7 Flood Damages Assessment

Flood damage assessments are an important component of any floodplain management framework and can be used to guide a mitigation options assessment. This type of analysis enables floodplain managers and decision makers to gain an understanding of the monetary magnitude of assets under threat from flooding. The information determined in the damages assessment is also used to inform the selection of mitigation measures via a cost benefit analysis.

Flood damages can be categorised as either tangible or intangible, depending on whether a monetary value can be assigned to a particular item. Tangible flood damages are those which can readily be assigned a monetary value such as damages to buildings. Tangible flood damages can be further divided into direct or indirect costs. Intangible flood damages are those which cannot be readily assigned a monetary value such as environmental and social costs. Each flood damage category is discussed in more detail below.

Direct tangible damages are the most easily quantifiable damages, as they are the damages that are directly attributable to the floodwater, such as damage to house and business contents. Direct damages can be further divided into:

- Building damages – the internal, external and structural damages caused to property.
- Agricultural damages – the damage to crops, livestock, fences, etc.; and
- Infrastructure damages – the damage to infrastructure such as roads and bridges.

Indirect tangible damages include losses due to the disruption of business, expenses of alternative accommodation, disruption of public services, emergency relief aid and clean-up costs. Thus indirect damages tend to be more difficult to quantify and are often included as a proportion of direct damages.

Intangible flood damages are not included in standard flood damages assessments as it is difficult to assign monetary value. However it is important that they are taken into consideration by floodplain managers and decision makers. The intangible damages are often used as a consideration when comparing one flood management measure against another.

The types of flood damages along with their categorisation are shown in Figure 7-1.

