

6 FLOOD DAMAGES ASSESSMENT

Flood damage assessment is an important component of any floodplain management framework. This type of analysis enables the floodplain manager to gain an understanding of the magnitude of assets under threat from flooding. The method adopted for the study is ANUFLOOD, which is described in more detail in the following sections. The damages assessment has been undertaken for properties identified by the CoGG as being “at risk” of flooding.

6.1 Methodology

The basic procedure for calculating the monetary flood damages is provided below.

- Identify the areas inundated and the depth of inundation for the range of design flood events (20%, 10%, 5% and 1% AEP) modelled using the TUFLOW hydraulic model.
- Determine the damages due to a particular flood event using the surveyed floor levels of properties that are flood-affected.
- Calculate the depth of above floor flooding within each property for each AEP event.
- Prepare stage-damage relationships for residential and commercial properties. These relationships will account for such factors as the relative degree of flood preparedness of the community.
- Produce total flood damages for the range of flood events for both residential and commercial/industrial properties.
- Sum damages for all properties for each AEP event and present the results in a probability-damage graph.
- Assume indirect damages are 30% of direct damages as recommended in the RAM (Rapid Appraisal Method) report (NRE 2000).
- Determine the average annual damages (AAD).

6.1.1 Stage-Damage Curves

ANUFLOOD residential stage-damage curves were used for this flood damage assessment. These curves were sourced from NRE (2000). The non-residential stage-damage curves, also ANUFLOOD curves, were sourced from a journal paper by Smith (1994) ‘Flood Damage Estimation – A review of urban stage-damage curves and loss functions’. The curves have all been indexed to the 1st Quarter 2011 units using appropriate CPI factors sourced from Bureau of Statistics.

ANUFLOOD has 15 non-residential stage-damage curves. For each building size (small, medium and large), there are 5 curves representing 5 value classes. Because the existing building floor level information did not include data on the type, size or condition of each of the buildings considered, the size and condition of each residential building was assumed to be medium and average respectively.

The RAM report suggests that the ANUFLOOD curves underestimate flood damages. To address this issue, increases of 60% have been applied to both the residential and non-residential curves, as recommended in the RAM.

Ratios to convert Potential damages to Actual damages were used as per the recommendations from the RAM. That is, for an inexperienced community with less than 2 hours warning time, a factor (ratio) of 0.9 is used to reduce the potential damages to actual damages. Flood damages were calculated for the 20%, 10%, 5% and 1% AEP design flood events.

6.1.2 Damages Outside Buildings

Damages to equipment outside the building are not included in the standard stage-damage curves used. Such damages may include damage to fences, driveways, lower level laundries and outdoor equipment. To account for this, an estimate of “ground equipment damages” was made as a function of ground level inundation. That is, assume a sliding scale from \$0 to \$1000 with \$1000 being the maximum. The full \$1000 damage is experienced once the flood level has reached the floor level of the building. The sliding scale works on the difference between the ground level and the floor level (e.g. a ground level of 1m, floor level of 2m, flood level of 1.5m receives ground equipment damages of \$500).

Other damages, such as the loss of plants, lawn and landscaping, are difficult to quantify and are therefore considered in the non-economic assessment.

6.1.3 Damages Calculations

The peak 20%, 10%, 5% and 1% AEP depth of flooding was determined at each property for which floor levels were available and the associated flood damages extracted from the stage-damage relationships. Total damages for each flood event were determined by summing the predicted damages for each individual dwelling. The AAD was then calculated.

The AAD is the average damage in dollars per year that would occur in a designated area from flooding over a 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 the AAD provides a basis for comparing the effectiveness of different management measures (i.e. the reduction in the AAD). The AAD is the area under the probability-damage graph. Ideally the probable maximum flood damages are included in the AAD analysis, and it is also necessary to assume a flood AEP in which no damages occur. As no flood larger than the 1% AEP event was modelled, the probability-damages graph was extrapolated, and it was assumed that no damages would occur in the 50% AEP event.

6.2 Existing Conditions Flood Damages

The total existing conditions damages for each design flood event are presented in Table 6-1. They are also illustrated in Figure 6-1. The existing conditions AAD for the Newcomb - Whittington drainage catchments, as presented in Table 6-1, is \$178,000.

Table 6-1 Existing Conditions Damages Summary

Event		Existing Case			
(Years ARI)	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF ⁺	0.0%			\$ 956,000	
100	1%	\$ 687,000	\$ 206,000	\$ 893,000	\$ 9,000
20	5%	\$ 495,000	\$ 148,000	\$ 643,000	\$ 30,000
10	10%	\$ 395,000	\$ 119,000	\$ 514,000	\$ 29,000
5	20%	\$ 317,000	\$ 95,000	\$ 412,000	\$ 46,000
2	50%	\$ -	\$ -	\$ -	\$ 64,000
Average Annual Damage					\$ 178,000

⁺ Note – PMF damages are an extrapolation of the 1% AEP data, i.e., they were not calculated using PMF flood levels

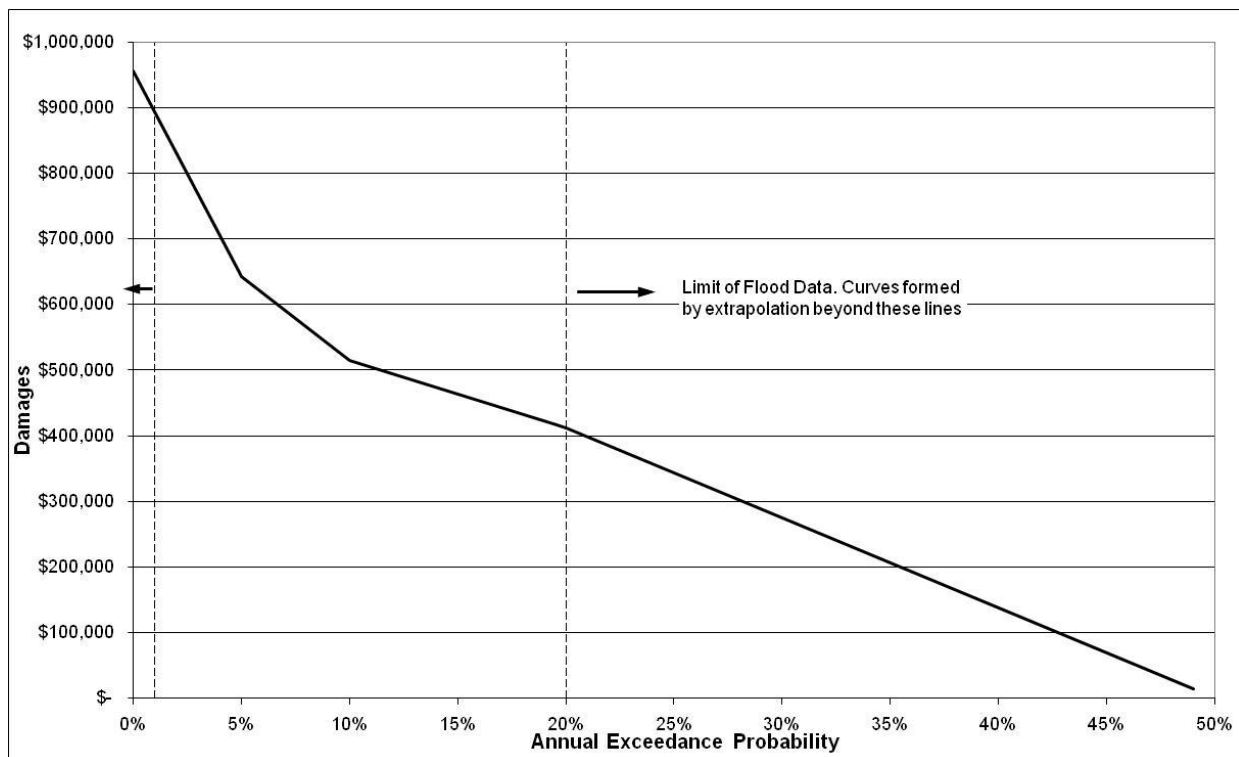


Figure 6-1 Existing Conditions Damages Probability Curve

7 MITIGATION SCHEMES ASSESSMENT

This section outlines and investigates Schemes designed to reduce existing flood damages: a scheme is a combination of several mitigation options. This section provides details on the formulation and evaluation of each of the Schemes and considers the benefit/cost of the proposed works (tangible benefits) along with various other economic and non-economic factors to assist in recommending a preferred strategy.

The assessment followed four key stages:

1. identification of focus areas;
2. mitigation option screening;
3. preliminary assessment of options; and
4. detailed assessment of Schemes.

7.1 Focus Areas

Through the modelling of the existing conditions in the Newcomb - Whittington drainage catchments, widespread flooding was observed throughout the study area. Despite the number of properties exposed to flooding, relatively few houses had above floor flooding. However, the majority of houses that would be subject to above floor flooding are concentrated within several different locations;

- Geelong – Portarlington Rd between Boundary Road and Wilsons Road,
- Between the intersection of Wilsons Road and Hickey Street, and the Southwest corner of the study area, and
- Between the Bellarine Rail Trail and the Bellarine Highway, west of Coppards Road.

The above floor flooding along Geelong – Portarlington Road is as a result of the high downstream water level adopted for this study to represent future sea level rise. As a result, conventional flood mitigation measures would not be successful in reducing the flood levels in this area, however further investigation into coastal protection from sea level rise in the Geelong region may aid flood management in this area and areas of similar circumstance.

Consequently, reducing the flood levels in the upper part of the study area, south of the Bellarine Highway formed the focus of the mitigation schemes.

7.2 Mitigation Option Screening

A wide range of mitigation options were considered as part of the “first pass” assessment. Options such as localised pipe system upgrades were considered to alleviate a number of the flooding issues in the areas of concern. Table 7-1 sets out the broad categories of options considered and whether any detailed investigation was undertaken. The decision on which options were to be considered was undertaken in consultation with the CoGG.

The options that were selected for consideration are described in more detail in the following sections.

Table 7-1 Mitigation Option Element Screening

Element Type		Strategy Elements	Comment	Assessed
Urban	Structural Measures	Pipe system upgrade	Considered	✓
		Pumps	Not appropriate	✗
		Soakage Pits	Not appropriate	✗
		Retarding Basin	Not feasible	✗
		Diversions	Considered	✓
		Floodways	Not appropriate	✗
		Open Drain	Not appropriate	✗
		Channel Improvement	Not appropriate	✗
		Bund Walls	Not feasible	✗
		Lot scale infiltration	Not appropriate	✗
		Lot scale detention	Not appropriate	✗
		Individual Property Floodproofing	Possible, however very expensive	✗
	Non Structural Measures	Planning Scheme Amendments	Considered	✗
		Voluntary House Purchase	Considered	✗
Voluntary House Raising		Not feasible	✗	
Rural	Structural Measures	Levees	Not applicable	✗
		Floodwalls	Not applicable	✗
		Floodways	Not applicable	✗
		Floodplain Modification	Not applicable	✗
		Channel Improvement	Not applicable	✗
		Individual Property Floodproofing	Not applicable	✗
		Flood Storage	Not applicable	✗
		Diversions	Not applicable	✗
	Non Structural Measures	Flood Warning Systems	Not applicable	✗
		Land Use Planning	Not applicable	✗
		Floodplain Education Programs	Not applicable	✗
		Purchase and Relocation	Not applicable	✗
		Information and Data Collection	Not applicable	✗
		Planning Scheme Amendments	Not applicable	✗
Regulation and Enforcement	Not applicable	✗		

7.3 Detailed Assessment

7.3.1 Non-Structural Options

The non-structural options considered for the economic assessment were voluntary house raising, voluntary house purchase and amendments to the planning scheme. Voluntary house raising was not considered further because it has limited application in these catchments, where many of the flood affected buildings cannot be economically raised. This is due in part to many vulnerable houses being of slab-on-ground construction. Voluntary house purchase was not considered viable because of the cost of the buy back and re-construction.

7.3.2 Structural Options

The CoGG required that three mitigation schemes be assessed, with one of the schemes being “do nothing”. The four schemes that were assessed for the Newcomb – Whittington drainage catchments are summarised in Table 7-2 and schemes one and three are shown in Figure 7-1 and Figure 7-2 respectively. Hydraulic and economic assessments were undertaken for each scheme.

Table 7-2 Newcomb – Whittington Drainage Catchments Mitigation Scheme Details

Scheme Number	Details
One	The diversion of all overland flow flowing east across Boundary Road and north across Townsend Road away from the study area and into a new pipe draining to the Barwon River.
Two	The triplication of all existing pipes within the study area. Whilst this is not a realistic mitigation option due to its prohibitive cost and disruption to the community, it is aimed at determining if significant drainage infrastructure improvements would deliver significant benefits to the community.
Three	Pipes laid along Wilsons Road to discharge into the Saltworks to alleviate overland flooding downstream of the intersection of Wilsons Road and Solar Drive. This option has not been tested in the hydraulic model as it was not deemed to be a feasible solution to the flooding problems in the Newcomb-Whittington drainage catchments. For further discussion refer to Section 7.3.3.3.
Four	Do Nothing

7.3.2.1 Pipe Works

The proposed pipe works have been summarised below for the respective schemes.

Scheme One Pipe Works

Scheme One proposed pipe works include five new 900 mm RCPs running south down Boundary Road for approximately 830 m from the intersection with Townsend Road, with the outlet into the Barwon River floodplain. Further smaller diameter pipes would be required to convey flow from the required inlet pits to the proposed main drain, however the dimensions, number and location of these pipes could not be determined until detailed design of the scheme is undertaken.

Scheme Two Pipe Works

Scheme Two proposed pipe works include the triplication of all existing pipes within the study area. This would involve the replacement of existing pipes with pipes of larger diameter or the installation of duplicate pipes.

Scheme Three Pipe Works

Scheme Three proposed pipe works include 15 new 600 mm RCPs to be laid along Wilsons Road from Solar Drive with the outlet into the open channel drain running along the southern boundary of the salt works.

7.3.2.2 Pit Works

The proposed pit works have been summarised below for the respective schemes.

Scheme One Pit Works

In conjunction with the design of the connector pipes a pit arrangement must also be designed in order to capture the flow that originates in the southwest of the catchments. While the dimensions, numbers and locations of the pit network cannot be determined until the detailed design phase, pits have been included in the scheme costing.

