



Planning Panels Victoria

Expert Witness Statement requested by Harwood Andrews

Arden Structure Plan

24/1/2022

V3000_145-REP-001-0

Job no. and Project Name: V3000_145 Arden Planning Panel
Doc Path File: \\online.com\files\ManagementMelbourne\Projects\V3000_Melbourne Water\V3000_145 Arden Planning Panel\07 Deliv\2. Report\V3000_145-REP-001-1-Arden_ExpertReport_Drainage.docx

Date	Description	Author	Reviewer	Project Mgr.	Approver
24/01/2022	Client Issue	Paul Clemson	Glenn Ottrey	Paul Clemson	Paul Clemson
Signatures					
					

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1 INTRODUCTION

This expert witness statement has been commissioned by Harwood Andrews on behalf of Melbourne Water. This report relates to drainage matters associated with the Arden Structure Plan area and its proposed implementation via the draft amendment C407melb to the Melbourne Planning Scheme.

Engeny Water Management (Engeny), including myself, prepared the flood management strategy for the proposed amendment area. It is assumed the reader of this report is familiar with the “Arden Macaulay Precinct Flood Management Strategy” prepared by Engeny Water Management and dated 26 August 2021.

1.1 AUTHOR / REVIEWER

1.1.1 Name and Address

Paul Clemson

Tenancy 5, Level 34, 360 Elizabeth Street

Melbourne, Victoria, 3000

1.1.2 Qualifications

Paul Clemson has the following qualifications:

Education

Bachelor of Civil Engineering (First Class Honours), Monash University, 2007

1.1.3 Experience and Expertise of the Author

I am a principal engineer, associate and Discipline Leader – Stormwater & Flooding at the Melbourne branch of Engeny. I have over fifteen years of experience in the water resources industry working as a consultant. My area of technical expertise is in the fields of flood modelling, catchment master planning, drainage design, and water sensitive urban design. I have presented at conferences on topics relating to flood modelling and catchment planning.

Since 2016, I have led Engeny’s work on flood modelling and drainage planning for the Arden and Macaulay Precincts. I was the author of Engeny’s Arden Macaulay Precinct Flood Management Strategy (August 2021) and have also been the author of numerous previous reports prepared by Engeny relating to flooding and drainage in the Arden and Macaulay Precincts. I have been assisted in some of this work by other members of the Engeny team, including Andrew Prout (senior principal engineer), Glenn Ottrey (principal engineer) and Daniel Hatzihristodoulou (senior engineer). This report has been reviewed by Glenn Ottrey in accordance with Engeny’s Quality Assurance System, however, all of the opinions in this report are mine.

I have visited publicly accessible areas within the proposed amendment area and prepared this report.

Based on my previous work experience and qualifications I am able to provide an expert opinion on flooding and drainage matters. A copy of my CV is attached in Appendix A.

1.2 INSTRUCTIONS

I have been instructed to prepare an expert witness statement to provide my expert opinion in relation to the following:

- Provide a concise overview of the work you undertook in preparing the Arden drainage strategy, including a summary of the key considerations and guiding principles that informed the preparation of the strategy.
- Review and respond to the submissions that fall within your expertise and relate to drainage issues.

1.3 SUMMARY OF MY OPINION

Some areas within the Arden and Macaulay Precincts have a recognised history of flooding, including Langford Street in North Melbourne on the eastern side of Moonee Ponds Creek, within the Arden Structure Plan area.

Engeny's and my drainage investigations relating to the Arden and Macaulay Precincts commenced at the beginning of 2016. Since 2016, Engeny has undertaken a series of drainage and flooding investigations relating to the Arden and Macaulay Precincts. These previous drainage investigations were part of the work that informed the preparation of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021).

The key tasks undertaken in the preparation of the Arden Macaulay Precinct Flood Management Strategy (August 2021) were:

- Site visits to understand catchment features.
- Collation and review of relevant information.
- Flood modelling to define and understand existing flood behaviour and flood risks related to Moonee Ponds Creek and local catchment runoff.
- Extensive stakeholder engagement to communicate existing flood behaviour and discuss a range of potential drainage works to manage flooding.
- Flood modelling of potential drainage works to analyse the benefits provided by different options and understand residual flooding.
- Documentation of outcomes in a series of reports, including the Arden Macaulay Precinct Flood Management Strategy (August 2021).

The Arden Macaulay Precinct Flood Management Strategy (August 2021) responds to predicted flooding in a year 2100 climate change scenario, including increased rainfall intensity and sea level rise due to climate change.

Flood modelling of the existing drainage system in place for the year 2100 climate change scenario predicts that the severity of flooding is not compatible with development for large areas of the Arden Precinct. In the 1 % AEP event for the year 2100 scenario, the predicted flooding poses an unacceptable risk to the safety of the community and would lead to extensive property damage for significant areas of the Arden Precinct. The existing drainage system is inadequate and if the Arden Precinct is to develop into a high-use urban area, drainage works will need to be implemented to manage the risk of flooding.

Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) identifies a working drainage strategy, which 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 key considerations that informed the preparation of the working drainage strategy Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) are:

- Inclusion of drainage works that respond to and reduce the significant flood risk in the Arden Precinct that is predicted in the year 2100.
- Inclusion of drainage works that reduce the risk of flooding in the Arden Precinct from flows in Moonee Ponds Creek (i.e. the proposed raised levees) as well as works on the local drainage system to reduce the risk of flooding due to local catchment runoff.
- Inclusion of drainage works that integrate and work together to reduce flood risk. There is no single solution that has been identified that can effectively manage flooding. The identified drainage works in the working drainage strategy are interdependent and the overall performance of the working drainage strategy relies on all drainage works being implemented. If any proposed component of the working drainage strategy is removed or reduced in scale then the predicted flood management performance of the working drainage may not be realised.
- Inclusion of sufficient land to provide above ground flood storage. Extensive stakeholder engagement and flood modelling investigations were undertaken to analyse different flood storage footprint options. This has considered:
 - The flood management benefits provided by different flood storage footprints.
 - Utilising low-lying land that is already prone to flooding.

- The complexity of land acquisition, with consideration of the number of properties to be acquired. This was informed by stakeholders including the VPA and Melbourne Water.
 - The presence of a gas transmission main.
 - Potential land contamination and high ground water issues.
 - Retaining areas with identified heritage values (the Lost Dogs Home).
- Inclusion of flood storage (the above ground flood storages and the underground storage tank) in order to retain some floodplain storage in the Arden Precinct. The drainage works proposed within and around the Arden Structure Plan area, including the raised levees for Moonee Ponds Creek and pump station upgrades, help to reduce the severity of flooding within Arden. This reduces the total floodplain storage within Arden. The proposed flood storage in the working drainage strategy is part of the efforts to retain some floodplain storage within the precinct, which helps to offset the downstream flooding impacts due to the loss of floodplain storage within Arden. Despite the provision of flood storage, the overall reduction in floodplain storage within Arden results in increased flooding downstream of the Arden Precinct. This was discussed with Melbourne Water and I was informed that the preparation of the Arden Macaulay Precinct Flood Management Strategy (August 2021) could proceed, showing the increased flood impacts in some areas.
 - Inclusion of drainage works that are compatible with topography and catchment constraints.
 - Ensuring a level of reliability in the working drainage strategy. A drainage strategy that relied predominantly on pump station upgrades and underground storage tanks may perform well when the system works as intended, but these works are more prone to compromised operation due to power failures and system blockages. The inclusion of above ground flood storages and gravity pipe system upgrades improves the reliability of the working drainage strategy.

The overall impact of the working drainage strategy is to reduce floodplain storage in the Arden and Macaulay Precinct, which enables development within Arden. However, this reduced floodplain storage causes year 2100 1 % AEP event flood levels in some other areas to increase. The proposed flood storages in the working drainage strategy (the above ground flood storages and the underground storage tank) are part of the efforts to retain some floodplain storage within the precinct, which helps to offset the downstream flooding impacts due to the loss of floodplain storage within Arden. The working drainage strategy will enable Arden to develop while balancing afflux impacts.

Despite the implementation of the working drainage strategy, there are still residual flood risks within the Arden Structure Plan area and it is important to understand and plan for the residual flooding.

I am satisfied that the working drainage strategy is a solid foundation to support the Arden Structure Plan.