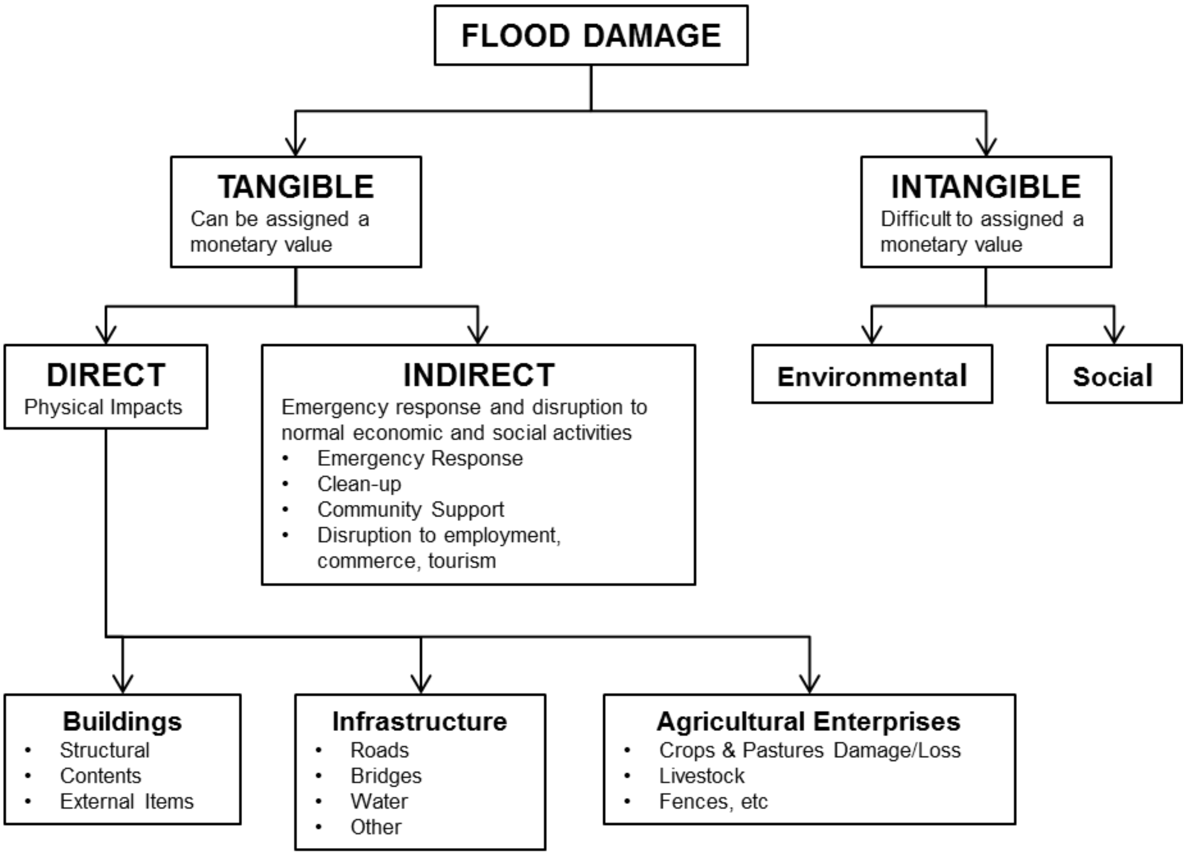


Figure 7-1 Types and Categorisation of Flood Damage Costs - Reproduced from *Rapid Appraisal Method (RAM) For Floodplain Management* (NRE 2000).

Flood damage assessments can either be carried out for an actual flood event or for a potential flood event (a design flood event). An assessment of an actual flood requires an extensive survey and data collection exercise carried out immediately following the flood for best accuracy. Rarely is it feasible to undertake an assessment on an actual flood given the large amount resources that are required. The method adopted for the Study was the Rapid Appraisal Method (RAM), described in more detail in the following Sections.

7.1 Methodology

The basic procedure for calculating monetary flood damages is provided below and is detailed in the following Sections. The basic procedure is:

- Prepare the appropriate relationships between depth of flooding and the assigned monetary value of damages (stage-damage curves).
- Gather the required input information detailing the characteristics of the buildings, agricultural enterprises and infrastructure that will be assessed. This includes data such as floor level, building type, size and condition, agricultural land use type and road type.
- Determine the design flood event impacts on individual buildings, properties, agricultural enterprises and roads. For this assessment the 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP design flood events have been used.
- Produce the total estimated potential damages for each design flood event across the study area and present the results in a probability-damage graph.
- Assume indirect damages based on the magnitude of direct damages.
- Determine the average annual damages (AAD).

7.2 Key Assumptions

In order to undertake a damage assessment a number of assumptions are required. The key assumptions for the flood damages assessment for the Study were as follows.

- The damage rates used in the RAM were indexed to a monetary value relative to that at the end of the 2015.
- The property boundaries were defined by the cadastral layer provided by GBCMA.
- For commercial properties the floor area was assumed to be 90% of the cadastral boundary and for industrial properties the floor area was assumed to be 40% of the cadastral boundary.
- To represent floor level inundation in the absence of floor level survey, residential properties were assumed to incur damages when more than 50% of a property is inundated and the depth of flooding is greater than 150 mm.
- To represent inundation in the absence of survey, commercial and industrial properties were assumed to incur damages when more than 33% of a property is inundated and the depth of flooding is greater than 100 mm.
- The damages were based on the provided cadastral layer and planning scheme. This includes a number of lots that are yet to be developed being classified as industrial or residential. This will result in a conservative estimate of damages; this assumption is consistent with the assumptions in the flood mapping.
- The total area of agricultural land and road length were defined in the VICMAP dataset provided by GBCMA and were confined to the study area.
- There are no damages as a result of flooding in a 2 year ARI design event.

- Velocities experienced within the floodplain were not of a magnitude to destroy a building beyond repair.
- Indirect damages were 30% of direct damages as recommended in the RAM guidelines (NRE 2000).
- The community is inexperienced with flooding and has between 2 and 12 hours warning time before a flood event occurs. This assumption was based on the potentially long time periods between major flood events in the catchment.
- The value of contents for all commercial and industrial buildings is assumed to be low. This assumption was made as there is no data available describing the condition or contents of individual buildings, and given the large floor area of many of the buildings there is likely to be much open floor space.
- All agricultural enterprises are flood sensitive orchards. This assumption was made as there was no data available describing the type of individual agricultural enterprises but the primary land use in the Shepparton East catchment is orchards.
- There is no agricultural land inundated for longer than one week.

