BRISBANE RIVER FLOOD STUDY

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June 1999

City Design
BRISBANE CITY COUNCIL

1. Introduction

The Brisbane River is an integral part of Brisbane. It has been the focus of City life, trade and commerce since the settlement of Brisbane. Thousands of residential, commercial and industrial properties are situated on the floodplain and along the banks of the River.

Until 1994 the State Government and Brisbane City Council's Water Supply and Department controlled the River. During the period up to 1994 a number of studies were carried out on the Brisbane River. While these studies included assessment of flooding, their primary focus was on the major dams and water supply for the City. The most recent Council study was completed by Council's Water Supply and Sewerage Department in 1984. The Department of Natural Resources (DNR) completed, to draft stage, a study of the River in 1993.

In 1994 control of the River passed to the then Works Department of Council (now Waterways Program). The Works Department determined that a study of the River was required that:

- determined the impacts of flooding on the City;
- was consistent with similar studies carried out for the major creeks of Brisbane;
- would provide improved data for advising the community and emergency services personnel during major floods; and
- would support development control and strategic planning in the River corridor.

This report provides an overview of the study, discusses key findings and presents options to address these findings. The report also recommends actions, for consideration by Council, designed to address the issues raised in this study.

2. Objective

The objective of this current study is to:

- investigate and understand flood behaviour in the River corridor. No previous study has assessed the flood carrying capacity of the River and its floodplain, the impact of development on flooding along the River and any actions required to minimise the impacts of flooding on development. The scope of this study also includes assessment of the effect of development in the catchment and cross-river structures on flood levels in the River, the significance on flood behaviour of re-vegetation strategies in Council's "Strategic Plan for Management of Brisbane Waterways" and the relevance of flood regulation lines in the Brisbane River corridor. There are currently no flood regulation lines set for the Brisbane River.

- determine flood levels to apply to development. Current development levels for the River corridor are based on the 1984 study. Flood profiles were developed for the River in that study, but not to the same rigorous standard as that now applied to Brisbane's Creeks. A key outcome from this study is to determine appropriate development levels in the River corridor.

- develop and provide improved flood emergency information. It is necessary to update flood level data so that Council can provide high quality flood advice to the public during a flood event. The Bureau of Meteorology provides flood warnings based on the three main gauges located at Moggill, Jindalee and the Port Office. The study will provide a flood forecasting model and data at other locations throughout the City so that Council can provide advice to residents more specific to their location and can more adequately advise emergency service personnel about affected areas and escape routes.

3. Study Approach

There are 160 years of recorded flood data at the Port Office gauge. The approach to the study is designed to make maximum use of this record. The historic record was analysed to determine the frequency of occurrence of significant historical floods (e.g. 1841, 1893 and 1974) and to predict the magnitude of specific "design" flood events (e.g. the 1 in 100 year flood). However, the construction of Somerset Dam (1943) and Wivenhoe Dam (1985) means that the flood record prior to 1943 cannot be directly compared with the record after dam construction. The historic flood record needs to be adjusted to take into account the effect of these dams.

This adjustment to the flood record was undertaken by establishing hydrologic and hydraulic computer models of the River. The models were calibrated to rainfall, flood flow and flood level data measured during floods which occurred after construction of the dams. The models were then modified by removing the dams and re-run to estimate the flood flows and levels in the River without the dams. In this way the 160 years of flood record for the River was adjusted to the same basis of "without dams".

The adjusted record was analysed to produce a flood frequency relationship for the River. Using this relationship the 1 in 100 year flood flow was determined "without dams".

To calculate the 1 in 100 year design flood for the current situation with dams, the hydrologic and hydraulic models were used. A "design" rainfall was applied over the catchment so that the model, without dams, calculated the 1 in 100 year "design" flood flow to be the same value as the flow determined by the flood frequency analysis. The models were then modified to include both Wivenhoe and Somerset Dams and re-run to provide an estimate of the 1 in 100 year design flood flows and levels along the River for the current situation with dams.

4. Preliminary Findings

The significant preliminary finding of the study was that the 1 in 100 year design flood levels in the River are significantly higher than the current development control level. The preliminary findings predicted that the 1 in 100 year design flood level will vary by approximately 2 m higher than the 1984 levels at the Port Office to more than 3 m higher further upstream. The levels estimated in the 1984 study formed the basis of development control levels in the Brisbane River corridor.

Another preliminary finding, which is contrary to the commonly held view, was that the 1974 flood is only the fourth largest on record and is estimated to have a frequency of occurrence of approximately only 1 in 40 years.

The hydrologic and hydraulic models developed in the study calibrated well to recorded flood data and were used to adjust the historic record for the effects of Wivenhoe and Somerset Dams. Analysis of the resulting flood frequency relationship estimated the 1 in 100 year design flow at 9,560 m³/s at the Port office (including the mitigation effects of Wivenhoe and Somerset Dams). This flow is significantly higher than the design flow of 6,800 m³/s

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estimated in the 1984 study. It is similar, however to the 1 in 100 year flow of 9,380 m^3/s estimated in the 1993 DNR study.

