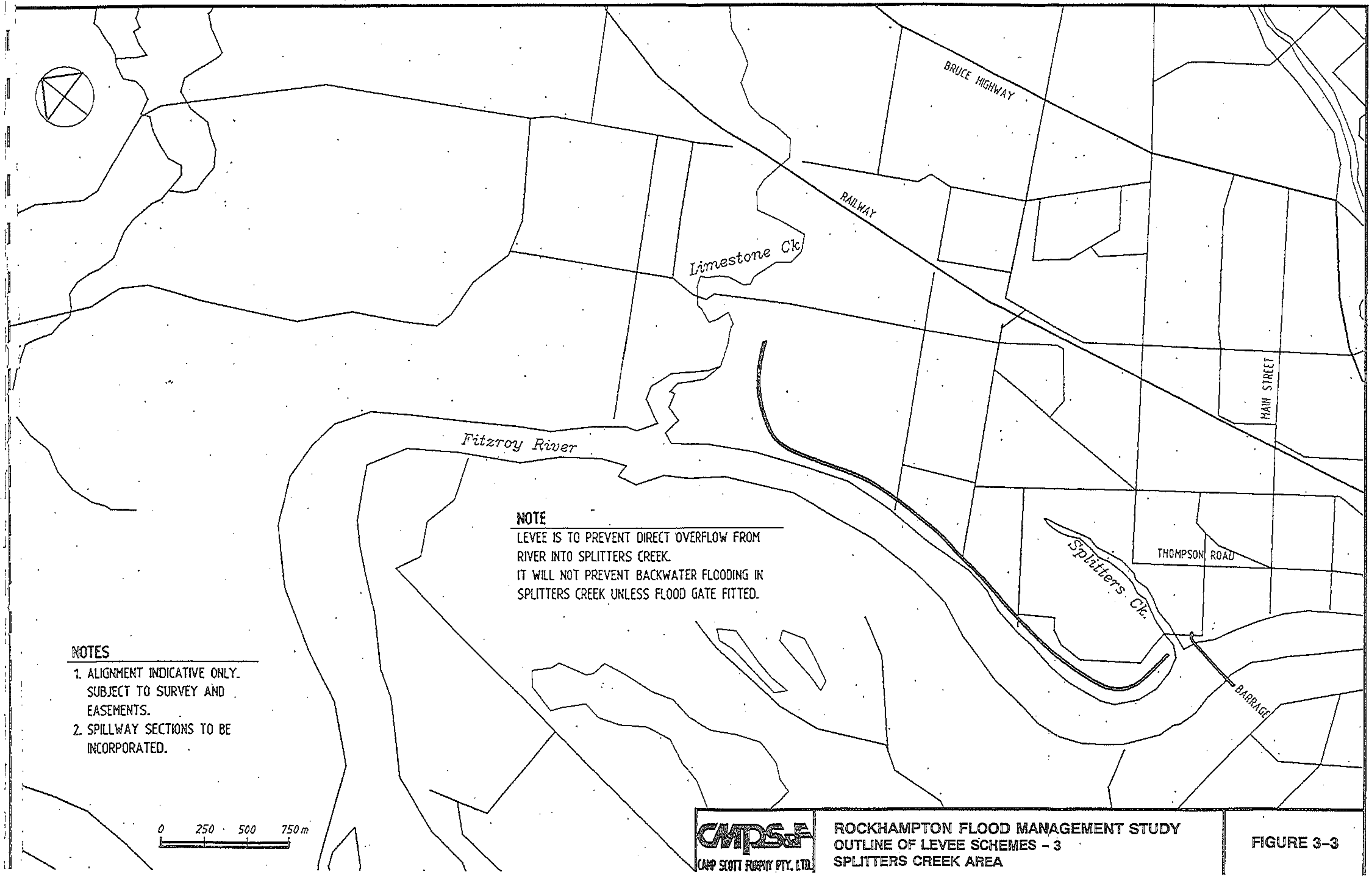
ROCKHAMPTON FLOOD MANAGEMENT STUDY
OUTLINE OF LEVEE SCHEMES - 2
ROCKHAMPTON AIRPORT AND ADJACENT AREAS

FIGURE 3-2



NOTE

LEVEE IS TO PREVENT DIRECT OVERFLOW FROM RIVER INTO SPLITTERS CREEK.
IT WILL NOT PREVENT BACKWATER FLOODING IN SPLITTERS CREEK UNLESS FLOOD GATE FITTED.