Further assumptions were made for each element of the damages assessment and are outlined in the description provided in the following sections.

7.3 Rapid Appraisal Method (RAM) Damages Assessment

The Rapid Appraisal Method (RAM) was developed for the rapid and consistent determination of flood damages. The RAM methodology can determine building, agricultural and road infrastructure damages, all of which have been determined for this Study.

7.3.1 RAM Building Damages

To determine damages to buildings, the RAM method assumes that if flooding occurs within a property that the maximum building damages will be incurred. The values adopted for this assessment were sourced from the RAM Guidelines (NRE 2000) and are summarised in Table 7-1. In order to convert the potential damages to actual damages the values were also factored by 0.8 to account for an inexperienced community with 2 to 12 hours warning.

For large non-residential buildings (commercial/industrial) with a floor area greater than 1,000m^2 there are three classes defining value of contents:

- low – offices, sporting pavilions, churches, etc.;
- medium – libraries, clothing businesses, caravan parks, etc.; and
- high – electronics, printing, etc.

As discussed above, all buildings were assumed to have a low value of contents. This assumption was made as there is no data available describing the condition or contents of individual buildings within the catchment.

Table 7-1 RAM Building Potential Damage Values

Building Type	Potential Damages
All Buildings other than Large Non-Residential	\$25,600
Large Non-Residential – Medium Value of Contents	\$56 per m^2

A summary of the RAM building damages for existing conditions is presented in Table 7-2. The summary highlights the number of properties inundated and the associated damages for the range of AEP events. The main drivers of damages within the catchment are from the commercial and industrial areas. As discussed above these damages include lots that are yet to be developed so should be considered a conservative estimate on damages within the catchment.

Table 7-2 Existing Conditions RAM Building Damages Summary

Event (AEP)	No. of Properties Inundated	Residential Damages	Commercial and Industrial Damages	Total Building Damages
0.2%	1130	\$20,070,400	\$46,653,430	\$66,723,800
0.5%	903	\$15,488,000	\$38,564,639	\$54,052,600
1%	734	\$11,801,600	\$33,625,225	\$45,426,800
2%	575	\$8,550,400	\$26,126,095	\$34,676,500
5%	404	\$5,504,000	\$19,745,673	\$25,249,700
10%	306	\$3,814,400	\$15,677,130	\$19,491,500
20%	230	\$2,918,400	\$9,960,172	\$12,878,600

7.3.2 RAM Agricultural Damages

RAM agricultural damages account for damage to crops and clean-up costs. The value of perished stock can also be incorporated; however the RAM Guidelines (NRE 2000) stipulates that many major flood events do not incur any loss of stock. For this reason stock losses have not been included in this assessment. Further there is likely to be little to no stock in the Shepparton East catchment.

The values adopted for the assessment, Table 7-3 were obtained from the RAM Guidelines (NRE 2000) for flood sensitive orchards. Clean-up costs are defined by the area of inundation within and outside of floodway areas. As the flood characteristics of the catchment are for relatively shallow and slow moving flood waters it was decided for the purpose of the RAM assessment to designate all flooding as non-floodway damages.

Table 7-3 RAM Agricultural Damage Values

Crop Type	Damages
Flood Sensitive Orchards Inundated for Shorter than 1 week	\$9,381 per hectare
Flood Sensitive Orchards beyond Floodway Area	\$19,483 per hectare

A summary of the RAM agricultural damages for existing conditions is presented in Table 7-4. The summary highlights the area of agricultural land inundated and the associated damages for the range of AEP events.

