5 FLOOD MAPPING

This section provides a brief overview of the floodplain mapping process used in the investigation and the flood extent map for each of the AEP events is presented.

TUFLOW produces a geo-referenced data set defining peak water levels throughout the model domain at the corners of its computational cells. The peak flood level from each of the five storm durations was selected for each computational cell to generate an envelope of peak flood level. These data were imported into GIS to generate a digital model of the flood surface. Contours of flood height (relative to AHD) were extracted directly from the flood surface.

Flood depths were calculated by subtracting the ground level from the flood surface. The GIS was used to carry out the calculation at a horizontal resolution identical to that of the DEM. The digital model of inundation depth was then contoured to map inundation depths over the model domain.

The existing condition flood depth is mapped for the 20%, 5% and 1% AEP events in Figure 5-1 to Figure 5-3 respectively. The flooding within the Portarlington East catchment is generally characterised by shallow sheet flow across most of the catchment, however, a number of key flow paths exist through the residential region. There are a number of depressions located in the lower catchment which act as flood storages

Hazard mapping was undertaken using the methodology prescribed in the Melbourne Water document *Guidelines for Development in Flood-prone Areas*. The analysis is designed to determine if it is safe for people to move about on a property during a flood event. Safety is defined in terms of the depth, velocity and velocity-depth product as follows:

- depth should be no more than 0.35m; and
- velocity should be no more than 1.5 m/s; and
- the product of depth and velocity should be no more than 0.35 m^2/s.

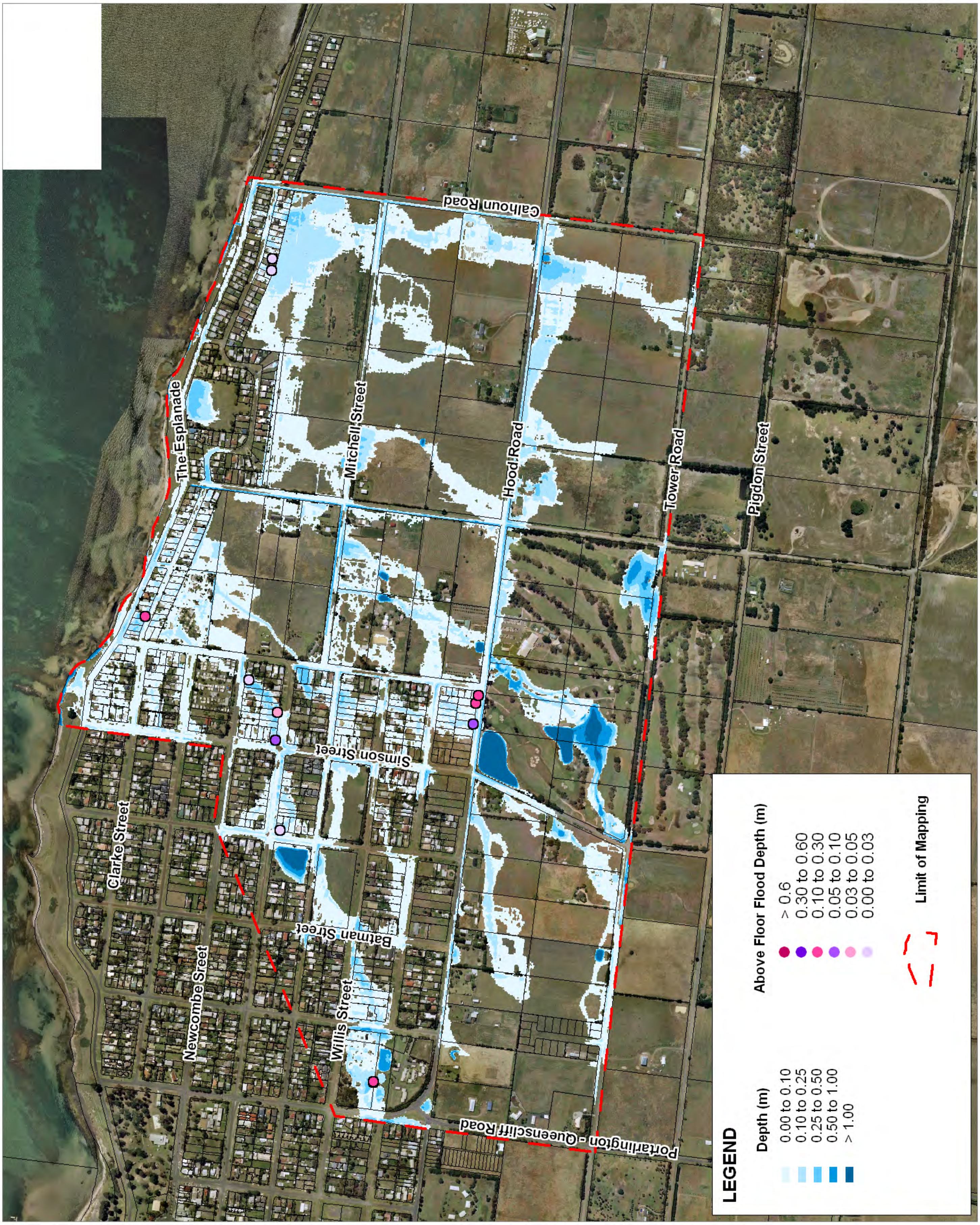
Hazard maps of the Portarlington East catchment for the three flood events are presented in Figure 5-4 to Figure 5-6. There are sections of the main overland drainage paths throughout the catchment that are classified as unsafe in a 1% AEP event. In addition to these main overland flowpaths, the Portarlington Golf Course, the retarding basins between Fisher Street and Gellibrand Street, the retarding basin at Fairfax Street and Seaforth Drive are all regions classified as unsafe in a 1% AEP flood. During the 20% AEP flood, areas considered unsafe are generally located where flood water is 'ponding' and include the retarding basins, the golf course, along table drains and behind road embankments.

The number of properties with flooding within the property boundaries has been determined and these figures are shown in Table 5-1. The number of properties experiencing flooding within the property boundary is significantly higher than those with above floor flooding because a large number of permanent caravan sites have been included in the within property flooding data.

Table 5-1 Number of Flooded Properties

AEP	Number of Flooded Properties	
	Portarlington East	
	Within Property	Above Floor*
1%	334	29
5%	285	21
20%	211	12

*Floor levels are based on properties surveyed (As determined by CoGG)



Title:

Existing 20% AEP Peak Flood Depth

Figure: 5-1

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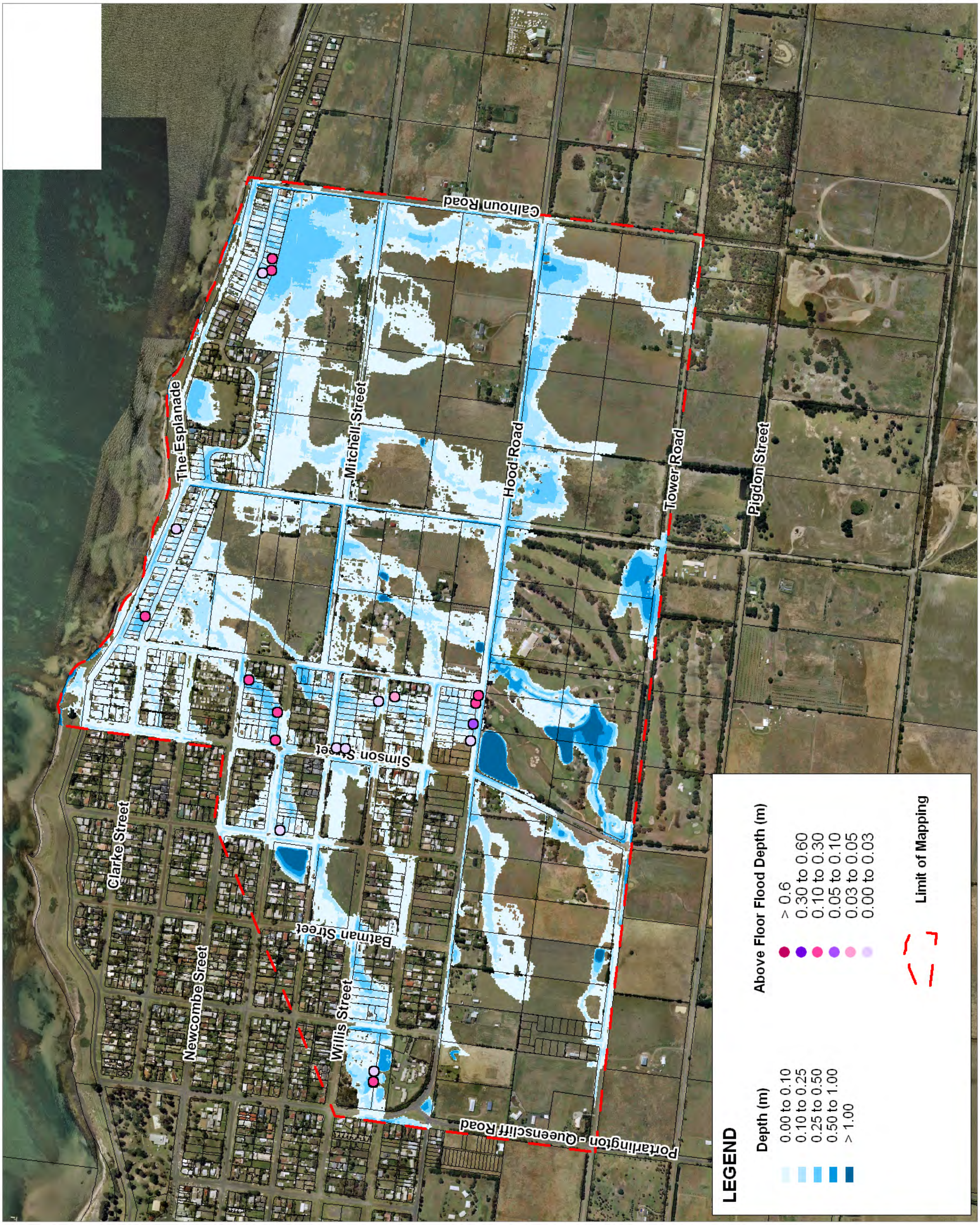

