Stormwater Drainage Assessment Report

East Village

V171434

Prepared for
Victorian Planning Authority

27 September 2018

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Glossary of Terms

Average Exceedance Probability (AEP)

The chance of a given discharge or level value being exceeded in a given year. A 1% AEP flood event has a 1% chance of occurring in any year (and is equivalent to the 1 in 100-year ARI event).

The conversion from ARI to AEP is shown in the table below

ARI (years)	AEP (%)
1	63%
2	39%
5	18% (usually approximated as the 20% AEP)
10	10%
20	5%
50	2%
100	1%

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Australian Rainfall and Runoff (AR&R)

Australian Rainfall and Runoff is the industry standard resources for the estimation of flood flows in Australia.

Average Recurrence Interval (ARI)

The average or expected value of the period between exceedances of a given discharge or event. A 100-year ARI event would occur, on average, once every 100-years. A 10-year ARI event would occur on average, once every 10 years.

Catchment

The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.

Council

The Glen Eira City Council

Design flood

A significant event to be considered in the design process; various works within the floodplain may have different design events. e.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.

Development

The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.

Difference Plot

A map showing the difference in flood depth between two flood events.

Discharge

The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.

Floodplain

Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.

Hydraulics

The term given to the study of water flow in a river, floodplain, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.

Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Land Subject to Inundation Overlay (LSIO)	This is an overlay in the Glen Eira planning scheme that provides for control of the development of land in areas subject to flooding from open watercourses
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Melbourne Water Corporation (MW)	The regional floodplain management and drainage authority.
MUSIC	MUSIC is an industry standard stormwater quality model that helps devise Water Sensitive Urban Designs to manage urban Stormwater and is widely used in Victoria.
Pluviograph	A recording of the rainfall depths over time. Typically this is recorded in millimetres at 6 minute intervals.
RORB	RORB is an industry standard hydrological model developed in Victoria at Monash University in the 1970's. It is freely available and widely used in Victoria
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In this report, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Runoff Coefficient	The proportion of rainfall that becomes runoff, usually estimated in a hydrological model. Typically runoff coefficients will increase as rainfall intensity and/or the proportion of hard surfaces increases.
Special Building Overlay (SBO)	This is an overlay that provides for control of the development of land in areas subject to flooding from formal drainage networks, including underground drains..
Topography	A surface which defines the ground level of a chosen area.
TUFLOW	A 1d2d hydraulic model used to predict the flow of water over land and through drainage infrastructure. TUFLOW is a commercially available model.
Water Sensitive Urban Design (WSUD)	Water sensitive urban design (WSUD) is an approach to planning and designing urban areas to make use of stormwater and reduce the environmental degradation it may causes to rivers and creeks.

1 Introduction

The Victorian Planning Authority (VPA) has engaged Cardno to prepare a Stormwater Drainage Assessment to assist in the preparation of a Structure Plan for the East Village (EV) redevelopment site located along East Boundary Road in Bentleigh East (Glen Eira).

1.1 Purpose of this Document

The purpose of this document is to provide a Stormwater Drainage Assessment for the EV site. This study involves detailed flood modelling outlining existing drainage issues as well as identifying and modelling potential options for the proposed future redevelopment of the site. These options were developed in consultation with stakeholders and the relevant drainage authorities

1.2 Study Area

The EV development site is approximately 25 Ha in size, and is currently industrial development. The site is bounded on the east by the Marlborough Street Reserve, East Boundary Road on the west, North Road to the north and Virginia Reserve to the south. Figure 1-1 shows the site extents of the redevelopment or “planning” area.

The EV site is located downstream of a wider catchment referred to as drainage investigation area of about 170ha. The drainage investigation area is shown in Figure 1-2. The site is currently zoned for industrial and commercial use.

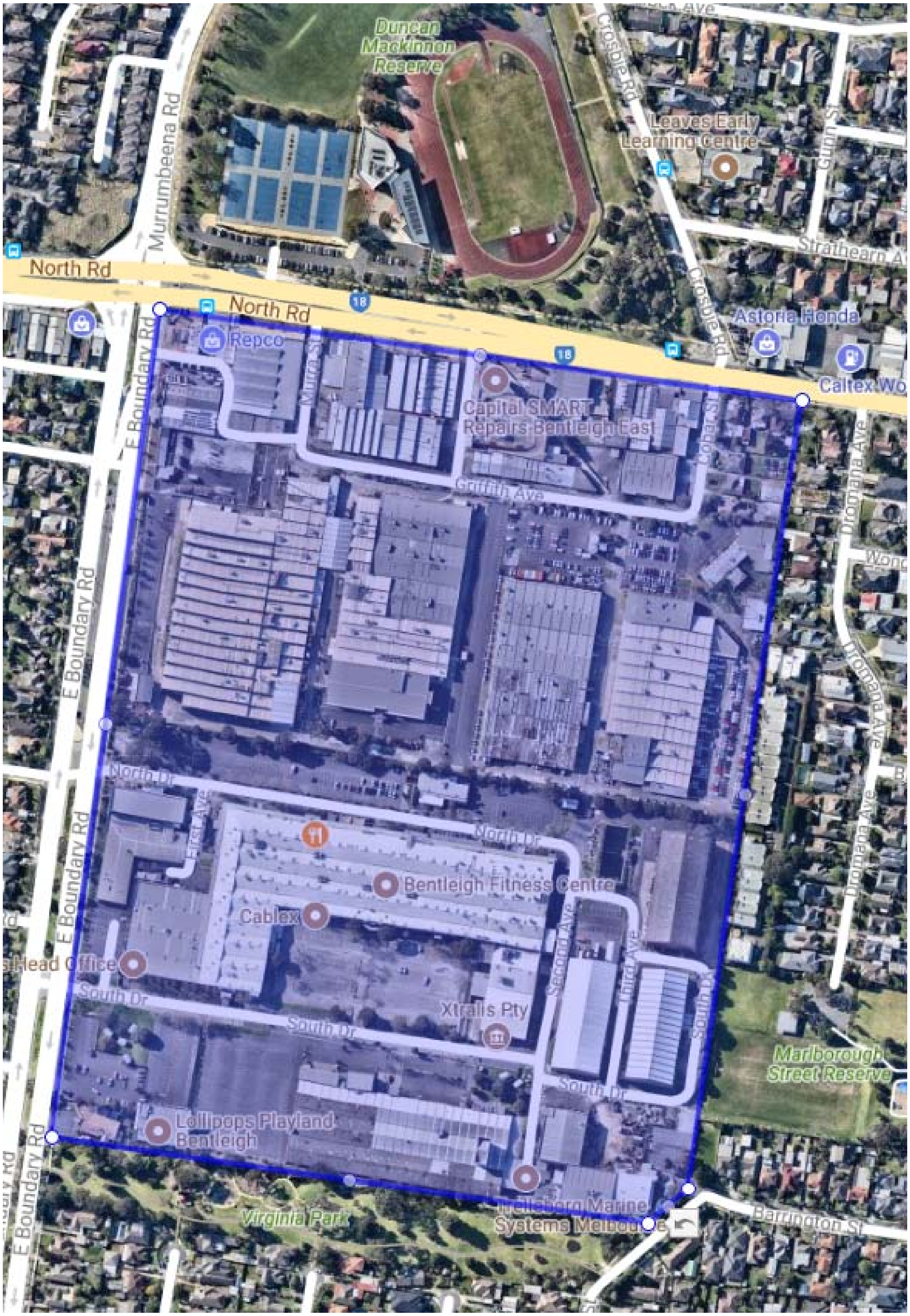

Figure 1-1 East Village Site Extent (image: Google Maps, 2017)

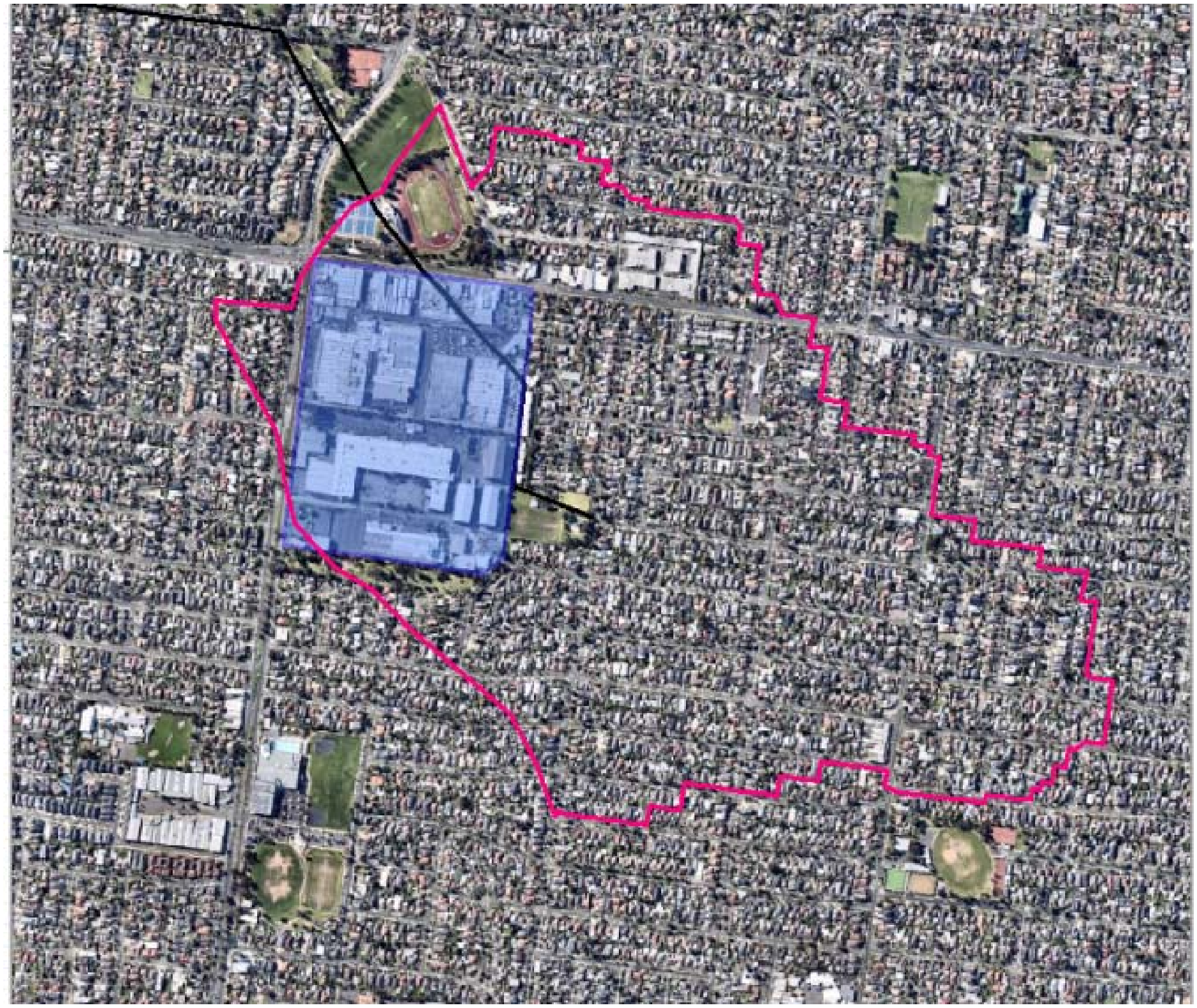

Figure 1-2 EV site (in Blue) and Drainage Investigation Area (in red)

2 Existing Stormwater Network

2.1 Existing Drainage Infrastructure

There are two components to the stormwater network at the EV, consisting of the regional catchment scale flows, and the flows generated internally to the development. Regional stormwater infrastructure on the site is owned by Melbourne Water, with the local drainage network consisting of a range of both privately owned and Council assets. Figure 2-1 below shows the current drainage infrastructure through the site.

Figure 2-1 Pits and Pipe Network within the hydraulic model

2.1.2 Local Drainage

There is an existing piped stormwater system within the EV site, consisting of both private and publically owned infrastructure. All paved roads and car parking areas are drained by grated pits or side entry pits. There are collector drains in South Drive which connect into a 1050mm diameter drain running north in Second Avenue. There is also a collector drain in North Drive which connects to the Second Avenue drain before discharging to the northeast via a 1400 x 900mm box culvert to the existing Melbourne Water 1200mm diameter drain.

Overland flows are conveyed through the site from west to east along North Drive and South Drive, and from south to north along Third Avenue. At the northern end of Second Avenue overland flows exit the site and continue north along Fourth Street through toward Griffith Avenue.

2.1.3 Regional Drainage

The site is traversed by Melbourne Water's Crosbie Street Drain, which starts at Marlborough Street Reserve and runs in a northerly direction along the eastern boundary of the site. The drain enters the EV site approximately 200 metres south of North Road, and flows in a north-westerly direction before crossing North Road. This drain forms part of the drainage network for the larger Elwood Canal/Elster Creek catchment.

The drain is sized to cater for the 20% AEP flows, which is standard for residential areas at the time at which the drain was constructed. The drain varies in diameter across the site, from 1500 mm at the eastern boundary, increasing to 1600 mm at North Road.

2.2 Existing Flooding Behaviour

The EV is subject to overland flows from Melbourne Water's Crosbie Street drain. This drain is in the upper catchment of the Elwood Canal. Overland flows are an above ground component of the drainage system and occur when underground drainage pipes reach their capacity and cannot cope with more runoff from heavy rainfall. The excess runoff then travels overland, following low-lying, natural drainage paths.

The floodwaters inundate Marlborough Street Reserve, and generally flow North towards North Road. Due to the existing topography of the EV site, there is a significant amount of floodwater stored around Griffiths Avenue and on the existing industrial site.

The approximate flood extent and overland flow path in this area is shown below. The 1% AEP flow for the Crosbie Park Drain at Marlborough Street has been calculated at 13.32 m^3/s with 6.72 m^3/s contained within the pipe and the rest (6.60 m^3/s) as overland flow. The size the drain in that location is 1350mm in diameter. The 1% AEP flow for the Crosbie Park Drain at North Road is 7.14 m^3/s with 4.77 m^3/s contained within the pipe and the rest (2.37 m^3/s) as overland flow. The size the drain in that location is 1600mm in diameter.

The Melbourne Water map shown in Figure 2-2 has been checked as part of the flood modelling undertaken in Section 3 of this report.

Figure 2-2 Melbourne Water 1% AEP flood map for the EV site

Figure 2-3 shows the Special Building Overlay of the Glen Eira Planning Scheme as it applies to the site. The SBO applies to areas that are subject to stormwater flooding in urban areas. These are generally areas which are inundated due to the inability of the stormwater infrastructure to convey the full flood flows in the 1% AEP flood event (also referred to as the 1 in 100 year ARI event). This overlay is suitable for areas where stormwater systems were implemented prior to current design standards and there has been substantial development since the underground infrastructure was constructed. The overlay extent was developed from earlier flood mapping completed by Melbourne Water, resulting in a slightly different expected flood extent than that shown in Figure 2-2.

The purpose of the Special Building Overlay is:

> To implement the State Planning Policy Framework and the Local Planning Policy Framework, including the Municipal Strategic Statement and local planning policies.

> To identify land in urban areas liable to inundation by overland flows from the urban drainage system as determined by, or in consultation with, the floodplain management authority.

> To ensure that development maintains the free passage and temporary storage of floodwaters, minimises flood damage, is compatible with the flood hazard and local drainage conditions and will not cause any significant rise in flood level or flow velocity.

> To protect water quality in accordance with the provisions of relevant State Environment Protection Policies, particularly in accordance with Clauses 33 and 35 of the State Environment Protection Policy (Waters of Victoria).

The Victorian Flood Strategy indicates that in general, new lots should not be created that are flood prone, especially for residential and commercial land uses.

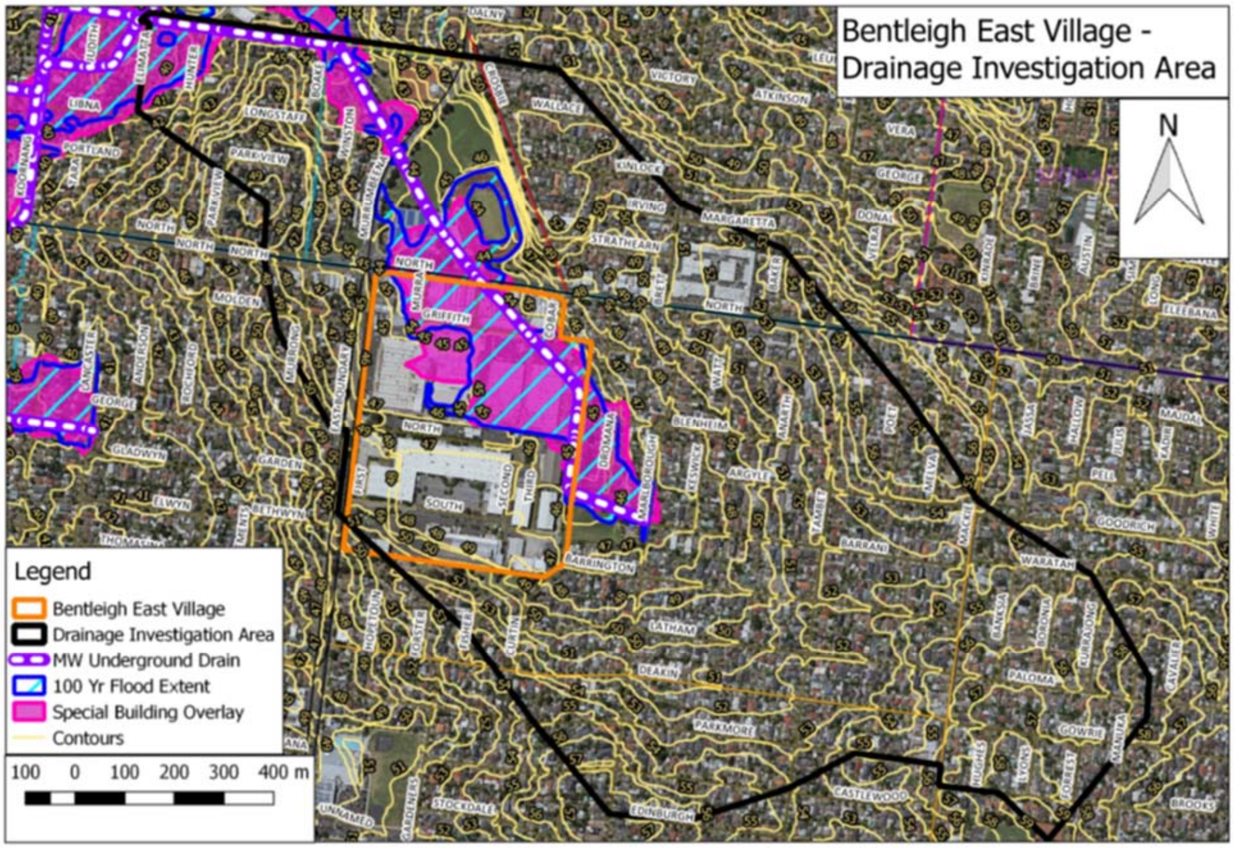

Figure 2-3 Existing Special Building Overlay Map

3 Existing Flooding Behaviour

The existing flooding behaviour of the EV site was assessed by considering the local and the Regional Flood Behaviour. The project brief requires analysis of existing flooding behaviour for both the existing 100 year (1% AEP) storm event and the predicted future 100year (1% AEP) climate change event.

3.1 Flood Hazard Categories

Maps of the maximum flood depths and hazards can be found in Section 3.2: Figure 3-3 to Figure 3-6 for both current climate conditions as well as projected climate change conditions.

The hazard categories shown in the afore mentioned maps have been defined according to those outlined in Australian Rainfall and Runoff 2016 which are presented below in Figure 3-1. According to these definitions, anything that is designated as above H1 (dark blue) is considered to be at least unsafe for small vehicles to traverse.

As the maps show, areas surrounding Griffith Avenue and North Road (downstream of the EV site) as well as Dromana Avenue (upstream of the EV site) are expected to experience up to H5 hazard levels under existing conditions. Significant flood depths have been modelled in these locations as well as the north-eastern section of the EV site itself due to flow unable to be conveyed within the Melbourne Water main drain.

