GUNNEDAH SHIRE COUNCIL

BLACKJACK CREEK
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN

APPENDIX B

FLOOD DAMAGES

OCTOBER 2010

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FIGURES

SYNOPSIS

Estimation of flood damages to urban development in flood prone areas bordering Blackjack Creek was carried out to assess the impact of flooding on the community. The objectives were to assist the Floodplain Management Committee in confirming the Flood Planning Level and allow an economic assessment of various flood management measures to be carried out. Damages were assessed for floods ranging between the 20 Year ARI and PMF events.

There were no data available on historic flood damages on Blackjack Creek. The analysis was carried out using the flood damages model attached to *"Floodplain Risk Management Guideline No 4. Residential Flood Damages",* which was prepared by DECCW to allow a consistent assessment across NSW for the comparison of flood management projects. For *Guideline No 4*, damage assessments which had been undertaken after major flooding in urban centres were adjusted and used to estimate damages likely to be experienced to typical residential development in NSW. Data for the flood damages model comprised the depths of inundation over the floodplain, as well as information on the unit values of damages to residential property. The depths of inundation was determined from the results of the hydraulic modelling described in the Main Report and from surveyed floor levels.

The estimated damages, which could occur for various floods, are summarised in **Table S1** below. Sub-division of urban flood damages is usually based on the three categories: "Residential", "Commercial" and "Public Buildings". Development on Blackjack Creek is almost entirely of a residential nature, with only one example of each of the other categories, which are therefore not significant in terms of damages experienced.

Residential damages versus flood frequency are shown graphically on **Figure B8.1**. Damages to contents were assumed to commence due to capillary and wave action once the flood level rose to an elevation 40 mm below the surveyed floor level. Under 20 year ARI conditions, 29 residences would be inundated to that level or greater. In the event of a 100 year ARI flood 104 properties would be similarly flooded. Under PMF conditions the number of flooded residences would increase to 192. The PMF is an extremely rare flood and for the purposes of assessing *average annual flood damages* was assumed to have a return period of 1 in 10^5 years. **Figure B8.2** shows the depths of inundation above surveyed floor level for the 100 year ARI flood in histogram format. Depths of inundation range between zero and 900 mm, with a median value of 250 mm. **Figure B8.3** shows the locations of flooded properties.

TABLE S1
FLOOD DAMAGES IN BLACKJACK CREEK STUDY AREA

Average Recurrence Interval Year ARI	Flood Damages to Each Category ($ x 10^6)			Total Damage ($ x 10^6)
	Residential	Commercial	Public	
20	1.39	0	0	1.39
50	2.43	0	0	2.43
100	3.45	0	0	3.45
Extreme Flood	9.07	0.05	0	9.12

B1. INTRODUCTION AND SCOPE

B1.1 Introduction

Damages from flooding belong to two categories:

- **Tangible Damages**
- **Intangible Damages**

Tangible damages are defined as those to which monetary values may be assigned, and may be subdivided into direct and indirect damages. Direct damages are those caused by physical contact of floodwater with damageable property. They include damages to commercial and residential building structures and contents as well as damages to infrastructure services such as electricity and water supply. Indirect damages result from the interruption of community activities, including traffic flows, trade, industrial production, costs to relief agencies, evacuation of people and contents and clean up after the flood.

Generally, tangible damages are estimated in dollar values using survey procedures, interpretation of data from actual floods and research of government files.

The various factors included in the **intangible damage** category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted method. Such factors may include:

- inconvenience
- isolation
- disruption of family and social activities
- anxiety, pain and suffering, trauma
- physical ill-health
- psychological ill-health.

B1.2 Scope of Investigation

In the following sections, damages to residential, commercial and industrial properties and public buildings have been estimated on Blackjack Creek. Damages to community assets have also been assessed where data were available.

B1.3 Terminology

Definitions of the terms used in this Appendix are presented in **Section 8** which also summarises the value of Tangible Flood Damages.