Title:

Existing 5% AEP Peak Flood Depth

Figure: **5-2**

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Approx. Scale

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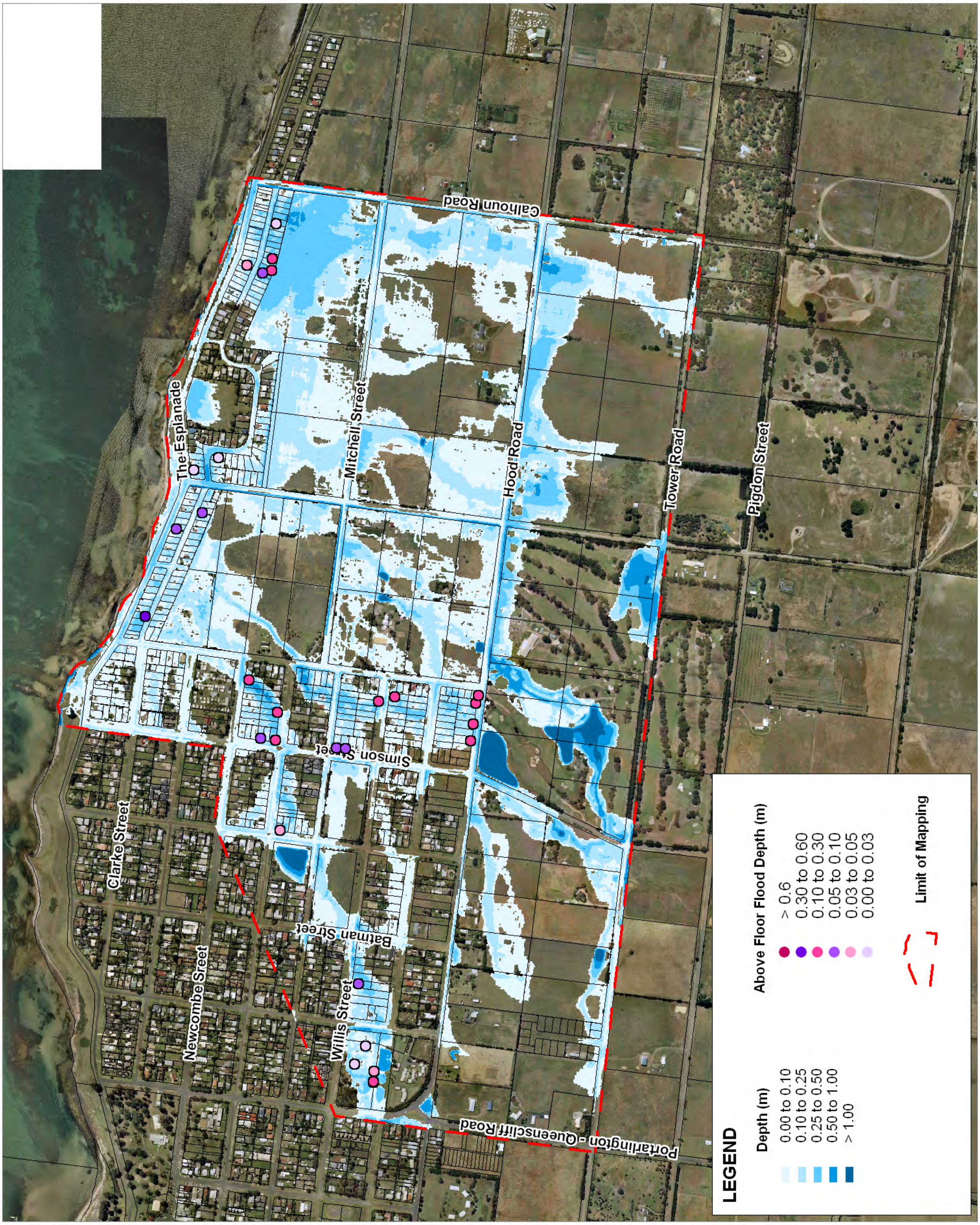

Title:

Existing 1% AEP Peak Flood Depth

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Title:
Existing 20% AEP Hazard Mapping

Figure: 5-4

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Title:

Existing 1% AEP Hazard Mapping

Figure: 5-6

Rev: A

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Title:

Existing 1% AEP Hazard Mapping

Figure: 5-6

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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.

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 (1%, 5% and 20% AEP) modelled using the TUFLOW hydraulic model.
- Determine the damages due to a particular flood event using the assumed 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 4th Quarter 2008 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 1%, 5% and 20% 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 (eg 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.

6.1.2.1 Caravan Park Damages

Within the Portarlington East drainage catchments, there are two caravan parks that were included in the damages assessment. Based on advice from CoGG and a review of depths of flooding indicated by the model, it was assumed that all caravan floor levels are above the 100-year flood level. Therefore the only damages to consider would be the damages that would be experienced by ground level annexes and their contents. Whilst not every site would have an annex, for the purposes of these calculations it was assumed that every site had an annex and that the maximum damage would be $1000. The damages are applied on a sliding scale as described in the previous section. The maximum damage of $1000 was applied once a flood depth of 0.6 metres was achieved.

6.1.3 Damages Calculations

The peak 1%, 5% and 20% 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 Portarlington East study area, as presented in Table 6-1, is $67,000.

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%			$ 446,000	
100	1%	$ 313,000	$ 94,000	$ 407,000	$ 4,000
20	5%	$ 190,000	$ 57,000	$ 247,000	$ 13,000
5	20%	$ 108,000	$ 32,000	$ 140,000	$ 29,000
2	50%	$ -	$ -	$ -	$ 21,000
Average Annual Damage					**$ 67,000**

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

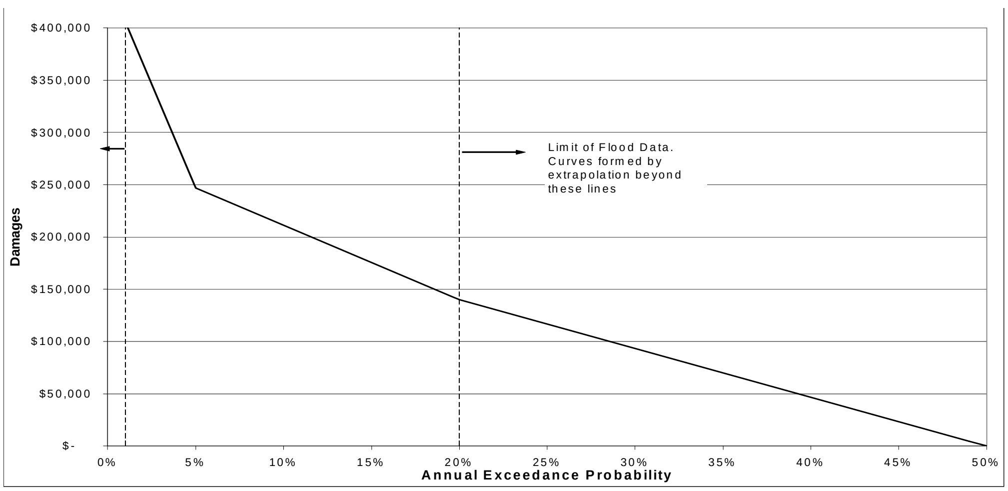

Figure 6-1 Existing Conditions Damages Probability Curve

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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 Portarlington East drainage catchments, widespread above ground flooding was observed throughout the study area. Despite the number of properties exposed to above ground flooding, relatively few houses had above floor flooding. However, the houses that would be subject to above flood flooding were grouped in four distinct areas. Consequently, reducing the flood levels in these four areas formed the focus of the mitigation schemes. The four areas of concern were:

1. The nursing home on Willis Street;
2. the residential area North of the Portarlington Golf Course;
3. the houses located in the overland flow path between the nursing home and Port Phillip Bay; and
4. the houses located between Port Phillip Bay and the rural land in the North East region of subject site.

7.2 Mitigation Option Screening

A wide range of mitigation options were considered as part of the "first pass" assessment. Options such as localised bund walls and pipe system upgrades were considered to alleviate a number of the flooding issues in the areas of concern. Large-scale levees, floodwalls and floodplain modification were not considered appropriate for the current study area. 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	Considered	✓
		Diversions	Not appropriate	✗
		Floodways	Not appropriate	✗
		Open Drain	Considered	✗
		Channel Improvement	Considered	✗
		Bund Walls	Considered	✓
		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	Not feasible	✗
		Voluntary House Raising	Not feasible	✗
Rural	Structural Measures	Levees	Considered	✗
		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 this catchment, 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 value of the properties in these areas.

