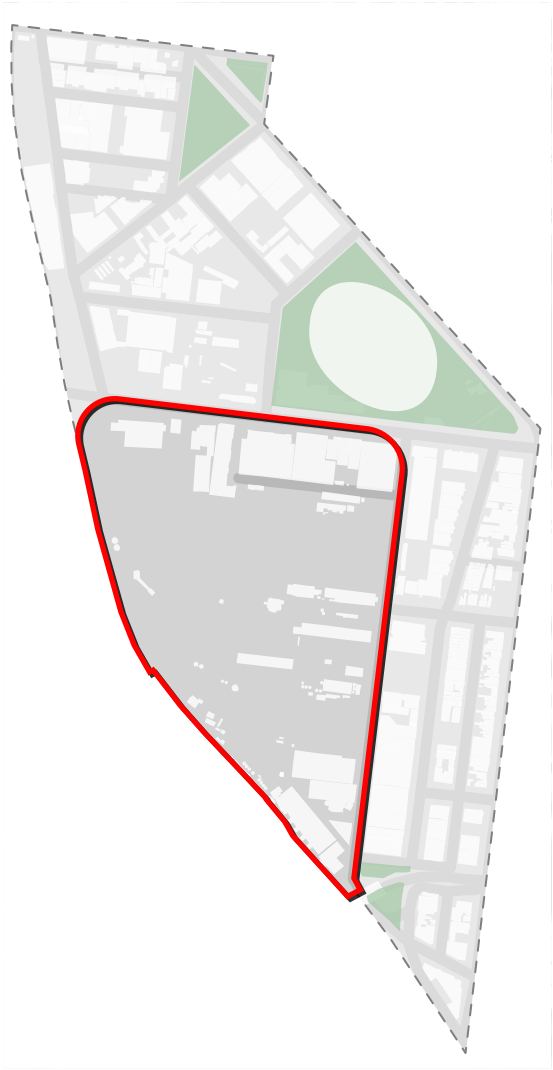
Arden Central

Arden Central currently has no open space, and little public realm, but has been identified as the location to focus employment with the greatest intensity of activity around the new underground North Melbourne railway station. It will be centred around a new civic heart in the form of a capital city open space that attracts visitors from across the state.

Arden Central is bound by Arden Street and Laurens Street. Laurens Street has strong architectural features and good quality avenues of trees. The area within the Moonee Ponds Creek is also subject to Aboriginal Cultural Sensitivity.

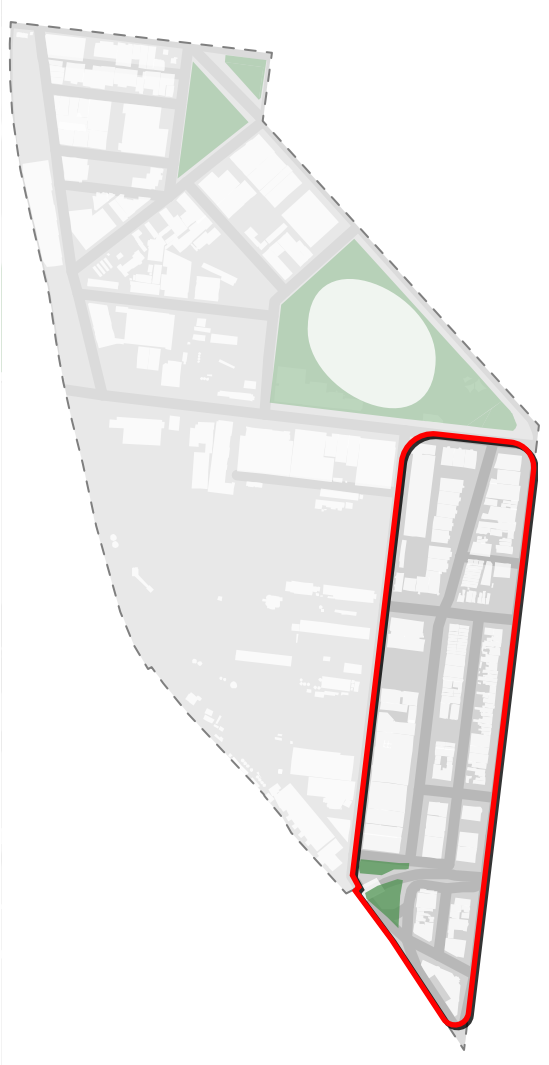


Arden Central - New North Melbourne Station Works

Laurens Street

Laurens Street sub-precinct with wide streets, some of which have been repurposed into public space, will marry the existing urban fabric, residential areas and industry with the intensification planned to occur in Arden Central. Laurens Street will transition existing activity and character into the new central sub-precinct, creating an active and vibrant precinct that celebrates its heritage buildings and wide streets.

Laurens Street and Queensberry Streets, together with the other streets in the sub-precinct contain original architecture, some of which has heritage value.



Queensberry Street

05

BENCHMARK REVIEW

The future vision for Arden as well as its existing characteristics informs the selection of precinct benchmarks that are instructive for informing the PROSS for the precinct. Whilst many idealised or preferred urban examples may exist all over the world, only a limited number can truly be useful in identifying the most appropriate and viable public realm and open space outcomes for Arden.

To be constructive benchmark precincts need to exemplify:

- Job-rich, mixed-use environments – providing highly productive urban environments rather than being residentially-focused neighbourhoods, nor exclusively employment zones. Places such as precincts in Silicon Valley, whilst attractive for their innovative industry focus, do not integrate diverse uses and communities as part of the environment.

- Contemporary urban renewal/ redevelopments – enjoying the benefits, as well as dealing with the constraints imposed on, contemporary development, including higher standards of universal access, environmental performance, technological and infrastructure requirements. Whilst many historic places, such as the Marais District in Paris, are renowned for their open spaces and public realm, their contemporary realisation would be inhibited for many of the above factors.

- Similar cultural settings – bearing resemblance to the modern, open and diverse community that Melbourne and Australia are, and with the lifestyle expectations that come with both that heritage and aspiration for the future. Places that have evolved or been designed with substantially different economic, political or social expectations, such as Marina Bay in Singapore, would provide difficult to implement models for Arden.

- City centre, metropolitan locations – managing vast movements of people both to but also through or around them whilst growing a sense of 'local' community by integrating a mix of uses and activities for both visitors and residents. Places at the fringes of cities or in smaller regional centres, such as Seaside in Florida, provide for smaller and more stable communities and can depend on little change in the future.

- A high-density environment – accommodating significant institutions and numbers of residents and workers, while managing the environmental impacts as well as the ongoing effects of human activity within the public realm. Lower density places, such as Vastra Hamnen in Malmo, are less adoptable for Arden as their streets and spaces can rely on fewer shadows, cars, as well as recreational users.

For these reasons only a handful of places have been used to inform the PROSS for Arden, the majority of them being local to Melbourne to ensure the social and cultural gauge is suitably set for Arden's public realm and open spaces, as well as providing a suitable comparator of provision.

01 Melbourne

02 Southbank

03 Docklands

04 BatteryCityPark,NY

05 KingsCrossCentral, London

01 Melbourne

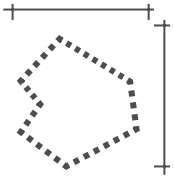
Melbourne's Hoddle Grid, whilst not a redevelopment or urban renewal 'precinct' has seen continuous and significant incremental change through the ongoing redevelopment of sites and substantial investment and change in the public realm by both Local and State Government. In many ways it exemplifies the type of job-rich, city-centre, mixed-use, high-density environment that Arden's vision seeks to achieve.

Characteristics of public realm and open space

- A pattern of squares, gardens or plazas at railway station entrances of various sizes and purposes, from Flagstaff Gardens to Southern Cross Station Plaza for movement, gathering and passive recreation
- Continuity of open spaces and pedestrian/ cycling pathways along waterways as alternative movement routes affording reflection, pause and connection to nature
- Main streets of generous width and provision of dedicated pedestrian and cycling space and continuity of substantial street-tree planting that provide shade and connect all open spaces
- A range of street types and sizes that provide (at times car-free) social and passive recreational spaces
- A range of building forecourts, foyers and interstitial spaces that provide smaller social spaces
- The significant cost of retrofitting open space provision as the city has evolved and intensified use.

Bourke Street Mall, Vic[4]

Quantities of public realm and open space

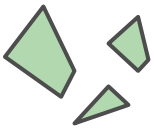


Total Area

259.97 hectares

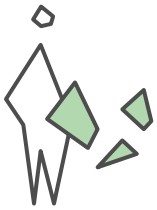
Total Population Resident /Worker (2011)

21,080 residents | 223,326 workers



Total Public Open Space

12.74 hectares (4.7% of precinct)



Total Public Open Space per Population (2011)

0.5m2 per capita

Total Public Realm (including streets)

94.87 hectares (39.7% of precinct)

Total Public Realm per Population (2011)

3.9m2 per capita

LEGEND

Arden

Melbourne

Open Space

0 100 200 500m

1:25000

N

02 Southbank

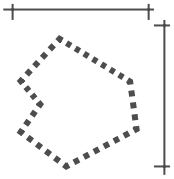
Southbank has increasingly become part of the Capital City with a mix of residential, commercial and cultural functions, which has only become so in the last 30 years. It represents one of Melbourne's first urban renewal precincts and its identity is tightly bound to its riverfront with a northern aspect. Southbank Promenade's significance and success has become part of Melbourne's global identity, however is not matched with more prolifically distributed and locally focused open spaces further from the waterfront that would provide for the local resident and worker population.

Characteristics of public realm and open space

- A significant destination with open spaces orientated to visitors and tourist leisure, much of which is maintained by private property interests
- A continuity of open space along the riverfront that provides for pedestrian and cycling movement and passive recreational activity
- The attraction of users has contributed to increasing pedestrian and cyclist conflicts as the precinct has evolved and developed
- Upfront investment into waterfront open space and public realm has catalysed significant development
- The significant cost of retrofitting open space provision when space is initially not secured
- A lack of soft landscape and open spaces orientated to local community need has driven negative perceptions and recent adaptation of road reservations to provide more landscape and pedestrian space

Southbank, Vic[5]

Quantities of public realm and open space

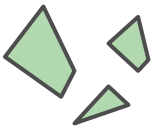


Total Area

157.62 hectares

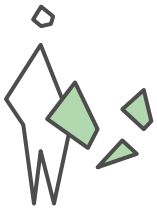
Total Population Resident /Worker (2011)

13,107 residents | 37,796 workers



Total Public Open Space

5.89 hectares (3.8% of precinct)



Total Public Open Space per Population (2011)

1.2m2 per capita

Total Public Realm (including streets)

66.45 hectares (44.7% of precinct)

Total Public Realm per Population (2011)

13.1m2 per capita

03 Docklands

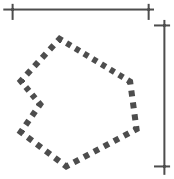
Docklands represents a more contemporary urban renewal neighbourhood in Melbourne with remaining parts still being developed after being initiated 20 years ago. It is a neighbourhood with significant commercial and residential functions, as well as accommodating one of Melbourne's key stadia. It's substantial waterfront and docks heritage has substantially contributed to its development form and character but has also resulted in distinct sub-precincts that are relatively difficult to access. Its substantial geological and contamination challenges have also contributed to ultimate built form scale and development costs, which have also informed its character.

Characteristics of public realm and open space

- A diverse range of open spaces and a public realm environment created 'from scratch' after the relocation of port activities
- A port-side and river-side location that significantly contributes to the layout, orientation, distribution and character of open spaces
- A mixed-use precinct with extremely distinctive patterns and intensity of use during the week, and during weekends.
- Ongoing development of the precinct, with some incomplete sub-precincts present over 20 years after its original project inception.
- Some key streets and elements of public realm substantially refurbished within ten years of completion to respond to climatic, social and transport mode conflicts that became apparent after opening.
- Innovative integration of stormwater management facilities into the public realm across the precinct with recreational and leisure use.

Docklands Park, Vic

Quantities of public realm and open space

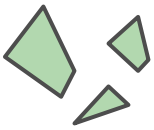


Total Area

310.51 hectares

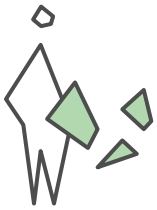
Total Population Resident /Worker (2011)

6,134 residents | 33,503 workers



Total Public Open Space

12.11 hectares (3.9% of precinct)



Total Public Open Space per Population (2011)

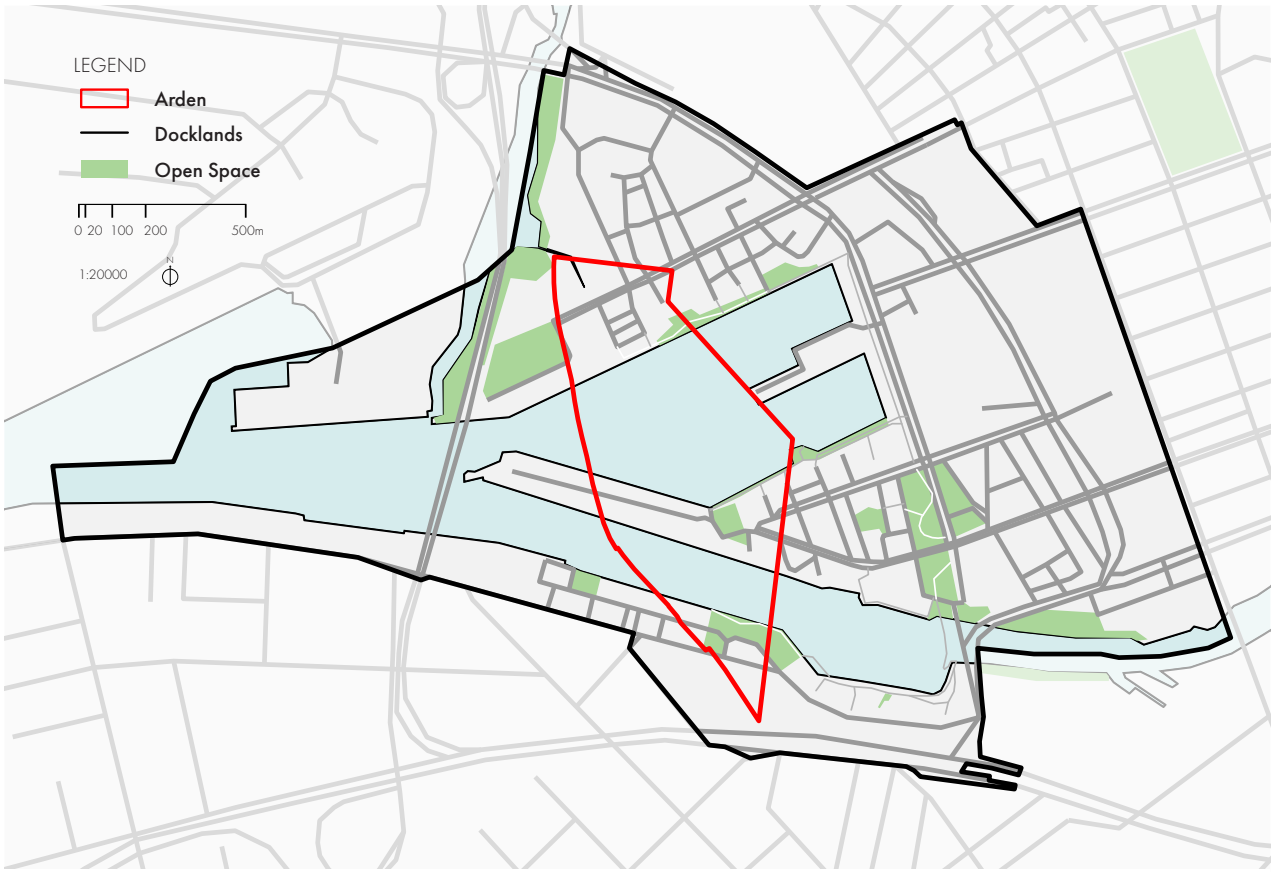
3.1 m2 per capita

Total Public Realm (including streets)

74.95 hectares (51.3% of precinct)

Total Public Realm per Population (2011)

18.9m2 per capita



04 BatteryParkCity,NY

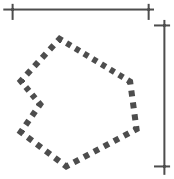
A former dock and land reclamation urban renewal precinct in downtown Manhattan as an extension of the financial district and adjacent to the World trade Centre site. The site took almost 25 years to complete after landfill had been completed, to then again need a re-examination of its commercial uses in the wake of September 11. The precinct accommodates residents, workers and student in three schools. Its waterfront location has enabled the focus of open space to be along a continuous riverside promenade.

Characteristics of public realm and open space

- A port reclamation project with a significant riverfront aspect that has provided a key open space interface for the whole of the precinct.
- A highly permeable street network, however with the presence of vehicles throughout the site, and integrating passive recreation uses into street medians.
- The incorporation of green roofs and communal open spaces into the precinct, either as publicly accessible open spaces or for limited user access.
- The creation of indoor 'public' space to provide opportunities for year-round space in a location with harsh winter conditions.
- The incorporation of sport fields as part of the daytime recreation space that is available to the general public.

Battery City Park, NY[6]

Quantities of public realm and open space

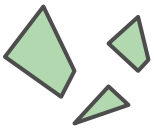


Total Area

37.94 hectares

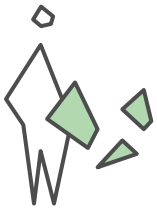
Total Population Resident /Worker (2016)

14,000 residents | 41,500 workers/students



Total Public Open Space

8.88 hectares (23.4% of precinct)



Total Public Open Space per Population (2016)

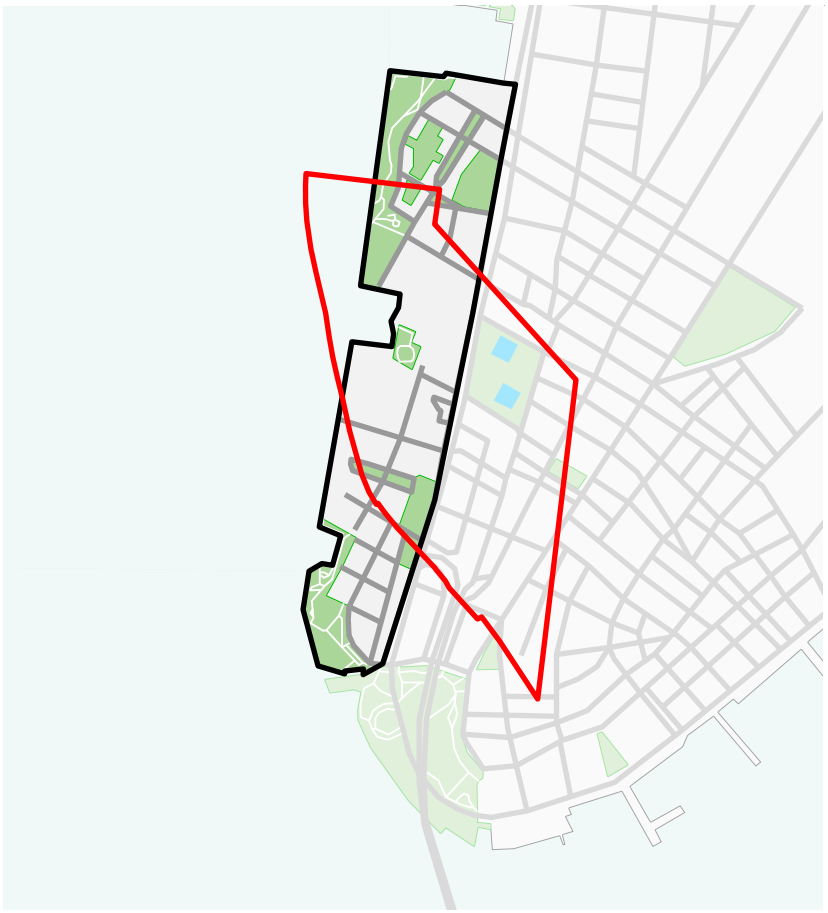
1.6m2 per capita

Total Public Realm (including streets)

23.11 hectares (60.9% of precinct)

Total Public Realm per Population (2016)

4.2m2 per capita



05 KingsCrossCentral,London

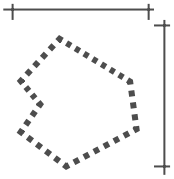
An urban renewal precinct of former rail yards at Kings Cross and St Pancras railway stations in central London. The site was in a single ownership has been developed to accomodate a diverse residential community as well as workers and students, including an affordable housing target and a strong emphasis of heritage protection and cultural activity to activate the precinct and support a diverse urban outcome.

Characteristics of public realm and open space

- A highly permeable street network, without the presence of vehicles throughout most of the site.
- A continuous series of open spaces and promenade connected to the riverfront and a car-free street and lane network that provide a diverse range of open space characters from formal green open space to highly urbanised squares
- A significant repurposing and integration of heritage built form into the new precinct's identity and public realm
- The use of high quality public realm materials with attention to the ongoing maintenance and management of spaces with identified local government and private land owner responsibilities.
- The integration of an existing waterway and water into the public realm network as one of several signature spaces that the precinct is identified by
- The provision of a diverse and extended year-round events program, including day and night time, weekends and weekdays to generate activation and increase visitors.

