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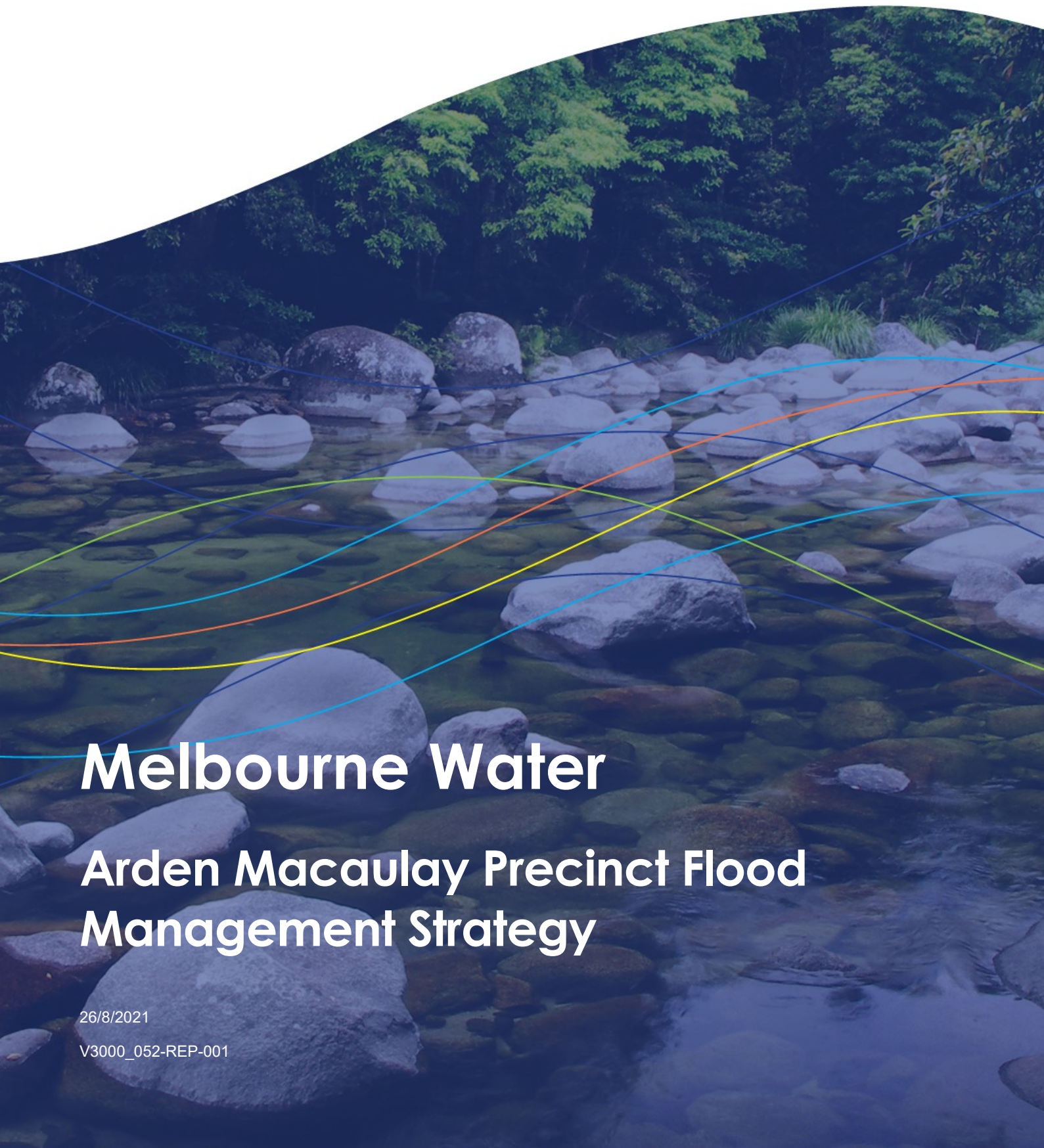

Melbourne Water

Arden Macaulay Precinct Flood Management Strategy

26/8/2021

V3000_052-REP-001

Job no. and Project Name: V3000_052 Arden Macaulay Precinct
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
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EXECUTIVE SUMMARY

The Victorian Government has identified the Arden Macaulay Precinct as a key urban renewal area. The precinct is to be transformed from a primarily industrial area into a high-density mixed-use zone, with the future Arden Station to be located within the Arden precinct as part of the Metro Tunnel project.

Some areas within the Arden Macaulay Precinct have a recognised history of flooding and the severity of flooding is not compatible with development. Moonee Ponds Creek flows through the Arden Macaulay Precinct. Prior to the development of Melbourne there was a significant natural swamp / floodplain along this section of Moonee Ponds Creek. Despite the construction of levee banks, drains and pump stations around the middle of the 20th century there has been a history of flooding that has contributed to a relative lack of development for an area so close to central Melbourne.

Without intervention, flooding poses an unacceptable risk to the safety of the community and will continue to lead to extensive property damage, with some areas experiencing flood depths of up to two metres. If the Arden Macaulay Precinct is to develop into a high-use urban area then this will require planning controls to manage development areas and floor levels and drainage works will need to be implemented to reduce the risk and severity of flooding.

This report documents the investigations that have been undertaken to develop a drainage strategy, referred to as the working drainage strategy, to manage flooding within the Arden Macaulay Precinct. The working drainage strategy has been developed through the investigation of a broad range of potential measures. Some measures that were investigated have not been included in the working drainage strategy as they were found to be less effective at managing flooding or were not feasible. While the working drainage strategy is focused on flood management outcomes, it is compatible with other potential objectives such as stormwater harvesting, landscaping and open space amenity. The working drainage strategy is at a concept level and is subject to revision and refinement as further information becomes available and further investigations and designs are undertaken. The working drainage strategy has been developed in collaboration with Melbourne Water, City of Melbourne and the Victorian Planning Authority.

The working drainage strategy refers to the combination of drainage works that is proposed to enable intensive development of the precinct while achieving an appropriate level of service for drainage and appropriate flood protection standards in the year 2100 climate conditions scenario. Adopting the year 2100 scenario as the design rainfall event reflects the long-term planning required for major developments to provide adequate flood protection for the future community in the Arden Macaulay Precinct.

The working drainage strategy includes the following key components:

- Raised and extended levees for Moonee Ponds Creek.
- Above ground flood storages (retarding basins).
- An underground flood storage tank beneath the Arden Street Oval.
- Upgrades to the six pump stations within the Arden Macaulay Precinct.
- Gravity pipe upgrades, including new gravity pipes and upgrades of existing gravity pipes.
- Pressure pipe upgrades, including pressurising part of Melbourne Water's Arden Street Main Drain.
- Site specific works for Arden Central, including a new pump station, gravity pipes, pressure pipes and swales to convey overland flows.

The working drainage strategy has a number of significant benefits and is essential to enable the development of the Arden MacAulay Precinct.

Figure i provides a layout plan of the working drainage strategy.

N
W E
S

PARSONS ST TO STUBBS ST PS1
GRAVITY PIPE: 300-1050mm dia

ALFRED ST TO SUTTON ST PS
GRAVITY PIPE: 300-600mm dia

SUTTON ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 0.9 m³/s

STUBBS ST PS1
EXISTING PS CAPACITY: 0.56 m³/s
PROPOSED PS CAPACITY: 2.0 m³/s

ROBERTSON ST
PRESSURE PIPE: 750mm dia

FLEMINGTON RD TO SUTTON ST
GRAVITY PIPE: 375-900mm dia

MARK ST PRESSURE
PIPES: 600-900mm dia

ROBERTSON ST TO STUBBS ST PS2
GRAVITY PIPE: 300-900mm dia

STUBBS ST FLOOD
STORAGE ~7500 m³

MARK ST TO LANGFORD ST PS2
GRAVITY PIPE: 900-1200mm dia

STUBBS ST PS2
EXISTING PS CAPACITY: 1.2 m³/s
PROPOSED PS CAPACITY: 1.8 m³/s

CANNING ST & MACAULAY RD
PRESSURE PIPE: 600mm dia

BENT ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 1.3 m³/s

LANGFORD ST PS2
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 2.4 m³/s

CITYWIDE FLOOD
STORAGE ~22500 m³

NEW LOCAL DRAINAGE SYSTEM
ALONG ARDEN ST TO CONNECT
TO LANGFORD ST PS1: 375-1200mm dia

CHELMSFORD ST
PRESSURE PIPE: 450-900mm dia

LANGFORD ST LINEAR
FLOOD STORAGES
~6500 m³

ARDEN ST OVAL
STORAGE TANK
~12500 m³

LANGFORD ST PS1
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 7.0 m³/s

NEW PITS AND PIPES
IN DRYBURGH ST
750-900mm dia

ARDEN CENTRAL
FLOOD STORAGE ~6000 m³

PRESSURISATION OF
ARDEN ST DRAIN
DETAILS TBC

ARDEN CENTRAL
FLOOD STORAGE OUTFALL
TO PROPOSED PUMP STATION

DIVERT EXISTING DRAINAGE SYSTEM
AWAY FROM ARDEN ST-DRAIN
GRAVITY PIPE: 450-750mm dia

NEW PRESSURE PIPES IN
LAURENS ST & ARDEN CENTRAL
900-1200mm dia

ARDEN CENTRAL
NEW PUMP STATION
PROPOSED CAPACITY: 2 m³/s
WITH RISING MAIN OUTFALL
TO MOONEE PONDS CREEK

REALIGN AND UPGRADE DRAINAGE
THROUGH ARDEN CENTRAL
900mm dia

ARDEN CENTRAL
PROPOSED CLOUDBURST
CONVEYANCE AND FLOOD
STORAGE WITHIN FUTURE
ROAD RESERVES

Racecourse Rd
Stubbs St
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

Arden Macaulay Precinct Boundary
Arden Central

Existing Assets

Melbourne Water Pipe
Council Pipe

Proposed Drainage Upgrades

Melbourne Water Works:

Gravity Pipe Upgrade
Pressurisation of Arden St Main Drain
Pump Station Upgrade (Langford St PS1)
Flood Storage - Underground Tank
Flood Storage - Above Ground
New / Raised Levee

City of Melbourne Works:

Gravity Pipe Upgrade
Pressure Pipe
Pump Station Upgrade
Flood Storage - Above Ground
Cloudburst Conveyance (Arden Central)

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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260
Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure i
Working Drainage Strategy

Job Number: V3000_052
Revision: 0
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Checked: AP
Date: 24 August 2021

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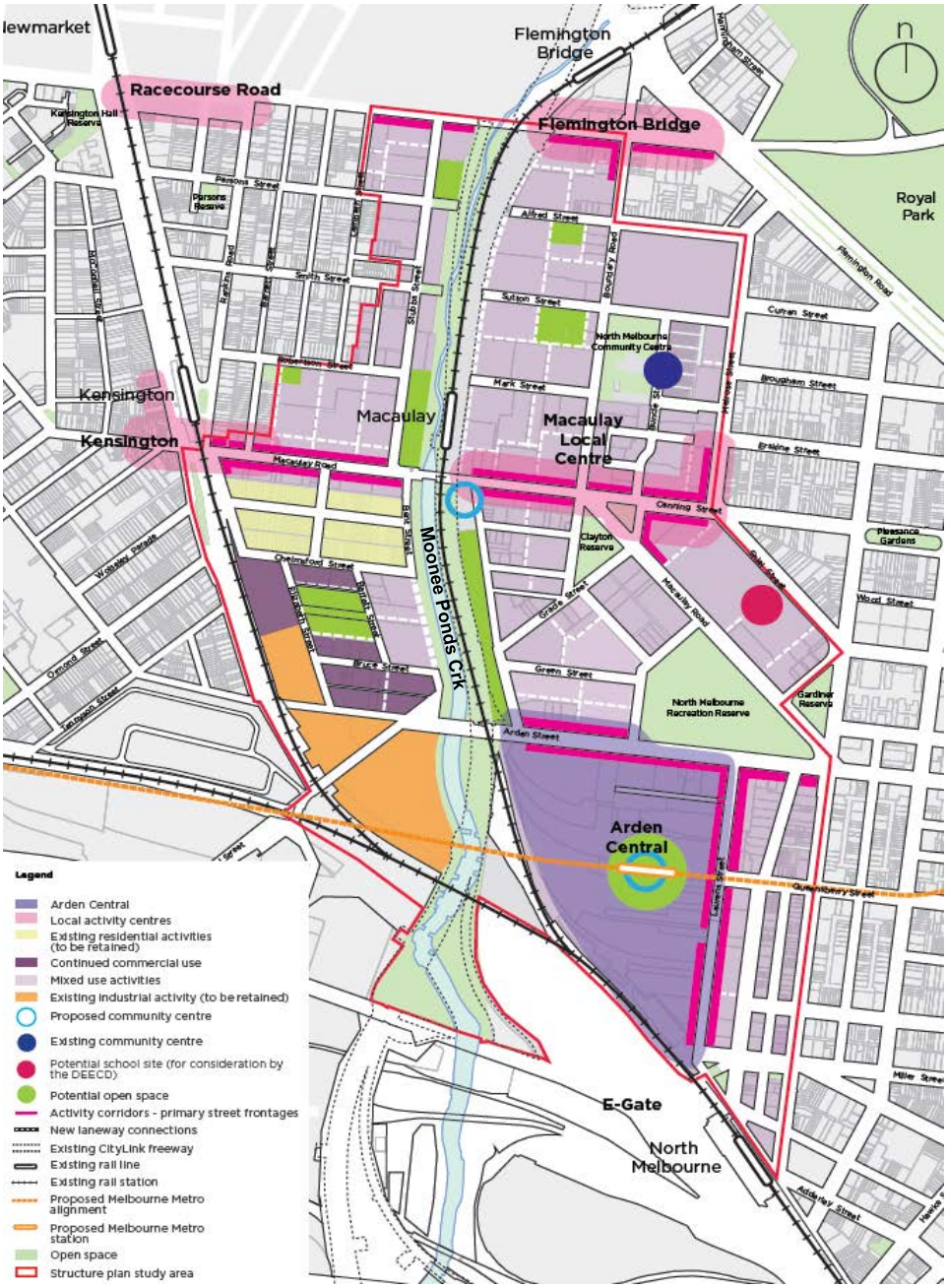
1 INTRODUCTION

1.1 STUDY AREA

The Victorian Government has identified the Arden and Macaulay Precincts as key urban renewal areas. The Arden and Macaulay precincts are referred to collectively as the Arden Macaulay Precinct in this report.

The precinct is to be transformed from a primarily industrial area into a high-density mixed-use zone, with the future Arden Station to be located within the Arden precinct as part of the Metro Tunnel project. Figure 1.1 shows the location and key features of the precinct as outlined in the 2012 Arden Macaulay Precinct Plan. Note that the structure plan is under review by current planning processes.

Figure 1.1: Arden Macaulay Precinct Plan (under review), source: Arden Macaulay Structure Plan, 2012, City of Melbourne



1.2 OBJECTIVES

Flooding and drainage are well recognised as significant factors in development planning of the precinct. The opportunity now exists to plan for the transformation of drainage in the area to ensure that:

- Intensive development of the Arden Macaulay Precinct can occur.
- Appropriate flood protection standards are achieved for the precinct.
- The potential to improve the amenity and public use of Moonee Ponds Creek is seized.
- The objectives of various stakeholders are met.
- An appropriate cost contribution and reimbursement model is developed to fund works to reduce flooding, improve drainage and enable the proposed redevelopment.

If the area is to redevelop, detailed investigation is needed to identify drainage and flood management opportunities and constraints along with associated drainage works that may be required. Where appropriate the implementation of a drainage scheme could ensure an equitable and fair funding arrangement for works.

The key focus of this report is to document the investigations that have been undertaken to develop a drainage strategy to manage flooding within the Arden Macaulay Precinct. While the drainage strategy is focused on flood management outcomes, it does not preclude other potential objectives such as stormwater harvesting, landscaping and open space amenity.

1.3 REPORT CONTEXT

Engeny Water Management (Engeny) has previously undertaken a flooding and drainage investigation for the Arden Macaulay Precinct, with the report titled Arden Macaulay Precinct Drainage Investigation (February 2017). The Arden Macaulay Precinct drainage investigation was undertaken in collaboration with Melbourne Water, City of Melbourne and the Victorian Planning Authority. The February 2017 report provided a review of flooding within the Arden Macaulay Precinct and identified a potential flood mitigation strategy, referred to as the optimal works strategy, which could be implemented to enable intensive development of the precinct while achieving an appropriate level of service for drainage and appropriate flood protection standards.

Since the February 2017 report, a number of further investigations have been undertaken by Engeny, with these investigations focusing on particular areas of the Arden Macaulay Precinct or particular components of the working drainage strategy. Section 2 of this report outlines these further investigations. The analyses and outcomes of these further investigations has led to the ongoing refinement of the working drainage strategy.

The current report provides consolidates the findings of the further investigations and provides an update on the working drainage strategy, while providing the background information that has guided the development of the working drainage strategy.

2 PREVIOUS INVESTIGATIONS

A series of drainage and flooding investigations relating to the Arden Macaulay Precinct have been undertaken by Engeny since 2016. These drainage investigations are listed below. The current report does not include all information that is within the reports listed below, but includes key information that has informed the development of the working drainage strategy.

Arden Macaulay Precinct reports:

- Arden Macaulay Precinct Stage 1 (January 2016)
- Arden Macaulay Precinct Stages 1 and 2 (February 2016)
- Arden Macaulay Precinct Stormwater Harvesting and Flood Storage Investigation (July 2016)
- Arden Macaulay Precinct On Site Storage Assessment (February 2017)
- Arden Macaulay Precinct Drainage Investigation (February 2017)
- Arden Macaulay Precinct Finalising Flood Mitigation Options (August 2018)
- Arden Macaulay Precinct Cloudburst Management Plan Flood Modelling Report (September 2018)
- Arden Macaulay Precinct & Moonee Ponds Creek Flood Modelling Model Build Report (August 2020)

Arden Central reports (previously referred to as the Arden Government Land):

- Arden Government Land Flooding and Drainage Investigation (September 2016)
- Arden Central Flooding and Drainage Investigation (March 2021)

Reports relating to specific drainage infrastructure relevant to the Arden Macaulay Precinct:

- Arden Macaulay Precinct Ievers Reserve Average Annual Damages Assessment (September 2018)
- Arden Macaulay Precinct Local Drainage System Concept Design (January 2018)
- Arden Macaulay Precinct Levee Failure Analysis (March 2018)
- Arden Macaulay Precinct Langford Street Flood Storage Investigation (May 2019)
- Arden Macaulay Precinct - Langford St Development Feasibility Analysis (October 2019)
- Arden Macaulay Precinct – North Melbourne Football Club Storage Investigation (November 2020)
- Arden Macaulay Precinct – Arden North Storage Investigation (March 2021)

3 FLOODING ISSUES

3.1 THE EXISTING DRAINAGE SYSTEM

3.1.1 Overview

The drainage system that currently services the Arden Macaulay Precinct can be separated into two key components:

- Moonee Ponds Creek, which conveys runoff from the Moonee Ponds Creek catchment, which covers an approximate area of 139 square kilometres.
- The local drainage system, which conveys runoff from the Arden Macaulay Precinct and the smaller (compared to the Moonee Ponds Creek catchment) local catchments that drain through the precinct into Moonee Ponds Creek.

In large storm events, there is interaction between Moonee Ponds Creek and the local drainage system, with creek flows influencing flooding within the Arden Macaulay Precinct. The following sections provide an overview of key details of the drainage systems influencing the Arden Macaulay Precinct.

3.1.2 Moonee Ponds Creek

Moonee Ponds Creek is a highly modified waterway that runs north-west through the middle of the Arden Macaulay Precinct, separating the precinct into two halves. Between Racecourse Road (the northern extent of the Arden Macaulay Precinct) and the train line crossing of Moonee Ponds Creek south of Arden Street (the southern extent of the Arden Macaulay Precinct), the Moonee Ponds Creek corridor has a width of approximately 50 metres and is partially covered by the elevated Citylink Tollway, which has numerous pier structures within the creek corridor. Figure 3.1 provides a photo of Moonee Ponds Creek at Racecourse Road.

Figure 3.1: Moonee Ponds Creek, looking south from the Racecourse Road Bridge

Key hydraulic features of Moonee Ponds Creek are the levees on both the eastern and western banks of Moonee Ponds Creek. The levees extend from Racecourse Road to Arden Street. The levees are earthen embankments with either a masonry blockwork or precast concrete parapet wall on top of the earthen embankment. The levees aim to prevent creek flows entering the low-lying areas adjacent to the creek. Figure 3.2 provides a photo of the eastern levee, looking from within the creek corridor, while Figure 3.3 provides a photo of the western levee, looking from the urban area behind the levees.