2 FACTS, MATTERS AND ASSUMPTIONS

2.1 LOCATION

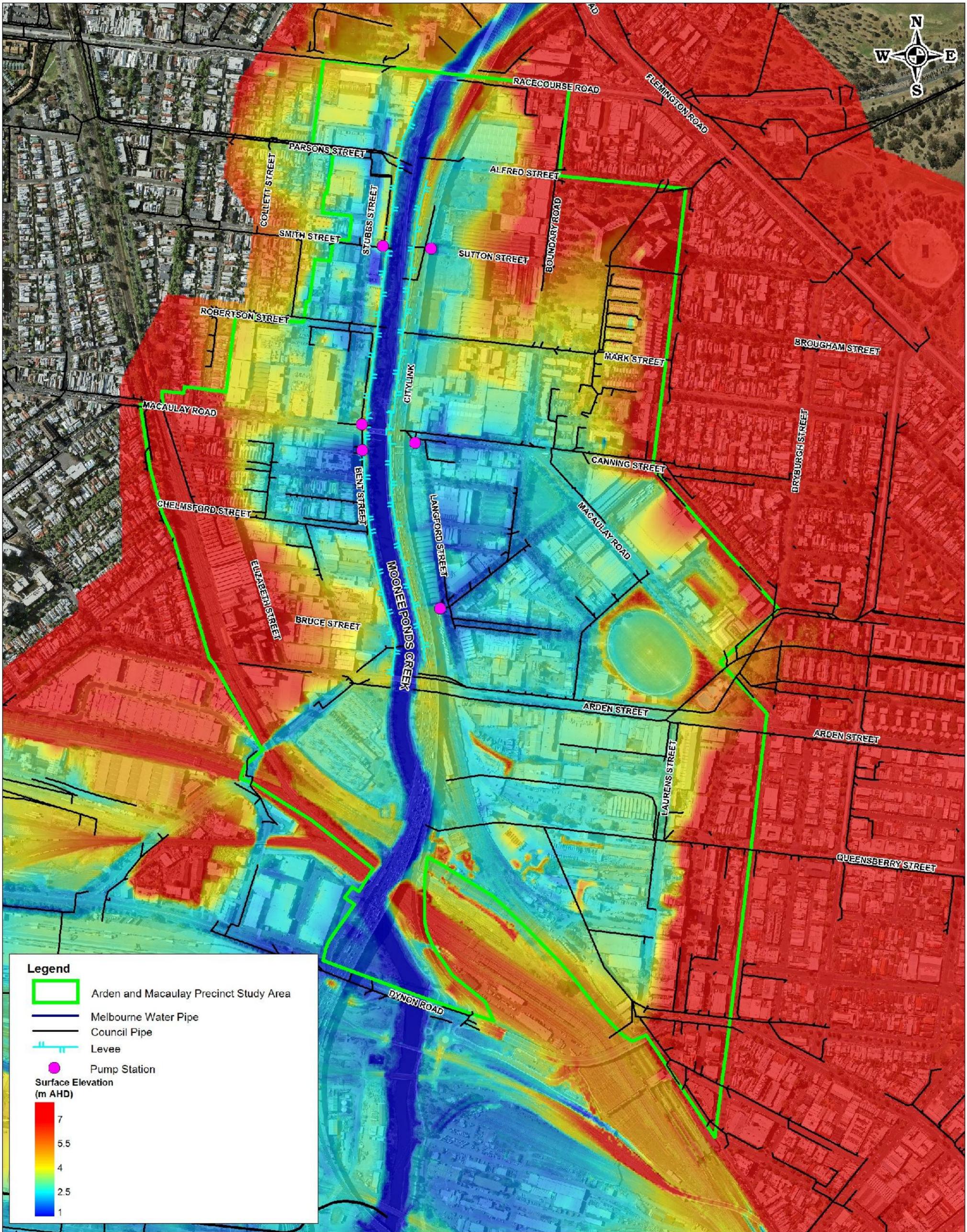
The Arden Structure Plan forms part of the Arden and Macaulay Precinct study area that has been the subject of Engeny's investigations. This area is north-west of and within close proximity to the Melbourne CBD. Moonee Ponds Creek is a highly modified waterway that runs north-west through the middle of the Arden and Macaulay Precincts.

Some areas within the Arden Macaulay Precinct have a recognised history of flooding, including Langford Street in North Melbourne on the eastern side of Moonee Ponds Creek, within the Arden Structure Plan area. Parts of the area of the Arden Structure Plan are very low-lying, with minimum surface levels at Langford Street of approximately 1.1 metres above sea level.

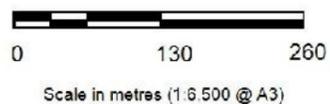
Flooding and drainage are well recognised as significant factors in development planning of the precinct.

Figure 2.1 shows the Arden and Macaulay Precinct study area. This plan also shows surface levels of the area (based on LiDAR, which is aerially captured topographical data) and the different components of the existing drainage system, including:

- Moonee Ponds Creek
- Melbourne Water drainage pipes (the Arden Street Main Drain)
- City of Melbourne drainage pipes
- City of Melbourne pump stations



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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

Study Area and Topography

Job Number: V3000_145
 Revision: 0
 Drawn: PC
 Checked: GO
 Date: 21 January 2022

2.2 SITE VISIT

I have visited areas within and surrounding the Arden Structure Plan on multiple occasions since 2016 as part of the preparation of the Arden Macaulay Precinct Flood Management Strategy (August 2021) and the background studies that informed the preparation of the flood management strategy.

Figure 2.2, Figure 2.3, Figure 2.4, Figure 2.5, Figure 2.6 and Figure 2.7 are a selection of photographs taken on the site visits.

Figure 2.2: Moonee Ponds Creek, looking north (upstream) from Arden Street (photo date 10 September 2016)



Figure 2.3: Arden Street bridge crossing of Moonee Ponds Creek, looking south (photo date 20 January 2016)



Figure 2.4: Rail bridge crossing of Moonee Ponds Creek south of Arden Street (photo date 20 January 2016)



Figure 2.5: Bent Street, looking south from Macaulay Road (photo date 20 January 2016)



Figure 2.6: Langford Street Pump Station 1, corner of Gracie Street and Langford Street (photo date 20 January 2016)



Figure 2.7: Laurens Street, looking north from corner of Miller Street south (photo date 11 May 2016)



3 PREPARATION OF THE ARDEN DRAINAGE STRATEGY

3.1 OVERVIEW

Engeny's and my drainage investigations relating to the Arden and Macaulay Precincts commenced at the beginning of 2016. Since 2016, Engeny has undertaken a series of drainage and flooding investigations relating to the Arden and Macaulay Precincts. These previous drainage investigations were part of the work that informed the preparation of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021). The previous drainage investigations are listed in Section 2 of the Arden Macaulay Precinct Flood Management Strategy (August 2021).

The key tasks undertaken in the preparation of the Arden Macaulay Precinct Flood Management Strategy (August 2021) were:

- Site visits to understand catchment features.
- Collation and review of relevant information.
- Flood modelling to define and understand existing flood behaviour and flood risks related to Moonee Ponds Creek and local catchment runoff.
- Extensive stakeholder engagement to communicate existing flood behaviour and discuss a range of potential drainage works to manage flooding.
- Flood modelling of potential drainage works to analyse the benefits provided by different options and understand residual flooding.
- Documentation of outcomes in a series of reports, including the Arden Macaulay Precinct Flood Management Strategy (August 2021).

3.2 ENGAGEMENT

Engeny's work has been delivered primarily through engagement by Melbourne Water. Some of Engeny's relevant previous studies were delivered through engagement by City of Melbourne.

Throughout the course of Engeny's investigations there has been extensive engagement and collaboration with Melbourne Water, City of Melbourne and the Victorian Planning Authority (VPA). Other stakeholders that Engeny has engaged with, to a lesser extent, include City West Water (now Greater Western Water), the Department of Environment, Land, Water and Planning (DELWP) and Development Victoria.

3.3 GUIDING PRINCIPALS

The key objective of Engeny's investigations was to identify a flood management strategy that would enable development of the Arden and Macaulay Precincts with appropriate flood protection standards. While Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) is focused on flood management outcomes, it does not preclude other potential objectives such as stormwater harvesting, landscaping and open space amenity.

Guiding principles that have informed the development of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) are:

- 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 design event for the Arden Macaulay Precinct Flood Management Strategy (August 2021) is the 1 % AEP event.
- The design event makes an allowance for the predicted impact of climate change by the year 2100. Adopting the year 2100 scenario as the design flood 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 year 2100 climate change allowance is:
 - An 18.5 % increase in rainfall intensity due to climate change. In Engeny's earlier drainage investigations, the rainfall intensity increase was 15.5 %. This was updated to 18.5 % to bring the Arden and Macaulay Precincts drainage planning

in line with the flood modelling assumptions made as part of planning scheme amendment C384 and guidance in Australian Rainfall and Runoff 2019 (which was not available at the time Engeny's studies commenced in 2016). The 18.5 % rainfall intensity increase is based on Representative Concentration Pathways (RCP) 8.5. The RCP8.5 scenario is the 'business as usual' climate change scenario wherein minimal curbing of emissions is undertaken. This scenario was adopted per Melbourne Water's Addendum 2 to the Flood Mapping Project Guidelines and Technical Specifications (September 2019).

- 0.8 metres sea level rise in Port Phillip Bay.
- 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 without compromising the safety of other properties. Engeny discussed with Melbourne Water how the conditions from these guidelines would be applied in the Arden and Macaulay Precincts, 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 predicted 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.

3.4 DO-NOTHING FLOOD RISK

The drainage system that currently services the Arden and Macaulay Precincts 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. Moonee Ponds Creek is a Melbourne Water managed asset.
- The local drainage system, which conveys runoff from the Arden and Macaulay Precincts and the smaller (compared to the Moonee Ponds Creek catchment) local catchments that drain through the precincts into Moonee Ponds Creek. The Arden Street Main Drain is the largest drainage asset in the local drainage system and is managed by Melbourne Water. Other elements of the local drainage system are managed by the City of Melbourne, including six pump stations which lift and discharge flow from low lying areas (such as within the Arden Structure Plan area) 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.

I have led Engeny's extensive flood modelling, which has been undertaken to define and understand flood behaviour relating to the Arden and Macaulay Precincts (including the influence of Moonee Ponds Creek) and to guide the development of the working drainage strategy. The flood modelling allows for representation of the existing drainage system (including Moonee Ponds Creek and the local drainage system) 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. These models were originally developed by AECOM. Melbourne Water provided the models to Engeny for the purpose of the Arden and Macaulay Precincts drainage investigations. Engeny made a series of updates to the flood modelling to improve their reliability and accuracy and so that the flood modelling represented the year 2100 climate change assumptions.

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).

Figure 3.1 provides a flood map showing the year 2100 1 % AEP flood depth, with the existing drainage system retained, as predicted by the flood modelling. This flood map defines the predicted 1 % AEP flooding by year 2100 (with allowance for the predicted impact of climate change) if no drainage works were implemented (the do-nothing scenario).