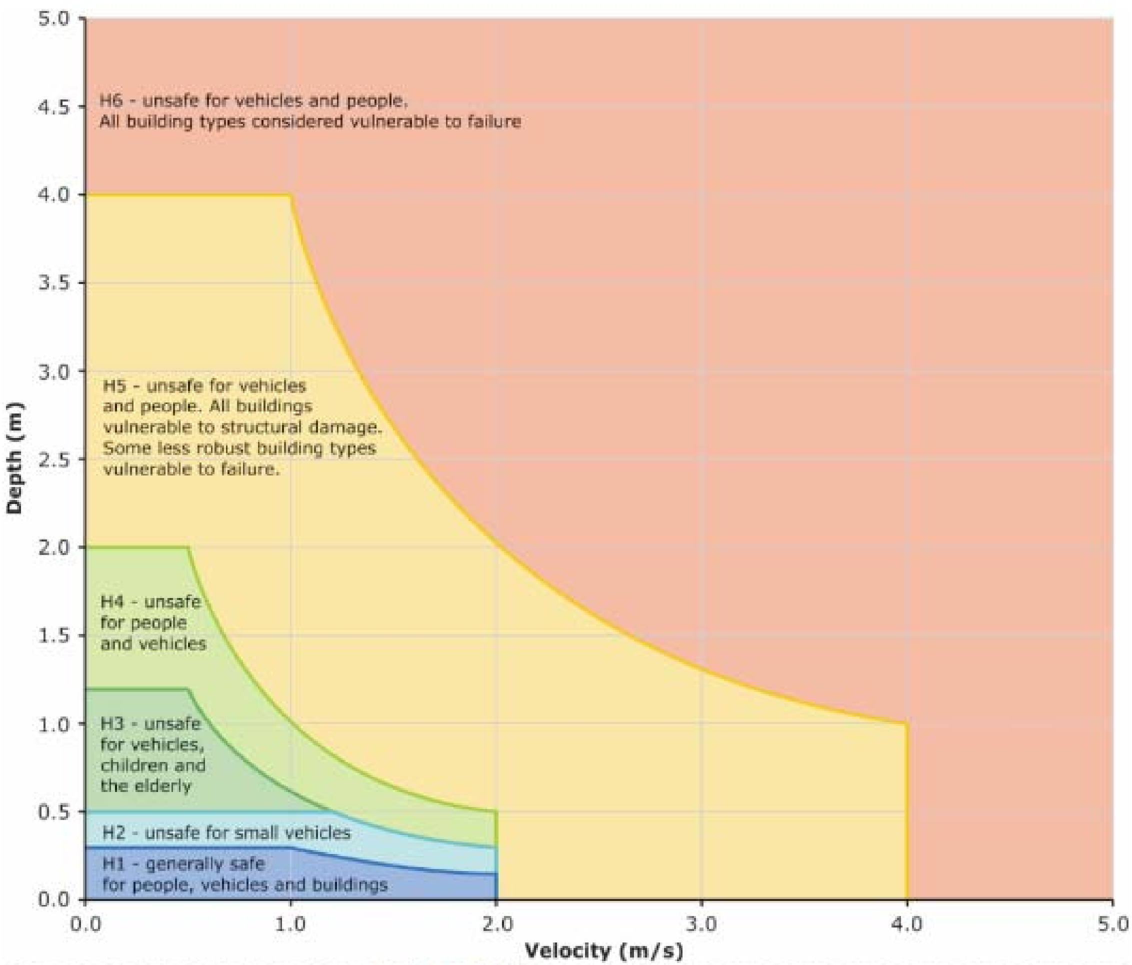

Figure 6.7.9. Combined Flood Hazard Curves (Smith et al, 2014)

Figure 3-1 Hazard Categories

3.2 Existing 10% AEP Flood Behaviour

Existing flood analysis for the EV site has been completed by Cardno and Venant Solutions. The analysis indicates that the local drainage network does not have capacity to fully convey the 10% AEP flows. Figure 3-2 shows the expected flood extents from the local drainage network in the 10% AEP event. This analysis does not include the consideration of any flows from the regional drainage network.

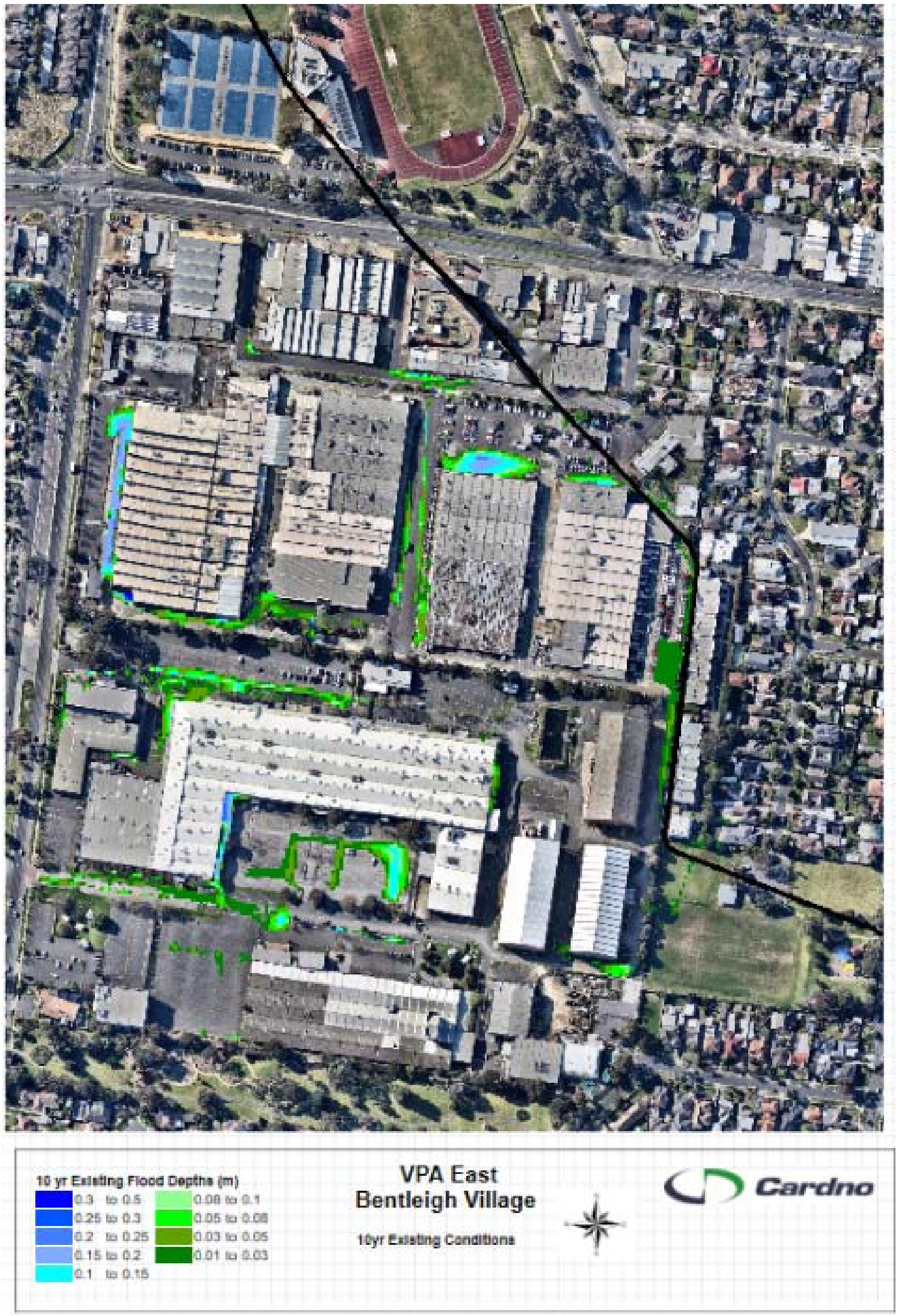

Figure 3-2 10% AEP events existing conditions depth plot

3.3 Existing Regional Flood Behaviour

Modelling of the existing conditions 1% AEP flood event was undertaken using the current TUFLOW model developed by Cardno and Venant Solutions as a basis. The model was run for a full suite of storm durations from 10 minutes to 6 hours, using the current MW RORB model.

The results of these model runs were analysed and it was found that the critical durations for the site were 25 minutes (for the upstream areas), 60 minutes (for the majority of the EV site itself) and 120 minutes on North Road and its surrounds. The difference in the critical storm events are a result of the combination of peak flow rates and flood volume generated by a rainfall event.

The approximate time of flooding for the internal network was found to be 2.5 hours. North Road approximately floods for 4 hours.

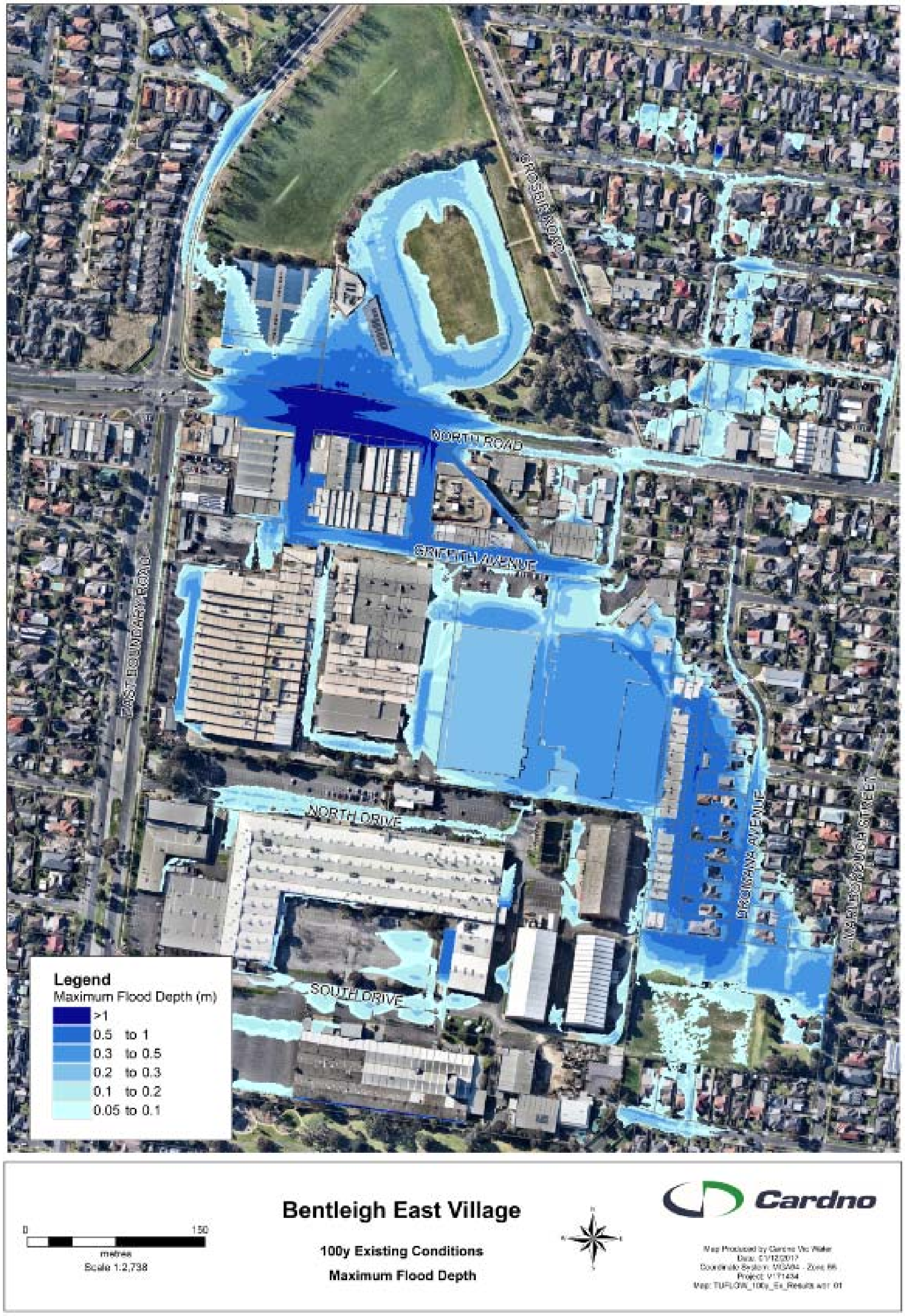

Figure 3-3 1% AEP Maximum Flood Depths (Existing Conditions)

Figure 3-4 1% AEP Maximum Flood Hazards (Existing Conditions)

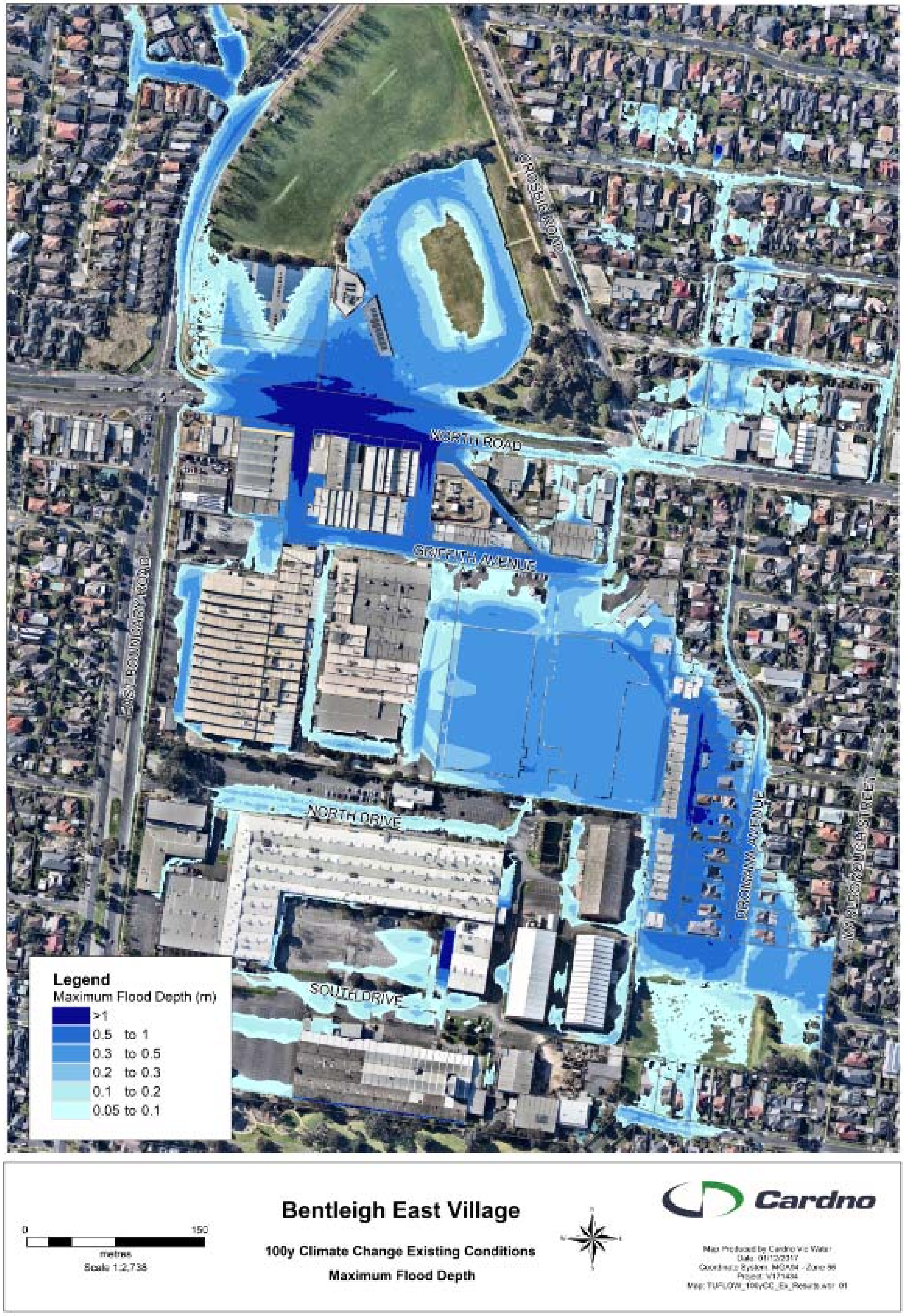

Figure 3-5 1% AEP Climate Change Maximum Flood Depths (Existing Conditions)

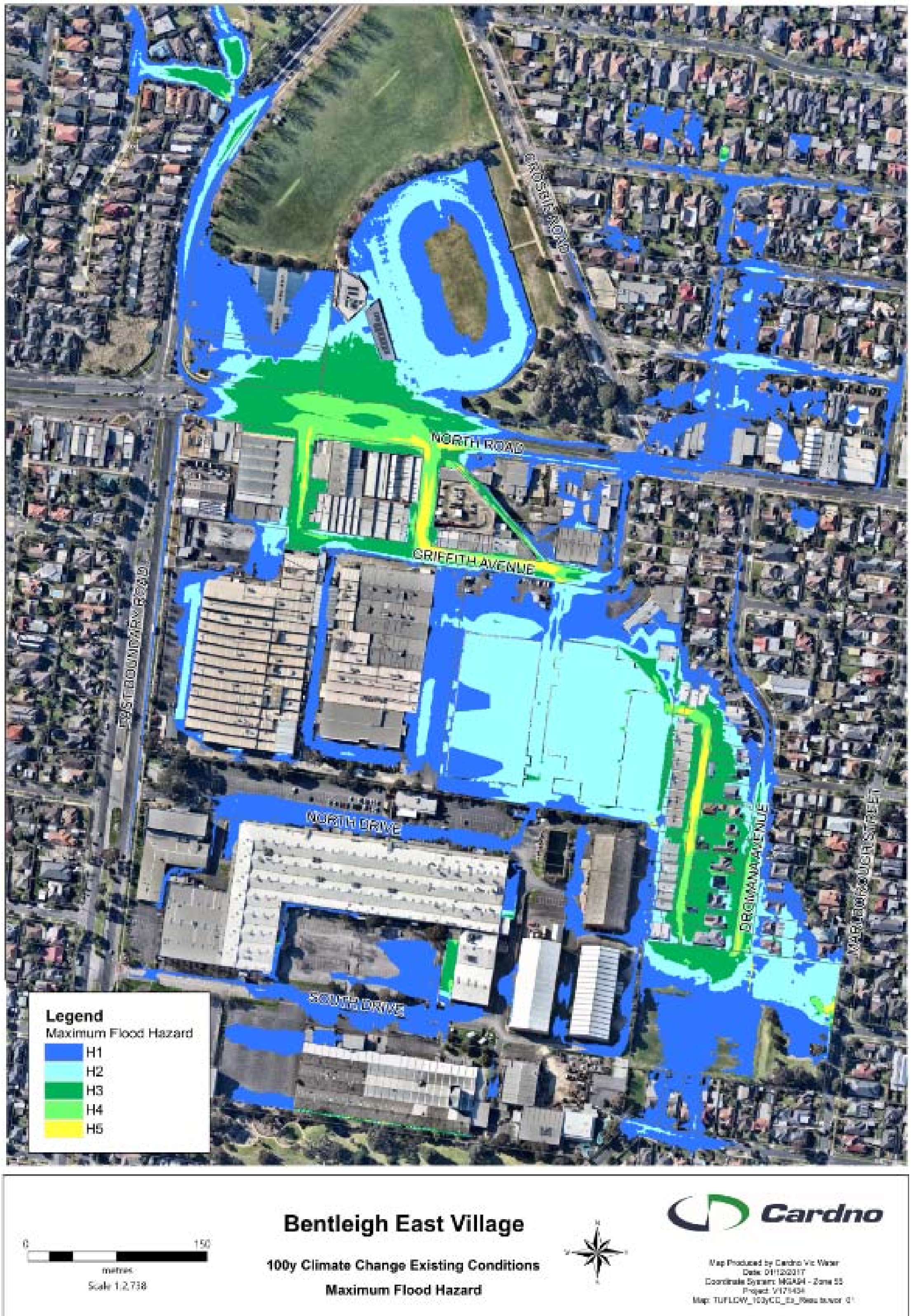

Figure 3-6 1% AEP Climate Change Maximum Flood Hazards (Existing Conditions)

4 Preliminary Stakeholder Feedback

The identified stakeholder for the planning and re-development of the EV site are:

- Melbourne Water (MW)
- DELWP Water & Catchments (DELWP)
- South East Water (SEW)
- Glen Eira City Council (GECC)

Several Stakeholder meetings/workshops took place at the VPA's offices where stormwater management constraints and opportunities were identified and discussed. This chapter presents each stakeholders' feedback and input gathered.

4.1 Melbourne Water

As flooding is a key concern downstream of the EV site (in the Elwood Canal Catchment), a realignment or upsizing of the MW drain would only transfer the flooding issue downstream and is considered an ineffective solution. Melbourne Water agrees that no flooding occurs across title boundaries, i.e. all flooding from the 1% AEP event is to be contained within an appropriate reserve. An underground storage mitigation option is not preferred either as MW does not manage any underground storage asset and is concerned with the associated lifecycle costs.

4.2 DELWP Water & Catchments

Chapter 5 of Water for Victoria outlines water's role in improving resilience and liveability in Victorian towns and cities. Chapter 5 of Water for Victoria encourages to adopt Integrated Water Management (IWM) when planning and managing water in urban areas which requires consideration of total water cycle interactions and maximising social, economic and environmental benefits.

DELWP would like to ensure that an IWM approach is considered in the planning and stormwater management of the EV site including a collaborative approach with an aim to maximise community benefits.