Table 7-4 Existing Conditions RAM Agricultural Damages Summary

Event (ARI)	Area of Agricultural Land Inundated (hectares)	Crop Damages	Clean Up Costs	Total Agricultural Damages
0.2%	1,253	$11,751,800	$685,500	$12,437,300
0.5%	1,105	$10,367,000	$604,700	$10,971,700
1%	986	$9,249,400	$539,500	$9,788,900
2%	887	$8,319,100	$485,300	$8,804,400
5%	736	$6,899,800	$402,500	$7,302,300
10%	607	$5,691,600	$332,000	$6,023,600
20%	505	$4,737,900	$276,400	$5,014,300

7.3.3 RAM Road Infrastructure Damages

RAM road infrastructure damages are determined by assigning a cost per length of road inundated. The values adopted for this assessment were obtained from the RAM Guidelines (NRE 2000) and are summarised in Table 7-5. The cost values incorporate initial road repair, subsequent accelerated deterioration, initial bridge repair, and subsequent increased maintenance. RAM defines road type in three categories: major sealed roads, minor sealed roads and unsealed roads. Within the study area road types for all roads were defined.

Table 7-5 RAM Road Infrastructure Damage Values

Road Type	Cost per kilometre of Inundation
Major Sealed Roads	$92,242
Minor Sealed Roads	$28,923
Unsealed Roads	$13,055

A summary of the RAM road infrastructure damages for existing conditions is presented in Table 7-6. The summary highlights the total length of road inundated and the associated damages for the range of AEP events.

Table 7-6 Existing Conditions RAM Road Infrastructure Damages Summary

Event (ARI)	Length of Road Inundated (kilometres)	Road Infrastructure Damages
0.2%	80	$2,449,100
0.5%	76	$2,322,900
1%	73	$2,204,300
2%	69	$2,101,400
5%	63	$1,905,500
10%	57	$1,722,000
20%	51	$1,535,200

7.4 Average Annual Damages

Average annual damages (AAD) are the average damage (in dollars) per year that would occur in a particular area from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of AAD provides a basis for comparing the effectiveness of different management measures (i.e. the reduction in the AAD) using benefit cost analysis.

The AAD are calculated as the area under the probability-damage curve. The lower limit on the curve is the 50% AEP design flood event and it is assumed to cause zero damages. The probability-damage curve is extrapolated to account for events with a probability between the 20% and 50% AEP.

Following the calculation of the individual direct damage elements, the total tangible flood damages across the study area can be determined.

The total tangible flood damages, for existing conditions for all modelled events, is presented in Table 7-7 and is illustrated in Figure 7-2. The existing condition AAD for the catchment is $11,996,500.

As discussed above, the damages within the catchment are largely driven by the damage to buildings, particularly commercial and industrial property. This is in part due to the conservative assumption of using the planning scheme rather than individual property assessments but also due to the widespread shallow flooding throughout the catchment which is a limitation of the Rapid Appraisal Method.

Table 7-7 Existing Conditions Damages Summary

Event (ARI)	ANUFLOOD Building Damages	RAM Agricultural Damages	RAM Road Infrastructure Damages	Indirect Damages	Total Damages	Contribution to AAD
PMP	-	-	-	-	$126,006,700	
0.2%	$66,723,800	$12,437,300	$2,449,092	$29,014,400	$110,624,600	$236,631
0.5%	$54,052,600	$10,971,700	$2,322,905	$20,204,200	$87,551,400	$297,264
1%	$45,426,800	$9,788,900	$2,204,335	$17,226,000	$74,646,000	$405,494
2%	$34,676,500	$8,804,400	$2,101,450	$13,674,700	$59,257,000	$669,515
5%	$25,249,700	$7,302,300	$1,905,514	$10,337,300	$44,794,800	$1,560,777
10%	$19,491,500	$6,023,600	$1,721,972	$8,171,100	$35,408,200	$2,005,075
20%	$12,878,600	$5,014,300	$1,535,233	$5,828,400	$25,256,500	$3,033,235
50%	-	-	-	-	-	$3,788,475
					Average Annual Damages	**$11,996,500**