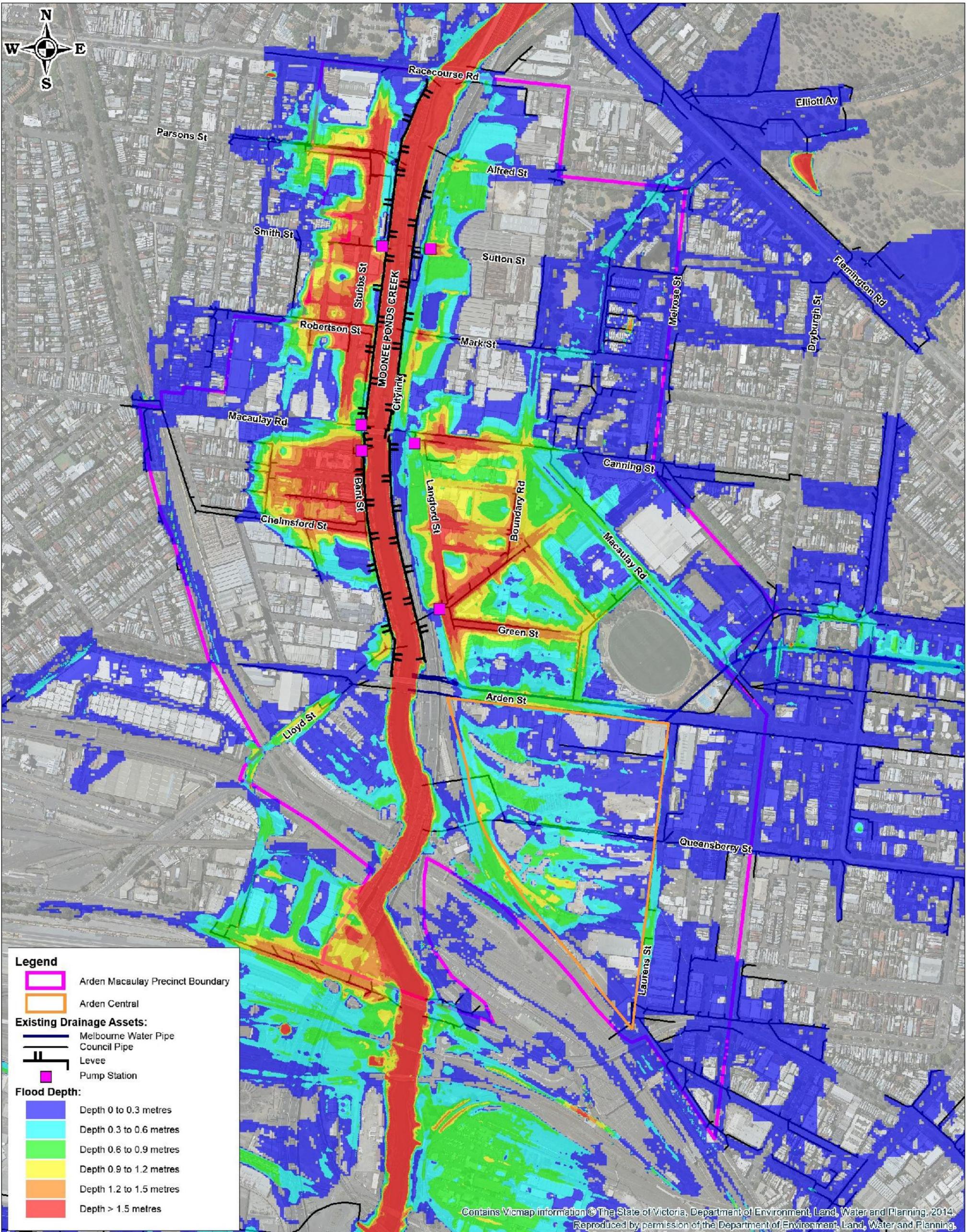
The flood modelling predicts significant flooding within the Arden and Macaulay Precincts in the year 2100 1 % AEP event. The model's year 2100 1 % AEP predicted peak flood depths at a selection of the low-lying roads are:

- At Langford Street (within the Arden Structure Plan area): 2.22 metres
- At Bent Street (western side of Moonee Ponds Creek): 2.59 metres
- At Stubbs Street (western side of Moonee Ponds Creek): 2.24 metres

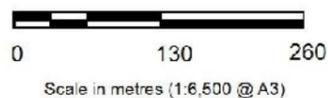
Flooding within the Arden and Macaulay Precincts in the year 2100 1 % AEP event (with allowance for the predicted impact of climate change) can be attributed to the following factors:

- 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
 - 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 flood level in the creek is higher than the flood level in the local catchment. While the existing flood mitigation measure of the creek's levees reduces the severity of riverine 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 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, with the existing drainage system in place, the severity of flooding predicted by the flood modelling is not compatible with development for large areas of the Arden Precinct. In the 1 % AEP event for the year 2100 scenario, the predicted flooding poses an unacceptable risk to the safety of the community and would lead to extensive property damage for significant areas of the Arden Precinct. The existing drainage system is inadequate and if the Arden Precinct is to develop into a high-use urban area, drainage works will need to be implemented to manage the risk of flooding.



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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 3.1
 Existing Drainage System (Pumps Working)
 1% AEP Flood Depth Map
 Year 2100 Climate Change Conditions

Job Number: V3000_145
 Revision: 0
 Drawn: PC
 Checked: GO
 Date: 20 January 2022



3.5 PROPOSED FLOOD MANAGEMENT STRATEGY

The working drainage strategy identified in Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) 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. I am satisfied that the working drainage strategy is a solid foundation to support the Arden Structure Plan.

The working drainage strategy includes the following key components:

- **Raised and extended levees for Moonee Ponds Creek.** 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 reduce the impact of riverine flooding on the Arden and Macaulay Precincts.
- **Above ground flood storages (retarding basins).** These assets would be designed to store flood water in large flood events (such as the 1 % AEP event) when the capacity of the drainage system is exceeded. The areas required for the above ground flood storages would not be developable (although may still provide an opportunity for recreational use).
- **An underground flood storage tank beneath the Arden Street Oval.** The underground tank would receive flow from a connection from Melbourne Water's Arden Street Drain when the flows are near the capacity of the drain and would discharge flow back into the drainage system at Arden Street.
- **Upgrades to the existing six pump stations.** These works would involve increasing the capacity of the pump stations within the Arden and Macaulay Precincts so that the pumps can convey a higher rate of flow from the local precinct areas into Moonee Ponds Creek.
- **Gravity pipe upgrades.** These works include new gravity pipes and upgrades of existing gravity pipes to increase the capacity of the pipe drainage system to convey flow to the pump stations.
- **Pressure pipe upgrades, including pressurising part of Melbourne Water's Arden Street Main Drain.** Pressure pipes are proposed to 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.
- **Site specific works for Arden Central.** These works within Arden Central include a new pump station, gravity pipes, pressure pipes, above ground flood storage and swales to convey overland flows.

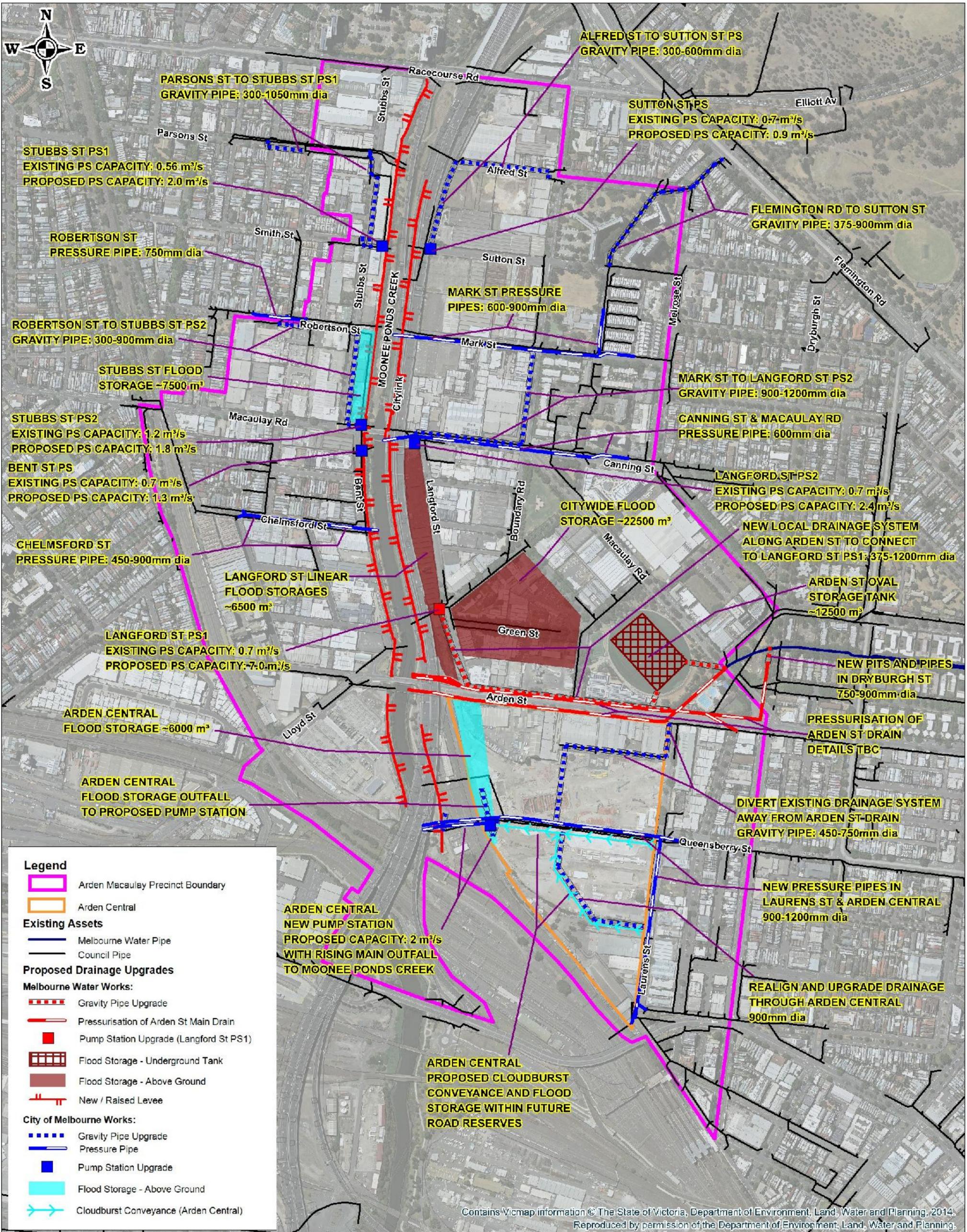
Figure 3.2 provides a layout plan showing the locations and key details of the working drainage strategy, including whether the drainage works will be owned and maintained by Melbourne Water or City of Melbourne.