Scheme Two Pit Works

Scheme Two proposed pit works include the triplication of all existing pits within the study area. This would involve replacing the existing pits with pits of larger inlet capacity or the installation of duplicate pits.

7.3.2.3 Further Works

Land Forming Works – Scheme One

In order to direct the diverted flow into the drainage network in scheme limited land forming works may be required. While need and hence nature of land forming works cannot be determined until the detailed design phase, the possibility of the impact of any such work has been accounted for in the contingency element of the scheme cost.



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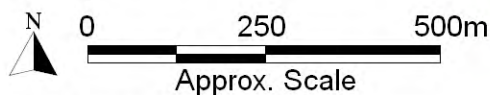
- Flood Mapping Extent
- Sub-Catchments of Diverted Flow
- ➔ Proposed Alignment of 5 x 900 mm RCP

Title:
Scheme One Proposed Mitigation Works

Figure:
7-1

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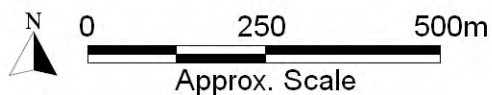


Title:
Scheme Three Proposed Mitigation Works

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7-2

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7.3.3 Hydraulic Assessment

The 20%, 10%, 5% and 1% AEP design floods were assessed using the same six storm duration events as used for the existing case. A peak flood height envelope was then developed for each flood event for Schemes One and Two. A hydraulic analysis of Scheme Three was not undertaken, as discussed further in Section 7.3.3.3. The change in peak flood height for each scheme was calculated by subtracting the existing case peak flood heights from the scheme peak flood heights at each TUFLOW grid. The change in peak flood height was then colour contoured and mapped. The modelling and mapping was not done for the “Do Nothing” scheme as there were no changes from the existing conditions.

Peak flood height surfaces were used to calculate the number of properties flooded and depth of above floor flooding, which was then used in the flood damages assessment for the schemes.

The mapping pertaining to each scheme in the hydraulic assessment illustrates no change in flood level within a ± 0.03 m tolerance as a yellow colour, reductions in flood level are shaded with greens and increases in flood level are shaded with browns/reds. A pink colour indicates a region where flooding currently occurs but would no longer occur if the scheme was implemented, and a blue colour indicates a region where flooding currently does not occur but would if the scheme was implemented.

7.3.3.1 Scheme One

The change in peak flood height and the properties with above floor flooding, for Scheme One of the Newcomb – Whittington drainage catchments, are mapped in Figure 7-3 to Figure 7-6 for the four flood events assessed. Table 7-3 summarises the reduction in flooded properties for Scheme One.

Modelling of the diversion of flow from the southwest corner of the study into the Barwon River has significantly impacted on flood levels within the area between the intersection of Wilsons Road and Hickey Street, and the Southwest corner of the study area. As shown in the mapping there are no occurrences of above floor flooding in the area of interest, and that up to the 1% AEP event, the majority of the flow is contained within the road network. This scheme also restricts the majority of flooding around Solar Drive to the road reserves and reduces the flood level in the storages created by the Bellarine Highway and the rail trail.

Table 7-3 Reduction in Flooded Properties – Scheme One

AEP	No. Flooded Grounds		Reduction	No. Flooded Floors*		Reduction
	Existing	Scheme One		Existing	Scheme One	
20%	1011	778	233	19	16	3
10%	1656	1231	425	33	17	16
5%	2162	1775	387	44	18	26
1%	2696	2430	266	65	25	40

* Results based on properties surveyed by CoGG.

7.3.3.2 Scheme Two

The change in peak flood height and the properties with above floor flooding, for Scheme Two of the Newcomb – Whittington drainage catchments, are mapped in Figure 7-7 to Figure 7-10 for the four flood events assessed. Table 7-4 summarises the reduction in flooded properties for Scheme Two.

Modelling of the triplication of existing drainage system capacity shows a reduction in flood levels across all AEP events, however with the exception of the areas whose flooding characteristics are dominated by the influence of the storage provide by the retarding basins and embankments the reduction in flood levels is generally restricted to the road reserves.

The reduction in flood levels may not be as great as expected with such a large increase in the capacity of the drainage system within the catchments. This is due to the flat nature of the catchments and the high sea level used in the modelling, which restricts the conveyance efficiency of the pipe network, so that the main benefit of the increased pipe capacity is the extra flood storage provided. The limited reduction in above floor flooding compared to Scheme One is due to the relatively small flood level reductions that Scheme Two achieve in the area between the intersection of Wilsons Road and Hickey Street, and the Southwest corner of the study area compared to Scheme One where flow is diverted from this area.

Table 7-4 Reduction in Flooded Properties – Scheme Two

AEP	No. Flooded Grounds		Reduction	No. Flooded Floors*		Reduction
	Existing	Scheme Two		Existing	Scheme Two	
20%	1011	542	469	19	16	3
10%	1656	713	943	33	19	14
5%	2162	1141	1021	44	24	20
1%	2696	1917	513	65	45	20

* Results based on properties surveyed by CoGG.

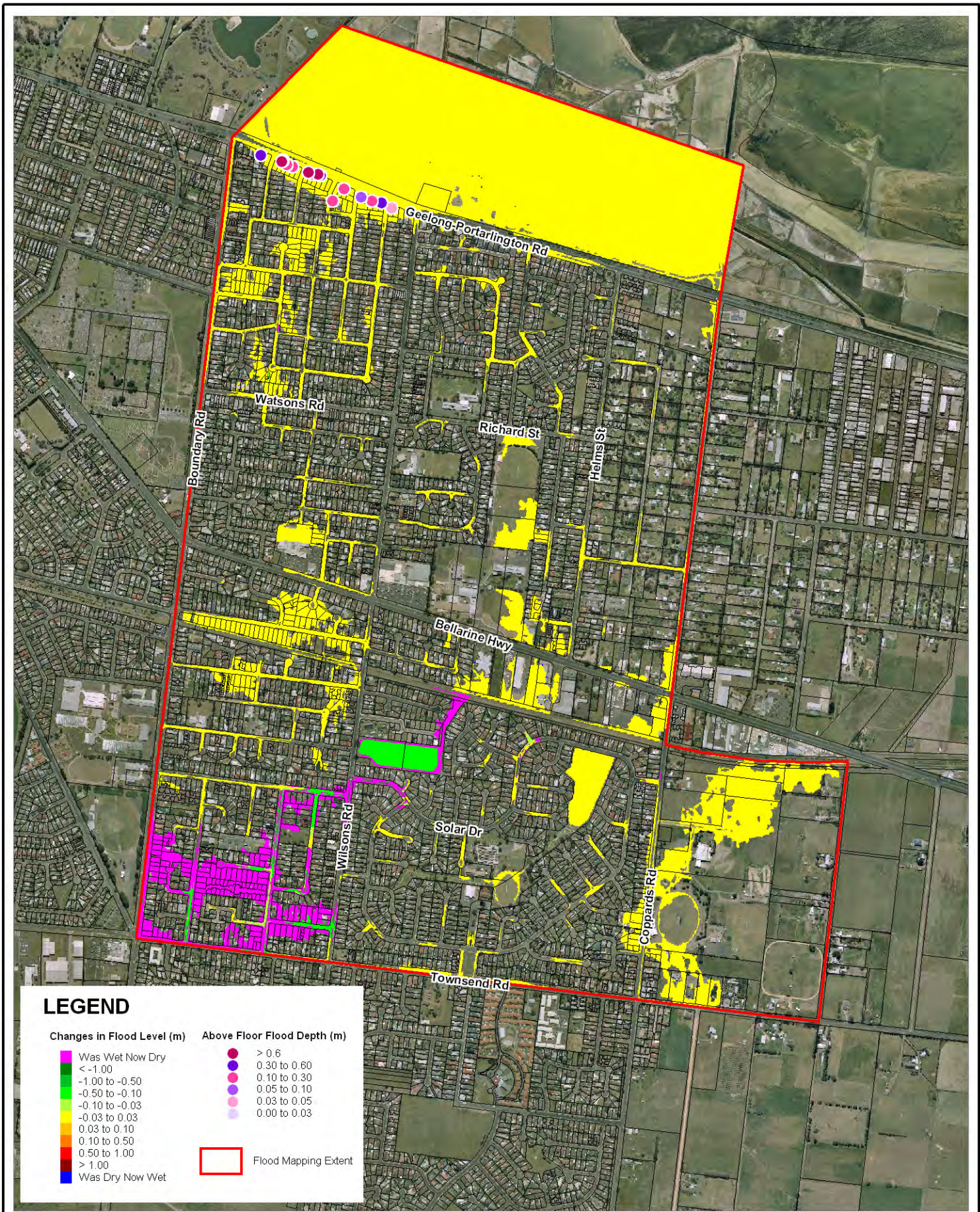
7.3.3.3 Scheme Three

This option has not been tested in the hydraulic model as it was not deemed to be a feasible solution to the flooding problems in the Newcomb-Whittington drainage catchments. The following section outlines the reasoning why.

Option Three explored the possibility of a new pipe along Wilsons Road to convey the overland flow from the area surrounding the intersection of Wilsons Road and Solar Drive. Based on an inspection of the Digital Elevation Model (DEM), the proposed pipe would have a pipe grade of only 1 in 715 (or 0.14%) if a minimum cover of 0.6 metres was maintained (the minimum for pipes along a road reserve). In order to maintain a self-cleaning velocity within the pipe of at least 0.5m/s, a potential pipe size that could fit in the proposed alignment would be 0.6 metre diameter. However, the discharge for a pipe of this size under these conditions would only be 0.25 cubic metres per second.

In order to capture the required 3.7 cubic metres per second overland flow, fifteen pipes would be required. Placing this number of pipes along the road is not realistic as it would require an easement of at least 14 metres (allowing for rubber ring jointed pipes with minimum pipe clearances), which

could not be accommodated within the existing road reserve. Given the required width of the easement, it is also likely that the alignment would have significant clashes with existing services (telecommunications, sewerage, water supply, etc) that could not easily (if at all) be resolved. Following discussion with CoGG it was agreed that further investigation of the Scheme was not required.

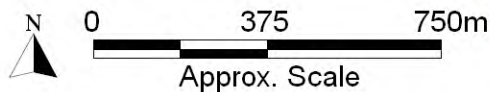


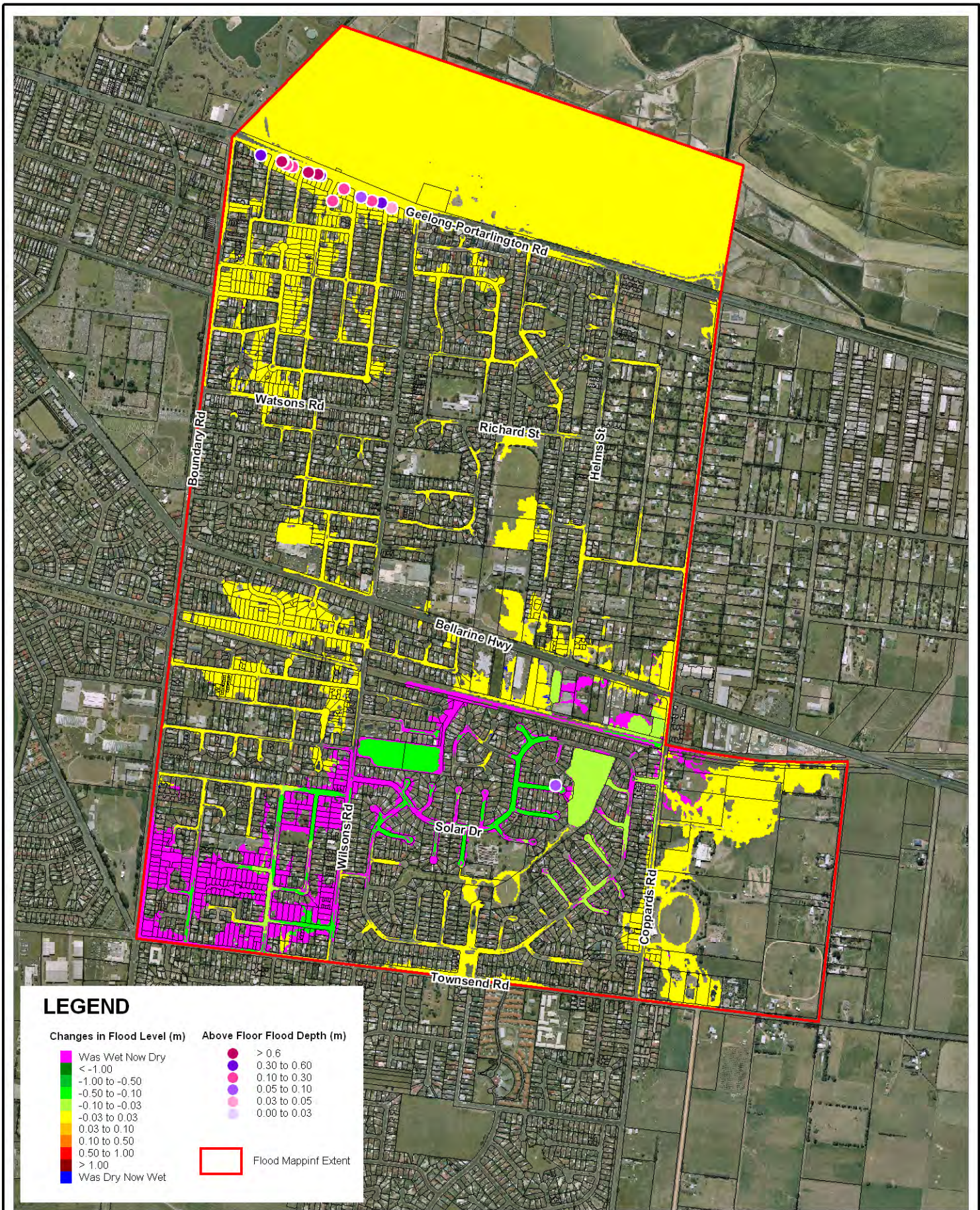
Title:
Mitigation Scheme One
20% AEP Peak Flood Impact

Figure:
7-3

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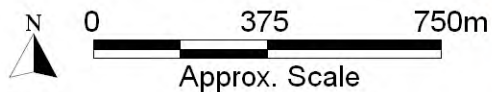


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Mitigation Scheme One
10% AEP Peak Flood Impact