The preliminary finding that the 1 in 100 year design flood level may be at least 2 m above current development control levels is of significant concern to Council. Professor Russell Mein of Monash University was commissioned to undertake an independent review of the work. While Professor Mein was satisfied that the overall approach to the hydrologic component of the study is appropriate, he raised a number of issues which he believed may influence the key findings of the study. These issues are:

- the flood record appears to be dominated by events in the last century which may affect the flood frequency analysis and hence the estimate of the 1 in 100 year design flow;
- the study may have over estimated the 1 in 100 year design flow due to:
  - non-use of an areal reduction factor on the design rainfall event;
  - use of zero losses for the design rainfall event; and
  - the assumption that Somerset and Wivenhoe dams are full at the start of the design event; and
- the method of fitting the flood frequency curve to the recorded data may not be appropriate.

In addition, Council became aware that the operating rules that the State Government will apply to Wivenhoe Dam during a major flood event have been revised since the 1984 study. Council were advised of the changes in 1998.

5. Assessment of Areas of Concern

The impact on the estimation of the 1 in 100 year design flood flow of the issues raised by Professor Mein and the new operating rules have been reviewed in the study. It is important that Council is confident that the estimate at the 1 in 100 year design flood is reliable, particularly if the calculated design flood level is different to the current development control level.

5.1 Historic Flood Record

During a flood event the maximum level of the flood is recorded. These recorded levels are then used to estimate the associated flood flow at a specific point in the River by applying the stage – discharge curve (sometimes referred to as the rating curve) for the River.

The stage – discharge curve provides the relationship between water level (stage) and flow. The curve is determined by measuring the velocity of flow in the stream then computing the flow rate for a number of water levels by multiplying the cross-sectional area by the measured velocity.

This is how the 160 years of historical flood flow records for the Brisbane River were developed. However, significant works have been carried out in the River which may impact on the recorded flood levels at the Port office and hence the recorded flood flow.

It is known from historical records that there was a bar at the mouth of the River when Brisbane was first settled and that the River was deepened by about fifteen feet at some stage around the turn of the century.

It was assumed in previous studies, and in the initial work in this study, that the historic flood record had been corrected for all changes caused by the removal of the bar and navigational dredging. Subsequent research of historic records has shown that this assumption is not valid.

The effect on recorded flood levels of these changes needs to be estimated so that all recorded flood levels are relative to the current state of the River. This is because flows for these historic events can only be estimated using the current stage – discharge curve at the Port office. The impact of these changes on the historic flood record are discussed below.

Brisbane River Bar

The bar caused a considerable barrier at the mouth of the River, with a quoted depth over the bar at low water of four feet (1.22m). The bar was removed in 1864. Records from the latter part of the nineteenth century show that the effect of removing the bar (on floods prior to 1864) was estimated to be in the order of 10 feet.

The hydraulic model developed in this study allows us to understand the effect of such a bar on flood levels up the River. The modelling approach to simulate the conditions that would exist if there were a bar at the mouth of the River is to vary water levels in Moreton Bay to assess the sensitivity of flood levels at the Port Office. The model showed that recorded flood levels (prior to 1864) may have been reduced by up to 0.4 metres when the bar was removed. The effect of removing the bar is clearly not as significant as estimated in the 19th century (i.e. 10 feet or approximately 3m). Recorded flood levels prior to 1864 need to be reduced by 0.4m to be consistent with records of floods after 1864.

Dredging

Records show that in 1917 the River was deepened by about fifteen feet to allow boats easy passage to the port at the current South Bank reach. Henderson, the Chief Hydrologist at the time and author of the text 'Open Channel Hydraulics' (still used by Universities) estimated, during design work for the dredging in 1896, that the effect of the dredging would be to reduce flood levels by about five feet.

The gauge at Moggill has a continuous flood record from 1891. The record is unaffected by the removal of the bar and dredging. Comparison of the stage – discharge curves for the Moggill and the Port Office gauges suggests that dredging will reduce smaller floods, but may have virtually no impact on larger floods.

On the basis of this finding all flood levels recorded prior to 1917, except the two largest floods recorded in 1841 and 1893 need to be reduced by about 5 feet (or 1.52m) to be consistent with levels recorded for floods occurring after 1917. The effect of dredging will be cumulative with the effects of removing the bar, so the recorded levels of floods prior to 1864 need to be reduced by a total of 1.92 metres from their actual measured value to be consistent.

Adopted Historic Flood Record

The adopted historic flood record for the Brisbane River is summarised in Table 1. The historic record of flood levels prior to 1917 was adjusted to account for removal of the bar and dredging as discussed above.