Figure 3.2: Moonee Ponds Creek eastern levee between Macaulay Road and Arden Street, underneath Citylink

Figure 3.3: Moonee Ponds Creek western levee at Bent Street, Kensington (image source: Google Maps, with Engeny annotations)

There are three road bridge crossings of Moonee Ponds Creek within the Arden Macaulay Precinct, at Racecourse Road, Macaulay Road and Arden Street. At the southern end of the Arden Macaulay Precinct, there are two rail bridge crossings of Moonee Ponds Creek. The elevations of the bridge decks and the bridge pier structures influence the hydraulic capacity of Moonee Ponds Creek. Figure 3.4 provides a photo of the Macaulay Road bridge, while Figure 3.5 provides a photo of one of the rail bridges south of Arden Street.

Figure 3.4: Macaulay Road bridge (looking north / upstream), with pipe bridge in-front of the road bridge

Figure 3.5: Rail bridge downstream of Arden Street (looking downstream)

3.1.3 Local Drainage System

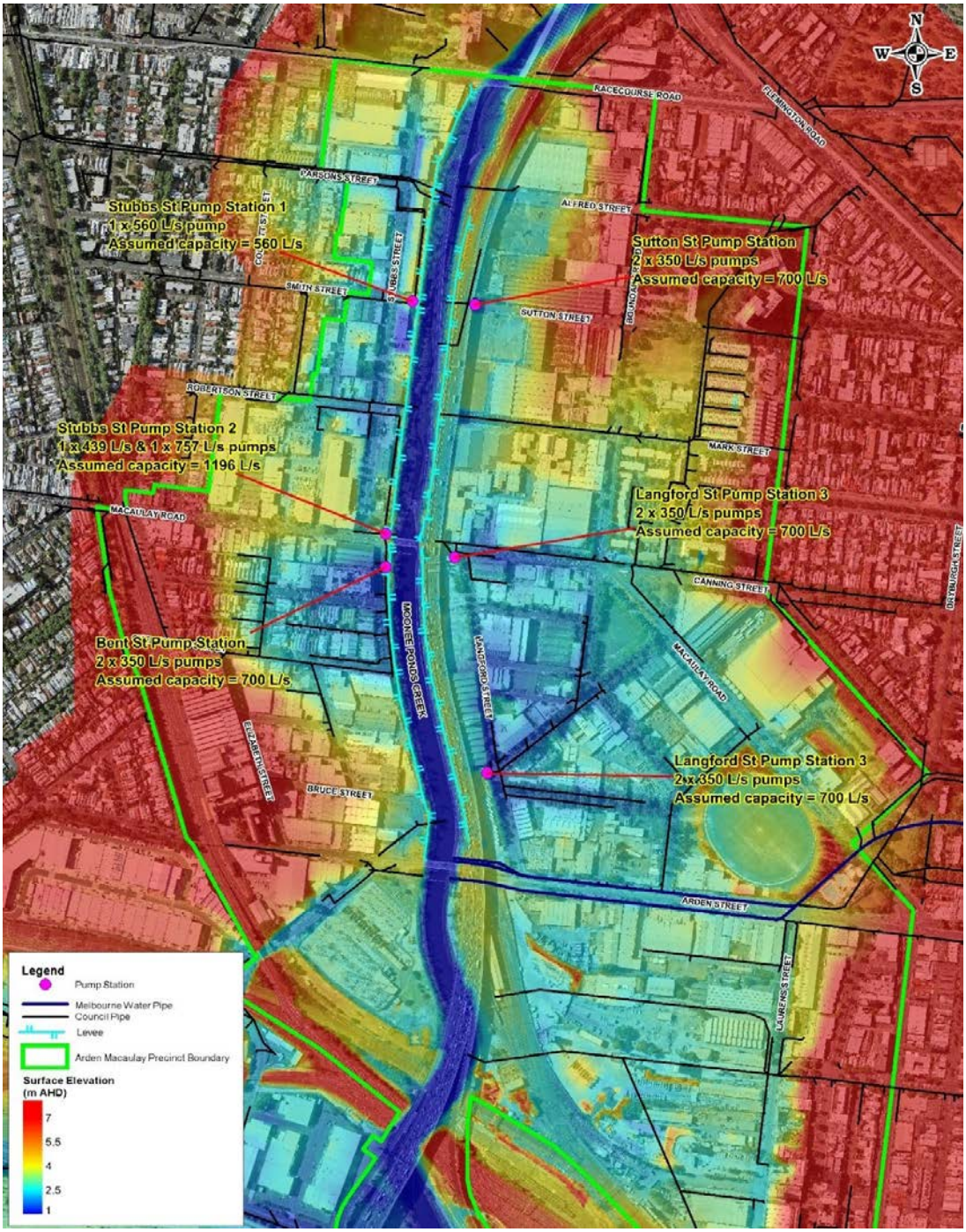
Behind the levees, both Melbourne Water and City of Melbourne manage underground drainage assets to convey local runoff into Moonee Ponds Creek. Melbourne Water's Arden Street Main Drain collects runoff as far east as the Melbourne Cemetery. Within the Arden Macaulay Precinct, the Arden Street Main Drain is an 1830 millimetre diameter pipe between Macaulay Road and Arden Street. It then splits into two parallel drains along Arden Street, with an 1830 millimetre pipe on the southern side of

the road and 2440 millimetre wide by 2260 millimetre high arch drain on the northern side of the road. The Arden Street Main Drain discharges directly to Moonee Ponds Creek.

The City of Melbourne's drainage system within the precinct is dependent on six pump stations to lift and discharge flow from low lying areas into Moonee Ponds Creek. The pump stations are required when the flood level of Moonee Pond Creek exceeds the flood level of the local drainage system, meaning that the local drainage system's conventional gravity outlets to Moonee Ponds Creek are not able to discharge local catchment flows into the creek.

Figure 3.6 provides an overview of the existing drainage system, which also shows the surface levels of the area (based on LiDAR, which is aerially captured topographical data) and the existing pump station capacities, which are based on information provided by City of Melbourne, including a 2012 drainage investigation report by others.

Figure 3.6: Existing drainage system and surface levels



3.2 FLOOD MODEL OVERVIEW

Flood modelling has been used as a key tool to develop an understanding of flood behaviour relating to the Arden Macaulay Precinct (including the influence of Moonee Ponds Creek) and to guide the development of the working drainage strategy. The flood modelling allows for representation of existing drainage infrastructure, topography and proposed drainage assets and provides a range of flooding outputs based on the simulation of storm events.

The flood modelling is based on a RORB hydrological model and a TUFLOW hydraulic model.

The extent of the TUFLOW model covers Moonee Ponds Creek from just north of Mt Alexander Road until the confluence with the Yarra River. The model also covers the local drainage catchments that contribute runoff to this reach of Moonee Ponds Creek, including the Arden Macaulay Precinct. The model uses dynamic flows in Moonee Ponds Creek so that the impact of the rising and falling tail water level in the creek is accounted for in the local drainage system and so that the impact of creek flows on the Arden Macaulay Precinct is represented.

Key technical details and assumptions relating to the flood model are documented in Arden Macaulay Precinct & Moonee Ponds Creek Flood Modelling Model Build Report (Engeny, August 2020).

3.3 THE DESIGN RAINFALL EVENT

The design rainfall event refers to the storm event for which development must meet appropriate flood protection standards. Based on Guidelines for Development in Flood Prone Areas (The State of Victoria Department of Environment, Land, Water and Planning, 2019) the 1% annual exceedance probability (AEP) flood, also known as the 1 in 100 year flood, is the current flood protection standard, which is used in providing flood level advice, in delineating land affected by flooding and setting requirements for most developments.

The predicted flooding relating to two scenarios of the 1% AEP flood event have been analysed in this report, which are:

- Existing conditions, reflecting:
  - Existing development conditions in both the local catchments draining through the precinct and the greater Moonee Ponds Creek catchment.
  - Current design rainfall intensities.
  - A static tail water level in Port Phillip Bay of 1.4 metres AHD.
- Year 2100 conditions, reflecting:
  - Imperviousness kept at existing levels, which reflects efforts within the local and greater Moonee Ponds Creek catchments to manage runoff through planning and development controls.
  - An 18.5% increase in rainfall intensity due to climate change.
  - 0.8 metres sea level rise in Port Phillip Bay. In the hydraulic modelling of the year 2100 scenario, a cyclical tide has been adopted as a boundary condition in order to represent the dynamic impact of the Port Phillip Bay tide level on flooding in the lower reach of Moonee Ponds Creek. The boundary condition is based on a 10 % AEP tide, with an allowance of 0.8 metres of sea level rise. The peak of the cyclical tide is 1.975 m AHD.

Following discussions between Engeny and Melbourne Water, the year 2100 scenario has been adopted as the design event. This event provides sufficient robustness by making allowance for increased rainfall intensities and sea level rise, but also reflects that efforts are expected to be made across the wider catchment to manage runoff so that downstream areas (such as the Arden Macaulay Precinct) are not unfairly impacted. Adopting the year 2100 scenario as the design rainfall event reflects the long-term planning required for major developments to provide adequate flood protection for the future community in the Arden Macaulay Precinct.

Flooding in lower magnitude storm events than the 1% AEP event is also important. City of Melbourne's target level of service for the operation of its drainage system is the 5% AEP event (1 in 20 year storm). This report includes a review of flooding for the 5% AEP event with the current drainage system, as well as identification of drainage works to achieve a 5% cent AEP level of service. The assumptions made in the year 2100 scenario have also been applied to the 5% AEP event, in terms of the same cyclical tide level in Port Phillip Bay and an 18.5 per cent increase in rainfall intensities compared to existing design rainfall.

3.4 RELEVANT GUIDELINES AND CONDITIONS

The Victorian Planning Scheme currently includes a Land Subject to Inundation Overlay (LSIO) covering Moonee Ponds Creek and low-lying areas within the Arden Macaulay Precinct, including a large portion of Arden Central. The LSIO relates to flooding along major waterways and is typically based on the predicted flood extent in a 1% AEP storm event. In terms of development management, the LSIO only requires a permit for buildings and works and does not prohibit either use or development. At the time of this report, a planning amendment introduced by the City of Melbourne is intending to update flood overlays, which includes areas within the Arden Macaulay Precinct.

Guidelines for Development in Flood Prone Areas (The State of Victoria Department of Environment, Land, Water and Planning, 2019) provides advice on planning of properties, buildings and structures so that they are safe from flooding from the outset without compromising the safety of other properties. Engeny has discussed with Melbourne Water how the conditions from these guidelines will be applied in the Arden Macaulay Precinct, which can be summarised by the following:

- 0.60 metres freeboard above 1% AEP flood level (based on year 2100 flood levels in a pump failure scenario) is required for habitable building floor levels where buildings are impacted by tidal inundation, flooding from Moonee Ponds Creek or ponded stormwater.
- 0.30 metres freeboard above 1% AEP flood level (based on year 2100 flood levels in a pump failure scenario) is required for habitable building floor levels where buildings are impacted by overland flow paths.
- Some critical levels in the Arden Macaulay Precinct, such as entry points to the underground Arden Central train station, may be based on flood levels in higher magnitude events than the 1% AEP storm. This is due to the severe consequences of flooding the underground train station.
- Flood-affected properties will need to ensure access is possible where depth of flooding is less than 0.5 metres deep for the 1% AEP event (when pumps operate effectively). Where the flood depth impacting property access is more than 0.5 metres deep, this may be considered acceptable if the duration that the flooding exceeds a depth of 0.5 metres is less than 1 hour.
- If levees are raised or new levees are constructed, no or minimal freeboard is required from the 1% AEP flood level to the crest of the levee.
- City of Melbourne is seeking to achieve a 5% AEP level of service, in which the underground drainage system will convey flows to Moonee Ponds Creek with limited overland flow or ponding in streets and no flooding of private property.

3.5 IMPACT OF FLOODING

3.5.1 Observed Flooding

Some areas within the Arden Macaulay Precinct have a recognised history of flooding, in particular Stubbs Street in Kensington on the western side of Moonee Ponds Creek and Langford Street in North Melbourne on the eastern side of Moonee Ponds Creek. These are very low-lying areas, with minimum surface levels at Stubbs Street of approximately 1.9 metres above sea level and minimum surface levels at Langford Street of approximately 1.1 metres above sea level. The Arden Macaulay Precinct Plan identifies intensive development of these areas.

Figure 3.7 provides a photo of previous flooding of Stubbs Street due to a storm event in December 2010. Further information and photos provided by City of Melbourne indicates that shops on Stubbs Street were flooded above floor level in this storm. Figure 3.8 provides a photo of previous flooding around Langford Street in March 2010.

Figure 3.7: Flooding of Stubbs Street Kensington taken from within shop on 8/10/2010 (source of photo: City of Melbourne)

Figure 3.8: Flooding around Langford Street North Melbourne on 7/3/2010 (source of photo: hersaldsun.com.au)

3.5.2 Existing Conditions Modelling Assessment

The results of the flood modelling assessment based on existing climate conditions predict that large areas of the Arden Macaulay Precinct are significantly impacted by flooding in a 1% AEP event. Figure 3.9 provides a flood depth map representing the flood model's predicted flooding in a 1% AEP event for existing climate conditions. Appendix A provides flood maps for both the 1% and 5% AEP events for existing conditions. Section 0 provides a tabulation of key flood related statistics.

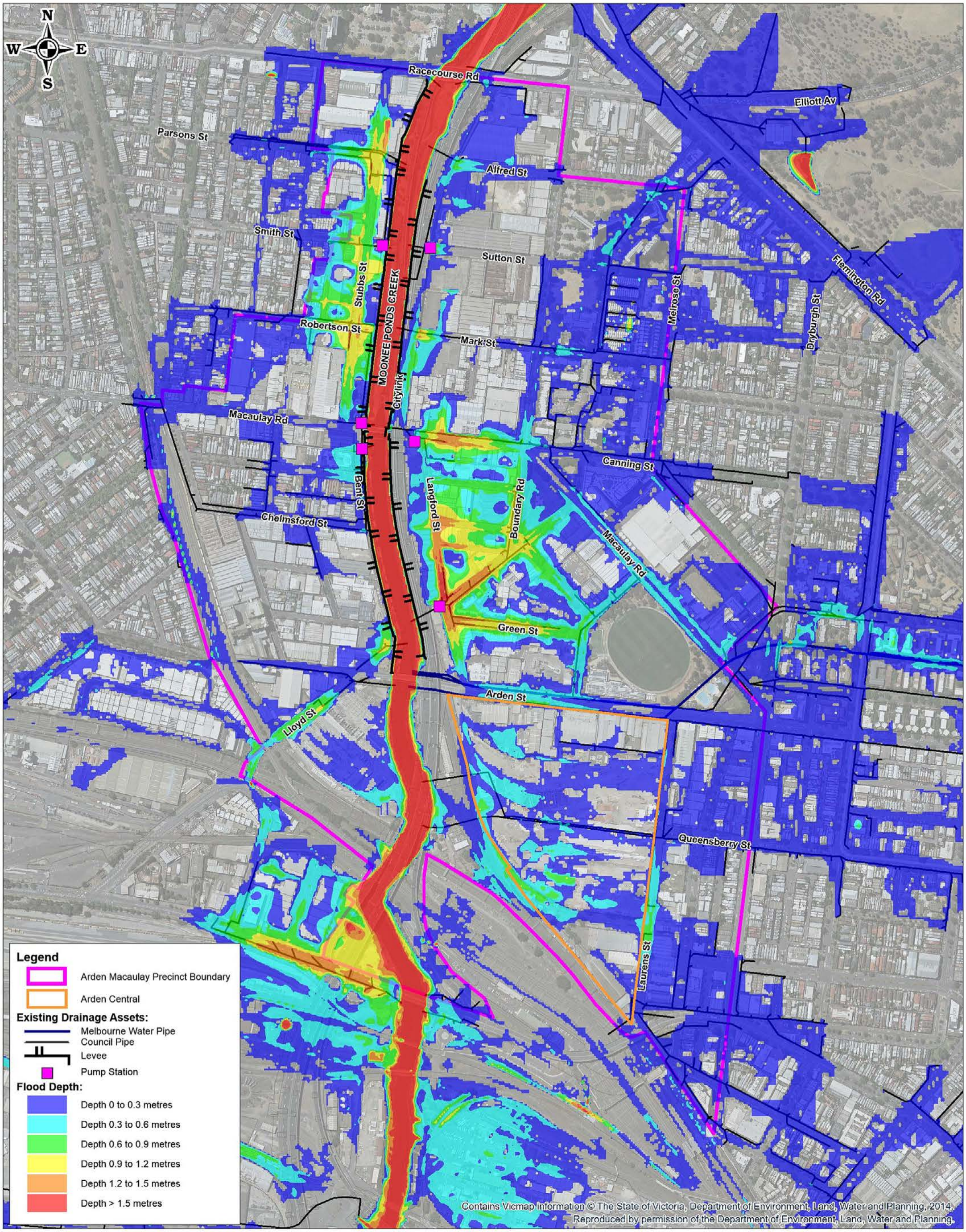
A key constraint that leads to the severity of flooding is the topography of the precinct, with significant areas adjacent to Moonee Ponds Creek below the flood level in the creek. While the creek's levees provide some protection to these surrounding areas, the flood modelling shows that the levees are overtopped in the 1% AEP event in the following areas:

- Stubbs Street south of the Smith Street intersection to Macaulay Road (western side of Moonee Ponds Creek), depth of overtopping varies with a maximum of approximately 0.15 metres.
- Bent Street between Chelmsford Street and Hardiman Street (western side of Moonee Ponds Creek), maximum depth of overtopping approximately 0.03 metres.
- Between Mark Street and Macaulay Road (eastern side of Moonee Ponds Creek), levee just overtopped by approximately 0.01 metres.
- Moonee Ponds Creek also overflows into Arden Central, south of Arden Street. There is no formal levee structure at this location.
- Flow is also predicted to break out from Moonee Ponds Creek at the Racecourse Road bridge and then flow behind the eastern levee into the eastern side of the Arden Macaulay Precinct.

The levees are not predicted to be overtopped in the 5% AEP event.

Overall, flooding within the Arden Macaulay Precinct for existing conditions can be attributed to the following factors:

- High flood levels in Moonee Ponds Creek overtopping the levees and flowing into low lying areas. The high flood levels in the creek are caused by a combination of flows from the upstream catchment, downstream tidal levels and the hydraulic restriction of bridges.
- Local flows from within the precinct and upstream local catchments draining to low lying areas, and once runoff is in the low lying areas the drainage system is dependent on the operation and capacity of the pump stations to convey flow into Moonee Ponds Creek when the water level in the creek is higher than the water level in the local catchment. While the existing flood mitigation measure of the creek's levees reduces the severity of flooding in the local catchment, it also raises the flood level in the creek, increasing the constraint of the tail water level on the local drainage system.
- Effective drainage of some areas of the precinct is limited as not all sections of the drainage system are directly connected to a pump station or are connected by only very small pipes. This includes Melbourne Water's Arden Street Main Drain, which is not directly connected to a pump station. When the flood level in Moonee Ponds Creek at the Arden Street Main Drain outfall is high, the drain is unable to effectively discharge flow, which contributes to the significant inundation predicted around the Langford Street area.



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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 3.9
Existing Drainage System (Pumps Working)
1% AEP Flood Depth Map
Existing Climate Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

3.5.3 Year 2100 Conditions

The results of the flood modelling of the 1% AEP for the year 2100 conditions (but with the existing drainage system retained) predict that the forecast increases in rainfall intensity and sea level rise will have a significant impact on flooding of the precinct. Figure 3.10 provides a flood depth map representing the flood model's predicted flooding in a 1% AEP event for year 2100 climate conditions. Appendix B provides flood maps for both the 1% and 5% AEP events for the year 2100 scenario. Section 0 provides a tabulation of key flood related statistics.