NOTES

1. ALIGNMENT INDICATIVE ONLY. SUBJECT TO SURVEY AND EASEMENTS.
2. SPILLWAY SECTIONS TO BE INCORPORATED.

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ROCKHAMPTON FLOOD MANAGEMENT STUDY
OUTLINE OF LEVEE SCHEMES – 3
SPLITTERS CREEK AREA

FIGURE 3–3

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.

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.

Note: NPV at 5% (7%)

Summary of Levee Options
Figure 3–4

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

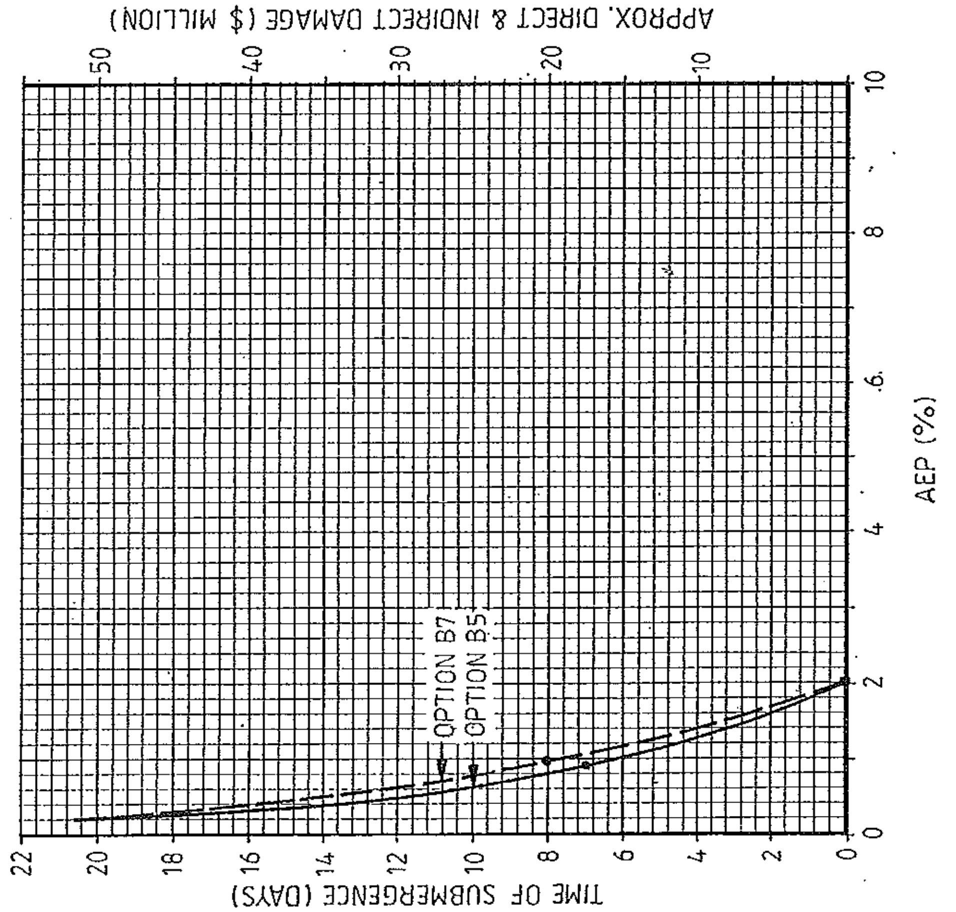
Option	Description	Table J-10
B6	Increase waterway area by lowering invert by 2 m	