7.3.2 Structural Options

The CoGG required that three mitigation schemes be assessed, with one of the schemes being "do nothing". A scheme is a combination of individual mitigation options. The three schemes that were assessed for the Portarlington East drainages catchment are summarised in Table 7-2 and in Figure 7-1 and Figure 7-2. Hydraulic and economic assessments were undertaken for each scheme.

Table 7-2 Portarlington East Catchment Mitigation Scheme Details

Scheme Number	Details
One	A new bund wall along the north side of the drainage easement between Fisher Street and Gellibrand Street to prevent flooding of the nursing home on Willis Street. Improvements would be made to the existing pipe network between the nursing home on Willis Street and the outfall at Mercer Street to help reduce the overland flow along this flowpath. The upgrade to the pipe network between the nursing home and the existing basin on the corner of Stevens and Fairfax Street will result in increased flows to the retarding basin. Therefore, improvements would be made to the performance of the existing retarding basin on the corner of Stevens and Fairfax Street and through the creation of additional flood storage in the public reserve located in the block bounded by Batman, Stevens, Fairfax and Willis Streets. . A new pipe network would be constructed from the corner of Hood Road and Simson Road to capture the overland flow currently flooding properties in the vicinity. This pipe would flow into the upgraded Mercer Street pipes at Simson Street. A new bund wall would be constructed along the southern edge of the properties on Seaforth Drive and Sunset Boulevard to prevent the overland flow from entering their properties
Two	A new pipe network would be constructed from the corner of Hood Road and Simson Road to capture the overland flow currently flooding properties in the vicinity. This pipe would flow along Mercer Street and Mitchell Street to follow the alignment of the originally proposed Mitchell Street Main Drain. The open drain currently utilised along Mitchell Street and Oxley Street would be covered and replaced with a pipe network. A new bund wall would be constructed along the southern edge of the properties on Seaforth Drive and Sunset Boulevard to prevent the overland flow from entering their properties
Three	Do Nothing

7.3.2.1 Pipe Works

The proposed pipe works are extensive and have been summarised below for the two modelled mitigation schemes.

Scheme One Pipe Works

The Scheme One pipe works are in two components; a new pipe network from the corner of Simson Street and Hood Road to Fenwick Street and an upgrade to the existing network between Gellibrand Street and the Mercer Street outfall.

The capacity of the existing pipe network between Gellibrand Street and the Mercer Street outfall was increased at selected locations to reduce overland flooding (in conjunction with the other structural methods). The pipes between Gellibrand Street and Batman Street have been upgraded to twin 900 mm reinforced concrete pipes (RCP). At the corner of Batman Street and Willis Street this pipe network reverts back to the existing pipe size (single 900mm RCP) with the excess flow being diverted into the flood storage). The pipes from the corner of Simson Street and Fenwick Street to the corner of Mercer Street and Newcombe Street have been upgraded to twin 1500 mm RCP to account for the additional water entering the system from the new pipe network (see following paragraph). This upgraded pipe network does not follow the original alignment through the existing residential area; rather it follows the existing road alignments. This alignment would limit the disruption to the existing residents and prevent new pipes being laid in the existing drainage easement (and the possibility of having to enlarge the easement). From the corner of Mercer Street and Newcombe Street, the pipe has been upgraded to triple 750 mm RCPs (due to lack of available pipe cover for large pipes). This configuration continues until the outfall which has been upgraded from a single 1200 mm wide x 600 mm high rectangular box culvert to three 1200 mm wide x 600 mm high rectangular box culverts. The outfall was sized to prevent any localised flood level increases through the surcharging of the side entry pits and manholes.

The new pipe network consists of twin 1500 mm reinforced concrete pipess (RCP) along Hood Road (between Simson Street and Mercer Street) and then along Simson Street to its intersection with Fenwick Street. At this point, the new pipe network connects into the upgraded pipe network.

Scheme Two Pipe Works

The Scheme Two pipe works are a variation on the main drain design originally proposed by the Shire of Bellarine for the Mitchell Street Main Drain.

The new pipe alignments for Scheme Two follow the existing road alignments rather than the existing drainage easements to reduce the disruption to the local residents. The new pipe network consists of twin 1200 mm RCPs along Hood Road (between Simson Street and Mercer Street) and along Mercer Street until Willis Street. Single 750 mm RCP culverts are also proposed along Payne Street and Mercer Street to capture additional overland flow and these pipes connect into the twin 1200 mm RCPs along Mercer Street. From Willis Street, the pipes along Mercer Street increase to twin 1500 mm RCPs to cater for the increased flow. An additional 750 mm RCP enters the system at Stevens Street before the twin 1500 mm RCPs are continued along Mitchell Street. The pipe network follows the path of the open channel and results in this open channel being replaced with the twin 1500 mm pipes. The twin 1500 mm RCPs continue along Oxley Street before reverting to triple 750 mm RCPs due to the lack of available cover for the pipes as the system approaches Valerie Avenue. The existing outfall under The Esplanade is retained and any excess water bubbles up from the pipe system on the South side of The Esplanade before travelling overland into Port Phillip Bay.

7.3.2.2 Retarding Basin Works

Existing Basin on Fairfax Street (between Stevens and Fenwick Street)

The outlet pipe has been increased from 300 mm to 525 mm to improve the basin performance. There are no changes proposed to the storage volume characteristics of the basin because of vegetation constraints.

Proposed Flood Storage bounded by Batman, Stevens, Fairfax and Willis Streets

The proposed works are designed to make better use of the public open space as flood storage. The proposed works include the construction of a bund wall with crest elevation of 10.5 metres AHD along the northern and eastern boundaries. Other than the locations of the bund walls, the remainder of the site would be left at the natural surface level. Water would enter the site via overland flow paths and through a 'bubble' pit located in the south-west corner. The basin would drain through an outlet structure consisting of a 600 mm diameter RCP structure in the north-east corner into the existing pipe network along Fairfax Street.

7.3.2.3 Flood Bund Works

Nursing Home Flood Bund

A flood bund would be constructed on the northern side of the drainage reserve between Fisher Street and Gellibrand Street. This bund would prevent floodwaters from all flood events up to and including the 1% AEP flood event from entering the nursing home on Willis Street. There are no changes to the drainage reserve other than the creation of the flood bund and the existing lakes would be retained without modification. This flood bund would be set approximately 0.5 metres above the existing ground level.

Seaforth/Sunset Flood Bund

A flood bund would be constructed along the southern boundaries of the properties along Seaforth Drive and Sunset Boulevard. This bund would prevent floodwater from all events up to and including the 1% AEP flood event from the rural properties located upstream. The flood bund only exists behind the properties and allows water to flow overland down Calhoun Road into Port Phillip Bay. On average, this flood bund would be set approximately 0.3 metres above the existing ground level

7.3.3 Hydraulic Assessment

The 1%, 5% and 20% AEP design floods were assessed using the same five storm duration events as used for the existing case. A peak flood height envelope was then developed for each flood event for each scheme. 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" schemes 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 each scheme.

The mapping pertaining to each scheme in the hydraulic assessment illustrate no change in flood level within a ± 0.03 m tolerance as yellow, 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 Portarlington East catchments, are mapped in Figure 7-3 to Figure 7-5 for the three flood events assessed.

The modelling of Scheme One indicates that bund wall constructed between Fisher Street and Gellibrand Street will prevent flooding in the nursing home in all flood events. Whilst localised flood levels have increased throughout the adjacent drainage reserve in all events, the increases do not extend past Gellibrand Street. The upgraded pipe network and basins have reduced or removed flooding for a number of properties along the overland flow path between Gellibrand Street and Batman Street. As expected there are increased flood levels in the proposed flood storage. The storage has significantly reduced flooding in the public open land immediately to the east of the storage as well as successfully mitigating the increased flows generated by the upgraded pipe network from Gellibrand Street to the additional storage.

The proposed pipe from the corner of Simson Street and Hood Road has reduced and eliminated flooding in all flood events for a large number of properties between Simson Street and Mercer Street. During the 100 year flood event, this pipe caused localised flood level increases at the corner of Simson Street and Payne Street, but the majority of these increases are contained within the road reserve. There are increases in flood level for the property located on the north-east corner of this intersection. No habitable properties are evident in the available aerial photography; however, additional consideration for this property may be needed during the detailed design of the mitigation scheme.

The proposed bund wall along the Southern edge of the properties along Seaforth Drive and Sunset Boulevard prevents all these properties from being flooded as a result of flood water flowing to the North. In the 5% and 1% AEP impacts of up to 100mm are experienced upstream of this bund wall as a result of increased water ponding in the area.

Overall, Scheme One reduces or prevents flooding in all four of the target areas with relatively few areas experiencing increased flood levels.

Table 7-3 Reduction in Flooded Properties – Scheme One

AEP	No. Flooded Grounds		Reduction	No. Flooded Floors*		Reduction
	Existing	Scheme One		Existing	Scheme One	
1%	334	234	*100*	29	12	*17*
5%	285	190	*95*	21	5	*16*
20%	211	160	*51*	12	3	*9*

*Number of flooded floors is based on properties surveyed.