B2. DESCRIPTION OF APPROACH

The damage caused by a flood to a particular property is a function of the depth of flooding above floor level and the value of the property and its contents. The warning time available for residents to take action to lift property above floor level also influences damages actually experienced. A spreadsheet model which had been developed for previous investigations of this nature was used to estimate damages on a property by property basis according to the type of development, the location of the property and the depth of inundation.

Using the results of the Flood Study (LACE, 2005), a peak flood elevation for each event was interpolated at each property. The interpolated property flood levels were input to the spreadsheet model which also contained property characteristics and depth-damage relationships. The depth of flooding was computed as the difference between the interpolated flood level and the surveyed floor elevation at each property.

The depth-damage curves for residential damages were determined using procedures described in *"Floodplain Management Guideline No 4. Residential Flood Damage Calculation"*, *2007* published by DECCW. Damage curves for commercial and industrial developments were derived from previous floodplain management investigations.

It should be understood that this approach is not intended to identify individual properties liable to flood damages and the values of damages in individual properties, even though it appears to be capable of doing so. The reason for this caveat lies in the various assumptions used in the procedure, the main ones being:

- the assumption that computed water levels and topographic data used to define flood extents are exact and without any error;
- the assumption that the water surfaces between hydraulic model cross sections are adequately represented by interpolation and are not subject to localised influences;
- the use of "average" stage-damage relationships, rather than a relationship for each property;
- the uncertainty associated with assessing an appropriate factor to convert potential damages to actual flood damages experienced for each property after residents have taken action to mitigate damages to contents.

The consequence of these assumptions is that some individual properties may be inappropriately classified as flood liable, while others may be excluded. Nevertheless, when applied over a broad area these effects would tend to cancel, and the resulting estimates of overall damages, would be expected to be reasonably accurate.

The information contained in the spreadsheets used to prepare the estimates of flood damages for the catchments should not therefore be used to provide information on the above-floor inundation of individual properties.

B3. SOURCES OF DATA

B3.1 General

To estimate A*verage Annual Flood Damages* for a specific area it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the area beneath the damage – frequency curve over the whole range of frequencies. To do this it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this:

- The ideal way would be to conduct specific damage surveys in the aftermath of a range of floods, preferably immediately after each. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier (DWR, 1990). This approach would not be practicable in the present case due to the absence of recent major flooding on Blackjack Creek.

- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.

- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kinds of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.

- The fourth way is to adapt or transpose, data from other flood liable areas. This was the approach used for Blackjack Creek. For the assessment of residential damages the *DECCW Guideline No 4, 2007* procedure was adopted, which was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the Blackjack Creek area. The data collected during site inspection in the flood liable areas of Blackjack Creek assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations (LACE, 2009).

B3.2 Property Data

The properties were divided into three categories: residential, commercial/industrial and public buildings.

For residential properties, the data used in the damages estimation included:

– the location/address of each property

– an estimate of the residence's value, age and size

– an assessment of the construction type and foundations

- a description of any external buildings/structures
- floor level of the residence

The residential descriptions were used to classify the properties into three categories which relate to the magnitude of likely flood damages (**Table B4.1**).

For commercial/industrial properties, the Property Survey obtained information regarding:

- the location of each property
- the nature of each enterprise
- an estimation of the floor area
- floor level

The property descriptions were used to classify the commercial developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages.

Properties lying within the extent of the PMF were included in the database.

B4. RESIDENTIAL DAMAGES

B4.1 Damage Functions

The procedures identified in *DECCW Guideline No 4, 2007* allow for the preparation of a depth versus damage relationship which incorporates structural damage to the building, damage to internals and contents, external damages and clean up costs. In addition, there is the facility for including allowance for accommodation costs and loss of rent. Separate curves are computed for three residential categories:

- Single storey slab on ground construction
- Single storey elevated floor
- Two storey residence

The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean up costs are not usually capable of significant mitigation.