In some areas of the catchment, such as Bent Street on the western side of Moonee Ponds Creek, flood depths are predicted to increase by close to 2 metres in the year 2100 scenario compared to existing conditions. The increase in flooding is most evident in the low-lying areas of the precinct adjacent to Moonee Ponds Creek. Flooding in these areas increases significantly due to:

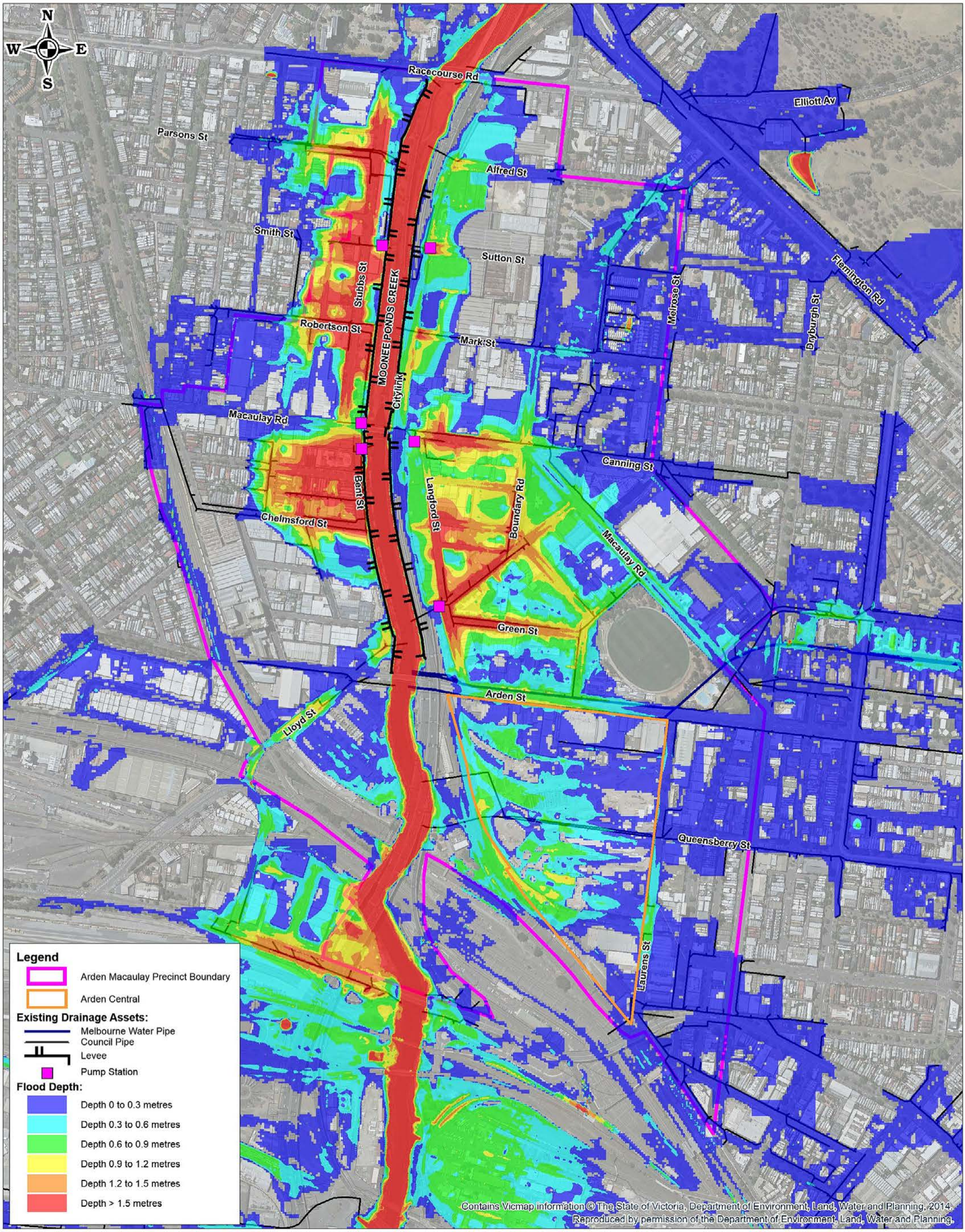
- The increased rainfall intensity results in increase flows in Moonee Ponds Creek, while the capacity of Moonee Ponds Creek to convey flows is reduced due to sea level rise. This results in higher flood levels within Moonee Ponds Creek, increasing the flow that overtops the creek's levees in the 1% AEP event and causing more severe flooding of the Arden Macaulay Precinct. In the year 2100 scenario the levee on the western side of Moonee Ponds Creek is overtopped along essentially the entire length of the levee downstream of Racecourse Road. The eastern levee is also extensively overtopped, but to a lesser severity than the western levee. There is also an increase in the flow breaking out from Moonee Ponds Creek at the Racecourse Road bridge and flowing behind the eastern levee into the eastern side of the Arden Macaulay Precinct due to the higher creek flows in the year 2100 scenario. The levees are not predicted to be overtopped in the year 2100 5% AEP event.
- Runoff generated in the local catchments of the Arden Macaulay Precinct also increases due to the increased rainfall intensity in the year 2100 scenario. Drainage from the local catchment into Moonee Ponds Creek is also more constrained due to the high flood levels in Moonee Ponds Creek, which make it harder for the local drainage system to convey flow into the creek. These factors increase flooding in potentially developable areas of the precinct.
- The adopted cyclical tide has a peak level of 1.975 m AHD, which is above the surface levels of some of the lower lying areas of the Arden Macaulay Precinct, such as at Langford Street, Bend Street and Stubbs Street. Even without a rainfall event in the Moonee Ponds Creek catchment or in the local catchment, a tide of this level has the potential to inundate parts of the Arden Macaulay Precinct.

3.5.4 Impact of Pump Failure

While pump stations can be very effective, particularly in areas such as the Arden Macaulay Precinct where drainage of the area is constrained by high downstream tail water levels in Moonee Ponds Creek, they have the potential to be unreliable in major storm events if there is a power failure or blockage.

The flood model has been simulated for a scenario in which all six pump stations within the Arden Macaulay Precinct fail to operate for a 1% AEP storm event, for year 2100 climate conditions. Figure 3.11 provides a flood depth map representing the flood model's predicted flooding in a 1% AEP event for year 2100 climate conditions, in the pump failure scenario. Section 0 provides a tabulation of key flood related statistics.

The results of the flood modelling predict that the severity of flooding in the year 2100 scenario, with the existing drainage system retained, is not sensitive to the operation of the pump stations, with only minor increases in flood depths compared to when the pumps operate successfully. This indicates that in the year 2100 scenario for the 1% AEP event, flows from Moonee Ponds Creek are having the greatest influence on flooding within the Arden Macaulay Precinct, rather than the performance of the local drainage system.



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Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 3.10
Existing Drainage System (Pumps Working)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
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Checked: AP
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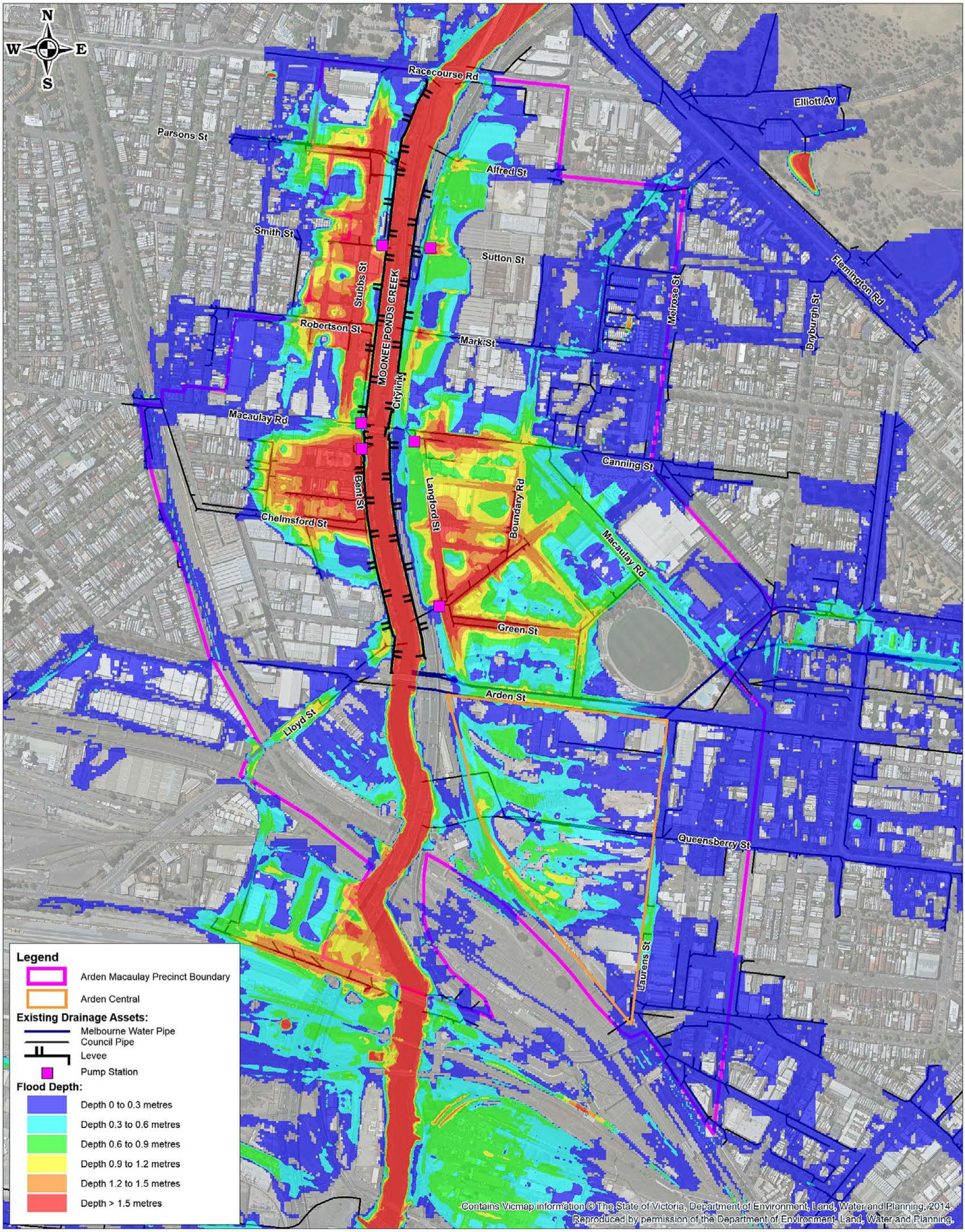

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Arden Macaulay Precinct

Figure 3.11
Existing Drainage System (Pump Failure)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
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3.5.5 Summary of Flood Impacts

Table 3.1 provides a comparison of key flood relates statistics based on the results of the flood modelling of existing conditions, year 2100 conditions and year 2100 conditions with pump failure. The statistics include key inflows to the Arden Macaulay Precinct from Moonee Ponds Creek and the Arden Street Main Drain, peak flood depths at the low-lying roads in the precinct and the area of the precinct that is subject to flood depths exceeding 0.5 metres (excluding the Moonee Ponds Creek corridor). The majority of the statistics are based on the flood modelling of the 1% AEP event with the existing drainage system, with some results relating to the 5% AEP event (a pump failure scenario has not been modelled for the 5% AEP event).

Table 3.1: Comparison of key flooding statistics (existing drainage system)

Statistic	Existing Conditions	Year 2100	Year 2100, Pump Failure
Moonee Ponds Creek 1% AEP peak flow at Racecourse Road	209 m^3/s	257 m^3/s	257 m^3/s
Eastern levee 1% AEP overtopping peak flow	1.9 m^3/s	10.3 m^3/s	9.4 m^3/s
Western levee 1% AEP overtopping peak flow	13.5 m^3/s	53.9 m^3/s	51.0 m^3/s
Creek break out 1% AEP flow at Racecourse Road bridge	1.7 m^3/s	8.7 m^3/s	8.6 m^3/s
Creek 1% AEP overflow into Arden Central (south of Aden Street)	1.1 m^3/s	1.5 m^3/s	1.5 m^3/s
Arden Steet MD 1% AEP peak flow into the precinct (combined pipe and overland)	15.8 m^3/s	18.8 m^3/s	18.8 m^3/s
Stubbs Street, 1% AEP peak flood depth	1.32 m	2.24 m	2.24 m
Stubbs Street, 5% AEP peak flood depth	0.86 m	0.88 m	Not modelled
Bent Street, 1% AEP peak flood depth	0.63 m	2.59 m	2.59 m
Bent Street, 5% AEP peak flood depth	0.56 m	0.73 m	Not modelled
Langford Street, 1% AEP peak flood depth	1.73 m	2.22 m	2.26 m
Langford Street, 5% AEP peak flood depth	1.33 m	1.50 m	Not modelled
Area of the precinct flooded by depth > 0.5 m (not including Moonee Ponds Creek) in 1% AEP event	12.4 ha	33.6 ha	34.5 ha

Key observations based on the results in Table 3.1 include:

- The increased rainfall intensity in the year 2100 scenario results in flow increasing from 209 m^3/s in existing conditions to 257 m^3/s in the year 2100 scenario.
- This increase in flow in Moonee Ponds Creek has a significant impact on the peak flows overtopping the levees. The western levee is more susceptible to overtopping compared to the eastern levee.
- The peak flows overtopping the levees is predicted to reduce in the year 2100 scenario when the pumps fail compared to when the pumps operate successfully. This is due to the minor reduction in flows in Moonee Ponds Creek south of Racecourse Road when the pumps have failed and are therefore not contributing to creek flows.
- There is only a minor increase in flow that breaks out from Moonee Ponds Creek into Arden Central in the year 2100 scenario compared to existing conditions. This occurs south of Arden Street. The flow that exceeds the capacity of Monee Ponds Creek has already overtopped the levees by Arden Street, which means the flow downstream of Arden Street is relatively similar in existing conditions and the year 2100 scenario.
- Significantly high flood depths are predicted Stubbs Street, Bent Street and Langford Street. At Stubbs Street and Bent Street (both on the western side of Moonee Ponds Creek), the flood depths increase considerably in the year 2100 scenarios due to the overtopping of the western levee.

- While flood depths at Langford Street also increase in the year 2100 scenarios, the change compared to existing conditions is not as significant as the eastern levee is less susceptible to overtopping. Overland flows into the precinct associated with the Arden Street Main Drain flow to Langford Street.
- In the pump failure scenario, there is not a significant increase in peak flood depths at the low-lying roads. This indicates that in the year 2100 scenario for the 1% AEP event, flows from Moonee Ponds Creek are having the greatest influence on flooding within the Arden Macaulay Precinct, rather than the performance of the local drainage system.
- The total area of the Arden Macaulay Precinct, excluding the Moonee Ponds Creek corridor, is approximately 133 hectares. The flood modelling predicts that 9% (12.4 hectares) of the precinct is flooded by depths exceeding 0.5 metres in existing conditions, which increases to 25% (33.6 hectares) in the year 2100 scenario and 26% (34.5 hectares) in the year 2100 scenario when the pumps fail.

Overall, the severity of flooding predicted by the flood modelling is not compatible with development for large areas of the Arden Macaulay Precinct. In the 1% AEP event for the year 2100 scenario, which is the adopted design standard, the predicted flooding is likely to pose an unacceptable risk to the safety of the community and lead to extensive property damage. If the Arden Macaulay Precinct is to develop into a high-use urban area, drainage works will need to be implemented to manage the risk of flooding.

4 THE WORKING DRAINAGE STRATEGY

4.1 OVERVIEW

The working drainage strategy refers to the combination of drainage works that is proposed to enable intensive development of the precinct while achieving an appropriate level of service for drainage and appropriate flood protection standards in the year 2100 climate conditions scenario. The working drainage strategy is at a concept level and is subject to revision and refinement as further information becomes available and further investigations are undertaken.

The working drainage strategy includes the following key components:

- Raised and extended levees for Moonee Ponds Creek.
- Above ground flood storages (retarding basins).
- An underground flood storage tank beneath the Arden Street Oval.
- Upgrades to the six pump stations within the Arden Macaulay Precinct.
- Gravity pipe upgrades, including new gravity pipes and upgrades of existing gravity pipes.
- Pressure pipe upgrades, including pressurising part of Melbourne Water's Arden Street Main Drain.
- Site specific works for Arden Central, including a new pump station, gravity pipes, pressure pipes and swales to convey overland flows.

Figure 4.1 provides a layout plan showing the locations and key details of the working drainage strategy, including whether the drainage works will be owned and maintained by Melbourne Water or City of Melbourne. The following sections of this report provide conceptual details of each component of the working drainage strategy. Section 5 presents the flood modelling of the working drainage strategy.

The working drainage strategy has been developed through the investigation of a broad range of potential measures. Some measures that were investigated have not been included in the working drainage strategy as they may have been less effective at managing flooding or were not feasible. Section 6 of this report provides discussion of options that have been considered, but not included in the working drainage strategy.

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PARSONS ST TO STUBBS ST PS1
GRAVITY PIPE: 300-1050mm dia

ALFRED ST TO SUTTON ST PS
GRAVITY PIPE: 300-600mm dia

SUTTON ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 0.9 m³/s

STUBBS ST PS1
EXISTING PS CAPACITY: 0.56 m³/s
PROPOSED PS CAPACITY: 2.0 m³/s

FLEMINGTON RD TO SUTTON ST
GRAVITY PIPE: 375-900mm dia

ROBERTSON ST
PRESSURE PIPE: 750mm dia

MARK ST PRESSURE
PIPES: 600-900mm dia

ROBERTSON ST TO STUBBS ST PS2
GRAVITY PIPE: 300-900mm dia

STUBBS ST FLOOD
STORAGE ~7500 m³

MARK ST TO LANGFORD ST PS2
GRAVITY PIPE: 900-1200mm dia

STUBBS ST PS2
EXISTING PS CAPACITY: 1.2 m³/s
PROPOSED PS CAPACITY: 1.8 m³/s

CANNING ST & MACAULAY RD
PRESSURE PIPE: 600mm dia

BENT ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 1.3 m³/s

LANGFORD ST PS2
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 2.4 m³/s

CITYWIDE FLOOD
STORAGE ~22500 m³

NEW LOCAL DRAINAGE SYSTEM
ALONG ARDEN ST TO CONNECT
TO LANGFORD ST PS1: 375-1200mm dia

CHELMSFORD ST
PRESSURE PIPE: 450-900mm dia

LANGFORD ST LINEAR
FLOOD STORAGES
~6500 m³

ARDEN ST OVAL
STORAGE TANK
~12500 m³

LANGFORD ST PS1
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 7.0 m³/s

NEW PITS AND PIPES
IN DRYBURGH ST
750-900mm dia

ARDEN CENTRAL
FLOOD STORAGE ~6000 m³

PRESSURISATION OF
ARDEN ST DRAIN
DETAILS TBC

ARDEN CENTRAL
FLOOD STORAGE OUTFALL
TO PROPOSED PUMP STATION

DIVERT EXISTING DRAINAGE SYSTEM
AWAY FROM ARDEN ST DRAIN
GRAVITY PIPE: 450-750mm dia

NEW PRESSURE PIPES IN
LAURENS ST & ARDEN CENTRAL
900-1200mm dia

ARDEN CENTRAL
NEW PUMP STATION
PROPOSED CAPACITY: 2 m³/s
WITH RISING MAIN OUTFALL
TO MOONEE PONDS CREEK

REALIGN AND UPGRADE DRAINAGE
THROUGH ARDEN CENTRAL
900mm dia

ARDEN CENTRAL
PROPOSED CLOUDBURST
CONVEYANCE AND FLOOD
STORAGE WITHIN FUTURE
ROAD RESERVES

Racecourse Rd
Stubbs St
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Flemington Rd
Melrose St
Dryburgh St
Robertson St
Mark St
MOONEE PONDS CREEK
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

Arden Macaulay Precinct Boundary
Arden Central

Existing Assets

Melbourne Water Pipe
Council Pipe

Proposed Drainage Upgrades

Melbourne Water Works:

Gravity Pipe Upgrade
Pressurisation of Arden St Main Drain
Pump Station Upgrade (Langford St PS1)
Flood Storage - Underground Tank
Flood Storage - Above Ground
New / Raised Levee

City of Melbourne Works:

Gravity Pipe Upgrade
Pressure Pipe
Pump Station Upgrade
Flood Storage - Above Ground
Cloudburst Conveyance (Arden Central)

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Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 4.1
Working Drainage Strategy

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Checked: AP
Date: 24 August 2021

4.2 MOONEE PONDS CREEK LEVEE IMPROVEMENTS

These works would involve raising the existing levees on both sides of Moonee Ponds Creek between Racecourse Road and Arden Street and constructing new levees on both sides of Moonee Ponds Creek south of Arden Street. The objective of raising and extending the levees is to prevent the levees from being overtopped.

The raised levees could be achieved by increasing the height of the existing concrete wall levees, or rebuilding the concrete wall levees to the required height, or the raised and new levees could be incorporated into a revised creek landscape, with a shared trail located on the crest of the levee. Figure 4.2 provides an indicative photo of a levee with a shared trail on the crest of the levee. Due to existing land uses adjacent to the levees (including the train line) there may not be sufficient width along Moonee Ponds Creek to provide an earth levee and/or path and a narrow concrete wall is the more likely option.