7.3.3.2 Scheme Two

The change in peak flood height and the properties with above floor flooding, for Scheme Two of the Portarlington East catchments, are mapped in Figure 7-6 to Figure 7-8 for the three flood events assessed.

The proposed pipe removes and/or decreases the overland flooding from the residential areas between Simson Street and Mercer Street. However, this pipe does not match the performance of the existing open drain and water now flows overland across properties north of Mitchell Street towards the Oxley Street outfall. This additional water elevates flood levels along Oxley Street and consequently allows flood waters onto some properties during the 1% AEP flood event that were considered 'dry' under Scheme One. This scheme also results in increased flooding along Seaforth Drive during the 20% AEP flood event

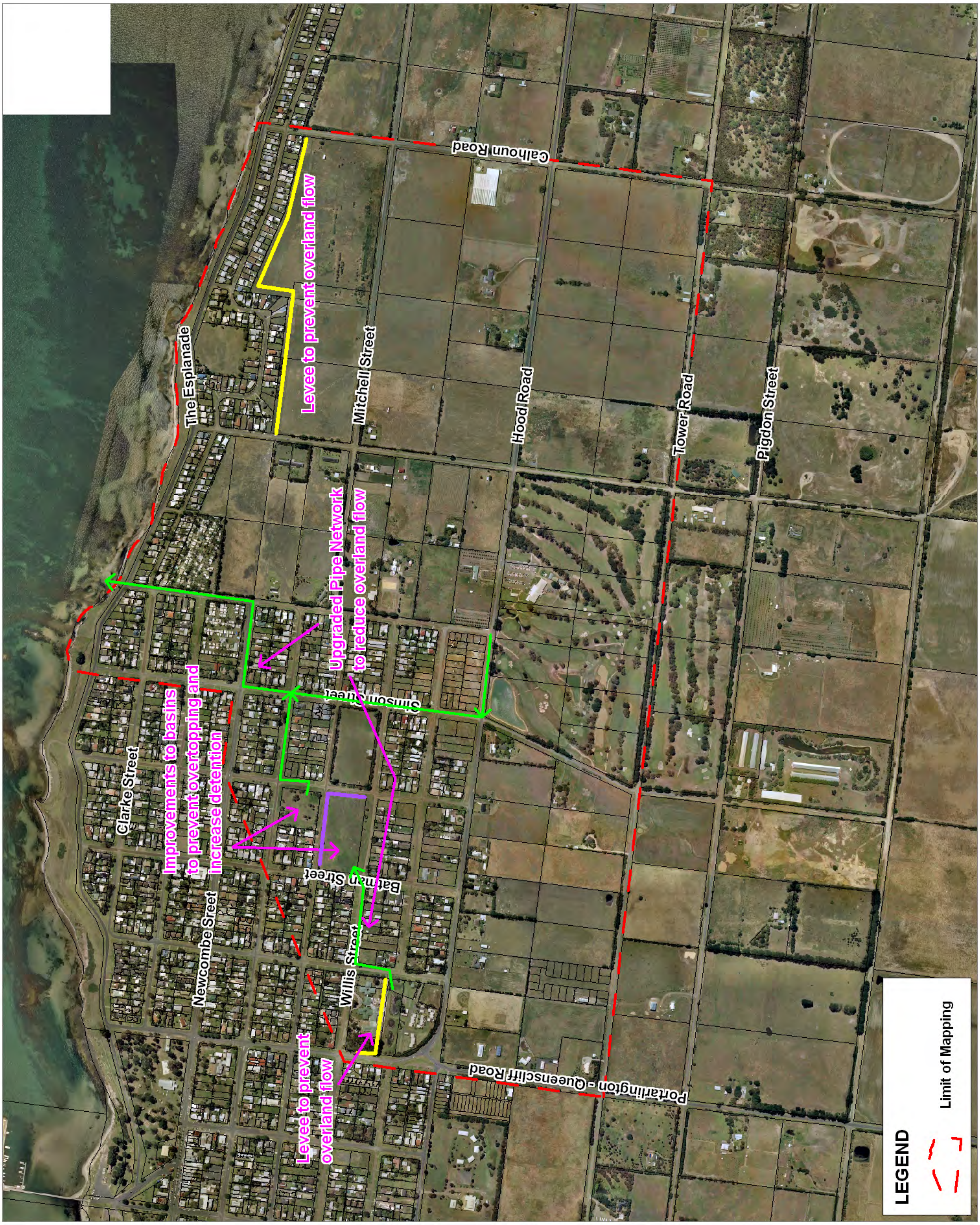
The proposed bund wall along the Southern edge of the properties along Seaforth Drive and Sunset Boulevard prevents all these properties from being flooded as a result of flood water flowing to the North. As discussed above the effectiveness of this bund wall has been reduced due to additional floodwater travelling overland from Mitchell Street. In the 5% and 1% AEP impacts of up to 100mm are experienced upstream of this bund wall as a result of increased water ponding in the area.

Overall, Scheme Two reduces or prevents flooding in two of the four of the target areas, however there is significantly increased flooding through property that was previously considered 'flood-free'. In this scheme, above floor flooding remains at the nursing home on Willis Street

Table 7-4 Reduction in Flooded Properties – Scheme Two

AEP	No. Flooded Grounds		Reduction	No. Flooded Floors*		Reduction
	Existing	Scheme Two		Existing	Scheme Two	
1%	334	262	*72*	29	19	*10*
5%	285	232	*53*	21	12	*9*
20%	211	178	*33*	12	7	*5*

*Number of flooded floors is based on properties surveyed.



Title:

Scheme One Drainage Works

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Scheme Two Drainage Works

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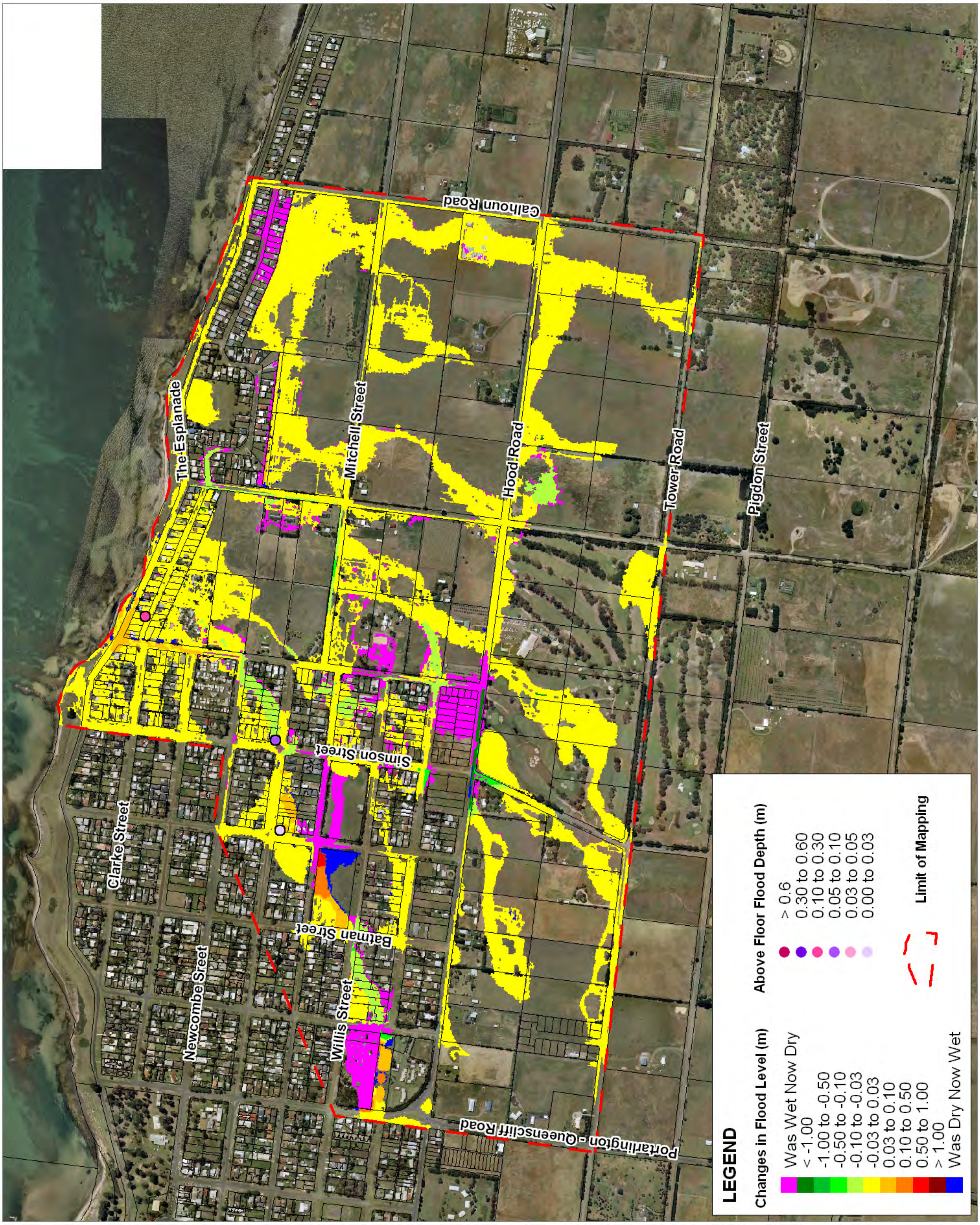