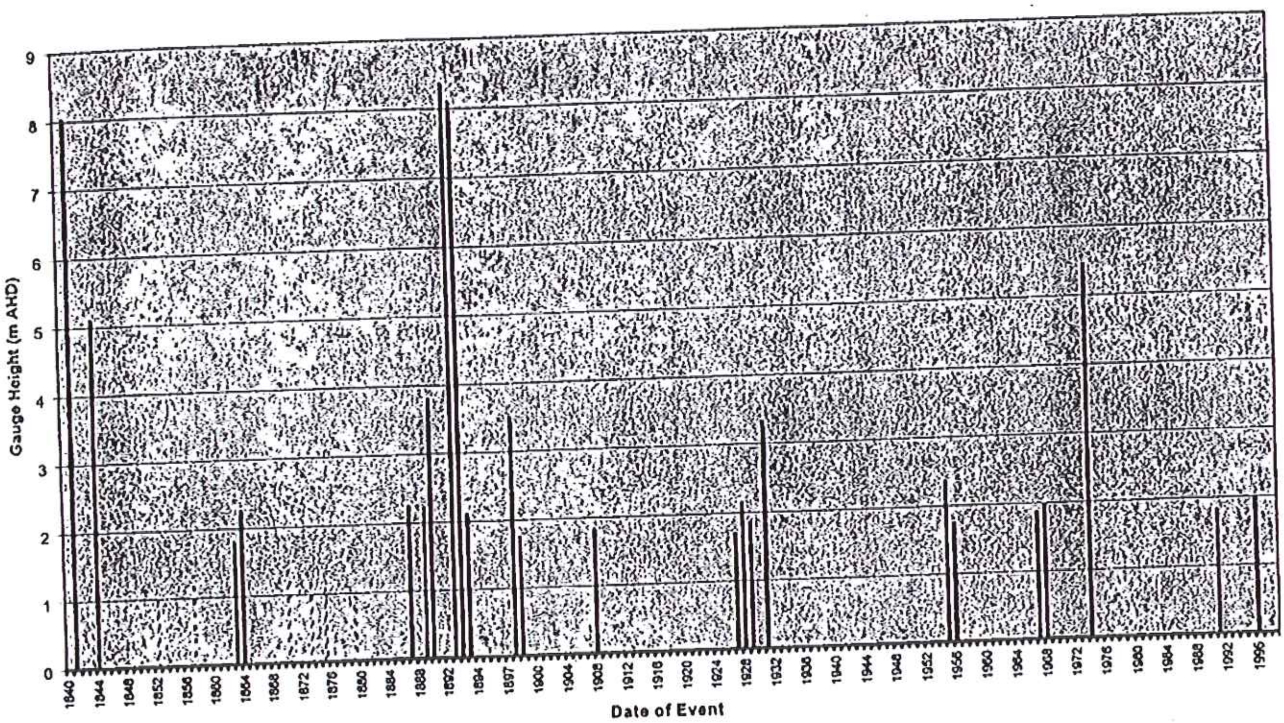
In addition, the record after 1943 was adjusted to take into account the effects of Somerset Dam, while records after 1985 were also adjusted to account for the effects of Wivenhoe Dam. The method of analysis to make these adjustments is described in Section 3.

Table 1 Adopted Historic Flood Record

Date	Recorded Flood Level (metres AHD)	Adjusted Flood Level (m AHD)	Discharge, Adjusted for Removal of Bar and Dredging (m^3/s)	Discharge, Adjusted to Account for Somerset and Wivenhoe Dams (m^3/s)
1841	8.43	8.03	14100	14100
1843	2.76	0.84	1940	1940
1844	7.03	5.11	8924	8924
1845	6.5	4.58	8120	8120
1852	2.91	0.99	2252	2252
1857	3.27	1.35	2963	2963
1863	3.32	1.80	3789	3789
1864	3.78	2.26	4574	4574
1870	2.89	1.37	3001	3001
1873	2.69	1.17	2614	2614
1875	2.61	1.09	2455	2455
1879	2.46	0.94	2149	2149
1887	3.78	2.26	4574	4574
1889	3.75	2.23	4525	4525
1890	5.33	3.81	6972	6972
1893	8.35	8.35	14600	14600
1898	5.02	3.45	8500	8500
1908	3.35	1.83	6100	6100
1927	1.70	1.70	3618	3618
1928	2.15	2.15	4398	4398
1929	1.85	1.85	3884	3884
1931	3.32	3.32	7000	6245
1955	2.36	2.36	5990	6704
1956	1.75	1.75	3707	4189
1967	1.87	1.87	2600	2990
1968	1.97	1.97	4200	4704
1971	1.47	1.47	2100	2478
1974	5.45	5.45	9873	10364
1991	1.82	1.82	1700	2387
1996	2.00	2.00	2400	3087

Figure 1 shows the adjusted historic flood record plotted on a time scale for all floods higher the 1.7 m at the Port Office (this is the Bureau of Meteorology's definition of a minor flood). It can be seen that the adjustments made to the historic flood record result in a more even distribution of floods across the whole period of record.