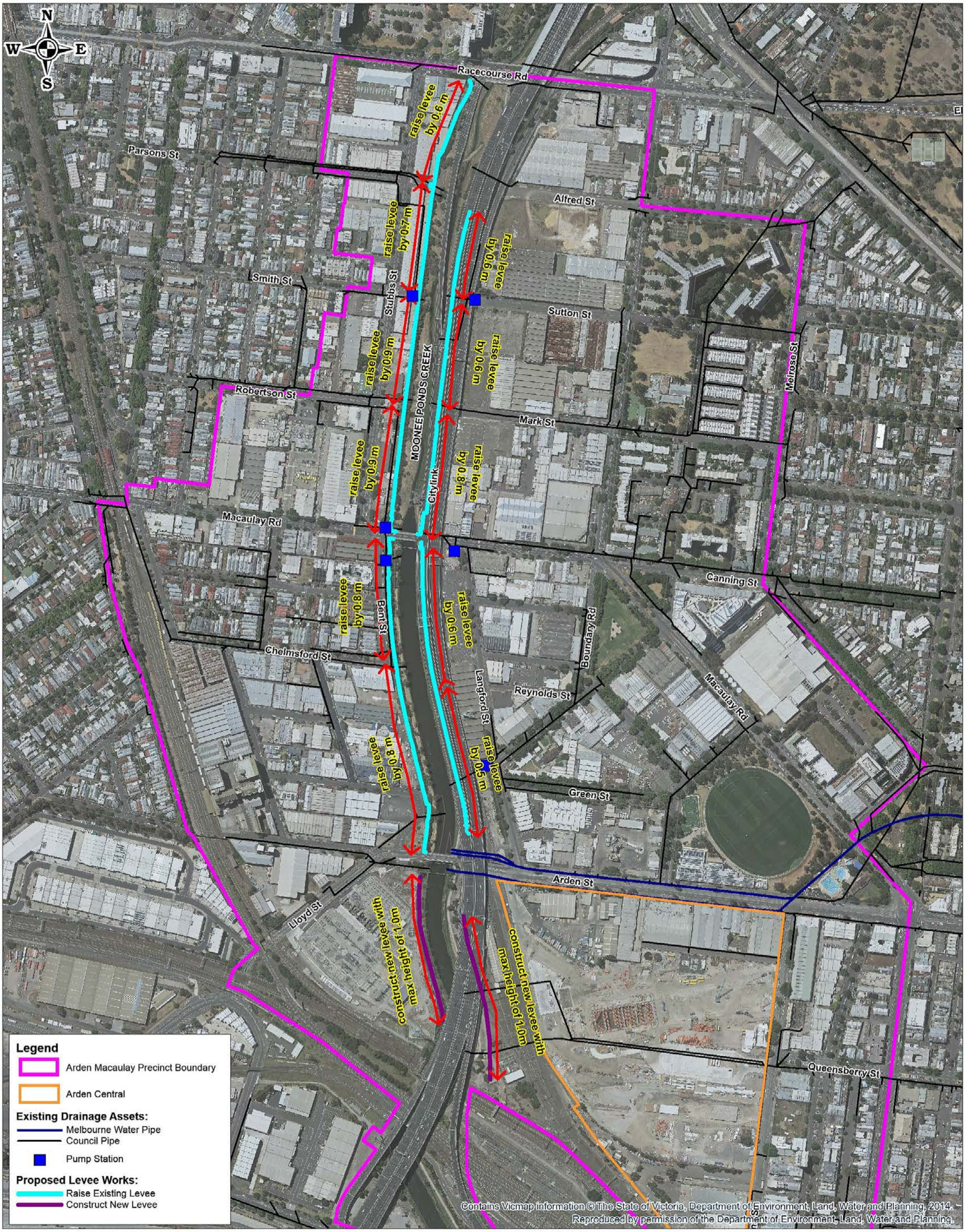
Figure 4.2: Indicative photo of levee as part of a creek landscape, shared path is the crest of levee (source: https://en.wikipedia.org/wiki/Green_River_Trail)

The levees would be raised so that they are not overtopped in a 1% AEP event for the year 2100 scenario. Melbourne Water has indicated that if levees are raised, minimal freeboard (approximately 0.10 metres) is required from the year 2100 1% AEP flood level in Moonee Ponds Creek to the crest of the levee, which provides some protection from wave action and tolerance in modelling accuracy. Melbourne Water guidelines recommend a typical 0.60 metres freeboard for levees as the consequence of levees being overtopped or failing can be catastrophic. The adopted freeboard could be less than 0.60 metres if the top of the levee is not an earthen embankment (the current levees are essentially concrete walls) as earthen embankments are subject to erosion and greater variability in construction height. Engeny has adopted the 0.10 metres suggested by Melbourne Water, but recommends that the freeboard and levee are subject to further consideration before levee works are designed or constructed.

New levees are recommended south of Arden Street on both sides of Moonee Ponds Creek. Raising the existing levees north of Arden Street will mean that there is an increase in 1% AEP flows in Moonee Ponds Creek south of Arden Street, due to the levees no longer being overtopped. The eastern bank levee south of Arden Street would be located between the creek and the train line. This levee would prevent creek flows overtopping the train line and flowing into Arden Central. This would require a levee with a maximum height of 1.0 metres above the existing surface level and a length of 200 metres.

The western bank levee south of Arden Street is to provide increased flood protection of the power sub-station. For the year 2100 scenario for a 1% AEP event the power station site would be subject to some flooding in existing conditions. If the western bank levee was not provided, then the risk of flooding of the power sub-station is predicted to be slightly worse than existing conditions because of the increased flows being conveyed through this section of the creek due to the raised levees upstream. The western bank levee south of Arden Street would require a maximum height of approximately 1.0 metres above the existing surface level and a length of 250 metres to contain 1% AEP flows for the year 2100 scenario.

Figure 4.3 shows the proposed levee works, while Table 4.1 and Table 4.2 summarise key details of the works proposed on the western and eastern levees. The proposed crest levels of the levees are based on the 1% AEP event for the year 2100 scenario when the pumps are operational (with increased pump station capacities discussed in Section 4.4), as this results in higher flood levels in Moonee Ponds Creek compared to when the pumps fail.



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Scale in metres (1:5,000 @ A3)

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Arden Macaulay Precinct

Figure 4.3
Levee Works Layout Plan

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Table 4.1: Western levee upgrade key details

Section	Levee Length (m)	Required Levee Crest Level (m AHD)	Required Increase in Levee Crest Level (m)
Racecourse Road to Parsons St	160	5.20 to 5.15	0.6
Parsons St to Smith St	165	5.15 to 5.00	0.7
Smith St to Robertson St	165	5.00 to 4.90	0.9
Robertson St to Macaulay Rd	190	4.90 to 4.80	0.9
Macaulay Rd to Chelmsford St	180	4.35 to 4.30	0.8
Chelmsford St to Arden St	290	4.30 to 4.25	0.8
Arden St to rail bridge (new levee)	230	3.70 to 3.60	1.0

Table 4.2: Eastern levee upgrade key details

Section	Levee Length (m)	Required Levee Crest Level (m AHD)	Required Increase in Levee Crest Level (m)
Alfred St to Sutton St	130	5.15 to 5.00	0.6
Sutton St to Mark St	160	5.00 to 4.90	0.6
Mark St to Macaulay Rd	185	4.90 to 4.80	0.8
Macaulay Rd to Reynolds St	205	4.35 to 4.30	0.6
Reynolds St to Arden St	230	4.30 to 4.25	0.5
Arden St to rail bridge (new levee)	200	3.70 to 3.60	1.0

4.3 FLOOD STORAGES

4.3.1 Overview

The Arden Macaulay Precinct currently does not include any designated flood storage areas. The working drainage strategy proposes a series of above ground flood storages (retarding basins) and an underground flood storage tank to be located within the precinct. These assets would be designed to store flood water in large storm events (such as the 1% AEP storm) when the capacity of the drainage system is exceeded. Typically, the flood storages are proposed in flood prone low-lying areas of the Arden Macaulay Precinct.

It may be possible to use the flood storage areas for multiple benefits, such as providing water quality assets (e.g. a wetland) in the base of the above ground flood storages, or using the underground storage tank as part of a stormwater harvesting scheme. This potential for multiple uses would require further investigation.

Table 4.3 lists the proposed flood storages and the volume of flood storage provided. The volume of flood storage represents the volume of flood water within the footprint of each flood storage area based on the year 2100 1% AEP modelling of the working drainage strategy (discussed in Section 5), when the pumps are operational.

The following sections provide an overview of each flood storage, with the exception of the Arden Central Flood Storage, which is discussed in Section 4.6.

Table 4.3: Proposed flood storages

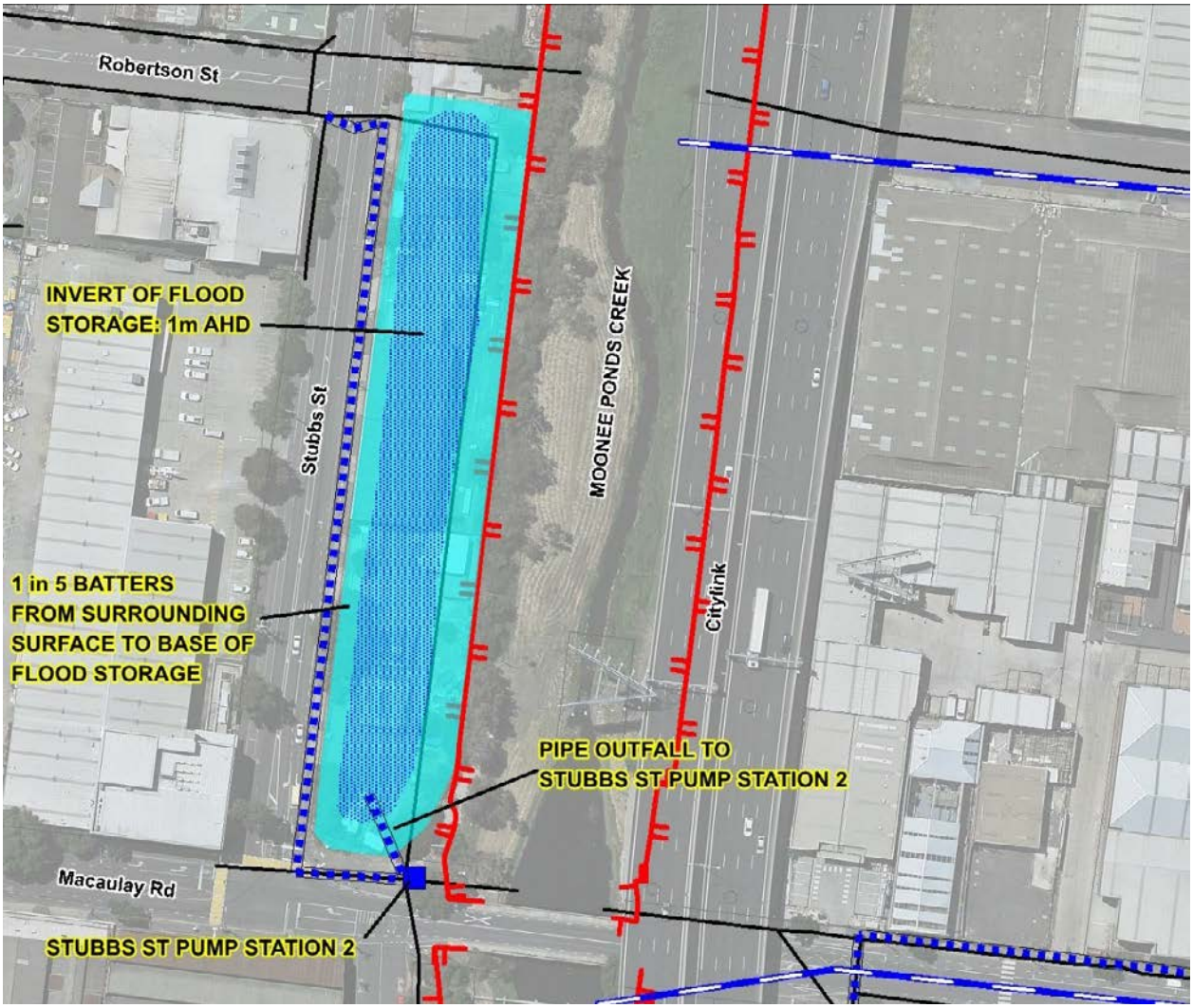
Flood Storage	Asset Footprint (m^2)	Year 2100 1% AEP Flood Storage (m^3)
Stubbs Street Above Ground Flood Storage	5,340	7,500
Citywide Above Ground Flood Storage	36,800	22,500
Langford Street Linear Above Ground Flood Storage	14,000	6500
Arden Street Oval Underground Tank	~10,000 (below surface)	12,500
Arden Central Above Ground Flood Storage	10,480	6,000

4.3.2 Stubbs Street Flood Storage

The Arden Macaulay Precinct Structure Plan (subject to review) identifies potential open space on the eastern side of Stubbs Street, between Robertson Street and Macaulay Road. The working drainage strategy proposes to use this area as an above ground flood storage. The flood storage would be provided by excavation only, with no embankment. At this stage, the concept design adopts 1 in 5 batters from the surrounding surface levels to the invert of the retarding basin at 1.0 metres AHD. A pipe outfall from the Stubbs Street flood storage area would drain flow to the Stubbs Street Pump Station 2.

Figure 4.4 provides a concept sketch of the Stubbs Street flood storage.

Figure 4.4: Stubbs Street above ground flood storage layout



4.3.3 Langford Street Linear Storage and Citywide Flood Storage

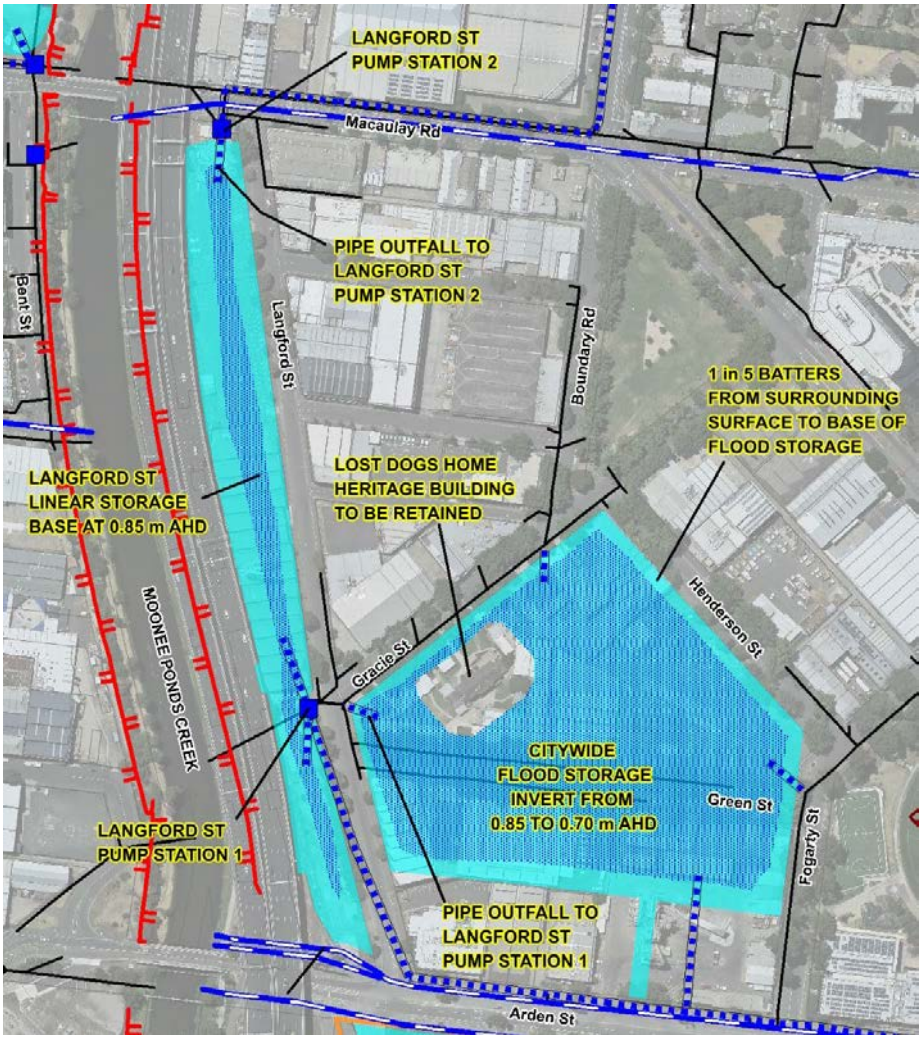
The Langford Street Linear Storage and Citywide Flood Storage are both above ground flood storages proposed in the low-lying area around Langford Street.

The Langford Street Linear Storage is located on the western side of Langford Street between Arden Street and Macaulay Road, utilising land that is predominantly owned by State Government entities. The Langford Street Linear Storage would be provided by excavation only, with no embankment. At this stage, the concept design adopts 1 in 5 batters from the surrounding surface levels to the invert of the retarding basin at 0.85 metres AHD. Pipe outfall from the flood storage area would drain flow to Langford Street Pump Station 2 and Langford Street Pump Station 1. The footprint of the Langford Street Linear Flood Storage is relatively narrow, which slightly reduces its efficiency in providing flood storage, when accounting for the space required to achieve the batters from surrounding surface levels to the base of the flood storage.

The Citywide Flood Storage is proposed to utilise land that is currently part of the Citywide Depot, as well as the Lost Dogs Home. The heritage building within the Lost Dogs Home is to be retained. The Citywide Flood Storage would also use the area that is currently Green Street, which would be closed permanently. The Citywide Flood Storage would be provided by excavation only, with no embankment. At this stage, the concept design adopts 1 in 5 batters from the surrounding surface levels to the invert of the retarding basin grading from 0.85 to 0.70 metres AHD. A pipe outfall from the flood storage area would drain flow to the Langford Street Pump Station 1. There is a high-pressure gas main on Green Street and the design of the Citywide must ensure that this asset is protected.

Figure 4.5 provides a concept sketch of the Langford Street Linear and Citywide Flood Storages.

Figure 4.5: Langford Street Linear and Citywide Flood Storages layout



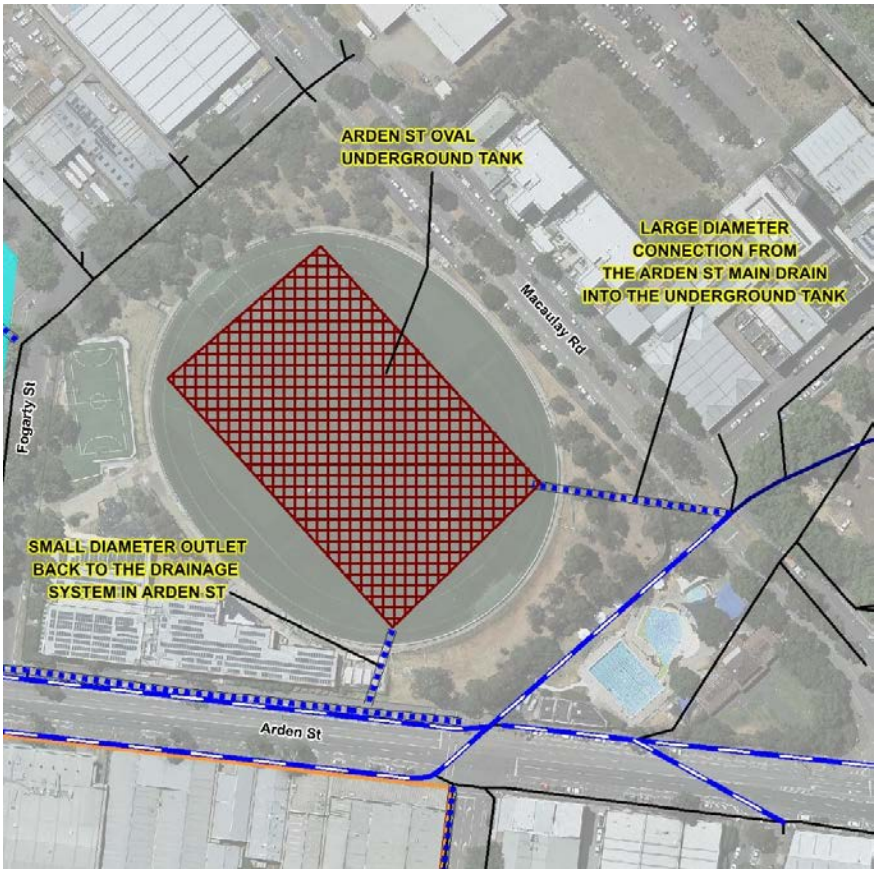
4.3.4 Arden Street Oval Underground Tank

The Arden Street Oval is located east of the proposed Citywide Flood Storage. It is proposed to construct a large capacity underground storage tank beneath the Arden Street Oval. This has the potential to provide approximately 12500 cubic metres of flood storage, based on a storage system with a surface area of 10,000 square metres (approximately 50 per cent of the oval surface area) and a tank depth of 1.25 metres.

The underground tank would receive flow from a connection from the Arden Street Drain and would discharge flow back into the drainage system at Arden Street. There is potential to use the underground storage tank for stormwater harvesting.

Figure 4.5 provides a concept sketch of the Arden Street Oval Underground Tank.

Figure 4.6: Arden Street Oval Underground Tank layout



4.4 PUMP STATION UPGRADES

The performance of the local drainage system in the Arden Macaulay Precinct when levels in Moonee Ponds Creek are high is dependent on the operation of the six existing pump stations. The working drainage strategy proposed to upgrade the capacity of each pump station. A new pump station is also proposed in Arden Central, which is discussed in Section 4.6.

Table 4.4 provides a summary of the existing and proposed pump station capacities. The proposed pump station capacities represent the total capacity of the pump station, and this capacity could be provided through a number of pumps working together to provide the total capacity. The pumps could also include variable speed drives to operate at lower rates during minor storm events.