4.3 South East Water

South East Water (SEW) has advised that preliminary hydraulic assessment indicates that the existing potable water infrastructure has sufficient capacity to supply the proposed development with the main source of supply being the existing 300mm water main located in East Boundary Road. The service the development with potable water internally requires the extent of 150mm reticulated water mains. SEW also notes that there are existing 100mm mains within the northern portion of the development site that may need to be upsized subject to the nature of the surrounding development.

Regarding sewers, the proposed development site is to be serviced by sewer lines that ultimately discharge into an existing Melbourne Water 1830mm Caulfield Intercepting Sewer located in North Road. These consist of an existing 300mm Leila Road Branch Sewer traversing the north east corner of the development site and running along the north boundary in North Road and discharging into Melbourne Water's sewer and an existing 225mm sewer in the northwest corner discharging into the 300mm Leila Road Branch.

South East Water provided no comment regarding stormwater drainage or integrated water management.

4.4 Glen Eira City Council

GECC notes that legal point of discharge for the EV development likely to be directed to the existing MW drain. The internal EV drainage should be able to cater for 5% AEP flows and the internal drainage within the road network will ultimately be under the responsibility of Council. GECC will likely require a maximum permissible lot discharge for each property within the development. Any proposal that impacts the Marlborough Street Reserve should not significantly inhibit the use of land for recreation and open space as well as demonstrate a reduction in flood levels for the surrounding properties

5 Draft EV Future Urban Structure Plan

Figure 5-1 includes the draft future urban structure plan for East Village that includes a mix of both residential and commercial activity. It is envisaged that East Village will become a major hub for employment and mixed use activity within Glen Eira that will service the broader community over the next 10-15 years. A feature of the future urban structure plan is a .65ha extension of the existing Marlborough Street Reserve that is proposed to be used for both passive and active recreation. The future EV site is planned to cater for approximately 3,000 dwellings, 5,000-6,000 people and 3000 jobs.

Figure 5-1 Draft Future EV site Urban Structure

6 Future Development Flooding and Modelling Criteria

6.1 Flood Criteria

The future development flood criteria is based upon the original project brief requirements and subsequent stakeholder consultation. The EV site requirements will be:

- New lots should not be created that are subject to inundation from 1% AEP flows
- Any overland paths in road reserves must meet Melbourne Water's floodway safety criteria for depth of flow and flow velocity
- Any overland flows must be fully contained with reserves (roads, open space)
- Flooding cannot be increased either upstream or downstream of the EV or for existing landholders
- Council requires the drainage network to have capacity for the 5% AEP (1 in 20 year ARI) flood, which is the standard for mixed-use developments in Glen Eira.

6.2 Climate Change

Climate change will be computed for the following two scenarios:

- 1% AEP storm event within the drainage investigation area for the existing development;
- 1% AEP storm event incorporating the future EV site redevelopment with a minimum of 2 stormwater drainage management options

All Options were modelled to reflect climate change scenarios. A 15.5% increase in rainfall intensity is a requirement of the project brief. The following computations confirm this as an appropriate criterion.

Future climate rainfall intensities have been estimated based on guidance from ARR 2016 which recommends the use of a 5% increase in rainfall intensity per °C. Projected rainfall intensity or equivalent depth (Ip) was obtained from the following equation:

Ip=I_ARR×1.05(T_m)

Where:

IARR is the design rainfall intensity (or depth) for current climate conditions; and

Tm is the temperature midpoint of the selected class interval.

ARR 2016 Book 1 suggests that a temperature midpoint value of 3°C is a conservative estimate and as such has been adopted for this study due to the uncertainties involved in predicting future climate conditions. Using this value, climate change increases of 15.5% to rainfall intensities are adopted.

6.3 Modelling Inputs

The existing conditions model was modified to include an expected schematic layout of the EV site. In accordance with the design requirements, the modifications included:

- Raising any land that is not a public reserve (road or park) to be above the expected flood levels
- Where roadways act as floodways, a road cross section has been adopted that allows for a depth of flooding of up to 20 cm across the road reserve. The sections assume:
  - Roads grade generally from south to north, and where intended to act as floodway, east to west.
  - For the major roads acting as floodways for regional drainage, the road cross sections assume a footpath section of 1.8 metres on both sides of the roadway reserve that is not intended to flood. The section transitions to a 20 cm deep channel for the remaining roadway width. See Figure 6-1.
  - For the major roads not acting as floodways for regional drainage, the road cross sections assume a footpath section of 1.8 metres on both sides of the roadway reserve that should be flood free. The section transitions to a 10 cm deep channel for the remaining roadway width.
  - For the laneway in Option 1, the laneway transitions immediately from the property edge to a 20 cm deep channel adopting a 50% sloping batter. See Figure 6-2 and Figure 6-3.
- Inclusion of retarding basins and local drainage as per the option assessed.

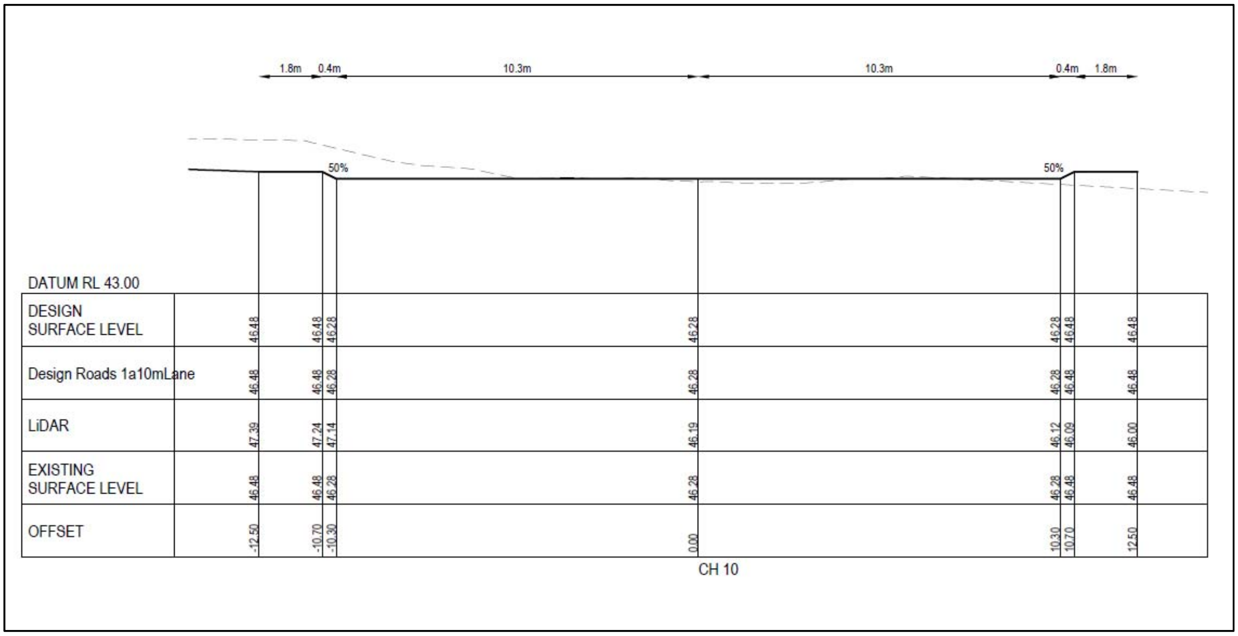

Figure 6-1 Major Road Acting as Floodway Cross Section (20cm depth)

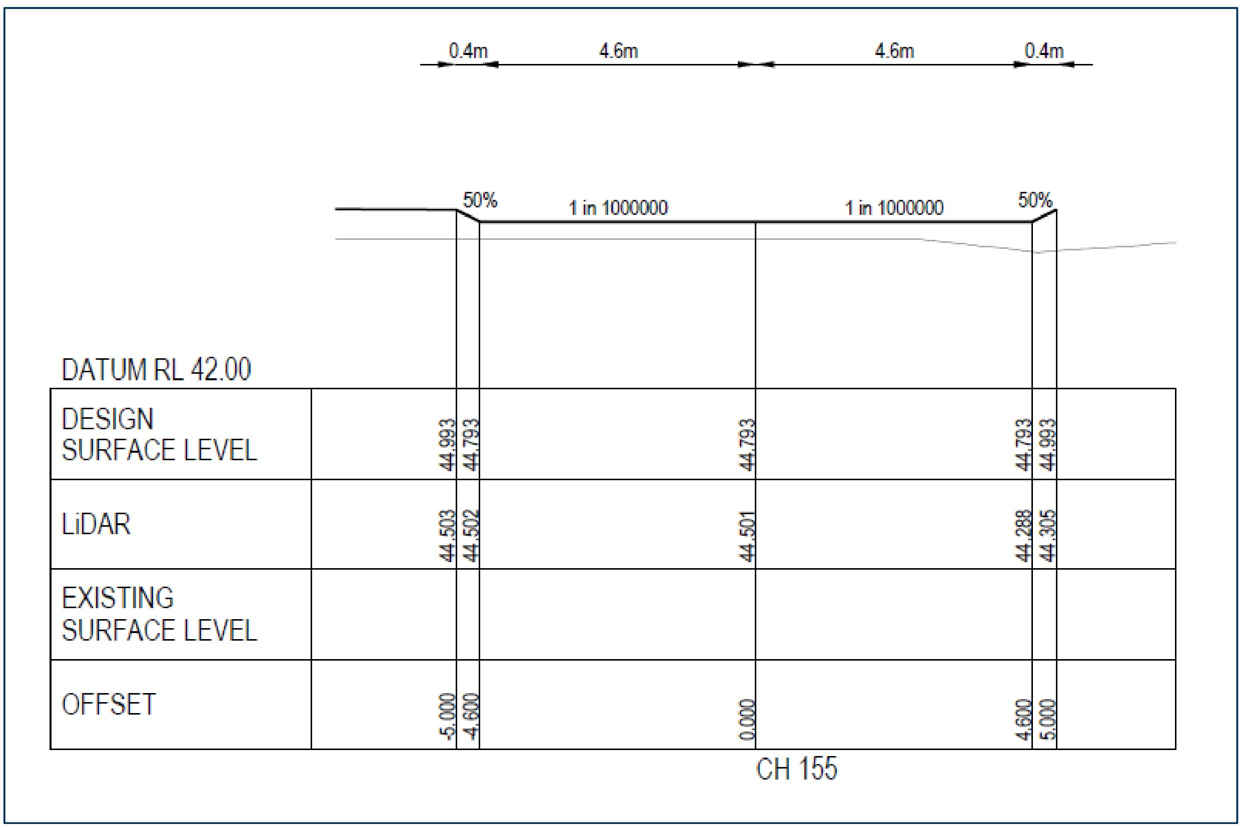

Figure 6-2 10m Laneway Cross Section (20cm depth)

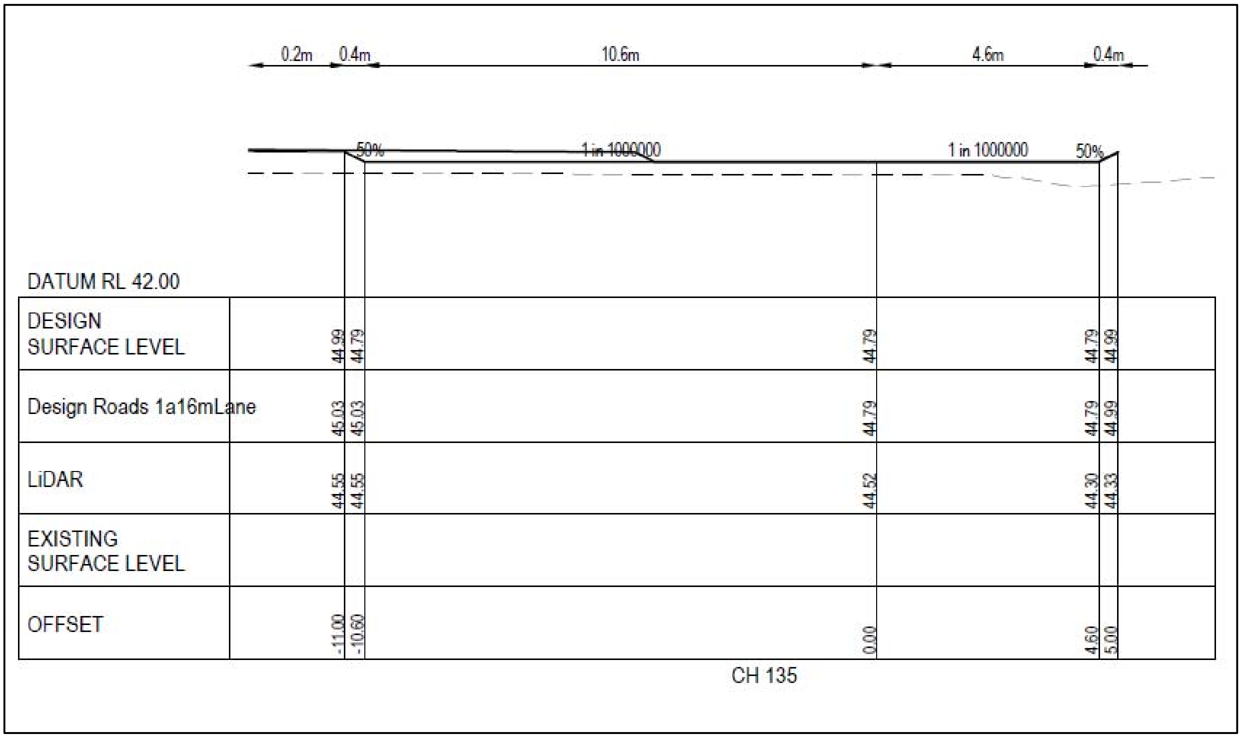

Figure 6-3 16m Laneway Cross Section (20cm depth)

7 Flood Mitigation Options

Flood mitigations options to alleviate flooding in and around the EV site and meeting the criteria set above were identified and discussed with stakeholders before being taken to further modelling. All options include storage and conveyance of overland flows in a safe manner and use part of the Marlborough Street Reserve upstream of the EV site as a flood storage location as the reserve currently acts as an informal retarding basin with some storage of overland flows prior to flooding occurring along Dromana Avenue. The flood mitigation options do not require interception of drainage flows from the Crosbie Street Drain and this drain would continue to function identically to the existing conditions. The storage options simply formalise and enhance the retarding function of Marlborough Street Reserve.

The three options identified were:

Option 1: Partial storage of flood waters within the EV site (approximately 2000m^3) on the new open space area near the Marlborough Street Reserve and Overland Flow Paths using a 16m wide laneway at the back of Dromana Avenue townhouses and the internal EV road network;

Option 2: Storage of flood waters within the Marlborough Street Reserve and on the new open space area and Overland Flow Paths using the internal road network.

Option 3: Partial storage of floodwaters within the Marlborough Street Reserve and on the new open space area and Overland Flow Paths using using a 16m wide laneway at the back of Dromana Avenue townhouses and the internal EV road network. This option allows for a senior sized soccer field within the existing reserve with an elevation above 1% AEP flood levels for water associated with the Crosbie Street Main Drain.

All mitigation options presented assume the following treatment for local catchment flows:

- Drainage for the road network adopts a 5% AEP design flow from road areas and public open spaces. A preliminary local drainage network is included in the model.
- On site detention is provided at each building area limiting discharge such that the overall site discharge to the pipe network is no greater than the MW drain capacity
- The flows rates have been included in the model as constant inflows based the size of the developable portion
- 1% AEP flows are directly applied to the roads in the development as part of the options assessment

7.1 Option 1 Modelling and Results

Figure 7-1 shows a schematic of Option 1.

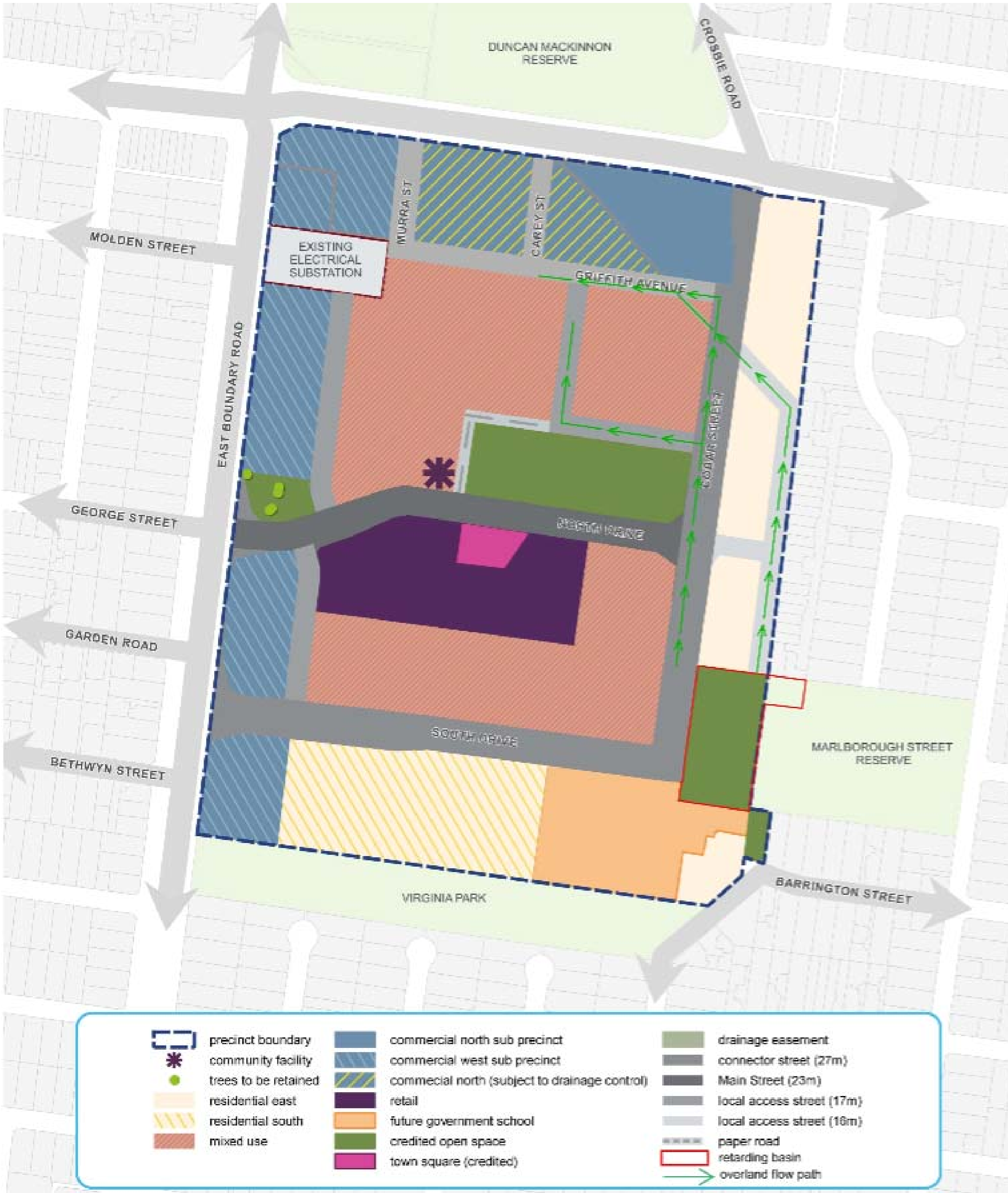

Figure 7-1 Option 1

Hydraulic modelling of Option 1 was undertaken by including the following aspects in the current TUFLOW model developed by Cardno:

- Include a 2,016 m^3 storage in open space by localised lowering of modelled terrain in location indicated;
- Include 16m wide laneway as indicated; and

- Include proposed road layout within EV site.

Aside from the roads, all other areas within the EV site were blocked out as it is assumed that they will be designed to be flood free, thus encouraging water to flow along the roadways.

Figure 7-2 and Figure 7-3 show the change in water surface elevation with the introduction of the mitigation option for both current climate and future climate conditions while figures 7-4 to 7-7 show depths and hazards plots. The results show:

- There is a small reduction in flooding in the areas surrounding Dromana Avenue.
- For roads within the EV site, flood hazard is generally low (Class H1)
- The laneway floodway has flood hazard classes of “H3” and “H4”, under both existing and climate change conditions. Flood hazards “H3” and “H4” within the 16m laneway are unacceptable because:
  - The laneway will be used for vehicle access and potentially for pedestrian access Australian Rainfall and Runoff safe access criteria adopted by MW) (Figures 7-4 to 7-7).;
  - Flooding at the rear of the adjoining Dromana Avenue townhouses is made worse compared to the existing development 1% AEP climate change scenario;
  - This fully encapsulates the adjoining Dromana Avenue townhouses within a “H3” or “H4” hazard.
- The main entry road has some areas of high hazard under climate change conditions.
- Flood levels on Griffith Avenue, Murray Street, Carey Street, the diagonal laneway and North Road remained practically unchanged. Whilst the flood hazards “H3”, “H4” and “H5” at these locations do not meet safe access criteria, these are:
  - Associated with an existing flooding problem;
  - Not as a result of future redevelopment at EV;
  - An issue requiring further consideration by Council and Melbourne Water.
- The flood hazards “H3” and “H4” in Dromana Avenue do not meet safe access criteria, however these are:
  - Outside the EV site;
  - Associated with an existing flooding problem;
  - Not as a result of future redevelopment at EV;
  - An issue requiring further consideration by Council and Melbourne Water.