Figure 1 – Brisbane River Flooding since 1841 (adjusted)



A thorough review has been completed of all elements which have affected the historic flood record. The principal effect has been to reduce significantly the recorded value of the 1844 flood flows, with the 1974 flood now the third largest (rather than the fourth largest) flood on record, with a frequency of occurrence of approximately 1 in 50 years.

The work undertaken in this study provides reasonable confidence that the adjusted flood record provides a good estimate of historic flood events and is a sound basis for estimating the 1 in 100 year design flood.

5.2 Flood Frequency Curve

The adopted historic flood record was analysed to determine the flood frequency relationship for the Brisbane River at the Port office. The relationship is used to estimate the 1 in 100 year design flood (without dams).

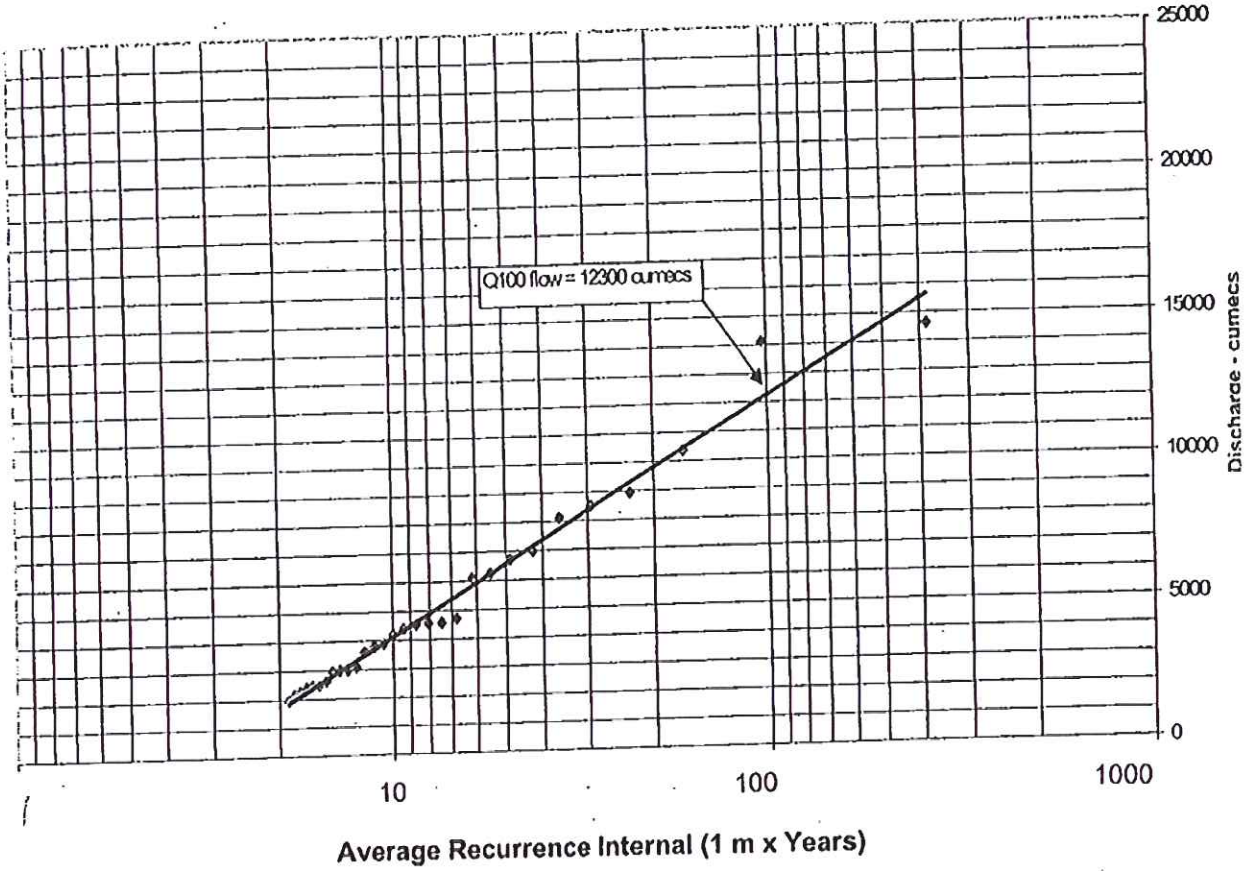
In his review Professor Mein suggested that a Log Pearson Type III (LPTIII) distribution be used rather than the "fit by eye" adopted in the initial work.

The LPTIII analysis produced a similar estimate of the 1 in 100 year flood flow event as the "fit by eye" method. Because the "fit by eye" curve appears to fit the data better it has been adopted.