The reduction in damages to contents is site specific, being dependent on a number of factors related to the time of rise of floodwaters, the recent flood history and flood awareness of residents and emergency planning by the various Government Agencies (Bureau of Meteorology and State Emergency Service).

Blackjack Creek is a "flash flooding" catchment with a time of rise of floodwaters limited to only one or two hours There is no catchment specific flood warning system operated by the Bureau of Meteorology and no specific response procedures for Blackjack Creek are incorporated in the Namoi River Local Flood Plan developed by SES. Consequently, there would be limited time in advance of a flood event in which to warn residents and for them to take action to mitigate flood losses.

Provided warning were available, house contents may be raised above flood level to about 0.9 m, which corresponds with the height of a typical table/bench height. The spreadsheet provides two factors, one for above and one for below the typical bench height. The reduction in damages is also dependent on the likely duration of inundation of contents, which on Blackjack Creek would be limited to no more than an hour for most flooded properties. The "Total Contents Adjustment Factor" which converts potential damages to actual damages to contents was 0.9 for depths of inundation up to 0.9 m and 0.94 for greater depths.

Table B4.1 below shows total flood damages estimated for the three classes of residential property using the procedures identified in *Guideline No 4*. A typical ground floor area of 135 m^2 was adopted, representative of house floor areas in the study area.

TABLE B4.1
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.5 m Depth of Inundation Above Floor Level	1m Depth of Inundation Above Floor Level
Single Storey Slab on Ground	$38,800	$46,000
Single Storey High Set	$42,200	$49,700
Two Storey Residence	$29,600	$34,700

Note: These damages include allowances for structural, contents, external and clean up costs.

B4.2 Total Residential Damages

Table B4.2 summarises residential damages for a range of floods. The damage estimates were carried out for floods between the 20 Year ARI and the PMF, which were modelled hydraulically in the Main Report.

TABLE B4.2
RESIDENTIAL DAMAGES ON BLACKJACK CREEK

Flood Event Year ARI	No. of Flooded Residences*	Flood Damages $\$ \times 10^6$
20	29	1.39
50	66	2.43
100	104	3.45
PMF	192	9.07

Note: A residence is categorised as "flooded" when the flood level rises to within 40 mm of the surveyed floor level. Capillary and wave action is assumed to initiate damages to floors, carpets and fittings.

B5. COMMERCIAL AND INDUSTRIAL DAMAGES

B5.1 Direct Commercial and Industrial Damages

The method used to calculate damages requires each property to be categorised in terms of the following:

- damage category
- floor area
- floor elevation.

The damage category assigned to each enterprise may vary between "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages also depend on the floor area.

It has recently been recognised following the 1998 flood in Katherine that previous investigations using stage damage curves contained in proprietary software tends to seriously underestimate true damage costs (*DECCW Guideline No 4, 2007*). DECCW are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the Blackjack Creek study.

On the basis of previous investigations (LACE, 2009) the following typical damage rates are considered appropriate for potential external and internal damages and clean up costs for both commercial and industrial properties They are indexed to a depth of inundation of 2 metres. At floor level and 1.2 m inundation, zero and 70% of these values respectively were assumed to occur:

Low value enterprise	\$280/m^2	(e.g. Commercial: small shops, cafes, joinery, public halls. Industrial: auto workshop with concrete floor and minimal goods at floor level, Council or Government Depots, storage areas.)
Medium value enterprise	\$420/m^2	(e.g. Commercial: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. Industrial: warehouses, equipment hire.)
High value enterprise	\$650/m^2	(e.g. Commercial : electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. Industrial: service stations, vehicle showrooms, smash repairs.)

The factor for converting potential to actual damages depends on a range of variables such as the available warning time, flood awareness and the depth of inundation. Given sufficient warning time a well prepared business will be able to temporarily lift property above floor level. However, unless property is actually moved to flood free areas, floods which result in a large depth of inundation, will cause considerable damage to stock and contents.