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

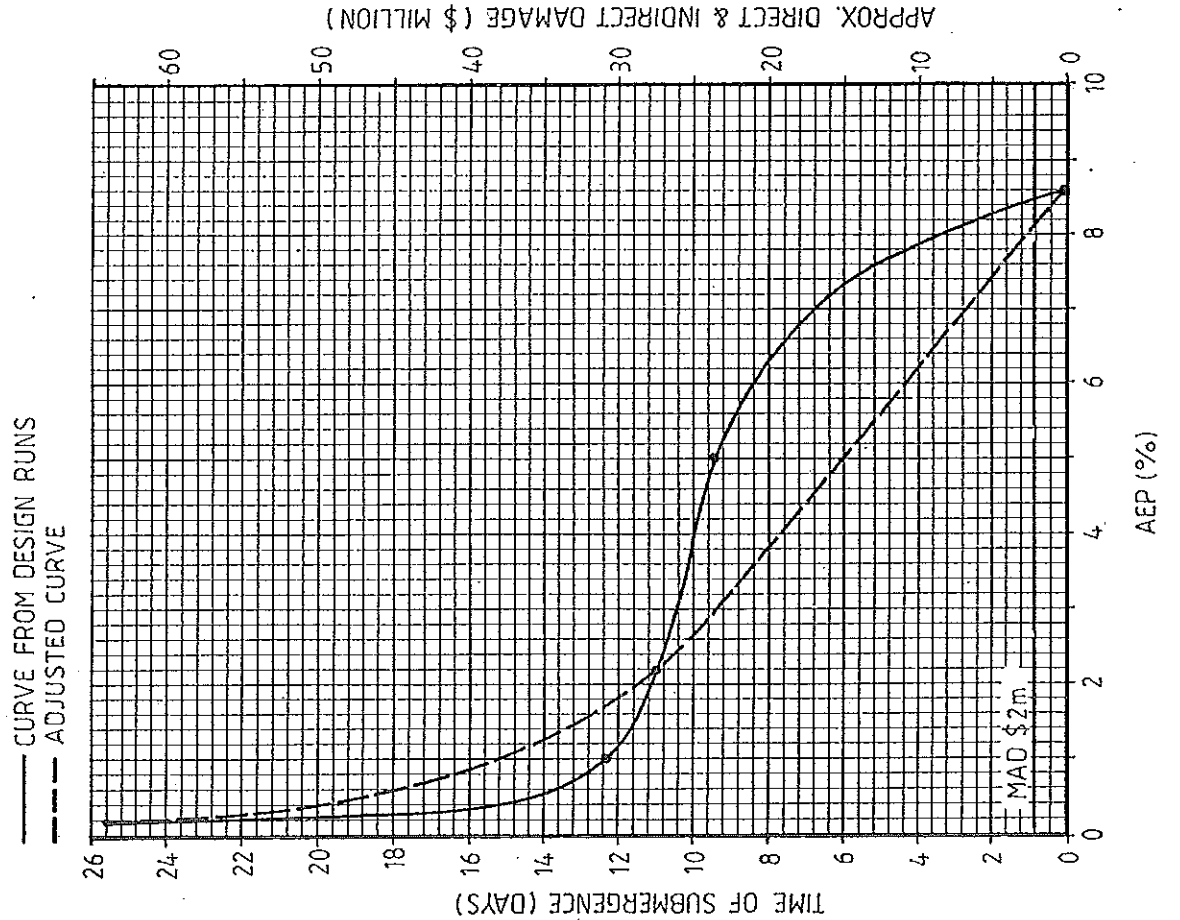
Options shaded thus are carried forward for further consideration.

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

Figure 3-5



TIME OF SUBMERGENCE & DAMAGE COST vs PROBABILITY FOR UPGRADED YEPPEN CROSSING



TIME OF SUBMERGENCE & DAMAGE COST vs PROBABILITY FOR EXISTING YEPPEN CROSSING

CMPS&F CAMP SCOTT FURPHY PTY. LTD.	**ROCKHAMPTON FLOOD MANAGEMENT STUDY** **TIME OF SUBMERGENCE AND DAMAGE PROBABILITY CURVES – YEPPEN CROSSING**	**FIGURE 3-6**

BREAKOUT CONTROL

Option	Description	Table J-14
D1	Raise Breakout Level at Pink Lily by 1.0 m	

Impact on Flood Levels:
Increases level at Yaamba by 0.03 m 2% AEP, 0.01 m 1% AEP
Increases level at barrage 0.32 m for 2% AEP, 0.12 m for 1% AEP
Increases level at City Flood Gauge 0.13 m, 0.06 m for 2%, 1 % AEP.
Reduces levels Nine Mine Road by 0.21 m, 0.1 m for 2%, 1% AEP.
Reduces levels Airport by 0.44 m, 0.14 m for 2%, 1% AEP.
Reduces levels Fairybower Road by 0.26 m, 0.12 m for 2%, 1% AEP.
Reduces levels Yeppen Crossing by 0.22 m, 0.09 m for 2%, 1% AEP.
Negligible impact at Depot Hill.
NOT EFFECTIVE

Option	Description	Table J-16
D3	Raise Breakout Level at Pink Lily by 2.5 m	

Compromise between D1 and D2 gives significant reduction in time of submergence at Yeppen to 6.5 d at 2% AEP, 9 days at 1% AEP. Levels at Yeppen reduced by 0.71 m for 2% AEP, 0.49 m for 1% AEP.
But raises levels at Yaamba by 0.07 m, 0.06 m for 2%, 1% AEP, at Barrage by 0.71 m, 0.55 m and at City flood gauge by 0.27 m, 0.19 m.