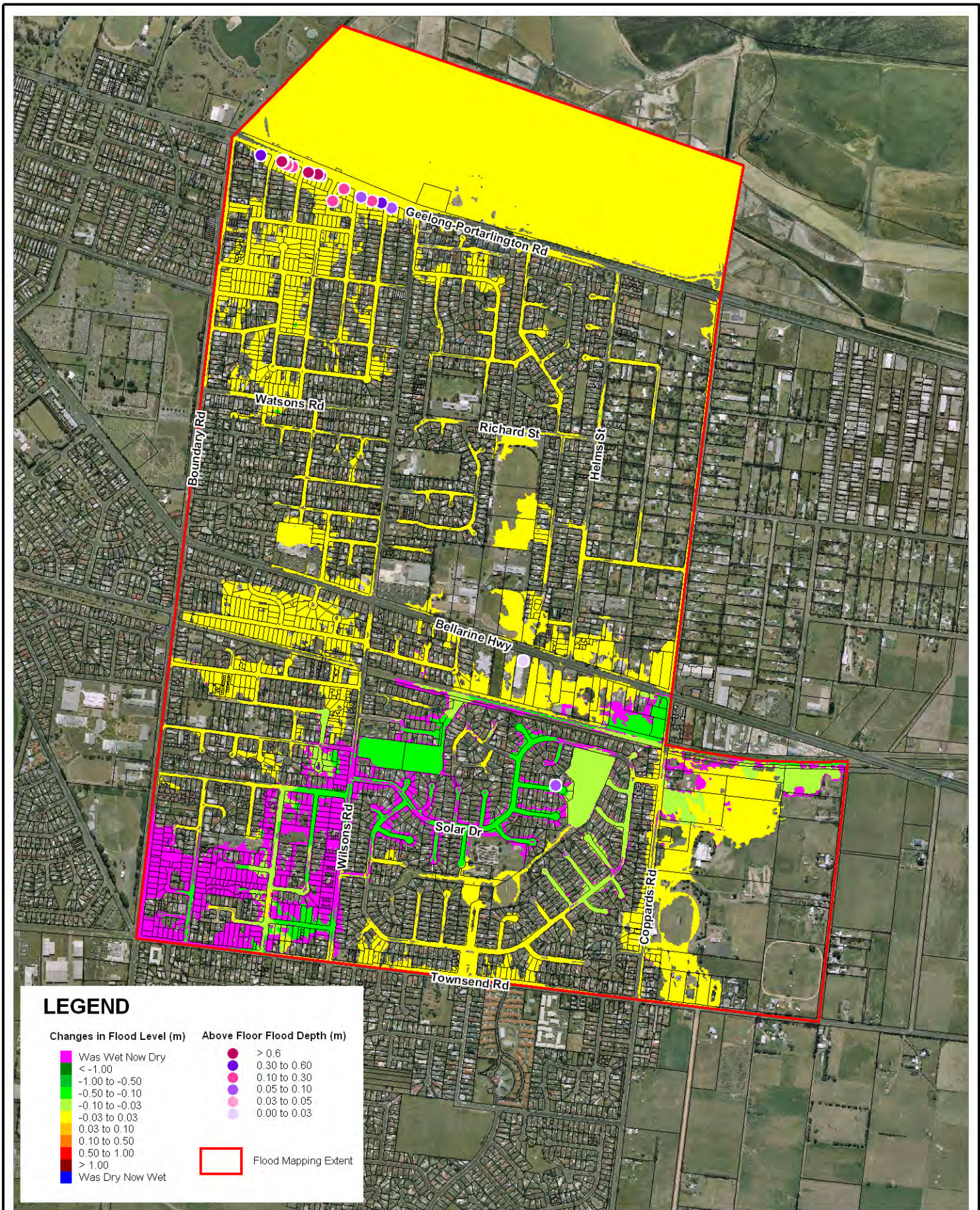
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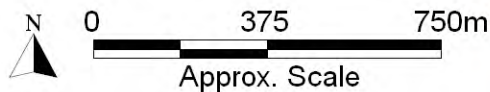


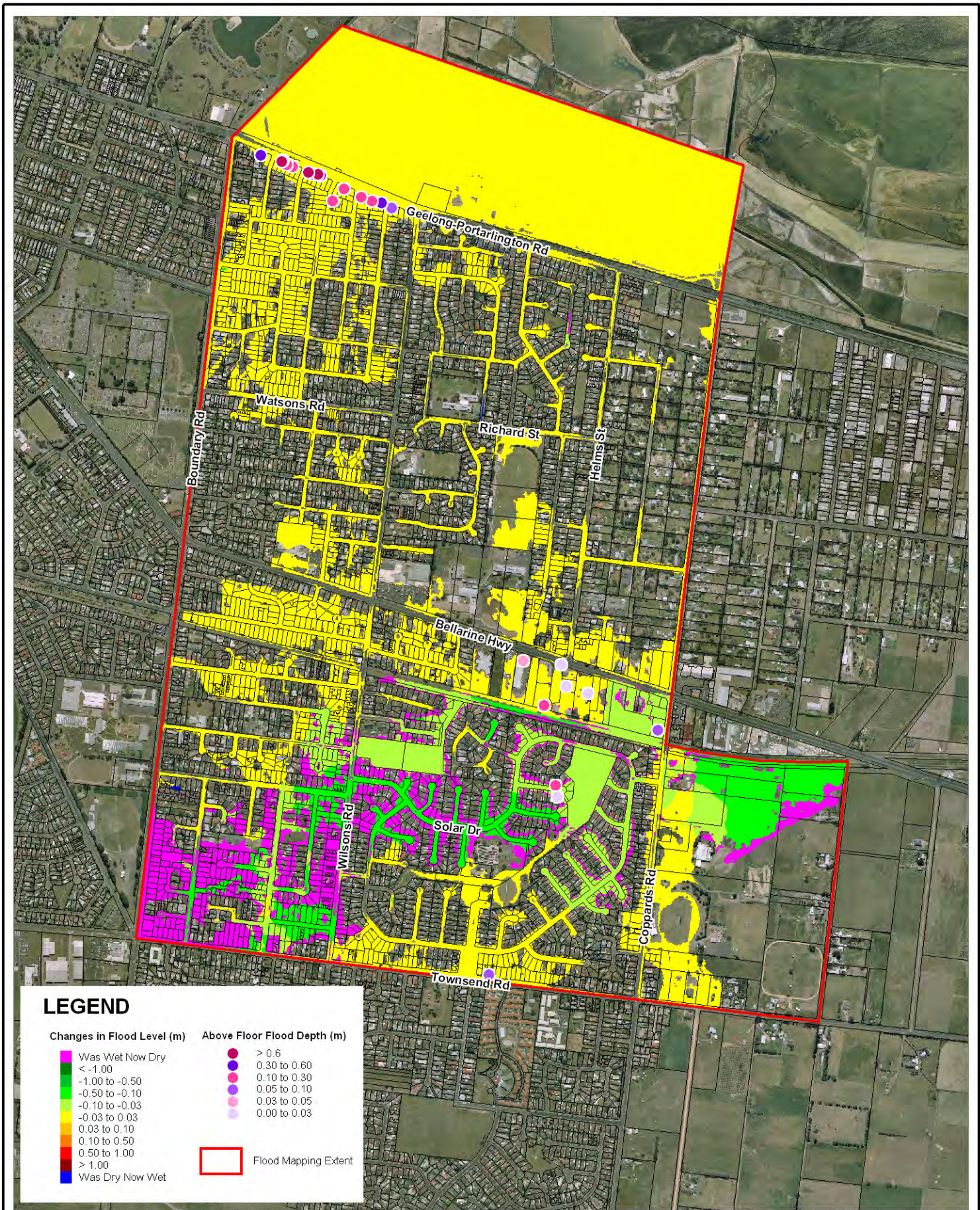
Title:
Mitigation Scheme One
5% AEP Peak Flood Impact

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7-5

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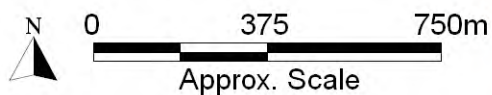


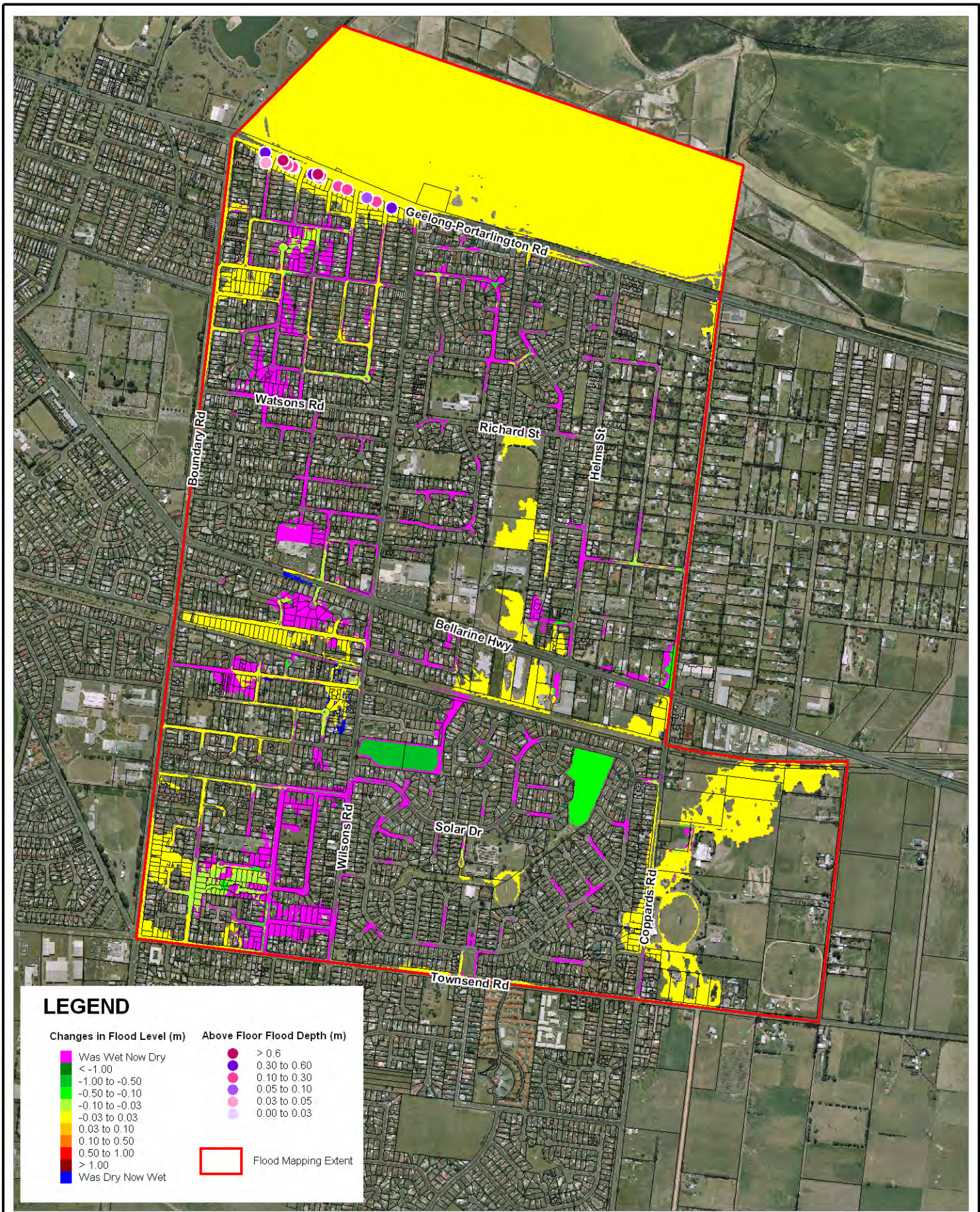
Title:
Mitigation Scheme One
1% AEP Peak Flood Impact

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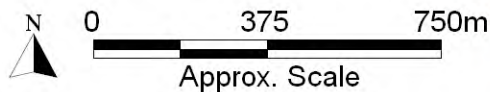
Changes in Flood Level (m)	Above Floor Flood Depth (m)
■ Was Wet Now Dry	● > 0.6
■ < -1.00	● 0.30 to 0.60
■ -1.00 to -0.50	● 0.10 to 0.30
■ -0.50 to -0.10	● 0.05 to 0.10
■ -0.10 to -0.03	● 0.03 to 0.05
■ -0.03 to 0.03	● 0.00 to 0.03
■ 0.03 to 0.10	
■ 0.10 to 0.50	
■ 0.50 to 1.00	
■ > 1.00	
■ Was Dry Now Wet	 Flood Mapping Extent