The key considerations that informed the preparation of the working drainage strategy Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) are:

- Inclusion of drainage works that respond to and reduce the significant flood risk in the Arden Precinct that is predicted in the year 2100 climate change scenario.
- Inclusion of drainage works that reduce the risk of flooding in the Arden Precinct from flows in Moonee Ponds Creek (i.e. the raised levees) as well as works on the local drainage system to reduce the risk of flooding due to local catchment runoff.
- Inclusion of drainage works that integrate and work together to reduce flood risk. There is no single solution that has been identified that can effectively manage flooding. The identified drainage works in the working drainage strategy are interdependent and the overall performance of the working drainage strategy relies on all drainage works being implemented. If any proposed component of the working drainage strategy is removed or reduced in scale then the predicted flood management performance of the working drainage may not be realised.
- Inclusion of sufficient land to provide above ground flood storage. Extensive stakeholder engagement and flood modelling investigations were undertaken to analyse different flood storage footprint options. This has considered:
 - The flood management benefits provided by different flood storage footprints.
 - Utilising low-lying land that is already prone to flooding.
 - The complexity of land acquisition, with consideration of the number of properties to be acquired. This was informed by stakeholders including the VPA and Melbourne Water.
 - The presence of a gas transmission main.

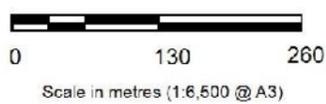
- Potential land contamination and high ground water issues.
- Retaining areas with identified heritage values (the Lost Dogs Home).
- Inclusion of flood storage (the above ground flood storages and the underground storage tank) in order to retain some floodplain storage in the Arden Precinct. The drainage works proposed within and around the Arden Structure Plan area, including the raised levees for Moonee Ponds Creek and pump station upgrades, help to reduce the severity of flooding within Arden. This reduces the total floodplain storage within Arden. The proposed flood storage in the working drainage strategy is part of the efforts to retain some floodplain storage within the precinct, which helps to offset the downstream flooding impacts due to the loss of floodplain storage within Arden. Despite the provision of flood storage, the overall reduction in floodplain storage within Arden results in increased flooding downstream of the Arden Precinct. This was discussed with Melbourne Water and I was informed that the preparation of the Arden Macaulay Precinct Flood Management Strategy (August 2021) could proceed, showing the increased flood impacts in some areas.
- Inclusion of drainage works that are compatible with topography and catchment constraints.
- Ensuring a level of reliability in the working drainage strategy. A drainage strategy that relied predominantly on pump station upgrades and underground storage tanks may perform well when the system works as intended, but these works are more prone to compromised operation due to power failures and system blockages. The inclusion of above ground flood storages and gravity pipe system upgrades improves the reliability 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 Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) provides discussion on options that were been considered, but not included in the working drainage strategy. The decision on the works included in the working drainage strategy was informed by discussions between Engeny, Melbourne Water, City of Melbourne and the VPA.



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Arden Macaulay Precinct

Figure 3.2 Working Drainage Strategy

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 Date: 20 January 2022



3.6 RESIDUAL FLOODING

The working drainage strategy has been represented in the flood modelling to understand the benefits achieved and residual flooding. Figure 3.3 provides a flood map showing the year 2100 1 % AEP flood depth, with the working drainage strategy in place, as predicted by the flood modelling.

While pump stations can provide an effective drainage function in low lying areas such as the Arden 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. To inform potential future habitable flood levels, the flood modelling has been simulated for a scenario where the working drainage strategy is implemented but all pump stations fail to operate.

Figure 3.4 provides a flood map showing the year 2100 1 % AEP flood depth, with the working drainage strategy in place but when the pumps fail to operate, as predicted by the flood modelling.

The flood modelling predicts that the working drainage strategy is effective at reducing flooding impacts in the Arden Precinct. Figure 3.5 shows the changes to predicted flooding (afflux) in the year 2100 1 % AEP event as a result of the working drainage strategy compared to the existing drainage system.

While the working drainage strategy provides an effective reduction in flooding in the Arden Precinct, the flood modelling predicts that the following areas are subject to increased peak flood levels in the year 2100 1 % AEP event due to the implementation of the working drainage strategy:

- Areas downstream of the Arden and Macaulay Precincts. The increased flooding downstream of the precinct is due to:
 - The raised levees, which increase the capacity of Moonee Ponds Creek, reducing the flow from Moonee Ponds Creek that spills into the Arden and Macaulay Precinct but increasing the flow that is conveyed to areas downstream of the Arden and Macaulay precincts, resulting in higher flood levels within and adjacent to Moonee Ponds Creek.
 - The increased capacity of the local drainage system within the Arden Macaulay Precinct, including the pump station upgrades, pressure pipe upgrades and gravity pipe upgrades. These upgrades increase the flow discharged from the local drainage system into Moonee Ponds Creek.
- Areas upstream of the Arden and Macaulay Precincts. The increased flooding upstream of the precinct (i.e. upstream of Racecourse Road) is due to the raised levees. The raised levees increase the flood level in Moonee Ponds Creek, which results in increased flow spilling from Moonee Ponds Creek upstream of Racecourse Road.
- Areas adjacent to the eastern side of Moonee Ponds Creek, between Racecourse Road and Macaulay Road. This increased flooding is the result of the raised levees, which increase the flood level in Moonee Ponds Creek. This results in increased flow spilling across Racecourse Road and flowing behind the eastern levee of Moonee Ponds Creek.
- A small area on Bruce Street, on the western side of Moonee Ponds Creek. This increased flooding is the result of the raised levees. This area of Bruce Street has a direct stormwater pipe connection to Moonee Ponds Creek and is not connected to a pump station. The raised levees increase the tail water level on the Bruce Street drainage system, reducing the capacity of the drainage system to discharge flow into Moonee Ponds Creek in the year 2100 1 % AEP event, with increased flooding at Bruce Street.
- A small area to the east of Dryburgh Street, on either side of Plane Tree Way. This small increase in flood level is due to the pressurisation of the Arden Street Drain, which increases the flood level in the drainage system, causing increased flood levels in this area.

The overall impact of the working drainage strategy is to reduce floodplain storage in the Arden and Macaulay Precinct, which enables development within Arden. However, this reduced floodplain storage causes year 2100 1 % AEP event flood levels in some other areas to increase. The proposed flood storages in the working drainage strategy (the above ground flood storages and the underground storage tank) are part of the efforts to retain some floodplain storage within the precinct, which helps to offset the downstream flooding impacts due to the loss of floodplain storage within Arden. The working drainage strategy will enable Arden to develop while balancing afflux impacts.

The afflux impacts are based on year 2100 climate conditions, including increased rainfall intensity and sea level rise. Flood modelling of the working drainage strategy has not been undertaken for existing climate conditions to show afflux impacts for

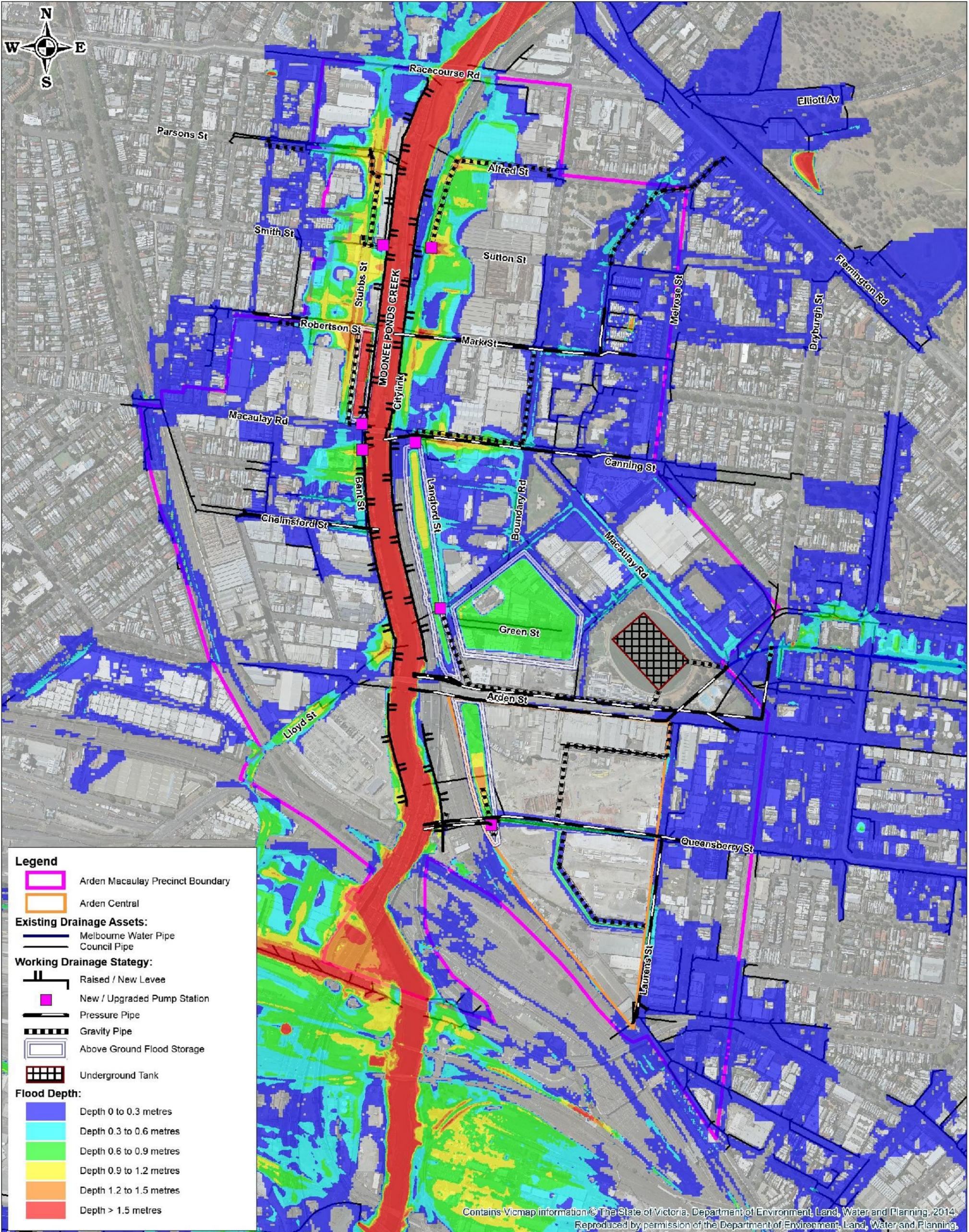
existing climate conditions. However, the flood modelling of the existing drainage system for existing climate conditions shows less floodplain storage in the Arden and Macaulay Precinct and therefore the reduction in floodplain storage because of the working drainage strategy may be less for existing climate conditions, which may reduce afflux impacts for existing climate conditions compared to year 2100 climate conditions.