Option	Description	Table J-15
D2	Raise breakout level at Pink Lily to prevent overflow in 2% AEP	

Flood Free at Yeppen 1% AEP

Impact on levels:
Increased level at Yaamba by 0.11 m, 0.15 m for 2%, 1% AEP.
Increased level at Stanwell PS by 1.3 m, 1.66 m for 2%, 1% AEP.
Increased level at Pink Lily by 1.82 m, 2.22 m for 2%; 1% AEP.
Increased level at Barrage by 1.14 m, 2.35 m for 2%, 1% AEP.
Increased level at City Flood Gauge by 0.49 m, 0.51 m for 2%, 1% AEP.
Reduces level at Airport by 1.81, 1.48 m for 2%, 1% AEP.
Reduces level at Yeppen by 1.57 m, 1.27 m for 2%, 1% AEP.
TOS: Yeppen 0, for 1% AEP
GIVES FLOOD FREE CROSSING AT YEPPEN FOR 1% AEP BUT RAISES LEVEL IN RIVER BY UNACCEPTABLE AMOUNT.

Option	Description	Table J-16
D4	Raise breakout threshold at Gavial Creek to reduce tailwater at Yeppen	

This was investigated for 2% AEP only.
As a means of reducing levels at Yeppen Crossing this was ineffective, reducing levels by only 0.08 m but raising levels in the river by up to 0.7 m at the Gavial Creek junction.
NOT CONSIDERED FURTHER.

None of the above were considered to warrant further consideration as stand alone measures, but could be useful in conjunction with other measures.

These measures were not costed.

Measures to Vary Breakout Control
Figure 3-7

MISCELLANEOUS OPTIONS

a) PINK LILY - YEPPEN - GAVIAL CREEK FLOODWAY

Option	Description	Table J-19
E1	Pink Lily - Gavial Creek	

Investigated only briefly, the aim of this would be to carry a signficant part of the flood flow to the south of the city. Modelling showed that a channel 1,000 m wide for 3 m depth and 1,000 m wide right overbank section would only be able to carry about 3,500 m³/s at 2% AEP, and 4,600 m³/s at 1% AEP. This would cause increased levels in the city reach of the river of up to 0.3 m at 1% AEP. The cost would be prohibitive and environmental impact on the lagoon system would be high. It would however, allow filling of adjacent land for development.
NOT CONSIDERED FURTHER

Option	Description	Table J-17
F3	Remove Old Burnett Hwy bridge and disused rail embankment	

Cost: $0.5 million
Impact on levels:
Reduction u/s of Yeppen crossing - 0.06 m, 0.07 m for 2%, 1% AEP floods
NOT WORTHWHILE AS A STAND ALONE MEASURE BUT MAY BE USEFUL IN CONJUNCTION WITH OTHER OPTIONS
SEE FIGURE

Option	Description	Table J-18
F4	F3 + Enlarge Channel d/s Yeppen	

The effectiveness of excavating a channel from the downstream side of the Yeppen Crossing in addition to the works in Option F3 was investigated as a means of reducing tailwater levels and hence increasing the capacity of the existing structures.
This was found to be ineffective.
NOT CONSIDERED FURTHER.

b) OTHER

Option	Description	Table J-20
M1	Commonage Landfill	

The effect of the commonage landfill on flood levels was investigated.

This was found to have an insignifcant impact on flood levels.

Option	Description	Table J-22
M3	Lower Capricorn Highway by 1.0 m	

The impact of lowering those sections of the Capricorn Highway above ground level by 1.0 m was investigated.
This was found to be ineffective.
NOT CONSIDERED FURTHER

Options shaded thus are carried forward for further consideration.

Miscellaneous Flood Mitigation Measures
Figure 3-8

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

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

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 C9 — Description: (C8 + A3 + A5) ie. as C8 + Levee Airport + Splitters Creek — Table J–31

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 C10 — Description: as C9 + Raise Pink Lily Breakout by 1.25 m — Table J–32

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

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 (shaded)

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 C6 — Description: (B5 + A1) Yeppen upgrade + levee Depot Hill to CBD — Table J–28

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 C7 — Description: (C6 + A3 + A5) – as C3 + levee Airport & Splitters Creek — Table J–29

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)