For the present study, the above potential damages were converted to actual damages using a multiplier which ranged between 0.3 and 0.7 depending on the depth of inundation above the floor. The factors also took into consideration the absence of recent floods in the catchment.

B5.2 Indirect Commercial and Industrial Damages

Indirect commercial and industrial damages comprise costs of removal of goods and storage, loss of trading profit and loss of business confidence.

Disruption to trade takes the following forms:

- The loss through isolation at the time of the flood when water is in the business premises or separating clients and customers. The total loss of trade is influenced by the opportunity for trade to divert to an alternative source. There may be significant local loss but due to the trade transfer this may be considerably reduced at the regional or state level.

- In the case of major flooding, a downturn in business can occur within the flood affected region due to the cancellation of contracts and loss of business confidence. This is in addition to the actual loss of trading caused by closure of the business by flooding.

Loss of trading profit is a difficult value to assess and the magnitude of damages can vary depending on whether the assessment is made at the local, regional or national level. Differences between regional and national economic effects arise because of transfers between the sectors, such as taxes, and subsidies such as flood relief returned to the region. Some investigations have lumped this loss with indirect damages and have adopted total damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, i.e. turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 50% of direct actual damages.

B5.3 Total Commercial and Industrial Damages

Table B5.1 summarises estimated commercial and industrial damages within the flood liable portion of Blackjack Creek.

TABLE B5.1
COMMERCIAL AND INDUSTRIAL DAMAGES ON BLACKJACK CREEK

Flood Event Year ARI	Number of Properties with Floors Inundated	Damages $ x 10^6
20	0	0
50	0	0
100	0	0
PMF	1	0.05

B6. DAMAGES TO PUBLIC BUILDINGS

B6.1 Direct Damages – Public Buildings

There are no public buildings located on Blackjack Creek within the extent of the PMF.

B7. DAMAGES TO INFRASTRUCTURE AND COMMUNITY ASSETS

Infrastructure in the Blackjack Creek, such as electrical and telephone supply, sewerage and water supply systems, and road network, are potentially prone to damaging flooding. Community assets such as parks and other recreational amenities could also suffer damages. No data are available on damages experienced during historic flood events. However, a qualitative matrix of the effects of flooding on these categories is presented in **Table B7.1**.

TABLE B7.1
QUALITATIVE EFFECTS OF FLOODING ON INFRASTRUCTURE AND COMMUNITY ASSETS ON BLACKJACK CREEK

Damage Sector	Flood Event ARI				
	5	20	50	100	PMF
Electricity	0	0	0	X	X
Telephone	0	0	0	X	X
Roads	0	X	X	X	X
Bridges	0	0	0	X	X
Sewerage	0	0	0	0	0
Water Supply	0	0	X	X	X
Parks and Gardens	0	X	X	X	X

Notes: 0 = No significant damages likely to be incurred.
X = Some damages likely to be incurred.

B8 SUMMARY OF TANGIBLE DAMAGES

B8.1 Tangible Damages

Flood damages under existing conditions have been computed for a range of flood frequencies from 20 year ARI to the PMF. Flows up to the 5 year ARI are conveyed within the channel. Larger flows would result in surcharges of Wandobah Road into the residential areas, with inundation extending eastwards with increasing flood magnitude. The 20 year ARI is the "threshold" flood magnitude at which significant damages are experienced in Blackjack Creek.

The total damages for each flood event are shown on **Table B8.1**. Cumulative average annual damages were assessed and are also shown. A 1 in 100,000 year return period was assigned to the PMF. **Figure B8.1** shows the damage - frequency curve. **Figure B8.2** is a histogram of the depths of residential above floor inundation for the 100 year ARI flood. **Figure B8.3** shows properties flooded by the 100 year ARI event.