The adopted historic flood record (Table 1) is plotted on Figure 2 and the adopted "fit by eye" flood frequency curve is fitted. The 1 in 100 year design flood flow is estimated at 12,300 m^3/s(without dams).

When this flood is run through the hydrologic and hydraulic models with both Somerset and Wivenhoe Dams in place, the calculated flood flow at the Port office is reduced to 8,600 m^3/s. This is approximately 1,000 m^3/s less than the estimate of 9,560 m^3/s developed in the initial work on the study (refer Section 4), but still some 1,800 m^3/s larger than the 6,800 m^3/s estimated in the 1984 study.

Figure 2 Flood Frequency Curve at Port Office



5.3 Effect of Water Level in Dams

Professor Mein questioned the assumption made in the initial work that the dams would be full at the start of the analysis.

The Department of Natural Resources supplied 96 years of daily rainfall data for the Wivenhoe Dam catchment and daily storage volumes in Wivenhoe Dam since its construction. The storage behaviour of Wivenhoe Dam was simulated for the 96 years of record.

The analysis showed that the mean water level in the dam was 66.4 m (the spillway is at RL 67 m) and that the water level was above 65 m at least 90% of the time. Analysis of rainfall records for the 1974 flood show that general rain preceding the main event was sufficient to fill the dam to spillway level.

Therefore, the assumption that the dam will be full at the start of the analysis is considered reasonable.

5.4 Areal Distribution of Rainfall and Losses

Wivenhoe Dam is a major influence in the catchment, controlling some 50% of the catchment. Therefore, different patterns of rainfall, each producing the same 1 in 100 year design flood in the "without dams" case, will produce a different flood flow in the "with dams" condition. This is because each different rainfall pattern will produce a different volume of run off from the catchment that is influenced by the dams.

Five different rainfall patterns were analysed. Actual rainfall patterns obtained from the Bureau of Meteorology for the significant floods of 1893, 1931, 1955, 1974 and 1996 were analysed.

To simulate the 1 in 100 year design flood event the recorded areal and temporal patterns of each rainfall event were adopted. The depth of rainfall was increased (compared with the actual event) until the model (without dams) produced the 1 in 100 year flow estimated by the flood frequency analysis (i.e. 12,300 m^3/s– refer Section 5.2). Wivenhoe and Somerset Dams were then included in the model to assess the effects of areal distribution of rainfall on the 1 in 100 year design flood with dams.

The results, summarised in Table 2, show a significant variation in the estimate of the 1 in 100 year design flood flow at the Port Office. The adopted 1 in 100 year design flow of 8,600 m^3/s, estimated using rainfall with an areal and temporal pattern based on Bureau of Meteorology analysis of all rainfall records in the catchment, is within the range of values calculated from specific flood rainfall patterns.

It is not possible to define precisely the probability that a particular pattern of rainfall will occur. From records of historic floods we know the pattern of rainfall can vary considerably and that the impact on floods in the River will be significant. Based on the analyses described above it is concluded that the adoption of the rainfall pattern derived by the Bureau of Meteorology provides a reasonable basis to estimate the 1 in 100 year design flood in the Brisbane River.

Table 2 Effect of Rainfall Pattern on Estimate of Flood Flow

Rainfall Pattern Event	1 in 100 Year Flow With Dams ($m^{3/s}$)
1893	8,810
1931	8,270
1955	8,150
1974	8,180
1996	10,050

5.5 Dam Operating Rules

The rules applied to the operation of Wivenhoe Dam in a major flood were altered in 1994. The analysis of these new rules showed that for the estimated 1 in 100 year design flow of 8,600 m^3/s there will be no change in flood flow at the Port Office, compared with the original 1984 rules. This is because the mitigation effects of Wivenhoe Dam diminish as the magnitude of the flood increases. The operating rules have virtually no impact on floods larger than 8,000 m³/s.

6. Flood Levels Along The River

The hydraulic model has been used to calculate a flood profile along the entire length of the Brisbane River within the City of Brisbane. This profile is plotted on Figure 3, together with the flood profile adopted from the study.

At the Port Office gauge the flood level corresponding to the calculated 1 in 100 year design flow of 8,600 m³/s is estimated to be 5.0 m, AHD. The current development design flood level, based on the 1984 study, is 3.8 m AHD some 1.2 m lower than the level predicted in this study. From the two flood profiles plotted on Figure 3 it can be seen that the flood levels calculated in this study vary from about 1.0 m to almost 3.0 m higher than the current development design flood level in Brisbane.

7. Conclusion

An extensive and comprehensive analysis has been undertaken of flooding in the Brisbane River within the City of Brisbane. All elements of the study have been subjected to independent peer review because the key findings have significant implications for Council. The overall approach to the study, the detailed methodology and results have all been scrutinised and tested.