Kings Cross Central, London[7]

Quantities of public realm and open space

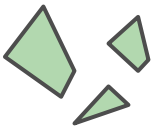


Total Area

27.56 hectares

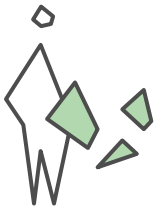
Total Population Resident/Worker Forecast

7,000 residents | 35,000 workers/students



Total Public Open Space

3.65 hectares (13.2% of precinct)



Total Public Open Space per Population Forecast

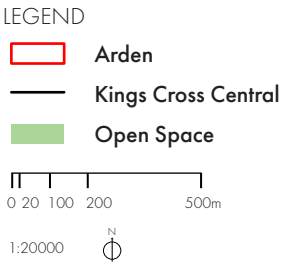
0.9m2 per capita

Total Public Realm (including streets)

14.99 hectares (54.4% of precinct)

Total Public Realm per Population Forecast

3.6m2 per capita



Key learnings for Arden PROSS

The benchmark precincts highlight a number of important attributes that must be considered in developing the Strategy for Arden's public realm and open space. These include:

- Quantity of open space alone being no guarantee for a successful outcome, exemplified by almost identical open space provision in Southbank and Melbourne 3000, however with markedly different outcomes.
- Residents and workers having different recreational needs which can often overlap in complementary ways over a day, week or year as evident in Kings Cross Central and Docklands.
- Active management of urbanised spaces to both activate spaces as well as accommodate for quieter periods for maintenance and landscape recovery as evident in Kings Cross Central.
- Highly urbanised environments requiring more hard surfaces in open spaces to handle intense amounts of use and pedestrian traffic and protection of soft landscape as visible in Melbourne 3000 and Battery Park City.
- Streets and laneways having the ability to provide a significant range of open space benefits, even in streets accommodating vehicular traffic as evident in Battery Park City and Kings Cross Central.
- The importance of diversity of open space and public realm scales and characters to accommodate different type of individuals and groups who seek out softer/harder, faster/slower or more passive/active environments and pursuits, evidenced in all the precincts.
- Buildings having the ability to extend the space and benefits afforded by the public realm through the use of forecourts, roof gardens, internal spaces and undercrofts as visible in Battery Park City and Kings Cross Central.

Docklands Park, Vic

06

APPLYING LEARNING TO ARDEN

For a world class public realm and open space outcome in Arden, the strategy must take heed of the vision for the future of the Precinct and respond to the specific spatial and qualitative characteristics of the existing place, before adopting any measures that other places have used successfully.

Both the qualitative and quantitative characteristics of the public realm and open space of Arden will need to be carefully composed to ensure that the outcome serve the anticipated future community of Arden and attract the investment, as well as the ultimate residents, workers or visitors to the Precinct

Quantitative rationale

Whilst this Strategy strongly advocates for an emphasis on achieving the qualities needed in the public realm and open space rather than adhering to strict quantitative targets, an understanding of how these provision rates are generated and could relate to Arden is needed.

Almost universally, the standards relating to the measurement of open space provision in urban areas has evolved from British standard that emerged during the early 1900s as part of the Garden City Movement. These standards and practices responded to the significant growth and change in British cities as the Industrial Revolution called for ever larger concentrations of population to staff the growing industrial sector. This movement sought a healthier urban outcome for populations that were experiencing chronic health problems related to poor hygiene and sanitation, poor air quality and poor access to most amenities and facilities, including open space.

The metrics that were adopted assumed a relatively low-density urban fabric which over time has become the development model for urban areas across most of the New World, essentially once transport technology enabled a decentralisation of urban populations.

Local contemporary measures or standards documented in practice notes, strategies and local planning schemes still maintain a strong relationship to those original ideas established over a century ago.

As Australian cities have grown and rediscovered the benefits and opportunities or renewing established urban areas, and remaking older industrial areas, the resultant denser urban forms have been challenged with the standards that were originally conceived for suburban areas. The more complex and costly urban forms that are now needed in these areas rely on more intensive investment in a range of infrastructure (access, drainage, and decontamination to name a few), and similarly the provision of open space provision has demanded deeper and more bespoke examination. Spatial aspiration for the broader 'public realm' as a whole has had little attention in Australia.

Current practice for open space spatial metrics have been developed on the basis of:

- Urban area proportion – targeting a percentage of a precinct to be provided as open space, and
- Per capita – targeting a rate of open space provision per person.

Measure by urban area proportion

A range of international and Australian authorities have adopted open space provision standards that are based on a proportion of an urban area, precinct or large development site. Their basis is in a predominantly low-rise, greenfield suburban model of development that gave rise to the planning of open spaces as part of the Garden City movement of the late 1800's and early 1900s.

This type of standard has remained somewhat static over time, evolving to some degree to respond to a more highly urbanised and denser form of urban development. However, it should be noted that statutory authorities typically acknowledge the complexity of developing denser urban forms and typically provide alternate means to contribute to the provision of open space.

International bodies have also developed standards, largely to assist city planners in developing economies to advocate for minimum standards for public health purposes in rapidly expanding cities, and by exception make the only claim to a public realm target.

The measures for provision of open space in urban areas on a proportion of an area are difficult to implement universally across urban areas as they may vary significantly in density and may struggle to accommodate for the needs of a high-density population. Similarly, authorities have only more recently begun to consider how employment land uses, or mixed-use areas, which may have a large concentration of the workers during the day, should provide for open space.

Of note from the above, the Melbourne Planning Scheme Open Space Contribution rate applies to developable land only, so for an urban renewal precinct that is already developed it is a measure that is not directly comparable to that established by the UN Habitat or the VPA, it does not take into consideration road reservations in an urban renewal precinct which can make up to 30% of the urban area

Open space measurements by area

Authority	Open Space Measure	Other Details
UN Habitat (Public Space Toolkit)	15-20%	Total of 45-50% of public realm including open space
New York City (CERQ Technical Manual)	No percentage measure	
London Borough of Camden (Open space	No percentage measure	
VPA (Precinct Structure Planning Guidelines)	10% of net developable area in residential areas 2% of net developable area in employment land	Developed for greenfield areas 60% of open space to be provided as active open space to accommodate sport ovals
City of Melbourne (Open Space Strategy)	No percentage measure	
City of Melbourne (Melbourne Planning Scheme – Open space contributions)	7.06% of development site	Applies to urban renewal areas with a preference for space provision over a cash in lieu contribution

Measure per capita

Per capita measures were originally established on the basis of a residential population only, and more recently expanded to consider users who are not residents, acknowledging that some cities, or parts of cities have a significant daytime population who legitimately have open space needs but are not residents.

Note: An often-cited World Health Organisation per capita measure of 9m2 of open space per person is unpublished and not formally part of the WHO's position on urban open space.

These measures are more closely aligned with population size, and arguably more appropriate across a range of urban densities, however their disconnect from the spatial limits of a city or precinct can generate open space demands that are completely incompatible with the (re)development outcome that they seek to provide for.

Of note from the above is the acknowledgement in other jurisdictions that open space needs for workers (or non-residential users) are of a vastly different type and scale than those of residents.

For Arden, adopting a position on generic quantitative provision of open space alone would not generate the type of place that would support the dynamic and diverse residential and working community it hopes to become. It is only in combination with the analysis of the existing characteristics and review of other benchmark precincts that a more sophisticated approach to quantities of space can be confidently proposed in tandem with qualitative characteristics.

Open space measurements by population

Authority	Open Space Measure	Other Details
UN Habitat (Public Space Toolkit)	No per capita measure	
New York City (CERQ Technical Manual)	10m2 per resident 0.6m2 per worker	80% as active open space 20% as passive open space
London Borough of Camden (Open space	9m2 per resident 0.47m2 per worker	Preference for unpaved spaces Cash contribution in lieu of space is possible.
VPA (Precinct Structure Planning Guidelines)	No per capita measure	
City of Melbourne (Open Space Strategy)	7.1m2 per daytime population (resident & worker)	No distinction between residents & workers
City of Melbourne (Melbourne Planning Scheme – Open space contributions)	No per capita measure	

Arden PROSS evaluation framework

To inform the qualitative and quantitative outcomes for Arden Public Realm and Open Space a set of principles have been developed that reflect the Arden Vision directions, objectives and planned outcomes and respond to the specific opportunities present in the existing place. These principles establish the framework by which the Strategy has developed its qualitative and quantitative elements.

The Principles

01

A distinctive Arden identity

- Reinforce Arden's identity of a centre of innovation with new open spaces and a connected, generous public realm
- Shape a high quality precinct that reflects the needs and values of the community and future residents and workers
- Retain the North Melbourne Football Club, Recreation Centre and Pool and leverage them as core community-building assets.

02

A diverse, connected precinct that provides for all needs

- Maximise the availability and usability of open space throughout the precinct by accommodating and integrating multiple functions in streets and spaces.
- Focus on providing environmental benefits in Arden North, events and informal use in Arden Central, and unstructured recreation in the Laurens Street sub-precinct
- Integrate existing and new open spaces into a cohesive network available to both the immediate precinct and the wider neighbourhood

03

A water-positive precinct

- Visually and functionally integrate the stormwater basin as a core part of the open space provided in Arden North
- Create an internal blue-green infrastructure network that connects key natural attributes and new links beyond the precinct.
- Futureproof a broad, direct open space connection between Moonee Ponds Creek and North Melbourne Recreation Reserve through the layout of open spaces that serve a stormwater function

04

A network of public and private spaces

- Augment public open space provision providing private open spaces in large developments that enhance access and benefits of the public realm and public open space
- Improve access, safety and visibility of private open spaces that are to be used by the public

05

A universally accessible precinct

- Provide for universal access to the whole of the public realm and open space and integrate necessary level changes as part of the experience in the landscape
- Maximise personal safety and security through activation of ground floors around open spaces and key streets
- Ensure all streets prioritise safe and convenient pedestrian and cycling movement
- Ensure that unencumbered open space is within 300 metres of all parts of the precinct

06

A comfortable, green and cool precinct

- Provide tree canopy to at least 40% of the public realm and open space
- Maximise soft landscape throughout the public realm and open space and augment this through the use of landscape to walls and rooftops of buildings
- Provide and improve biodiversity and habitat through integration of multi-storey and indigenous planting
- Protect winter solstice solar access to unencumbered public open spaces, and protect equinox solar access to encumbered and restricted public open spaces

07

A public realm of continuous small spaces

- Create small local open spaces throughout the precinct and adapt parts of streets for informal use
- Create the majority of new streets within Arden Central as exclusively pedestrian and cycling spaces
- Reduce or eliminate carriageways and on-street car parking adjacent to or between open spaces in order to increase their usability

Public realm and open space provision in Arden

The focus on the provision on the appropriate qualities of public realm and open space in Arden, has also informed the approach to spatial provision.

The precinct benchmarks highlight three critical insights:

- The benefit of access to light and air is gained from space that is not built upon – even if not usable for recreation – typically waterways or conservation areas,
- Recreation, and other open space benefits can be integrated into encumbered and restricted public open spaces, and
- Public realm, beyond traditional public open spaces, have a role in providing legitimate recreation and other benefits that have conventionally been the domain of public open space, particularly in high density and employment-focused precincts.

For Arden's PROSS this suggests:

- Provision of unencumbered open space on an urban area proportion basis, considering the substantial encumbered and restricted public open spaces that will be present in Arden, and
- Provision of total public realm should meet a high standard of per population measurement, assuming a majority of this will be car-free given Arden's transport mode split targets.

Urban Area Proportion to define Unencumbered Public Open Space

From the local precinct benchmarks Melbourne 3000 is the most populated, most job-centric, and simultaneously provides the highest proportion of open space, at 4.7% of the precinct. Given it embodies many of the desirable urban qualities that a highly activated and job-centric mixed-use precinct would have the, its open space provision rate – rounded up to 5.0% to unambiguously provide leadership in open space provision - has been adopted for the provision of unencumbered, unrestricted public open space for Arden.

This has been recommended considering the sizeable contribution of open space (though encumbered or restricted) that the North Melbourne Recreation Reserve and the future stormwater management facility will provide to Arden, and on the assumption that both will maintain a high degree of public availability and provide a range of open space benefits.

Arden PROSS open space provision

Public Realm Element	Area (hectares)	Proportion
(Existing) Clayton Reserve	0.65 ha	1.3%
(Existing) Canning Street & Macaulay Road Reserve	0.25 ha	0.5%
(Existing) Railway Place & Miller Street Reserve	0.11 ha	0.2%
Proposed Additional Unencumbered Unrestricted Open Space	1.60 ha	3.1%
Total Unencumbered Unrestricted Open Space	2.61 ha	5.0%
Proposed Encumbered Open Space (Stormwater Management)	7.10 ha	13.6%
Existing Restricted Open Space (North Melbourne Recreation Res.)	4.52 ha	8.7%
Total Open Space (Encumbered, Restricted & Unencumbered)	14.07 ha	27.0%
Arden Precinct	52.10 ha	100%

Through the provision of an additional 1.60 ha of unencumbered open space, the total open space (unencumbered, encumbered and restricted) provision would substantially exceed the standard proposed by UN Habitat for public open space as well as the standards provided by the authorities in which the benchmark precincts are located.

When compared to the benchmarks precincts themselves, Arden would far exceed the local precincts, and even double one of the international precincts' provision (King Cross Central). If unencumbered open space alone were to be measured it would still exceed all three of the local benchmarks.

It should be noted that open space restriction and encumbrance details of the international precincts are unknown, while local examples do include open spaces that have a degree of encumbrance, such as:
- Enterprize Park in Melbourne 3000 which includes large areas under railway viaducts, and
- Docklands Community Hub Reserve in Docklands which includes large areas with infrastructure access pits.

Open space provision - area proportion - precinct comparison

Precinct	Area (hectares)
Arden (proposed)	27.0% (total open space)
Arden (proposed)	13.7% (unencumbered open space)
Arden (proposed)	5.0% (unencumbered unrestricted open space)
Melbourne 3000	4.7%
Southbank	3.8%
Docklands	3.9%
Battery City Park	23.4%
Kings Cross Central	13.2%

Public realm per capita

Whilst City of Melbourne's Open Space Strategy has used a total daytime population measure equating to total residents and total workers, this does not reflect the distinction in open space needs between these two user types that has more recently been reflected in the per population provision targets of New York City (Battery Park City authority) and London Borough of Camden (Kings Cross Central authority). Both have similar measures per workers of 0.47/0.6 m2 and per resident of 9.0/10.0m2. This provides greater precision in targeting open space to mixed use precincts such as Arden and as such 0.5m2 per worker and 10.0m2 per resident of Arden has been adopted for the provision of total car-free public realm, that includes streets and lanes that do not provide for public vehicular traffic (service and emergency vehicles expected).

*Identified in previous Area Proportion Table
**Estimated total new streets and lanes in Arden Central based on a 30% 'rule of thumb' of the single site, noting that proportion will need to carry vehicles.

Arden public realm and open space provision - per capita

Public Realm Element	Number	Per capita	Area
Residential population	15,000	10.0m2	15.0 ha
Worker population	34,000	0.5m2	1.7 ha
Total Provision of Public Realm Identified			16.7 ha
Proposed Total Open Space* (unencumbered, encumbered and restricted)			14.07 ha*
Estimated new streets and lanes in Arden Central*			4.52 ha
Total (Car-free) Public Realm Provision			18.59 ha
Total existing streets and lanes			15.30 ha
Total (Proposed) Public Realm Provision			33.89 ha

The above assumes that most of the new streets and lanes in Arden Central will (and can be) carless given the substantial sustainable transport targets identified in the Arden Vision. However no further assumption has been made throughout the Precinct's existing streets, some of which may be partially closed to the benefit of pedestrian and cycling users.

For the purposes of comparison with other precincts, both the car-free and total public realm, including all streets with cars, for Arden have been included that highlights Arden's proposed total car-free public realm being comparable to the international benchmarks and Melbourne 3000. When comparing the whole of the public realm (including streets and lanes that accommodate vehicles) Arden would exceed that provided in Battery Park City and double the public realm currently available in Melbourne 3000 or Kings Cross Central.

Whilst seemingly less generous when comparing with Southbank and Docklands, it should be noted that all of the local benchmark population numbers have been extracted from the City of Melbourne Open Space Strategy which relied on 2011 population (resident and worker) statistics. This therefore compares these precincts at a time when they are only partially redeveloped, with Arden's ultimate population.

By way of example, Development Victoria has provided a 2019 estimate of Docklands residents (13,000) and workers (65,000) and forecast of an ultimate future resident population of 25,000 and worker population of 80,000-100,000. When this is compared with Arden's ultimate planned population a clearer picture of Arden's open space and public realm spatial lead is visible.

Public realm and open space provision - per capita - precinct comparison

Precinct	Residents	Workers	Public Realm per Population
Arden (proposed)	15,000 (at completion)	34,000 (at completion)	3.8 m^2 (car free)
Arden (proposed)	15,000 (at completion)	34,000 (at completion)	6.9 m^2 (includes all roads)
Melbourne 3000	21,080 (2011)	223,326 (2011)	3.9 m^2 (includes all roads)
	37,321 (2016)	221,700 (2016)	3.7 m^2 (includes all roads)
Southbank	13,107 (2011)	37,796 (2011)	13.1 m^2 (includes all roads)
	18,709 (2016)	41,800 (2016)	11.0 m^2 (includes all roads)
Docklands	6,134 (2011)	33,503 (2011)	18.9m^2 (includes all roads)
	10,964 (2016)	58,000 (2016)	9.8m^2 (includes all roads)
	25,000 (2025 est.)	100,000 (2025 est.)	6.0 m^2 (includes all roads)
Battery City Park	14,000 (2018)	41,500 (2018)	4.2 m^2 (includes all roads)
Kings Cross Central	7,000 (at completion)	35,000 (at completion)	3.6 m^2 (includes all roads)

07

ARDEN PROSS STRATEGY

The Plan

The Arden PROSS seeks to provide a public realm and open space environment that supports the Arden Vision by creating the foundation for a seamless, integrated and inclusive public environment that supports social and economic exchange and provides environmental and climatic benefits.

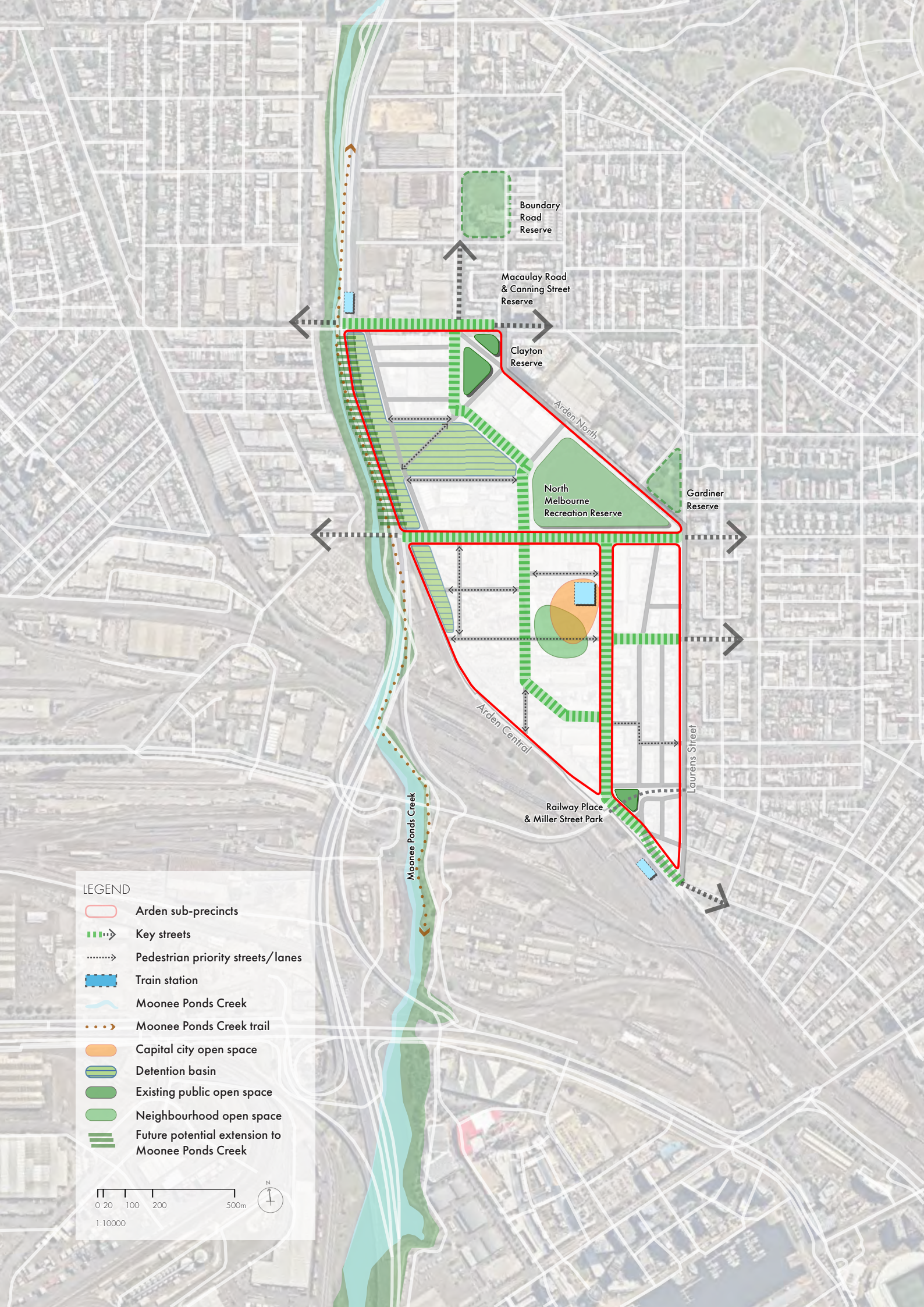
The public realm and open space of Arden will need to deliver on a wide range of expectations for the future local community and Melbourne more broadly within a Precinct that must be robust and hard-working if it is to deliver on all aspects of the Arden Vision.