- Approximate flooding times for Option 1 are:
  - 5.5 hours for the Retarding Basin in Marlborough Street Reserve
  - 2.5 hours for the internal network
  - 6 hours for North Road

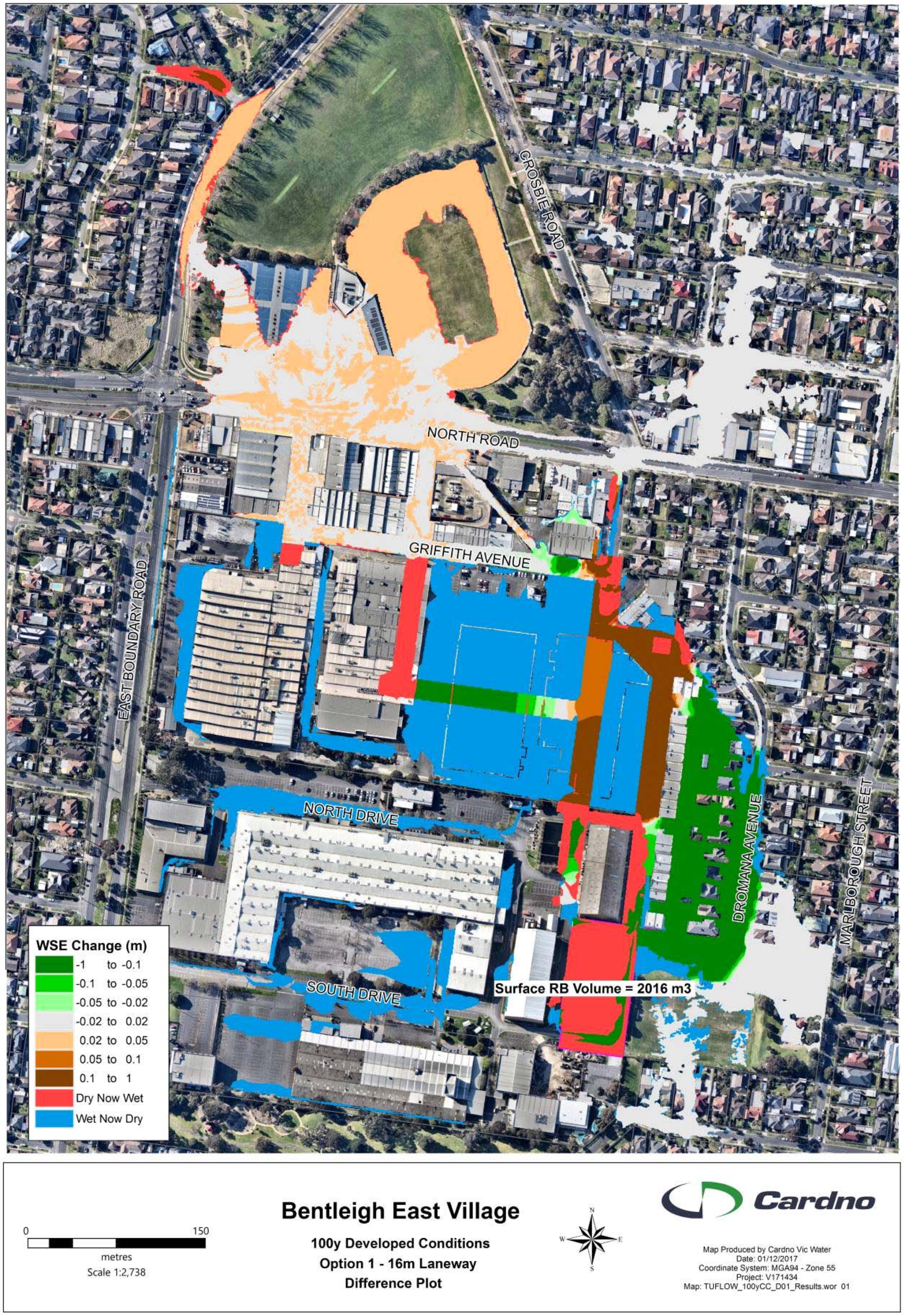

Figure 7-2 1% AEP Difference Plot (Option 1)

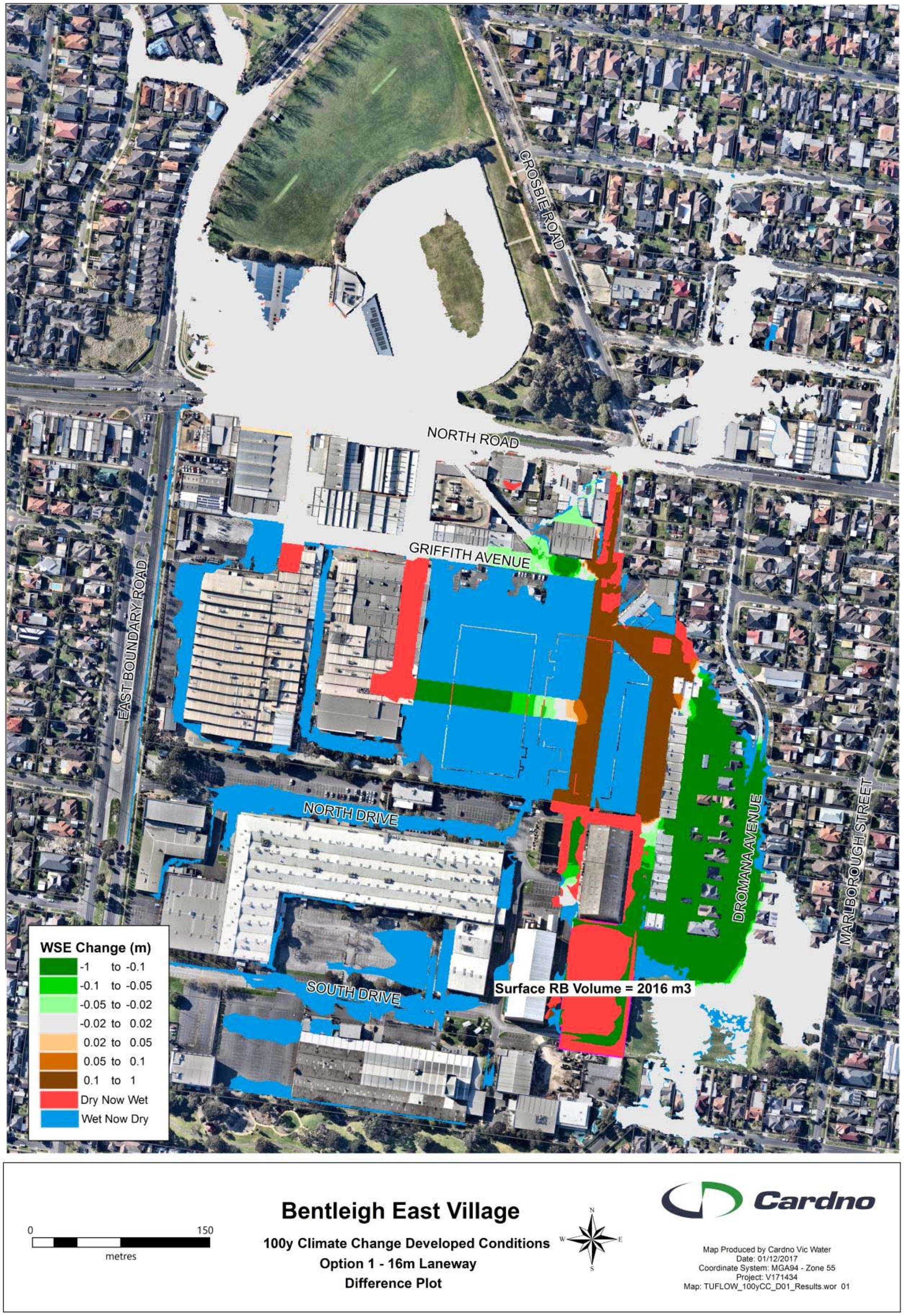

Figure 7-3 1% AEP Climate Change Difference Plot (Option 1)

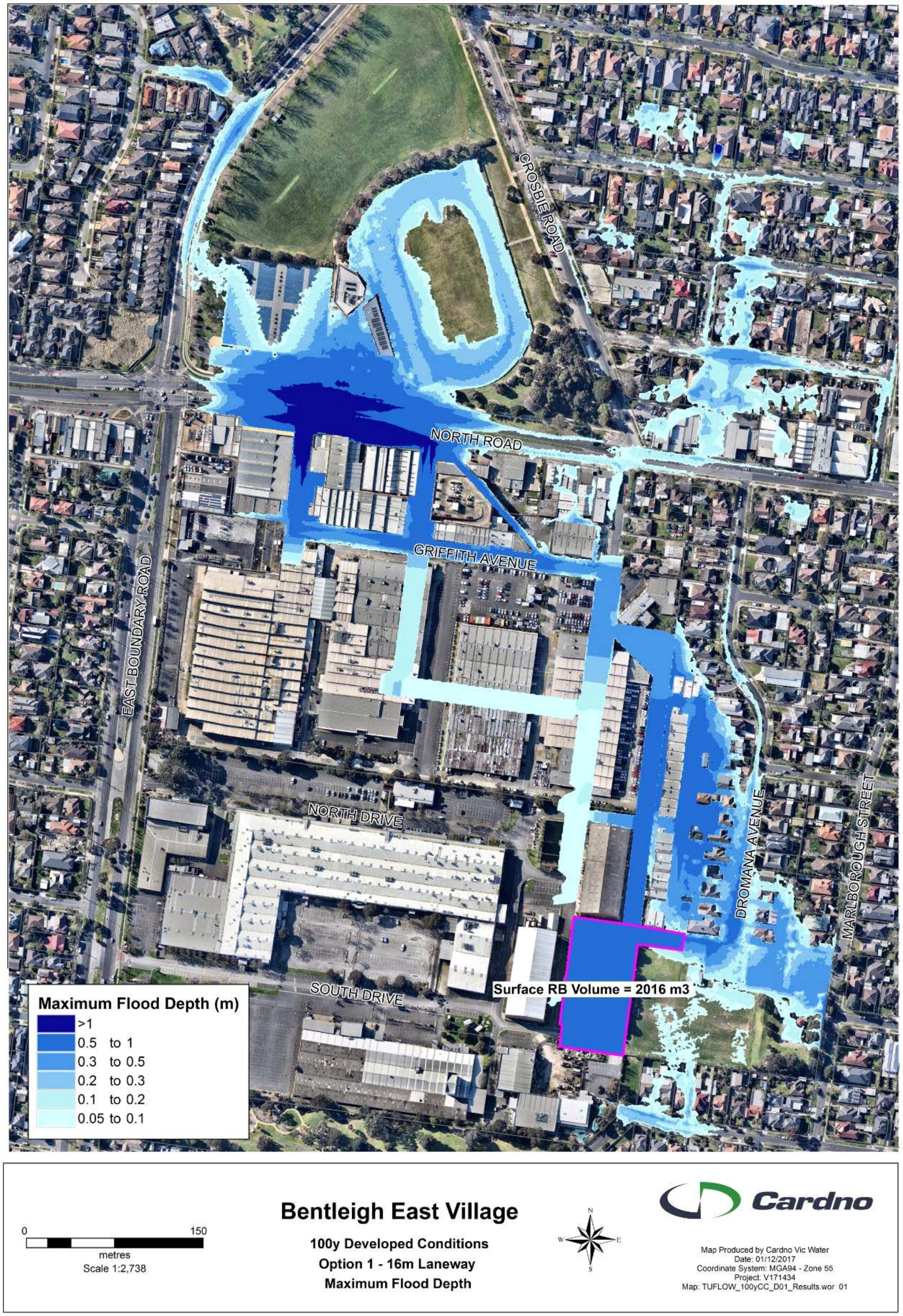

Figure 7-4 1% AEP Maximum Flood Depths (Option 1)

Figure 7-5 1% AEP Maximum Flood Hazards (Option 1)

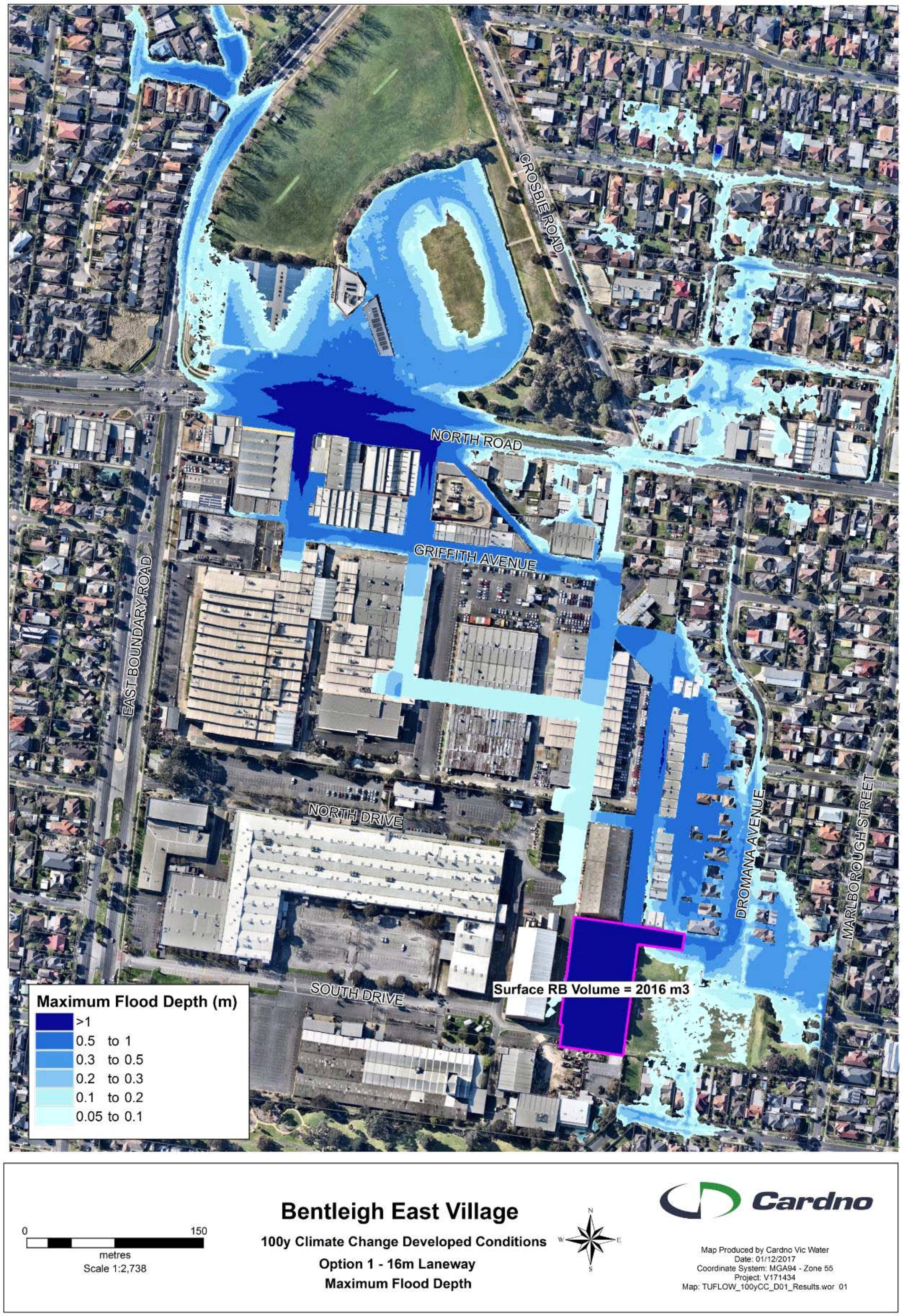

Figure 7-6 1% AEP Climate Change Maximum Flood Depths (Option 1)

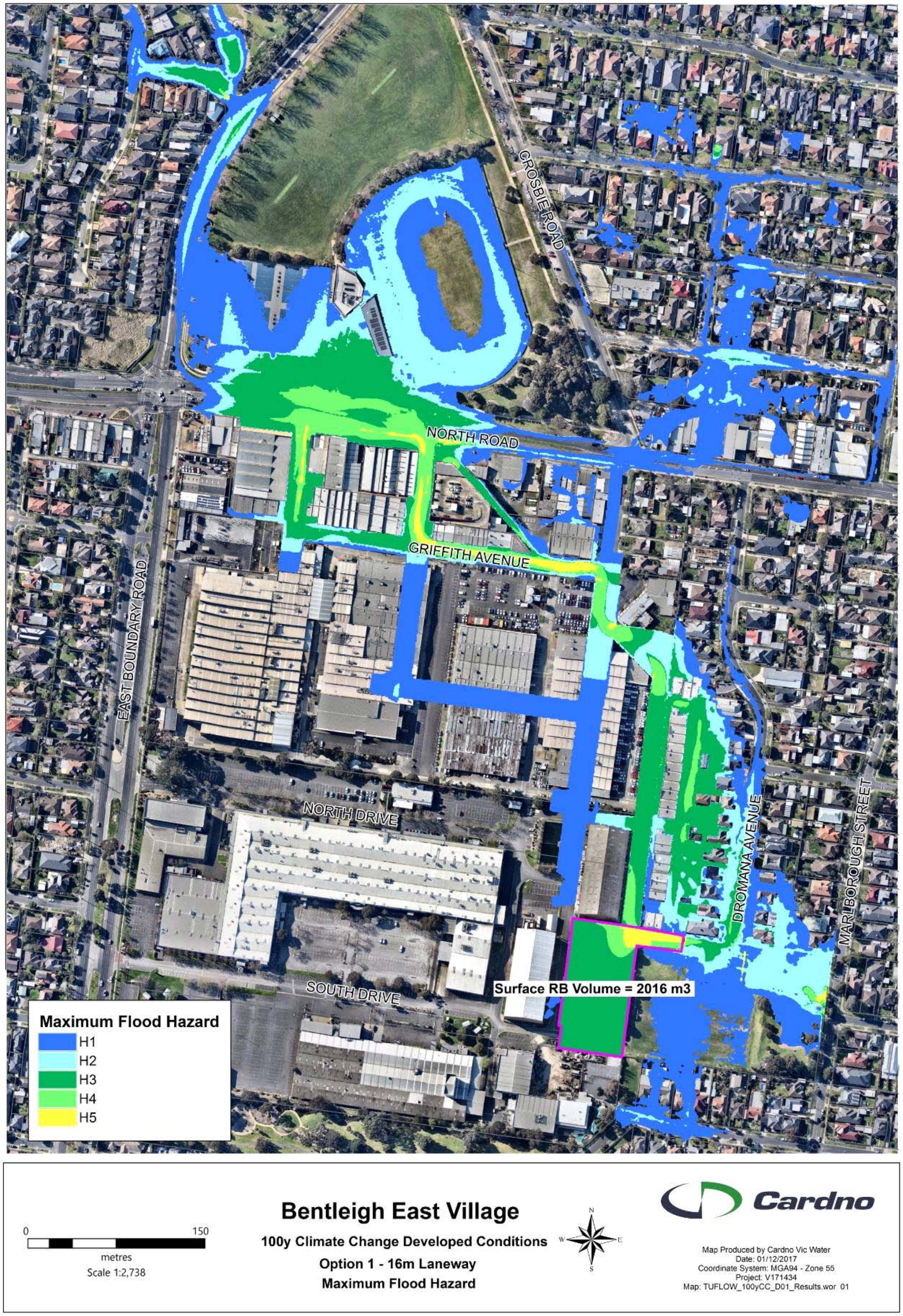

Figure 7-7 1% AEP Climate Change Maximum Flood Hazards (Option 1)

7.2 Option 2 Modelling and Results

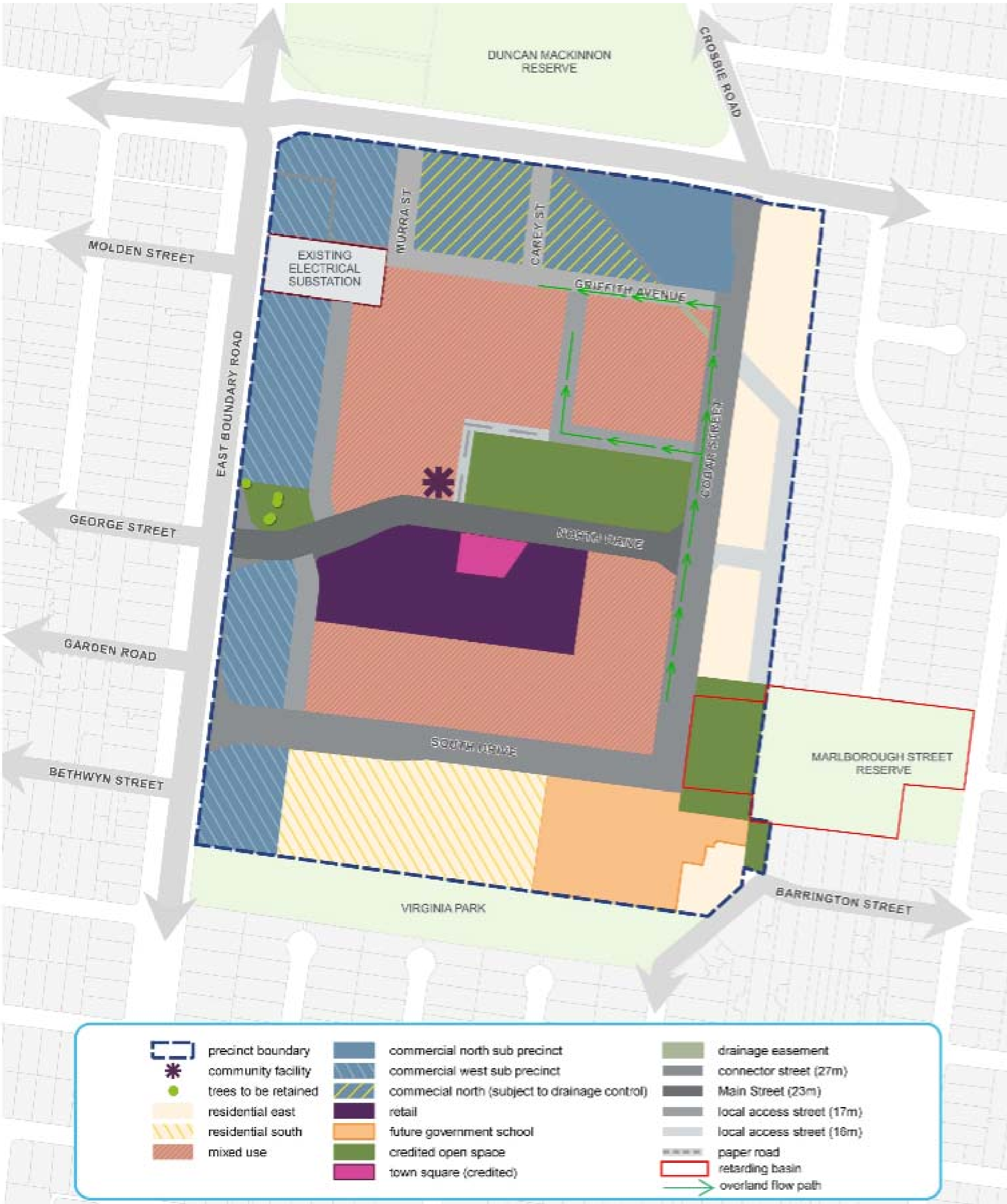

Figure 7-8 Option 2

Hydraulic modelling of Option 2 was undertaken by including the following aspects in the current TUFLOW model developed by Cardno:

- Include a 13,675 m^3 storage in open space by localised lowering of modelled terrain in location indicated;
- The inclusion of a flood barrier along the northern end side of Marlborough Reserve, set at 46.5 mAHD.