Upgrades to the local drainage systems that drain to the pump stations are also proposed to increase the capacity of the drainage systems to convey flow to the pump stations to utilise the benefit of the upgraded pump stations. Section 4.5 provides details of the proposed local drainage system upgrades.

Table 4.4: Summary of proposed pump station upgrades

Pump Station	Location	Existing Pump Station Capacity	Proposed Pump Station Capacity	Comment
Stubbs St 1	Stubbs St opposite Smith St	0.56 m^3/s	2 m^3/s	Works also provided to improve the connectivity of the drainage system around Stubbs St and Parsons St to this pump station.
Stubbs St 2	Stubbs St at Macaulay Rd	1.196 m^3/s	1.8 m^3/s	Works also provided to improve the connectivity of the drainage system around Stubbs St and Robertson St to this pump station.
Bent St	Bent St at Macaulay Rd	0.7 m^3/s	1.3 m^3/s	-
Langford St 1	Langford St, opposite Gracie St	0.7 m^3/s	7 m^3/s	Significant pump upgrade to reduce flood depths at Langford Street. High capacity inlet pits to be provided at the low point of Langford Street.
Langford St 2	Langford St at Macaulay Rd	0.7 m^3/s	2.4 m^3/s	Works also provided to improve the connectivity of the Mark St drainage to this pump station. The Mark St drainage system was previously not connected to a pump station.
Sutton St	West end of Sutton St	0.7 m^3/s	0.9 m^3/s	Pump station appeared over-sized for its small current catchment. However, as part of the working drainage strategy the Alfred St drainage system is proposed to be connected to this pump station. The Alfred St drainage system was previously not connected to a pump station.

4.5 LOCAL DRAINAGE SYSTEM UPGRADES

Upgrades to the local drainage system consist of:

- Constructing pressure pipes. Pressure pipes convey flow from higher areas of the local catchment, with no connections or inlets in the low-lying areas of the precinct, and discharge flow into Moonee Ponds Creek under pressure.
- Replacing some existing pipes with larger diameter pipes or constructing new gravity pipes. The general intention of these upgrades is for the local drainage system to be able to convey more flow to the pump stations. Some gravity pipe upgrades are required as part of the drainage system modifications for the pressure pipes.

The pressure pipes are a key component of the working drainage strategy. The pressure pipes effectively result in separate drainage systems for the higher areas and low areas of the local catchments, with the higher areas discharging to Moonee Ponds Creek by the pressure pipes and the lower areas discharging to Moonee Ponds Creek by the pump stations. The pressure pipes can discharge flow into Moonee Ponds Creek even when the flood level in Moonee Ponds Creek is high as long as the flood level in the drainage system in the higher areas of the precinct is sufficiently above the flood level in Moonee Ponds Creek. Choosing the starting location of the pressure pipes is a balance between ensuring there is sufficient elevation difference in the drainage system compared to the flood level in Moonee Ponds Creek, but also trying to maximise the catchment area connected to the pressure pipes, which helps to reduce the size of the low-lying catchments that are serviced by the pump stations.

Some parts of the existing local drainage system already utilise pressure pipes, such as at Parsons Street west of Stubbs Street and Robertson Street west of Stubbs Street. However, the elevations that the existing Parsons Street and Robertson St pressure pipes starts at are not high enough to be able to discharge runoff into Moonee Ponds Creek in a 1% AEP event, as the flood level in Moonee Ponds Creek exceeds the flood level in the pressure pipe systems. The working drainage strategy includes modifications to the Parsons Street pressure pipe and the Robertson Street pressure pipe and the local drainage systems in these areas so that the pressure pipes starts at higher elevations.

A key component of the pressure pipes strategy is to pressurise the Arden Street Main Drain (which is not connected to a pump station) downstream of Macaulay Road. Pressurising the Arden Street Main Drain involves:

- Removing or bolting down all pit connections to the Arden Street Main Drain downstream of Macaulay Road.
- Diverting the pipes that connect into the Arden Street Main Drain downstream of Macaulay Road from the northern side of Arden Street to a new pipe along the northern side of Arden Street. The new pipe along the northern side of Arden Street would provide drainage of street flows along Arden Street.
- Diverting the pipes that connect into the Arden Street Main Drain downstream of Macaulay Road from the southern side of Arden Street through Arden Central.

Further investigation how the best way to achieve the pressurisation of the Arden Street Main Drain is recommended. The Arden Street Main Drain is an old asset and it may not be suitable for pressurisation in its current state. The further investigation is recommended to analyse whether the condition of the existing Arden Street Main Drain pipes is appropriate for pressurisation, whether the existing Arden Street Main Drain could be re-lined to achieve pressurisation or whether new pipes along a similar alignment are required.

Table 4.5 lists key details of the pressure pipe upgrades, while Table 4.6 provides key details of gravity pipe upgrades. Local drainage system upgrades relating to Arden Central are discussed in Section 4.6.

Table 4.5: Summary of proposed pressure pipe works

Location	Proposed Diameter (mm)	Total Length (m)	Comment
Arden Street Main Drain	900	70	Proposed pipe diameters / lengths include new pipes only, assuming that the existing Arden Street Main Drain can be retrained and pressurised (subject to further investigation).
Parsons Street	-	-	Works only required on the gravity system (refer Table 4.6), with the pressure pipe system extended upstream using existing pipes.
Robertson Street	750	105	Extension of the existing Robertson St pressure pipe further upstream, utilising the existing pressure pipes on Robertson St east of Lambeth St.
Chelmsford Street	450 750 900	10 15 135	New pressure pipe along Chelmsford St with new outfall to Moonee Ponds Creek.
Mark Street	600 900	70 95	New pressure pipes along Mark St and Buncle St, with new outfall to Moonee Ponds Creek.
Canning Street / Macaulay Road	600	475	New pressure pipe along Canning St and Macaulay Rd with new outfall to Moonee Ponds Creek.

Table 4.6: Summary of proposed gravity pipe works

Location	Proposed Diameters (mm)	Total Length (m)	Comment
Parsons St to Stubbs St 1 PS	300 375 450 600 750 1050	15 75 10 15 35 30	Includes modifications to improve the performance of the existing Parsons St pressure pipe and duplication of the existing drainage system on Stubbs Street to provide improved conveyance to Stubbs St PS 1.

Location	Proposed Diameters (mm)	Total Length (m)	Comment
Robertson St to Stubbs St 2 PS	300	10	Includes modifications to improve the performance of the existing Robertson St pressure pipe and duplication of the existing drainage system on Stubbs Street to provide improved conveyance to Stubbs St PS 2.
	375	15	
	450	35	
	675	15	
	750	180	
	900	25	
Alfred St to Sutton St PS	300	15	To facilitate connection of drainage in Alfred St to the Sutton St PS
	375	175	
	600	175	
Flemington Road to Sutton St	375	20	Pipe upgrade to reduce overland flow into the precinct
	750	55	
	900	170	
Mark St to Langford St 2 PS	900	185	New pipe connection from Mark St drainage system (currently not connected to a pump station) to Langford St 2 PS and pipe upgrade along Macaulay Rd
	1200	15	
Arden St new local drainage to Langford Street 1 PS	375	45	New local drainage required on Arden Street due to the pressurisation of the Arden Street Main Drain, will provide a connection to Langford St 1 PS
	450	75	
	1200	160	
Langford St inlets and pipes	825	45	New inlets and pipes to drain the low point of Langford Street to the Langford St 1 PS
Dryburgh St inlets and pipes	750	15	New inlets and pipes to connect into the upstream end of a new pressure pipe as part of the Arden Street Main Drain pressurisation
	900	25	

4.6 ARDEN CENTRAL

Arden Central is the land bound by Arden Street to the north, Laurens Street to the east and the Upfield train line to the south and west. This is the site for the proposed Arden Central Station, which is a key component of the Arden Macaulay Precinct, as well as high-density urban development. It is likely that Arden Central will be the first area of the Arden Macaulay Precinct to undergo intensive re-development and planning for Arden Central is more advanced than planning for the remainder of the Arden Macaulay Precinct.

In collaboration with Melbourne Water and the Victorian Planning Authority, Engeny has developed a site specific drainage strategy for Arden Central, which has been incorporated into the overall working drainage strategy for the Arden Macaulay Precinct. The Arden Central drainage strategy is document in Arden Central Flooding and Drainage Investigation (Engeny, March 2021). It should be noted that the Arden Central drainage strategy is subject to review.

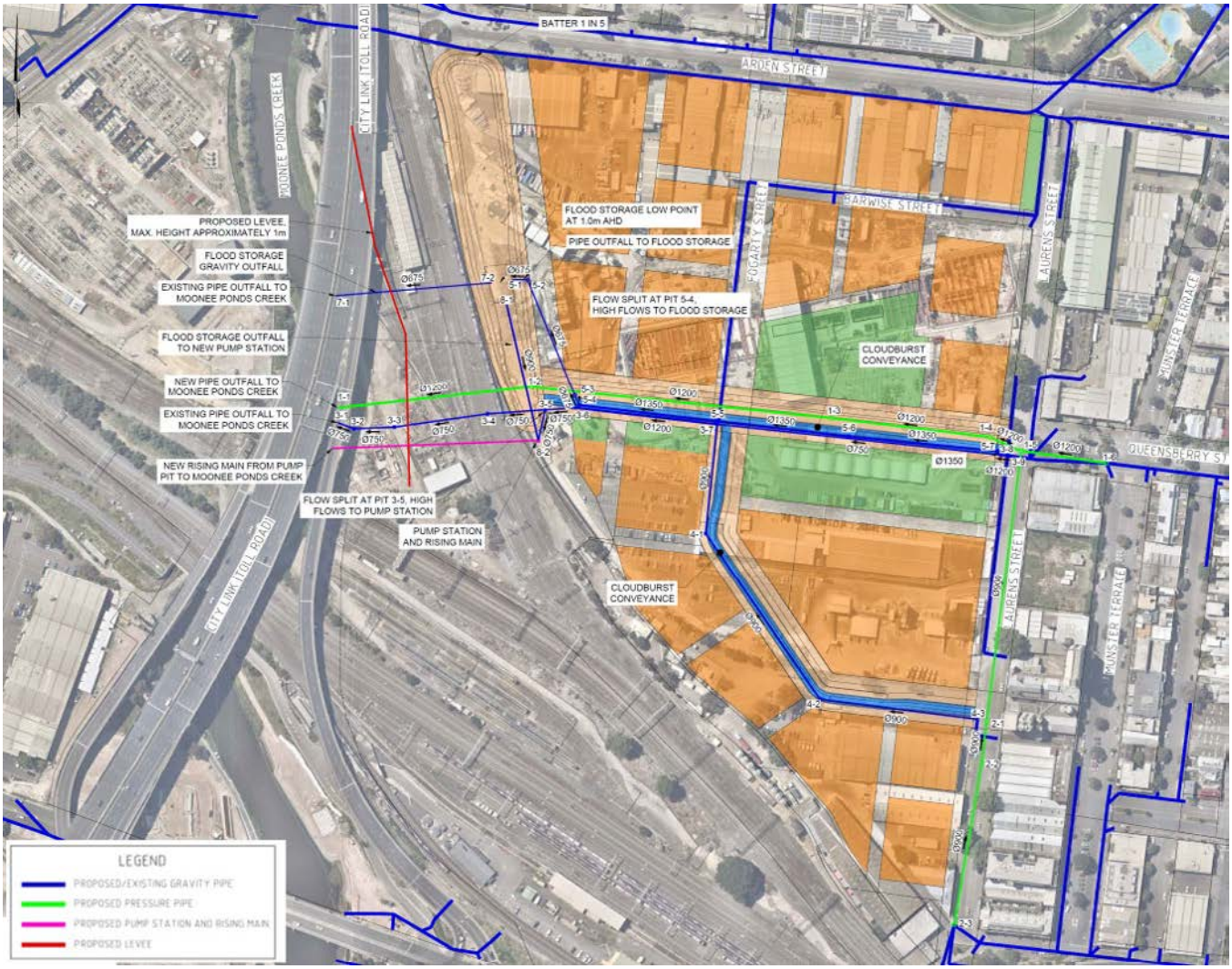
The key components of the Arden Central drainage strategy are:

- Improved underground drainage system, including pipe re-alignments to suit the proposed urban layout and pressure pipes to separate pipe flows from the higher parts of the upstream catchment (east of Laurens Street) from drainage within Arden Central. The intention of the underground drainage is to convey runoff in regular storms.
- A new pump station with a capacity of 2 m^3/s to allow flow from Arden Central to be discharged into Moonee Ponds Creek. It is likely that the pump station will require a dedicated rising main to convey flow from the pump station into Moonee Ponds Creek. Without the pump station, the drainage system within Arden Central will not function effectively if the flood level in Moonee Ponds Creek is high.

- Overland flows paths: this includes using the proposed Queensberry Street extension through Arden Central and the Fogarty Street extension, from the low point of Laurens Street to the Queensberry Street extension, as designated flows paths to convey external flows through the site. These road extensions are identified in the Arden Central urban planning as a combination of pedestrian and bike paths, with some vehicle movement, as well as formalised flow conveyance areas identified as cloudburst conveyance. These cloudburst conveyance areas are essentially small swales. The intention of these formalised overland flow paths is to convey flow when the capacity of the underground drainage system is exceeded. Due to the proposed levels on the site, the overland flow paths will also form part of the flood storage.
- Flood storage: a designated area within the western boundary of Arden Central to provide above ground flood storage, with a capacity of 6,000 m^3. The flood storage will store flood water when the capacity of the underground drainage system is exceeded.
- Moonee Ponds Creek levee: a new levee on the eastern side of Moonee Ponds Creek, south of Arden Street, to prevent flows from Moonee Ponds Creek flowing into Arden Central in events up to the 1 % AEP storm. The proposed levee has a maximum height of 1.0 metres above the existing surface level and a length of 200 metres.

Figure 4.7 provides a concept layout plan of the proposed drainage strategy for Arden Central.

Figure 4.7: Arden Central drainage strategy concept layout plan



4.7 PLANNING SCHEME CONTROLS

In addition to the working drainage strategy, which involves structural drainage measures, the City of Melbourne and Melbourne Water are intending to implement new flood related planning scheme overlays across the municipality, including within the Arden Macaulay Precinct. The intention of the flood related planning scheme overlays is to control land use and development in flood affected areas and to ensure new developments are designed with flood resilience in mind. These planning scheme overlays would be implemented as part of Amendment 384.

The proposed planning scheme overlays are based on the 1% AEP storm event for the year 2100 climate change scenario.

Relevant to the Arden Macaulay Precinct, the following planning scheme overlays are proposed to be implemented as part of Amendment 384:

- Land Subject to Inundation Overlay Schedule 3 (LSIO3), a Melbourne Water referral overlay relating to Moonee Ponds Creek.
- Special Building Overlay Schedule 2 (SBO2), a Melbourne Water referral overlay relating to the Arden Street Main Drain overland flow path.
- Special Building Overlay Schedule 3 (SBO3), a City of Melbourne referral overlay relating to overland flows path associated with some parts of City of Melbourne's drainage system.

At the time of this report, the Minister for Planning has authorised Amendment 384 to be prepared and exhibited. Exhibition (formal consultation) is likely to occur in late 2021.

4.8 STAGING PLAN

A preliminary staging plan has been developed by Melbourne Water to indicate the sequencing of delivery for the various components of the working drainage strategy, in terms of whether drainage works will be implemented in the short term, medium term or long term. The staging plan is subject to ongoing review.

The staging plan considers:

- The timing of development, such as delivering works that benefit Arden Central in the short term.
- Logical sequencing of works, such as grouping pump station upgrades and works on the local drainage system that convey flow to the pump station together.
- The potential complexity in delivering some assets, such as land acquisition that may be required for flood storages.

Figure 4.8 shows the proposed staging plan of the working drainage strategy.

N
W E
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PARSONS ST TO STUBBS ST PS1
GRAVITY PIPE: 300-1050mm dia

STUBBS ST PS1
EXISTING PS CAPACITY: 0.56 m³/s
PROPOSED PS CAPACITY: 2.0 m³/s

ROBERTSON ST
PRESSURE PIPE: 750mm dia

ROBERTSON ST TO STUBBS ST PS2
GRAVITY PIPE: 300-900mm dia

STUBBS ST FLOOD
STORAGE ~7500 m³

STUBBS ST PS2
EXISTING PS CAPACITY: 1.2 m³/s
PROPOSED PS CAPACITY: 1.8 m³/s

BENT ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 1.3 m³/s

CHELMSFORD ST
PRESSURE PIPE: 450-900mm dia

LANGFORD ST LINEAR
FLOOD STORAGES
~6500 m³

LANGFORD ST PS1
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 7.0 m³/s

ARDEN CENTRAL
FLOOD STORAGE ~6000 m³

ARDEN CENTRAL
FLOOD STORAGE OUTFALL
TO PROPOSED PUMP STATION

ALFRED ST TO SUTTON ST PS
GRAVITY PIPE: 300-600mm dia

SUTTON ST PS
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 0.9 m³/s

FLEMINGTON RD TO SUTTON ST
GRAVITY PIPE: 375-900mm dia

MARK ST PRESSURE
PIPES: 600-900mm dia

MARK ST TO LANGFORD ST PS2
GRAVITY PIPE: 900-1200mm dia

CANNING ST & MACAULAY RD
PRESSURE PIPE: 600mm dia

LANGFORD ST PS2
EXISTING PS CAPACITY: 0.7 m³/s
PROPOSED PS CAPACITY: 2.4 m³/s

CITYWIDE FLOOD
STORAGE ~22500 m³

NEW LOCAL DRAINAGE SYSTEM
ALONG ARDEN ST TO CONNECT
TO LANGFORD ST PS1: 375-1200mm dia

ARDEN ST OVAL
STORAGE TANK
~12500 m³

NEW PITS AND PIPES
IN DRYBURGH ST
750-900mm dia

PRESSURISATION OF
ARDEN ST DRAIN
DETAILS TBC

DIVERT EXISTING DRAINAGE SYSTEM
AWAY FROM ARDEN ST DRAIN
GRAVITY PIPE: 450-750mm dia

NEW PRESSURE PIPES IN
LAURENS ST & ARDEN CENTRAL
900-1200mm dia

REALIGN AND UPGRADE DRAINAGE
THROUGH ARDEN CENTRAL
900mm dia

ARDEN CENTRAL
NEW PUMP STATION
PROPOSED CAPACITY: 2 m³/s
WITH RISING MAIN OUTFALL
TO MOONEE PONDS CREEK

ARDEN CENTRAL
PROPOSED CLOUDBURST
CONVEYANCE AND FLOOD
STORAGE WITHIN FUTURE
ROAD RESERVES

Racecourse Rd
Stubbs St
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets

- Melbourne Water Pipe
- City of Melbourne Pipe

Working Drainage Strategy, Short Term Works

- Raised / New Levees
- Pump Station Upgrade
- Pressure Pipe
- Gravity Pipe
- Flood Storage
- Cloudburst Conveyance (Arden Central)

Working Drainage Strategy, Medium Term Works

- Raised / New Levees
- Pump Station Upgrade
- Pressure Pipe
- Gravity Pipe
- Flood Storage

Working Drainage Strategy, Long Term Works

- Pump Station Upgrade
- Pressure Pipe
- Gravity Pipe
- Flood Storage

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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260
Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 4.8
Working Drainage Strategy
Staging of Works
Subject to Ongoing Review

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

5 WORKING DRAINAGE STRATEGY FLOOD MODELLING

5.1 FLOOD MAPS

The flood model has been used to analyse the performance of the working drainage strategy. A scenario was developed in the flood model including all elements of the working drainage strategy, as detailed in Section 4. The flood modelling of the working drainage strategy has been simulated for the following events:

- Year 2100 climate change conditions 5% AEP event
- Year 2100 climate change conditions 1% AEP event, with pumps working
- Year 2100 climate change conditions 1% AEP event, pump failure scenario

Figure 5.1 provides a flood depth map representing the flood modelling of the working drainage strategy (with pumps working) for the 1% AEP event, year 2100 climate change conditions. Figure 5.2 provides an afflux map, which shows the change in flooding achieved by the working drainage strategy (with pumps working) compared to the existing drainage system (with pumps working), for the 1% AEP event, year 2100 climate conditions.

Figure 5.3 provides a flood depth map representing the flood modelling of the working drainage strategy in a pump failure scenario for the 1% AEP event, year 2100 climate change conditions.

Appendix C provides flood depth and afflux maps for both the 1% and 5% AEP events for the year 2100 climate change conditions.

The following sections of this report provide key results and discussion of outcomes based on the flood modelling of the working drainage strategy.