The following investigations could be undertaken to address the predicted areas of increased flooding in year 2100 1 % AEP due to the working drainage strategy:

- Investigate the potential to reduce flows in Moonee Ponds Creek by constructing flood storage within the catchment. This flood storage could be located upstream of the Arden and Macaulay Precinct.
- Investigate the feasibility of hydraulic improvements to the Macaulay Road, Arden Street, and first rail bridge downstream of Arden Street. These works have been demonstrated (by flood modelling) to reduce the flood level in Moonee Ponds Creek, which reduces flooding upstream of Racecourse Road. However, these works are predicted to lead to further increases in flooding downstream of the Arden and Macaulay Precincts.
- Investigate potential works to increase the capacity of Moonee Ponds Creek downstream of the Arden and Macaulay Precincts. This could include measures such as creek widening or levee works.
- Investigate modifications to the Bruce Street drainage system, including connecting it to Bent Street pump station.
- Investigate refinements to the Arden Street Drain pressurisation works to address the increase flooding east of Dryburgh Street.

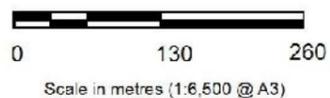
Despite the implementation of the working drainage strategy, there are still residual flood risks within the Arden Structure Plan area and it is important to understand and plan for the residual flooding. Setting appropriate habitable floor levels is a key strategy to manage residual flood risks.

Another measure to manage residual flooding in the Arden and Macaulay Precincts in the implementation of flood related planning scheme overlays, as proposed in Amendment C384 to the Melbourne Planning Scheme. This amendment would change the existing flood overlays through the implantation of a land subject to inundation overlay 3 (LSIO3), special building overlay 2 (SBO2) and special building overlay 3 (SBO3). Development of properties impacted by these overlays would be referred to City of Melbourne and / or Melbourne Water, to consider flood risk and resilience strategies as part of a planning permit application.



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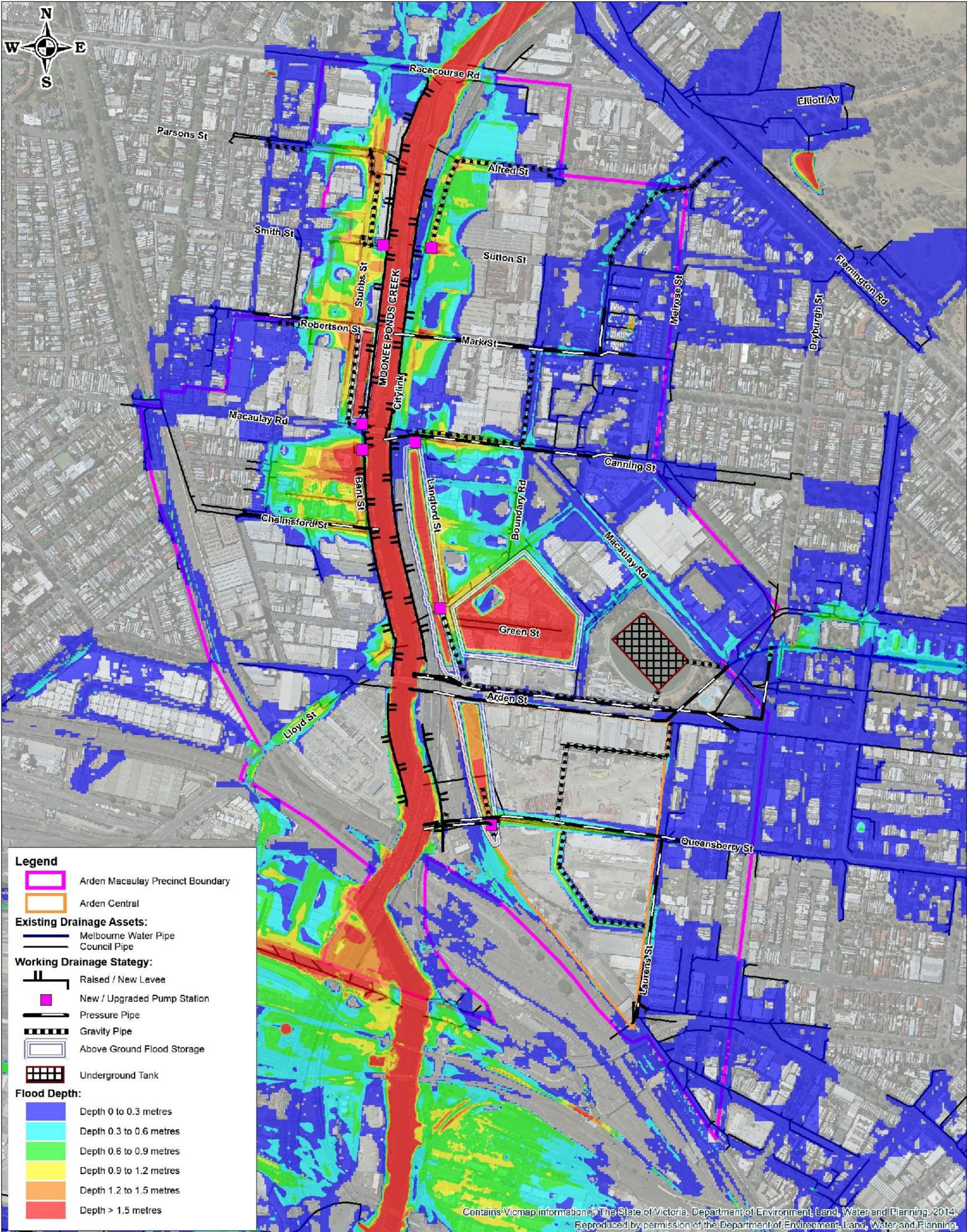
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Arden Macaulay Precinct

Figure 3.3
 Working Drainage Strategy (Pumps Working)
 1% AEP Flood Depth Map
 Year 2100 Climate Change Conditions

Job Number: V3000_145
 Revision: 0
 Drawn: PC
 Checked: GO
 Date: 20 January 2022





Legend

- Arden Macaulay Precinct Boundary
- Arden Central

Existing Drainage Assets:

- Melbourne Water Pipe
- Council Pipe

Working Drainage Strategy:

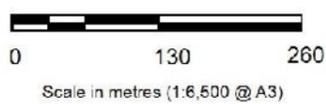
- Raised / New Levee
- New / Upgraded Pump Station
- Pressure Pipe
- Gravity Pipe
- Above Ground Flood Storage
- Underground Tank

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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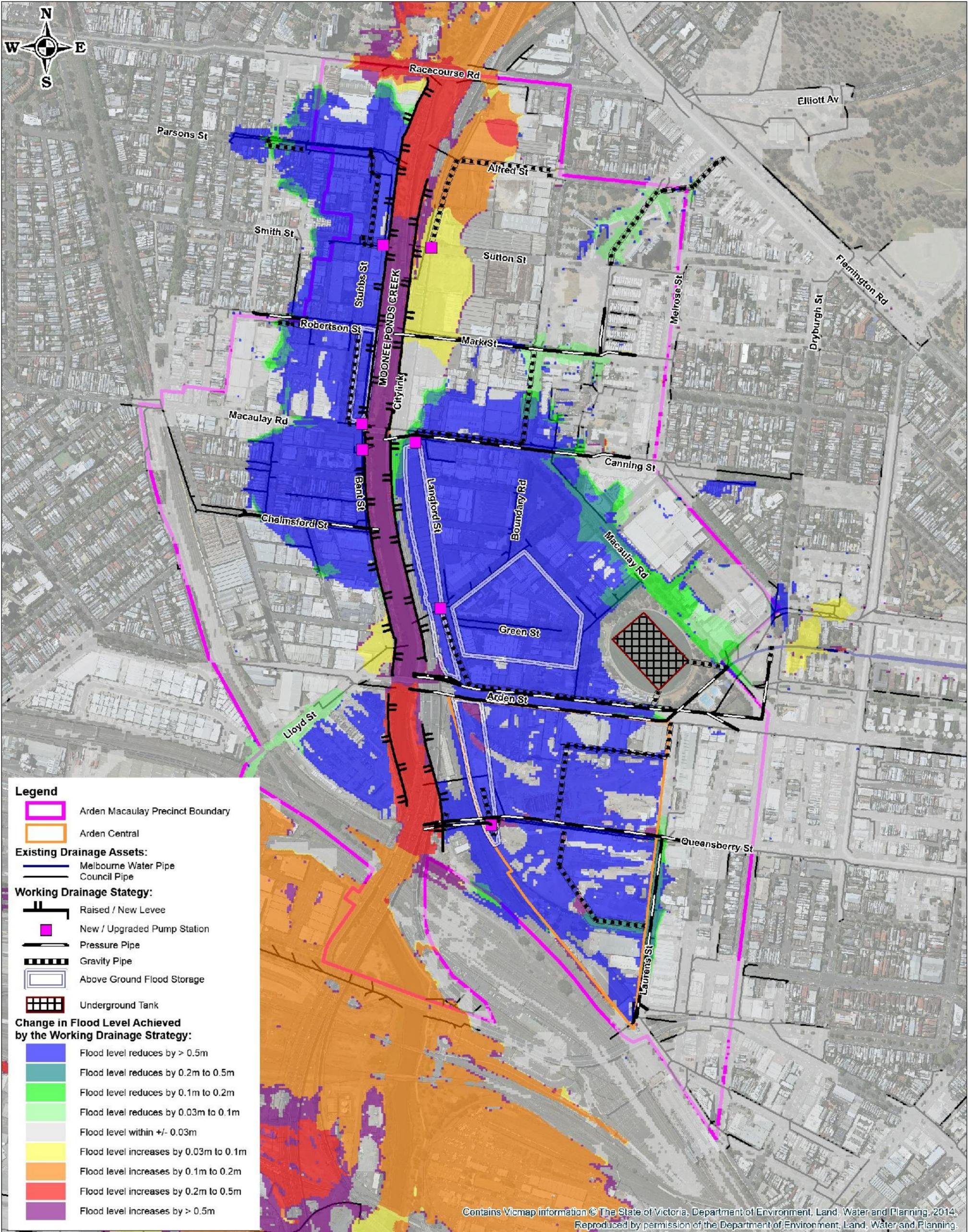
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Arden Macaulay Precinct