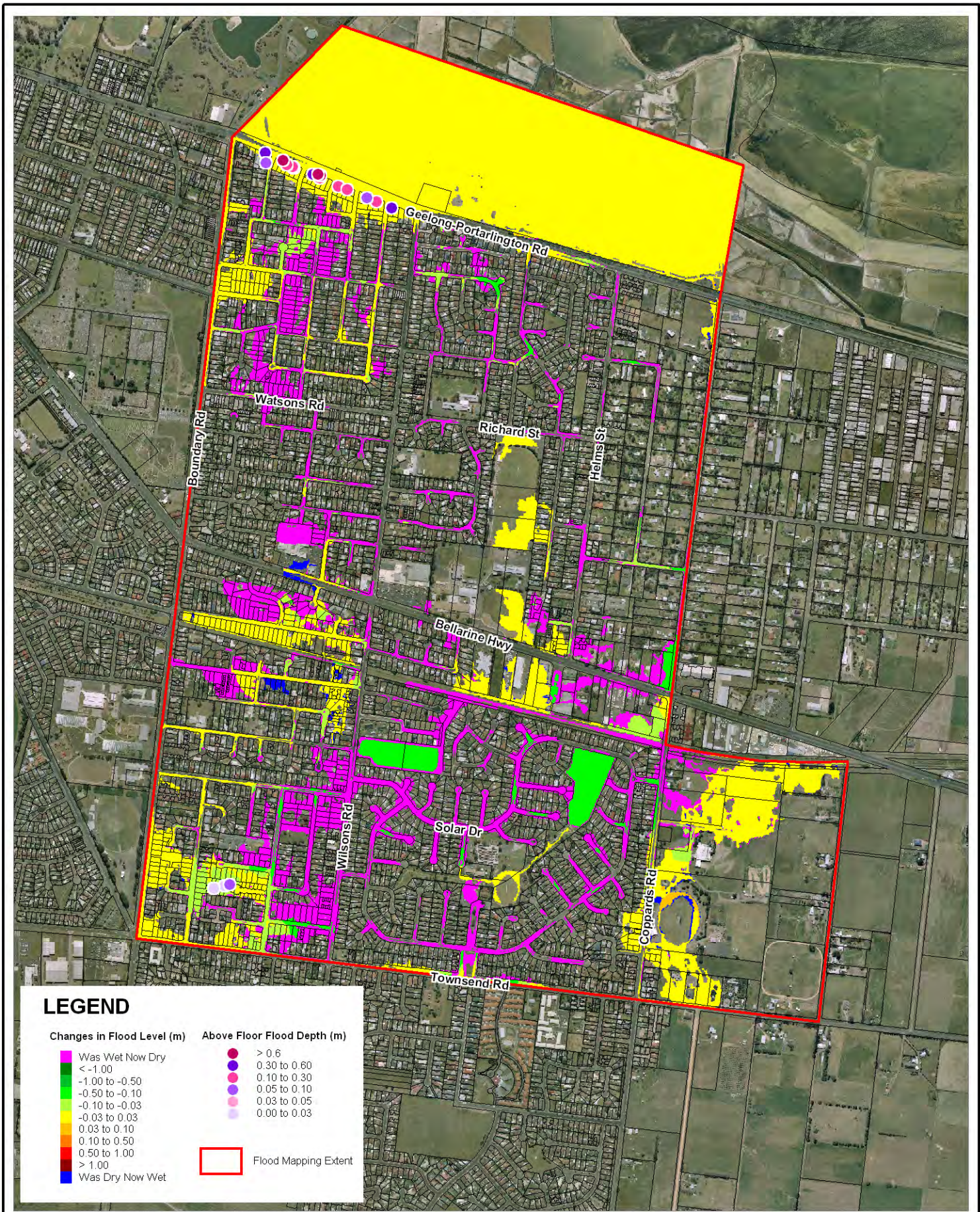
Title:
Mitigation Scheme Two
20% AEP Peak Flood Impact

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7-7

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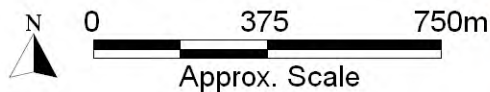


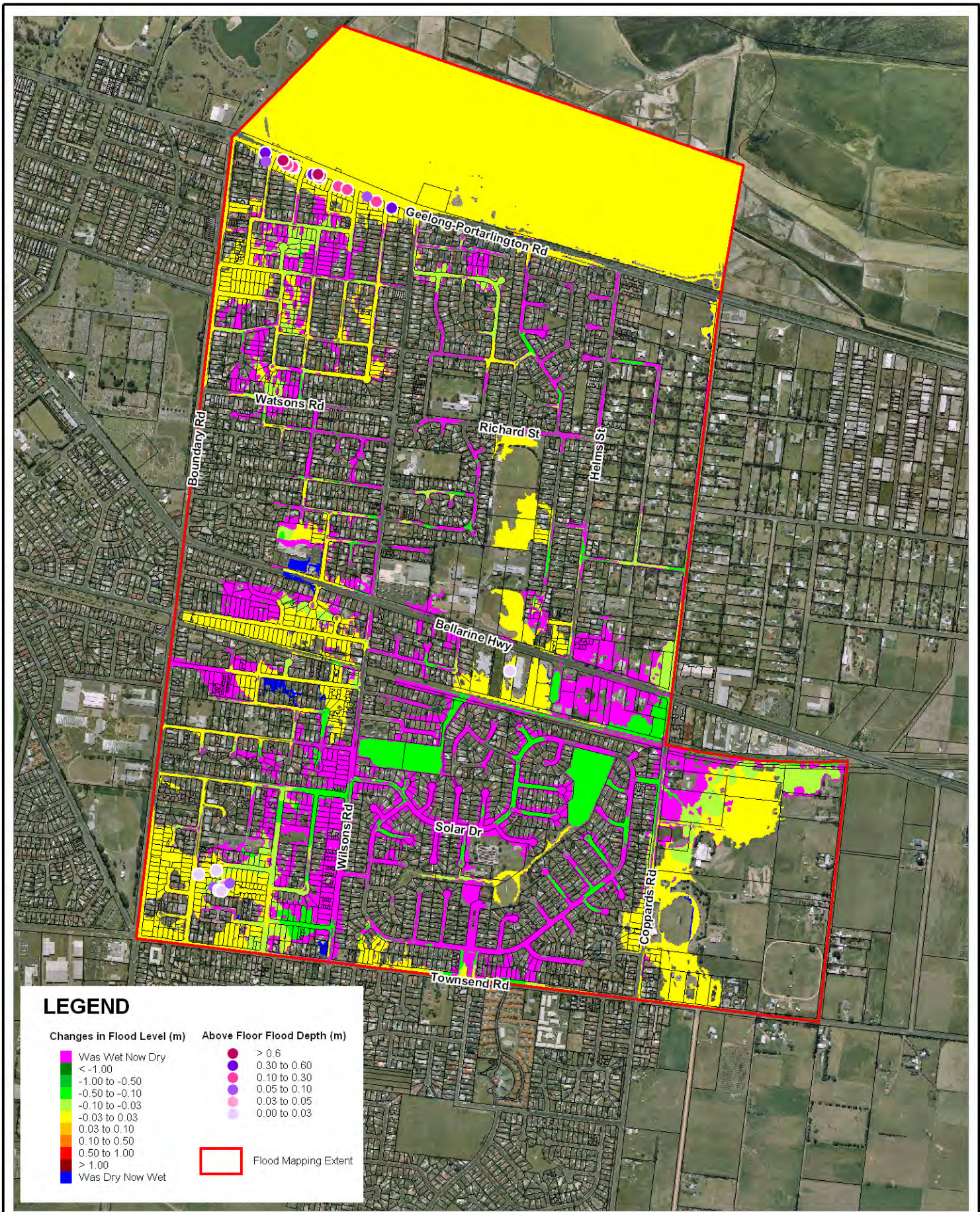
Title:
Mitigation Scheme Two
10% AEP Peak Flood Impact

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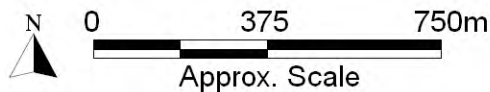


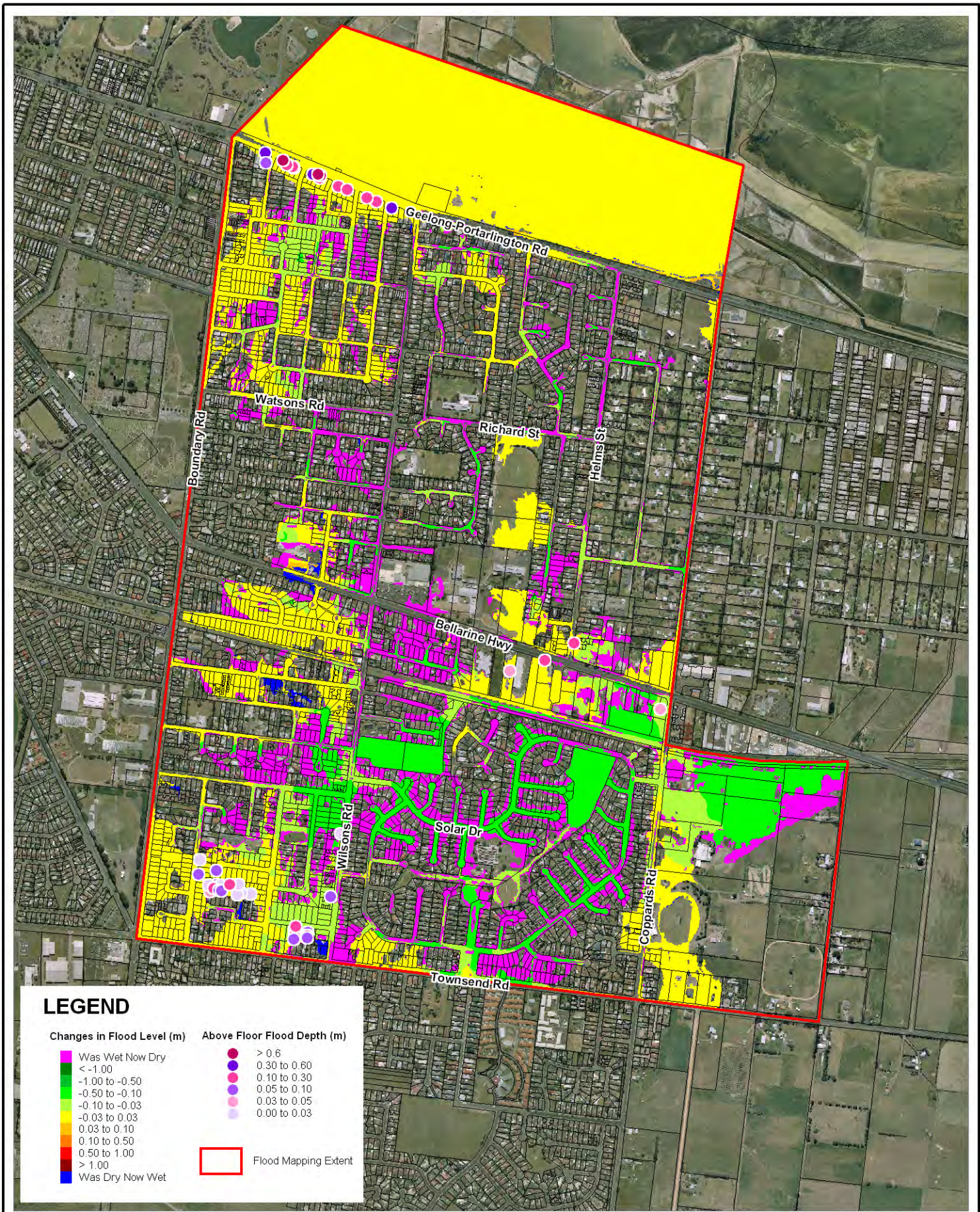
Title:
Mitigation Scheme Two
5% AEP Peak Flood Impact

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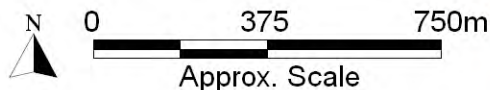


Title:
Mitigation Scheme Two
1% AEP Peak Flood Impact

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7-10

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8 MITIGATION OPTIONS ASSESSMENT

8.1 Economic Assessment

8.1.1 Basis of Assessment

In general, the benefits of the construction of flood management schemes are as follows:

- increased flood immunity of properties protected by the scheme;
- increased flood immunity of roads protected by the scheme and thus improved mobility of the community during flooding events;
- decreased cost of flood damage to properties protected by the scheme;
- decreased potential for loss of life during a flood event within the area protected by the scheme; and
- decreased emotional, social and psychological trauma experienced by residents in times of flooding.

It is important to note that flood management schemes can have the effect of increasing flood levels in other areas, thereby resulting in increased flood damages to properties elsewhere.

Of the factors listed above, the change in flood damages is the only one that can be easily quantified in monetary terms. In Section 6, the flood damages for the existing study area were calculated. The reductions (or increases) in these damages have been calculated to quantify the monetary benefit of each scheme.

The overall financial viability of a scheme is initially assessed by calculating the monetary benefit-cost ratio (BCR). These ratios are used to evaluate the economic potential for the option to be undertaken. A monetary benefit-cost ratio of 1.0 indicates that the monetary benefits are equal to the monetary costs. A ratio greater than 1.0 indicates that the benefits are greater than the costs while a ratio less than 1.0 indicates that the costs are greater than the benefits. The change in infrastructure damage as a result of implementing the scheme is not included in the benefit-cost analysis.

In floodplain management, a BCR substantially less than 1.0 may still be considered viable because the economic analysis does not include the intangible benefits of a flood mitigation scheme.

In order to calculate the BCR, the annual financial benefit (the change in average annual damages) of a scheme is summed over the financial project life and converted to present value.

A financial project life of 30 years was chosen for this study. This does not imply that the projected structural life of the scheme is only 30 years. In fact, some measures should be effective in reducing the frequency of flooding for centuries to come.

It is not correct to simply multiply a long term average annual benefit by the financial project life of 30 years to derive a total worth of the benefits. To do so would ignore the important point that the benefits from this scheme (i.e. reduced flood damages) will occur over time and in the future.

For example, a benefit of \$2.3 million to be gained in 10 years time is not worth \$2.3 million now but only \$1.2 million now. This is because \$1.2 million could be invested now and appreciate at say 7% p.a. over and above inflation for 10 years. This would then be equivalent to \$2.3 million in 10 years time. This is called the Present Value of the benefit. It is a universally accepted economic theory and used in all major project economic analyses. The adopted rate of 7% is called the discount rate and is the middle of the range 6 to 8% typically considered for assessing public works.

As an example, Table 8-1 shows the present value of the annual benefit realised at different times over a 50 year period.

Table 8-1 Present Value of Annual Benefits

Year	Average Annual Benefit (\$ million)	Present Value (\$ million)
0	2.3	2.3
1	2.3	2.2
10	2.3	1.2
25	2.3	0.4
50	2.3	0.1

If the present value benefits for each year are totalled for the 50 years, the total present value (or total benefit) of the benefits is \$31.7 million. The calculation of the total benefit can be simplified through the use of a Present Value Factor. Rather than calculating the present value for each year and summing to calculate the total benefit, a Present Value Factor can be used when the average annual benefit is identical in each year. The Present Value Factor is calculated using equation (1). The Present Value Factor is multiplied by the average annual benefit to calculate the total benefit. The Present Value Factor is 13.8 for a 50 year period and a discount rate of 7%.

It is interesting to note that if a longer financial project life of say, 100 years was chosen then the total present value of the benefits is only \$1.1 million more at \$32.8 million. This is due to the fact that the present value of the benefits to be accrued in the second 50 year period is low because of the length of time until the benefits are realised.

$$\frac{\left[1 - \left(\frac{1}{(1+i)^n}\right)\right]}{i} \quad (1)$$

where
n is the number of years
i is the discount rate(%)

The procedure for calculating benefit-cost ratios is outlined below:

- calculate the average annual benefit associated with the option (i.e. the reduction in average annual damages) using the method described in Section 6;
- convert the average annual benefit to a total benefit by multiplying by the present value factor; and
- calculate the total cost of the option.