There must be a triple bottom line of benefits that can accommodate for:

Social benefits
Foster a sense of connectedness and provide for physical and mental health of residents and workers that come with access to green and open spaces, as well as and celebration and reflection of the existing cultural and heritage assets and characteristics of each sub-precinct.

Environmental benefits
Improving environmental and climatic outcomes through the mitigation of urban heat island effect, contribution to biodiversity, and management of flood and water resources sustainably by leveraging all spaces, properties and systems across the precinct.

Economic benefits
Attracting investment and high-value research and commercial activities, and the talent needed to establish and maintain them by accommodating physical, social and mental needs of the modern workforce efficiently by using space to perform multiple functions, creatively in a high-quality environment that attract visitors and activates the precinct.


Boundary Road Reserve
Macaulay Road & Canning Street Reserve
Clayton Reserve
Arden North
North Melbourne Recreation Reserve
Gardiner Reserve
Arden Central
Laurens Street
Railway Place & Miller Street Park
Moonee Ponds Creek
LEGEND
Arden sub-precincts
Key streets
Pedestrian priority streets/lanes
Train station
Moonee Ponds Creek
Moonee Ponds Creek trail
Capital city open space
Detention basin
Existing public open space
Neighbourhood open space
Future potential extension to Moonee Ponds Creek
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The key moves

Integrated – unlocking the potential of the whole of the Precinct by flexibly and efficiently using all the space available for multiple open space and other purposes across the day, week and year.

The whole of the public realm operates as a highly efficient organism that accommodates for all of the Precinct's necessities from utility provision to universal access, stormwater drainage, transport, recreation, biodiversity and maintenance processes within an elegantly simple and highly flexible form.

Seamless – a continuous network of spaces and corridors that form a connected public sphere, amplifying the benefits provided by the individual component parts.

The public realm transitions from the conventionally understood collection of streets, spaces and building into a high-performance multi-functional connective tissue that stitches the precinct together. Unlocking the potential of the whole public realm for continuous commercial and social exchange, high amenity active transport and environmental performance.

Inclusive – inviting everyone to share in the Precinct by removing the barriers that discourage or prevent individuals from using spaces due to economic means, physical abilities, or perceptions.

Melbourne's diversity is one of its strengths, and similarly, for Arden to be successful it must provide for a wide range of uses, activities and groups and individuals. It will need to provide a vibrant, safe and inclusive environment that provides a range of open spaces that deliver opportunities for productive and creative activity, spontaneous social interactions, opportunities to dwell, spaces for respite and places for events.

The sub-precincts

The future Arden as an innovation precinct will need to respond both to Melbourne as a whole, as well as the local setting it is in, however the sub-precincts within Arden will play different leading and supportive roles in establishing this metropolitan or even global role.

As a result, the public realm and open space of our newest precinct needs to be calibrated across its sub-precincts to allow the maximum utility of the space it has and the flexibility to adapt as more is known about its future users' needs.

Whilst distinctive in their function and identity the sub-precincts of Arden will be identifiable through gradual hierarchical and typological shifts in their spaces and public realm, rather than definitive functional and material changes to ensure it remains an integrated and seamless public realm across the whole Precinct, as well as remaining stitched into the adjacent, existing community of North Melbourne.

Arden North

A community-focused neighbourhood that strengthens the already strong tree canopy and provides a green, cool setting that celebrates the heritage of existing open spaces and environmental values. This includes the strengthening of the natural landscape and Indigenous heritage values connected with Moonee Ponds Creek.

Accommodating a mix of residential and commercial uses that integrate the existing heritage and open spaces of the North Melbourne Recreation Reserve and others, with a new, expansive stormwater management facility to provide almost 13 hectares of interconnected, green open spaces. This will be available for a range of recreation, biodiversity, stormwater storage and community uses, as well as opportunity for more passive recreational pursuits that offer respite to Arden's residents and workers, and provide for a future direct connection to the Moonee Ponds Creek.

Arden Central

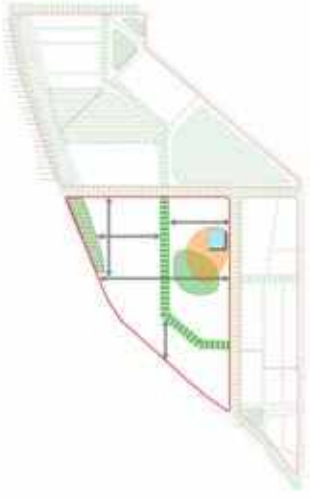
A new globally-significant hub of innovation that most resembles a bustling business distrinct, however set in a seamless, almost completely car-free public realm that is centred on a new Capital City Open Space that is a destination in its own right.

With over 6 hectares of public realm that accommodates not only larger events and high levels of pedestrian movement to and from the railway station, but also more neighbourhood-focused passive spaces for the immediate community of this neighbourhood. Despite the need for robust and hard-working spaces it will provide for prolific shade and maintain the visible presence of water that links it to the rest of Arden and the nearby Moonee Ponds Creek. It will also exemplify the most extensive integration of private open spaces into a diverse, accessible network of green.

Laurens Street

An already transforming neighbourhood of residential and commercial use that grafts and adapts the long industrial heritage of the Precinct into a gritty, urban experience, which contrasts and complements Arden Central's newer, larger and more institutionally-scaled activities and built forms and spaces.

It will continue to accommodate the remaining industrial activities that are visibly present while incrementally changing over time to provide for smaller business operations and additional low and medium rise residential developments. Its public realm and open space will similarly be of a small, local purpose and character, adapting and growing from small seeds of space in a similar way to Railway Place Reserve. Over time it will make better, more efficient and locally-prioritised use of over 5 hectares of public realm that is already available in the neighbourhood. To this will be added more rooftop and undercroft space further providing opportunity for greening and recreation.



The Places

To successfully provide for the Precinct and the community the specific elements of the public realm will need to reflect and provide for the rhythms of daily life, the weekly and monthly calendar as well as seasonal changes. This will ensure that the network leverages most of the space available, and provides the qualities, characteristics integrated infrastructure to support a healthy, thriving public life for the growing and diverse communities.

Constitution Avenue, CBR[8]

Chrofi, Maitland, NSW[9]

Yanweizhou Park, Jinhua City, China[10]

Capital city open space

A centre-piece and civic heart to the whole of Arden, and a recognisable space, synonymous with Melbourne's identity and establishing a role within the city's cultural and social event calendar. It will be seamlessly connected into the surrounding network of streets and lanes and onto other spaces and accommodate the activity that comes with a metropolitan railway station serving a globally significant innovation hub. This should include:

- Centrally located in Arden Central and connecting the forecourt of the new station and the Laurens, Queensberry and Fogarty Street corridors.
- Incorporating facilities that can accommodate a range of event types and scales that can be quickly established and dismantled, whilst providing high levels of access to the railway station.
- Providing approximately 0.6 hectares of the additional unencumbered open space provision for the precinct
- Securing solar access from 10am to 3pm on June 21 (winter solstice) to all of the open space.
- Incorporating a water element as a reflection of the other large open space in the Precinct and a reminder of the proximity to Moonee Ponds Creek as part of the Precinct's identity
- Actively managed by a dedicated team that develops and maintains a prolific events calendar that encourages both local attendees and a wide range of visitors
- Providing robust, hardwearing surface that can handle intensive use as well as protect the soft landscape elements from regular pedestrian traffic.

- Providing high levels of tree canopy and a proportion of soft landscape that reduces urban heat and prolongs its usability during summer months.
- Combining and integrating the adjacent neighbourhood open space to maximise continuity and flexibility of use, as well as allowing some extension of some of the more locally orientated functions in parts of the space during non-event mode.

Zollhallen Plaza, Freiburg, Germany[11]

Neighbourhood open space

Orientated to their more immediate residents and workers, the neighbourhood and local open spaces of Arden will be formed in a number of ways that reflect the opportunities and characteristics of each sub-precinct. They will provide a network of open spaces, that despite having similar roles will offer choice to the local community. This should include:

- Maximising soft landscape with generous, flexible lawn spaces that can provide for a range of informal recreational activities.
- Providing substantial tree canopy coverage that provide shade for users and protect lawn areas in summer months.
- Providing for small social gathering and picnic facilities and play equipment for a range of age groups.

Arden Central

- Centrally locating a neighbourhood open space to maximise accessibility from across the southern half of the Precinct and immediately adjacent to the Capital City open space to provide flexibility and leverage the open space provided by both.
- Providing at least 1.0 hectare of the additional unencumbered open space provision for Arden for this open space.
- Defining an edge to the more 'public' Capital City open space that limits spill over of events conducted there to only part of the neighbourhood open space.
- Providing a mix of facilities for workers and residents including of sports, quiet spaces for lunches, adequate provision of furniture, fixtures and shelter.
- Maintaining continuity of character and material qualities with the Capital City open space, notwithstanding the contrast of hardscape and soft landscape.
- Servicing solar access from 10am to 3pm on June 21.

North Arden

- Leveraging the open space provided by the existing open spaces and the future integrated stormwater management facility to create small local open spaces in locations immediately adjacent to development.
- Providing areas of approximately 0.03-0.1 hectares of level, usable space for local open space functions that may be formed from the encumbered space of the integrated stormwater facility site and road reservations.
- Securing solar access from 10am to 3pm on June 21 (winter solstice) to a majority of the open space that provides for recreation use.
- Providing more passive, informal and low intensity use that is focussed on the provision of more intimate open spaces with high quality biodiverse planting, strong tree canopy coverage, and interfaces with integrated water management.

Laurens Street

- Locating small local open spaces in locations with good solar access, highly accessible by immediate residents, and making use of road reservation space.
- Encouraging complementary built form interface such as additional space through the provision of adjacent undercrofts and active frontages.
- Providing areas greater than 0.03 hectares for small local open space with some form of protection from any passing vehicular traffic.
- Securing at least 3 hours of solar access between 10am to 3pm on September 21 (equinox) to a majority of the open space.
- Providing a single facility in each space orientated to immediate residents such as group gatherings, passive quiet spaces, informal active recreation, playgrounds and dog walking
- Accommodating environmental benefits including integrated water management, tree canopy coverage and large planted garden beds for biodiversity values which are underprovided in this sub-precinct.

Integrated stormwater management

North Arden's stormwater retarding facility will form a series of accessible, usable open spaces that will provide a chain of recreational opportunities from the Moonee Ponds Creek Corridor to North Melbourne Recreation Reserve and contribute significantly to the green, cool character of this sub-precinct. This should include:

- Retaining, where possible, the significant trees of Gracie and Green Streets and further contributing substantial tree canopy throughout the space.
- Using the level changes and bunding necessary for the stormwater function as integrated passive recreation, garden bed and trail network elements that invite use and provide universal access.
- Providing some sporting and fitness facilities that are located in areas that reduce inundation and allow for a range of active recreational opportunities.
- Integrating opportunities for biodiversity improvement, ecological restoration, and the permanent presence of water in parts of the open space.
- Maintaining the opportunity for future broad and direct connection to Moonee Ponds Creek, that could afford immediate integration with the Moonee Ponds Creek Trail, and additional space created under transport infrastructure.
- Integrating and celebrating the Indigenous heritage of the area, connected to Moonee Ponds Creek.

Development Bank Of The Meurthe, Freiburg, Vosges, France[12]


INTEGRATED PASSIVE
RECREATION
MOONEE PONDS
CREEK TRAIL


INTEGRATED PASSIVE
RECREATION
INCREASED
BIODIVERSITY

Pedestrian Priority Streets and Lanes

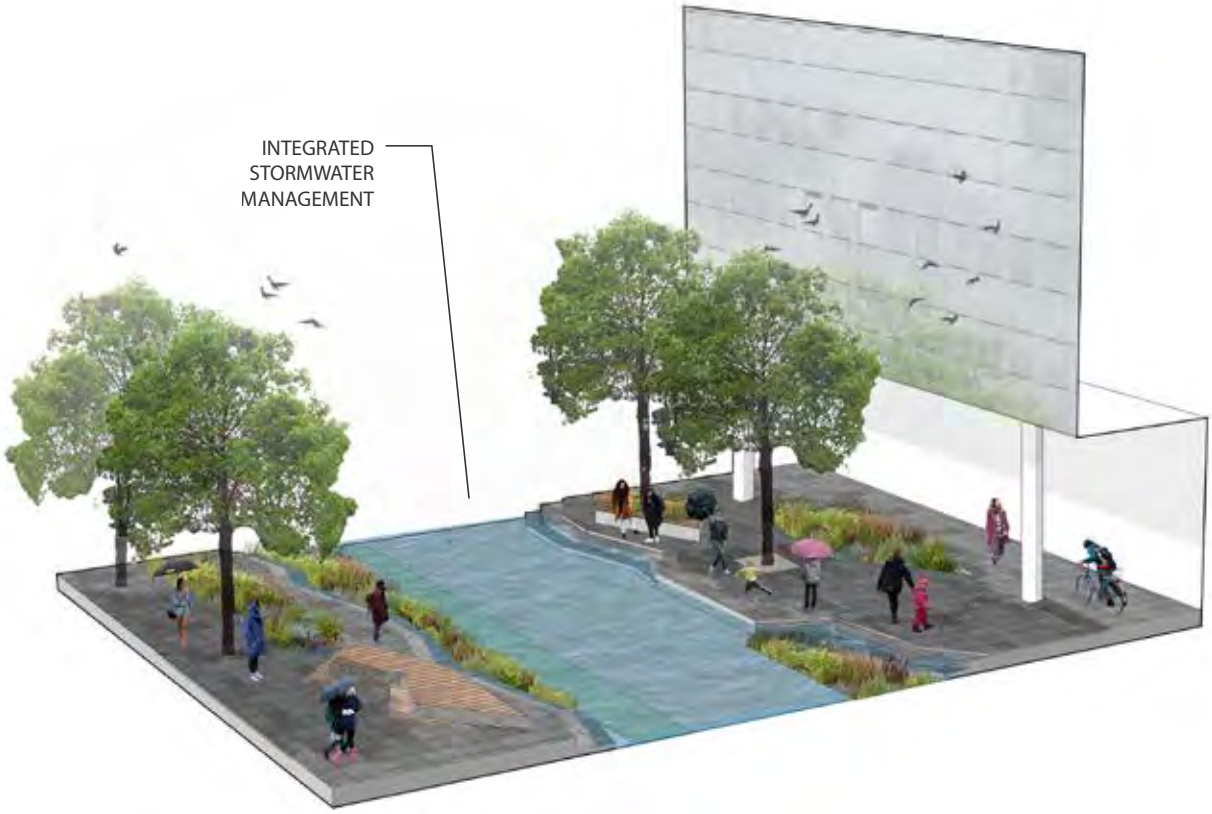
Traditionally focused on movement and transport, Arden's generous street network will provide for numerous informal recreational and environmental opportunities with the transition to more active and public transport modes. In addition, new streets and lanes that are created in Arden Central will provide limited vehicle volume and prioritise safe pedestrian space. This should include:

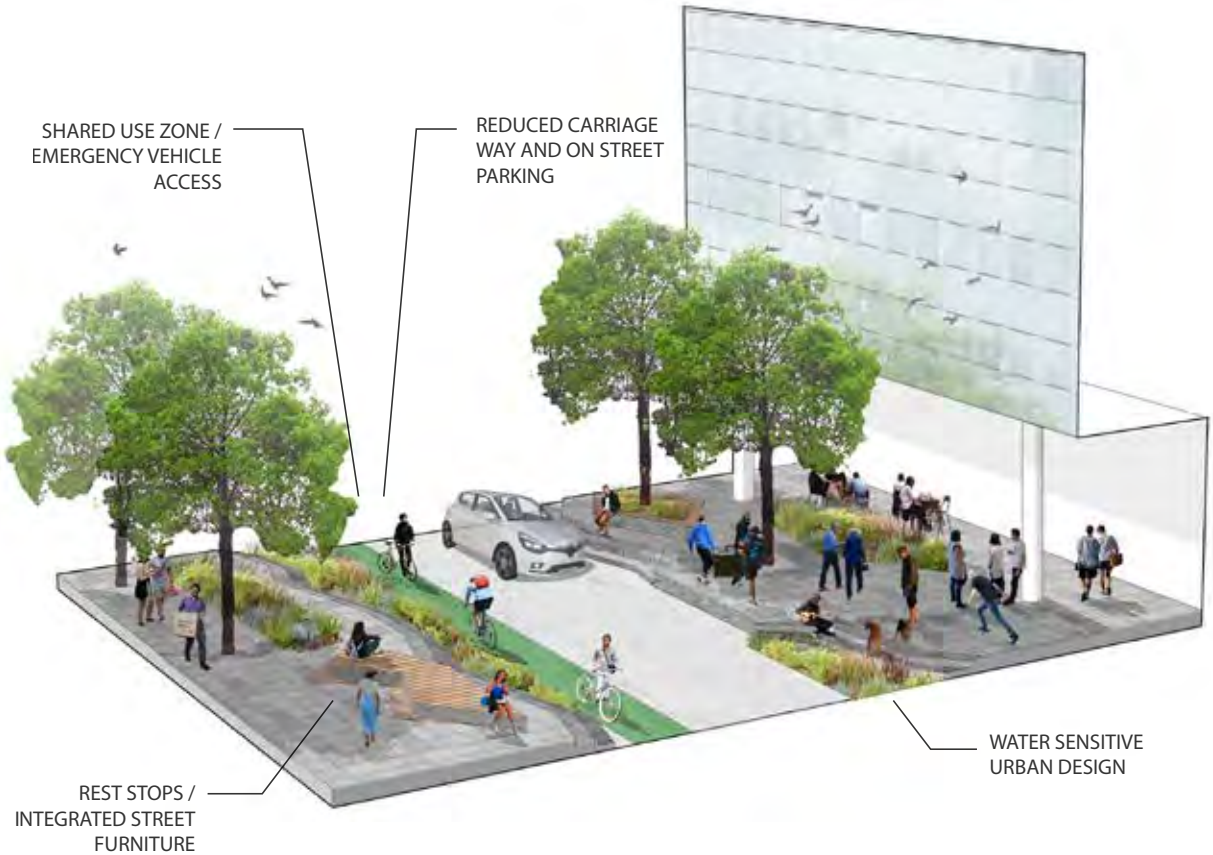
- Introducing landscaped garden beds and water sensitive urban design in areas that require protection from vehicle traffic.
- Providing continuous street tree planting and associated improvements to stormwater drainage that will increase water supply to trees and help establish continuous tree canopies.
- Providing for respite points and informal rest stops through use of integrated street furniture, bollards and garden bed edges, particularly at intersections and routes that connect public transport nodes.
- Providing the majority of streets and lanes throughout Arden Central as car-free or as shared zones that except service and emergency vehicle access but maintain a safe and pedestrian-dominated environment.

These measures should be adopted in any existing street where traffic volumes are likely to decrease, including:

- Introducing localised traffic changes, particularly along Fogarty Street and in the Laurens Street sub-precinct, that slow vehicles in local streets and create substantial new local open spaces that can be afforded good solar access in highly accessible locations.
- Reducing carriageway lanes and on street car parking in key streets to provide more generous pedestrian, cycling and landscape zones, especially Fogarty, Laurens, Queensberry and Arden Streets and Macaulay Road.

Cheonggyecheon, South Korea[13]


INTEGRATED
STORMWATER
MANAGEMENT


SHARED USE ZONE /
EMERGENCY VEHICLE
ACCESS
REDUCED CARRIAGE
WAY AND ON STREET
PARKING
WATER SENSITIVE
URBAN DESIGN
REST STOPS /
INTEGRATED STREET
FURNITURE

Private / communal open spaces

Despite being privately owned, Arden's private open spaces will perform as part of the public realm, providing the opportunity to both leverage access to the benefits of the surrounding public open spaces and further complementing them with open space and facilities that would otherwise take up valuable open space. This should include:

- Developing new buildings, especially community facilities, to extend ground level open spaces with undercrofts, arcades and colonnades that provide shaded space at interfaces with open spaces and the public realm that can accommodate activities that require hard surfaces such as social gathering and small events. In line with Central Melbourne Design Guide, ensure that spaces are provided with generous ceiling heights, are well activated and provided with natural surveillance.
- Providing rooftop garden spaces that both overlook the public realm, as well as contribute further to landscape qualities, particularly at podium levels that have a visual connection to street level.
- Providing well-managed, safe and visible public access to indoor, rooftop and ground level private open spaces, especially where they are part of a development or institution that will attract large numbers of visitors.
- Providing for smaller social gatherings such as barbeques and parties in private open spaces that can augment these types of facilities in public open spaces
- Integrating necessary level changes between streets and ground floors that are required for flood mitigation as thoughtful 'edge' elements of the public realm that can be occupied as seating, informal play or garden beds.