0080G803.B02

Summary of Combined Flood Mitigation Options
Figure 3–9

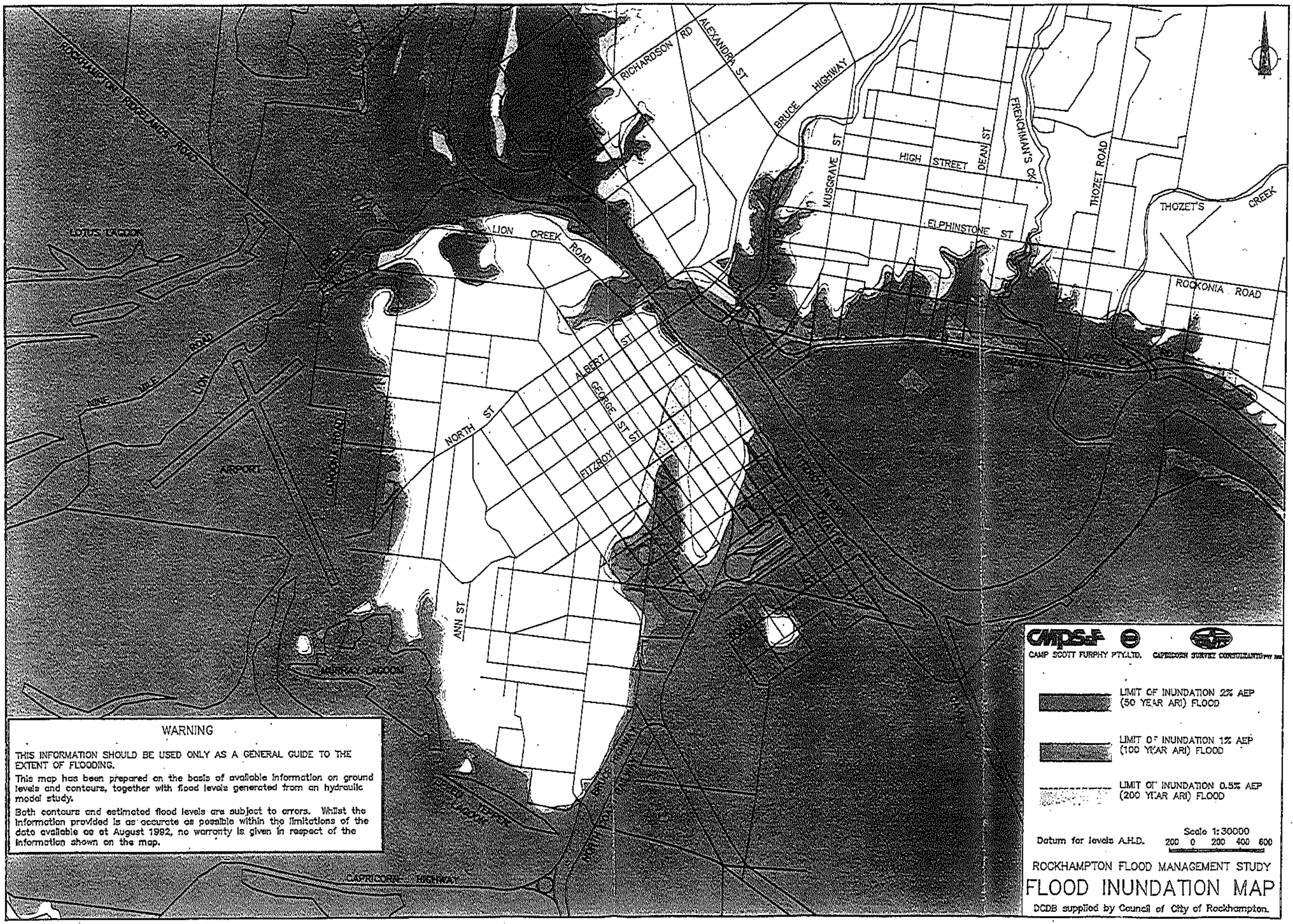
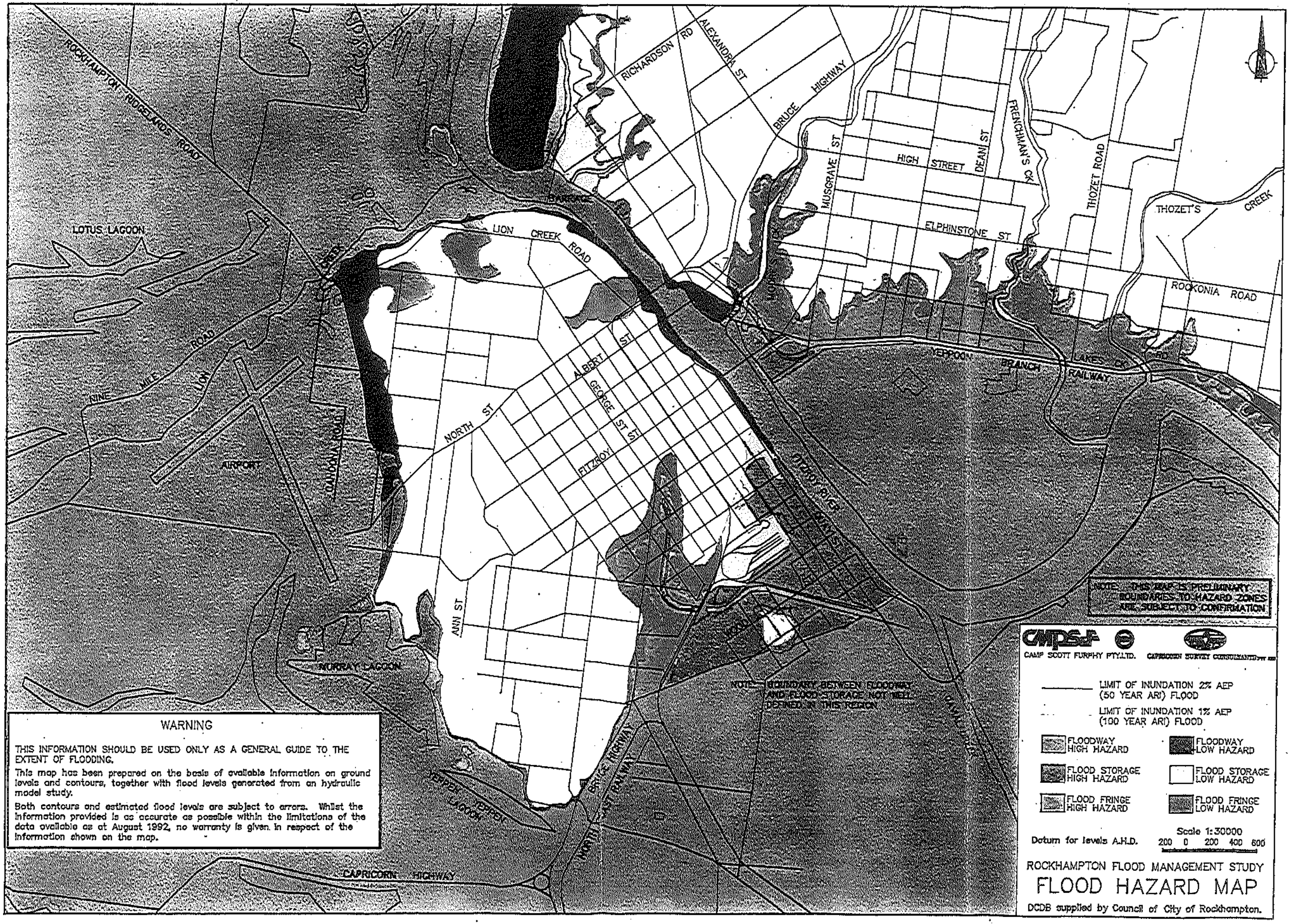