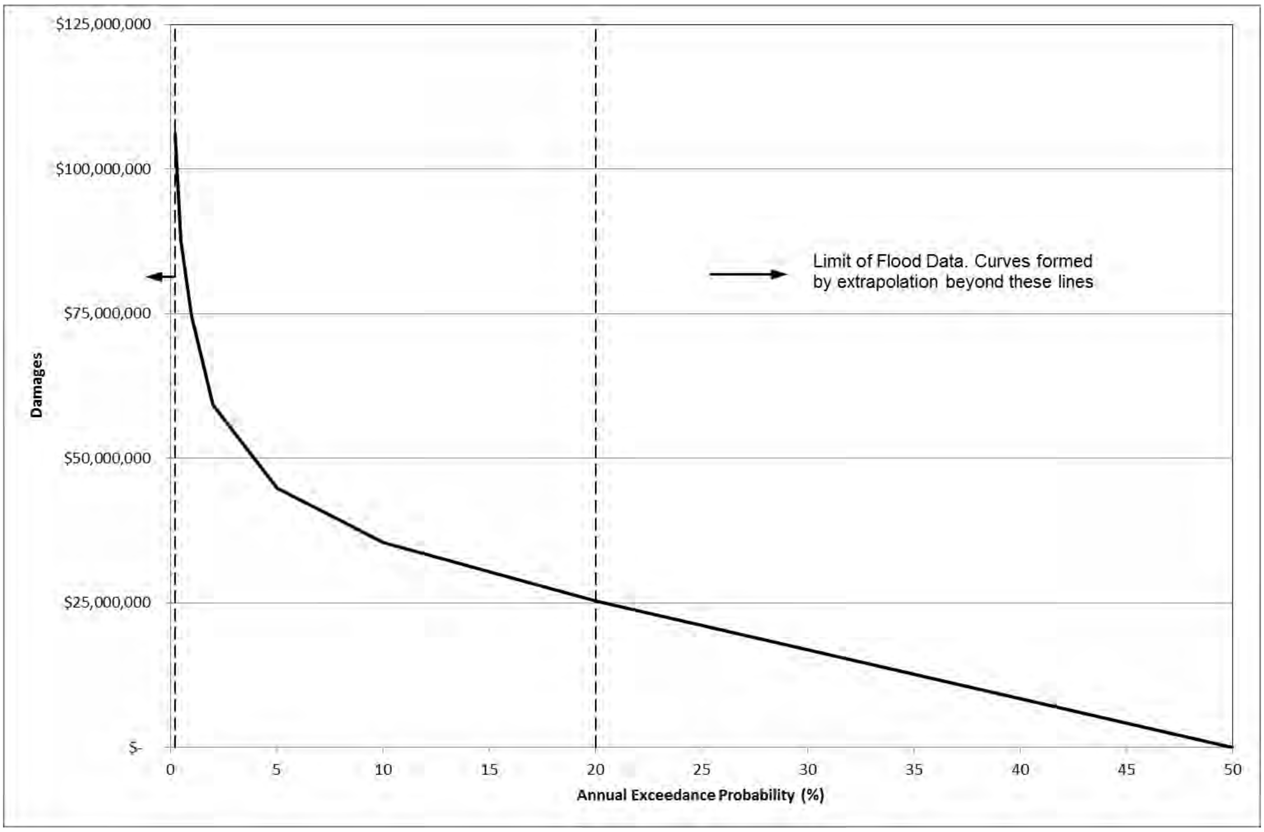


Figure 7-2 Existing Condition Probability-Damages Curve

8 Flood Management

8.1 Background

There are two major categories of floodplain management options that can be used to reduce the risk and consequences of flooding:

(1) Structural Measures – Works that alter the behaviour of flood waters to mitigate the impact of flooding for a certain area.

(2) Non-Structural Measures

  (a) Land Use Planning Controls – Incorporating flooding into land use planning and implementing building control measures; effective in reducing the impact of flooding to future developments.

  (b) Emergency Management and Response – Aimed at reducing the impact of flooding by improving the community's ability to respond to a flood event.

For a floodplain and drainage management plan to be effective it needs to consider and integrate all three of these categories.

8.2 Key Issues

It is important to establish a clear and thorough understanding of the issues to be addressed in order to manage flood risk to Shepparton East.

Through flood modelling and mapping undertaken for the Study it is evident that Shepparton East is at most risk from widespread slow moving, shallow and frequent flooding. Areas of high hazard are generally restricted to retarding basins and a number of road reserves.