Exhaustive research of all aspects of the data used in the study has been undertaken. It was found that the historic record required adjustment to account for changes in the River since flood records were first kept in 1841.

As a consequence the results of the study are considered to provide the "best estimate" of flooding in the Brisbane River corridor within the City of Brisbane.

Flood Behaviour in the River Corridor

The study has provided a comprehensive understanding of flood behaviour in the River corridor and the interaction between flooding and development. Flood profiles along the River have been developed and peak flood levels and flows at each cross-section have been tabulated.

Major hydraulic structures along the River (e.g. bridges) were assessed. It was determined that no upgrade of these structures was required to mitigate the impact of flooding.

Waterway management issues have also been addressed in the study. This involved testing the impact of re-vegetation along the River in accordance with the current "Strategic Plan for Management of Brisbane Waterways" and assessing the potential to set regulation lines to manage development in the corridor.

It was found that the re-vegetation strategy will increase flood levels by a maximum of 20 mm.

A comprehensive assessment of the application of Council's Flood Regulation Line policy was completed and potential strategies to implement flood regulation lines were assessed.

An interesting finding of the study is that while navigational dredging will certainly reduce the impact of less severe floods it may have virtually no impact on major floods in the River.

Flood Levels To Apply To Development

The major finding of this study is that the calculated 1 in 100 year design flood flow is 8,600 m^3/s The corresponding flood level is about 1.0 to 2.0 m higher than the current development control level in the Brisbane River corridor. This is a significant outcome of the Study, and options to deal with the issues raised by this finding are discussed in Section 8.

Flood Emergency Information

A flood forecasting model has been developed for the Brisbane River in conjunction with development of flood "contours" for inclusion in Council's Bimap system. In addition, an assessment has been made of possible escape routes and areas within the City which may become insolated during major flood events. This data has been incorporated into Council's Flood Information Centre's operating procedures.

8. Options To Address Issues Associated With Increased Design Flood Levels

Significant floods have occurred six times in the last 160 years in Brisbane. These floods cause significant damage and disruption to Brisbane, even with the mitigating effect of Wivenhoe Dam. Larger, though rarer, floods may also occur. There is a perception in Brisbane that Wivenhoe Dam will control and limit the damage associated with all future floods. This is not the case and complacency in the community as a result of this perception could well lead to increased damages due to the failure of flood affected residents to react to flood warnings.

Because there has only been one major flood since 1893 (i.e. in the last 100 years), it is an attractive option to suggest that the 1974 flood, modified to take into account the affects of Wivenhoe Dam, could represent the 1 in 100 year design flood. This view was implied by Professor Mein in his comment that the historic record appears to be biased to the early part of the record.

This option could be supported by an argument that data recorded in the 19th Century is of doubtful accuracy and therefore should be ignored. On this basis the design flood flow would be 6,800 m^3/s, consistent with the current development control design flood levels for the River.

However, on the basis of the thorough and intensive research undertaken in this study, this approach cannot be supported. The simple option of saying that the current development control level represents the 1 in 100 flood level is not valid.

Therefore, there are essentially two options available to Council to deal with the issues raised by the finding of this study that the 1 in 100 year design flood is 1.0 to 2.0 m higher than the current development control levels. These are:

- maintain the current development control levels; or

- adopt the 1 in 100 year design flood levels calculated in this study.

Option 1 Maintain Current Development Control Levels

The implications of adopting this option are:

- Development design levels within the River corridor remain consistent with development since 1984.
- The flood immunity of properties is less than previously assessed. For example, the flood corresponding to current development control levels has a 1 in 55 year average recurrence interval.
- The average flood damages associated with flooding will be significantly larger (on the basis of the flood frequency analysis in this study) than if development levels are increased as in Option 2.
- There are potential legal implications for Council by allowing development to occur in higher risk areas. As a minimum developers and residents may need to be advised of the actual flood risk on their property.
- Property owners may not be able to insure their property for flood risk, or may face very high premiums to obtain adequate cover.
- Council may lose access to National Disaster Relief (NDR) funding.
- It will be necessary to review and modify existing flood emergency plans.

Option 2 Adopt 1 in 100 Year Design Levels In This Study

This option preserves the position which Council believes it now has, with respect to development control, on the assumption that the current development control level is in fact the 1 in 100 year flood level. While adopting this option would offset the negative implications of Option 1, it will cause some transitional problems. These may be summarised as follows:

- existing development. There will be no requirement to change, but Council must recognise the increased flood risk to these properties (many of the implications of Option 1 will apply to this case).
- current applications. Each application will need to be treated on its merits, but ideally Council should attempt to impose new conditions.
- new development. Impose new conditions.
- re-development. Attempt to impose new conditions, but recognise that a "sliding scale" may be required to integrate with adjacent development (e.g. need to consider aesthetics).