- Include proposed road layout within EV site.

Aside from the roads, all other areas within the EV site were blocked out as it is assumed that they will be designed to be flood free, thus encouraging water to flow along the roadways.

The maximum likely available land area available within the reserve, taking into consideration the desire to leave a portion of the land unencumbered during construction, is 13,675 m^3.

Figure 7-9 and Figure 7-10 show the change in water surface elevation with the introduction of the mitigation option for both current climate and future climate conditions while figures 7-11 to 7-14 show depths and hazards plots. The results show:

- There is a significant reduction in flooding in the areas surrounding Dromana Avenue, Griffith Avenue and North Road.
- The hazard levels for the majority of roads within the EV site are H1, with only a small area of the site being above this. Localised works at the detailed design stage would likely be able to reduce these further.
- Melbourne Water's safe access criteria can be met throughout the site, other than for:
  - Griffith Avenue, Murray Street and Carey Street ("H3" and "H4");
  - The overland flow transition from Dromana Avenue townhouses to the main access road ("H3"), although this could be removed by minor adjustment of the proposed works.
- Whilst the flood hazards in Dromana Avenue are reduced, the remaining "H3" hazard does not meet safe access criteria. However, this flooding is:
  - Outside the EV site;
  - Associated with an existing flooding problem;
  - Not as a result of future redevelopment at EV;
  - An issue requiring further consideration by Council and Melbourne Water.
- Approximate flooding times for Option 2 are:
  - 4 hours for the Retarding Basin in Marlborough Street Reserve
  - 2.5 hours for the internal network
  - 6 hours for North Road

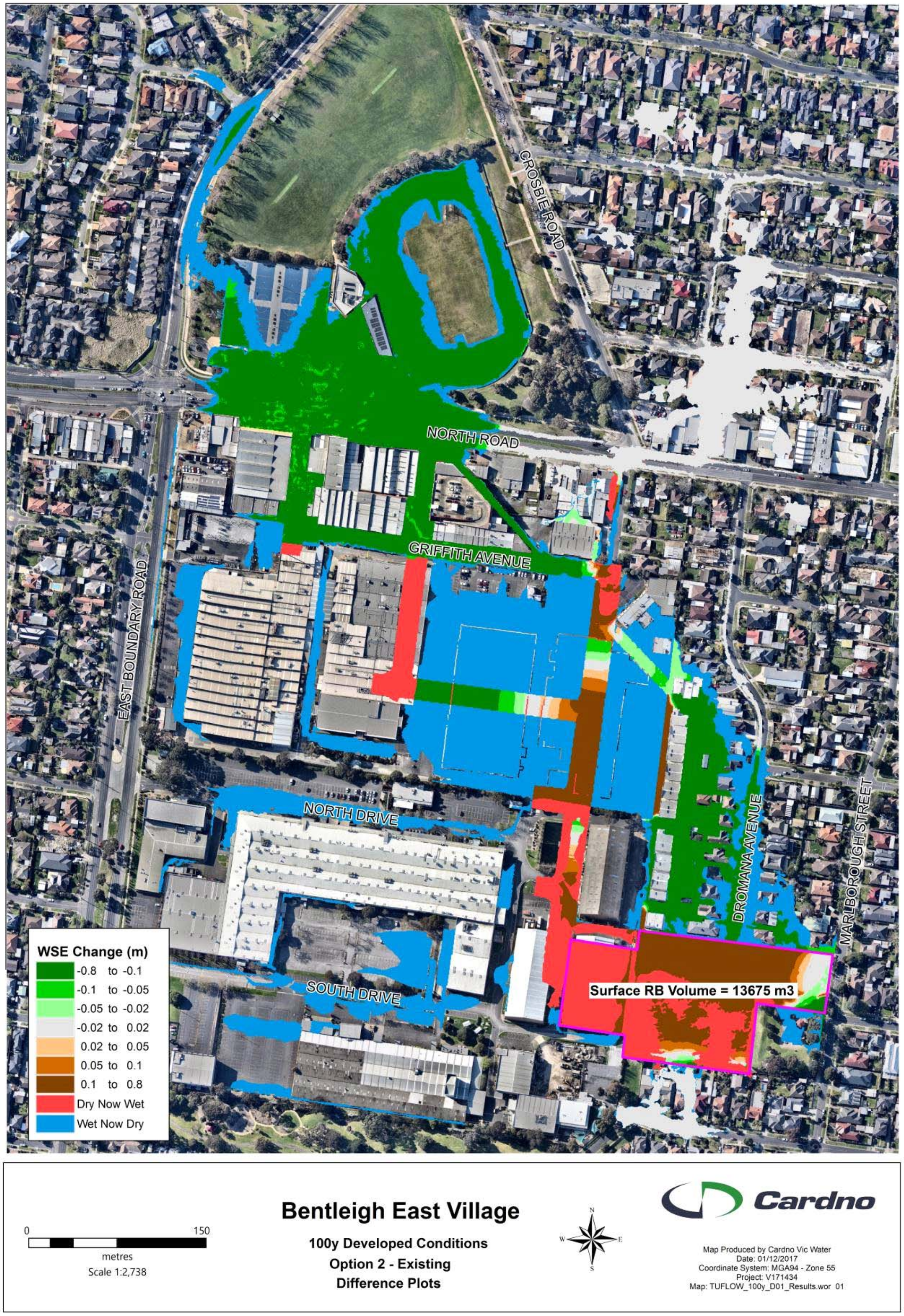

Figure 7-9 1% AEP Difference Plot (Option 2)

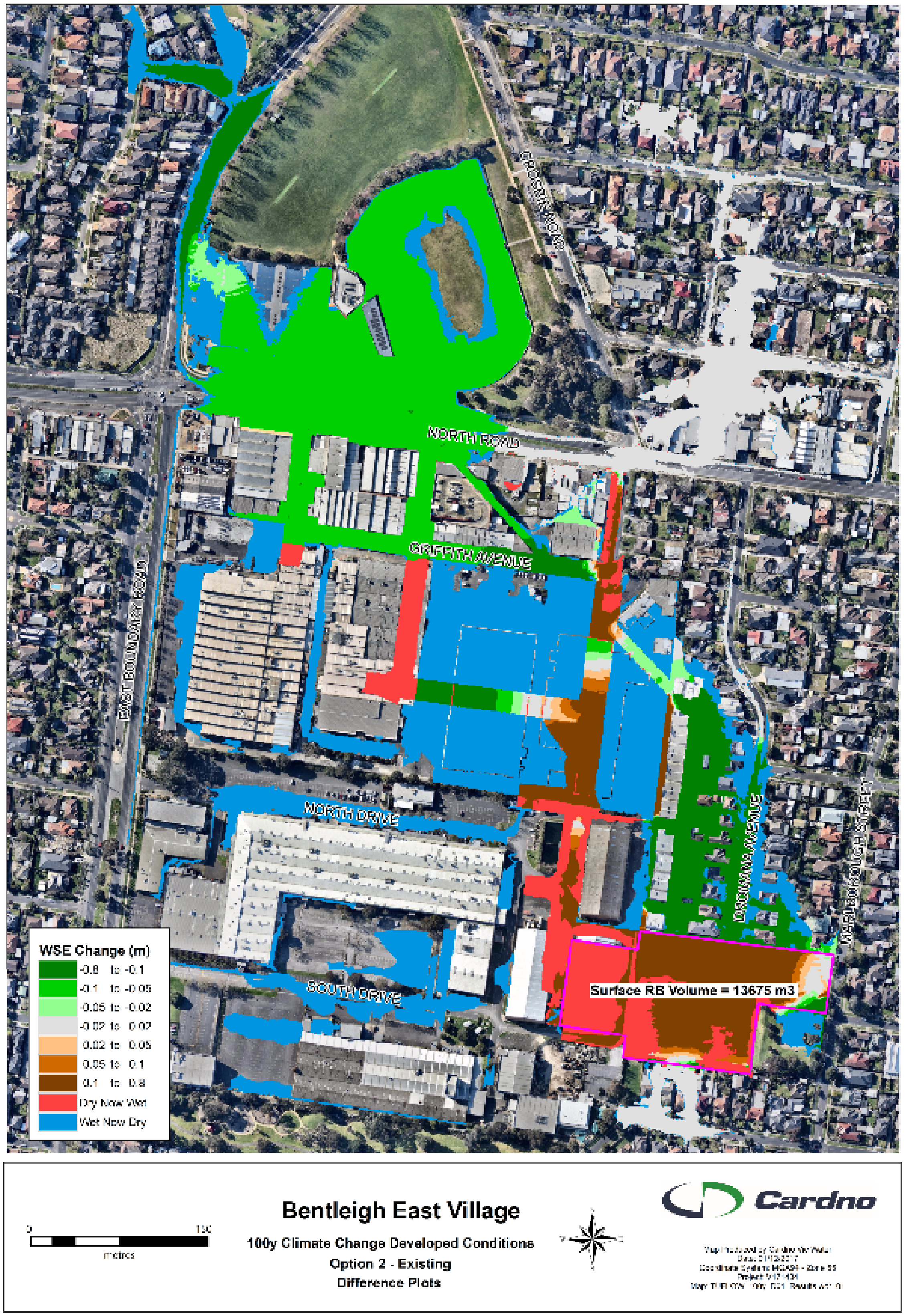

Figure 7-10 1% AEP Climate Change Difference Plot (Option 2)

Figure 7-11 1% AEP Maximum Flood Depths (Option 2)

Figure 7-12 1% AEP Maximum Flood Hazards (Option 2)

Figure 7-13 1% AEP Climate Change Maximum Flood Depths (Option 2)

Figure 7-14 1% AEP Climate Change Maximum Flood Hazards (Option 2)

7.3 Option 3 Modelling and Results

Option 3 was developed after multiple feedback sessions and workshops with Glein Eira City Council, in order to incorporate several design intentions for the Marlborough Street Reserve into the drainage and stormwater modelling.

Council has identified a future need to provide soccer field(s) in the reserve and have requested that surface storage in the Marlborough Street Reserve should provide for at least one senior sized soccer field to be free of inundation with its levels set above the 1% AEP Flood levels. As the design intentions are preliminary at this stage, several configurations are possible in the future. Figure 7-15 shows the preferred option at this stage.

Figure 7-15 Option 3 Marlborough Street preferred configuration

Because several configurations are possible, the following stage-storage (or elevation-volume) relationship for the detention basin within the Marlborough Street Reserve was developed as shown in Figure 7-16. This stage-storage relationship can serve as a basis of design for any future design. A potential preliminary design was included in the Tuflow model. A key element of this option is the inclusion of a flood barrier along the northern end side of Marlborough Street reserve, set at 46.5 mAHD. This enables additional storage in the reserve, without the need for further excavation. As a guide, this level is the elevation of the reserve at the north east and north west corners. The low point of the reserve is at the existing Dromana Avenue entrance with an elevation of approximately 46 mAHD.

Figure 7-17 below shows how the overland flows are conveyed throughout the site.

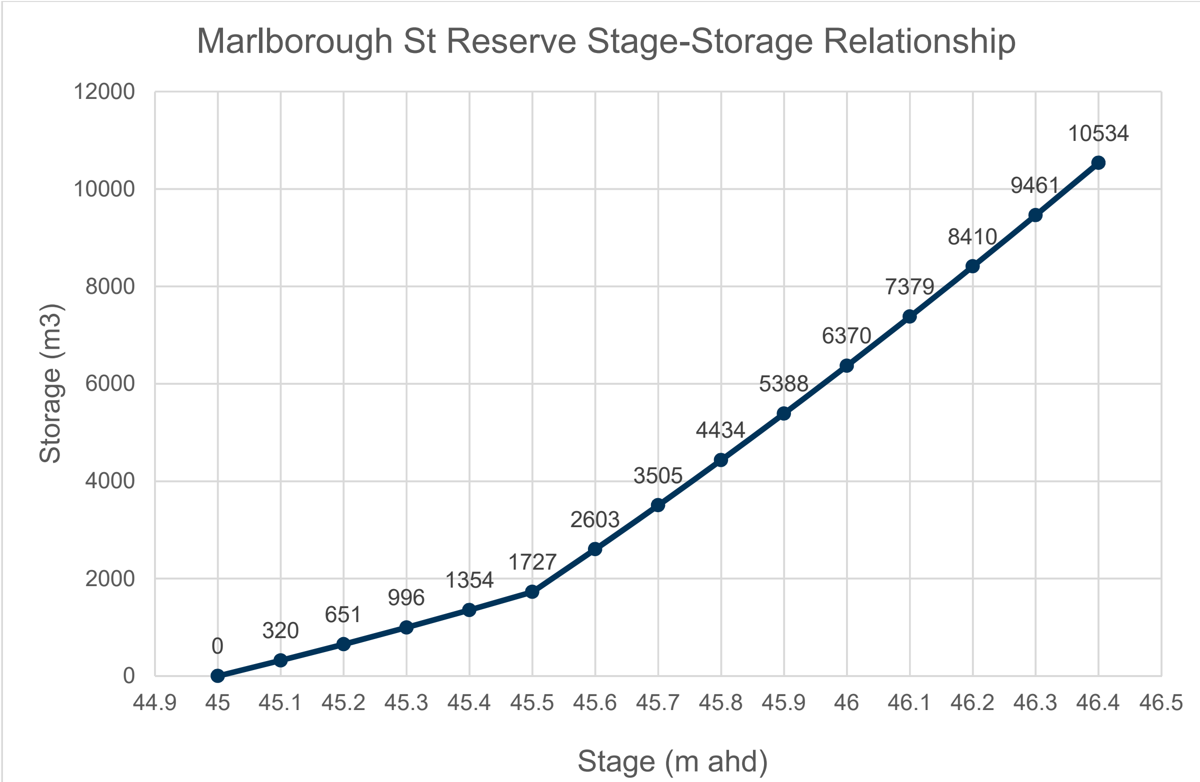

Figure 7-16 Marlborough Street Reserve Option 3 Stage-Storage Relationship

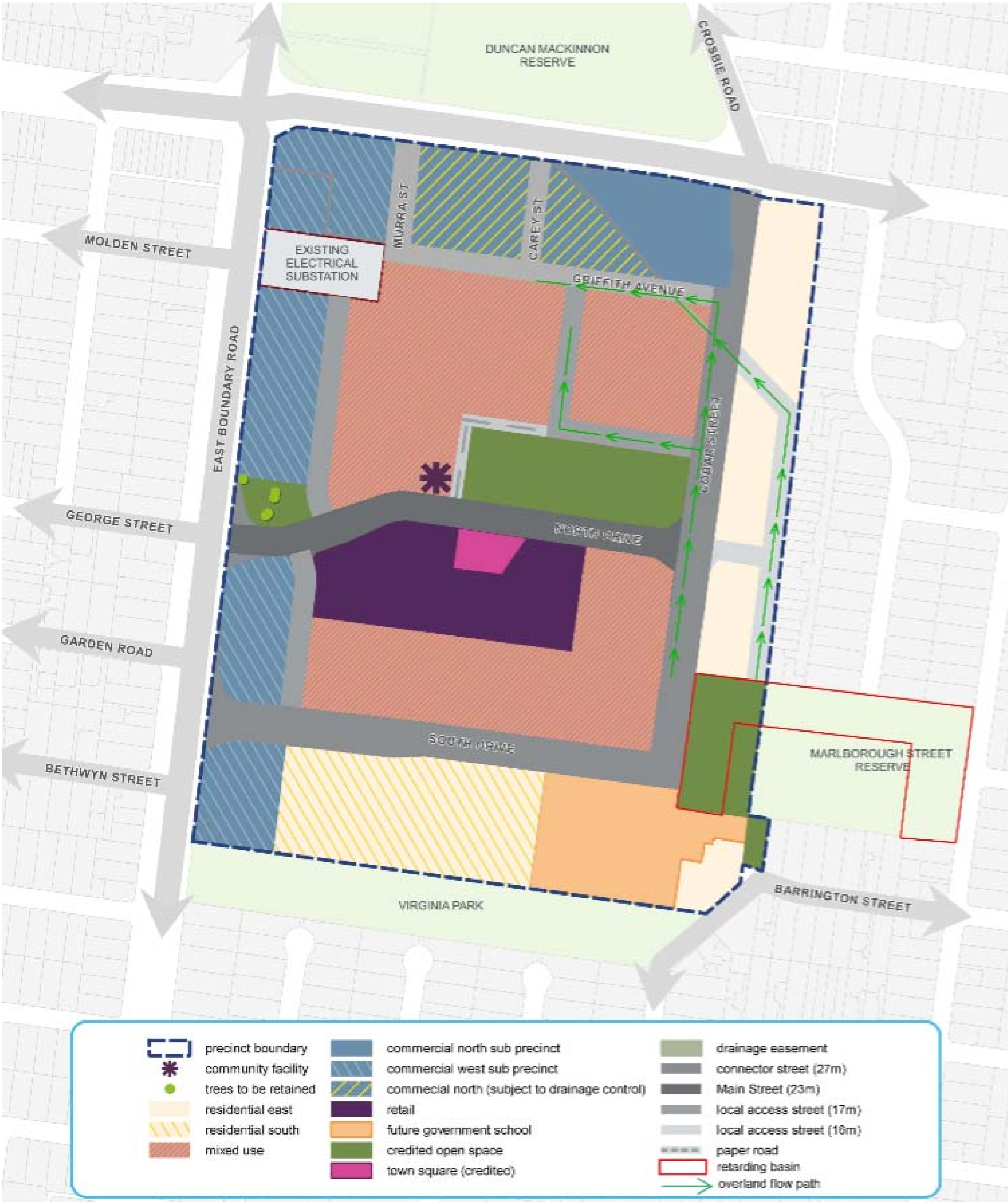

Figure 7-17 Option 3

Hydraulic modelling of Option 3 was undertaken by including the following aspects in the current TUFLOW model developed by Cardno:

- Include a 10,000 m^3 storage in Marlborough Street open space by localised lowering of modelled terrain in location and configuration indicated above;

- The inclusion of a flood barrier along the northern end side of Marlborough Street Reserve, set at 46.5 mAHD.
- Include 16m wide laneway as indicated; and
- Include proposed road layout within EV site.