Summary of proposed Arden public realm and open space provision

Open Space	Catchment	Character
New Capital City	Capital City	Square Urban plaza Water feature Events
North Melbourne Recreation Reserve	Municipal	Restricted sporting Heritage Sporting
New Integrated Stormwater Management Open Space	Municipal	Water feature Nature conservation Recreation Sporting
New Neighbourhood/Local Open Space	Neighbourhood	Play Recreation Informal use
Clayton Reserve	Local	Formal Recreation Informal use
Macaulay Road & Canning Street Reserve	Small Local	Formal Recreation Informal use
Railway Place & Miller Street Park	Small Local	Recreation Informal use Play
New private open spaces	Small Local	Civic space Play Seating/viewing
New streets	Small Local Link	Linking space Seating/viewing Informal use

Implementation

Planning

The recommendations of this Strategy have been developed to help inform the development of the Arden Precinct Structure Plan being undertaken by the City of Melbourne and the Victorian Planning Authority. This planning document will provide the framework for infrastructure investment in Arden (and the mechanisms that will be used to pay for these), as well as establish the design and planning controls for development that will occur within Arden. The public realm and open space are one of a range of important elements that the Precinct Structure Plan will align and coordinate to achieve the Arden Vision including: transport; service infrastructure; character, community facilities, cultural and heritage management and building heights, shadows and interfaces.

Development

The Precinct Structure Plan will also assign responsibilities and identify lead agencies to individual initiatives to ensure that actions can be undertaken in a coordinated way, that are well aligned with capability and authority. Once agreed and approved by the Minister for Planning, development and realisation can occur.

For the public realm and open space recommendations of this Strategy, a number of key asset investments and development phases are crucial to its successful realisation. These include:

- Implementation of the Stormwater Management Facility in North Arden – The specific location and form of this important element of the public realm will directly impact the connectivity, character and functionality of the open spaces and public realm of North Arden. Ensuring an integrated and collaborative planning, design and delivery process is conducted will be crucial to ensure that it:
  - Forms broad connection to North Melbourne Recreation Reserve, Clayton Reserve and potential connection to the Moonee Ponds Creek,
  - Provides space and level areas for passive recreation and walking trails, and
  - Designed to maximise its availability for recreational purposes safely and attractively.

- Development of Arden Central – The significance of the central site's location and size cannot be overstated given the substantial contribution it will make to the open space and public realm of Arden, both in quantity and character. The aspiration for the Capital City Open Space is for a metropolitan if not international role for the whole of Melbourne. The design process, delivery quality and management arrangements that are undertaken will determine its ability to successfully and confidently establish itself.

- Realisation and Upgrades to Key Streets – Macaulay Road and Arden, Queensberry, Lauren and Fogarty Streets will all undergo some degree of extension, change or upgrade in order to manage the changes to their transport roles. Ensuring that their design detail incorporates all of the expectations that a high-quality public realm would require of them, will establish an important signal to the development interests of the step change that is expected in Arden, as well as provide an opportunity to change perceptions of what a street's role in an urban precinct can be.

Management

The public realm and open spaces of Arden can only continue to be successful once developed with active and ongoing management. A high-quality environment, particularly one that is asked to be efficient, flexible and hardworking can only meets its functional performance targets through careful monitoring, management and maintenance.
All stakeholders, asset and land managers will be required to participate in this if the vision for the Precinct is to be realised.

The City of Melbourne will be instrumental in this with extensive experience and established standards and practices in managing the public realm. However there is likely to also be an important role for private land owner(s) participation, particularly in the case of Arden Central, and specialist stormwater authority experience, specifically in the case of the stormwater management facility, and water sensitive urban design assets more broadly.

As the Precinct is redeveloped, the public realm and open spaces of Arden will continue to grow, adapt and evolve as the specific needs of the type of residents and workers that occupy Arden become more apparent with every new proposal and development. The ongoing presence of these asset managers will be required to actively manage what will be a complex, living, urban ecosystem that will need be impacted by and need to respond to the social, environmental and economic demands that will be present in Arden and Melbourne in

Endnotes

1 Victorian Planning Authority, Victorian State Government, City of Melbourne: Arden Vision 2018

2 Karkarook Park, Vic, available at: www.visitvictoria.com/regions/Melbourne/Things-to-do/Nature-and-wildlife/National-parks-and-reserves/Karkarook-Park

3 The State of Victoria Department of Environment, Land, Water and Planning, Plan Mel bourne 2017-2050

4 Bourke Street Mall, Vic, available at: www.sidespace.com.au/media/bourke-street-mall-to-become-smoke-free

5 Southbank, Vic by James Dominko on Unsplash

6 Battery Park City, NY, available at: www.cityof.com/ny/new-york-city/local/attractions

7 Kings Cross Central, London, available at: www.silicon.co.uk/e-regulation/surveillance/kings-cross-facial-recognition-shut-283135

8 Constitution Avenue, CBR, available at: www. landezine.com/index.php/2017/04/constitution-avenue-canberra-by-jane-irwin-landscape-architecture/20170269_jg_1892/

9 Chrofi, Maitland, NSW available at: www.chrofi.com/project/maitland-riverlink

10 Yanweizhou Park, Jinhua City, China available at: www.landezine.com/index.php/2015/03/a-resilient-landscape-yanweizhou-park-in-jinhua-city-by-turenscape/

11 Zollhallen Plaza, Freiburg, Germany available at: www.landezine.com/index.php/2015/04/flood-zone-on-public-plaza-design-atelier-dreiseitl-landscape-architecture/

12 Development Bank Of The Meurthe, Freiburg, Vosges, France Germany available at: www.landezine.com/index.php/2013/03/development-bank-of-the-meurthe-by-atelier-cite-architecture/

13 Cheonggyecheon, South Korea available at: https://www.thestar.com.my/lifestyle/living/2017/11/11/restoration-cheonggye-stream-seoul/

Arden Open Spaces
Development Contributions Plan

RFQ Version
November 2020

CITY OF MELBOURNE

Arden Structure Plan Proposed Public Open Spaces
Framework Plans for the Development Contributions Plan

DCP REF	NAME	CATCHMENT	SIZE	FUNCTION	INTERFACES	REFERENCES
DR-01	**Langford Street ISM & Open Space**	Municipal	14196m2	Flood Storage (**10,000m3**) Passive recreation Heritage Nature conservation Water feature	Langford Street SCC Innovation heart Residential / mixed use Moonee Ponds Creek/ Trail	Public Realm Strategy (p.92) IWM Strategy
DR-02	**Arden North ISM & Open Space**	Municipal	33917m2	Flood Storage (**17,500m3**) Passive recreation Heritage Nature conservation Water feature Active Recreation (TBC)	Langford Street SCC. Stalker/Green Streets PPZ Henderson St LCC/ Public Transport route Innovation heart Residential / mixed use	Public Realm Strategy (p.89) IWM Strategy
DR-03	**Arden Central ISM & Open Space**	Municipal	10716m2	Flood Storage (**2,300m3**) Passive recreation Nature conservation Water feature	Langford Street (local) Innovation heart Institutional Use Moonee Ponds Creek/ Trail	Public Realm Strategy (p.89) IWM Strategy
DR-04	**Queensberry Street ISM**	Neighbourhood 500m	1939m2	Blue-Green Street	Innovation Heart Neighbourhood Open Space	Section HH Public Realm Strategy (p.92)
LP-03	**Queensberry Street Linear Open Space**	Neighbourhood 500m	2502m2	Rest Stops / integrated furniture nodes		
LP-01	**Fogarty Street ISM**	Local 300m	1365m2	Stormwater capture & filtration. Urban Greening	Fogarty Street Local Cycling Corridor & Pedestrian Priority Zone	Section FF Public Realm Strategy (p.92)
LP-02	**Arden Central Plaza**	Neighbourhood 500m	640m2	Urban Plaza Outdoor Dining Urban Greening	Innovation heart Signalised intersection Arden Street SCC, Public Transport route Barwise Street Pedestrian Priority	Section BB: Laurens Street
LP-04	**Arden Central Neighbourhood Open Space**	Neighbourhood 500m	approx 1ha	Recreation Play Informal/ passive use	Queensberry Street SCC Fogarty Street PPZ / LCC Laurens Street SCC/ Public Transport route Indoor Recreation and Community Facilities.	Public Realm Strategy (p.87)

Arden Development Contributions Plan (Key map)

LANGFORD STREET LINEAR FLOOD STORAGE & OPEN SPACE
DR-01

Catchment	Size	Functions	Interfaces
Municipal	14196m2 1.4ha	• 10,000m3 Flood Storage • Passive recreation • Heritage • Nature conservation • Wetlands / water feature	• Langford Street SCC • Innovation heart • Residential / mixed use • Moonee Ponds Creek/ Trail

Indicative Framework Plan

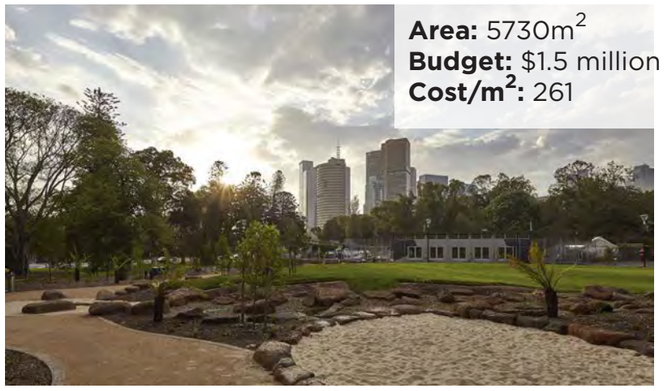
1:2000 @ A3

- DCP boundary
- Wetland opportunity
- Seating / look out node
- Indicative lawn area
- Indicative wetland/ flood storage area (subject to engineer advice)
- Indicative soccer pitch (TBC)
- New pedestrian/cycle paths
- Existing mature Plane Trees to be retained
- Outdoor fitness station
- Proposed pump station
- Picnic/ BBQ area
- Playground
- Indicative tree planting
- Heritage building for future reuse
- Indicative community garden
- Moonee Ponds Creek Trail
- Indicative runnning track
- Proposed bike lanes
- Proposed road closure to vehicles
- Proposed pedestrian priority street
- Potential trail connection & rail crossing
- Arden Central
- Arden North
- Residential / mixed use
- Innovation heart
- Community facilities

Design objectives

- Establish an ecological corridor adjacent to Moonee Ponds creek comprising a linear wetland within the flood storage area supporting indigenous flora and fauna. (Further investigations required to confirm size of wetland)
- Establish pedestrian pathways, bridges, look-out areas and interpretive signage within the wetland to allow users to connect with the landscape.
- Provide flexible lawn areas for passive recreation including picnic areas, seating, shelters and canopy vegetation.
- Establish a community garden to the north of the reserve consistent with the Integrated Water Management Strategy.
- Investigate opportunity to establish pedestrian and cycle connections from Langford Street to Moonee Ponds Creek (including rail crossings) consistent with the Strategic Opportunities Plan.
- Support a pedestrian priority zone within the road closure along Langford Street while managing pedestrian and cycle safety.
- Explore the opportunity to facilitate a public art installation within the wetland that celebrates the cultural heritage of Moonee Ponds Creek.

Precedent Projects



Fitzroy Gardens, Melbourne

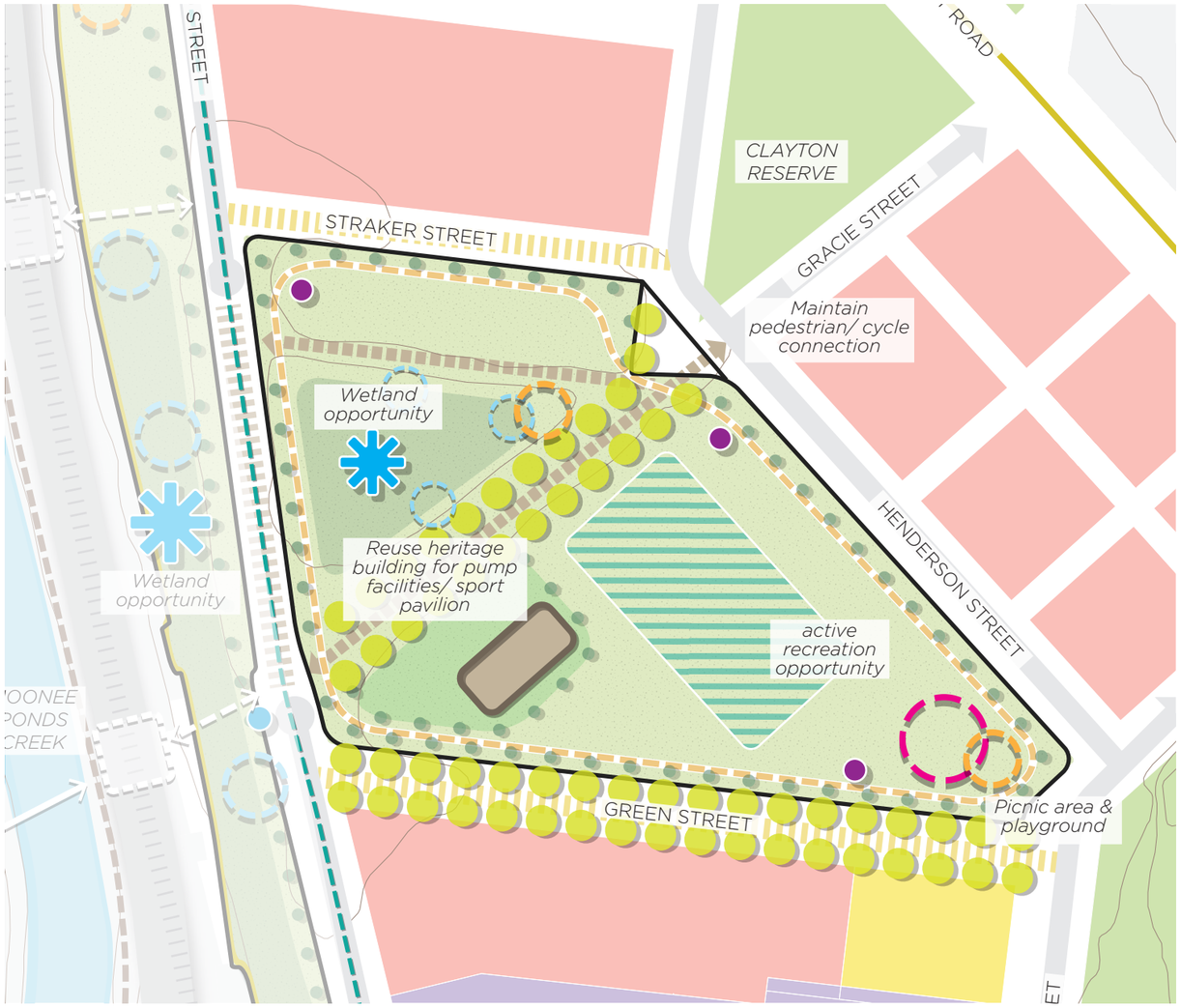
Edinburgh Gardens Raingarden, GHD, Melbourne

Trin Warren Tam-boore wetland (Royal Park)

ARDEN NORTH ISM & OPEN SPACE
DR-02

Indicative Framework Plan

1:2000 @ A3



- DCP boundary
- Wetland opportunity
- Seating / look out node
- Indicative lawn area
- Indicative wetland/ flood storage area (subject to engineer advice)
- Indicative soccer pitch (TBC)
- New pedestrian/cycle paths
- Existing mature Plane Trees to be retained
- Outdoor fitness station
- Proposed pump station
- Picnic/ BBQ area
- Playground
- Indicative tree planting
- Heritage building for future reuse
- Indicative community garden
- Moonee Ponds Creek Trail
- Indicative runnning track
- Proposed bike lanes
- Proposed road closure to vehicles
- Proposed pedestrian priority street
- Potential trail connection & rail crossing
- Arden Central
- Arden North
- Residential / mixed use
- Innovation heart
- Community facilities

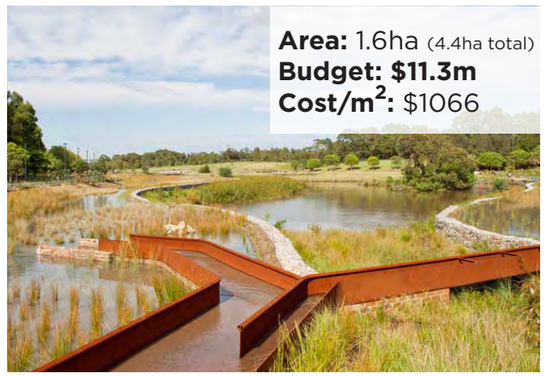
Catchment	Size	Functions	Movement Network	Interfaces
Municipal	33917m2 3.4ha	• 17,500m3 Flood Storage • Passive recreation • Heritage • Nature conservation • Water feature • Active recreation TBC	Henderson to Langford Street shared user path	• Langford Street SCC. • Stalker/Green Streets PPZ • Henderson St LCC/ Public Transport route • Innovation heart • Residential / mixed use

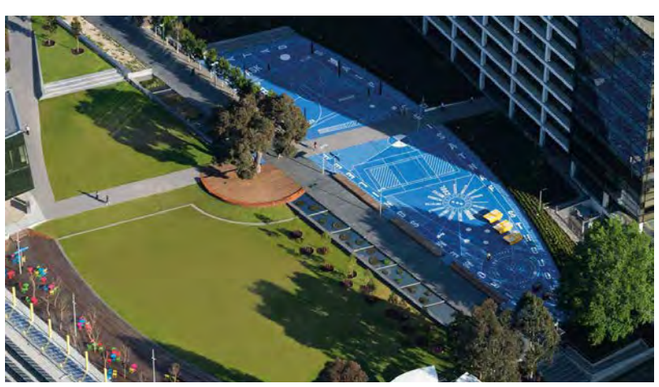
Design objectives

- Retain alignment of Gracie Street as a primary pedestrian/cycle connection to Moonee Ponds Creek. Retain the avenue of mature Plane Trees.
- Retain the alignment of the Reynolds Street as a pedestrian/cycle connection to Langford Street, providing a direct connection to Macaulay Station.
- Establish a wetland within the flood storage area adjacent to the linear wetland opposite Langford Street supporting greater biodiversity while also enabling the irrigation of surrounding lawn areas and/or sports fields. (Further investigations required to confirm size of wetland)
- Establish pedestrian pathways, bridges, look-out areas and interpretive signage within the wetland to allow users to connect with the landscape.
- Utilise the LDH heritage site within the water storage area for flood management functions & other complementary uses (Integrated Water Management Strategy).
- Implement large flexible lawn areas for passive recreation and flood storage.
- Implement BBQ/picnic facilities throughout the reserve including a playground adjacent to Green Street & Forgarty Street.
- Incorporate a recreational running loop (Approx 750-800m) to the periphery of the reserve, providing connections to Moonee Ponds Creek Trail.
- Provide fitness stations along the running track including in proximity to Henderson and Fogarty Streets.
- Provide extensive trees and planting to provide shade and amenity within the reserve.
- *Further information required regarding active recreation (soccer pitches) to perform flood management functions and meet recreational needs.*

Precedent Projects

Sydney Park Water Re-Use Project, Turf Design Studio





Monash University - Caufield campus green

ARDEN CENTRAL ISM & OPEN SPACE
DR-03

Indicative Framework Plan 1:2000 @ A3

- DCP boundary
- Wetland opportunity
- Seating / look out node
- Indicative lawn area
- Indicative wetland/ flood storage area (subject to engineer advice)
- Indicative shared user path
- Outdoor fitness station
- Picnic/ BBQ area
- Indicative tree planting
- Moonee Ponds Creek Trail
- Indicative skatepark
- Arden Central
- Arden North
- Residential / mixed use
- Innovation heart
- Community facilities
- Capital City Open Space
- New open space
- New integrated stormwater management open space

Catchment	Size	Functions	Movement Network	Interfaces
Municipal	10716m2 1ha	• **2,300m3** Flood Storage (Short term) • Passive recreation • Heritage • Nature conservation • Water feature	Shared User Path between Arden Street and Railway Place	• Langford Street (local) • Innovation heart • Institutional Use Moonee Ponds Creek/ Trail

Design objectives

- Implement a shared user path along the east of the reserve including connections to Queensberry Street cycle path (to be confirmed).
- Establish a wetland within the flood storage area supporting greater biodiversity while also enabling the irrigation of surrounding lawn areas (Further investigations required to confirm size of wetland).
- Establish pedestrian pathways, bridges, look-out areas and interpretive signage within the wetland to allow users to connect with the landscape.
- Provide flexible lawn areas for passive recreation including picnic areas, seating, shelters and canopy vegetation.
- Provide at least 1 fitness station in proximity to Queensberry Street linear open space.
- Consider outlook from potential future hospital site onto the open space. Maximize garden beds and trees to the north east of the reserve.
- Provide extensive trees and planting to provide a natural buffer from the rail reserve to the west (with consideration of flood management/ maintenance requirements).
- Planting & landscape to utilise indigenous species where reference Moonee Ponds Creek.
- Provide an all-ages and abilities skatepark of at least 700m2 within the reserve comprising passive surveillance from surrounding streets and paths as well as integrated seating areas and landscaping

Precedent Projects

Edinburgh Gardens Raingarden, GHD, Melbourne

Adelaide Botanic Garden wetland

Victoria Green, Docklands

QUEENSBERRY STREET
LP-03 / DR- 04

Catchment	Size	Functions	Movement Network	Interfaces
Neighbourhood 500m	4441 m2	Blue-Green Street Rest Stops / integrated furniture nodes	Strategic link to DR-03	Innovation Heart Neighbourhood Open Space

Indicative Framework Plan

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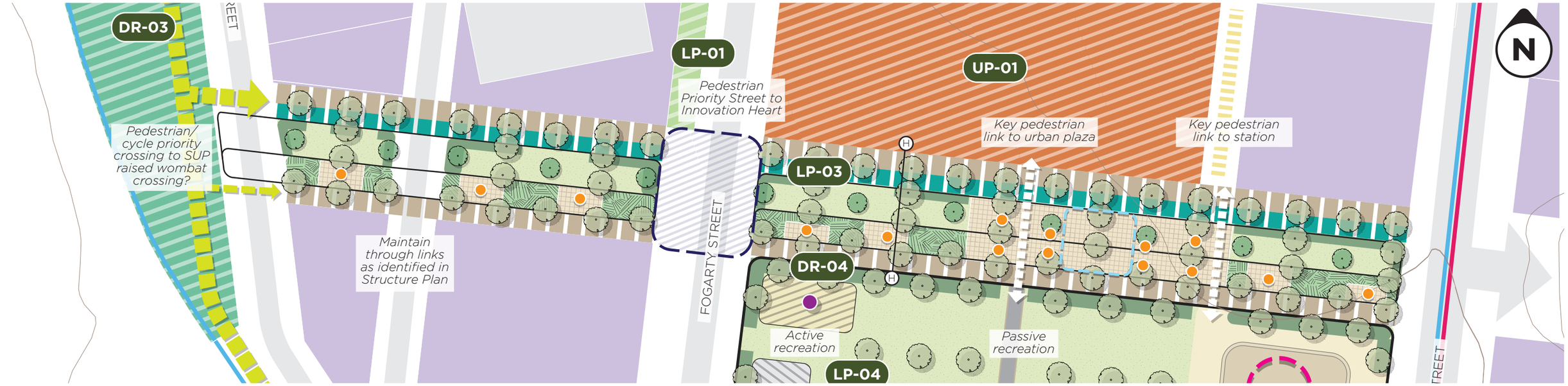


- DCP boundary
- Indicative lawn area
- Indicative granitic gravel paving
- Indicative permeable paving
- Indicative WSUD raingarden
- Outdoor fitness station
- Multi-use court
- Indicative garden bed
- Indicative asphalt path
- Playground
- Picnic/ BBQ area
- Indicative seating/furniture node
- Potential water play/ feature
- Critial pedestrian connection
- Proposed bike lanes
- Proposed pedestrian path
- Proposed pedestrian priority street
- Arden Central
- Laurens Street
- Arden Station above-ground facilities
- Innovation heart
- Community facilities
- Capital City Open Space
- New integrated stormwater management open space

Design objectives

All

- Maximise WSUD opportunities including rain gardens, bio-retention swales and permeable paving (subject to engineering advice).
- Implement a large permeable paved area between the civic square and neighbourhood open space to enable pedestrian access between spaces.
- Providing seating areas and shade structures to provide passive recreation opportunities near high density commercial development.
- Provide feature lighting within the reserve opposite the civic square to ensure nighttime use.
- Explore the opportunity to integrate an urban water play feature within the paved area.