Mitigation Strategies

There are also a wide range of structural and non-structural measures which may be implemented in conjunction with either of these options to reduce the damage and disruption associated with major floods in the River. A workshop was organised to develop and assess the strategies available to Council. The participants included experts in floodplain management, risk management, legal aspects and river engineering.

The strategies developed through the workshop are summarised in Table 3. The strategies have been ranked on the basis of a preliminary benefit – cost analysis, undertaken using available data and previous reports. The assessment of the strategies showed that non-structural options generally offered a more attractive benefit – cost ratio compared with the structural options, largely because of the large capital costs associated with structural options.

Table 3 Flood Risk Management Strategies

Rank	Strategy	Aim	Implications	Effectiveness
1	Develop flood risk plans for essential services (lifelines)	A Other Lifelines – Limited catastrophic disruption to lifelines by a major flood B Transport Lifeline	▪ Reduced residual risk ▪ Better understanding of community risk	Good
2	Develop flood action plan for each residential property	Reduce residential AADs by 50%	▪ Increase awareness of flood risk ▪ Better knowledge of power to respond to a flood warning	Good
3	Flood warning – community awareness	Improve dissemination/ understanding of flood warnings	▪ Raised risk awareness (community concern) (primarily avoid deaths) ▪ Save 50% residential damage	Very high
4	Develop flood action plans for each industrial/ commercial property	Reduce commercial/ industrial AADs by 50%	▪ Raised awareness of flood risk ▪ Reduced losses in floods	Good
5	Accept flood study and leave planning requirements as is	Maintain current standards FL+'98 H_{100} + 0.5	▪ NDR funds available ▪ May have to defend Planning requirements in court ▪ May impact on subdivisions ▪ Rating based may change due to property re-valuation	Medium
6	Modify Wivenhoe Dam	Reduce frequency of flooding of properties	▪ Loss of water supply – Water Supply (1.1G1), - Flood Supply (1.4G1) ▪ Detailed study needed ▪ Reduce peak discharges to 1984 study scenarios	Medium
7	Flood Control Dam(s)	Reduce frequency of flooding of properties	▪ Conflict with agriculture ▪ Environmental flows ▪ Possible dam use	Good

			▪ Benefits for Ipswich & Brisbane	
8	Review town planning, requirements (+ building codes)	Develop risk based planning conditions and building codes	▪ Redevelopment of existing properties ▪ Extensions to existing properties	Good long term
9	Levees	Reduce frequency of flooding op properties	▪ Could be 8m high ▪ Only protect limited areas	Very poor
10	Review Residential Properties in high hazard area	Reduce elements of risk in high hazard areas	▪ Remove properties under great threats ▪ Raising does not solve all problems	Medium
11	Reduce afflux at bridges	Reduce frequency of flood levels in local areas	▪ Reduce flood levels (debris blockage) ▪ Possible impacts on transportation system	Medium
12	BCC to subsidise/ underwrite residential flood insurance	To offset financial loss to affected residents	▪ Does not reduce AADs ▪ Financial risk to Council	Poor
13	No change-adopt current development control levels	To maintain the status quo	▪ Flood/development levels remain consistent ▪ Flood immunity reduced ▪ Liability to Council's ▪ Loss of NDR funds	Poor

Note that strategies ranked 5 and 13 are in fact Options 2 and 1 respectively. In the assessment for ranking purposes these two options were considered without other mitigation strategies being adopted in conjunction.

In principle, any of the mitigation strategies listed in Table 3 could be implemented in conjunction with either of the two options proposed. In the case of Option 1, adopting any of these strategies may be sufficient to offset the impacts on residents whose properties lie below the 1 in 100 year flood levels calculated in this study. This approach gives rise to a third option.

Option 3 Maintain Current Development Controls With Complimentary Mitigation Strategies

This option consists of maintaining the current development controls (Option 1) in conjunction with a range of short and medium term non-structural flood mitigation strategies.

Short Term Strategies

- Investigate alternative operating rules for Wivenhoe Dam with the State Government.
- Develop a flood risk strategy for essential services.

Medium Term Strategies

- Develop risk based planning conditions and building codes.
- Develop flood action plans for each residential property (this could include some commercial/industrial properties).
- Undertake and maintain a community awareness campaign including advise and verification and developments of the true flood immunity of their property or development.
- Remove residential properties in high hazard areas.

The workshop assessed, on the basis of available data, that these mitigation strategies have the potential to offset the additional damages which may be attributed to maintaining the current development control levels.

If this option is adopted it would be prudent to undertake a risk assessment to quantify the potential flood damages and ensure that risk minimisation strategies are effective and appropriate.