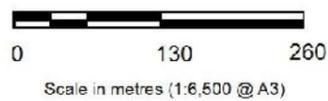
Figure 3.4
 Working Drainage Strategy (Pump Failure)
 1% AEP Flood Depth Map
 Year 2100 Climate Change Conditions

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Arden Macaulay Precinct

Figure 3.5
 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_145
 Revision: 0
 Drawn: PC
 Checked: GO
 Date: 21 January 2022



4 RESPONSES TO SUBMISSIONS

4.1 OVERVIEW

I have reviewed submissions made to the VPA following public consultation of the Arden Structure Plan in September and October 2021. The following sections provide my responses to submissions relevant to drainage and flooding that I believe require my response. Some submissions that relate to drainage are concerned with water quality or other drainage issues, which were not part of my work on the Arden Macaulay Precinct Flood Management Strategy (August 2021) and I have not responded to these submissions.

I have responded to the following submissions:

- Submission 38
- Submission 72
- Submission 78
- Submission 81
- Submission 82
- Submission 99
- Submission 100
- Submission 101
- Submission 103

4.2 SUBMISSION 38

Submission 38 raises the following point that is relevant to my area of expertise:

But, because this likely reduces the vegetation in Arden, this places an even greater premium on prompt naturalistic restoration of Moonee Ponds Creek and surrounds (ie early in the development process - not waiting 2, 5 or 10 years). One only needs to look at the Maribyrnong River, Merri Creek, Yarra, etc to see what an asset the waterways can be to people, and the amenity and environmental benefits are likely to be greater the sooner this is undertaken.

While I am supportive of efforts to naturalise waterways, any modification to Moonee Ponds Creek would need to ensure that the waterway's flood management and flow conveyance values are maintained or enhanced. Works associated with naturalisation of Moonee Ponds Creek is a separate process and not part of the flood management strategy.

4.3 SUBMISSION 72

Submission 72 raises the following points that are relevant to my area of expertise:

- *The documentation should be amended to indicate that overland flow paths are managed without impact to existing commercial vehicle access to the Bowens land.*
- *Any future flood mitigation infrastructure works should not reduce the ability for heavy vehicles of varying sizes to deliver goods to and from the subject land.*

The above comments relate to the Arden flood management plan on page 62 of the Arden Structure Plan and wording on page 64 of the Arden Structure Plan.

At this stage, the development of the flood management strategy is based on a conceptual level of design. In future stages of drainage design, I don't think it will be an issue and would expect that issues such as vehicle access and property access would be resolved.

4.4 SUBMISSION 78

Submission 78 raises the following point that is relevant to my area of expertise:

The FoMPC strongly opposes constructing culverts under levees and extending and increasing the heights of levees that would involve the destruction of existing, established vegetated embankments (Bent St/Kensington Embankment; see photograph below) or the recognised Remnant River Red Gums along the western Racecourse Rd to Macaulay Rd stretch and the eastern section below Arden St. We oppose the inclusion in the Arden Structure Plan of such destructive measures, and specifically in the Precinct Infrastructure plan for raising and extending levees (Appendix 2, item 74). We believe alternative flood management measures that do not destroy these established areas of vegetation should be sought.

The current form of the levees is typically an earthen embankment with either a masonry blockwork or precast concrete parapet wall on top of the earthen embankment. Engeny has been unable to obtain design plans for the levees and the depth of the concrete walls below the top of the earthen embankment is unknown. Therefore, I am uncertain whether the earthen embankments are for aesthetic purposes or are part of the structural design of the levee.

Typically, larger vegetation (such as trees) is undesirable on levees and embankments for structural integrity, surveillance and maintenance reasons. The presence of larger vegetation on levees has the potential to lead to failure of a levee.

At this stage, the flood management strategy identifies that the crest levels of the levees are to be raised to increase the capacity of Moonee Ponds Creek to convey flows. This is an essential component of the flood management strategy in order to improve protection of existing and future urban areas within Arden from flows in Moonee Ponds Creek. I expect that the design of the how the levee crest levels will be raised will be part of the future work. This future design work would consider the significance of the existing vegetation and identify whether it is possible and / or appropriate to retain the existing vegetation.

4.5 SUBMISSION 81

Submission 81 raises the following point that is relevant to my area of expertise:

Need to consider all sources of flooding from the Moonee Ponds Creek, in particular, those upstream. The precinct (particularly existing low-lying areas already subject to an LSIO overlay) needs to be able to protect itself from the creek's floodwaters during extreme events. For example, design to include landscaped levees.

The flood modelling that is the basis for the Arden Macaulay Precinct Flood Management Strategy (August 2021) considers stormwater inflows from the entire Moonee Ponds Creek catchment. The raised levees proposed in the Arden Macaulay Precinct Flood Management Strategy (August 2021) have been included to improve protection of existing and future urban areas within Arden from flows in Moonee Ponds Creek.

4.6 SUBMISSION 82

Submission 82 raises the following point that is relevant to my area of expertise:

It follows that any works to the existing Reserve to construct the requisite underground storage tanks should not occur until the new sporting field within the integrated stormwater management open space is delivered and available for use by the Club's football programs whilst these works are occurring.

The above comment relates to the staging of drainage works. Figure 4.8 of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) indicates the potential staging of works (subject to ongoing review), which was developed by Melbourne Water. The staging of works identifies that the integrated stormwater management open space is planned to be delivered prior to the underground storage tank, as is requested in submission 82.

4.7 SUBMISSION 99

Submission 99 raises the following point that is relevant to my area of expertise:

It is noted that the Amendment does not propose any modification to the flooding provisions that currently apply throughout the precinct, despite the degree to which the management of flooding and drainage has influenced the development of the Arden Structure Plan and the associated planning controls.

The Minister for Planning Authorised the preparation and exhibition of Amendment C384 on 18 August 2021. Whilst already authorised, it is understood that the Amendment will not be exhibited until later in 2021.

The City of Melbourne website advises that it has partnered with Melbourne Water to refresh flood modelling for a number of areas in our municipality. This new information on flood risk is the basis for our proposed Amendment C384 to the Melbourne Planning Scheme. It seeks to update the flood overlay maps and schedules to support new development being designed with flood resilience in mind.

The whole of the Citywide Land is currently affected by a Land Subject to Inundation Overlay (Schedule 1) and Amendment C384 proposes to introduce a replacement Schedule 3.

To confirm, the flood modelling that is the basis for the revision of the Land Subject to Inundation Overlay (LSIO), including climate change assumptions, is the same as the flood modelling that has been undertaken to inform the development of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021). The LSIO and other proposed flood overlays that impact the Arden Precinct are based on the do-nothing year 2100 climate change 1 % AEP event.

Submission 99 also raises the following points that are relevant to my area of expertise:

- *The proposed PAO land is not owned by the City of Melbourne (as set out in the final dot point above). It is owned by Citywide Service Solutions Pty Ltd. As to the composition of Citywide's corporate structure, this should not be a relevant consideration for the drainage outcomes.*
- *The extent of Citywide Land required for the acquisition is unreasonable and without sound hydrological basis. In simple terms, the size and location of the drainage works does not represent the most appropriate drainage outcome for the precinct. In addition, the proposed arrangements would be prejudicial to the operations of the Asphalt JV. The 2018 and 2019 studies prepared by Engeny contemplated a different flooding framework for the Citywide Land where the 'integrated stormwater open space' was contained to the Green Street land only (and extended further north across Gracie Street), which was then translated into the 2020 draft Arden Structure Plan. This arrangement has been substantially modified to now require acquisition of land to the south in Arden Street and limited justification has been provided for the basis of this change. This change is material to Citywide and the Asphalt JV.*

The first dot point above refers to wording in Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021), which states that the proposed Citywide flood storage footprint provides a balance between acquiring land currently owned by City of Melbourne and private land. Stating that part of the proposed Citywide flood storage footprint is land currently owned by City of Melbourne is a factual error of Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021).

I do not agree that the Citywide Land required for the acquisition is unreasonable and without sound hydrological basis. The Citywide Land and surrounds are predicted to be significantly flood prone in a 1 % AEP event. The drainage works proposed within and around the Arden Structure Plan area, including the raised levees for Moonee Ponds Creek and pump station upgrades, help to reduce the severity of flooding within Arden, including the Citywide site. This reduces the total floodplain storage within Arden. The Citywide Flood Storage is part of the efforts to retain some floodplain storage within the precinct, which helps to offset the downstream impacts due to loss of floodplain storage within Arden.