Aside from the roads, all other areas within the EV site were blocked out as it is assumed that they will be designed to be flood free, thus encouraging water to flow along the roadways.

Figure 7-18 and Figure 7-19 show the change in water surface elevation with the introduction of the mitigation option for both current climate and future climate conditions while Figure 7-20 to Figure 7-23 show depths and hazards plots. The results show:

- There is a significant reduction in flooding in the areas surrounding Dromana Avenue, Griffith Avenue and North Road.
- For roads within the EV site, flood hazard is generally low (Class H1), with only a small area of the site being above this. Localised works at the detailed design stage would likely be able to reduce these further.
- Melbourne Water's safe access criteria can be met throughout the site, other than for:
  - Griffith Avenue, Murray Street and Carey Street ("H3" and "H4");
  - The overland flow transition from Dromana Avenue townhouses to the main access road ("H3"), although this could be removed by minor adjustment of the proposed works.
- Whilst the flood hazards in Dromana Avenue are reduced, the remaining "H3" hazard does not meet safe access criteria. However, this flooding is:
  - Outside the EV site;
  - Associated with an existing flooding problem;
  - Not as a result of future redevelopment at EV;
  - An issue requiring further consideration by Council and Melbourne Water.
- The "semi-circular" flood shape in the Marlborough Street Reserve at the location of the senior size soccer field and flooding south of the reserve is due to local drainage issues along Barrington Street and can be solved locally. This flooding is not due to the MW main drain or EV site and is minimal on the Marlborough Street reserve. Several solutions are available such as upsizing of the pipes along Barrington Street or a channel that would drain and connect to the MW main drain in the future.
- Approximate flooding times for Option 3 are:
  - 5.5 hours for the Retarding Basin in Marlborough Street Reserve
  - 2.5 hours for the internal network
  - 6 hours for North Road

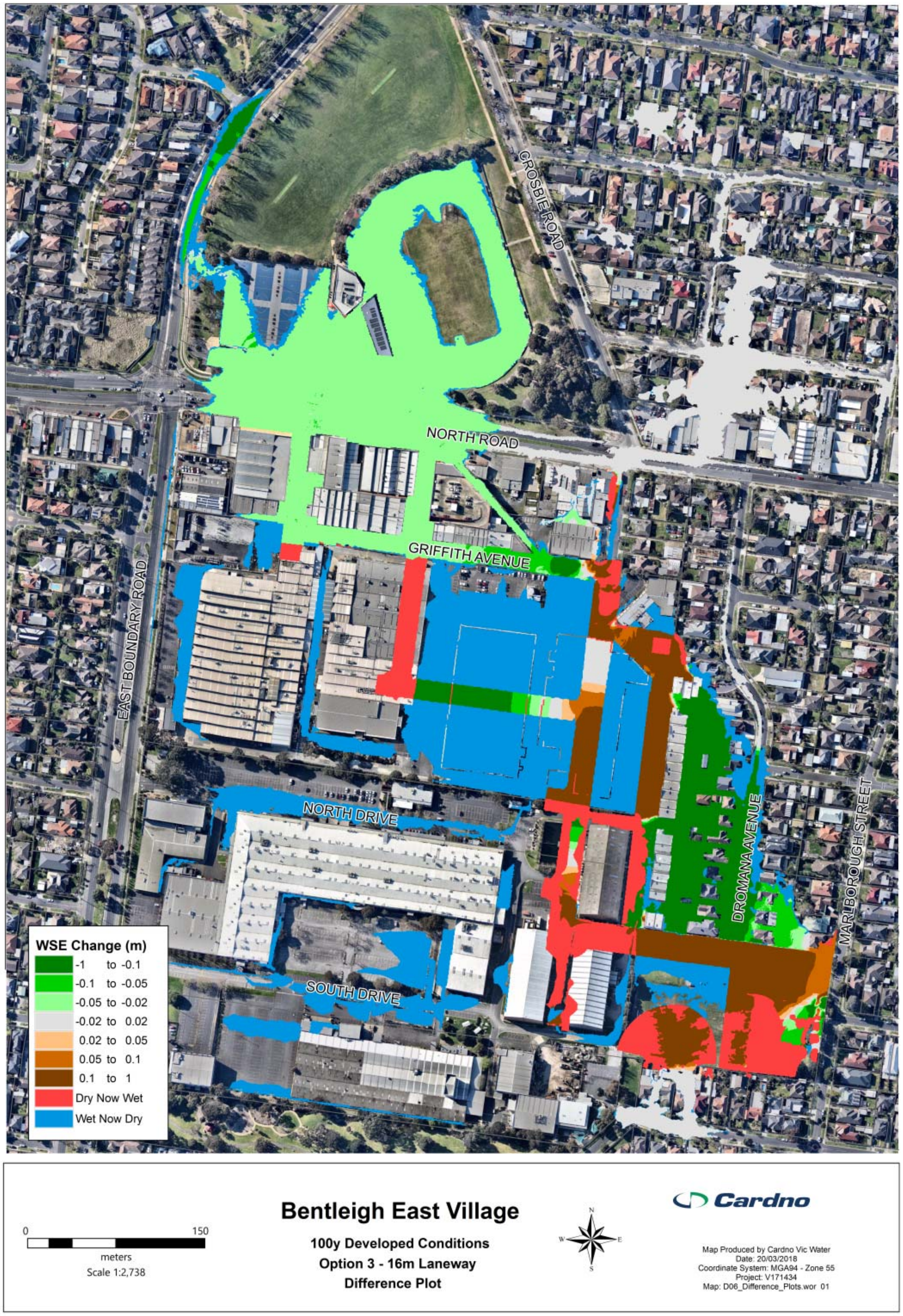

Figure 7-18 1% AEP Difference Plot (Option 3)

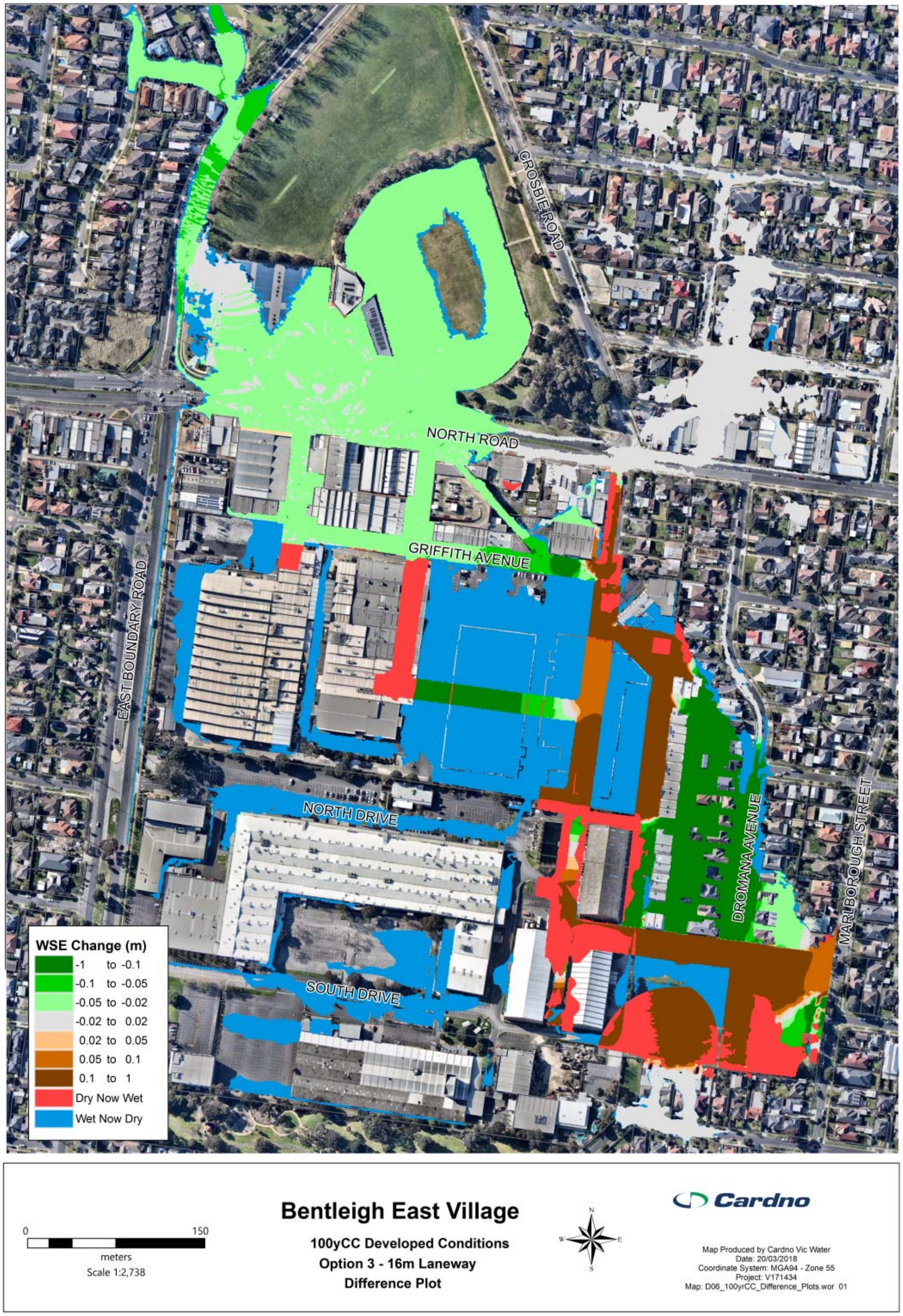

Figure 7-19 1% AEP Climate Change Difference Plot (Option 3)

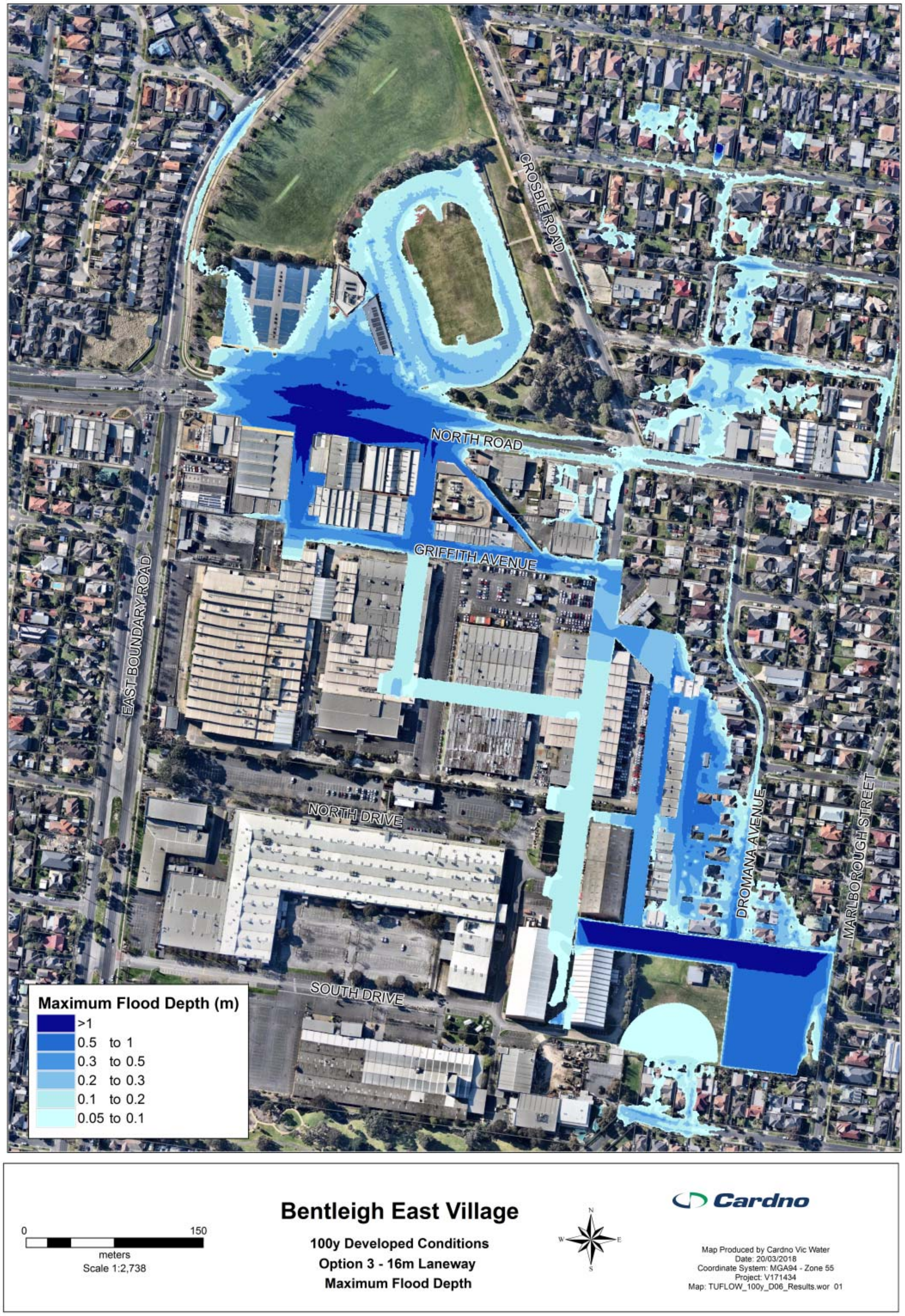

Figure 7-20 1% AEP Maximum Flood Depths (Option 3)

Figure 7-21 1% AEP Maximum Flood Hazards (Option 3)

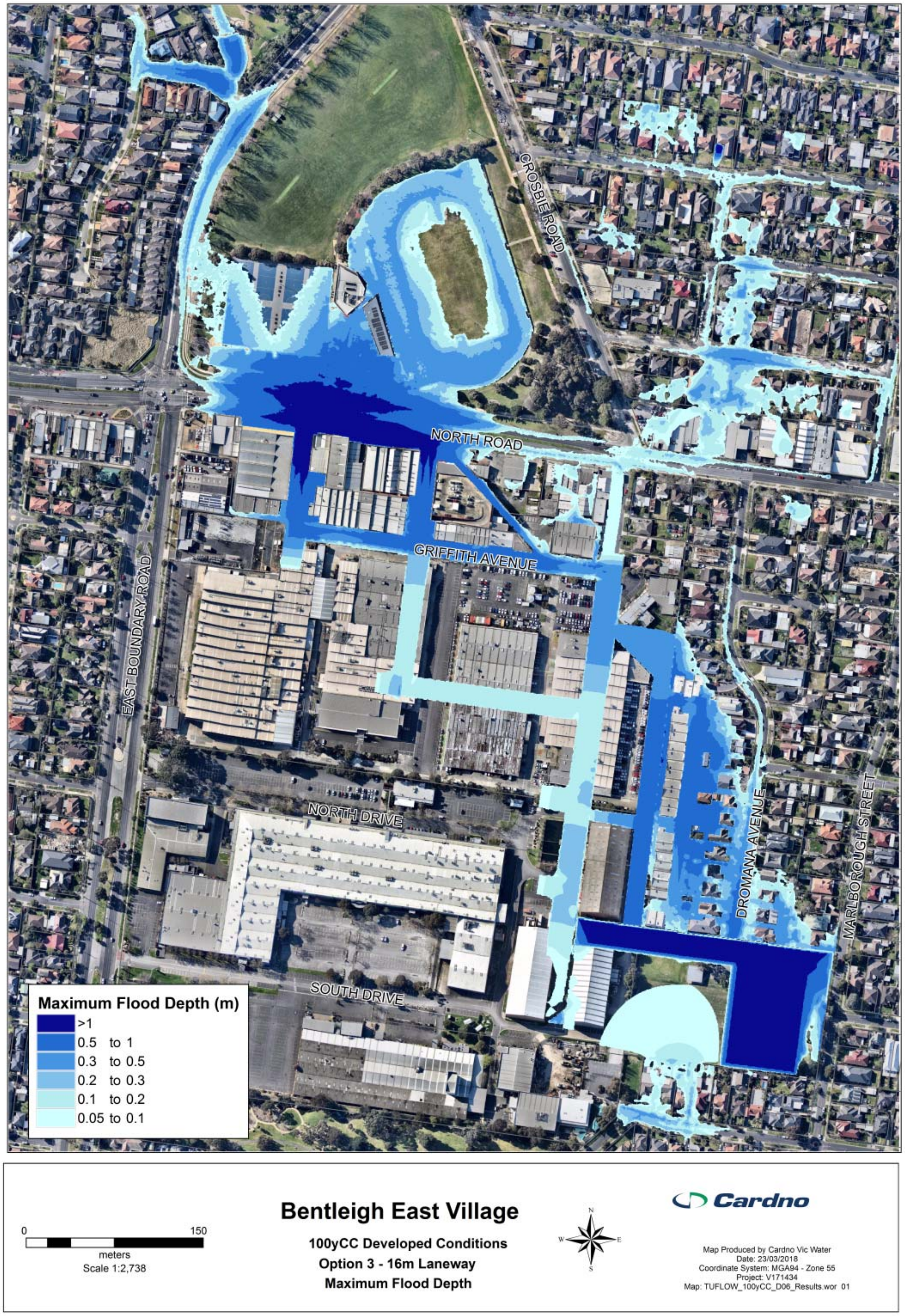

Figure 7-22 1% AEP Climate Change Maximum Flood Depths (Option 3)

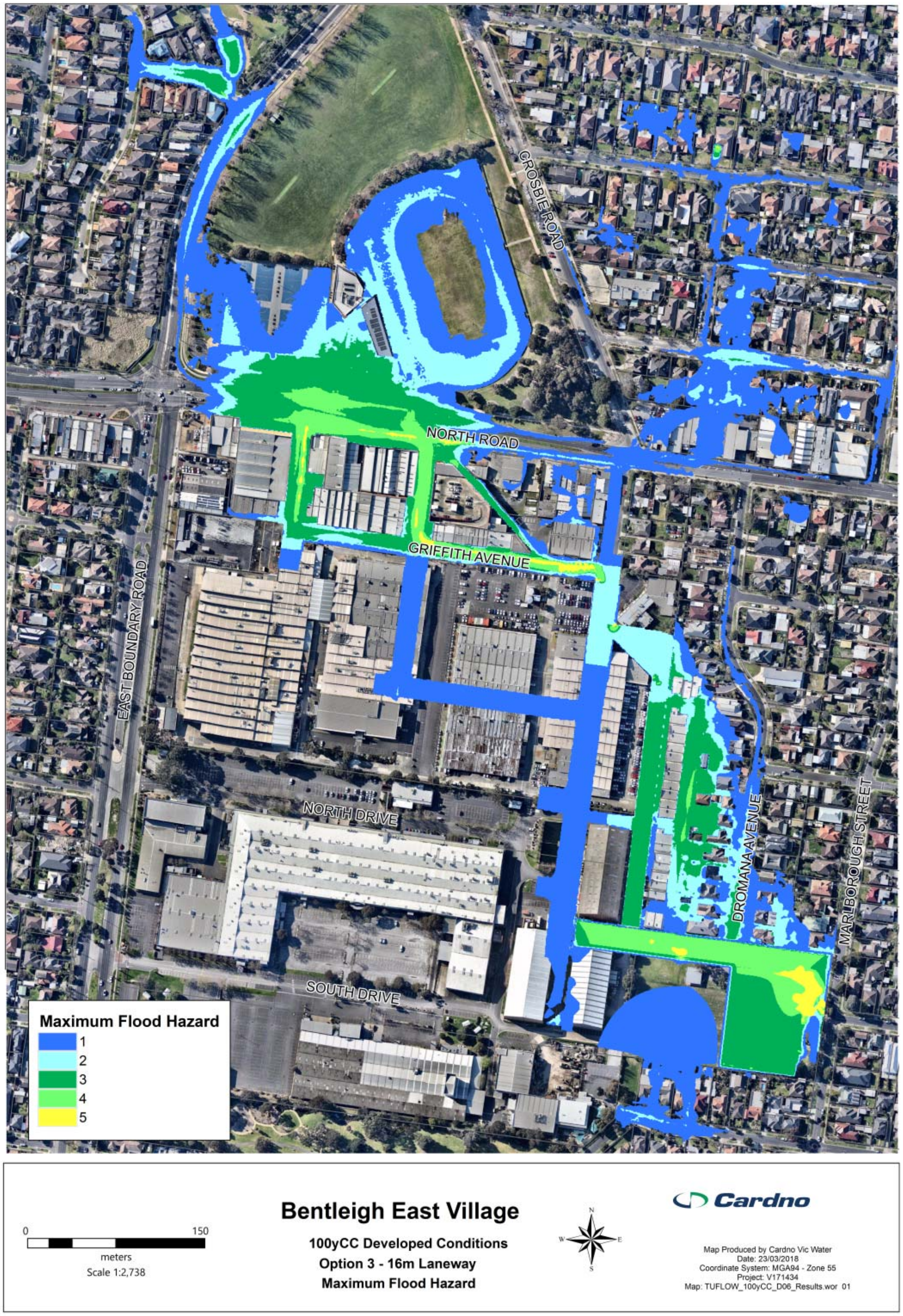

Figure 7-23 1% AEP Climate Change Maximum Flood Hazards (Option 3)

8 Economic Damages

The economic impact of flooding is defined by what is commonly referred to as 'flood damages'. Flood damages are classified into direct, indirect or intangible classes, as shown in Figure 8-1.