Calculate the monetary **benefit-cost** ratio:

$$\text{Benefit - Cost Ratio} = \frac{\text{Total Benefit}}{\text{Total Cost}}$$

It is important to recognise that the monetary benefit-cost ratios represent only one of the issues that must be considered in respect to the viability of an option. Other issues such as social and psychological impacts, although difficult to quantify, must be included in the complete assessment.

Benefit-cost ratios may be sensitive to variations and/or inaccuracies in the following:

- difficulties associated with upgrading pipes under existing roads;
- service conflicts;
- difficulties associated with trenching near buildings and power poles; and
- construction, maintenance and operation costs.

Data from Melbourne Water's Land Development Manual and Melbourne Water rate estimates for drainage works were used to estimate the total cost of each option. These rates are summarised in Appendix A. The rates for stormwater pipes and rising mains were factored by 1.5 for sections constructed alongside or under roads. Stormwater pipes were costed on the basis of flush jointed construction with 100% fine crushed rock backfill. An allowance for engineering and contingencies of 15% and 20% has been allowed for in the proposed works with an Administration allowance of 9% (applied to the cost estimate inclusive of the engineering allowance).

Maintenance costs were calculated based on recommendations made in the CoGG publication, Report on Asset Maintenance Benchmarking (GHD, 1997). Table Two of this report shows that CoGG are currently spending 0.4% of asset value on maintenance of drainage assets and recommends expenditure be increased to 2.4% of asset value. BMT WBM has adopted the recommended value of 2.4%.

8.1.2 Scheme One

The damages under Scheme One for each design flood event are summarised in Table 8-2 and illustrated in Figure 8-1. The Scheme One AAD, also presented in Table 8-2, is \$134,000, which is a reduction of \$44,000 from the existing conditions AAD of \$178,000 per annum.

A summary of the capital costs for Scheme One is presented in Table 8-3 and the benefit cost analysis is summarised in Table 8-4. The BCR for Scheme One is 0.12. Based on the figures presented in Table 7-3 and Table 8-3, the capital cost of Scheme One per property floor saved from flooding during a 1% AEP flood event is \$85,000.

Table 8-2 Scheme One Damages Summary

Event		Scheme One			
ARI	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF ⁺	0.0%			\$508,000	
100	1%	\$374,000	\$112,000	\$486,000	\$ 5,000
20	5%	\$308,000	\$ 92,000	\$400,000	\$ 17,000
10	10%	\$292,000	\$ 88,000	\$380,000	\$ 19,000
5	20%	\$280,000	\$ 84,000	\$364,000	\$ 37,000
2	50%	\$-	\$-	\$-	\$ 56,000
Average Annual Damage					\$134,000

* Note – PMF damages are an extrapolation of the 1% AEP data, i.e., they were not calculated using PMF flood levels

Table 8-3 Scheme One Capital Cost Estimates

Item	Capital Cost
Pipe Works	\$ 2,334,000
Contingencies (20%)	\$ 467,000
Engineering (15%)	\$ 350,000
Administration (9%)	\$ 242,000
Total	\$ 3,392,000

Table 8-4 Scheme One BCR Summary

Item	Existing	Scheme One
Damages (PA)	\$178,000	\$ 134,000
Benefit (PA)		\$ 44,000
Benefit (NPV)		\$ 546,000
Capital Cost		\$3,392,000
Maintenance (PA)		\$ 81,000
Maintenance (NPV)		\$1,005,000
Total Option Cost		\$4,397,000
BCR		0.12

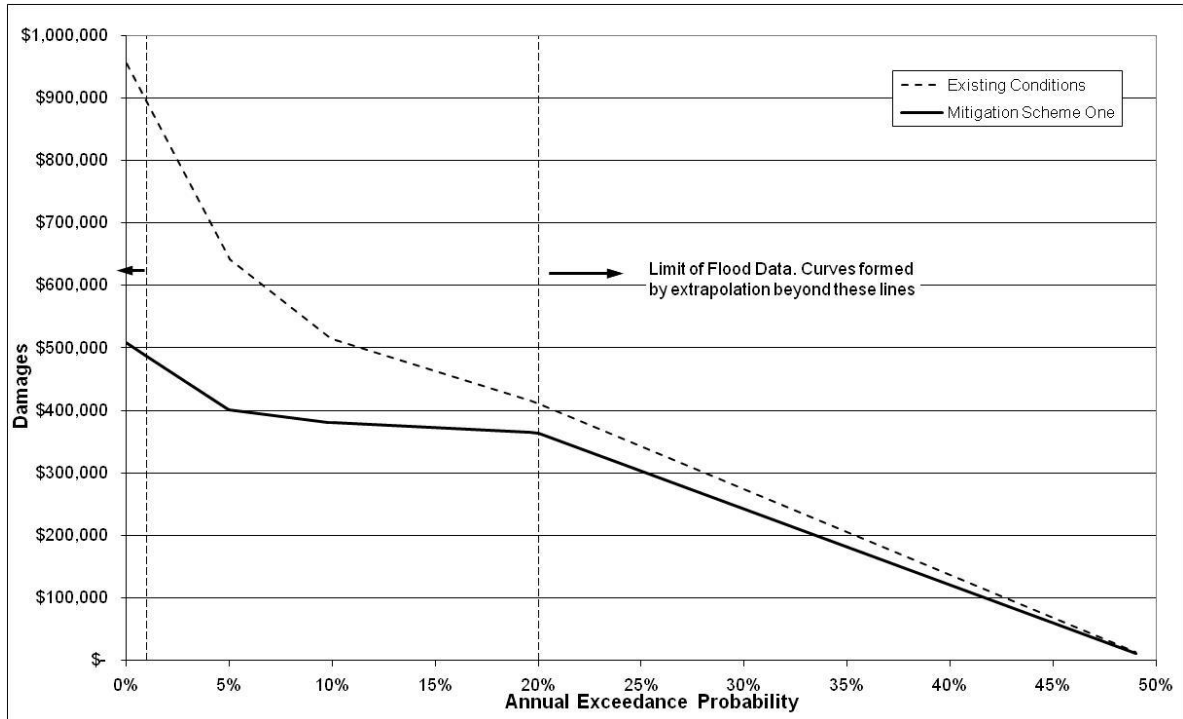


Figure 8-1 Scheme One Probability Damages Curve

8.1.3 Scheme Two

The damages under Scheme Two for each design flood event are summarised in Table 8-5 and illustrated in Figure 8-2. The Scheme Two AAD, also presented in Table 8-5, is \$144,000, which is a reduction of \$34,000 from the existing conditions AAD of \$178,000.

A summary of the capital costs for Scheme Two is presented in Table 8-6 and the benefit cost analysis is summarised in Table 8-7. The BCR for Scheme Two is 0.01. From the figures presented in Table 7-4 and Table 8-6, the capital cost of Scheme Two per property floor saved from flooding during a 1% AEP flood event is \$2,242,000.

Table 8-5 Scheme Two Damages Summary

Event		Scheme Two			
ARI	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF ⁺	0.0%			\$721,000	
100	1%	\$511,000	\$153,000	\$664,000	\$ 7,000
20	5%	\$338,000	\$102,000	\$440,000	\$ 22,000
10	10%	\$309,000	\$ 93,000	\$402,000	\$ 20,000
5	20%	\$286,000	\$ 86,000	\$372,000	\$ 38,000
2	50%	\$-	\$-	\$-	\$ 57,000
Average Annual Damage					\$144,000

⁺Note – PMF damages are an extrapolation of the 1% AEP data, i.e., they were not calculated using PMF flood levels

Table 8-6 Scheme Two Capital Costs

Item	Capital Cost
Pipe Works	\$ 30,854,000
Contingencies (20%)	\$ 6,171,000
Engineering (10%)	\$ 4,628,000
Administration (9%)	\$ 3,193,000
Total	\$ 44,846,000

Table 8-7 Scheme Two BCR Summary

Item	Existing	Scheme Two
Damages (PA)	\$178,000	\$ 144,000
Benefit (PA)		\$ 34,000
Benefit (NPV)		\$ 422,000
Capital Cost		\$44,846,000
Maintenance (PA)		\$ 1,076,000
Maintenance (NPV)		\$13,352,000
Total Option Cost		\$58,198,000
BCR		0.01

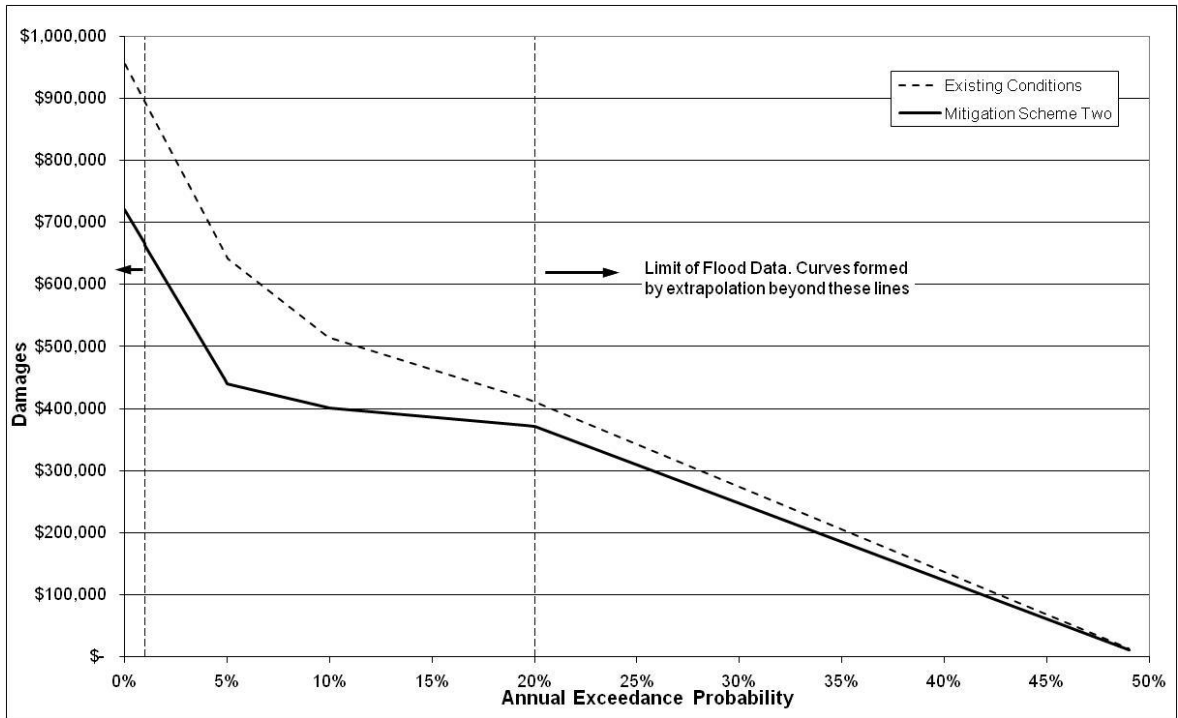


Figure 8-2 Scheme Two Probability Damages Curve

8.2 Environmental Assessment

Environmental impacts, associated with the construction and operation of each flood mitigation option, are discussed in this section. Table 8-8 presents details regarding the environmental implications for each scheme in the Newcomb – Whittington drainage catchments. It is not anticipated that any of the schemes will have long-term environmental impacts.

Table 8-8 Environmental Implications

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	Scheme Two	Scheme Four “Do Nothing” (Existing Case)
Ecological impact.	No Change	No Change	No Change.
Noise.	Minor impacts associated with the construction of the pipe works.	Minor impacts associated with the construction of the pipe works.	No Change.
Receiving Water Quality.	Increased runoff into the Barwon River from diverted flow. As this runoff is coming from an urban catchments it could contain higher levels of pollutants consistent with urban areas. Following further investigation stormwater water quality works may be required to mitigate environmental impacts and meet stormwater management legislation.	No Change	No Change.
Air.	Minimal impact. Manage via construction management plan.	Minimal impact. Manage via construction management plan.	No Change.

8.3 Social Assessment

Table 8-9 outlines the social implications related to each flood mitigation scheme proposed for the Newcomb – Whittington drainage catchments.

Table 8-9 Social Indicators

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	Scheme Two	Scheme Four “Do Nothing” (Existing Case)
Recreation and Aesthetic.	No Change	No Change.	No Change.
Cultural Heritage.	Manage via Cultural Heritage Management Plan (if required).	Same as Scheme One.	No Change.
Public Safety.	Moderate risk due to potentially deep trenching. Manage risk with appropriate construction phase management plans as applicable. Some potential risk from large drainage structures. Manage with best practice design.	Same as Scheme One.	No Change. Areas of unsafe flooding would remain.

8.4 Feasibility and Performance Indicators

Table 8-10 presents the feasibility and performance indicators for the Newcomb – Whittington drainage catchments mitigation schemes. The main inhibitors to both schemes are the capital costs and relatively low BCR values; however Scheme One is more favourable than Scheme Two for these two indicators.

Table 8-10 Feasibility and Performance Indicators

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	Scheme Two	Scheme Four “Do Nothing” (Existing Case)
Maintenance costs.	Limited increase in annual maintenance cost as proposed pipe would only make up a small percentage of the drainage infrastructure within the study area.	Large increase in annual maintenance cost as a result of the magnitude of the underground drainage infrastructure being tripled.	No Change
Ease of Construction	Difficulties associated with the laying of new pipes, in particularly under Boundary Road, whilst minimising disruption to traffic flow. Difficulties associated with retro-fitting new pit and connector pipe configuration with already established development/drainage network. Potential for other utilities such as sewerage, potable water and gas to be located within the area.	Difficulties associated with the laying of new pipes, in particularly under main roads such as Geelong – Portarlington Road and the Bellarine Highway whilst minimising disruption to traffic flow. Difficulties with integrating new pipes and pits with an already complex drainage network. Potential difficulties with restrictions on space available as a result of limited road reserve and easement widths, and clashes with other utilities.	Not applicable.
Funding and feasibility.	Moderate capital costs and a low BCR of 0.12 would make funding difficult. Capital cost of Scheme per property floor saved from flooding during a 1% AEP flood event is far lower than scheme two at \$85,000.	Very high capital cost and a low BCR of 0.01 would make funding difficult. Capital cost of Scheme per property floor saved from flooding during a 1% AEP flood event is \$2,242,000.	Not applicable.