TABLE B8.1
TOTAL DAMAGES ON BLACKJACK CREEK

Flood Event Year ARI	No. of Properties with Floors Inundated			Total Damages $ x 10^6$	Cumulative AAD $
	Residential	Commercial/ Industrial	Public		
5	0	0	0	0	0
20	29	0	0	1.39	104,250
50	66	0	0	2.43	161,550
100	104	0	0	3.45	190,950
PMF	192	1	0	9.12	253,500

B8.2 Definition of Terms

Average Annual Damages (also termed "expected damages") are determined by integrating the area under the damage-frequency curve. They represent the time stream of annual damages, which would be expected to occur on a year by year basis over a long duration.

Using an appropriate discount rate, average annual damages may be expressed as an equivalent "*Present Worth Value"* of damages and used in the economic analysis of potential flood management measures.

Cumulative Annual Average Damages may be referenced to a particular flood frequency. They represent the average damages which would be expected on an annual basis for all flood events up to and including that nominated frequency.

For example, the cumulative average annual value of damages on Blackjack Creek for all floods up to the 100 year ARI level is $190,950 (**Table B8.1**). A flood management scheme which has a design 100 year ARI level of protection, by definition, will eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme expressed on an average annual basis.

Under current NSW Treasury guidelines, economic analyses are carried out assuming a 20 year economic life for projects and discount rates of 7% pa. (best estimate) and 10% and 4% pa. (sensitivity analyses).

B8.3 Present Worth of Damages in Blackjack Creek

The *Present Worth Values* of damages likely to be experienced in the study area for all flood events up to the 100 year ARI, a 20 year economic life and discount rates of 4, 7 and 10 per cent are shown on **Table B8.2**. Corresponding values for all floods up to the Extreme Flood are shown on **Table B8.3**.

For a discount rate of 7% pa, the *Present Worth Value* of damages for all flood events up to the PMF is about $2.68 Million for a 20 year economic life. Therefore a scheme costing up to $2.68 Million could be economically justified if it eliminated damages for all flood events up to this level. Similarly, a scheme providing a 100 year ARI level of protection could be economically justified if it cost up to $2.02 Million.