9. Recommendations

The recommendations of this study are:

- Council adopt the 1 in 100 year design flood flow as calculated in this study and the associated flood profile along the River;
- Council maintains the current development control levels along the Brisbane River in conjunction with strategies listed below;
- Council implement a range of non-structural flood mitigation strategies, including:
  - Develop a flood risk strategy for essential services.
  - Develop risk based planning conditions and building codes.
  - Develop flood action plans for each residential property (this could include some commercial/industrial properties).
  - Undertake and maintain a community awareness campaign including advise and verification and developments of the true flood immunity of their property or development.
  - Remove residential properties in high hazard areas.
- Council more accurately assess the risks, benefits and costs of these recommendations and review the detailed implementation of the recommendations in the light of this risk assessment.
- That the regulation line analysis be used to establish the boundary of the waterway corridor for the Brisbane River.

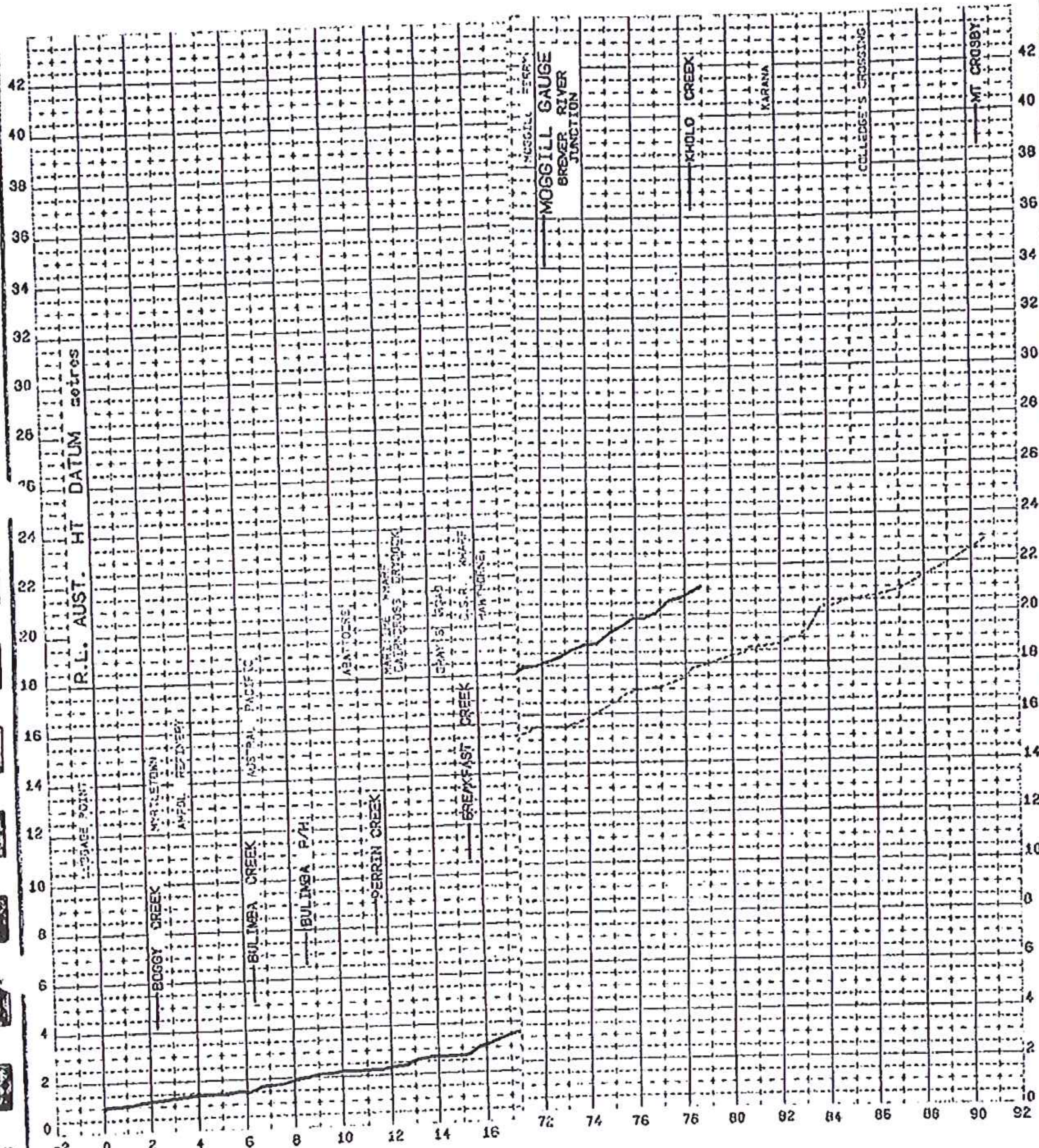


Figure 3

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AMENDMENT | DATE | CHECKED | AUTHORIZED | MICRO

FLOOD STUDY
SBANE RIVER
ON OF FLOOD LEVELS
MARCH 1999

BRISBANE CITY COUNCIL
CITY BUSINESS DIVISION
CITY DESIGN

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