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	Scheme Two	Scheme Four "Do Nothing" (Existing Case)
Public acceptability.	There would be issues related to this scheme as works are proposed to be undertaken on existing road infrastructure disturbing transportation.	There would be major issues related to this scheme as works are proposed to be undertaken on existing road infrastructure on a very large scale disturbing transportation.	Issues relating to Council being seen to be doing nothing structurally about the problem. However, this issue may not be as significant within the study catchments as in other catchments, due to the communities' experience of flooding and a general appearance that they accept the area as flood prone.

9 PREFERRED MITIGATION SCHEME

9.1 Description of Preferred Scheme

Scheme One is the preferred mitigation scheme for the Newcomb – Whittington drainage catchments. Through consultation with the CoGG, the preferred scheme was selected as it focuses on the mitigation of overland flows and flood depths to reduce the flood hazard within the Newcomb – Whittington drainage catchments, in particular the area between the intersection of Wilsons Road and Hickey Street, and the southwest corner of the study area. Scheme One also presents a realistic mitigation option in terms of capital cost and the disturbance caused to transportation within the area.

As documented in previous sections, and summarised below in Table 9-1, in comparison with Scheme Two, Scheme One doubles the number of floors saved with a \$38.3M decrease in capital cost. Hence, Scheme One has significantly more flood benefit for the community, in terms of reducing flooded floors and flood hazard, whilst maintaining a feasible capital cost per floor saved.

Table 9-1 Comparison of Scheme One and Scheme Two

Scheme	Capital Cost	BCR	Flooded Floors Saved in 1% AEP Flood Event*	Capital Cost per floor saved (1% AEP Flood Event)
One	\$3,392,00	0.12	40	\$85,000
Two	\$44,846,000	0.01	20	\$2,242,000

* Results based on properties surveyed by CoGG.

Also considered in the selection of the preferred scheme were key indicators such as environmental, social and feasibility and performance. This analysis in regard to the preferred scheme, when compared to the other schemes, is summarised as follows:

- its potential environmental impact is minimal and similar to the other scheme;
- the social impacts arising from Scheme One are very limited and similar to the other scheme; and
- the feasibility and performance indicators are far more favourable than Scheme Two.

9.2 Structural Components

Scheme One is schematised in Figure 7-1 and involves the following key elements:

- Five new 900 mm RCPs running south down Boundary Road for approximately 830 m from the intersection with Townsend Road, with the outlet into the Barwon River floodplain.
- Further smaller diameter pipes would be required to convey flow from the required inlet pits to the proposed main drain, however the dimensions, number and location of these pipes could not be determined until detailed design of the scheme is undertaken.
- A pit arrangement that is able to capture the flow that originates in the southwest of the catchments. The dimensions, numbers and locations of the pit network cannot be determined until the detailed design phase.

- Potential limited land forming works may be required in order to direct the diverted overland flow into the drainage network.

9.3 Non-Structural Components

In addition to the structural works associated with Scheme One, a number of additional recommendations are made in regard to the protection of individual buildings and property not provided with flood immunity by the preferred strategy. The following section summaries the additional components recommended for use in conjunction with Scheme One.

- Further investigation into the feasibility of localised flood mitigation measures, such as lifting footpaths and/or underground drainage augmentation, in order to reduce the flood risk for properties that would not benefit from Scheme 1 but have been the subject of previous drainage/flooding requests for service that have identified capacity deficiencies rather than blockages. These investigations would be undertaken in accordance with the priority ranking established by applying the City's prioritisation method for drainage investigation/design work.
- Further investigation into the feasibility of property-specific measures to manage risk from residual flooding with Scheme 1 in place. Potential measures include flood-proofing of individual or groups of buildings/properties by landowners, and property buy-back with on-sell following modifications (where feasible) with conditions known to purchaser.
- Education and awareness program to inform landowners how to minimise the magnitude of damage in a flood event.
- Development controls via designation of areas as liable to flooding in accordance with Building Regulations 2006 and use of flood zones/overlays within the Greater Geelong Planning Scheme.
- Recognition that further development within the catchments has the potential to increase flood risk to people and property. Assessment of rezoning proposals to include application of principle of zero adverse flood impact on adjacent, upstream and downstream areas. Assessment of development and subdivision applications to include application of best practice guidelines for development within or upstream of flood-prone areas.
- Best practice environmental management for stormwater runoff to be encouraged as part of development and subdivision applications in order to reduce runoff and improve water quality, where not a statutory requirement.

9.4 Flood Mapping of Preferred Scheme

Flood mapping has been undertaken for the preferred scheme for each flood event as follows:

- Flood Impacts – Figure 7-3 to Figure 7-6; and
- Flood Hazard Maps - Figure 9-1 to Figure 9-4.

The flood hazard maps (Figure 9-1 to Figure 9-4) show that, as with the existing conditions hazard mapping, the areas of unsafe hazard are restricted to the road reserves with the exception of the flood storages, both formal and informal and the area inundated by Stingaree Bay. No increase in flood hazard has occurred as a result of Scheme One.

Large scale A1 plans show detailed mapping of flood extent and flood impacted properties for each of the 20%, 10%, 5% and 1% AEP events. These have been provided to CoGG as part of the data delivery in hard copy and digital GIS formats.

9.5 Funding of Preferred Scheme

Funding mechanisms available to Council for the upgrade of drainage infrastructure typically fall into one of two categories:

- **Private Benefit** for which a user-charge typically applies associated with a direct link between the infrastructure provided and the benefit received; and
- **Public Benefit** is related to infrastructure that provides a benefit to the wider community throughout the municipality.

Clearly, augmentation works undertaken within the Newcomb – Whittington drainage catchments are for the direct benefit of those residents with an existing flooding problem or threat. There also exists an indirect benefit to those residents within the catchments associated with increased trafficability of roads subject to flooding, as well as public health and safety issues and other non-economic benefits. Benefit may also be deemed to apply to residents with properties that are not flood effected but discharge stormwater within the catchments. This principle of catchment wide benefit within drainage schemes has been successfully implemented under legislation previous to the Local Government Act 1989.

Special Rates and Charges are the typical mechanism for funding of drainage works under user charges. Section 163 of the Local Government Act 1989 sets out the provisions for the application of a special rate, charge or combination of these. The purpose of the rate or charge is to recoup costs associated with the provision of infrastructure. The charge is typically a one-off payment while a rate is generally an annual payment made over a number of years.

Recent decisions handed down at VCAT or AAT suggests a more confined application of special rates and charges particularly in relation to main drainage augmentation schemes. In essence the Ball decision (Appeal No 1993/37685) concluded:

- a special rate or charge can only be levied where a special benefit is received;
- the special benefit must be received by the land owners (rather than the property);
- in this context, a special benefit was recognised by the Tribunal as an increase in property values.

That is, according to the Tribunal, while every property in the catchment receives, to a greater or lesser degree, a benefit from the main drainage augmentation works, that benefit does not translate into an increase in property values and is therefore not a *special benefit*. Thus, according to the tribunal, funding via special rates and charges is not applicable.

Furthermore, the Tribunal ruled that where:

... properties are already drained to lawful points of discharge and the provision of additional capacity in the main drainage system, although obviously required to drain the entire catchment, will not provide a special benefit to them as owners of their land.

Appeal No 1993/37685 pg 7

This would indicate that the main drainage augmentation works within an area with made and kerbed streets is not considered by the Tribunal to provide a specific benefit to property owners in the catchment. Therefore the ruling would imply that in the case of the Newcomb-Whittington catchments, funding via special rates and charges may be problematic due to potential legal uncertainty and social resistance.

It is recommended that Council seek independent legal advice to confirm the rationale of a test case involving a special rates and charges scheme.

9.6 Strategy for Implementation

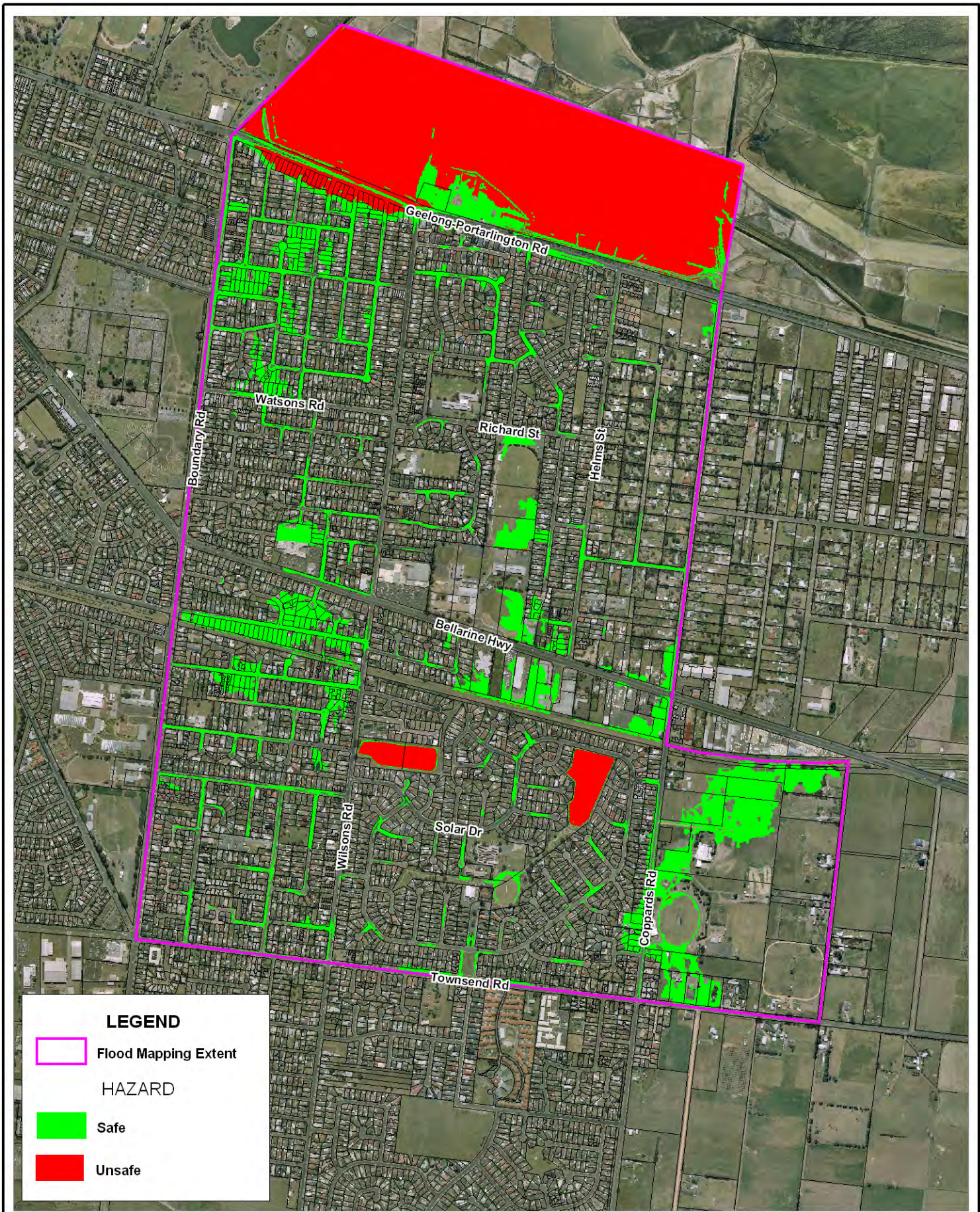
The capital cost for the catchments are approximately \$3.9M. Council currently allocates approximately \$2M per annum for major drainage works. Assuming that \$0.5M per annum could be allocated for this program, then the construction program could be staged over a period of 8 years. Allowing four years for the determination and arrangement of funding sources and the design of the drainage works, the period of implementation would be 12 years.

It is worth noting that once the main pipe proposed in Scheme One that runs under Boundary Road and outflows into the Barwon River floodplain is constructed then the existing drainage network can then be systematically diverted into the new pipe. As a result the staging of the scheme can be tailored to match funding and other limitations over the lifespan of the entire project.

The 12 year schedule allows for one year for the determination and arrangement of funding sources and two years for the design of the drainage works. The designation of flood levels and application of flood zones/overlays would occur in the first 2 years, individual flood proofing would commence in year 3 and an education and awareness program would be ongoing. An approximate schedule of implementation is shown in Table 9-2.

Table 9-2 Implementation Schedule

Item	Year 1	Year 2	Year 3	Year 4	Year 5 to 12
Determine Funding Source(s) and Prepare Business Case.					
Detailed Design of Scheme One					
Staged Construction of Scheme One					
Designation and Dissemination of Flood Information.					
Planning Scheme Amendment (Flood Zones/Overlays).					
Individual Flood proofing.					
Education and Awareness Program.					