8.3 Structural

Due to the shallow widespread flooding there are limited opportunities for structural mitigation management options within the catchment. For example levees and major retarding basins would be largely ineffective as there are few 'choke' points to concentrate flow and store or divert.

From the modelling it was observed that the Goulburn Valley Highway acts as a hydraulic control resulting in elevated water levels upstream. Through increasing the conveyance of Main Drain 2 and Main Drain 3 upstream water levels may be reduced, however this may lead to increased flooding downstream unless suitably designed.

8.4 Non-Structural

In the long term, one of the most effective means of flood mitigation is the establishment and enforcement of appropriate planning scheme controls in areas identified as at risk of flooding. Planning controls are effective over time as buildings are renewed they can be built in areas outside the floodplain, or if in an area of low flood risk, can be built above the declared flood level.

8.4.1 Overlays

There exists a number of planning controls that are used within Victoria for ensuring appropriate development in and around flood waters. The most applicable for Shepparton includes:

- Environmental Significance Overlay (ESO);
- Floodway Overlay (FO);
- Land Subject to Inundation Overlay (LSIO);
- Special Building Overlay (SBO); and
- Urban Flood Zone (UFZ).

Consistent with the Department of Planning and Community Development's guidelines, it would be recommended to manage the catchment through a combination of Floodway and Land Subject to Inundation Overlays. This method allows development to occur within floodwaters deemed low risk but restricts development in high risk areas.

The proposed planning scheme for the catchment is to assign areas identified as Extreme Hazard to Children (depth greater than 500 mm and/or velocity x depth greater than 0.6 m^2/s) to the more restrictive Floodway Overlay. Areas identified as lower hazard should be subjected to the less restrictive Land Subject to Inundation Overlay. The proposed planning scheme overlays are presented in Figure 8-1. These overlays are based on existing conditions. Consideration should be given to planning scheme overlays based on developed and/or climate change conditions.

8.4.1.1 Building Controls

Building controls recommended for Shepparton East are such that:

- Finished floor levels of all properties within the 1% AEP flood extent are set at a minimum of 300mm above the declared flood levels.
- Finished floor levels of all properties adjacent the 1% AEP flood event extents are set at a minimum of 300mm above the declared flood levels nearest the site.
- There is no development within the UFZ and FO.

8.4.1.2 Development Controls

Development controls should restrict the runoff generated by future developments to existing or pre-existing levels up to the 1% AEP design event. This could be achieved through water sensitive urban design principals and may include (but not limited to) technologies such as pervious pavement, soak pits, retention basins and so on.