DR-04

- Establish an ecological corridor along Queensberry to Langford Street by retaining a landscape buffer adjacent to the open space reserve (north).
- Provide extensive canopy vegetation and native planting (biodiversity planting palette) to create a high amenity streetscape that manages water run off and urban heat island effect.
- Provide expanded footpath widths and public seating nodes utilising permeable paving to allow for water capture/storage.

LP-03

- Provide flexible lawn areas for passive recreation including picnic areas, seating and canopy vegetation.
- Frame lawn areas with garden beds comprising indigenous plants to define passive recreation areas and guide pedestrian movement.

University Square, Melbourne (2000m2 biodiversity planting)

Neil Street Reserve, Carlton

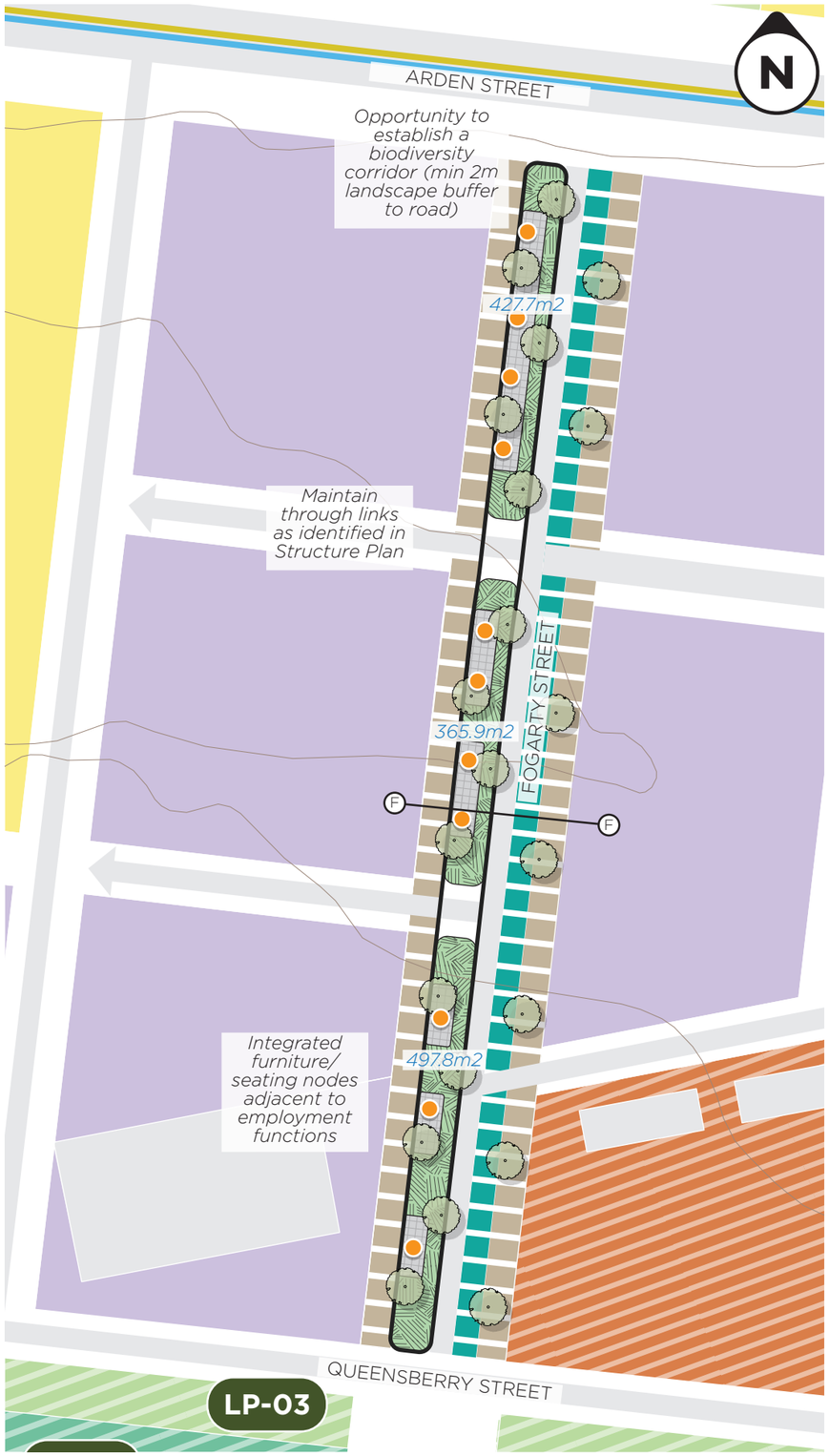
Darling Quarter playground, Aspect Studios

Darling Quarter open space, Aspect Studios

FOGARTY STREET LINEAR OPEN SPACE
LP-01

Catchment	Size	Functions	Movement Network	Interfaces
Small local 300m	1365m2	Blue-Green Street Urban Greening	Fogarty Street Local Cycling Corridor & Pedestrian Priority Zone	Innovation Heart

Indicative Framework Plan



- DCP boundary
- Indicative permeable paving
- Indicative WSUD raingarden
- Indicative seating/furniture node
- Proposed bike lanes
- Proposed pedestrian path
- Arden Central
- Arden North
- Arden Station above-ground facilities
- Innovation heart
- Community facilities
- Capital City Open Space
- New open space
- New integrated stormwater management open space

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0 5 10 15 20 25

Design objectives

- Maximise WSUD opportunities including rain gardens, bio-retention swales and permeable paving (subject to engineering advice).
- Establish an ecological corridor along the extent of Fogarty Street by retaining a minimum 2m wide landscape buffer adjacent to the carriageway.
- Provide extensive canopy vegetation and native planting (biodiversity planting palette) to create a high amenity streetscape that manages water run off and urban heat island effect.
- Provide expanded footpath widths and public seating nodes at the interface with high density commercial development utilising permeable paving to allow for water capture/ storage.
- Apply varied pavement configurations within each urban block, increasing permeability toward the lowest end the street.

Precedent Projects

University Square, Melbourne (2000m2 biodiversity planting)

Railway Place & Miller St Reserve

Eastwood Rankins

Howard St, Raingardens

ARDEN CENTRAL NEIGHBOURHOOD OPEN SPACE
LP-04

Indicative Framework Plan

1:1000 @ A3

0 5 10 15 20 25

- DCP boundary
- Indicative lawn area
- Indicative granitic gravel paving
- Indicative permeable paving
- Indicative WSUD raingarden
- Outdoor fitness station
- Multi-use court
- Indicative garden bed
- Indicative asphalt path
- Playground
- Picnic/ BBQ area
- Indicative seating/furniture node
- Potential water play/ feature
- Critial pedestrian connection
- Proposed bike lanes
- Proposed pedestrian path
- Proposed pedestrian priority street
- Arden Central
- Laurens Street
- Arden Station above-ground facilities
- Innovation heart
- Community facilities
- Capital City Open Space
- New integrated stormwater management open space

Catchment	Size	Functions	Interfaces
Neighbourhood 500m	Approx 1ha	• Active recreation • Playground • Passive recreation	• Queensberry Street SCC • Fogarty Street PPZ / LCC • Laurens Street SCC/ Public Transport route • Indoor Recreation and Community Facilities.

Design objectives

- A gateway passive open space having a strong relationship with Arden Station and the Civic Square, set within a significant employment precinct.
- Provide flexible lawn areas for passive recreation including picnic areas, seating and shelters.
- Provide at least 1 fitness station and a multi-use court in proximity to Fogarty Street.
- Provide extensive trees and planting to the perimeter of the reserve to provide a natural buffer from surrounding streets and connect to the linear open space at the north.
- Implement a playground to the east of the reserve in proximity to Arden Station and the Laurens Street precinct.
- Provide a BBQ and picnic facility adjacent to the playground to cater to families and group gatherings.
- Establish pedestrian connections through the reserve to connect the community use with the civic plaza and station.

Precedent Projects

Docklands City Park (stage 2): Active recreation

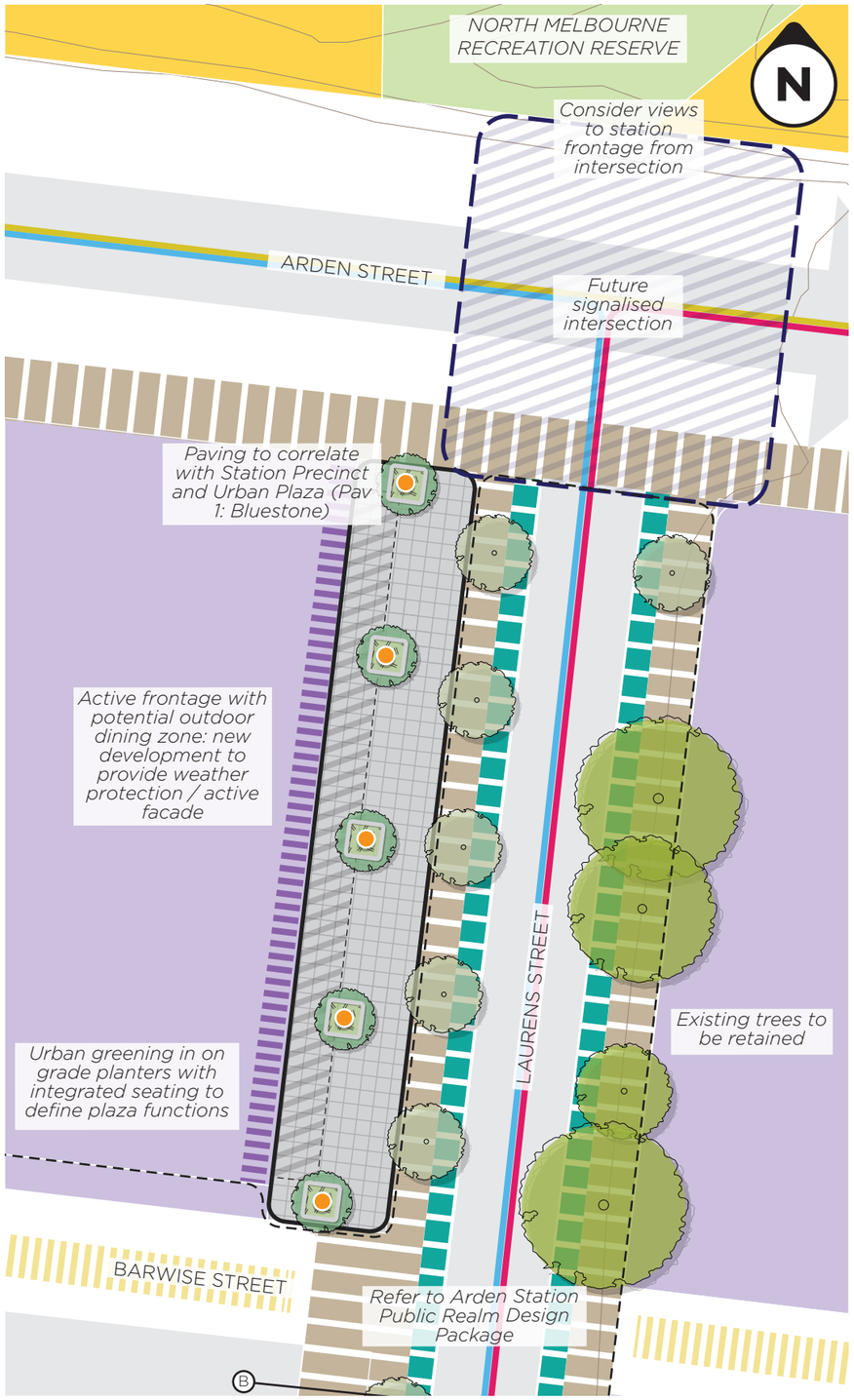
Boyd Park, Southbank

Hawke and Adderly: playspace

ARDEN CENTRAL PLAZA
LP-02

Catchment	Size	Functions	Movement Network	Interfaces
Small local 300m	640m2	• Seating / Gathering • Outdoor dining • Street Greening	• Proximity to Arden Station • Laurens Street SCC/ Public Transport route	• Innovation heart • Signalised intersection • Arden Street SCC, Public Transport route • Barwise Street Pedestrian Priority

Indicative Framework Plan



- DCP boundary
- Arden Station public realm extent
- Indicative bluestone paving
- Indicative WSUD raingarden
- Indicative seating/furniture node
- Proposed bike lanes
- Proposed pedestrian path
- Existing trees to be retained (Arden Station plans)
- Potential outdoor dining zone
- High quality interface response
- Proposed pedestrian priority street
- Arden Central
- Arden North
- Laurens Precinct
- Arden Station above-ground facilities
- Innovation heart
- Community facilities
- Indoor recreation
- New open space
- New integrated stormwater management open space

Design objectives

- Provide expansive bluestone paved areas to cater to large pedestrian volumes between the station and Arden Street.
- The design of the plaza should complement the public realm design of Arden Station and the Capital City Open Space.
- Consider long-range views through the plaza from North Melbourne Recreation Reserve to the Station Entry.
- Maximise WSUD opportunities including rain gardens and permeable paving (subject to engineering advice).
- Provide canopy vegetation with integrated seating to provide shade and amenity to Laurens Street.
- Implement feature lighting within the plaza (including uplights and pole lights) to ensure the space is useable at night.
- Implement an outdoor dining zone to the private realm interface to encourage activation and diverse uses within the plaza.
- Implement design guidelines for new development to ensure new development presents positive active frontages to the plaza.

Precedent Projects

Swanston Street, Melbourne

Londsdale Street, Dandenong

Elizabeth Street, Melbourne

Southbank Boulevard

Appendix 1: Strategic Background

Arden Context

- World-class innovation and technology precinct.
- new Arden train station scheduled to open in 2025.
- The station will connect the digital technologies, life sciences, health and education sectors in Arden with Victoria's growing knowledge economy.
- 34,000 jobs + 15,000 residents by 2051.

Arden Structure Plan
Relevant Objectives

Objective 4:
*Deliver a new urban structure for Arden that incorporates a **high-quality network of connected streets and open spaces** that help support a varied and walkable block structure.*

Objective 14:
*Mitigate the urban heat island effect in the design and delivery of the public realm and private developments accordant with desired **urban greening outcomes and standards**.*

Objective 17:
*New and existing streets will be **pedestrian-friendly and provide comfortable, green links** between open spaces and public transport routes and enhance the quality of the public realm.*

Objective 19:
***Safely manage the risk of flooding** to future development of Arden through **innovative and creative flood management solutions** in the natural landscape and built environment.*

Objective 20:
*Establish an **alternative water system** across Arden that provides access to high-quality alternative water to be used in buildings and to irrigate open spaces.*

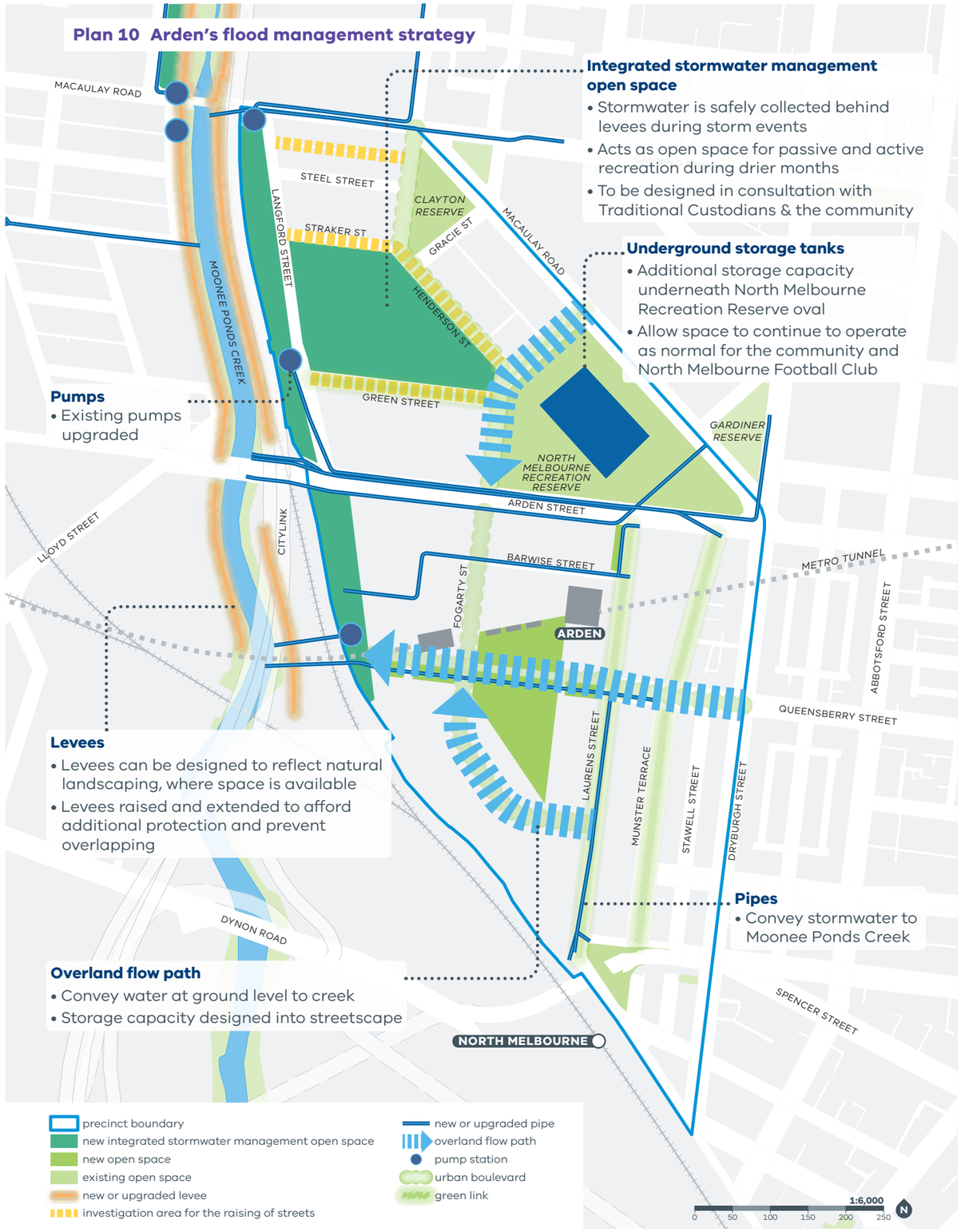
Objective 21:
*Provide **generous, well-designed and accessible open spaces** that are diverse and flexible to meet the needs of Arden's evolving community and visitors to the precinct.*

Objective 22:
*Establish **design excellence** and design objectives for streets, open spaces and development interfaces to ensure the public realm works as a seamless, integrated and continuous space for people.*

Arden Structure Plan
Public Open Space Network & Flooding Management

Plan 11 Arden's future public realm and open space network

Plan 10 Arden's flood management strategy



Arden Structure Plan
Understanding Interfaces: Urban Structure & Transport Network

Plan 5 Arden's future urban structure

Arden North will be defined by...