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Scheme One 20% AEP Peak Flood Impact

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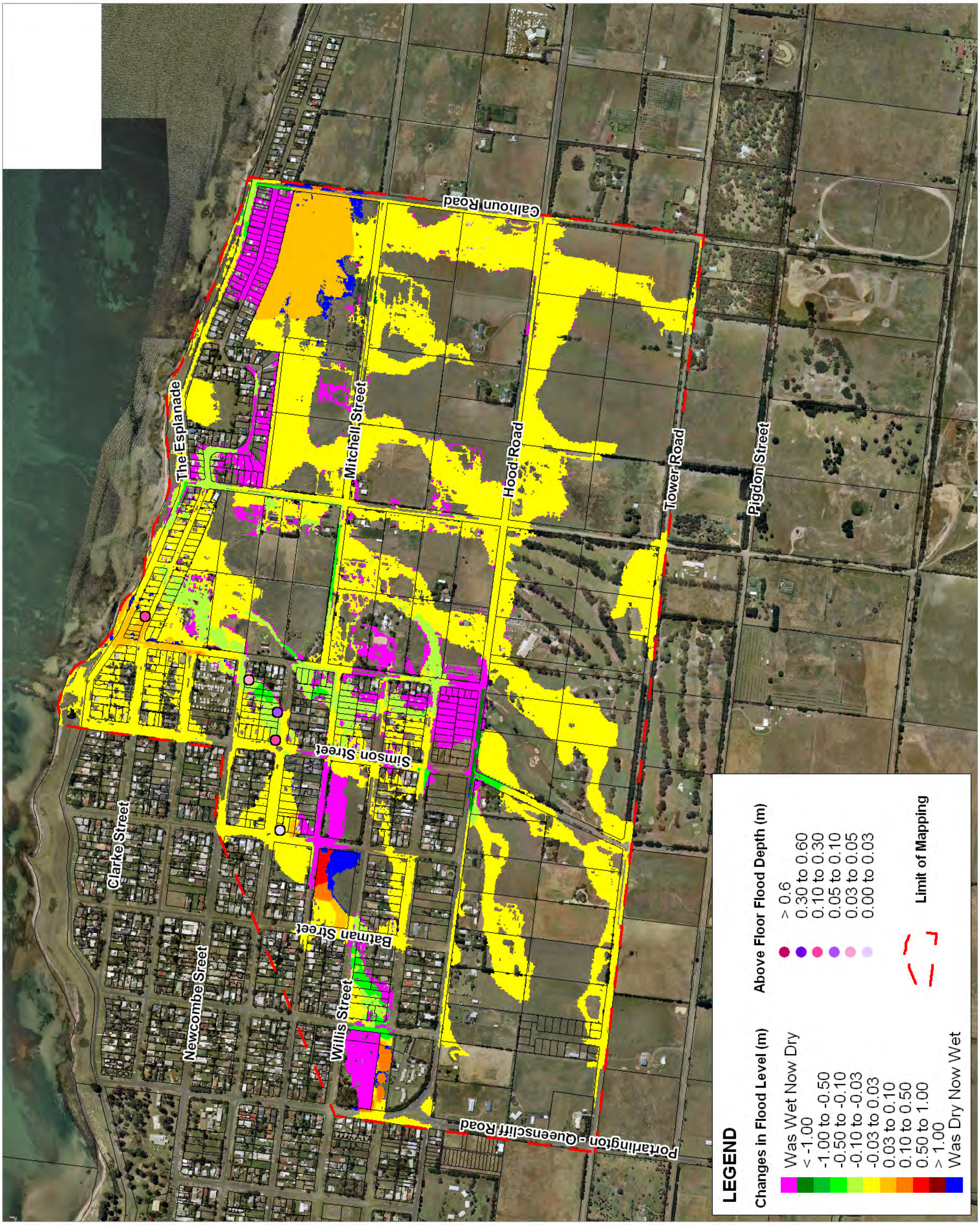

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Scheme One 5% AEP Peak Flood Impact

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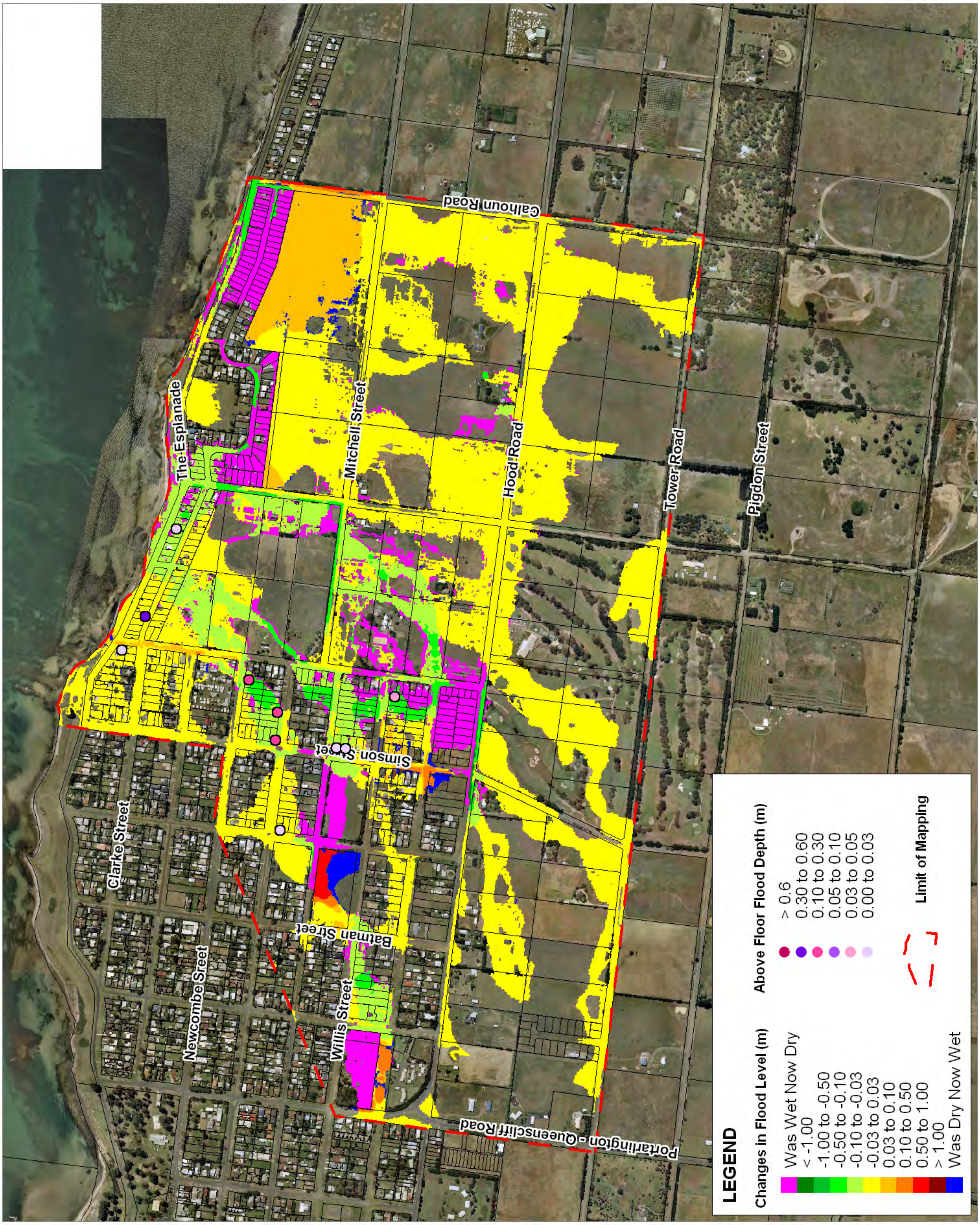

Title:

Scheme One 1% AEP Peak Flood Impact

Figure: 7-5

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Approx. Scale

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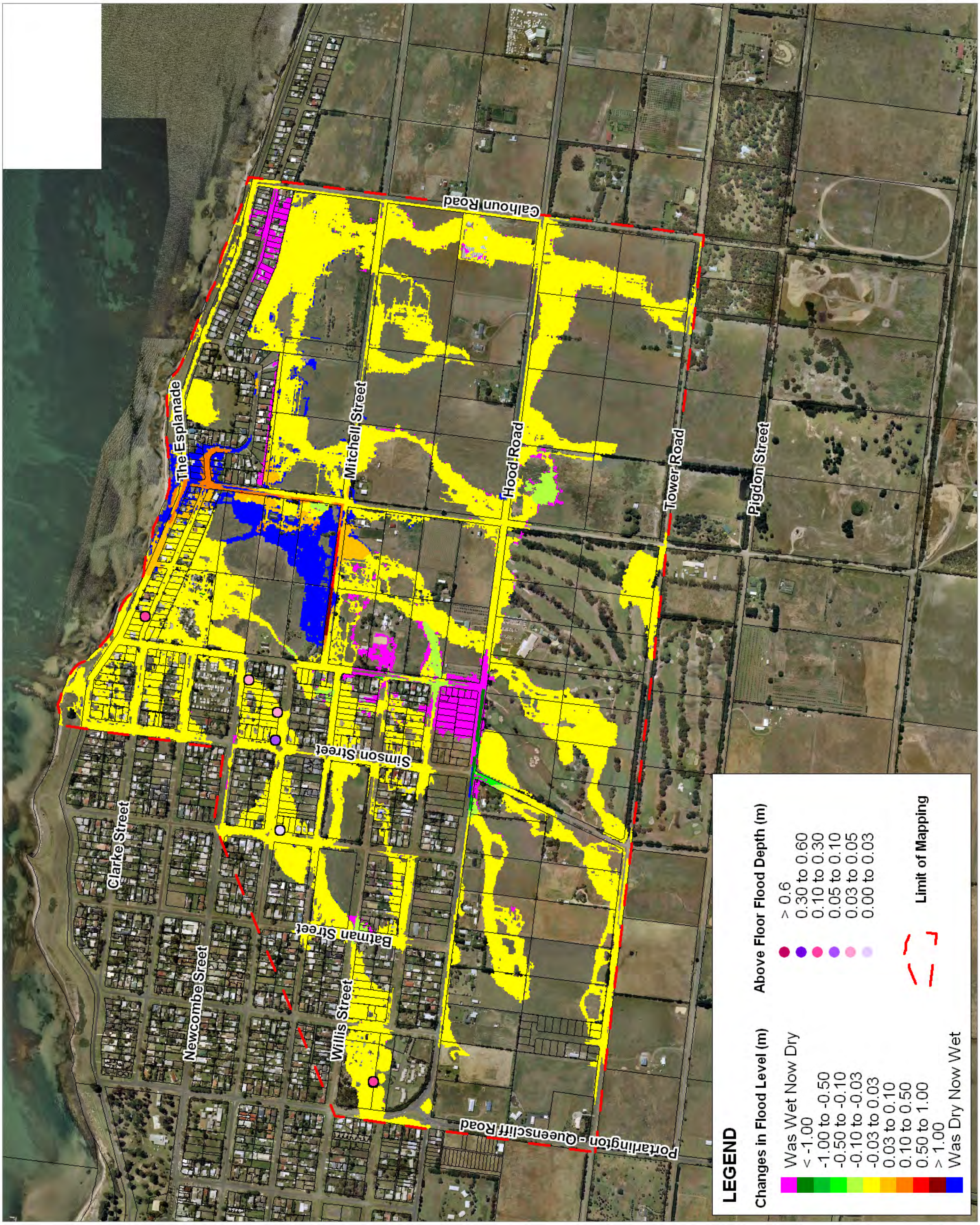

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Scheme Two 20% AEP Peak Flood Impact

Figure: 7-6

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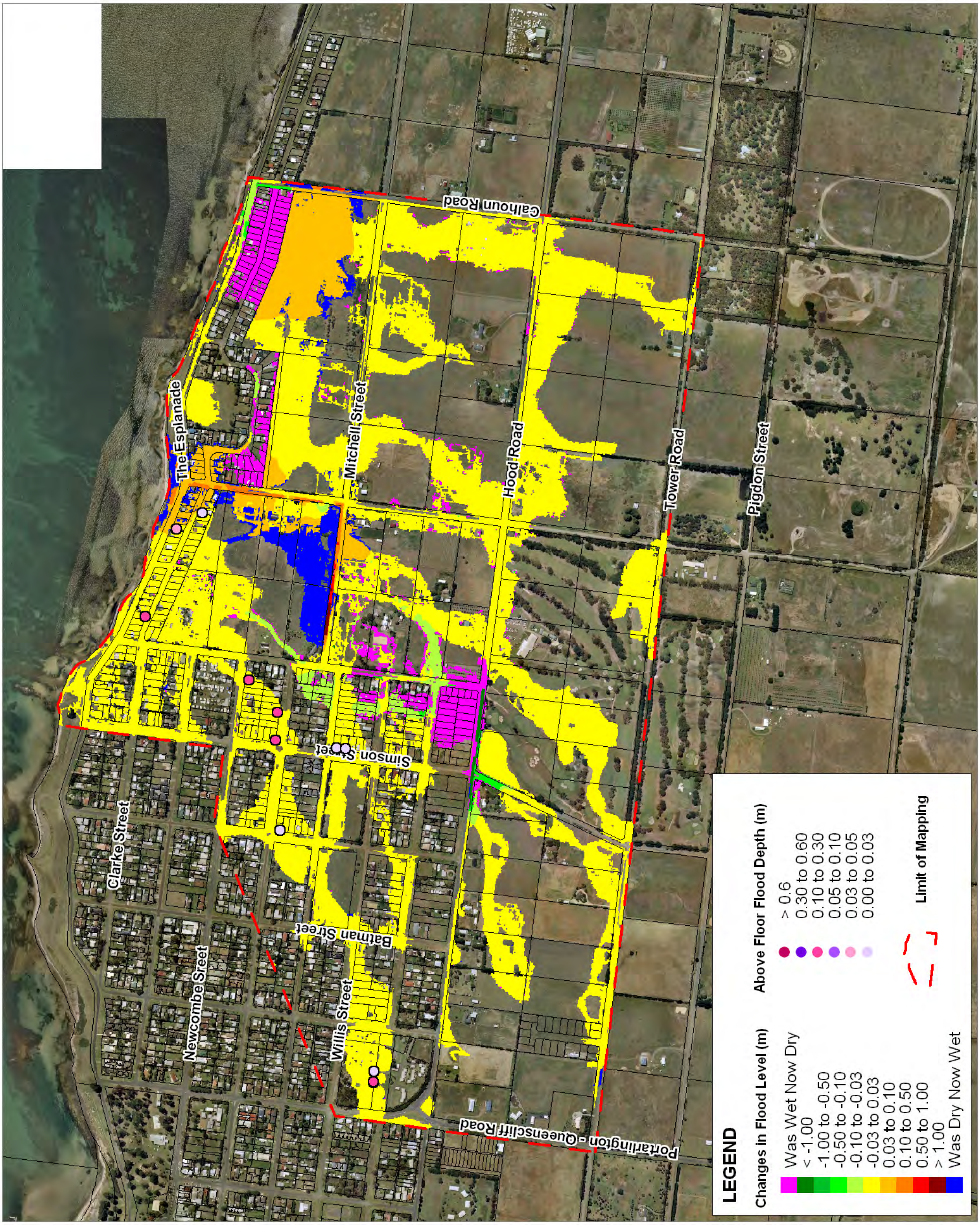

Title:

Scheme Two 5% AEP Peak Flood Impact

Figure: 7-7

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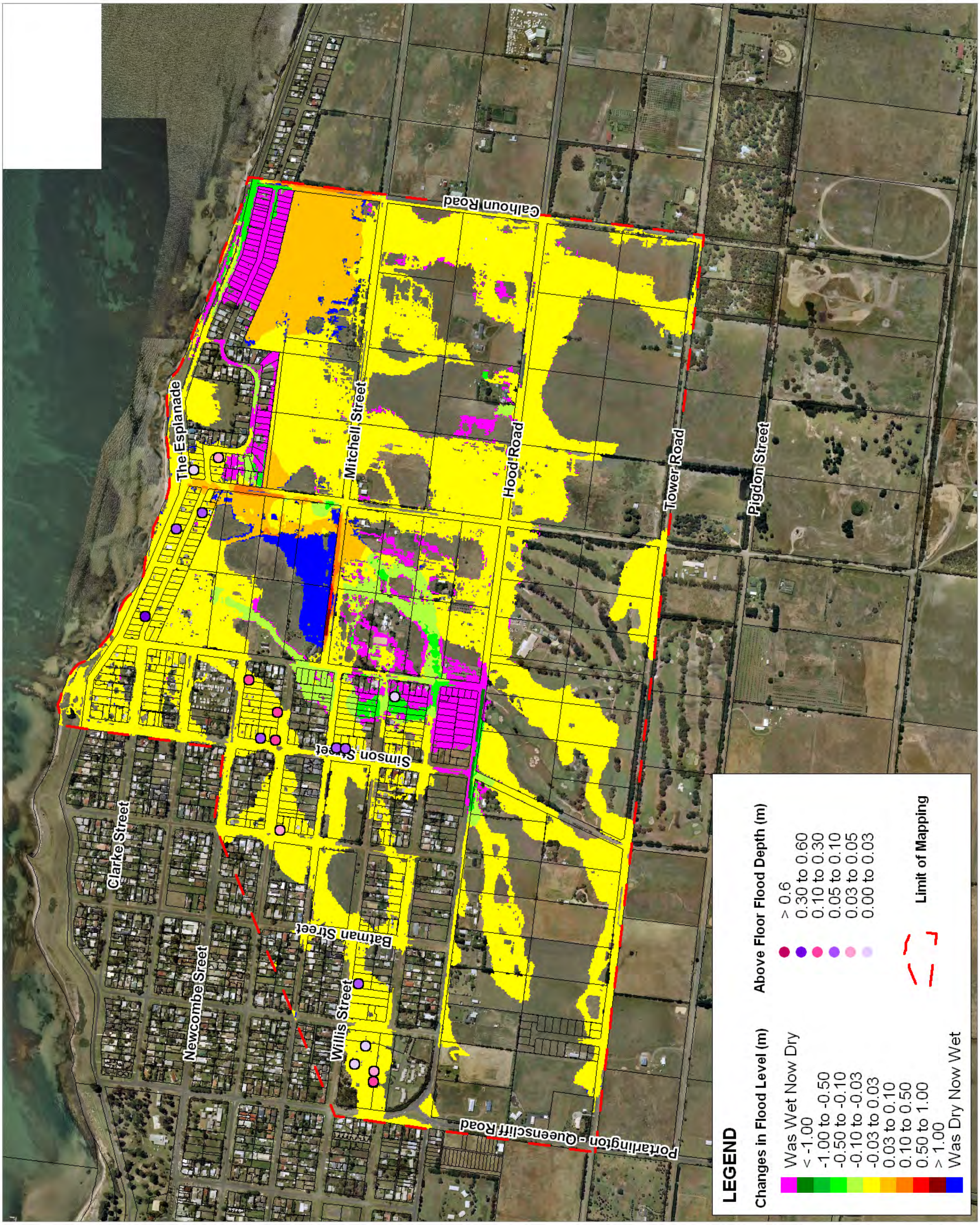

Title:

Scheme Two 1% AEP Peak Flood Impact

Figure: **7-8**

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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;
- 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 (ie. 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.