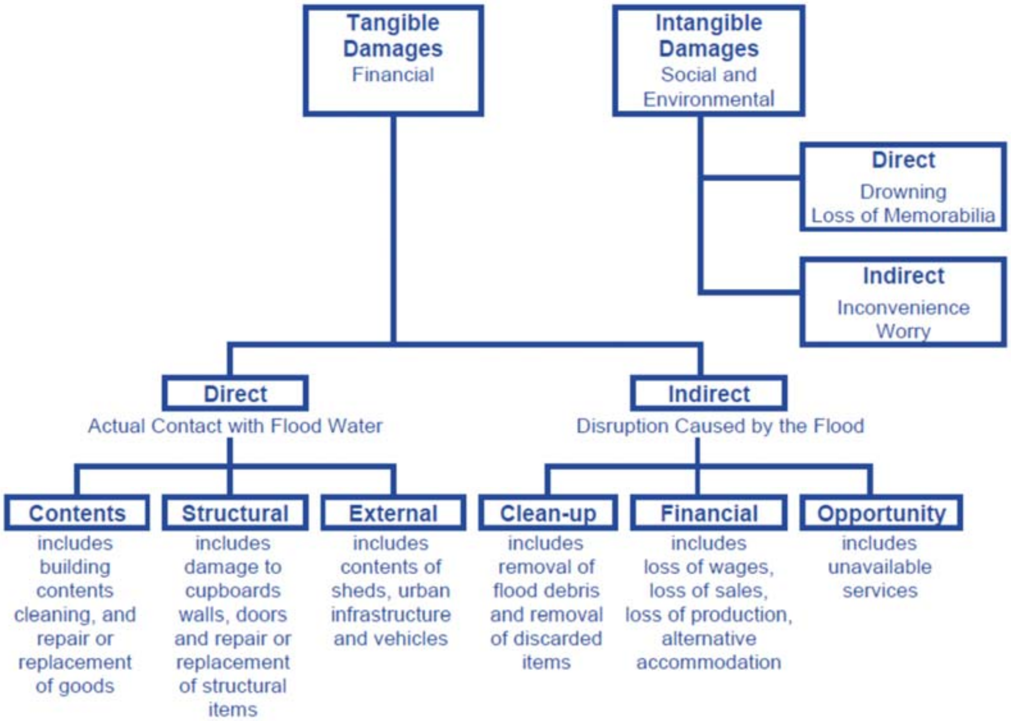

Figure 8-1 Types of flood damage (Floodplain Development Manual (NSW Gov, 2005))

As shown above, flood damages can be both tangible and intangible, with direct damage costs only forming part of the overall flood damage cost.

The damage assessment in this report is restricted to tangible damages only, and does not include an estimate of the costs associated with intangible damages, such as social distress and loss of memorabilia.

It has been assumed that residents will have little to no warning time in a flood event and hence no allowance has been made for the residents protecting or removing their valuables. This assumption has been made as it gives a more conservative estimate of flood damages as the maximum 'potential' damage is assessed.

Flood damages can be assessed by a number of methods including the use of computer programs such as FLDAMAGE, ANUFLOOD or via more general methods such as using spreadsheets. For the purposes of this project, spreadsheets have been used in line with Melbourne Water's approach and methods for calculating annual average damages, and consistent with Cardno's experience in this area.

In order to demonstrate the benefits of storage within the Marlborough Street reserve, future flood damages (after flood mitigation options are implemented) have been calculated and compared to the existing flood damages. Three different flood damages have thus been calculated for the purpose of this report:

- Existing Flood damages including the existing EV site (currently known as Virginia Park)
- Existing Flood damages excluding the existing EV site (currently known as Virginia Park)
- Flood damages under Option 3 scenario

8.1 Damage Analysis

A flood damage assessment has been undertaken for the existing catchment and floodplain within the East Village Area as part of the current study. The assessment has been based on damage curves provided by Melbourne Water, which relate flood depth to likely property damage.

The following sections provide an overview of the methodology applied for the determination of damages within the East Village catchment at Glen Eira. Damages have been divided into three main types:

- Building Damages (residential and commercial/industrial buildings).
- Property Damages (flooding over property with no buildings impacted).
- Road Damages (flooding occurring over roads).

8.1.1 Building Damages

Residential and Commercial Buildings Damage Curves

Some floor levels of residential and commercial properties were provided by Melbourne Water for use in the damage assessment. There were a number of properties where no data is available. Based on visual inspection through site visits and GIS mapping (including Google Street View) most residential properties in Glen Eira have been identified as being constructed as either slab on ground or on stumps, with floor levels relatively low to the ground. For these properties, we have assumed a floor level 150 mm above the natural surface as estimated from the surface lidar at the front of the property. It is noted that this provides the most conservative estimate of residential property damage.

Damage to buildings from flooding begins prior to any over floor flooding. The damage estimates included in this report are based on two possible scenarios:

- Where flooding overtops the property ground level but does not affect the base of the house (i.e. the slab), no building damages are incurred.
- Where flooding overtops the property ground level, residential building damages begin once the water level reaches the base of the house, defined as floor level minus 0.5m (slab on ground). Melbourne Water's damage curves allow for a starting damage of $11,182. This value also accounts for property damages as well as some damage to cars and structures.
- Where flooding overtops the property ground level, commercial building damages begins once the water level reaches the base of the building, defined as floor level. Melbourne Water's damage curves allow for a starting damage of $5,500 per 100m^2 of building area.

Residential and commercial damage curves provided by Melbourne Water are shown in Figure 8-2 and Figure 8-3

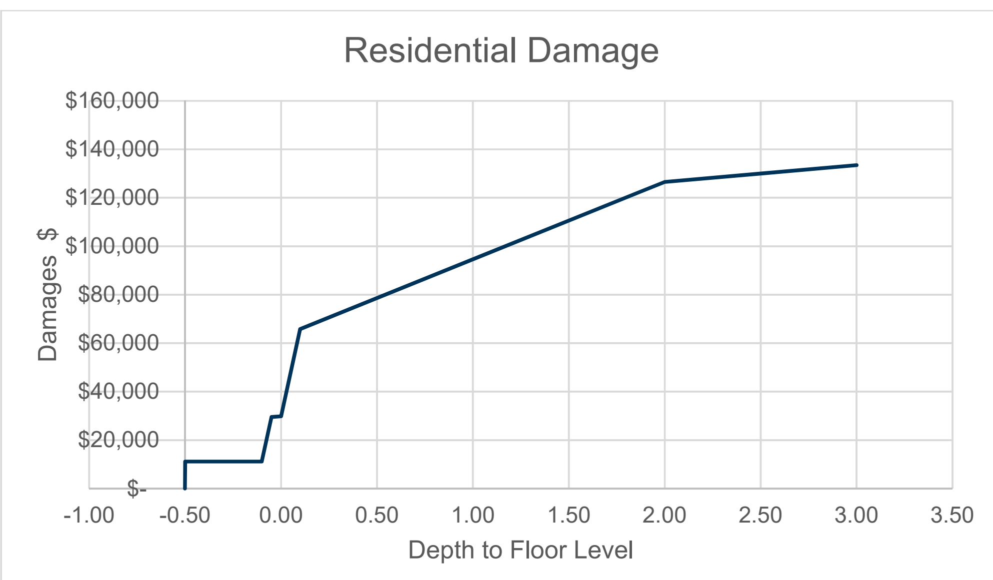

Figure 8-2 MW Residential Damage curve applied to the East Village flood investigation

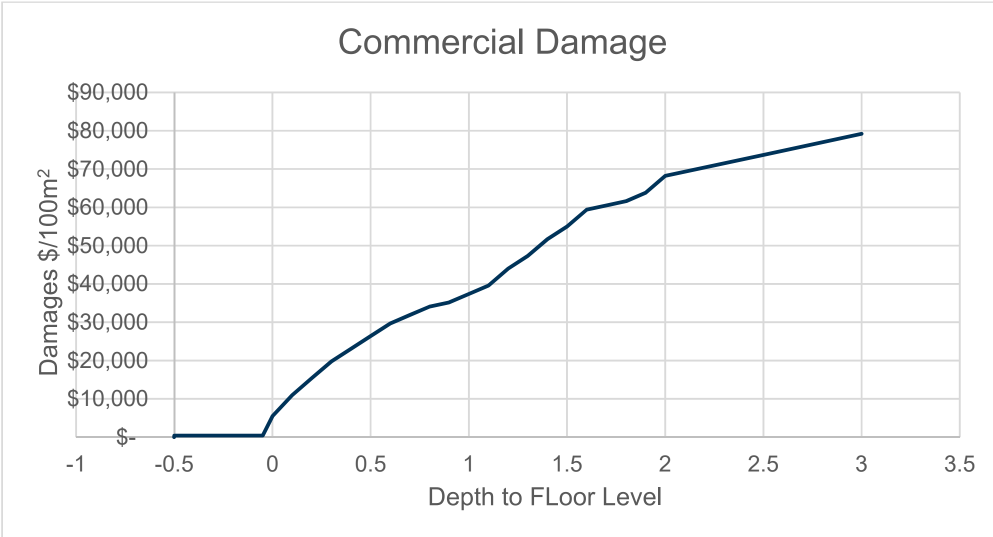

Figure 8-3 MW Commercial Damage curve applied to the East Village flood investigation

8.1.2 Property Damages

Property damage is defined as expected damages to property other than buildings due to flood waters impacting the site during and after a flood event. This includes damage to gardens, fencing, extended inundation, etc.

This analysis has only assessed property damage as occurring when the building on that property is not impacted by flood waters (i.e. flood level is within 0.5 m of the floor level, as defined above). This is because once flood levels rise above this level, general property damage is included in the building damage calculation.

This analysis has defined property damage as occurring when any delineated property is modelled to experiencing flooding to a depth greater than 10cm for more than 2% of the site area, where buildings have not been impacted (as discussed above). These factors have been applied as flood depths less than 10 cm and for an area of less than 2% will not generally cause significant damage to a property.

A flat damage rate of $500 has been applied to all properties assessed as being subject to property damage.

8.1.3 Road damages

Road damage have been assessed based on the Rapid Appraisal Method (RAM) which assigns a damage value for major roads, minor roads and unsealed roads. The RAM was developed in May 2000 with quoted in May 2000 dollars. To convert these to December 2017 dollars, the CPI was used to adjust for inflation. The adjustment factor is shown in Table 8-1.

Table 8-1 Roads damage adjustment factor

Month	Year	CPI
Mar	2000	69.7
Dec	2017	112.3
Change	62.06 %	

The RAM uses a single estimate cost per km for all roads inundated by flood water and includes:

- Initial repairs to roads
- Subsequent additional maintenance to roads
- Initial repairs to bridges (based on 1/3 of road damages)

- Subsequent additional maintenance to bridges.

The RAM estimates of costs per km of inundated road are shown in Table 8-2. These unit damages were adjusted using the CPI adjustment factor. The RAM also states that the damages to roads and bridges generally outweighs the costs associated with other infrastructure such as water, electricity, gas and sewerage services and is a good approximation for the overall damage to the regional infrastructure.

Table 8-2 Unit damages for roads and bridges (dollars per km inundated)

Road Type	Initial road repair	Subsequent accelerated deterioration of roads	Initial bridge repair and increased maintenance	Total cost applied per km to inundated roads (May 2000 $)	Total cost applied per km to inundated roads (Dec 2016 $)
Major sealed roads	*$ 32,000*	*$ 16,000*	*$ 11,000*	$ 59,000	**$ 93,113**
Minor sealed roads	*$ 10,000*	*$ 5,000*	*$ 3,500*	$ 18,500	**$ 29,197**
Unsealed roads	*$ 4,500*	*$ 2,250*	*$ 1,600*	$ 8,350	**$ 13,178**

8.2 Annual Average Damage

Annual Average Damage (AAD) are calculated on a probability approach using flood damages calculated for each design event using the methodologies described in the sections above. The total damage is the summation of the damage to all houses, properties and roads within the flood extent for that design event.

The AAD attempts to quantify the average flood damage that a floodplain would receive during a single year. It does this by using a probability approach. A probability curve is drawn, based on the flood damages calculated for each design event. This is shown in Figure 8-4. For example, the 1 in 100 AEP design event has a 1% chance of occurring in any given year and has a total estimated damages of $7,397,939 so is plotted at this point on the AAD curve. The AAD is then calculated by determining the area under the curve using the trapezoidal method.

Based on the above analysis, the AAD for the EV site and surrounding areas under existing conditions is **$ 487,000**. This calculation includes inundated buildings, roads and properties in the EV site (currently known as Virginia Park). The probability curve for this scenario is shown in Figure 8-4 below.

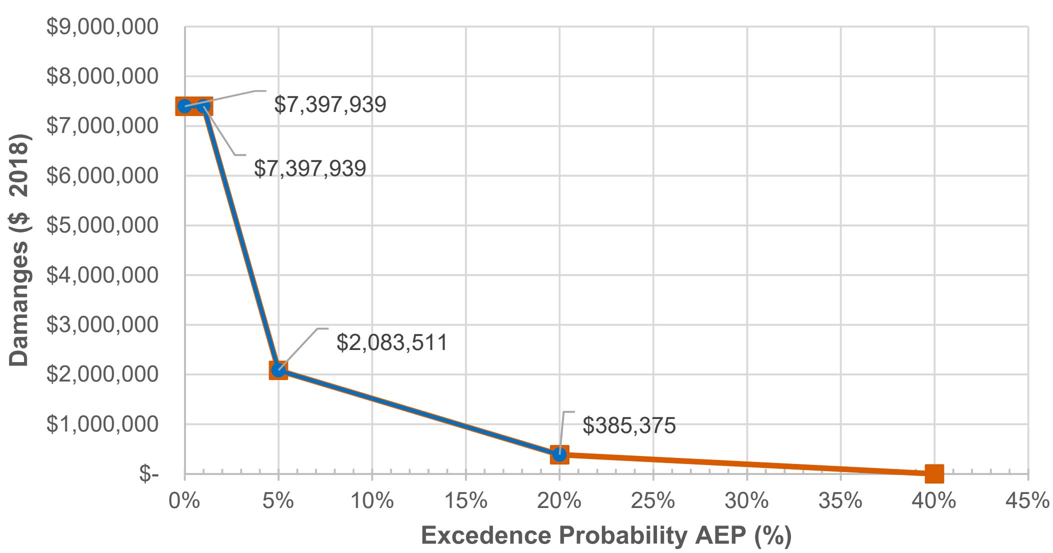

Figure 8-4 Flood damages used to estimate the Average Annual Damages under existing conditions including the EV site (Virginia Park)

Melbourne Water has previously calculated the Average Annual damages in this area to be approximately $500,000, consistent with this analysis.

The flood damages for the catchment, excluding the EV site area south of Griffith Avenue, has been calculated. This is to provide an assessment of the potential flood damage in the catchment not associated with the development. The AAD for this area is **$ 360,000**. The probability curve for this scenario is shown in Figure 8-5 below.

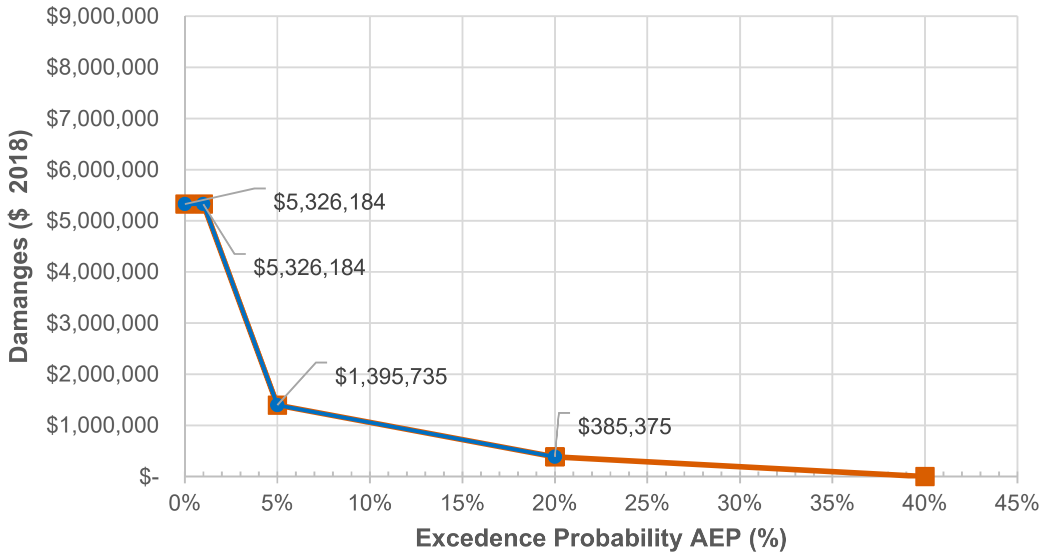

Figure 8-5 Flood damages used to estimate the Average Annual Damages under existing conditions excluding the EV site (Virginia Park)

The average annual damages were calculated for Option 3. This calculation also excludes consideration of areas within the development site that are south of Griffiths Avenue. Effectively, the option should reduce the flood damages at the EV development site to near zero values. The calculated average annual damages for Option 3 is **$ 275,000,** which is a reduction of $212,000 compared to the existing damages including the current EV site or $85,000 per annum compared to the existing damages excluding the current EV site.

The damage curve for this scenario is shown in Figure 8-6 below.

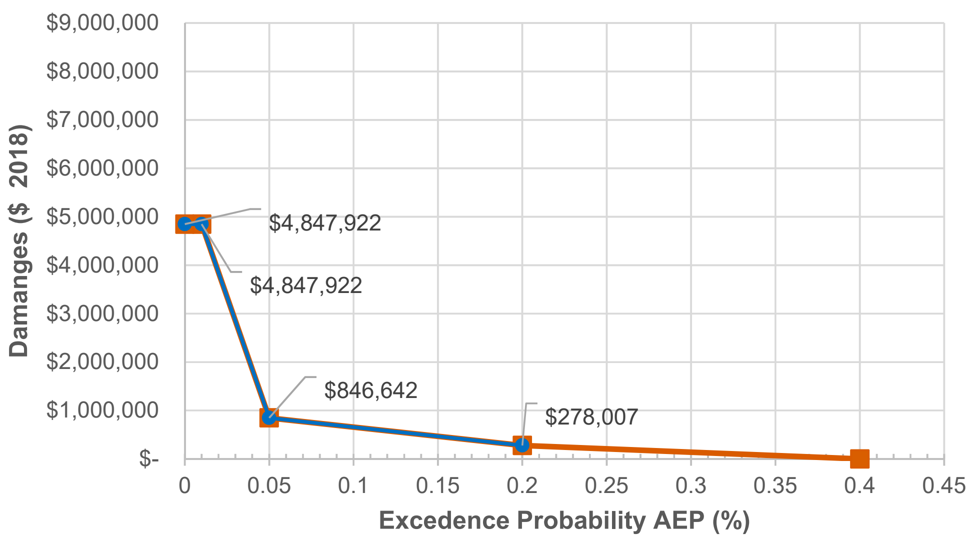

Figure 8-6 Flood damages used to estimate the Average Annual Damages under Option 3 Scenario.

9 Cost Estimates

This chapter presents high-level cost estimates for the storage required for each mitigation option described previously. It should be noted that since the options are at “proof of concept” level at this stage, the cost estimates assume a 50% contingency. The costs are for supply and placement of the storage system only. The total cost would need to include any required infrastructure removals, reinstatement and the usual delivery allowances, which VPA includes in all cost estimates.

A preliminary configuration of the basins (average excavation depth, bund height, etc.) is also included. Underground storage costs have been developed using the commercially available Stormtech Chamber system.

All costs are for the provision of the engineering drainage infrastructure only. We have not allowed any landscaping costs.

9.1.1 Stormtech Subsurface Chamber Systems

For underground storage options, and due to the relatively high volume of storage required, Stormtech subsurface chamber systems such as the one pictured below were chosen instead of concrete tanks for cost reduction purposes.

Figure 9-1 Stormtech subsurface chamber systems

The Stormtech subsurface chamber system is a structural water storage system for rainwater harvesting, stormwater detention and infiltration. They are specifically designed for use under sport fields, roadways and car parking areas. The lightweight chambers (34kg) require no on site assembly, can be cut to size and can safely be placed by only two people.