N
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Racecourse Rd
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Stategy:

- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

Flood Depth:

- Depth 0 to 0.3 metres
- Depth 0.3 to 0.6 metres
- Depth 0.6 to 0.9 metres
- Depth 0.9 to 1.2 metres
- Depth 1.2 to 1.5 metres
- Depth > 1.5 metres

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Melbourne Water

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Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 5.1
Working Drainage Strategy (Pumps Working)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

N
W
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S

Racecourse Rd
Elliott Av
Parsons St
Alfred St
Smith St
Stubbs St
MOONEE PONDS CREEK
Sutton St
Flemington Rd
Melrose St
Dryburgh St
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Stategy:

- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

Change in Flood Level Achieved by the Working Drainage Strategy:

- Flood level reduces by > 0.5m
- Flood level reduces by 0.2m to 0.5m
- Flood level reduces by 0.1m to 0.2m
- Flood level reduces by 0.03m to 0.1m
- Flood level within +/- 0.03m
- Flood level increases by 0.03m to 0.1m
- Flood level increases by 0.1m to 0.2m
- Flood level increases by 0.2m to 0.5m
- Flood level increases by > 0.5m

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Arden Macaulay Precinct

Figure 5.2
Afflux - Change in 1% AEP Flood Level
Working Drainage Strategy (Pumps Working)
compared to Existing Drainage
System (Pumps Working)
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

N
W
E
S

Racecourse Rd
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Stategy:

- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

Flood Depth:

- Depth 0 to 0.3 metres
- Depth 0.3 to 0.6 metres
- Depth 0.6 to 0.9 metres
- Depth 0.9 to 1.2 metres
- Depth 1.2 to 1.5 metres
- Depth > 1.5 metres

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Arden Macaulay Precinct

Figure 5.3
Working Drainage Strategy (Pump Failure)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
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5.2 MOONEE PONDS CREEK AND THE PERFORMANCE OF THE LEVEE UPGRADES

Without the raised levees, the levees were predicted to be overtopped in a 1% AEP event. The raising of the levees that has been adopted in the working drainage strategy prevents the levees from being overtopped, which provides improved flood protection for most areas of the Arden Macaulay Precinct in the 1% AEP event.

With the existing levee crest levels, 1% AEP flow was also predicted by the flood modelling to break out from Moonee Ponds Creek at the Racecourse Road bridge and then flow behind the eastern levee into the eastern side of the Arden Macaulay Precinct. When the levees are raised the 1% AEP flood level in Moonee Ponds Creek increases. This results in an increase in flow that breaks out from Moonee Ponds Creek at Racecourse Road (to both the western and eastern sides of the creek) and increasing 1% AEP flood depths in potentially developable areas of the Arden Macaulay Precinct behind the eastern levee and behind the western levee in the Stubbs Street area.

The raised 1% AEP flood level in Moonee Ponds Creek due the raised levees also results in flow breaking out from Moonee Ponds Creek where there are breaks between the levees at the Macaulay Road bridge, which impacts 1% AEP flooding in Bent Street and Stubbs Street. The raised 1% AEP flood level in Moonee Ponds Creek also makes the bridge crossings of Moonee Ponds Creek more susceptible to being overtopped.

Section 6.2 provides discussion on works that have been considered to reduce the impact of the increased flood level in Moonee Ponds Creek due to the levee works, but the additional works are not currently part of the working drainage strategy.

Table 5.3 provides year 2100 climate change conditions 1% AEP flood levels at each of the bridge crossings of Moonee Ponds Creek for the existing drainage system (with existing levees) and the working drainage strategy scenario, as well as the soffit and deck levels of the bridges. The bridge soffit and deck levels are based on information provided by Melbourne Water. Bridge levels at the upstream end of the bridge have been provided where bridge soffit and deck levels change from the upstream to the downstream side of the bridge. Flood levels that result in the bridge deck overtopping are shaded red and flood levels above the bridge soffit but below the bridge deck are shaded orange.

The results in Table 5.3 show that the year 2100 climate change conditions 1% AEP flood level at each of the bridge crossings increases due to the raised levees. While raising the levees does not change whether a bridge deck will be overtopped in a 1% AEP event, it does increase the depth of inundation on the Racecourse Road and Macaulay Road bridges. The Arden Street bridge, rail bridge downstream of Arden Street and Dynon Road bridge are also closer to being overtopped in a 1% AEP event due to the raised levees.

Table 5.1: Flooding impact on bridges

Bridge	Existing Bridge Soffit Level (m AHD)	Existing Bridge Deck Level (m AHD)	Year 2100 Flood Level with Existing Levees (m AHD)	Year 2100 Flood Level with Raised / New Levees (m AHD)
Racecourse Rd	4.04	4.90	5.23	5.41
Macaulay Rd	2.81	3.97	4.09	4.69
Arden St	3.39	4.34	3.50	4.13
First rail bridge south of Arden St	2.06	3.58	3.06	3.46
Dynon Rd	2.50	3.10	2.74	2.89

5.3 KEY FLOODING OUTCOMES

Table 5.2 provides a comparison of key flood relates statistics based on the results of the flood modelling of the working drainage strategy and the existing drainage system, both for year 2100 conditions and year 2100 conditions with pump failure. The statistics include key inflows to the Arden Macaulay Precinct from Moonee Ponds Creek and the Arden Street Main Drain, peak flood depths at the low-lying roads in the precinct and the area of the precinct that is subject to flood depths exceeding 0.5 metres (excluding the Moonee Ponds Creek corridor and flooding within the designated flood storage areas in the working drainage

strategy). The majority of the statistics are based on the flood modelling of the 1% AEP event, with some results relating to the 5% AEP event (a pump failure scenario has not been modelled for the 5% AEP event).

Table 5.2: Comparison of key flooding statistics for the working drainage strategy with the existing drainage system, year 2100 climate change conditions

Statistic	Year 2100, Existing Drainage System (Pumps Working)	Year 2100, Working Drainage Strategy (Pumps Working)	Year 2100, Existing Drainage System (Pump Failure)	Year 2100, Working Drainage Strategy (Pump Failure)
Moonee Ponds Creek 1% AEP peak flow at Racecourse Road	257 m^3/s	257 m^3/s	257 m^3/s	257 m^3/s
Eastern levee 1% AEP overtopping peak flow	10.3 m^3/s	0 m^3/s	9.4 m^3/s	0 m^3/s
Western levee 1% AEP overtopping peak flow	53.9 m^3/s	0 m^3/s	51.0 m^3/s	0 m^3/s
Creek break out 1% AEP flow at Racecourse Road bridge, to the east (towards Alfred Street)	8.7 m^3/s	15.5 m^3/s	8.6 m^3/s	14.4 m^3/s
Creek break out 1% AEP flow at Racecourse Road bridge, to the west (to Stubbs Street)	3.0 m^3/s	22.9 m^3/s	2.9 m^3/s	19.6 m^3/s
Creek 1% AEP overflow into Arden Central (south of Aden Street)	1.5 m^3/s	0 m^3/s	1.5 m^3/s	0 m^3/s
Arden Steet MD 1% AEP peak flow into the precinct (combined pipe and overland)	18.8 m^3/s	18.8 m^3/s	18.8 m^3/s	18.8 m^3/s
Stubbs Street, 1% AEP peak flood depth	2.24 m	1.58 m	2.24 m	1.69 m
Stubbs Street, 5% AEP peak flood depth	0.88 m	0.46 m	Not modelled	Not modelled
Bent Street, 1% AEP peak flood depth	2.59 m	1.16 m	2.59 m	1.92 m
Bent Street, 5% AEP peak flood depth	0.73 m	0.56 m	Not modelled	Not modelled
Langford Street, 1% AEP peak flood depth	2.22 m	0.61 m	2.26 m	1.49 m
Langford Street, 5% AEP peak flood depth	1.50 m	0.15 m	Not modelled	Not modelled
Area of the precinct flooded by depth > 0.5 m (not including Moonee Ponds Creek or within proposed flood storages)	33.6 ha	10.3 ha	34.5 ha	15.8 ha

Key observations from the results in Table 5.2 include:

- In the working drainage strategy scenario, the raised levees are no longer predicted to be overtopped, reducing 1% AEP inflow from Moonee Ponds Creek into the potentially developable areas of the precinct. However, the breakout flow from the creek at the Racecourse Road bridge increases due to the higher flood levels in Moonee Ponds Creek.
- Peak flood depths in the 5% and 1% AEP event are reduced at the low-lying areas of Stubbs Street, Bent Street and Langford Street. For the working drainage strategy, the peak flood depths at Stubbs Street and Bent Street in the 1% AEP event are influenced by the breakout flow from Moonee Ponds Creek at the Racecourse Road bridge.
- The working drainage strategy is generally effective at reducing flood depths across the Arden Macaulay Precinct. The potentially developable areas of the precinct that is subject to flood depths exceeding 0.5 metres is reduced from 33.6 hectares to 10.3 hectares.

Figure 5.4 and Figure 5.5 show the rise and fall of the 1% AEP and 5% AEP flood levels at the low point of Stubbs Street and the low point of Langford Street for the year 2100 scenario, comparing the performance of the working drainage strategy (with pumps operational) and the existing drainage system (with pumps operational). These graphs are based on the 2 hour duration storm for both the 1% AEP and 5% AEP events, which is typically the critical storm duration.

The graphs highlight the significant reduction in the duration of inundation at these low-lying areas. The key component of the working drainage strategy that reduces the duration of inundation is the increase to the pump station capacities.

Figure 5.4: Time of inundation at Stubbs St low point, working drainage strategy compared to existing drainage system, year 2100 climate change conditions

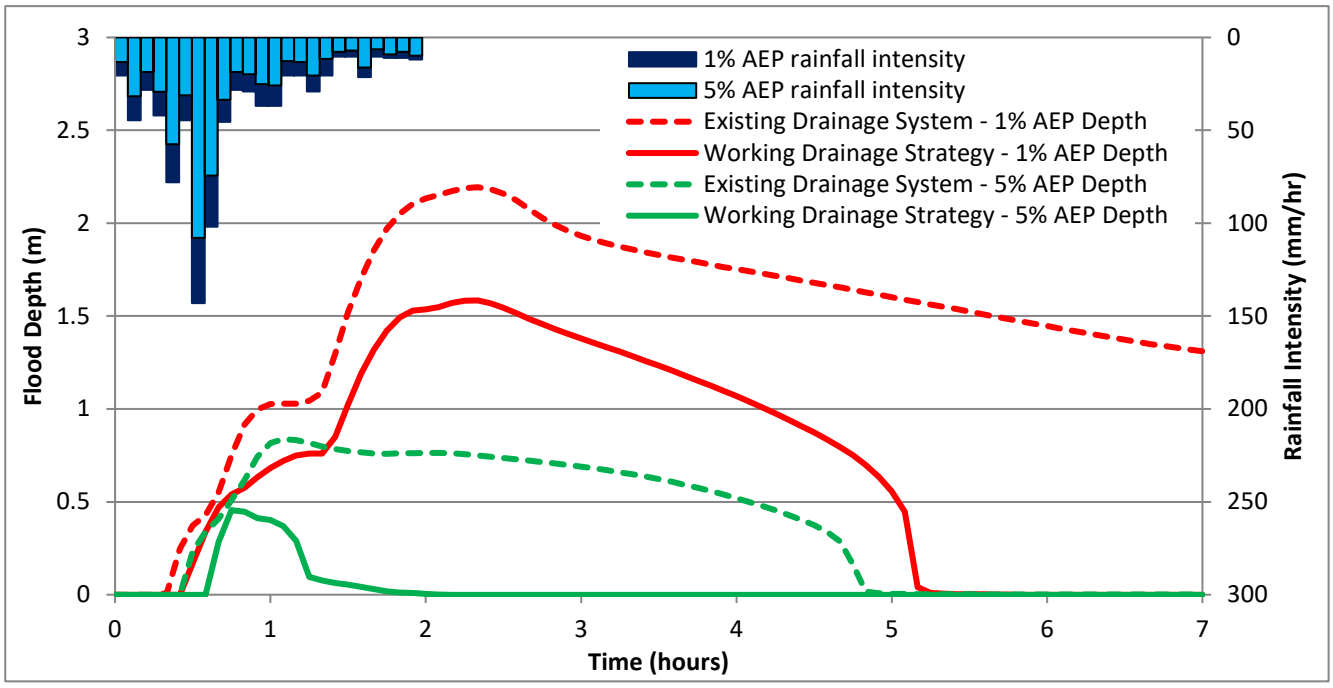
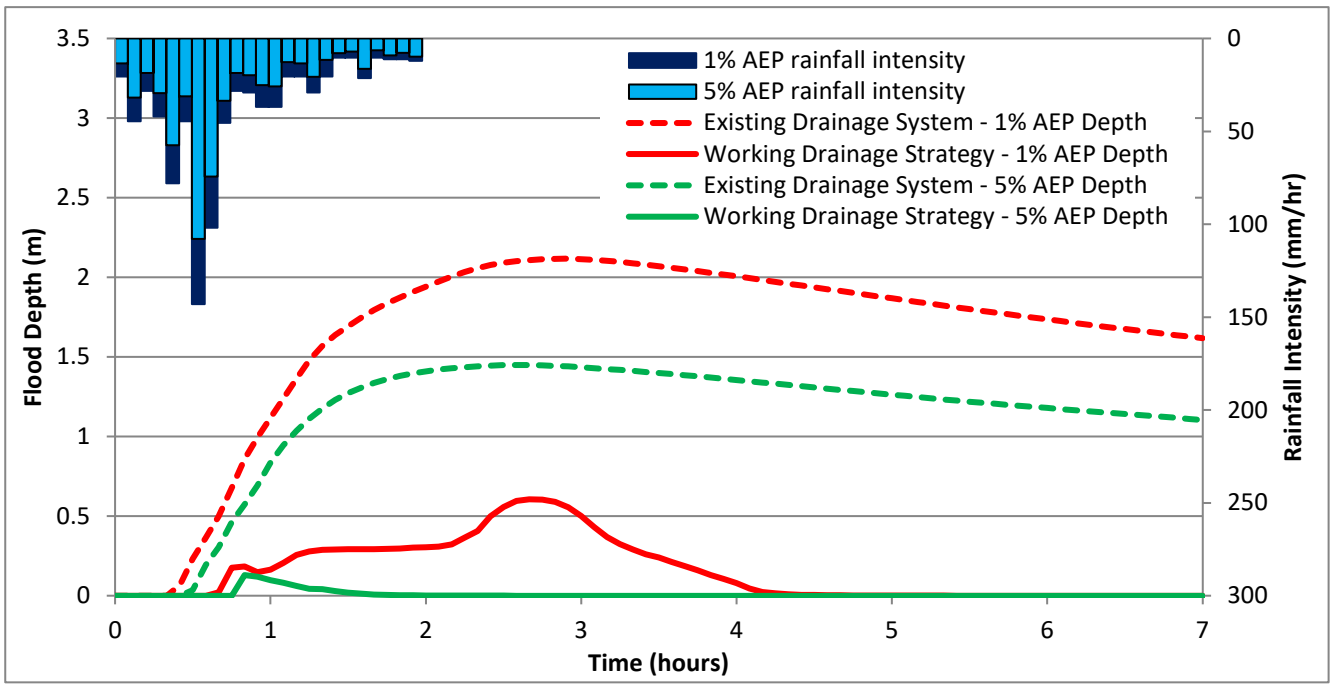


Figure 5.5: Time of inundation at Langford St low point, working drainage strategy compared to existing drainage system, year 2100 climate change conditions



5.4 HABITABLE FLOOR LEVEL ANALYSIS

It is very likely that habitable floor levels for some future developments within the Arden Macaulay Precinct will need to be raised above the footpath level in order to prevent habitable floor levels being flooded in a 1 % AEP event. Minimum habitable floor levels are typically based on the predicted maximum 1 % AEP flood level impacting a property, with consideration of appropriate freeboard. While raising floor levels is an effective flood management measure, it is often not desirable in terms of urban design due to the potential disconnect between streets and developments.

While pump stations can provide an effective drainage function in low lying areas such as the Arden Macaulay Precinct, they have the potential to be unreliable in storm events if they lose power. Due to this, to provide appropriate flood resilience for new developments Melbourne Water plans to set habitable floor levels based on the year 2100 1 % AEP flood level when the pumps fail to operate.

Using the flood modelling results, the heights of habitable floor levels above footpath level have been estimated for each property potentially developable property in the Arden Macaulay Precinct area based on the peak 1 % AEP flood depth along each property boundary and provision of 0.6 metres freeboard.

Table 5.3 and Table 5.4 provide a summary of the estimated heights of habitable floor levels above existing footpath level for the working drainage system compared to if the existing drainage system was retained (i.e. a do-nothing scenario). Table 5.3 presents the habitable floor level assessment as a proportion of property frontages in each height category, while Table 5.4 presents the results in terms of total length of property frontages in each height category. Note that the total length of property frontage reduces in the working drainage strategy due to the loss of potentially developable land that is used for flood storages.

Figure 5.6 provides a thematic map showing the required indicative heights of habitable floor levels above the existing footpath level based on the existing drainage system (for the year 2100 scenario), while Figure 5.7 provides a thematic map showing the indicative heights of habitable floor levels for the working drainage strategy (for the year 2100 scenario). Please note that the habitable floor level information presented on these plans is indicative only for comparative purposes.

The results in Table 5.3 and Table 5.4 indicate that the working drainage strategy reduces the required minimum habitable floor levels. This is achieved by:

- The reduced 1% AEP flood levels achieved by the working drainage strategy in the pump failure scenario.
- The flood storages utilising some of the most flood prone land in the low-lying areas of the precinct. If the land that is proposed to be used for flood storage was instead intended for development, it would require high habitable floor levels.

Table 5.3: Approximate habitable floor level height above footpath (%)

Scenario	Proportion of Property Frontages for Heights Above Footpath Level (%)						Total Length (m)
	Not flood affected	0.3 to 1.0 m	1.0 to 1.5 m	1.5 to 2.0 m	2 to 2.5 m	> 2.5 m	
Existing drainage system, pump failure	10%	42%	12%	12%	14%	9%	21625
Working drainage strategy, pump failure	14%	56%	13%	12%	5%	0%	19928

Table 5.4: Approximate habitable floor level height above footpath (metres)

Scenario	Proportion of Property Frontages for Heights Above Footpath Level (m)						Total Length (m)
	Not flood affected	0.3 to 1.0 m	1.0 to 1.5 m	1.5 to 2.0 m	2 to 2.5 m	> 2.5 m	
Existing drainage system, pump failure	2262	9088	2599	2702	3131	1842	21625
Working drainage strategy, pump failure	2867	11107	2623	2300	1031	0	19928

N
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Racecourse Rd
Elliott Av
Parsons St
Alfred St
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Flemington Rd
Dryburgh St
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe
- Levee
- Pump Station

Approximate Building Floor Level Height Above Footpath

- Not Flood Affected
- 0.3 to 1.0 metres
- 1.0 to 1.5 metres
- 1.5 to 2.0 metres
- 2.0 to 2.5 metres
- Greater than 2.5 metres

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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 5.6
Indicative Minimum Habitable Floor Levels
Existing Drainage System (Pump Failure)
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

N
W
E
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Racecourse Rd
Elliott Av
Parsons St
Alfred St
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Flemington Rd
Dryburgh St
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Stategy:

- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

Approximate Building Floor Level Height Above Footpath

- Not Flood Affected
- 0.3 to 1.0 metres
- 1.0 to 1.5 metres
- 1.5 to 2.0 metres
- 2.0 to 2.5 metres
- Greater than 2.5 metres

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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure 5.7
Indicative Minimum Habitable Floor Levels Working Drainage Strategy (Pump Failure) Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

6 OTHER DRAINAGE WORKS CONSIDERED

6.1 OVERVIEW

The working drainage strategy has been developed through the investigation of a broad range of potential options. Some options that were investigated have not been included in the working drainage strategy as they may have been less effective at managing flooding or were not feasible.

The following sections provide an overview of options that have been considered, but not included in the working drainage strategy.

6.2 ALTERNATIVE WORKS ON MOONEE PONDS CREEK

6.2.1 Creek Widening

These works considered widening the creek channel on the western side of Moonee Ponds Creek between Racecourse Road and the rail bridge south of Arden Street in order to increase the capacity of creek. This would be an alternative to raising the levees, although levees in some form would still be required with a widened creek. Widening of Moonee Ponds Creek on the eastern side of the creek was not considered due to the constraints of the train line and the elevated Citylink.

Investigations of this option, and discussions between Engeny, Melbourne Water, City of Melbourne and the Victorian Planning Authority, led to the creek widening being excluded from the working drainage strategy. This was based on:

- The location of multiple buildings adjacent to the existing creek reserve.
- Difficulties and costs associated in the land acquisition of the multiple land holdings adjacent to Moonee Ponds Creek (particularly at Stubbs Street).
- The low-lying areas along Stubbs Street and Bent Street, which would require a high wall between the road reserve and the creek reserve so that there was sufficient capacity in the creek reserve to convey 1% AEP flows without levees overtopping.

6.2.2 Creek Dredging

These works considered dredging the creek invert by approximately one to two metres between Racecourse Road and Footscray Road.