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

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;
- Calculate the total cost of the option.

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

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

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;
- construction, maintenance and operation costs.

Data from Melbourne Water guidelines and pipe, pump and valve suppliers were used to estimate the total cost of each option. These rates are summarised in Appendix C. The rates for stormwater pipes and rising mains were factored by 1.5 for sections constructed alongside or under minor roads, and by 2.0 for major roads or through developed property. Stormwater pipes were costed on the basis of flush jointed construction with 100% fine crushed rock backfill.

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. WBM have 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 $26,000, which is a reduction of $41,000 from the existing conditions AAD of $67,000. In calculating the AAD, the damages in the PMF were assumed to be the same as the existing case.

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 0.09. 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 $262,000.

Table 8-2 Scheme One Damages Summary

Event		Scheme One			
(Years ARI)	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF+	0.0%			$ 148,000	
100	1%	$ 105,000	$ 32,000	$ 137,000	$ 1,000
20	5%	$ 71,000	$ 21,000	$ 92,000	$ 4,000
5	20%	$ 43,000	$ 13,000	$ 56,000	$ 11,000
2	50%	$ -	$ -	$ -	$ 8,000
Average Annual Damage					**$ 26,000**

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

Table 8-3 Scheme One Capital Costs

Item	Capital Cost
Pipe Works	$ 2,977,000
Levee Works	$ 79,000
Contingencies (20%)	$ 917,000
Engineering (10%)	$ 458,000
Total	**$ 4,431,000**

Table 8-4 Scheme One BCR Summary

	Existing	Scheme One
Damages (PA)	$67,000	$ 26,000
Benefit (PA)		$ 41,000
Benefit (NPV)		$ 509,000
Capital Cost		$ 4,431,000
Maintenance (PA)		$ 106,000
Maintenance (NPV)		$ 1,315,000
Total Option Cost		$ 5,746,000
BCR		**0.09**

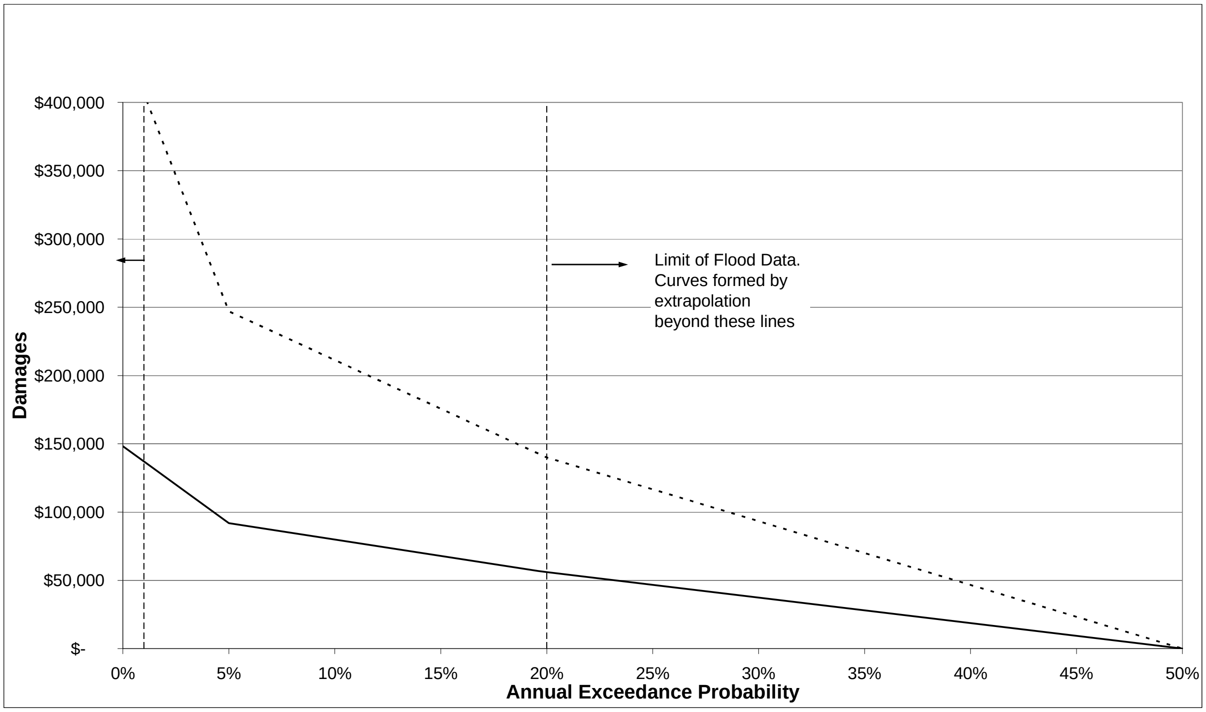

Figure 8-1 Scheme One Probability Damages Curve

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 $44,000, which is a reduction of $23,000 from the existing conditions AAD of $67,000. In calculating the AAD, the damages in the PMF were assumed to be the same as for the existing case.

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 0.05 because the annual benefit, and hence total benefit, is small. 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 $438,000.

Table 8-5 Scheme Two Damages Summary

Event		Scheme Two			
(Years ARI)	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF+	0.0%			$ 268,000	
100	1%	$ 189,000	$ 57,000	$ 246,000	$ 3,000
20	5%	$ 122,000	$ 37,000	$ 159,000	$ 8,000
5	20%	$ 73,000	$ 22,000	$ 95,000	$ 19,000
2	50%	$ -	$ -	$ -	$ 14,000
Average Annual Damage					**$ 44,000**

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

Table 8-6 Scheme Two Capital Costs

Item	Capital Cost
Pipe Works	$ 2,981,000
Levee Works	$ 27,000
Contingencies (20%)	$ 903,000
Engineering (15%)	$ 451,000
Total	**$ 4,362,000**

Table 8-7 Scheme Two BCR Summary

	Existing	Scheme 2
Damages (PA)	$ 67,000	$ 44,000
Benefit (PA)		$ 23,000
Benefit (NPV)		$ 285,000
Capital Cost		$ 4,362,000
Maintenance (PA)		$ 105,000
Maintenance (NPV)		$ 1,303,000
Total Option Cost		$ 5,665,000
BCR		**0.05**

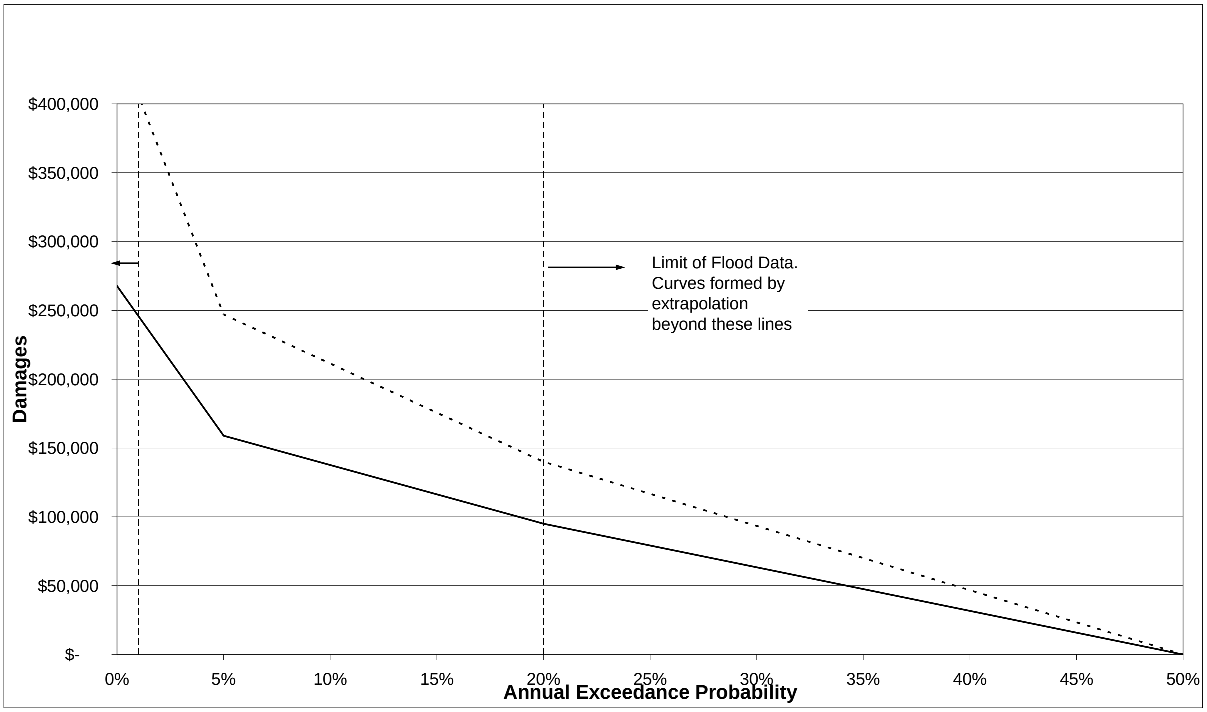

Figure 8-2 Scheme Two Probability Damages Curve

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 Portarlington East catchments. It is not anticipated that any of the schemes will have long-term environmental impacts.