WARNING
THIS INFORMATION SHOULD BE USED ONLY AS A GENERAL GUIDE TO THE EXTENT OF FLOODING.
This map has been prepared on the basis of available information on ground levels and contours, together with flood levels generated from an hydraulic model study.
Both contours and estimated flood levels are subject to errors. Whilst the information provided is as accurate as possible within the limitations of the data available as at August 1992, no warranty is given in respect of the information shown on the map.
CAMP SCOTT FURPHY PTY.LTD.
LIMIT OF INUNDATION 2% AEP (50 YEAR ARI) FLOOD
LIMIT OF INUNDATION 1% AEP (100 YEAR ARI) FLOOD
LIMIT OF INUNDATION 0.5% AEP (200 YEAR ARI) FLOOD
Datum for levels A.H.D.
Scale 1:30000
200 0 200 400 600
ROCKHAMPTON FLOOD MANAGEMENT STUDY
FLOOD INUNDATION MAP
DCDB supplied by Council of City of Rockhampton.
ROCKHAMPTON RIDGELANDS ROAD
LOTUS LAGOON
NINE MILE ROAD
LION
AIRPORT
CANOONA ROAD
MURRAY LAGOON
CAPRICORN HIGHWAY
BRUCE HIGHWAY
LION CREEK ROAD
NORTH ST
ALBERT ST
GEORGE ST
FITZROY ST
ANN ST
RICHARDSON RD
ALEXANDRA ST
BRUCE HIGHWAY
MUSGRAVE ST
HIGH STREET
DEAN ST
FRENCHMAN'S CK
THOZET ROAD
ELPHINSTONE ST
THOZET'S CREEK
ROCKONIA ROAD