‘Isolator Rows’ consisting of row of chambers wrapped in a nonwoven geofabric (white) and a layer of woven fabric (black), act as a Gross Pollutant trap (GPT) and have been tested to remove 98% of T.S.S. The Isolator Row can be cleaned, at low cost, through the inlet pit from the surface using Jet Vac equipment.

Installing additional volume for stormwater harvesting purposes can be easily accomplished as part of the design. This option would require additional pump and excavation costs on top of those shown below

9.2 Option 1 Storage Configuration and Cost Estimate

The storage volume of option 1 of 2016m^3 can be stored underground or aboveground. Table 9-1 and Table 9-2 below provide "high-level" cost estimates for both configuration. We have costed the aboveground excavation sizes based on the total stored volume with additional overage for batters. The aboveground option in this area would require average depths through the basin of approximately 1.2 metres, due to the location outside of the existing Marlborough Street Reserve.

DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
Excavation	6000	$25/m3	$150,000	
Supply of 2016 kL Stormtech tanks, including pipe connections and liners	1	item	$469,728	
Site establishment, stripping, stockpiling and reinstatement of topsoil, inlets and outlet structures and miscellaneous items	1	item	$150,000	**$769,728**

Table 9-1 Option 1 Underground storage cost estimate

DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
Excavation	2400	$25/m3	$60,000.00	
Site establishment, stripping, stockpiling and reinstatement of topsoil, inlets and outlet structures and miscellaneous items	1	item	$150,000.00	**$210,000.00**

Table 9-2 Option 1 Aboveground Storage Cost Estimate

9.3 Option 2 Storage Configuration and Cost Estimate

The storage volume of option 2 of 13700m^3 can be stored underground or aboveground. Tables 9-3 and 9-4 below provide "high-level" cost estimates for both configuration. For an aboveground or surface retarding basin configuration, the average excavation depth is estimated to be about 600mm throughout 18,000m^2 of surface area. The surface storage also assumes a bund with an average height of 0.4m, with a maximum bund height of 1.4m on the southern end of the basin and 0m in the northern end.

DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
Excavation	22000	25/m3	$550,000	
Supply of 13700kL Tank, including Stormtech tanks, pipe connections and liners	1	item	$3,192,100	
Site establishment, stripping, stockpiling and reinstatement of topsoil, inlets and outlet structures and miscellaneous items	1	item	$400,000	**$4,142,100**

Table 9-3 Option 2 Underground Storage Cost Estimate

DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
Excavation	16440	25/m3	$411,000	
Site establishment, stripping, stockpiling and reinstatement of topsoil, inlets and outlet structures and miscellaneous items	1	item	$500,000	**$911,000**

Table 9-4 Option 2 Above Ground Storage Cost Estimate

9.4 Option 3 Storage Configuration and Cost Estimate

The storage volume of option 3 of 10,000m^3 is assumed to be stored aboveground. Table 9-5 below provides a “high-level” cost estimate. The surface storage also assumes a bund with an average height of 0.4m, with a maximum bund height of 1.4m on the northern end of the basin and 0m in the southern end.

DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
Excavation	12000	25/m3	$300,000	
Site establishment, stripping, stockpiling and reinstatement of topsoil, inlets and outlet structures and miscellaneous items	1	item	$500,000	**$800,000**

Table 9-5 Option 3 Above Ground Storage Cost Estimate

Underground storage options are generally more expensive than aboveground options as they require larger excavation volumes as well as the purchase, installation and maintenance of the storage tanks.

10 Stormwater Quality

Water quality for the EV development can be managed through a number of different approaches. For the purpose of this report, three main options have been identified:

- A precinct scale treatment of stormwater by a single or multiple Water Sensitive Urban Design (WSUD) asset,
- A precinct scale treatment of stormwater with the addition of a stormwater harvesting for non-potable supply (e.g irrigation of the two MacKinnon Reserve ovals)
- A combination of rainwater harvesting from sub-precinct roof runoffs at the individual scale for non-potable supply to the sub-precinct and additional treatment of stormwater from road runoffs by multiple WSUD asset.

The main objective of the treatment measures is to meet best practice stormwater quality guidelines and objectives based on the "Best Practice Environmental Management Guidelines" (CSIRO 1999), which will be required for the redevelopment of the EV.

10.1 Water Quality Objectives

In order to achieve the required treatment objectives, water quality treatment measures will be incorporated into the site layout in order to meet the best practice management targets outlined in Table 10-1.

Table 10-1 Best Practice Water Quality Targets

Pollutant	Target Reduction
Total Suspended Solids	80%
Total Nitrogen	45%
Total Phosphorus	45%
Gross Pollutants	70%

To determine the effectiveness of the proposed treatment train in meeting the water quality objectives, stormwater quality modelling was performed using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) Version 6.0.

10.2 Water Sensitive Urban Design

10.2.1 Option A: A precinct scale treatment of stormwater by a single or multiple Water Sensitive Urban Design (WSUD) asset.

Music Modelling of the site has determined that a bioretention system (Raingarden) with a footprint of **800m^2** would provide the required water quality treatment for the entire EV site. It should be noted that the treatment train can consist of a single 800 m^2 bioretention asset or a combination of assets with a total area of 800m^2 distributed throughout the site (e.g tree pits, raingardens, etc...)

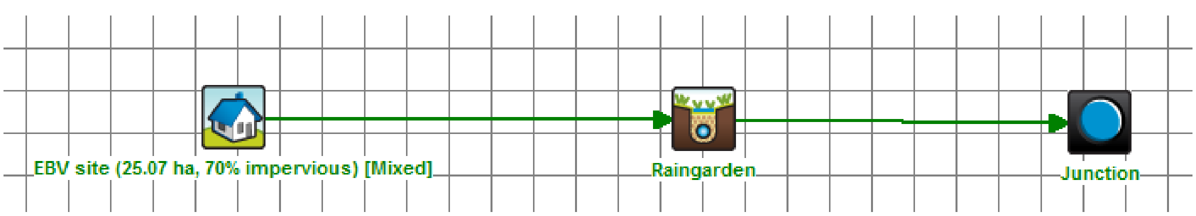

Figure 10-1 Option A MUSIC schematic

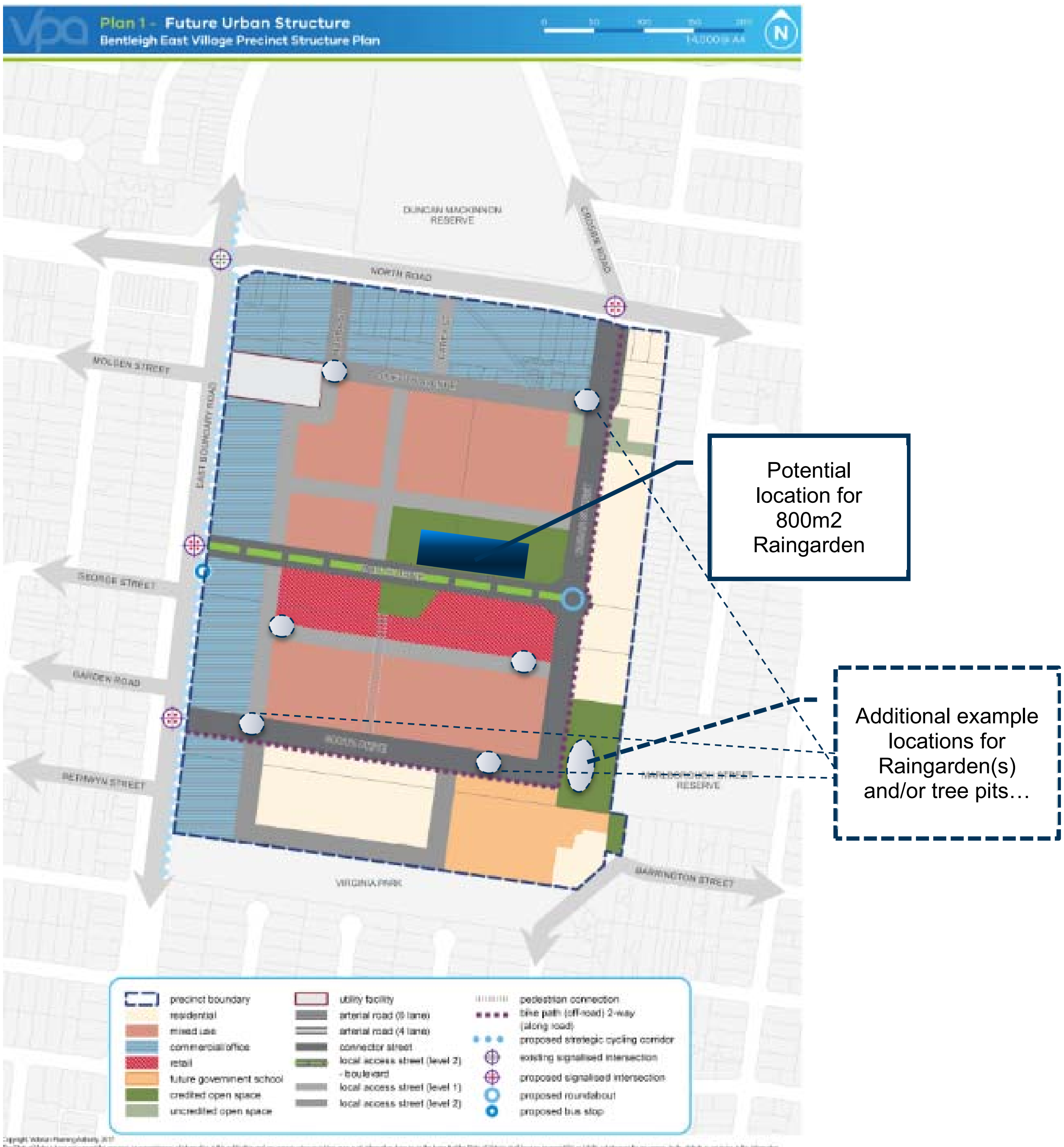

Figure 10-2 Option A potential location of WSUD assets.

	Advantages	Drawbacks	Cost Estimate (Contingency +/- 30%)
Option 1	Improves stormwater quality and achieves required treatment objectives	No diversification of water supply and provision of alternative supplies for resilience and Integrated Water Management aspects.	$ 800,000
	Increase native vegetation cover for biodiversity, soil moisture for human comfort and health, improve the quality of recreation spaces, amenity and liveability value		

Table 10-2 Option A: Advantages, drawbacks and Cost estimate (CAPEX only)

10.2.2 Option B: A precinct scale treatment of stormwater with the addition of a stormwater harvesting for non-potable supply (i.e. irrigation of the two MacKinnon Reserve ovals)

Another option to managing the stormwater treatment of the EV site consists in treating and reusing stormwater runoffs from the site. The proximity of the site to the MacKinnon reserve offers an opportunity to reuse stormwater runoffs to irrigate the two ovals which annual irrigation demand has been estimated to be **10.8ML/yr.**

The following infrastructure or similar will generally be required for stormwater reuse schemes:

Diversion

- Pump and transfer main
- Bioretention and/or multi-media filters
- Storage tanks
- Pump and transfer main
- UV disinfection treatment
- Chlorine disinfection treatment

Modelling of the system for the EV shows that a 50 m^3 buffer tank, a 700m^2 bioretention system (raingarden) and a 1000 m^3 stormwater reuse tank will provide for about 80% of the annual irrigation demand of the MacKinnon Reserve.

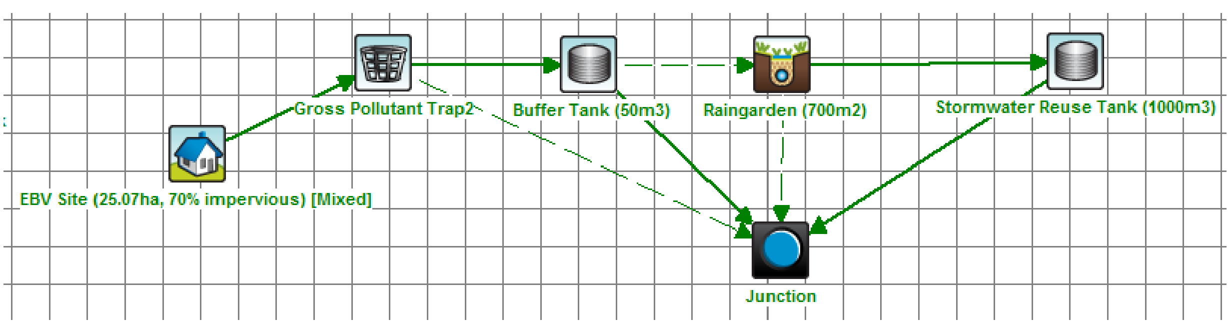

Figure 10-3 Option B MUSIC Schematic

Figure 10-4 Option B Stormwater harvesting and reuse Scheme location

	Advantages	Drawbacks	Cost Estimate (Contingency +/- 30%)
Option 2	Improves stormwater quality and achieves required treatment objectives	Cost, ongoing maintenance and operation requirements	$1,000,000
	Increase native vegetation cover for biodiversity, soil moisture for human comfort and health, improve the quality of recreation spaces, amenity and liveability value		
	Smaller WSUD asset required (700m2 instead of 800m2)		
	Diversification of water supply and provision of alternative supplies for resilience and Integrated Water Management aspects.		

Table 10-3 Option B Advantages, drawbacks and Cost estimate (CAPEX only)

10.2.3 Option C: A combination of rainwater harvesting from sub-precinct roof runoffs at the individual scale for non-potable supply to the sub-precinct and additional treatment of stormwater from road runoffs by multiple WSUD asset.

Option C considers the potential for rainwater tanks to be used for non-potable supply for all new buildings and the remainder of the EV site (mostly roadways) to be treated via WSUD assets. With 3000 dwellings and 5000 people expected in the EV, the non-potable reuse demand for toilet flushing and laundry use has been estimated at **340 kL/day**.

Music Modelling shows that to obtain a 70% reuse efficiency (for toilet flushing and laundry) and treatment of the roadways runoffs, 5000m^3 of rainwater tanks are required together with 100m^2 of bioretention assets

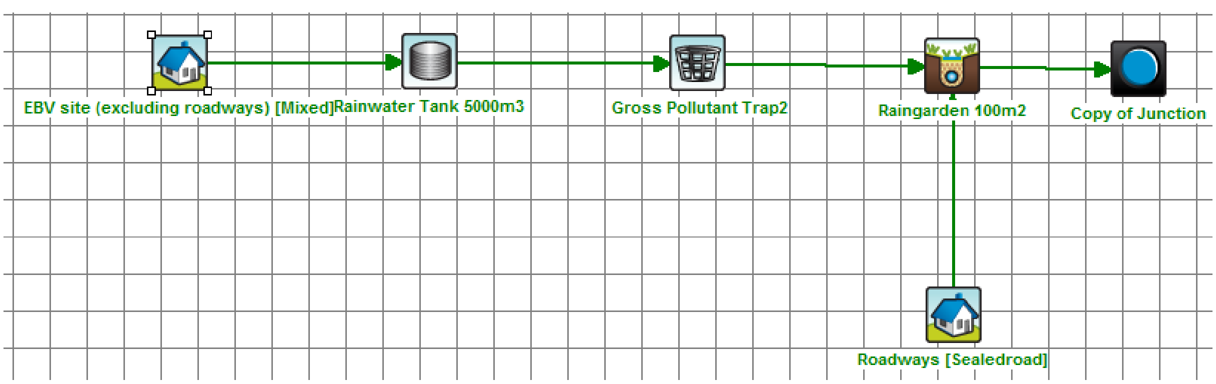

Figure 10-5 Option C MUSIC Schematic

	Advantages	Drawbacks	Cost Estimate (Contingency +/- 30%)
Option 3	Improves stormwater quality and achieves required treatment objectives	Cost	$1,500,000
	Increase native vegetation cover for biodiversity, soil moisture for human comfort and health, improve the quality of recreation spaces, amenity and liveability value		
	Smaller WSUD asset required for treatment of roadway runoffs (100m2)		
	Diversification of water supply and provision of alternative supplies for resilience and Integrated Water Management aspects.		
	Cost is distributed amongst property owners		

Table 10-4 Option C Advantages, drawbacks and Cost estimate (CAPEX only)

11 Conclusions

The report has identified that the East Village (EV) site is subject to overland flows from Melbourne Water's Crosbie Street Main drain for the in 1% AEP flood event and subject to a Special Building Overlay (SBO). The Crosbie Street drain traverses the Marlborough Street reserve ('the reserve') and runs in a northerly direction along the east boundary of the site. The reserve currently acts as an informal retarding basin, providing storage for overland flows, prior to flow travelling along Dromana Avenue and entering the EV site.

An existing flooding problem also exists to the north of the site at North Road and Griffith Avenue during the 1% AEP flood event. The volume of flood water traversing the site in a 1% AEP flood event requires that some level of flood storage occur upstream, in order to allow for the safe conveyance of flood water within the internal EV road network.
Given flood storage is occurring naturally within the reserve, the most fitting location for formalised flood storage from a flood plain management perspective is considered to be at this location, upstream of the site and of residential properties.

An above ground storage solution has been presented over a below ground storage solution, due to the significant costs associated with excavation and construction as well as maintenance and management costs for a tank (Refer Section 8).
Melbourne Water have also advised that they would not accept maintenance and management responsibility for any below ground storage asset at this location. In addition to their performance against flood criteria at Section 6.1, options have also been assessed in terms of their impact on the future upgrading of Marlborough street reserve to include more local sporting facilities.

Overall, the assessment has found:

Flood mitigation and management

- Option 1 was unable to meet all the requirements for floodplain management for the EV site. Specifically, the option did not meet the safe access provisions required by Melbourne Water under the Special Building Overlay (SBO).
- Option 2 and 3 met all the floodplain management criteria set by Melbourne Water and Council at Section 6.1 and under the SBO.
- Option 2 provided for the greatest storage volume in the reserve (13,000 cubic metres approx.) and demonstrated the greatest reduction in flood depths and flood hazard within EV site and the surrounding area for the 1% AEP flood event, in particular for at Dromana Avenue.
- Option 2 also required less land within the EV site for a designated flow path.
- Option 3 reduced the amount of flood storage modelled in the reserve to 10,000 cubic metres in order to incorporate a soccer field above the 1% AEP Flood event. This option therefore required an additional designated flow path through the EV site (16m wide).
- Despite the reduced flood storage, Option 3 still demonstrated a reduction in flood depths and flood hazard within the EV and surrounding area for the 1% AEP flood event.
- For all options flood levels at Griffith Avenue and North Road exceeded Melbourne Water's site safety criteria however, these roads are located outside the EV site, are associated with an existing MW flooding issue and are not due to the proposed structure plan.
- Safe egress from the EV site would also be provided at East Boundary Road in the event of a 1% AEP flood.

Impacts on Marlborough Street Reserve:
The use of Marlborough Reserve as a temporary retarding basin is not considered to have significant usability limitations on the reserve for the community given:

- Option 2 could be designed to allow the construction and development of sporting facilities, subject to specific design consideration when including artificial turf, to ensure that it would not lift in the event of inundation. Alternatively a proper drainage layer could be installed as part of the works to properly drain a grass field, increasing the usability of that turf.
- Option 3 has been designed to allow for the construction of some sporting facilities above the 1% AEP flood levels, providing additional protection for artificial turf surfaces.
- The frequency of flooding in the reserve would remain the same as for existing conditions for Option 2 & 3.
- The reserve would only be flooded for a maximum of 6-hours during a 1% AEP flood event and it is unlikely that in the event of a large storm, the reserve would be in use by the community.

Local drainage flows:

- Local drainage flows should be managed via on-site detention storages, limiting the outflows from the EV site to the capacity of the downstream drainage network.
- This storage enables the 5% AEP flows to be safely conveyed underground in accordance with requirements of the City of Glen Eira.

Best practice stormwater management

- There are a number of potential stormwater quality treatment options that will meet the Best Practice Environmental Management Guidelines.
- There is the potential for stormwater reuse to be incorporated into the design of the EV site, although this is not required by South East Water for the replacement of potable supply.

Reduction in Annual Average Damages

- It is calculated that for Option 3 there would be a significant reduction in Annual Average Damages to the Crosbie Street Drain catchment external to the EV development site.
- The absolute reduction in AAD for areas outside the EV site is $85,000, a 25% decrease when compared to the current conditions.
- It is likely that a similar or greater reduction in AAD to the drain would also be met for Option 2 which includes more storage capacity in the reserve.

The report has provided a Stormwater Drainage Assessment for the EV site. The report demonstrates that Options 2 & 3 both satisfy flood mitigation criteria identified at Section 6.1, whilst also reducing the depth of flooding within the EV site and also for surrounding properties in a 1% AEP flood event.

The use of Marlborough Reserve as a temporary retarding basin is not considered to have significant usability limitations on the reserve. There are a number of sporting fields that also act as temporary storage basins around Melbourne including the HLT Oulton Reserve at Bell Street in Preston.