Preliminary flood modelling of this option predicted that dredging Moonee Ponds Creek only provided limited benefits in terms of reducing the flood level in the creek. Downstream of Racecourse Road, the capacity of Moonee Ponds Creek partially influenced by Port Phillip Bay tide levels, when tide levels are high. Excavating the creek below the tidal level provides limited benefits in terms of flow capacity when the level in Port Phillip Bay is high.

Creek dredging was not included in the working drainage strategy due to the limited benefits provided.

6.2.3 Bridge Works

The existing bridge crossings of Moonee Ponds Creek reduce the capacity of the creek to convey flows due to the hydraulically inefficient support structures of the bridges and low bridge decks. The existing bridges increase the creek flood level, which requires the levees to be constructed to a higher level to contain creek flows.

The following options were considered for works on the bridges:

- Full bridge works: involved re-constructing the Arden Street bridge, Macaulay Road bridge and first rail bridge downstream of Arden Street so that they impose no hydraulic restriction on flows in Moonee Ponds Creek in a 1% AEP event (i.e. clear-spans bridges above the 1% AEP flood level with no pier structures impacting creek flows).
- Partial bridge works: involved removing piers and strengthening the Arden Street and Macaulay Road bridges so that they are both clear span bridges, with the bridge decks only impacting 1% AEP flows.

Preliminary flood modelling of the bridge works indicated the following potential benefits:

- Reduced levee heights. With the full bridge works, only minor increases of the existing levee crest levels may be required to elevate the levees to the 1% AEP flood level in Moonee Ponds Creek, although the new levees downstream of Arden Street would still be required. With the partial bridge works, the proposed increases in levee crest levels would be halved compared to the working drainage strategy proposed levels, but the proposed new levees south of Arden Street would need to be constructed to a higher level.
- Reduced year 2100 1% AEP flooding in potentially developable areas of the Aden Macaulay Precinct. This is achieved by:
  - The bridge works reducing the tail water impact that the creek imposes on the local drainage system, which helps to improve the performance of the local drainage system.
  - The bridge works reducing the amount of flow that spills from Moonee Ponds Creek into potentially developable areas behind the levees. While the objective of raising the levees is to contain creek flows within the creek corridor, year 2100 1% AEP flows are predicted to spill from the creek at the bridge crossings, in particular Racecourse Road and Macaulay Road.
- Reduced minimum habitable floor levels required for some new developments due to the reduced year 2100 1% AEP flood levels achieved by the bridge works.

Despite the flood management benefits that could be achieved by the bridge works, they have not been included in the working drainage strategy. This decision was based on:

- Uncertainty regarding the engineering feasibility of the works on the bridges. Raising bridges sufficiently may be constrained by other assets such as the train line (located immediately east of Arden Street and Macaulay Road) and the Citylink elevated roadway. Further investigation by bridge, road and rail specialists would be required to assess the feasibility of the bridge works.
- The likely high costs of the bridge works.

6.3 ALTERNATIVE LOCAL DRAINAGE SYSTEM UPGRADES

The following options for works on the local drainage system were previously considered:

- Connection of Melbourne Water's Arden Street Main Drain to the Langford Street 1 pump station. This option was not included in the working drainage based on:
  - It would likely require a significant upgrade to the Langford Street 1 pump station, with a capacity even greater than the proposed 7 m^3/s as part of the working drainage strategy.
  - The pressurisation of the Arden Street Main Drain being a more hydraulically effective and more economic option.
- A pressure pipe on Smith Street. This option was not included in the working drainage strategy as the catchment area it controlled was relatively small, so the flood management benefits provided were limited.

6.4 ADDITIONAL FLOOD STORAGES

The following flood storage options were previously considered:

- Royal Park flood storage (external to the Arden Macaulay Precinct), with above ground flood storages located in Royal Park next to Flemington Road, either side of Elliot Avenue. These flood storages were not included in the working drainage strategy as they provided limited benefits to flooding within the Arden Macaulay Precinct. These flood storages would only control flows from Royal Park, which is largely previous and therefore does not have significant runoff.
- Clayton Reserve flood storage, which was proposed to be an underground storage tank. Clayton Reserve is a relatively small area meaning there is not much space to fit storage and the drainage system that could be controlled by the storage is small. This flood storage was not included in the working drainage strategy as the hydraulic benefits were not sufficient to justify the works.
- Ievers Reserve flood storage (external to the Arden Macaulay Precinct), with options for an underground storage tank and above ground flood storage considered. This flood storage would aim to provide a reduction in flows in the Arden Street Main Drain, which is the second largest external catchment contributing to the Arden Macaulay Precinct (with Moonee Ponds

Creek being the largest). Ievers Reserve is relatively small, and this option was not included in the working drainage strategy due to the limited reduction to flooding in the Arden Macaulay Precinct that it provided.

Multiple investigations of the Citywide flood storage were also previously undertaken. These investigations analysed the benefits of alternatives to the Citywide flood storage footprint that has been adopted in the working drainage strategy. The alternative footprints were all located in the Langford Street area, but utilised different properties and / or existing road reserves to create the flood storage. The Citywide flood storage adopted in the working drainage strategy was chosen based on:

- The footprint has a large enough area to achieve sufficient flood storage so that it is an effective flood management measure.
- Its location at the low point of Langford Street, meaning overland flows will drain to the site.
- It provides a balance between acquiring land currently owned by City of Melbourne and private land.

6.5 ON-SITE AND STREETSCAPE FLOOD STORAGE

On behalf of City of Melbourne, consultants Ramboll developed a cloudburst flood management plan for the Arden Macaulay Precinct. Key elements of the cloudburst management plan included:

- Provision of on-site flood storage using green roofs and rainwater tanks.
- Incorporation of flood storage into the road reserve, including re-profiling of streets and rain gardens within the road corridor.

These elements of the cloudburst flood management plan have not been incorporated into the working drainage strategy as flood modelling predicted they provided limited flood management benefits in the year 2100 1% AEP event. However, these works may provide flood management benefits in more frequent storm events, and other potential benefits such as an alternative water supply and improvement to the urban heat island effect.

7 SUMMARY

The Victorian Government has identified the Arden Macaulay Precinct as a key urban renewal area. The precinct is to be transformed from a primarily industrial area into a high-density mixed-use zone, with the future Arden Station to be located within the Arden precinct as part of the Metro Tunnel project.

Some areas within the Arden Macaulay Precinct have a recognised history of flooding, in particular Stubbs Street in Kensington on the western side of Moonee Ponds Creek and Langford Street in North Melbourne on the eastern side of Moonee Ponds Creek. These are very low-lying areas, with minimum surface levels at Stubbs Street of approximately 1.9 metres above sea level and minimum surface levels at Langford Street of approximately 1.1 metres above sea level. The Arden Macaulay Precinct Plan identifies intensive development of these areas.

Flood modelling indicates that flooding of the Arden Macaulay Precinct can be attributed to the following factors:

- High flood levels in Moonee Ponds Creek overtopping the levees and flowing into low lying areas. The high flood levels in the creek are caused by a combination of flows from the upstream catchment, downstream tidal levels and the hydraulic restriction of bridges.
- Local flows from within the precinct and upstream local catchments draining to low lying areas, and once runoff is in the low-lying areas the drainage system is dependent on the operation and capacity of the pump stations to convey flow into Moonee Ponds Creek when the water level in the creek is higher than the water level in the local catchment. While the existing flood mitigation measure of the creek's levees reduces the severity of flooding in the local catchment, it also raises the flood level in the creek, increasing the constraint of the tail water level on the local drainage system.
- Effective drainage of some areas of the precinct is limited as not all sections of the drainage system are directly connected to a pump station or are connected by only very small pipes. This includes Melbourne Water's Arden Street Main Drain, which is not directly connected to a pump station. When the flood level in Moonee Ponds Creek at the Arden Street Main Drain outfall is high, the drain is unable to effectively discharge flow, which contributes to the significant inundation predicted around the Langford Street area.

Overall, the severity of flooding predicted by the flood modelling is not compatible with development for large areas of the Arden Macaulay Precinct. The predicted flooding is likely to pose an unacceptable risk to the safety of the community and lead to extensive property damage. If the Arden Macaulay Precinct is to develop into a high-use urban area, drainage works will need to be implemented to manage the risk of flooding.

This report documents the investigations that have been undertaken to develop a drainage strategy, referred to as the working drainage strategy, to manage flooding within the Arden Macaulay Precinct. While the working drainage strategy is focused on flood management outcomes, it does not preclude other potential objectives such as stormwater harvesting, landscaping and open space amenity. The working drainage strategy is at a concept level and is subject to revision and refinement as further information becomes available and further investigations are undertaken.

The working drainage strategy refers to the combination of drainage works that is proposed to enable intensive development of the precinct while achieving an appropriate level of service for drainage and appropriate flood protection standards in the year 2100 climate conditions scenario. Adopting the year 2100 scenario as the design rainfall event reflects the long-term planning required for major developments to provide adequate flood protection for the future community in the Arden Macaulay Precinct.

The working drainage strategy includes the following key components:

- Raised and extended levees for Moonee Ponds Creek
- Above ground flood storages (retarding basins).
- An underground flood storage tank beneath the Arden Street Oval.
- Upgrades to the six pump stations within the Arden Macaulay Precinct.
- Gravity pipe upgrades, including new gravity pipes and upgrades of existing gravity pipes.
- Pressure pipe upgrades, including pressurising part of Melbourne Water's Arden Street Main Drain.
- Site specific works for Arden Central, including a new pump station, gravity pipes, pressure pipes and swales to convey overland flows.

The performance of the working drainage strategy has been analysed based on flood modelling. Based on the flood modelling, the following benefits are achieved by the working drainage strategy:

- The working drainage strategy is generally effective at reducing flood depths across the Arden Macaulay Precinct. The potentially developable areas of the precinct that is subject to flood depths exceeding 0.5 metres is reduced from 33.6 hectares to 10.3 hectares.
- Moonee Ponds Creek's levees are no longer predicted to be overtopped, reducing 1% AEP inflow from Moonee Ponds Creek into the potentially developable areas of the precinct. However, flow spills from the creek at the Racecourse Road bridge and Macaulay Road bridges due to the higher flood levels in Moonee Ponds Creek caused by the raised levees.
- Peak flood depths in the 5% and 1% AEP event are reduced at the low-lying areas of Stubbs Street, Bent Street and Langford Street.
- The working drainage strategy reduces the required minimum habitable floor levels. This is achieved by:
  - The reduced 1% AEP flood levels achieved by the working drainage strategy in the pump failure scenario.
  - The proposed flood storages utilising some of the most flood prone land in the low-lying areas of the precinct. If the land that is proposed to be used for flood storage was instead intended for development, it would require high habitable floor levels.

The raised 1% AEP flood level in Moonee Ponds Creek due the raised levees results in 1% AEP flow breaking out from Moonee Ponds Creek at the Racecourse Road bridge (upstream of the levees) and at the Macaulay Road bridge (at a break between the levees). This impacts flooding within the Arden Macaulay Precinct. The raised 1% AEP flood level in Moonee Ponds Creek due to the raised also makes the bridge crossings of Moonee Ponds Creek more susceptible to being overtopped. Consideration could be given to measures to reduce the flood level in Moonee Ponds Creek.

8 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

ENGENY
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Appendix A:
Flood Maps – Existing Drainage System for Existing Climate Conditions

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Racecourse Rd
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Bent St
Langford St
Boundary Rd
Canning St
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe
- Levee
- Pump Station

Flood Depth:

- Depth 0 to 0.3 metres
- Depth 0.3 to 0.6 metres
- Depth 0.6 to 0.9 metres
- Depth 0.9 to 1.2 metres
- Depth 1.2 to 1.5 metres
- Depth > 1.5 metres

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ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Existing Drainage System (Pumps Working)
5% AEP Flood Depth Map
Existing Climate Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

N
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Racecourse Rd
Parsons St
Alfred St
Elliott Av
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Bent St
Langford St
Boundary Rd
Canning St
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe
- Levee
- Pump Station

Flood Depth:

- Depth 0 to 0.3 metres
- Depth 0.3 to 0.6 metres
- Depth 0.6 to 0.9 metres
- Depth 0.9 to 1.2 metres
- Depth 1.2 to 1.5 metres
- Depth > 1.5 metres

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E: melb@engeny.com.au

ENGENY WATER MANAGEMENT

Melbourne Water

0 130 260

Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

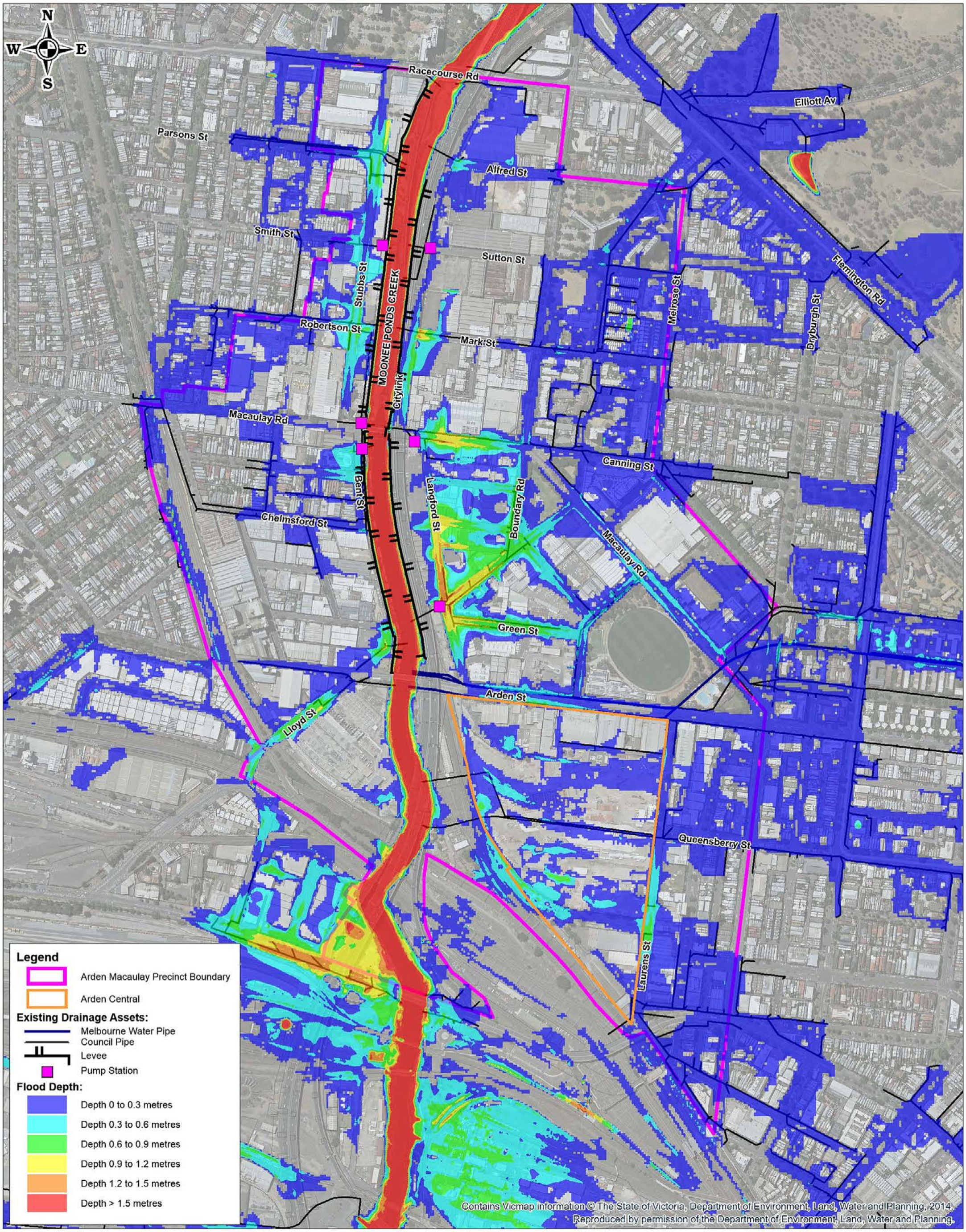
Arden Macaulay Precinct

Existing Drainage System (Pumps Working)
1% AEP Flood Depth Map
Existing Climate Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

ENGENY WATER MANAGEMENT

Appendix B:
Flood Maps – Existing Drainage System for Year 2100 Climate Conditions



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ENGENY WATER MANAGEMENT

Melbourne Water

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Map Projection: Universal Transverse Mercator
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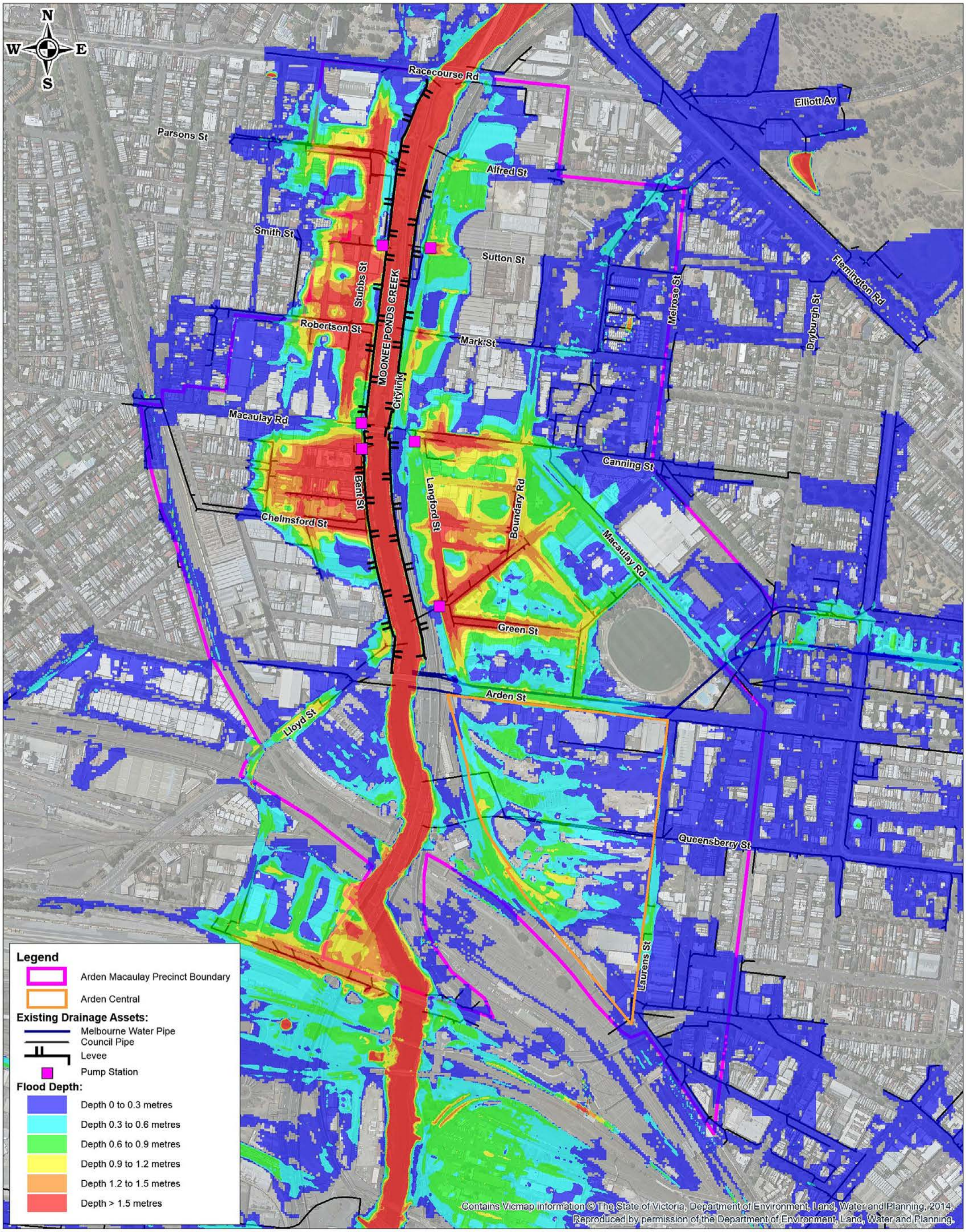
Arden Macaulay Precinct

Existing Drainage System (Pumps Working)
5% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021



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ENGENY WATER MANAGEMENT

Melbourne Water

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Vertical Datum: Australia Height Datum
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Arden Macaulay Precinct

Existing Drainage System (Pumps Working)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

N
W
E
S

Racecourse Rd
Parsons St
Elliott Av
Alfred St
Smith St
Sutton St
Stubbs St
MOONEE PONDS CREEK
Melrose St
Dryburgh St
Flemington Rd
Robertson St
Mark St
Citylink
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe
- Levee
- Pump Station

Flood Depth:

- Depth 0 to 0.3 metres
- Depth 0.3 to 0.6 metres
- Depth 0.6 to 0.9 metres
- Depth 0.9 to 1.2 metres
- Depth 1.2 to 1.5 metres
- Depth > 1.5 metres

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Scale in metres (1:6,500 @ A3)

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Arden Macaulay Precinct

Existing Drainage System (Pump Failure)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021