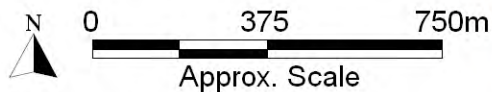


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Preferred Scheme (Mitigation Scheme One)
20% AEP Peak Flood Hazard

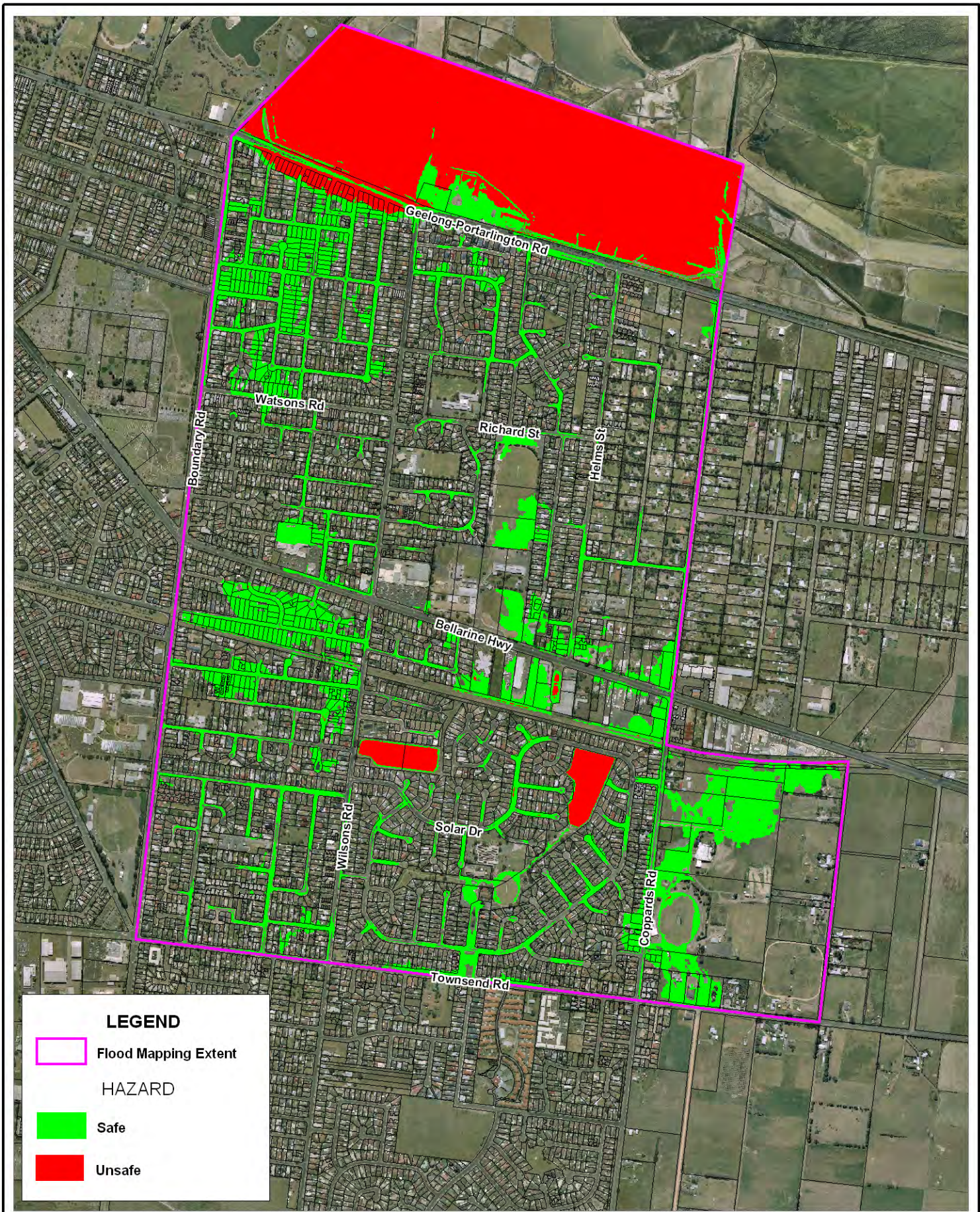
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LEGEND

 Flood Mapping Extent

HAZARD

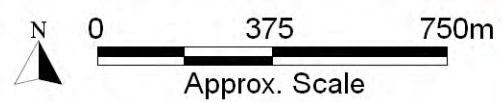
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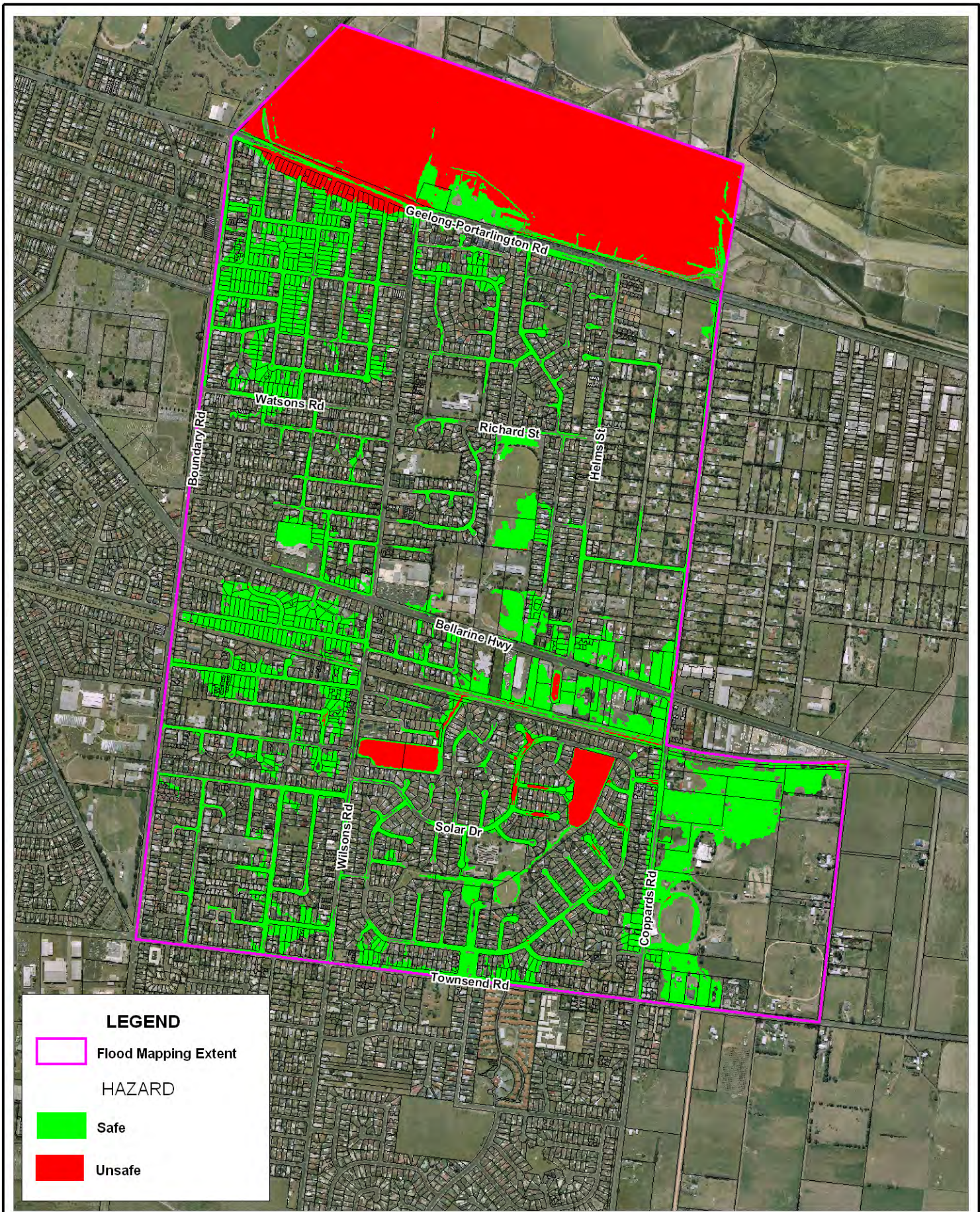
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Title:
Preferred Scheme (Mitigation Scheme One)
10% AEP Peak Flood Hazard

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LEGEND

 Flood Mapping Extent

HAZARD

 Safe

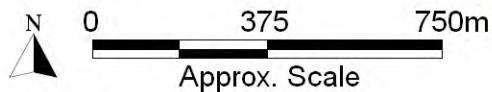
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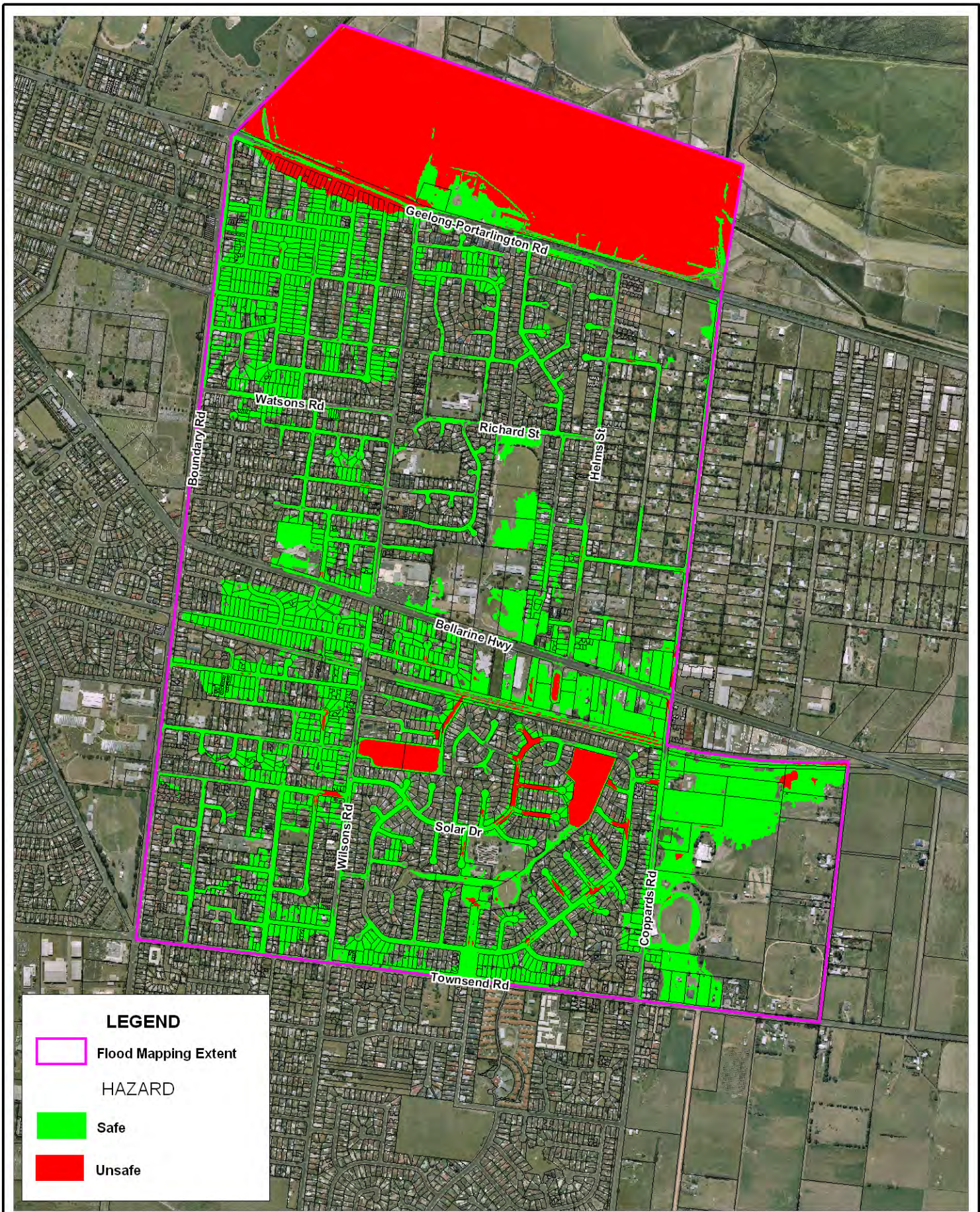
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Preferred Scheme (Mitigation Scheme One)
5% AEP Peak Flood Hazard

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LEGEND

 Flood Mapping Extent

HAZARD

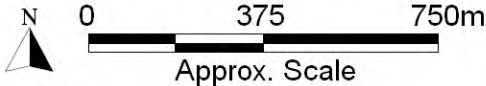
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Title:
Preferred Scheme (Mitigation Scheme One)
1% AEP Peak Flood Hazard

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10 PUBLIC CONSULTATION PROCESS

The Newcomb – Whittington Drainage/Flood Study Draft Report was placed on display for public consultation. The general public was advised of the exhibition via a public notice and the 2208 owners of properties affected by the 100 year ARI flood event received individual letters with explanatory fact sheets.

During the public consultation period six written submission and 16 verbal submissions or enquiries were received. Some of the submitters acknowledged that their properties or roads had experienced flooding in the past in a manner consistent with the Study's flood-mapping. The major issues of concern raised by owners of affected properties are detailed in Appendix C with the relevant responses by CoGG.

11 REFERENCES

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Melbourne Water 2008, *Guidelines for Development in Flood-prone Areas*, Melbourne Water, Melbourne.