1. Water in the landscape, where streets will manage water flows with green links and cloudbusrt elements. The new Arden North integrated stormwater management open space will help manage flooding during rain events.
2. Continuous green space that extends from the North Melbourne Recreation Reserve.
3. The Fogarty Street urban boulevard providing green links and public transport options, connecting Arden North to Arden Central and the Macaulay urban renewal area.
4. New and expanded community facilities at the North Melbourne Recreation Reserve.

Arden Central will be defined by...

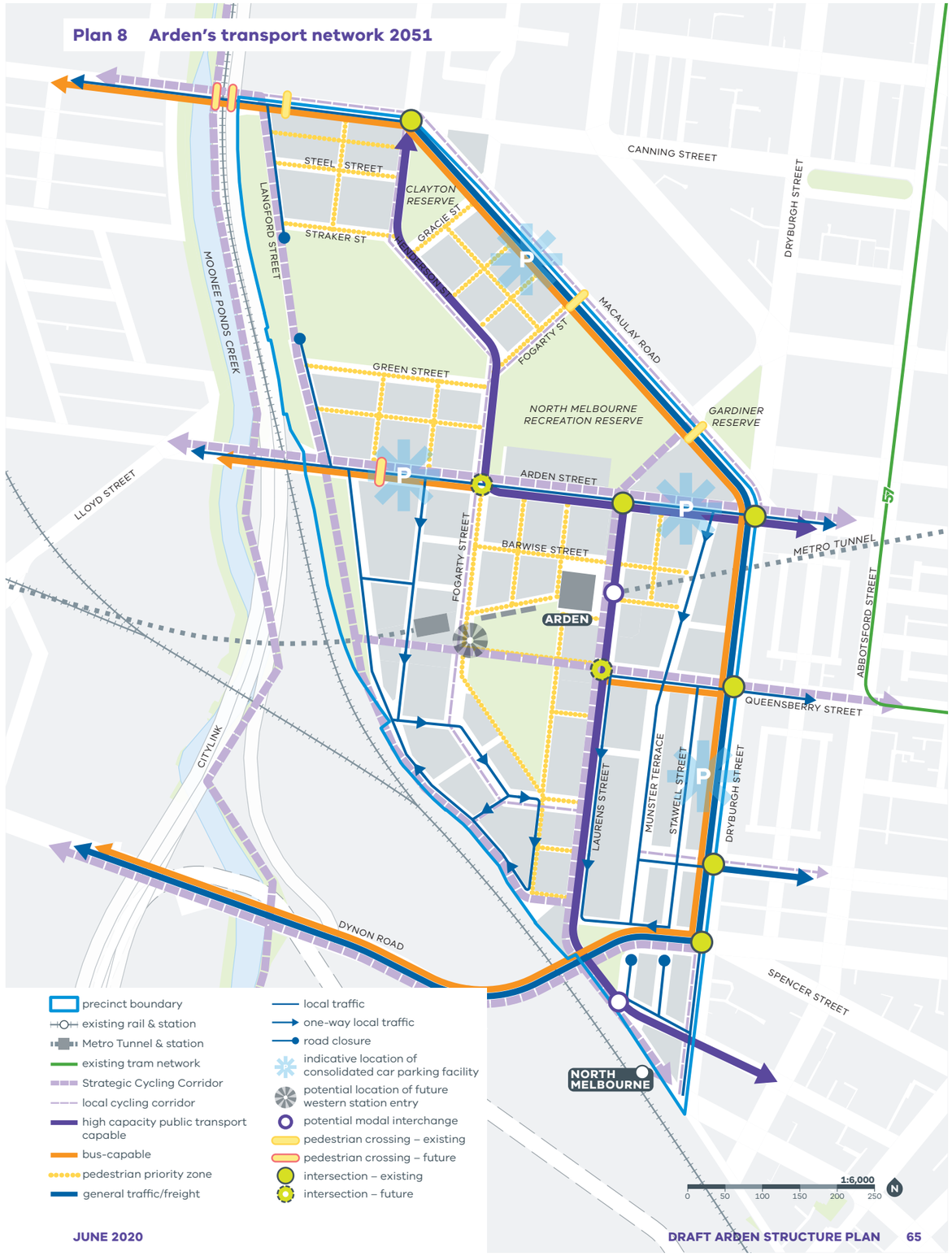
5. A major health or education institution embedded in the precinct to foster innovation.
6. Design excellence and leading sustainability practice in buildings and the wider public realm.
7. A major activity centre for Arden around the station and major intersections of Queensberry Street, Fogarty Street and Laurens Street.
8. A civic centre in Arden Central including open space, public transport, public institutions and a proposed government primary school, framed by mixed-use development.

Laurens Street will be defined by...

9. Transitional density opportunities that provide a comfortable interface to the activity of Arden Central.
10. Walkable and connected streets that invite visitors into the precinct with sustainable transport links along the Queensberry Street boulevard.
11. Built form that complements and builds on existing North Melbourne character, seamlessly interfacing with the existing residential areas to the east with creative and adaptive reuse of heritage buildings.

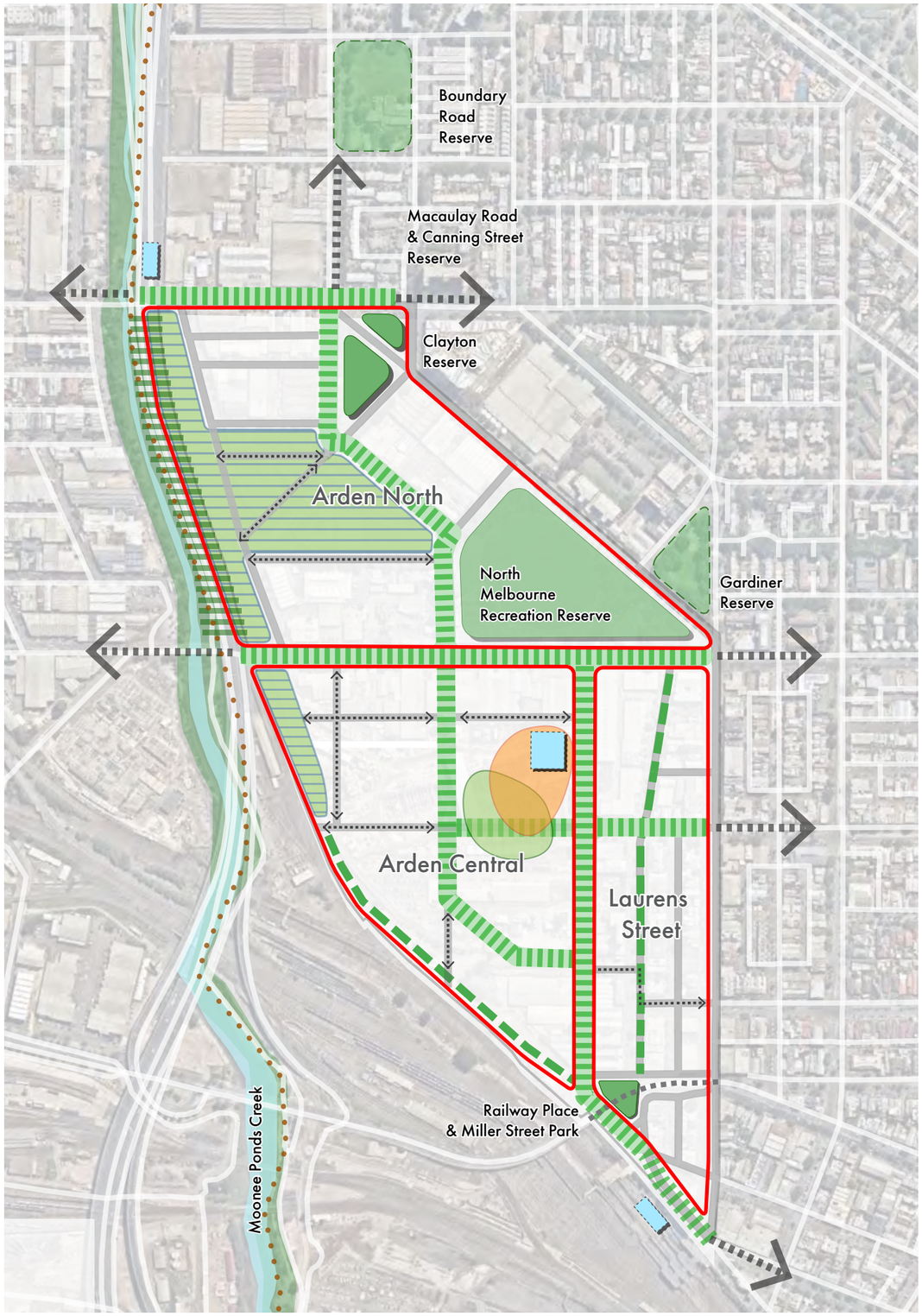
- precinct boundary
- innovation hub
- residential/mixed use
- transitional residential & business
- innovation heart
- community facilities
- potential institutional use
- local indoor recreation
- Capital City Open Space
- new open space
- existing open space
- new integrated stormwater management open space
- new Arden Station above-ground features

Plan 8 Arden's transport network 2051



- precinct boundary
- existing rail & station
- Metro Tunnel & station
- existing tram network
- Strategic Cycling Corridor
- local cycling corridor
- high capacity public transport capable
- bus-capable
- pedestrian priority zone
- general traffic/freight
- local traffic
- one-way local traffic
- road closure
- indicative location of consolidated car parking facility
- potential location of future western station entry
- potential modal interchange
- pedestrian crossing – existing
- pedestrian crossing – future
- intersection – existing
- intersection – future

Arden Public Realm & Open Space Strategy
Public Open Space Typologies



Capital City Open Space

Centrally located in Arden Central and connecting the forecourt of the new station.

Accommodates a range of event types and scales.

Providing robust, hard-wearing surfaces.

Providing high levels of tree canopy and soft landscape.

Combining and integrating the adjacent neighbourhood open space.

Neighbourhood Open Space

Maximising soft landscape with generous, flexible lawn spaces.

Providing substantial tree canopy coverage.

Providing for small social gathering and picnic facilities and play equipment.

Providing a mix of facilities for workers and residents including of sports, quiet spaces for lunches, adequate provision of furniture, fixtures and shelter.

Integrated Stormwater Management

A series of accessible, usable open spaces that will provide a chain of recreational opportunities.

Using the level changes for the stormwater function as integrated passive recreation, garden bed and trail network elements.

Opportunities for biodiversity improvement, ecological restoration, and the permanent presence of water.

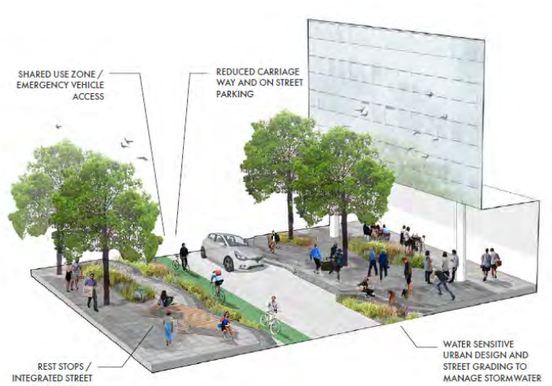
Maintaining the opportunity for future broad and direct connections to Moonee Ponds Creek.

Green Streets

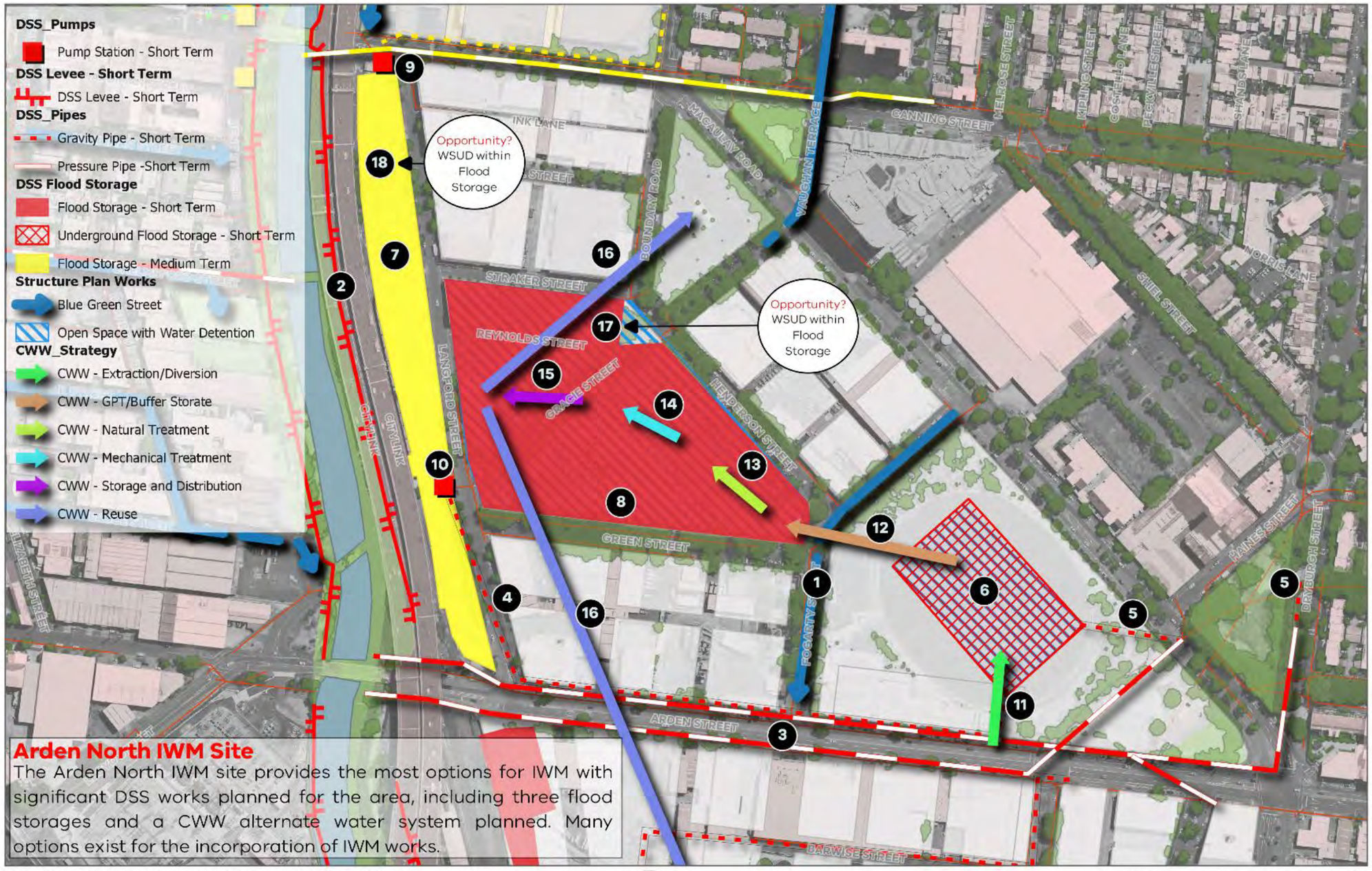
landscaped garden beds and water sensitive urban design in areas that require increased protection from vehicle traffic.

Providing continuous street tree planting and associated improvements to stormwater drainage.

Providing for respite points and informal rest stops through use of integrated street furniture, bollards and garden bed edges.

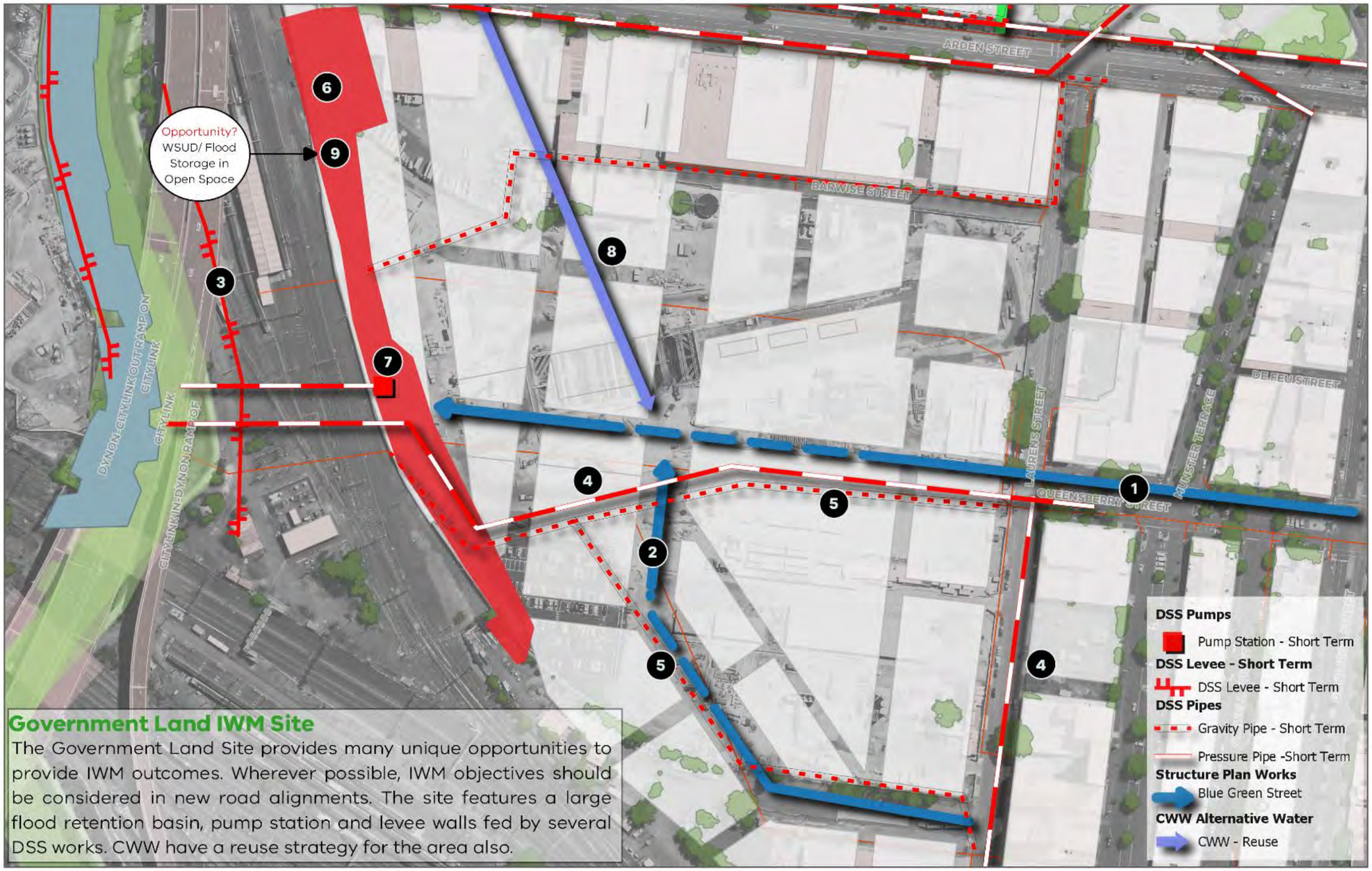


Integrated Water Management Strategy
Ambitions for flood storage in Arden



- 2022/23: Langford Street Linear Flood Storage (7)
- 2022/23: WSUD within the Flood Storage (18)
- 2022/23: Langford Street Pump Station 2 (10)
- 2027/28: CityWide/LDH Storage (8)
- 2027/28: natural treatment (13), mechanical treatment (14) and storage and distribution (15) and reuse diversion (16)
- 2027/28: The WSUD within the flood storage (17)

Integrated Water Management Strategy
Ambitions for flood storage in Arden



Arden Macaulay IWM Opportunities
Government Land Site

Data Sources: City of Melbourne, Melbourne Water

- 2025/26: Arden Government Land Flood Storage.
- WSUD within the flood storage (9)
- The Queensberry Street Blue Green Street (Opportunity 1) should be completed with or after the construction of the flood storage (Opportunity 6)

North Melbourne

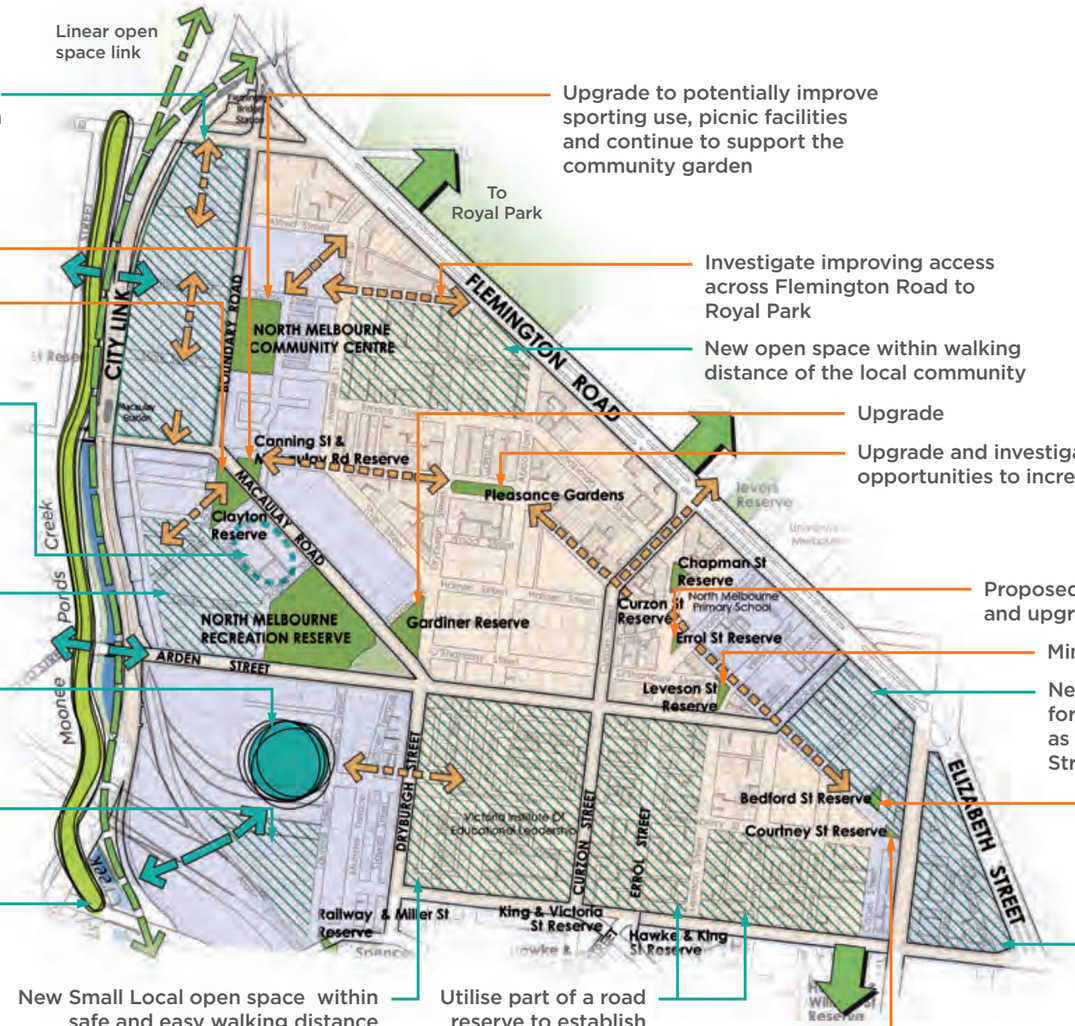


Diagram key

Sub-precinct for proposed Local and Small Local open space

Indicative location for proposed Capital City open space

Improved open space corridor along Moonee Ponds Creek

Refer to diagram key on page 12 for additional information.