As discussed in Submission 99 and in Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021), a range of footprints have been investigated for the Citywide Flood Storage site. Some earlier footprints for the Citywide Flood Storage site, as referred to in Submission 99, were based on previous climate change assumptions in the flood modelling, which adopted a lower rainfall intensity increase (15.5 % as opposed to the currently adopted 18.5 %). The adoption of a higher rainfall intensity increase in the current Arden Macaulay Precinct Flood Management Strategy (August 2021) would have some influence on the performance of the Citywide Flood Storage.

The provision of flood storage in the Langford Street area is an essential component of the flood management strategy. The flood storage works together with other elements of the flood management strategy to reduce the impact of flooding in Arden and increase the development potential of the precinct.

4.8 SUBMISSION 100

Submission 100 raises the following point that is relevant to my area of expertise:

Our Client's Land has been nominated as 'new integrated stormwater management open space' in the August 2021 iteration of the Arden Structure Plan. Our Client submits that:

1. The Land is not required for drainage purposes, and the Amendment lacks strategic justification in terms of setting aside otherwise developable land for drainage purposes;

Submission 100 relates to a property which is within the proposed footprint of the Citywide Flood Storage. A number of footprints for the Citywide Flood Storage have been investigated, some of which did not include the land that is the subject of Submission 100. The proposed footprint for the Citywide Flood Storage is based on the flood management requirements in Arden and extensive engagement with Melbourne Water, the Victorian Planning Authority and City of Melbourne. While it may be possible to achieve a similar flood management outcome if the land referred to in Submission 100 was not part of Citywide Flood Storage, this would likely require acquisition of alternative land as a replacement so that flood management objectives are not compromised.

4.9 SUBMISSION 101

Submission 101 raises the following point that is relevant to my area of expertise:

Location of the proposed integrated waterway management open space on privately owned land in Arden North does not appear to be justified. A transparent explanation about why this infrastructure has not been planned to be delivered across primarily government owned land is justified given this alternative would ensure the delivery of the strategies under the objective, and avoid the very significant costs (and time delays) of compulsory acquisition of the numerous affected privately held properties.

This submission refers to the proposed flood storage footprints in Arden North. The proposed flood storage footprints adopted in Engeny's Arden Macaulay Precinct Flood Management Strategy (August 2021) make use of government owned land north of Arden Street (in Arden North), but the total area of government owned land north of Arden Street is not sufficient to provide the full flood storage requirements. Therefore, the flood storage footprints in Arden North use a combination of government owned land and privately owned land.

There is a large area of government owned land south of Arden Street, in Arden Central. Arden Central and Arden North are in separate drainage catchments (with some hydraulic connectivity in large flood events) and the most flood prone area is in Arden North. This makes Arden North the preferable location to provide the majority of flood storage from a flood management perspective and providing additional flood storage in Arden Central would do little to manage flooding in the flood prone area of Arden North.

4.10 SUBMISSION 103

Submission 103 raises the following point that is relevant to my area of expertise:

Our Clients' Land has been nominated as 'new integrated stormwater management open space' in the August 2021 iteration of the Arden Structure Plan. RSA submits that:

1. The Land is not required for drainage purposes, and the Amendment lacks strategic justification in terms of setting aside otherwise developable land for drainage purposes;

Submission 103 relates to a property which is within the proposed footprint of the Citywide Flood Storage. A number of footprints for the Citywide Flood Storage have been investigated, some of which did not include the land that is the subject of Submission 103. The proposed footprint for the Citywide Flood Storage is based on the flood management requirements in Arden and extensive engagement with Melbourne Water, the Victorian Planning Authority and City of Melbourne. While it may be possible

to achieve a similar flood management outcome if the land referred to in Submission 103 was not part of Citywide Flood Storage, this would likely require acquisition of alternative land as a replacement so that flood management objectives are not compromised.

5 STATEMENT

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.



Paul Clemson
BEnvCiv (Hons)

Appendix A: Curriculum Vitae

Paul Clemson

Principal Water Resources Engineer

BEng (Civil) (Hons)



SUMMARY

Paul is a principal water resources engineer with fifteen years of experience in the water industry. Paul has extensive experience on a diverse range of projects including stormwater drainage and quality studies, flood mapping, potable water supply network planning, recycled water design and sewer network planning and design.

As a principal engineer with Engeny, Paul is involved in a technical and project management role on studies delivered for Melbourne Water, local councils and development industry clients.

Paul has extensive experience in hydraulic modelling including stormwater (1D and 2D), water supply and sewer networks. Paul has expertise in the use of hydrologic and hydraulic modelling software packages including TUFLOW, HEC-RAS, RORB, DRAINS, MUSIC, InfoWorks CS, H2Omap and GIS packages MapInfo, QGIS and GeoMedia.

KEY AREAS OF EXPERTISE

- Hydrological / hydraulic modelling and flood mapping
- Stormwater planning and design
- Water sensitive urban design
- Integrated water management
- Spatial data analysis (GIS)

EDUCATION

2006 Bachelor of Engineering (Civil) (Hons), Monash University, Melbourne

EXPERIENCE

2010 - present
Principal Water Resources Engineer
Engeny, Melbourne

Plumpton Road Wetland and Frog Pond Functional Design, Melbourne Water:

Paul project managed and undertook technical work for the functional design of a wetland and a Growling Grass Frog (GGF) pond system as part of the Plumpton Road Development Services Scheme (DSS). The functional design has been used as a demonstration of how an integrated design between a stormwater quality asset and a habitat asset can achieve multiple benefits within a GGF corridor. The design work has been undertaken in consultation with both Melbourne Water and DEWLP and has helped to satisfy the requirements of both stakeholders. The wetland design

was developed in accordance with the DRAFT Design, Construction and Establishment of Constructed Wetlands: Design Manual (MWC 2014) and informed by WSUD Engineering Procedures: Stormwater (Melbourne Water, 2005). The Growling Grass Frog ponds have been designed in accordance with DELWP requirements and Melbourne Water's draft guidelines. An options analysis was undertaken to determine the optimum arrangement for the frog ponds, including an analysis of the benefits of including a single large pond or two medium sized ponds.

**Arden Macaulay
Precinct, Melbourne
Water, City of
Melbourne, Victorian
Planning Authority,
City West Water:**

Paul was the project manager and undertook key technical work in the preparation of the flooding and drainage strategy and integrated water management strategy for the Arden Macaulay Precinct. The Arden Macaulay Precinct is one of the largest urban renewal projects in Australia. The objectives of Engeny's work was to work with stakeholders to:

- Allow intensive development of the Arden Macaulay Precinct to occur
- Achieve appropriate flood protection standards for the precinct
- Assess the reliability and benefits of an alternative water supply
- Seize the potential to improve the amenity and public use of Moonee Ponds Creek.
- Engeny's study included the following tasks to meet these objectives:
- Development of an understanding of the existing conditions and year 2100 (including climate change) scenario flooding within the precinct through updated two dimensional (TUFLOW) hydraulic modelling
- Communicating the existing conditions and year 2100 scenario flooding outputs with key stakeholders, including preparation of video simulations and easy to understand flood maps
- Identification of a range of potential flood mitigation works in collaboration with key stakeholders
- Assessment of an alternative water supply, through investigation of rainwater harvesting, stormwater harvesting and creek flow extraction, including water balance modelling and hydraulic modelling to determine the benefits that harvesting stormwater has on flooding within the precinct
- Undertaking detailed investigations (including hydraulic modelling) for a selection of the flood mitigation works and refining the works in order to achieve required flooding standards
- Provision of advice on infrastructure required for the flood mitigation and alternative water supply works

- Clear and concise reporting, including flood maps.

Development Services Scheme Engineering Reviews, Melbourne Water:

Paul has led Engeny's work with Melbourne Water to review an extensive range of development services schemes. The reviews involve analysing and amending drainage, waterway and water quality treatment works identified to provide the most effective and environmentally sound stormwater management for areas of increased development planned through the Melbourne 2030 Strategy. The emphasis of the scheme reviews is to ensure that works recommended are practical and take into account local constraints and opportunities. The outputs of the scheme reviews include layout plans, costing of each component and the scheme and reporting. Engeny's responsibilities have also included working with relevant stakeholders, including local councils and other asset owners.

Troups Road North Wetland and Retarding Basin Functional Design, Melbourne Water:

Paul project managed and undertook technical works for functional design of the Troups Road North Wetland and Retarding Basin system as part of the Leakes Road Development Services Scheme (DSS). Paul's work ensured that the assets fit within the allocated land-take for the stormwater assets in the PSP, ensured that the assets are designed and will function in accordance with their intent in the DSS and ensured that the appropriate level of service with respect to flood protection, conveyance and water quality will be provided. Engeny developed a two dimensional hydraulic model (TUFLOW) to analyse the complex hydraulics of the site, which include waterway crossings of a railway and major freeway. The functional design has provided works that are suitable for the complex hydraulics, satisfy environmental requirements including protection of existing vegetation and meet best practice water quality objectives.

Ryans Creek Rehabilitation Detailed Design, City of Melton:

Paul project managed and technical work in the detailed design of rehabilitation works for Ryans Creek in Melton. Ryans Creek consists of a winding grassed floodway with a concrete lined channel in the invert and stormwater drains flowing into the creek from both sides via concrete lined channels. The key aspect of the design was the removal of the existing concrete channel, which will be replaced with a natural vegetated pilot channel, as well as improvement of outlets to the creek and the construction of a rock chute within a steep section of the waterway. Paul undertook modelling (CHUTE, HECRAS and MUSIC) and design work to ensure that the project objectives for various stakeholders were met. Paul's efforts in corresponding with City of Melton and Melbourne Water throughout the project, as well as strong skills in design, resulted in Melbourne Water's response on the first issue of design drawings having no comments on the civil works. The design works were completed within a tight time frame (less than 10 weeks from approval to proceed) in

order to assist City of Melton with scheduling the constructions works within the low rainfall period.