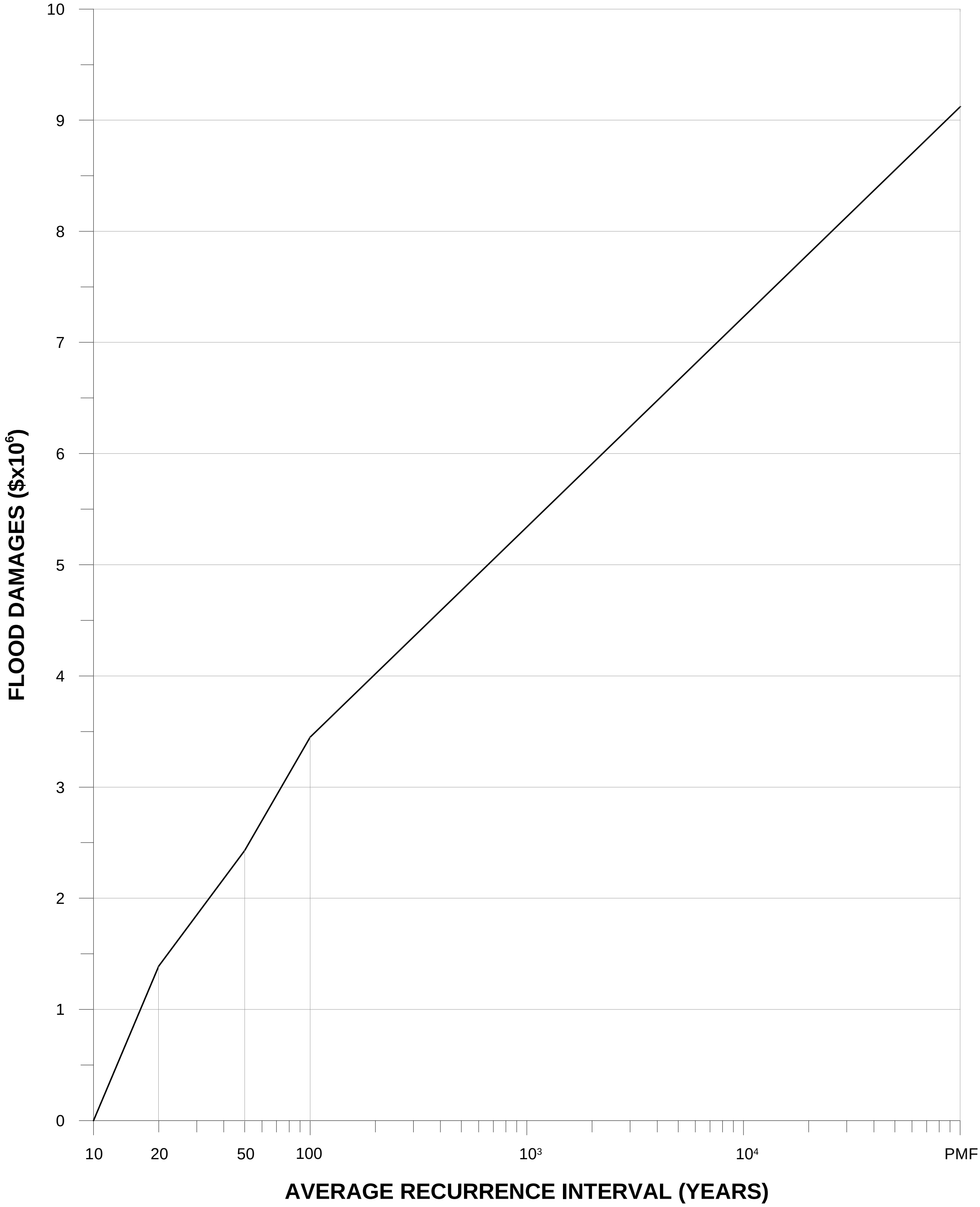
More expensive schemes would have a benefit/cost ratio less than 1, but may still be justified according to a multi-objective approach which considers other criteria in addition to economic feasibility. Flood management measures are considered on a multi-objective basis in the Main Report.