0 500m

Melbourne Water / MPA

Arden Macaulay Precinct

Stages 1 and 2




29 February 2016

V3000_052

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Appendices

1. INTRODUCTION

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 Melbourne Metro Rail Authority (MMRA) planning to locate the proposed underground Arden Central Station within the precinct. Figure 1.1 shows the location and key features of the precinct.

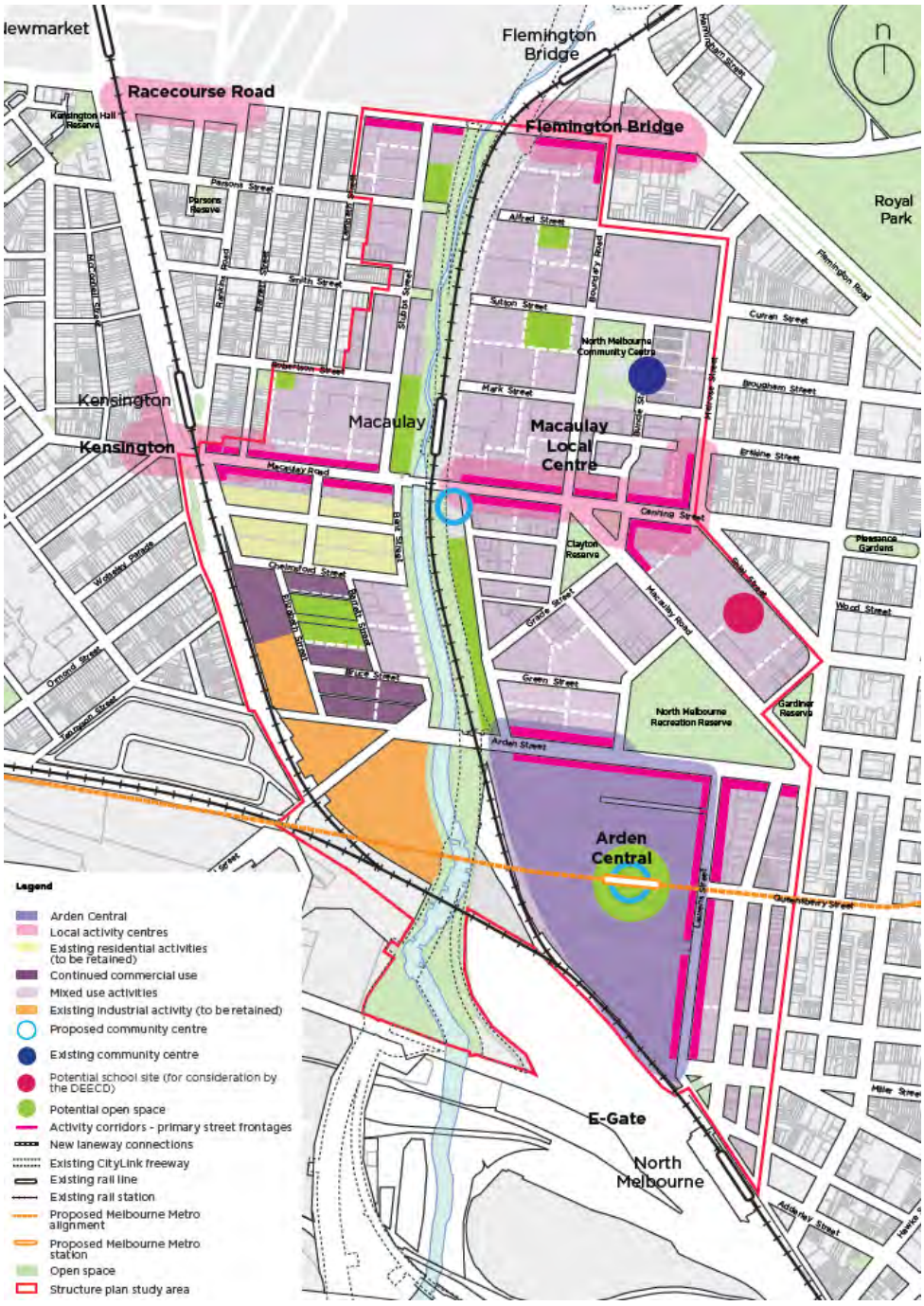


Figure 1.1 Arden Macaulay Precinct Plan (source: Arden Macaulay Structure Plan, 2012, City of Melbourne)

A key focus of the precinct is government owned land south of Arden Street. This is the site for the proposed Arden Central Station. Figure 1.2 and Figure 1.3 provide an impression of the proposed development south of Arden Street.

Figure 1.2 Aerial image of current development south of Arden Street (source: Google Earth)

Figure 1.3 Potential development of government land south of Arden Street (source: Arden Urban Renewal Precinct Strategic Vision, MGS Architects 2015)

The section of Moonee Ponds Creek that runs through the Arden Macaulay Precinct is visually unpleasant, offers limited environmental benefits and is subject to flooding. Drainage of low lying areas of the precinct relies on pump stations and flood gates. Figure 1.4 provides a photo of Moonee Ponds Creek taken from the Racecourse Road Bridge.

Figure 1.4 Moonee Ponds Creek, looking south from the Racecourse Road Bridge (date of photo 20/1/2016)

Flooding and drainage is well recognised as a significant factor in development planning of the precinct. The opportunity now exists to plan for the transformation of the creek and 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 develop to fund works.

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

Melbourne Water engaged Engeny to undertake a two stage investigation of drainage within the precinct. Stage 1 of the investigation is to:

- Develop an understanding of the baseline scenario and year 2100 scenario flooding within the precinct through updated two dimensional (TUFLOW) hydraulic modelling.
- Review the MPA's strategic vision for future redevelopment in the precinct.
- Review the MMRA's flood mitigation proposal.

Stage 2 of the investigation is to:

- Identify a range of potential flood mitigation works
- Conduct a workshop with key stakeholders to discuss the flood mitigation works
- Refine and conduct more detailed investigations (including hydraulic modelling) for a selection of the flood mitigation works, with the selected mitigation works based on the outcomes from the stakeholder workshop
- Provide advice on infrastructure required for the flood mitigation works
- Provide advice on the structure of the urban layout of the precinct

Engeny prepared a report for stage 1 of the investigation in January 2016. This current document expands on the stage 1 report to provide a consolidated report on both stages 1 and 2 of the investigation.

2. DEVELOPMENT WITHIN FLOOD PRONE AREAS

2.1 Previous Flooding Within the Precinct

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 1.3 metres above sea level. The Arden Macaulay Precinct Plan identifies intensive development of these areas.

Figure 2.1 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 2.2 provides a photo of previous flooding around Langford Street in March 2010.

Figure 2.1 Flooding of Stubbs Street Kensington taken from within shop on 8/10/2010 (source of photo: City of Melbourne)

Figure 2.2 Flooding around Langford Street North Melbourne on 7/3/2010 (source of photo: hersaldsun.com.au)

2.2 Land Subject to Inundation Overlay

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. The LSIO relates to flooding along major waterways and is typically based on the predicted flood extent in a one per cent annual exceedance probability (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.

The planning scheme also includes a Special Building Overlay (SBO) which covers a small section of the Arden Macaulay Precinct upstream of Arden Street Oval. The SBO is associated with flooding of overland flow path in areas with underground drainage systems and is also typically based on the flood extent in a 1% AEP event. The SBO is related to flooding above Melbourne Water's Arden Street Drain. The purpose of the SBO is to set appropriate conditions and building floor levels to address the flood risk and to ensure that flood waters are not obstructed or diverted by development.

There are no flood related overlays in the planning scheme related to flooding of City of Melbourne's drainage system.

Figure 2.3 provides the extent of the LSIO and the SBO within the Arden Macaulay Precinct.

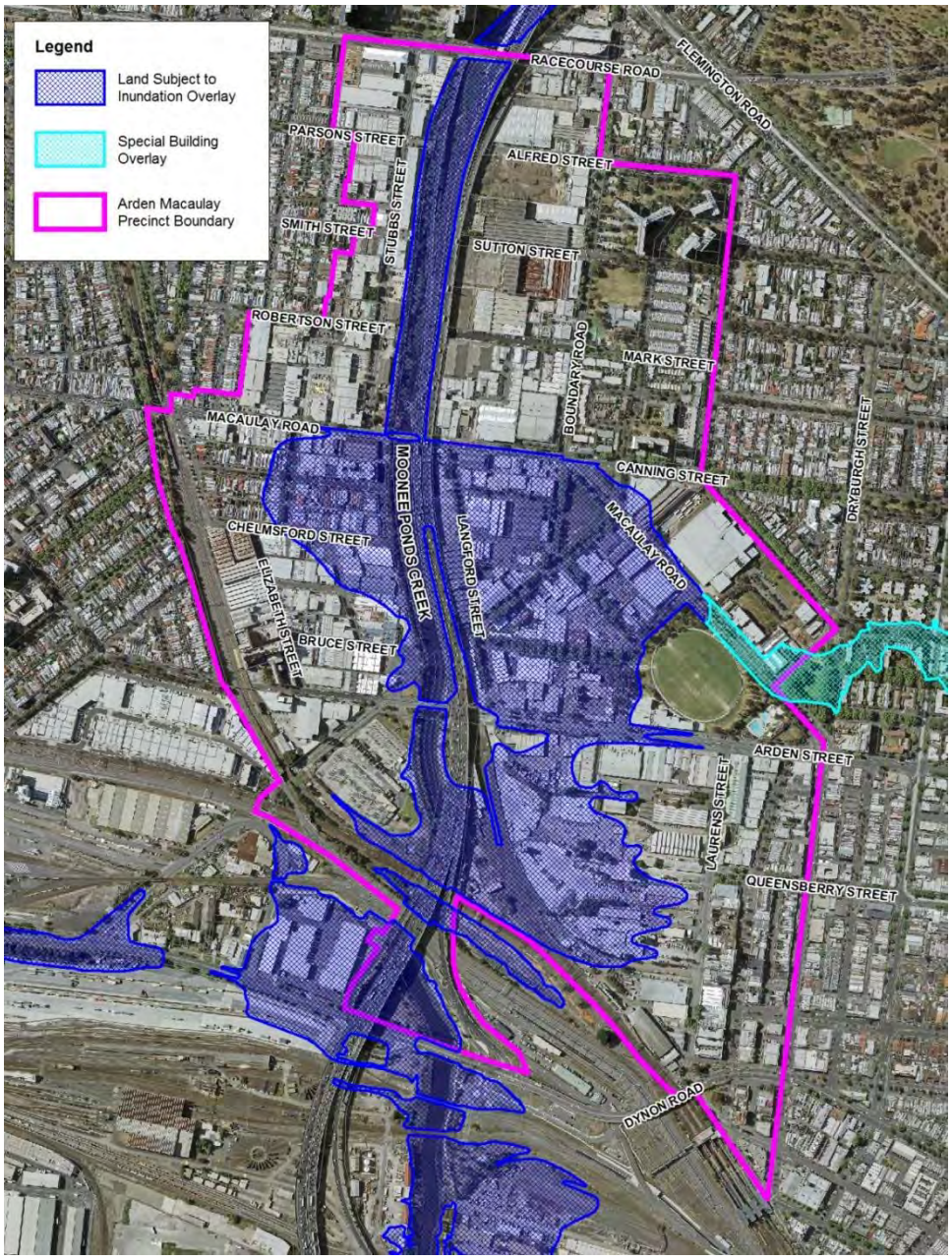


Figure 2.3 Land Subject to Inundation Overlay within the Arden Macaulay Precinct

2.3 Flood Hazards

Flood hazard assessment which is referred to in this report is based on the method described in Floodplain Management in Australia, Best Practice Principles and Guidelines, SCARM Report 73, 2000 (SCARM 73). SCARM 73 categorises land into a number of flood hazard categories, as follows:

- Flood free
- Low hazard

- Medium hazard
- High hazard
- Extreme hazard

There are a number of factors used in floodplain management that affect the flood hazard rating. The factors that are used in SCARM 73 to assess flood hazard for an area are:

- Depth of flooding
- Velocity of flooding
- Flood warning time
- Flood evacuation time

Appendix J of SCARM 73 uses the depth and velocity of floodwaters to obtain an "Initial Flood Hazard". In this report, flood depth has typically been used to categorise flood hazard, with a flood depth exceeding 1.2 metres indicative of extreme flood hazard. Figure 2.4 provides a copy of Figure J.1 from SCARM 73.

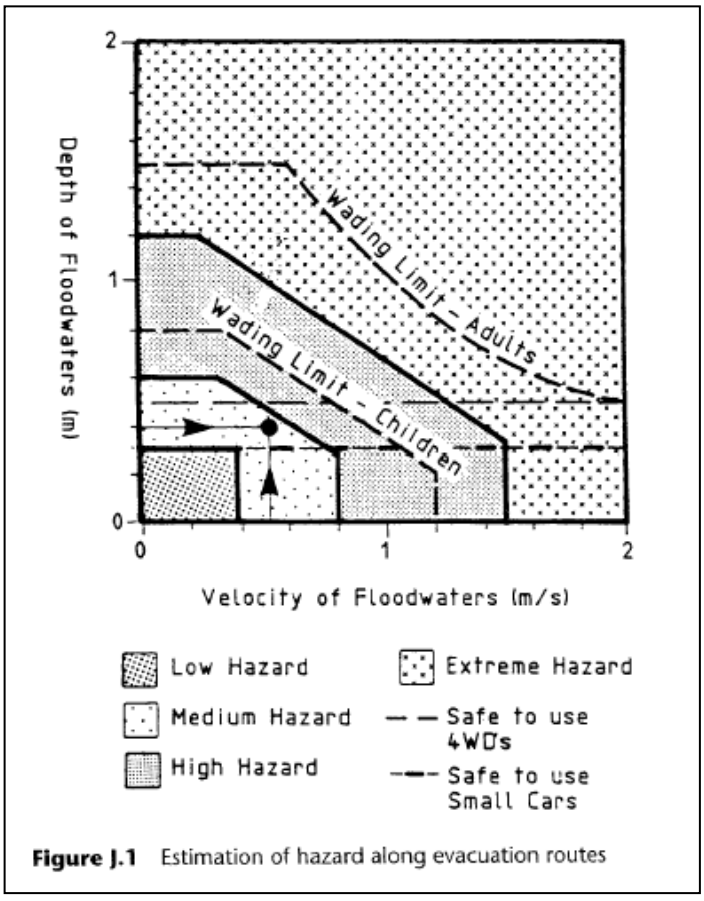


Figure 2.4 Initial flood hazard categorisation (source: SCARM 73)

2.4 Melbourne Water Guidelines

Melbourne Water's Guidelines for Development in Flood Prone Areas (May 2007, available online) 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. Key aspects from these guidelines include:

- The 1% AEP 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.
- Works or structures must not affect floodwater flow capacity.
- Works or structures must not affect floodwater storage capacity.
- A minimum of 600 millimetres must be provided between a building floor level and the 1% AEP flood level within floodplains.
- A minimum of 300 millimetres must be provided between a building floor level and the 1% AEP flood level within overland flow paths.
- Development cannot be allowed in circumstances where the depth and flow of floodwater affecting access to the property is hazardous.

Under existing flooding conditions, there are flood prone areas of the Arden Macaulay Precinct that do not satisfy the above requirements. Melbourne Water will need to consider the proposed development of the precinct and how this development can occur in such a way so that Melbourne Water meets its obligations as the floodplain management authority. This will have to consider how existing and proposed development and residents are appropriately protected from flooding.

3. DATA CONSOLIDATION AND REVIEW

A range of previous studies have been undertaken related to drainage in the Arden Macaulay Precinct and flooding associated with Moonee Ponds Creek and/or local drainage catchments. Engeny has reviewed these studies and used information from the studies as inputs to the current work, where appropriate. Additional information has also been sourced from relevant stakeholders. Table 3.1 summarises key data used in the current study.

Table 3.1 Summary of data used in the current study

Data	Source	Comments
Moonee Ponds Creek two dimensional (TUFLOW) hydraulic model, existing conditions	Provided by Melbourne Water, model developed by AECOM in 2013 on behalf of the Department of Transport, Planning and Local Infrastructure Victoria	Modified for the purpose of the current study as described in Section 4.1
Moonee Ponds Creek two dimensional (TUFLOW) hydraulic model, mitigation scenario	Provided by Melbourne Water, model developed by AJM in 2015 on behalf of the MMRA	Includes drainage works as part of the MMRA flood mitigation proposal
Moonee Ponds Creek one dimensional (HECRAS) hydraulic model	Melbourne Water	Data used for verification of bridge structures in the TUFLOW model
Moonee Ponds Creek catchment RORB hydrology model for existing conditions	Melbourne Water	Used for application of inflows to Moonee Ponds Creek at Mt Alexander Road in the TUFLOW model
Moonee Ponds Creek catchment RORB hydrology model for future development conditions	Melbourne Water, developed by GHD as part of the Arden Macaulay IWM Plan (2015)	Used for application of inflows to Moonee Ponds Creek at Mt Alexander Road in the TUFLOW model
Arden Macaulay Precinct local catchment RORB hydrology model	Provided by Melbourne Water, model developed by AECOM in 2013 on behalf of the Department of Transport, Planning and Local Infrastructure Victoria	Used for application of inflows to local catchments in the TUFLOW model

Data	Source	Comments
City of Melbourne drainage GIS data	City of Melbourne	There is more confidence in this data than Melbourne Water's records for City of Melbourne's drainage data
Melbourne Water's Arden Street Drain design plans	Melbourne Water	These plans are old and difficult to read, but provide some information on the irregular shape of the Arden Street Drain
Survey of Moonee Ponds Creek between Macaulay Road and Arden Street	Melbourne Water	Data used to revise definition of this reach of Moonee Ponds Creek in the TUFLOW model
Survey of levees between Arden Street and Racecourse Road	Melbourne Water	Data used to revise definition of the levees in the TUFLOW model
Arden Urban Renewal Precinct Strategic Vision	Provided by MPA, document prepared by MGS Architects (2015)	The preliminary master plan from this document used to review the MPA strategic vision for development

4. EXISTING CONDITIONS ASSESSMENT

4.1 Updates to the Models

A two dimensional (TUFLOW) hydraulic model originally developed by AECOM in 2013 has been used as the basis for hydraulic assessment of drainage within the Arden Macaulay Precinct. The extent of this model covers Moonee Ponds Creek from just north of Mt Alexander Road until the confluence with the Yarra River. The model also extends to local catchments draining 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.

Engeny understands that the original purpose of this model when developed by AECOM was to investigate flooding of Arden Street and the E-Gate site (south of Dynon Road). Upon review of the model it was deemed necessary to make some changes to the model to improve confidence in the model's results and therefore make it suitable for use for the current study. Table 4.1 summarises the key changes made to the TUFLOW model.