FIGURE 4-1


ROCKHAMPTON RIDGELANDS ROAD
LOTUS LAGOON
NINE MILE ROAD
LION
AIRPORT
CANOONA ROAD
NORTH ST
ANN ST
MURRAY LAGOON
YEPPEN YEPPEN LAGOON
CAPRICORN HIGHWAY
NORTH BRUCE HIGHWAY
NORTH COAST RAILWAY
LION CREEK ROAD
ALBERT ST
GEORGE ST
FITZROY ST
FITZROY RIVER
RICHARDSON RD
ALEXANDRA ST
BRUCE HIGHWAY
MUSGRAVE ST
HIGH STREET
DEAN ST
FRENCHMAN'S CK
ELPHINSTONE ST
THOZET ROAD
THOZET'S CREEK
ROCKONIA ROAD
YEPPOON BRANCH RAILWAY
LAKES CK
NOTE: BOUNDARY BETWEEN FLOODWAY AND FLOOD STORAGE NOT WELL DEFINED IN THIS REGION
NOTE: THIS MAP IS PRELIMINARY. BOUNDARIES TO HAZARD ZONES ARE SUBJECT TO CONFIRMATION
WARNING
THIS INFORMATION SHOULD BE USED ONLY AS A GENERAL GUIDE TO THE EXTENT OF FLOODING.
This map has been prepared on the basis of available information on ground levels and contours, together with flood levels generated from an hydraulic model study.
Both contours and estimated flood levels are subject to errors. Whilst the information provided is as accurate as possible within the limitations of the data available as at August 1992, no warranty is given in respect of the information shown on the map.
CAMP SCOTT FURPHY PTY.LTD.
LIMIT OF INUNDATION 2% AEP (50 YEAR ARI) FLOOD
LIMIT OF INUNDATION 1% AEP (100 YEAR ARI) FLOOD
FLOODWAY HIGH HAZARD
FLOODWAY LOW HAZARD
FLOOD STORAGE HIGH HAZARD
FLOOD STORAGE LOW HAZARD
FLOOD FRINGE HIGH HAZARD
FLOOD FRINGE LOW HAZARD
Datum for levels A.H.D.
Scale 1:30000
200 0 200 400 600
ROCKHAMPTON FLOOD MANAGEMENT STUDY
FLOOD HAZARD MAP
DCDB supplied by Council of City of Rockhampton.

SECTION 5

5. SUMMARY OF RECOMMENDATIONS

5.1 GENERAL

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 total estimated cost of the recommended works is about $35 million of which the non-structural works comprise only $0.3 million. The structural works have been broken down into four priority levels. These priorities may be used in phasing the works according to budget constraints.

5.2 SUMMARY OF RECOMMENDATIONS

5.2.1 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). The cost of this is difficult to determine without investigation of the PABX system currently installed but may be of the order of $20,000 – $30,000 if queuing facilities have to be provided compared to just a few thousand for the recorded message facility itself. An indicative cost of $30,000 has been included herein. 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 $143,000 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 5-1.

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.

5.2.2 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 envisaged, for example, as a 4 year work programme. This timing must be determined by the Local Authorities in regard to their budgets 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 5-1.

a) **Priority 1**

- upgrading Yeppen crossing by raising embankment height to bridge height for the full width of the floodplain crossing, together with doubling bridge waterway area by increasing bridge length to about 840 m from the existing 420 m.

  The cost of these works is estimated to be $16.5 million.

  This would raise the flood immunity of the southern road and rail approaches to Rockhampton to 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 for these alternatives assuming a 5% discount rate (1.1 for 7%).

  The Department of Transport's position regarding funding this upgrade is given in Appendix L.

- 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, as the 0.5% AEP level of protection would have some negative impact on flood levels in the floodplain, it is recommended that the levee be designed to give protection to the 1% AEP flood, with controlled flooding for more extreme events.

- Removal of the bridge/causeway along the section 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 which would otherwise be 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.

The combination of the above will have no adverse impact on flood levels in occupied areas at 2% AEP and at 1% AEP compared to existing conditions.

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. The direct benefits are relatively low with BCR for 1% AEP at only about 0.35 at 5% (0.26 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. There is a substantial cost penalty of raising protection to 0.2% AEP as the total cost would then be $7.4 million. Because of negative impacts on flood levels for protection against floods greater than 1% AEP, the 1% AEP level is recommended.

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. 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.

5.2.3 Design Stage

If the Local Authorities resolve to proceed with the measures outlined above, it will be necessary for detailed engineering studies to be carried out prior to construction. These costs have been allowed for in the estimates given, the approximate allowance of 10% of capital costs includes detail design, preparation of contract documentation and construction supervision. These costs may be included in the FWRAP funding application. Final alignment of the proposed levees would be determined in the design stage.

In the case of the non-structural works, these can proceed without further engineering input, except for determining the PABX requirements for the installation of the recorded telephone service.

5.2.4 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;

TABLE 5-1

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.	

- 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.

5.3 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. The Department of Transport's positioin in this regard is the subject of the statement given in 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 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.