**Randwick Avenue
Bioretention Design,
Urban Design
Management:**

Paul project managed and undertook the design of a bioretention system as part of Stage 1 of the Randwick Avenue development in Bacchus Marsh. Engeny's design was in accordance with WSUD Engineering Procedures (CSIRO/Melbourne Water, 2005), Constructed Wetlands Guidelines (Melbourne Water, 2010) and Infrastructure Design Manual Version 4.2 (November 2013). Engeny's tasks included water quality modelling (MUSIC), design calculations of bioretention system key parameters and plans to indicate how the proposed asset will fit within the creek corridor.

**EJ Whitten Bridge
Water Sensitive Road
Design, VicRoads:**

Responsibilities included the project management of a study analysing the current bridge drainage and the impacts of the proposed widening of the bridge on drainage and water quality. The project involved hydraulic calculations of pit and pipe capacities to determine whether overland flows on the bridge are acceptable and development of water sensitive road design options to treat runoff from the expanded bridge deck.

**Sunbury Growth Area
Development Services
Scheme, Melbourne
Water:**

Paul project managed and undertook key technical works for the preparation of developer services schemes (DSS) as part of extensive growth planned in Sunbury. This project required a range of skills and capabilities, including knowledge of Melbourne Water's DSS principles, understanding of Melbourne Water's DSS costing spreadsheet, hydrologic modelling, stormwater quality modelling, stakeholder consultation, catchment planning and knowledge of the impact of development on sensitive downstream waterways. A unique aspect of the Sunbury DSS was the innovative works included to protect steep tributaries that are highly sensitive to erosion.

**Flood Mapping
Projects (various),
Mornington Peninsula
Shire Council:**

Paul was the project engineer for the development of RORB hydrological and TUFLOW hydraulic models across a number of small to large catchments for the Shire including McCrae, Mount Martha, Gregory Street Drain and Tootgarook catchments. The outputs from these studies have included flood maps showing flood extents for all of the Shire's assets and development of flood mitigation strategies to reduce flood risks in the catchments.

**Cranbourne Town
Centre Flood
Mapping, City of
Casey:**

Paul project managed and provided key technical input for flood modelling of three catchments covering the Cranbourne Town Centre. Engeny undertook a detailed review of available information, conducted hydrological modelling of each catchment and flood mapped the study area for ARIs ranging from 5 years to 500 years. Flood mapping was produced for existing conditions and a projected future development scenario, assuming lots of a certain size would

subdivide as has been the case over the last 10 years. Engeny used the outputs from the flood mapping to identify key flooding hotspots in the study area to assist the City of Casey with capital works prioritisation.

Lower Werribee Drains Flood Mapping, Melbourne Water:

Paul project managed and provided key technical input in the Lower Werribee Drains catchments flood mapping study. The scope of Engeny's study included a thorough review of available data, development of validated hydrological models for each catchment (RORB), development of a hydraulic model (TUFLOW) including existing underground drainage and production of flood extents and other GIS deliverables for a range of flood extents and a climate change scenario.

Yarragon Flood Modelling and Drainage Strategy, Baw Baw Shire Council:

Paul project managed and undertook the majority of technical work for this study, which involved a comprehensive analysis of the Yarragon drainage system based on a range of information, including the results of a 2D hydraulic model produced as part of the project. Paul facilitated two community consultations with residents from Yarragon and other key stakeholders, while a comprehensive collation and review of drainage data formed vital inputs to study. A series of structural and non-structural measures were identified to improve the management and performance of the Yarragon drainage system. The hydraulic model was used to assess the feasibility of future development in Yarragon and to identify works to control the impact of future development on the township.

Brandon Park Reserve Retarding Basin Design Review, City of Monash:

The study involved the development of a hydrological (RORB) and two-dimensional hydraulic model (TUFLOW) model build for a catchment before and after the construction of a retarding basin and determining flood extents for design and recorded rainfall events. This allowed Council to gain an understanding of the change in hydraulic performance of the drainage network and flood extents due to the construction of a retarding basin. Additional work involved identification and modelling design refinements to improve the performance of the system.

Mallia Drive Dam Break Analysis, Esler & Associates:

The study involved development of a TUFLOW model including a proposed retarding basin, with the model set up to simulate the dynamic failure of a dam wall in storm events up to the probable maximum flood. Key outputs included flood maps and video animations showing differences in flood extents and depths due to the failure of the dam wall compared to the existing scenario

<p>City of Monash Flood Management Plan, Melbourne Water & City of Monash:</p>	<p>Paul undertook project management responsibilities for this project which involved organising and facilitating workshops with Council, Melbourne Water and other key stakeholders to identify gaps and issues with regards to flood management within the City of Monash. With a detailed knowledge of the municipality, an action plan was devised to address the deficiencies and document a Flood Management Plan to be adopted for the following five years.</p>
<p>Hazeldean Road Retarding Basin Detailed Design, Baw Baw Shire Council:</p>	<p>Paul project managed and undertook technical works as part of the detailed design for a retarding basin and open channel drainage system adjacent to Hazeldean Road, Yarragon. The design followed previous work undertaken by Engeny at Yarragon that identified the magnitude of an existing flooding problem for a residential development located adjacent to Hazeldean Road. The design objectives for this project were to mitigate the existing flooding problem and to allow future development in the area by intercepting and retarding overland flow. The design included a series of drop structures to reduce flow velocity within the open channel and a retarding basin outlet arrangement that reduced peak catchment flows whilst avoiding impact to a gas transmission pipeline located near the outlet.</p>
<p>Victory Road Drainage Design, City of Kingston:</p>	<p>Paul undertook the preliminary design of a new drainage pipeline on Victory Road in Clarinda. The purpose of the pipe is to cater for runoff from the proposed capped Victory Road Landfill and the pipe will receive flow from three detention ponds within the landfill. The pipe alignment was complicated by existing sewer assets and a connection into the Clayton Main Drain. Engeny investigated various options for consideration by council, undertook hydraulic modelling of the pipeline to account for high tail water levels in the main drain and developed preliminary design plans.</p>
<p>Deals Road Drainage Scheme, City of Kingston:</p>	<p>Paul project managed and delivered the majority of technical work for the development of the Deals Road Drainage Scheme. The scheme's catchment is dominated by a series of landfills in various stages of development and as the sites are filled and then capped, a drainage system will be required to accommodate the additional runoff this process creates. Paul undertook a detailed review of available data and previous studies, development of a hydrological model of the catchment (RORB), development of several scenarios in a hydraulic model (TUFLOW) and the preparation of design plans and layout plans to clearly communicate the proposed drainage scheme and the key assumptions made in the preparation of the design. Hydraulic modelling included modification of the catchment terrain to replicate future clay capping of landfills, proposed retarding basins and the future Dingley Bypass.</p>

**Dunes Drain
Floodway Design,
WBCM:**

Paul was the project manager and project engineer for a design of the Dunes Drain. The drain was designed as a 100 year ARI floodway, and satisfied Melbourne Water requirements including freeboard, safety requirements in terms of maximum velocities and flow depths, maintenance access and environmental considerations. The design included three rock chutes in order to slow down flow along the steep floodway. Melbourne Water provided approval of Engeny's design.

**Merri Creek Bike Trail
Hydraulic
Assessment, City of
Moreland:**

This project analysed changes to flooding of Merri Creek due to the proposed elevation of the shared bicycle / pedestrian path to improve cyclist and pedestrian safety. Responsibilities included modification of existing HEC-RAS model to take into account the potential blockage from the proposed bike path, field inspections, collation of results and documentation to be provided to Melbourne Water on behalf of Council to seek approval for the works.

**Colac-Ballararat Road
Drainage Impact
Assessment,
VicRoads:**

The study involved an assessment of drainage performance in a rural area before and after a proposed development. A RORB model and TUFLOW model were developed to provide flood maps showing changes to flood extents and provide VicRoads with advice to help base their approval or rejection of the development.

**Copelands Road
Drainage Strategy,
Baw Baw Shire
Council:**

The study investigated the requirements for stormwater works for proposed residential development in the Copelands Road catchment, east of Warragul. Tasks conducted included hydrological (RORB) and MUSIC modelling to ensure that adequate flow retardation is provided by the development, as well as concept design of wetland and retarding basins. Responsibilities also included meetings with Council and developers.

**Capital Avenue
Overland Flow
Investigation, City of
Monash:**

This project looked at high level options to improve flooding at a known problem area for Council, where a Melbourne Water pipe track crosses Capital Avenue. Work involved reviewing plans provided by Melbourne Water, site visit with council to discuss options and a report to provide council with advice on how the drainage situation could be improved.

**Mosaic Stage 5
Wetland Safety Audit,
Meinhardt
Infrastructure and
Environment:**

Project involved review of design plans for proposed wetlands and sedimentation ponds to assess whether Melbourne Water Guidelines and Royal Lifesaving Guidelines are satisfied.

**Underbank Farm,
Kataland:**

The study involved a surface water investigation for a large development in Bacchus Marsh. Key tasks included 1-D hydraulic modelling to produce flood extents for internal and adjacent waterways, identification of WSUD measures to achieve Best Management water quality objectives and reporting of suitable quality and detail to submit to Council and regulatory authorities for approval.

**Highlands Estate
Raingarden Testing,
Stockland:**

The study including field testing of filter media hydraulic conductivity rates to determine whether rates are in the desired range as well as a general assessment of raingardens in order to provide recommendations on whether the raingarden was ready for handover to Council.

2006 - 2010

Engineer

MWH (now Stantec),
Melbourne

Employed in the Network Planning Group gaining experience on a wide variety of hydraulic modelling, planning and design projects for sewer, water supply and recycled water systems. While employed with MWH, Paul spent time on secondments at South East Water Limited (Victoria), Gladstone Regional Council (Queensland) and the Utility Services Alliance (capital works delivery alliance incorporating South East Water, Thiess Services, Siemens Limited and MWH).



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