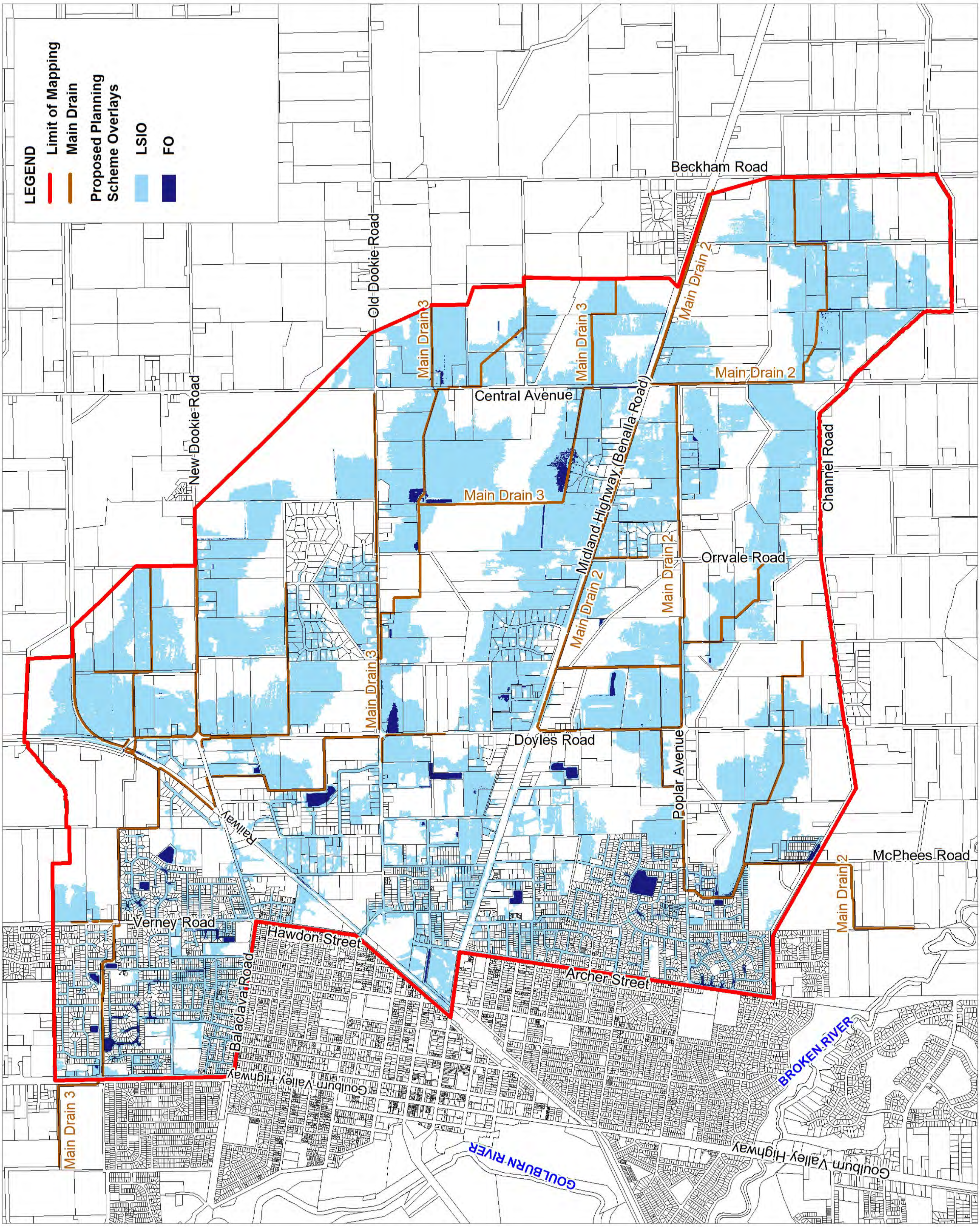
8.4.2 Declared Flood Levels

The 1% AEP flood levels determined by the flood modelling undertaken as part of the flood investigation were supplied to the GBCMA, and Greater Shepparton City Council. It is understood that these flood levels will be adopted as the Declared Flood Levels, as prescribed by Section 204 of the Water Act 1989. The mapped flood levels have a 1% chance of being equalled or exceeded in any one year.

8.4.3 Planning For Climate Change

The DELWP have recommended that the impact of climate change on flooding is assessed by increasing the rainfall intensity of design events. To ascertain the likely impact of climate change, an increased rainfall intensities (and therefore total depth of rainfall) was modelled as described in Section 6.3. The scenario had the rainfall intensity increased by 32% for the design events. The resulting flood depth maps are contained within Appendix E along with the other scenario maps.

At present there is no requirement from State Government for the incorporation of climate change into floodplain management decisions. The incorporation of climate change information into floodplain management decisions is undertaken on a Council by Council basis. These decisions may take the form of setting building controls at the climate change flood levels, for instance.



Title:

Shepparton East Proposed Planning Scheme

Figure: **8-1**

Rev: **A**

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Approx. Scale

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9 Summary and Recommendations

This report has documented the methodology and findings of the Shepparton East Flood Study. The study has defined the flood behaviour for the catchment through the development of calibrated hydrologic and hydraulics models and the determination of flood behaviour for a range of flood events. These models have been used to determine the flood damages within the catchment. A number of flood management measures have been documented and recommended for adoption within the catchment with the aim of reducing flood risk to Shepparton. These recommendations include:

- Declaring Designated Flood Levels (Section 8.4.2)
- Implementation of Planning Scheme Controls (Section 8.4.1)
- Implementation of Building Controls (Section 8.4.1.1)
- Consideration of Planning For Climate Change (Section 8.4.3)

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