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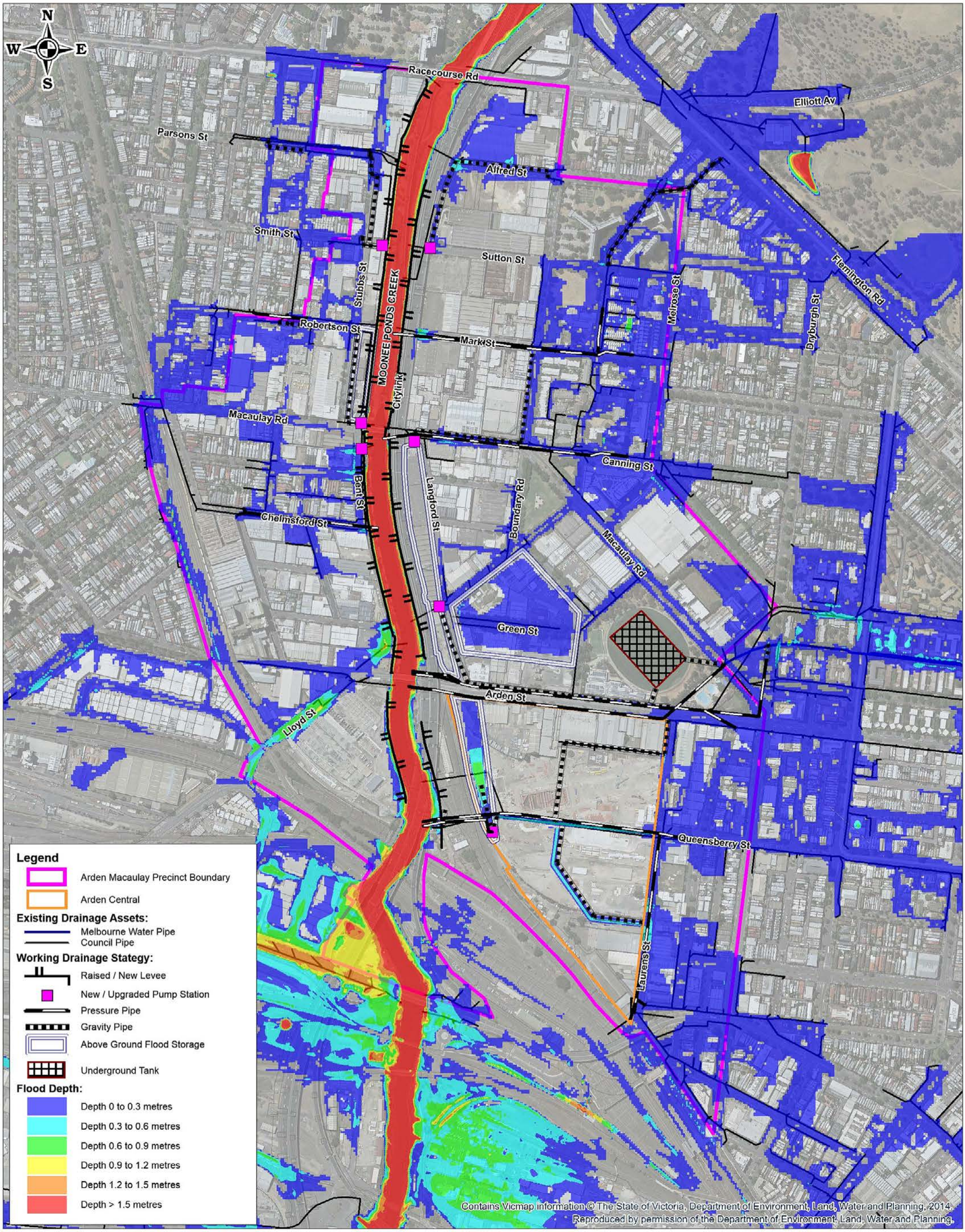
WATER MANAGEMENT

Appendix C:
Flood Maps – Working Drainage Strategy for Year 2100 Climate Conditions



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ENGENY WATER MANAGEMENT

Melbourne Water

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Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
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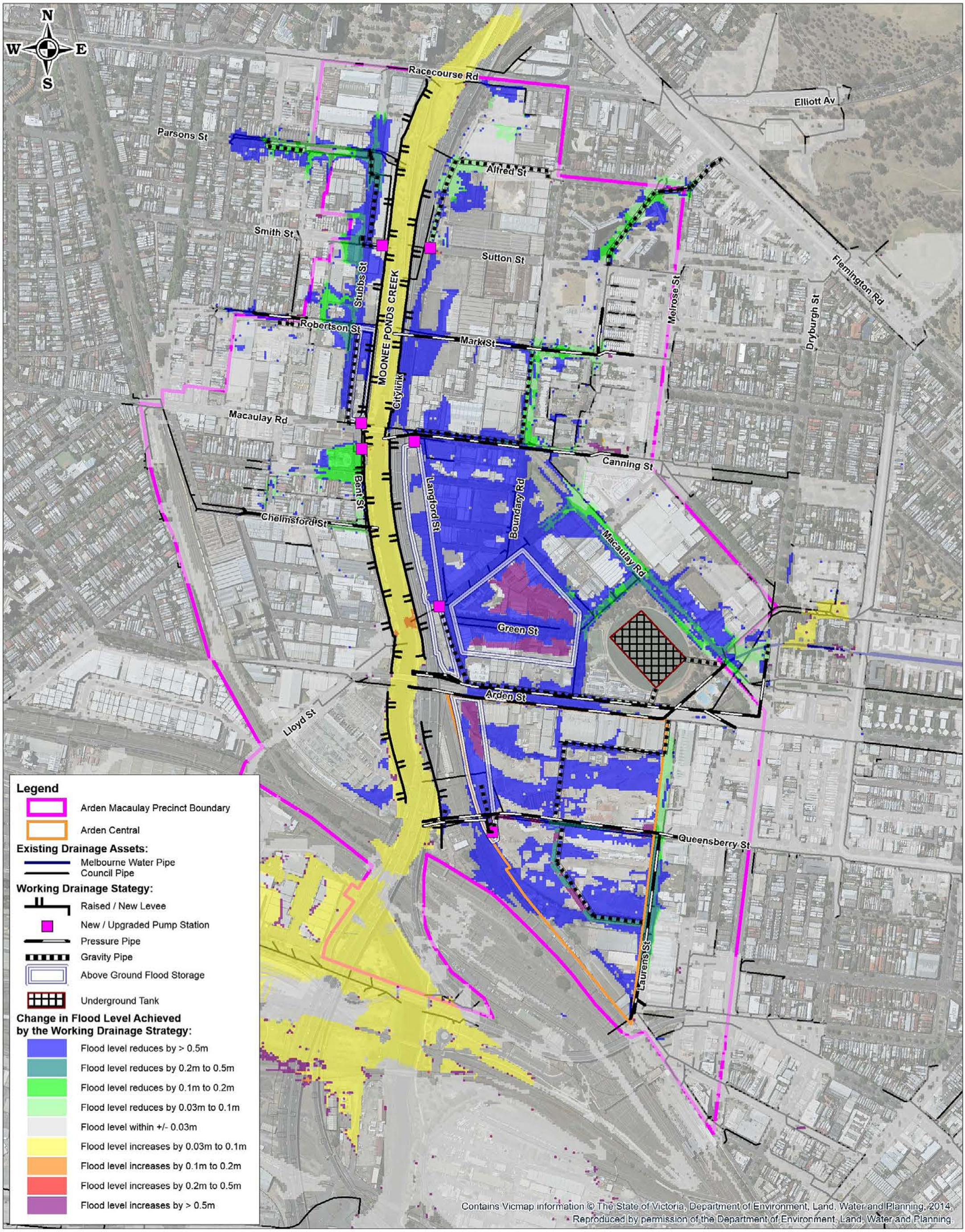
Arden Macaulay Precinct

Working Drainage Strategy (Pumps Working)
5% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021



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Melbourne Water

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Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
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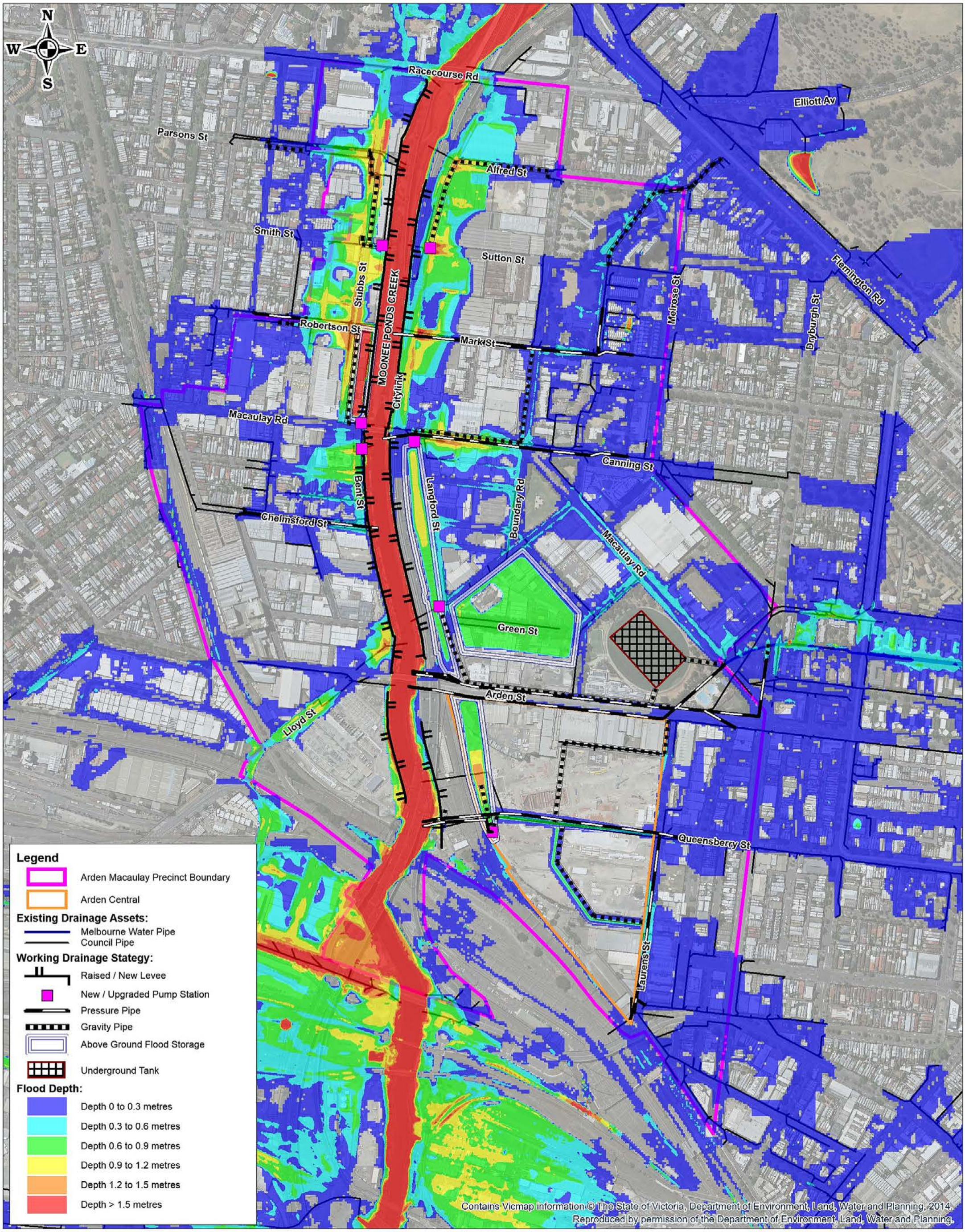
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Afflux - Change in 5% AEP Flood Level Working Drainage Strategy (Pumps Working) compared to Existing Drainage System (Pumps Working) Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021



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ENGENY WATER MANAGEMENT

Melbourne Water

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Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
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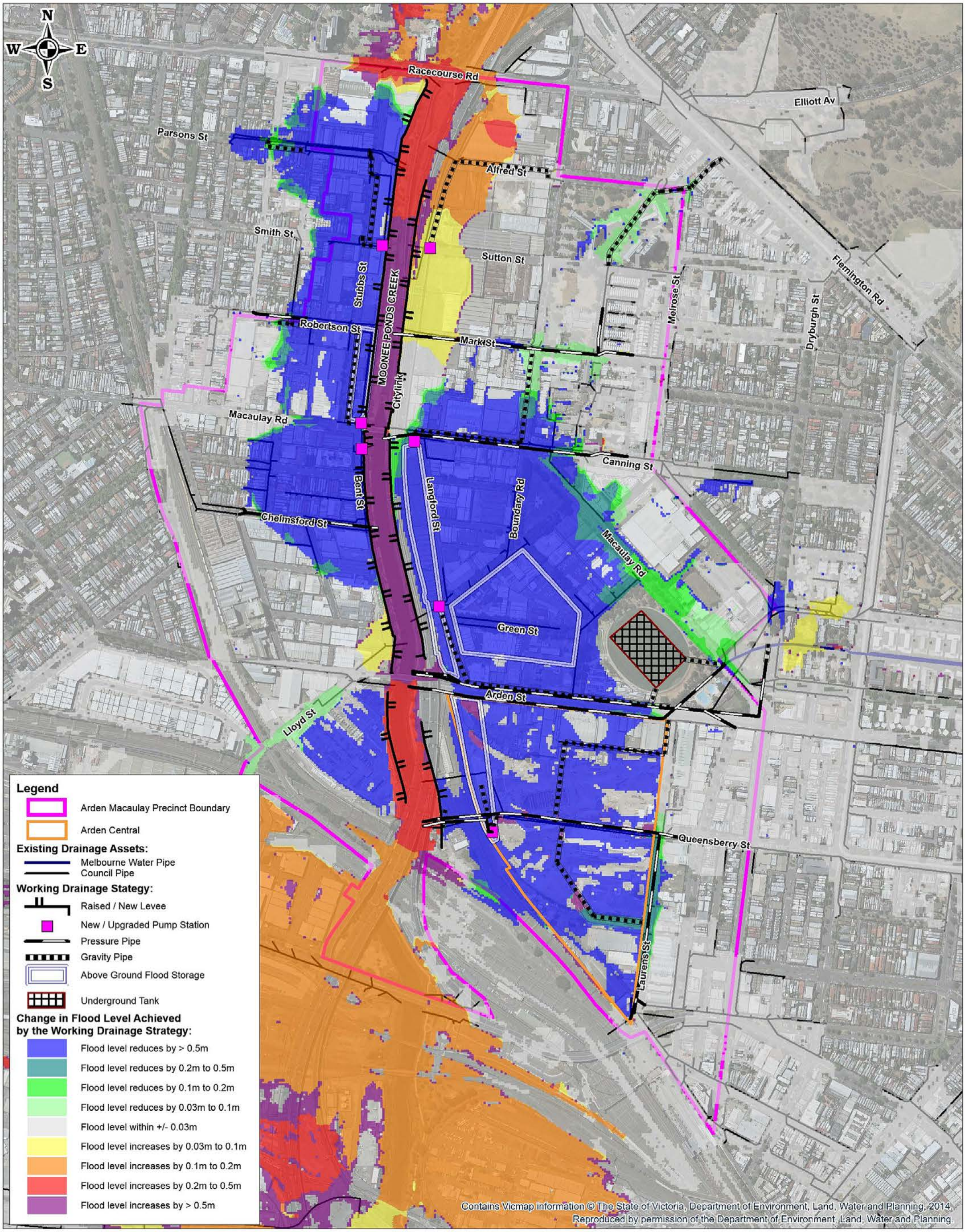
Arden Macaulay Precinct

Working Drainage Strategy (Pumps Working)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021



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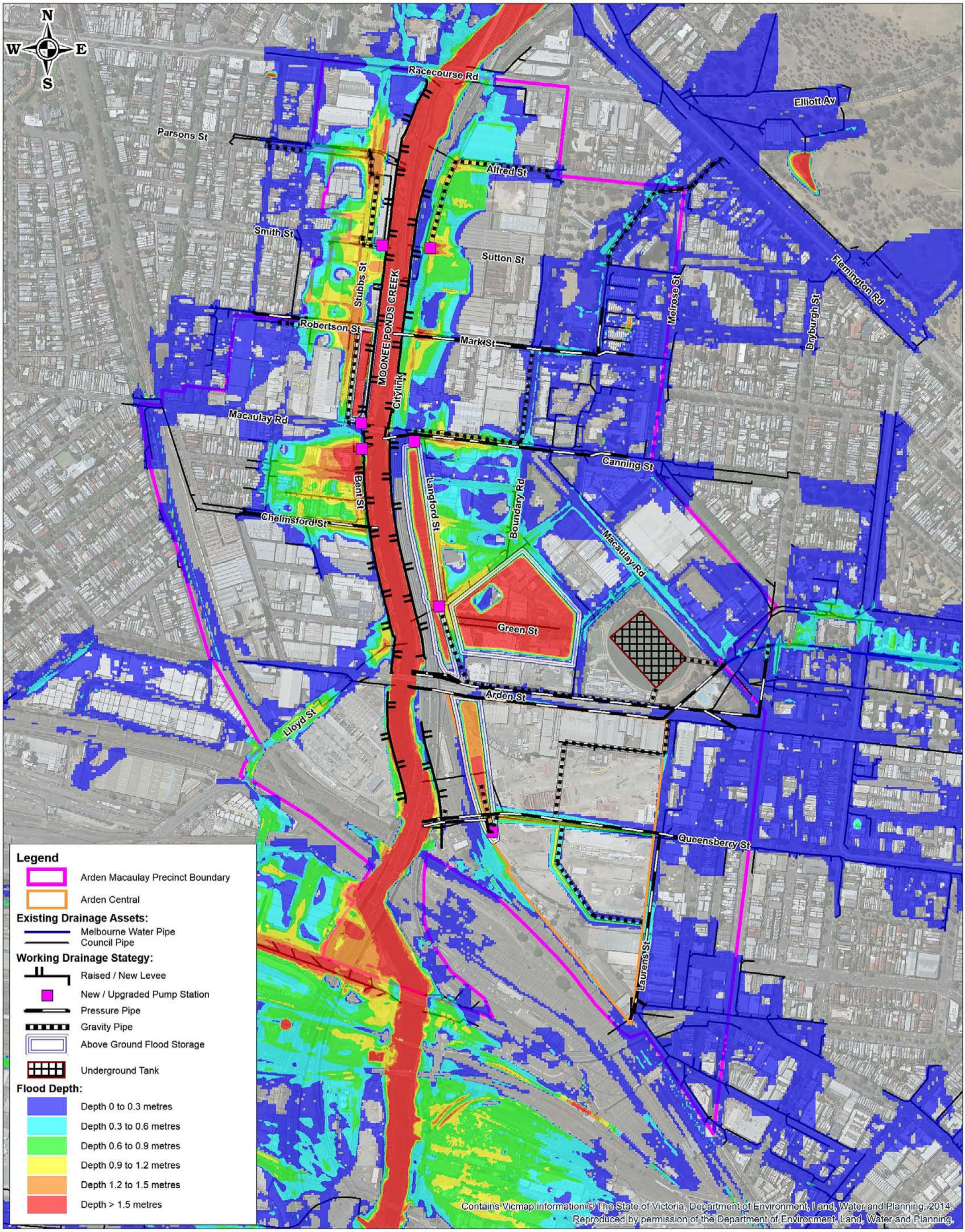
Scale in metres (1:6,500 @ A3)

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Afflux - Change in 1% AEP Flood Level
Working Drainage Strategy (Pumps Working)
compared to Existing Drainage
System (Pumps Working)
Year 2100 Climate Change Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 24 August 2021



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Arden Macaulay Precinct

Working Drainage Strategy (Pump Failure)
1% AEP Flood Depth Map
Year 2100 Climate Change Conditions

Job Number: V3000_052
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N
W E
S

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Alfred St
Smith St
Stubbs St
MOONEE PONDS CREEK
Citylink
Sutton St
Flemington Rd
Melrose St
Dryburgh St
Robertson St
Mark St
Macaulay Rd
Canning St
Bent St
Langford St
Boundary Rd
Chelmsford St
Macaulay Rd
Green St
Arden St
Lloyd St
Queensberry St
Laurens St

Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Stategy:

- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

Change in Flood Level Achieved by the Working Drainage Strategy:

- Flood level reduces by > 0.5m
- Flood level reduces by 0.2m to 0.5m
- Flood level reduces by 0.1m to 0.2m
- Flood level reduces by 0.03m to 0.1m
- Flood level within +/- 0.03m
- Flood level increases by 0.03m to 0.1m
- Flood level increases by 0.1m to 0.2m
- Flood level increases by 0.2m to 0.5m
- Flood level increases by > 0.5m

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Arden Macaulay Precinct

Afflux - Change in 1% AEP Flood Level
Working Drainage Strategy (Pump Failure)
compared to Existing Drainage
System (Pump Failure)
Year 2100 Climate Change Conditions

Job Number: V3000_052
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