Table 8-8 Environmental Implications Portarlington East Schemes

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	**Scheme Two**	**Scheme Three "Do Nothing" (Existing Case)**
Ecological impact.	Increased water levels in the artificial lakes between Fisher Street and Batman Street will be experienced during flood events. These increases will be of a short duration (of the order of a few hours). No changes are proposed to the lake outlets and hence the permanent water level will not be altered from the current condition. Studies would need to undertaken to determine if any significant fauna species or habitats are present and if they are likely to be impacted by the proposed changes. Ecological assessments may be required for proposed modifications to the stormwater outfalls.	Ecological assessments may be required for proposed modifications to the stormwater outfalls.	No Change.
Noise.	Minor impacts associated with the construction of bund walls and pipe works.	Same as Scheme One	No Change.

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	**Scheme Two**	**Scheme Three "Do Nothing" (Existing Case)**
Receiving Water Quality.	Insignificant impact. The upgraded pipe networks will increase the flow of stormwater through the outfalls into Port Phillip Bay and potentially reduce the deposition of pollutants upstream within storage areas. However, this potential impact would be offset by reductions in contaminated overland flows (contaminated with sediment from localised erosion and sewerage from sewer overflows) entering Port Phillip Bay. A thorough Construction Management Plan would be required for any works to minimise sediment entering the receiving water during construction of the proposed mitigation options.	Same as Scheme One.	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 Portarlington East.

Table 8-9 Social Indicators Portarlington East Schemes

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	**Scheme Two**	**Scheme Three** **"Do Nothing" (Existing Case)**
Recreation and Aesthetic.	Low impact. Minor impacts to the public reserve surrounded by Willis, Batman, Stevens and Fairfax Street during construction of the bund wall. This space may be unsuitable for use after prolonged heavy rain. Aesthetic values may be impacted during construction of the various components of the mitigation scheme	Aesthetic values may be impacted during construction of the various components of the mitigation scheme No impact is expected on the recreation values of the catchment	No Change.
Cultural Heritage.	Manage via Cultural Heritage Management Plan.	Same as Scheme One.	No Change.
Public Safety.	Risk would be minimal during construction. Manage risk with appropriate construction phase management plans. Some potential risk from large drainage structures. Manage with best practice design.	Same as Scheme One	Areas of unsafe flooding would remain.

8.4 Feasibility and Performance Indicators

Table 8-10 presents the feasibility and performance indicators for the Portarlington East mitigation schemes.

Table 8-10 Feasibility and Performance Indicators Portarlington East Schemes

ISSUE	FLOOD MITIGATION SCHEMES		
	Scheme One	**Scheme Two**	**Scheme Three "Do Nothing" (Existing Case)**
Maintenance costs.	Increases associated with new and modified flood storages, new and upgraded pipe systems and bund walls.	Increases associated with new and upgraded pipe systems and bund walls.	No Change.
Ease of Construction	Difficulties associated with the upgrading of existing pipes and laying of new pipes. By using new alignments along roads instead of existing easements through properties, these difficulties are reduced	Same as Scheme One	Not applicable.
Funding and feasibility.	High capital costs would make funding difficult, although BCR of 0.09 is the more attractive of the two schemes. Capital cost of Scheme One per property floor saved from flooding during a 1% AEP flood event is lowest at $262,000.	High capital cost and a low BCR of 0.05 would make funding difficult. Capital cost of Scheme Two per property floor saved from flooding during a 1% AEP flood event is $438,000.	Not applicable.
Public acceptability.	There may be some issues during construction of the proposed measures.	Same as Scheme One	Issues relating to Council being seen to be doing nothing structurally about the problem.

9 PREFERRED MITIGATION SCHEME

9.1 Description of Preferred Scheme

Scheme One is the preferred mitigation scheme for the Portarlington East 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 City.

As documented in the previous sections, and summarised below in Table 9-1, Scheme One has a similar capital cost when compared to Scheme Two, however, it has significantly more flood benefit to the community and hence has a higher BCR than Scheme Two. Scheme One also has a lower capital cost per floor saved in the 1% AEP flood event.

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	$4,459,000	0.09	17	$262,000
Two	$4,378,000	0.05	10	$478,000

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 schemes;
- the social impacts arising from Scheme One are very limited; and
- the feasibility and performance are comparable to the other schemes.

9.2 Structural Components

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

- A new bund wall along the north side of the drainage easement between Fisher Street and Gellibrand Street to prevent flooding of the nursing home on Willis Street. Improvements would be made to the performance of the existing retarding basin on the corner of Stevens and Fairfax Street and additional flood storage would be created in the public reserve located in the block bounded by Batman, Stevens, Fairfax and Willis Streets. Improvements would also be made to the existing pipe network between the nursing home on Willis Street and the outfall at Mercer Street to help reduce the overland flow along this flowpath.
- A new pipe network would be constructed from the corner of Hood Road and Simson Road to capture the overland flow currently flooding properties in the vicinity. This pipe would flow into the upgraded Mercer Street pipes at Simson Street.
- A new bund wall would be constructed along the southern edge of the properties on Seaforth Drive and Sunset Boulevard to prevent the overland flow from entering their properties

Increased surveillance of critical drainage assets for blockages or obstructions is also recommended until such time as the works recommended above have been constructed.

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.

A number of non-structural components are recommended for implementation in conjunction with the structural measures. These additional measures are summarised below.

- Further investigation into the feasibility of property-specific measures to manage risk from residual flooding (with Scheme One 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, although opportunities for the latter may be limited because of recent increases in property values.
- Education and awareness program to inform landowners how to minimise the magnitude of damage during 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 catchment 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 (planning permit) 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 strategy for each flood event as follows:

Flood Impacts - Figure 7-3 to Figure 7-5;

Flood Hazard Maps - Figure 9-1 to Figure 9-3

The flood hazard maps (Figure 9-1 to Figure 9-3) show areas of increased flood hazard where floodwaters have ponded in the newly created flood storages (behind the bund walls). Appropriate signage may need to be provided in these areas to inform the public of the risk floodwaters pose to their safety.

Large scale A1 plans show detailed mapping of flood extent and flood impacted properties for each of the 1%, 5% and 20 % 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;
- ***Public Benefit*** is related to infrastructure that provides a benefit to the wider community throughout the municipality.

Clearly, augmentation works undertaken within the Portarlington East 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 catchment 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 catchment. 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 Portarlington East Drainage Catchments area, 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 catchment is approximately $3.8M, excluding engineering costs. Council currently allocates approximately $2M per annum for major drainage works. Assuming that Council increases funding for drainage works and that $0.35M per annum could be allocated for this program, and then the construction program could be staged over a period of 8 years. Allowing one year for the determination and arrangement of funding sources and the design of the drainage works, the period of implementation would be 9 years. The designation of flood levels and application of flood zones/overlays would occur in the first 2 years, and individual floodproofing would commence in year 8, 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	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 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 Floodproofing.				■	■	■	■	■	■	■	■	■
Education and Awareness Program.	■	■	■	■	■	■	■	■	■	■	■	■

Title:

Preferred Scheme 20% AEP Hazard Mapping

Figure: 9-1

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Title:
Preferred Scheme 5% AEP Hazard Mapping

Figure: 9-2

Rev: B

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.

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Title:
Preferred Scheme 1% AEP Hazard Mapping

Figure: 9-3

Rev: A

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10 PUBLIC CONSULTATION PROCESS

The Draft Report of the Portarlington East Drainage/Flood Study and associated flood mapping were placed on public exhibition with an invitation for submissions. The general public was advised of the exhibition via public notices, and owners of properties affected by the 100 year ARI flood extent within the study area (approximately 450 properties) received individual letters with explanatory sheets.

A total of 27 submissions were received; 14 written and 13 verbal. A number of submissions were from owners of properties that had experiences flooding problems that were consistent with the flood mapping produced by the Study. The majority of submissions were from property owners concerned about designation of their properties under Building Regulations 2006. The major issues of concern and the City's responses are listed in

11 REFERENCES

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