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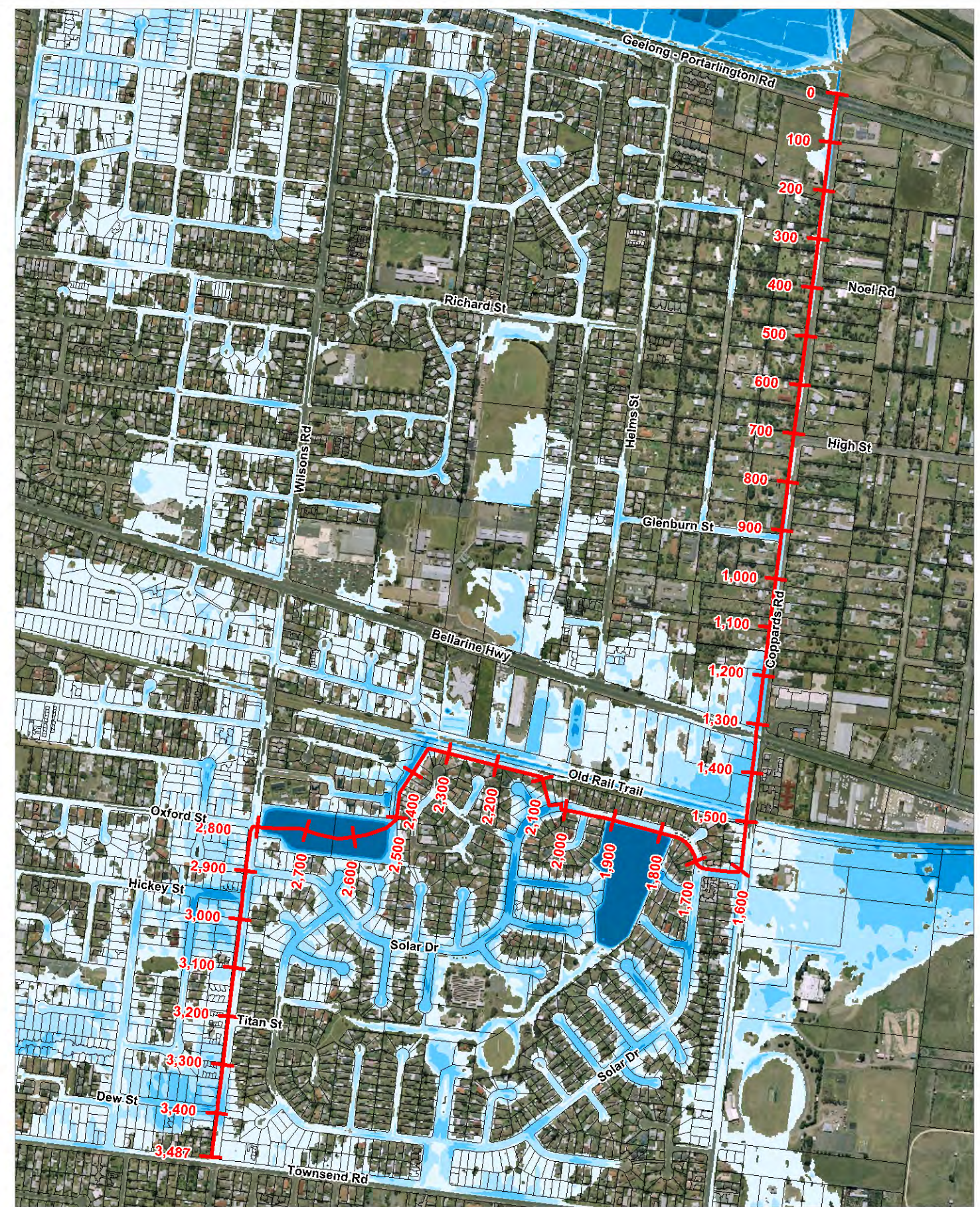
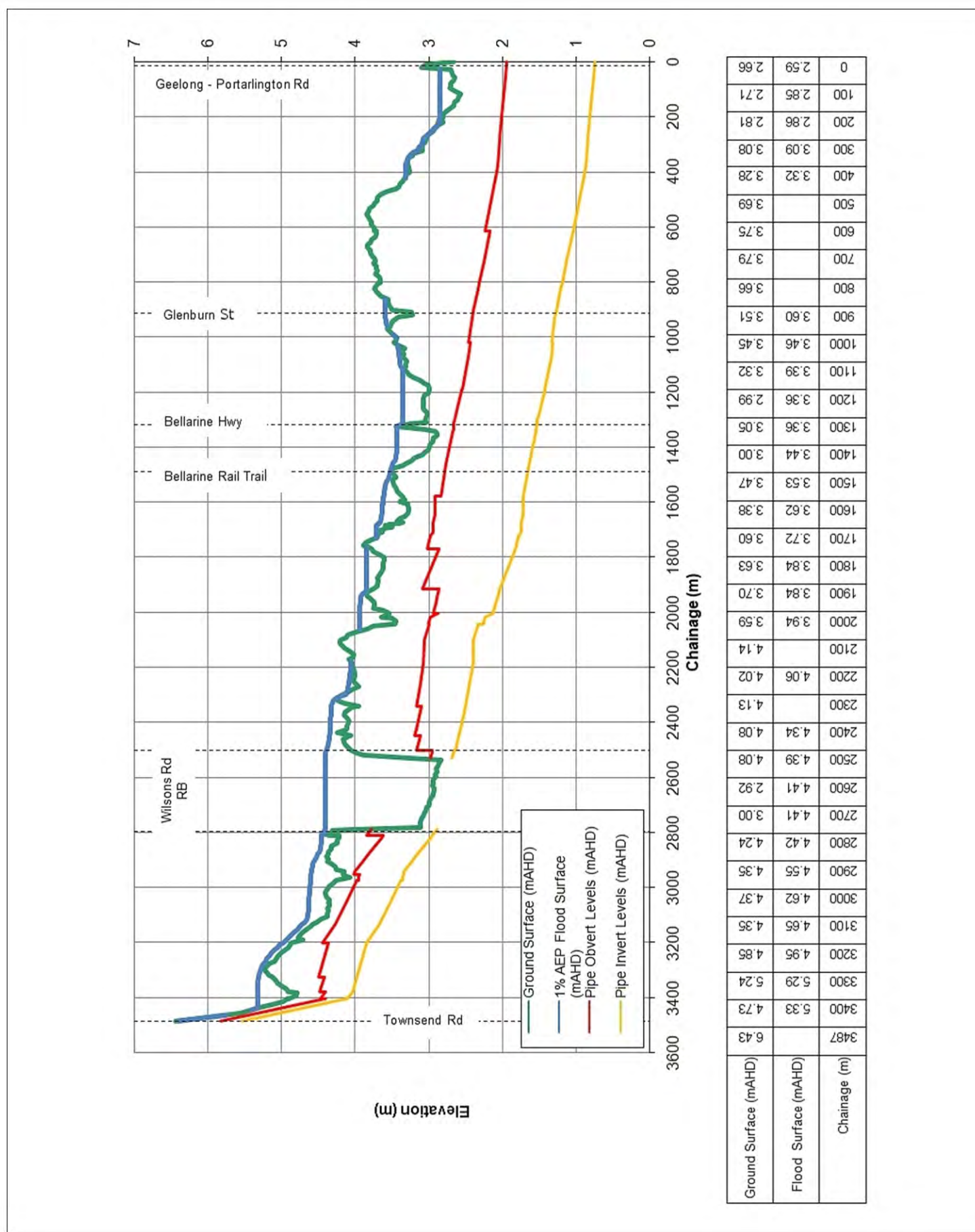
Smith, D 1994, 'Flood Damage Estimation – A review of urban stage-damage curves and loss functions', *Water SA*, vol. 20, pp. 231-238.

WBM Oceanics Australia 2004, *Moolap Industrial Area Flood Management Plan Final Report*, WBM Oceanics Australia, Melbourne.

APPENDIX A: CONSTRUCTION RATES

West Region Pipeline Rates (\$ per m)			
Nominal pipe diameter (mm)	Interlocking / Flush Jointed pipes	Adopted rates for pipes in road reserves	„Jacking’ Rates
	100% FCR backfill	100% FCR backfill	
300	129	194	271
375	156	234	328
450	188	282	395
525	218	327	458
600	249	374	523
675	276	414	580
750	309	464	649
825	343	515	720
900	378	567	794
1050	460	690	966
1200	570	855	1197
1350	696	1044	1462
1500	841	1262	1766
1650	1,013	1520	2127
1800	1,244	1866	2612
1950	1,538	2307	3230
2100	1,901	2852	3992
2250	2,452	3678	5149
2400	3,061	4592	6428

APPENDIX B: LONGITUDINAL PROFILE PLOTS

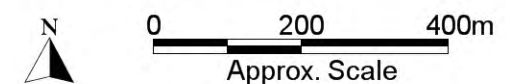


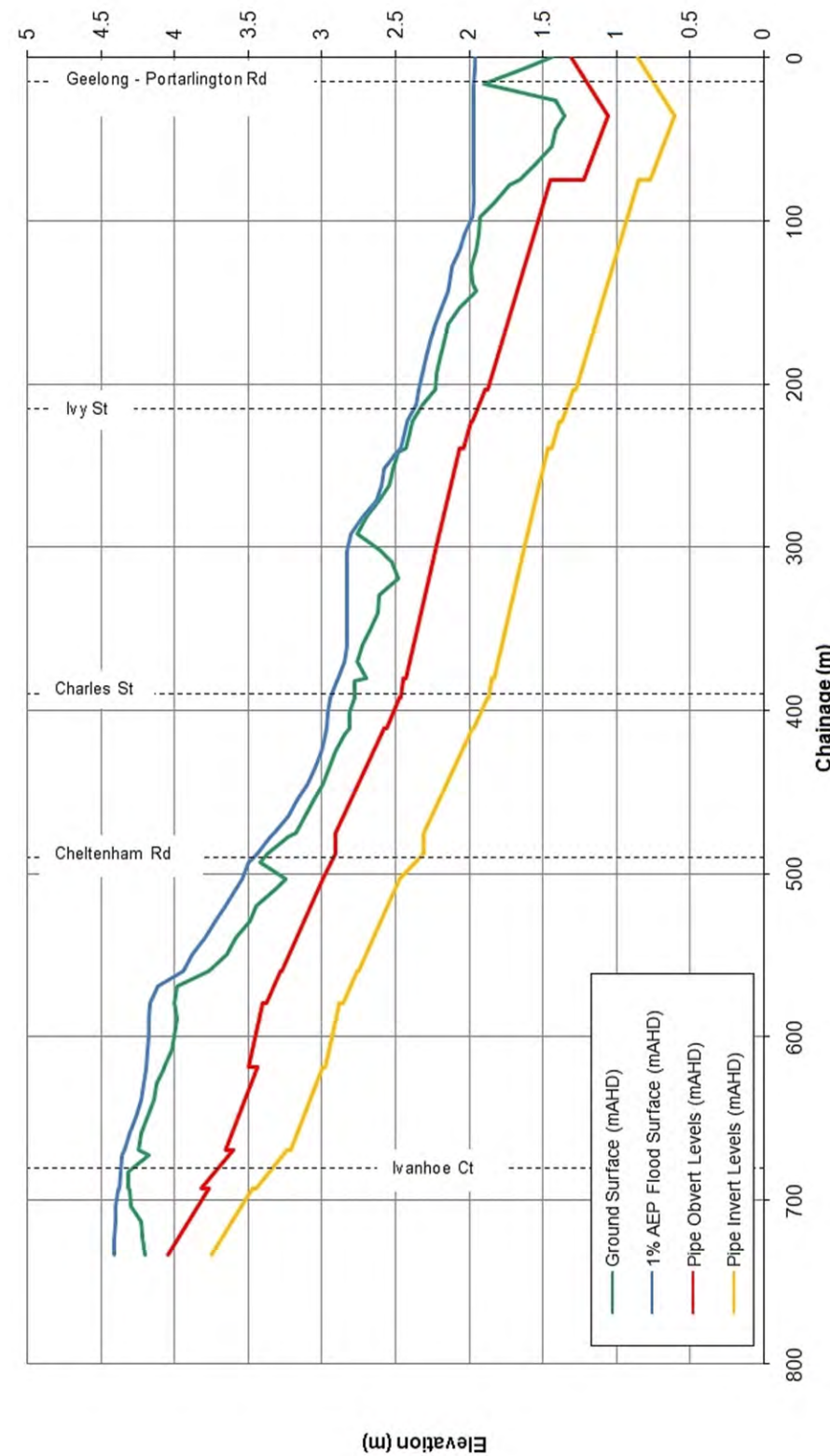
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**1% AEP Existing Conditions Flood Surface Longitudinal Profile
 Geelong - Portarlington Road to Townsend Road**

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B-1

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Ground Surface (mAHD)	0	100	200	300	400	500	600	700	733
Flood Surface (mAHD)	1.96	1.98	2.33	2.82	2.96	3.52	4.17	4.39	4.41
Chainage (m)	0	100	200	300	400	500	600	700	733

Note: Pipe section under Geelong - Portarlington Rd runs uphill in accordance with council pipe data.

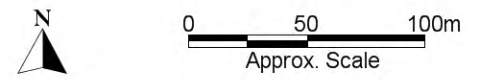


Title:
**1% AEP Existing Conditions Flood Surface Longitudinal Profile
 Geelong - Portarlington Road to Ising St**

Figure:
B-2

Rev:
A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.



Filepath : T:\M7725.JL.Whittington\MapInfo\Drawings\Final\FigB-2_LongSectB_RevA.WOR

APPENDIX C: PUBLIC SUBMISSIONS AND RESPONSES

Six written submission and 16 verbal submissions or enquiries were received. Some of the submitters acknowledged that their properties or roads had experienced flooding in the past in a manner consistent with the Study's flood-mapping.

The major issues of concern raised by owners of affected properties are listed below with the relevant responses provided by the City of Greater Geelong:

1. How can my property be considered subject to flooding when it has never flooded?

Response:

It cannot be assumed that flooding has not previously or will not occur at any given property, on the basis that there are no records of flooding or flooding to the extent identified by the mapping of the 1 in 100 year overland flows.

There is no evidence that the 1 in 100 year or 100 year Average Recurrence Interval (ARI) flood event for the Newcomb-Whittington catchments has occurred within living memory. When reliable rainfall figures have been available, proper analysis has indicated that actual storms were less than the critical event for 1 in 100 year flooding within the catchments.

2. Are flood mitigation works proposed?

Response:

The drainage/flood study included the identification and modelling of flood mitigation options, preparation of cost estimates, feasibility analysis, identification of preferred options and development of a strategy.

Scheme 1 was assessed to be the preferred mitigation scheme and this scheme shall be presented to Council for consideration within future budgets.

3. Will the designation affect my house insurance?

Response:

The Insurance Council of Australia has advised Melbourne Water that most home insurance policies, which provide coverage for storm damage, include cover for damages resulting from overland flows. Residents are advised to check with their insurance companies, but the nature of flooding, i.e. drainage-related rather than waterway, would need to be disclosed to the insurer.

4. Is the information being gathered by Council going to affect property values or saleability?

Response:

It is important to note that designation of an area as liable to flooding does not cause or change the likelihood of flooding, but recognises the existing condition of land.

The designation will not be described on title, but will be disclosed in Land Information Certificates issued under the Local Government Regulations, and for building permits under the Building Regulations.

The value of any property is determined by the complex interplay of many different factors such as demand/supply, location, streetscape and amenity, and it is difficult to assign what effect if any, the identification of land as liable to flooding may have on the value of a property. Devaluation of properties (identified as being liable to flooding) is considered unlikely once the nature of flooding is explained and taken into account.

5. If the value of my property is adversely affected by the flood mapping information, is there compensation available?

Response:

There is no reason for payment of compensation, as nothing has changed about the likelihood of a severe storm occurring or the path that overland flow will take. The City now has accurate information which, in many cases, may already be known by people who have lived at a property for many years.

There is also no case for compensation for subdivision of flood-prone land or construction of dwellings without elevated floors as subdivision and building permit applications were assessed in accordance with the planning scheme provisions and the building regulations, respectively, which were in place at that time.

6. I believe flooding of my property is due to blocked drains and pits.

Response:

Flooding is due mainly to lack of hydraulic capacity within older drainage systems that were designed to the lower standards that were applicable at that time, as well as the lack of easement drainage in some areas.

The City's Infrastructure Operations Unit endeavours to check critical council drainage assets for blockages or obstructions, in order to maximise use of capacity that may be available.



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