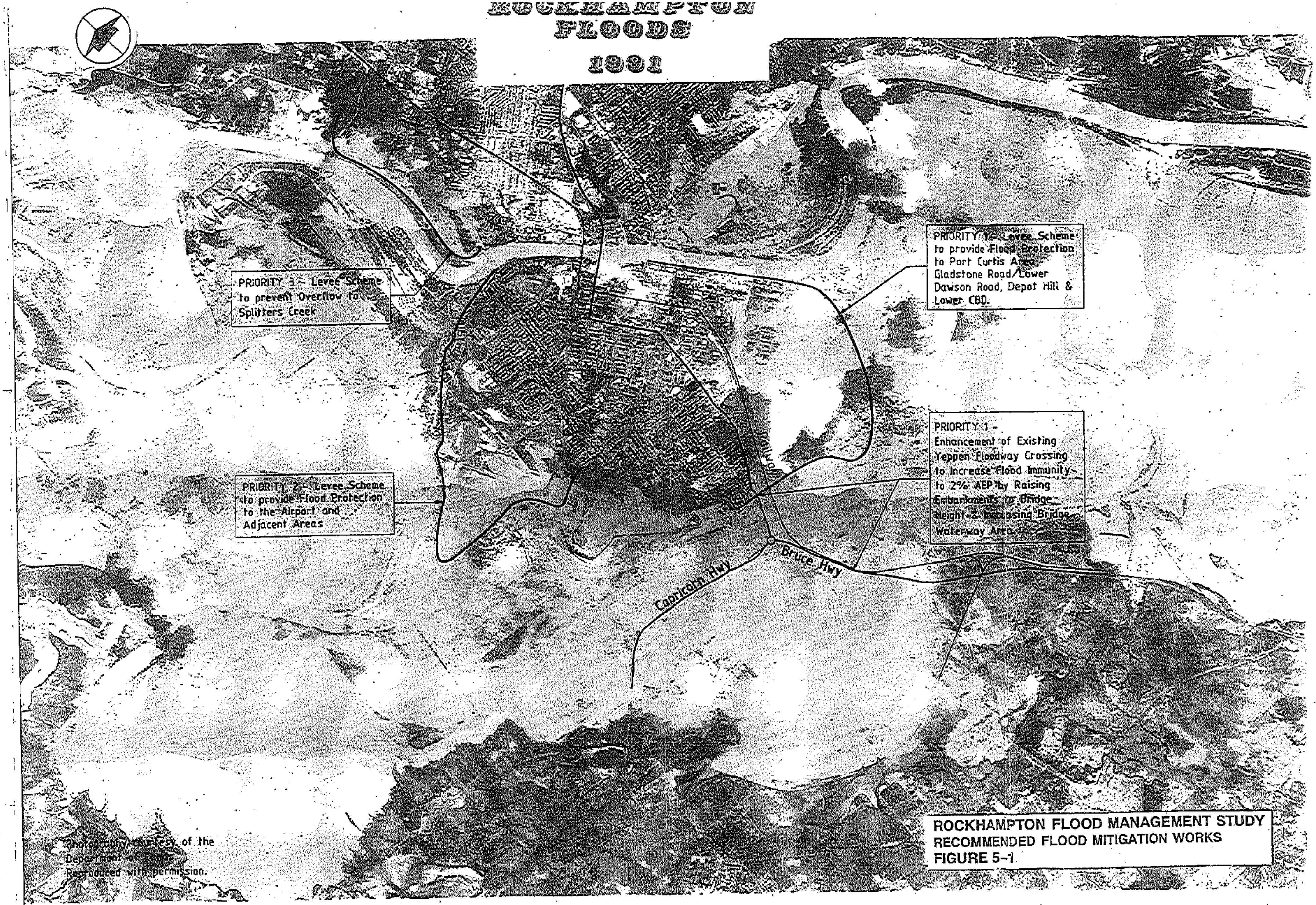
SECTION 6

6. REFERENCES

CAMP SCOTT FURPHY (1992), 'Rockhampton Flood Management Study – Phase 1 Report', prepared for the Water Resources Commission.

CAMERON McNAMARA (1981) 'Fitzroy River Erosion in the Pink Lily Area', prepared for the Queensland Water Resources Commission.

NEW SOUTH WALES GOVERNMENT (1986), 'Floodplain Development Manual', PWD 86010, Sydney.



ROCKHAMPTON FLOOD MANAGEMENT STUDY
RECOMMENDED FLOOD MITIGATION WORKS
FIGURE 5-1

DEPT. OF PRIMARY INDUSTRIE
CAMP SCOTT FURPHY PTY, LTD
ROCKHAMPTON FLOOD MANAGEMENT

PI-09676940-00-002