TABLE B8.2
PRESENT WORTH OF DAMAGES ON BLACKJACK CREEK
ALL FLOODS UP TO 100 YEAR
ECONOMIC LIFE OF 20 YEARS
$ X 10^6

Discount Rate – per cent		
4	**7**	**10**
2.60	2.02	1.62

TABLE B8.3
PRESENT WORTH OF DAMAGES ON BLACKJACK CREEK
ALL FLOODS UP TO PMF
ECONOMIC LIFE OF 20 YEARS
$ X 10^6

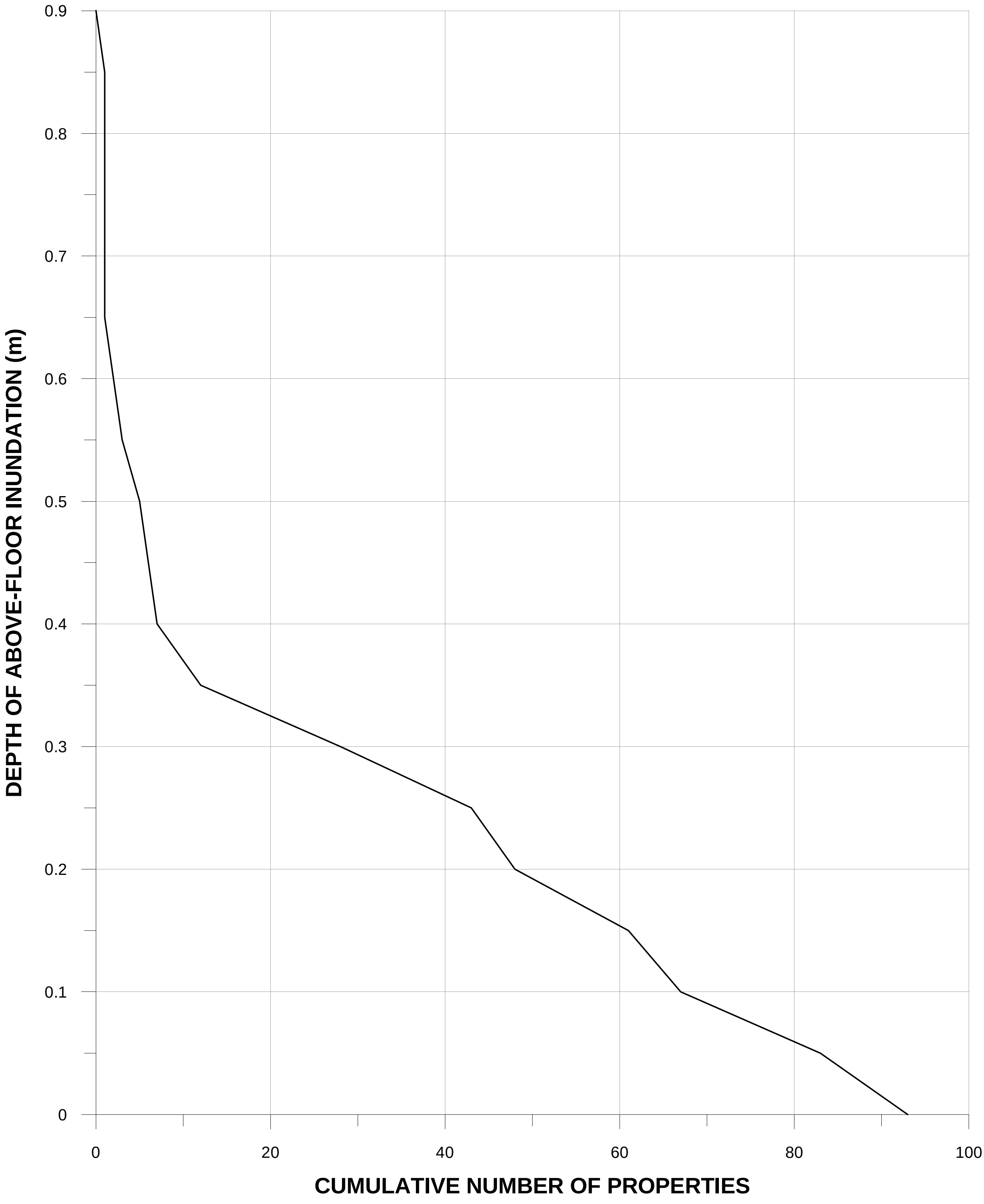
Discount Rate – per cent		
4	**7**	**10**
3.44	2.68	2.16



BLACKJACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

Figure B8.1

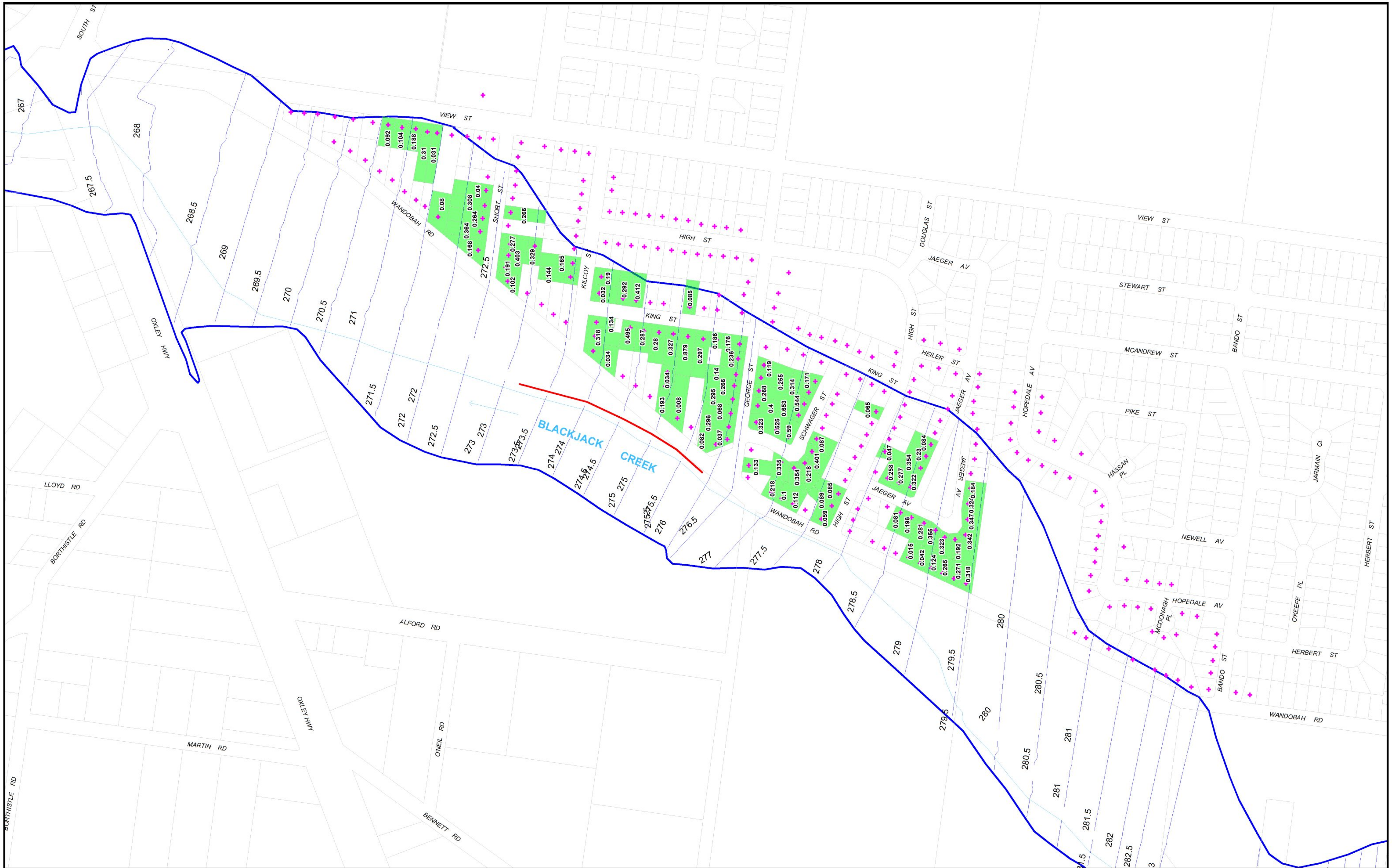
RESIDENTIAL DAMAGE - FREQUENCY CURVE



BLACKJACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

Figure B8.2

HISTOGRAM OF FLOODED RESIDENTIAL PROPERTIES - 100 YR ARI



LEGEND

0.192	DEPTH OF ABOVE-FLOOR INUNDATION (m)
278.5	WATER SURFACE CONTOURS (m)
(red line)	EXISTING LEVEE
(+)	SURVEYED RESIDENTIAL PROPERTIES
(green)	RESIDENTIAL PROPERTIES FLOODED ABOVE FLOOR LEVEL

N

100 0 100 200 300m

Scale: 1:5,000

BLACKJACK CREEK FLOODPLAIN RISK MANAGEMENT STUDY

Figure B8.3
FLOODED PROPERTIES
100 YEAR ARI

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