Table 4.1 Key changes to the TUFLOW model for existing conditions

Component of Model	Description of changes
Piped drainage system	A comprehensive review of the piped drainage system in the model was undertaken. The following key changes were made: • Revised pipe dimensions and network connectivity using GIS data from the City of Melbourne. The City of Melbourne's GIS data has been updated since the original model build and is different to Melbourne Water's records of City of Melbourne's drainage system. • Revised invert levels in order to resolve pipes that had positive grades. All pipes now have a negative grade (graded downstream) or are at least flat. • Revised pipe directions so that all pipes are digitised from upstream to downstream.
Representation of levees	The definition of the levees has been refined based on 2013 survey provided by Melbourne Water.
Definition of Moonee Ponds Creek	The definition of Moonee Ponds Creek between Macaulay Road and Arden Street has been revised based on 2007 survey provided by Melbourne Water.
Bridges	The original model build's representation of bridges is generally consistent with the Moonee Ponds Creek HECRAS model (which has bridges modelled based on survey). Some minor modifications were made to fix anomalies in the data. The representation of CityLink has been revised, with each pier impacting flow in Moonee Ponds Creek modelled separately.

Component of Model	Description of changes
Application of external local catchment inflows	The TUFLOW model does not cover the full extent of the external catchments that drain through the Arden Macaulay precinct, but accounts for runoff contributing to the drainage system within the precinct from these areas using routed flows from the local catchment RORB hydrology model. Some changes were made to ensure that these external flows were applied to appropriate parts of the model.
Application of Moonee Ponds Creek inflows	The TUFLOW model uses an inflow hydrograph from the Moonee Ponds Creek RORB model to represent dynamic flows in the creek. The TUFLOW model was referencing a RORB hydrograph at the confluence of Moonee Ponds Creek and the Yarra. This has been revised so that a hydrograph of Moonee Ponds Creek at Mt Alexander Road is applied.
Surface roughness	The TUFLOW model defines surface roughness based on City of Melbourne's 2008 Land Cover data. Some modifications have been made, particularly at roads, where overhanging trees captured in the Land Cover data set had inappropriately increased surface roughness.
Tail water level	The tail water level at the downstream end of Moonee Ponds Creek has been increased from 1.22 metres AHD to 1.4 metres AHD to reflect Melbourne Water's recommendations in Melbourne Water's Flood Mapping Guidelines and Technical Specification (2015).

A key revision made to the model was the updated pipe dimensions and network connectivity using GIS data from the City of Melbourne obtained by Engeny in 2016. This data was particularly useful to update the model's representation of sections of the piped drainage where previously modelled details appeared to be incorrect. Figure 4.1 provides an example of the changes made to the model using the City of Melbourne's updated GIS data, with the key changes highlighted in the image on the right. This area is within the Arden Macaulay Precinct.

Figure 4.1 Example of changes to the pipe data in the TUFLOW model

4.2 Limitations of the Model

Engeny believes that the changes made to the TUFLOW model increase confidence in the accuracy of the model's outputs. There are still some limitations to the modelling, which are summarised in Table 4.2. Overall, Engeny believes that the model is appropriate to be used as a planning tool for the Arden Macaulay Precinct.

Table 4.2 Model limitations

Component of Model	Limitation
Piped drainage system	Despite significant updates to the model's representation of the piped drainage system, some limitations remain: • Melbourne Water's Arden Street Drain has been represented as a rectangular pipe (as per the original model build), using height and width dimensions consistent with Melbourne Water's GIS. Design plans provided by Melbourne Water show that this pipe is an irregular shaped arch drain, with the cross-section of the drain changing numerous times along its length. These plans are old and it may be difficult to obtain the necessary dimensions to model an irregular shaped culvert in TUFLOW. Modelling this pipe as rectangular-shaped may slightly overestimate its capacity. • There are still some uncertainties in sections of the City of Melbourne's drainage system. An

Component of Model	Limitation
	example is at the western end of Mark Street, where a 1200 mm diameter pipe reduces down to a 375 mm diameter pipe. City of Melbourne was unable to provide design plans or other information at this location and the 375 mm diameter pipe has been retained in the model. Engeny believes that these uncertainties generally have a minor impact on the reliability of the model, but should be considered when investigating potential drainage mitigation options as part of future work.
Pump stations	The existing conditions model does not include any of the six pump stations that are located in the Arden Macaulay Precinct. These pump stations are located in low lying areas below the Moonee Ponds Creek levees and lift flow into the creek when flood levels in Moonee Ponds Creek are above the flood level in the local drainage system. Discussion with Melbourne Water indicated that these pump stations have to be turned on manually. The pumps may also be unreliable as they rely on a power source, which may not be available in a major rainfall event. Engeny believes that not including the pump stations is a conservative but appropriate way to model the drainage system. The pump station bypass pipes that allow runoff to discharge to Moonee Ponds Creek when the pump is not operating have been included in the model, as have non return valves on outlets as appropriate.
Topography	Engeny understands that the TUFLOW model's definition of topography is based on LiDAR aerial survey data. This data is commonly used for developing two dimensional hydraulic models. There are some areas where this data may not provide reliable definition of topography, such as along the train line on the eastern side of Moonee Ponds Creek. The train line is located beneath CityLink and the overhead freeway may have prevented accurate definition of the surface levels when the LiDAR aerial survey was captured.
Cell size	The TUFLOW model adopts a cell size of four metres. The model cell size impacts how the model represents topography, with a smaller cell size allowing for more refined definition of topography but also resulting in longer computer simulation times. Melbourne Water's Flood Mapping and Technical Specification (2015) recommend a cell size of 2-3 metres for urban areas. The model was tested with a three metre cell size, but this caused longer simulation times and some model instabilities. Due to time constrains the model cell size has been retained at four metres.
Regional Rail Link drainage	The TUFLOW model includes the piped drainage system for the Regional Rail Link around Dynon Road. There appears to be some inconsistencies and errors in this data. This area does not impact on the accuracy of the model's results within the Arden Macaulay Precinct and no changes have been made to the data.
Moonee Ponds Creek RORB model	The Moonee Ponds Creek RORB model is relatively coarse and only includes seven subareas to represent the 49 square kilometre catchment area contributing to Moonee Ponds Creek between the Jacana Retarding Basin and the Yarra River. Engeny has assumed that flows in the RORB model have been suitably validated and further validation has not been undertaken by Engeny as part of the current study.

4.3 Outputs

The TUFLOW model has been simulated for the 1% AEP event for a range of storm durations. Some previous studies only analysed the impact of the 1% AEP 2 hour storm as this event creates peak flows in Moonee Ponds Creek. However, Engeny's analysis indicates that flooding within the developable areas of the Arden Macaulay Precinct is also sensitive to shorter and longer duration storms. Flooding in the higher areas of the precinct, where drainage is not impacted by the flood level in Moonee Ponds Creek, is generally most sensitive to the 15 minute duration storm as the drainage system struggles to cope with the high peak flows in short intense storms. Flooding in the low lying areas of the precinct below the Moonee Pond Creek levees is most sensitive to the 9 hour duration event as the drainage system struggles to cope with the large volume of runoff in this storm. The outputs presented in this report represent of a combination of the peak flood levels and depths from the three different durations so that critical flooding for a 1% AEP event is depicted.

Appendix A provides the following flood maps for existing drainage conditions:

- Figure A1: Arden Macaulay Precinct 1% AEP flood map
- Figure A2: Arden Street Government Land 1% AEP flood map
- Figure A3: Comparison of predicted flooding with current flood overlays
- Figure A4: Cross Section – Parsons Street to Alfred Street
- Figure A5: Cross Section – Hardiman Street to Steel Street
- Figure A6: Cross Section – Government Land South of Arden Street.

Table 4.3 provides peak 1% AEP flood levels at the upstream side of each of the bridge crossings of Moonee Ponds Creek as well as the soffit and deck levels of the bridges. 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. These results give an indication of which bridges are subject to inundation and therefore which bridges have significant impact on the creek's flow capacity in a 1% AEP storm.

Table 4.3 Existing conditions flood results at bridges

Location	Bridge Soffit Level (m AHD)	Bridge Deck Level (m AHD)	1% AEP Flood Level (m AHD)	Comment
Mt Alexander Road	5.42	6.28	5.23	Flow under bridge soffit
Racecourse Road	4.04	4.90	4.90	Flow above bridge soffit
Macaulay Road	2.81	3.97	3.96	Flow above bridge soffit
Arden Street	3.39	4.34	3.21	Flow under bridge soffit
First Rail Bridge D/S of Arden St	2.06	3.58	2.90	Flow above bridge soffit
Second Rail Bridge D/S of Arden St	3.50	4.00	2.58	Flow under bridge soffit
Dynon Road	2.50	3.10	2.49	Flow under bridge soffit

4.4 Existing Flooding Discussion

The results of the hydraulic modelling show that large areas of the Arden Macaulay Precinct are significantly impacted by flooding in a 1% AEP event. This is consistent with the findings of previous studies. SCARM 73 (refer to Section 2.3) states that flood hazard is extreme where flood depths exceed 1.2 metres. The flood mapping predicts that 1% AEP flood depths exceed 1.2 metres in large sections of the precinct.

The key constraint 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 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 the crown land south of Arden Street just upstream of the rail bridge. There is no formal levee structure at this location.

As shown in Table 4.3, flood levels at several of the bridge crossings of Moonee Ponds Creek are above the soffit of the bridge. In combination with the pier structures underneath the soffit level, the bridges restrict the flood capacity of the creek.

Overall, flooding within 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 unable 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.

Figure A3 in **Appendix A** provides a comparison of the existing LSIO with flooding predicted by the hydraulic model. The LSIO shows a close correlation with the model's predicted flooding downstream of Macaulay Road, with the LSIO extended beyond the creek and into the low lying areas of the precinct, including the crown land south of Arden Street. Upstream of Macaulay Road the LSIO does not extend outside of Moonee Ponds Creek, while the modelling predicts significant flooding through this area, particularly around Stubbs Street. The predicted flooding in this area is consistent with expectations based on historical flooding.

5. YEAR 2100 ASSESSMENT

5.1 Updates to the Models

The RORB and TUFLOW models have been updated in order to develop a year 2100 scenario, including the potential impacts of climate change and redevelopment. Table 5.1 provides the changes made to the model and the basis for these changes. No changes have been made to the drainage system as part of this assessment.

Table 5.1 Changes to the models for the year 2100 scenario

Change	Basis
Increased rainfall intensity	Rainfall intensities in both the local catchment and Moonee Ponds Creek RORB models have been increased by 15.5%. This is based on: • An Australian Rainfall and Runoff discussion paper titled *An Interim Guideline for Considering Climate Change in Rainfall and Runoff* (2014) states that an allowance should be made for 5% rainfall intensity increase for each 1 degree C of global temperature increase, which is consistent with other research. • Until new information becomes available, the discussion paper recommends that a warming range of 1.4 to 3.1 degrees for the years 2081-2100 is adopted. • For the current study, the upper limit of 3.1 degrees warming has been adopted, which corresponds to a 15.5% rainfall intensity increase.
Increased fraction impervious	For the Moonee Ponds Creek RORB model, fraction impervious values have been increased in accordance with previous modelling undertaken by GHD as part of the Arden Macaulay IWM Plan (2015). The increases in fraction impervious assumed in GHD's modelling represents infill development of residential areas, with typical fraction impervious values increasing from 50% to 60-80%. For the local catchment RORB model, the following increases in fraction impervious have been adopted: • For areas within the Arden Macaulay Precinct, any subarea with an existing fraction impervious less than 85% has been increased to 85%. No fraction impervious increase has been applied to the subarea that covers the Arden Street Reserve. • For areas outside the Arden Macaulay Precinct, the fraction impervious has been increased by 15% up to a maximum of 85%. No fraction impervious increase has been applied to the subareas that cover Royal Park.
Increased tail water level	Melbourne Water's Planning for Sea Level Rise states that the Victorian Government has asked relevant authorities to begin planning for a sea level rise of no less than 0.8 metres by 2100. Based on this, the tail water level at the downstream end of Moonee Ponds Creek has been increased to 2.2 metres AHD.

The changes in Table 4.1 have been proposed by Engeny and approved by Melbourne Water.

An alternative year 2100 scenario has been developed in which rainfall intensities and sea levels are predicted to increase as per Table 5.1, but no increase in fraction impervious has been applied. This scenario represents efforts within the local and greater Moonee Ponds Creek catchments to keep runoff at existing levels through a range of possible methods. Section 8.1 provides further information on this scenario. Throughout the remainder of this document, this scenario is referred to as the year 2100 with planning controls scenario.

5.2 Limitations of the Model

The limitations of the year 2100 scenario model are consistent with the limitations of the existing conditions scenario model. In addition, the assumptions made to predict the impact of development and climate change between now and the year 2100 are a forecast only and subject to change based on government policy and other factors.

5.3 Outputs

The year 2100 scenario model has been simulated for the 1% AEP for the 15 minute, 2 hour and 9 hour duration events. The outputs presented in this report represent of a combination of the peak flood levels and depths from the three events so that critical flooding across the study area for a 1% AEP event is depicted.

Appendix B provides the following flood maps for the year 2100 scenario:

- Figure B1: Arden Macaulay Precinct year 2100 1% AEP flood map
- Figure B2: Arden Street Government Land year 2100 1% AEP flood map
- Figure B3: Arden Macaulay Precinct year 2100 1% AEP afflux. The afflux represents the change in flood level between the existing conditions and year 2100 scenarios.
- Figure B4: Cross Section – Parsons Street to Alfred Street for year 2100 scenario
- Figure B5: Cross Section – Hardiman Street to Steel Street for year 2100 scenario
- Figure B6: Cross Section – Government Land South of Arden Street for year 2100 scenario.

Appendix C provides the following flood maps for the year 2100 with planning controls scenario:

- Figure C1: Arden Macaulay Precinct year 2100 with planning controls 1% AEP flood map

- Figure C2: Arden Street Government Land year 2100 with planning controls 1% AEP flood map

Table 5.2 provides a comparison of existing conditions with year 2100 and year 2100 with planning controls scenarios for peak flows and flood levels in Moonee Ponds Creek.

Table 5.2 Comparison of existing conditions and year 2100 scenario key results

Model result at Moonee Ponds Creek	Existing Conditions	Year 2100 with Planning Controls	Year 2100 Scenario
1% AEP flow at Mt Alexander Road	217 m^3/s	261 m^3/s	295 m^3/s
1% AEP flood level at Mt Alexander Road	5.23 m AHD	5.59 m AHD	5.84 m AHD
1% AEP flood level at Macaulay Road	3.96 m AHD	4.11 m AHD	4.18 m AHD
1% AEP flood level at Arden Street	3.21 m AHD	3.58 m AHD	3.69 m AHD
1% AEP flood level at existing southern outlet from Arden Street government land	2.90 m AHD	3.12 m AHD	3.18 m AHD

Table 5.3 provides year 2100 predicted peak 1% AEP flood levels at each of the bridge crossings of Moonee Ponds Creek as well as the soffit and deck levels of the bridges. Table 5.4 provides a similar comparison for the year 2100 with planning controls scenario. 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.

Table 5.3 Year 2100 scenario flood results at bridges

Location	Bridge Soffit Level (m AHD)	Bridge Deck Level (m AHD)	1% AEP Flood Level (m AHD)	Comment
Mt Alexander Road	5.42	6.28	5.84	Flow above bridge soffit
Racecourse Road	4.04	4.90	5.33	Bridge deck overtopped
Macaulay Road	2.81	3.97	4.18	Bridge deck overtopped
Arden Street	3.39	4.34	3.69	Flow above bridge soffit
First Rail Bridge D/S of Arden St	2.06	3.58	3.18	Flow above bridge soffit
Second Rail Bridge D/S of Arden St	3.50	4.00	2.84	Flow under bridge soffit
Dynon Road	2.50	3.10	2.83	Flow above bridge soffit

Table 5.4 Year 2100 with planning controls scenario flood results at bridges

Location	Bridge Soffit Level (m AHD)	Bridge Deck Level (m AHD)	1% AEP Flood Level (m AHD)	Comment
Mt Alexander Road	5.42	6.28	5.59	Flow above bridge soffit
Racecourse Road	4.04	4.90	5.21	Bridge deck overtopped
Macaulay Road	2.81	3.97	4.11	Bridge deck overtopped
Arden Street	3.39	4.34	3.58	Flow above bridge soffit
First Rail Bridge D/S of Arden St	2.06	3.58	3.12	Flow above bridge soffit
Second Rail Bridge D/S of Arden St	3.50	4.00	2.81	Flow under bridge soffit
Dynon Road	2.50	3.10	2.80	Flow above bridge soffit

5.4 Year 2100 Flooding Discussion

The modelling shows that predicted increases in fraction impervious, rainfall intensity and sea level rise will have a significant impact on flooding of the precinct. In some areas of the catchment, flood depths are predicted to increase by in excess of one metre compared to existing conditions. The increase in flooding is most evident in the low lying areas of the precinct adjacent to Moonee Ponds Creek. A significant portion of the precinct is predicted to be impacted by extreme flood hazard.

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 maximum depth of overtopping is approximately 0.3 metres. The eastern levee is also extensively overtopped, but to a lesser severity than the western levee.

Through the low lying areas of the precinct, flood depths in the year 2100 with planning controls scenario are typically 0.2 metres lower than flood depths in the year 2100 scenario. Within the crown land south of Arden Street, flood depths in the year 2100 with planning controls scenario are typically 0.1 metres lower than flood depths in the year 2100 scenario.

6. REVIEW OF THE MPA STRATEGIC VISION

6.1 Updates to the Model

Engeny has undertaken a preliminary hydraulic review of the MPA's strategic vision for development of the area around Arden Street. This review is based on the preliminary master plan in the Arden Urban Renewal Precinct Strategic Vision (MGS Architects, 2015) as shown in Figure 6.1. Street names have been added to this plan for clarity. Note that this area only covers a section of the overall Arden Macaulay Precinct.

Figure 6.1 MPA Strategic Vision (modified version of plan from Arden Urban Renewal Precinct Strategic Vision, MGS Architects, 2015)

To assess the potential impact of the development shown in the preliminary master plan, the existing flood storage with the proposed building footprint areas has been removed from the model. No potential drainage mitigation works have been added to the model at this stage. This is a preliminary assessment approach with the purpose of reviewing the impact the proposal could have on flooding and how the proposal is impacted by flooding if no drainage works are constructed.

6.2 Outputs

Appendix D provides the following flood maps for the MPA strategic vision:

- Figure D1: MPA Strategic Vision for existing flows 1% AEP flood map
- Figure D2: MPA Strategic Vision 1% AEP afflux for existing flows
- Figure D3: MPA Strategic Vision for year 2100 flows 1% AEP flood map
- Figure D4: MPA Strategic Vision for year 2100 with planning controls flows 1% AEP flood map

6.3 MPA Strategic Vision Discussion

The modelling shows that the flood storage that may be lost due to development identified in the preliminary master plan of the Arden Urban Renewal Precinct has a minor impact on flooding of adjacent areas. Increases in flood depths of between 100 to 200 millimetres are predicted in surrounding areas to the development.

The area south of Arden Street is not significantly flood prone under existing conditions. It is considered that setting appropriate surface levels and some flood mitigation works will make development of most of this area feasible. However, flood depths, flood volumes and hazards in this area increase for the year 2100 scenario. The City of Melbourne land north of Arden Street is more flood prone and presents a greater challenge in achieving development with a satisfactory flood hazard.

7. REVIEW OF THE MMRA PROPOSAL

7.1 Updates to the Model

The memorandum Arden Precinct Flood Mitigation Strategy (November 2015) prepared by AJM on behalf of the MMRA outlines an investigation of flood mitigation works for the Arden Macaulay Precinct as part of supporting documentation for the Melbourne Metropolitan Rail Project business case.

The memorandum proposes a concept level set of flood mitigation works with the intention to confirm that a flood mitigation strategy is feasible. Figure E1 in **Appendix E** provides a plan from the AJM memorandum showing the proposed mitigation works.

AJM tested these mitigation works in a TUFLOW model, which Melbourne Water provided to Engeny. This model is a modified version of the original AECOM model. As part of the current study, the works proposed by AJM have been added to the revised existing conditions model in order to review the benefits and limitations of the works. The mitigation works have been modelled in line with how they were modelled by AJM, with some minor modifications so that modelling of the works is compatible with changes made by Engeny to the existing conditions model.

Table 7.1 summarises the mitigation works proposed by AJM that have been added to the TUFLOW model.

Table 7.1 AJM proposed flood mitigation works

Mitigation Works	Description
New pipes	A series of new 1800 millimetre diameter pipes (with new inlet pits) that all discharge into Moonee Ponds Creek have been added to the model. The proposed new pipes are intended to intercept overland flows from higher in the local catchment and pipe this flow directly through the Moonee Ponds Creek levee, using the elevation from the higher parts of the catchment to drive the flow through the pipes. If effective these pipes would reduce the amount of flow from the local catchment getting to the low areas behind the levee. These pipes have been added at the following locations: • Through the southern section of the government land south of Arden Street, starting from Lauren Street • Along Queensberry Street and then through the centre of the government land south of Arden Street • Along Arden Street, starting from Dryburgh Street • Along Canning Street and then along Macaulay Road, starting from Melrose Street • Along Mark Street, starting from Buncle Street
New culverts under levees	A series of new 1200 x 1500 millimetre box culverts (with flood gates) under the Moonee Ponds Creek levees have been added to the model. The culverts will be directly connected to the local

Mitigation Works	Description
	catchment runoff that ponds behind the levee. These culverts are designed to drain the low lying areas as quickly as possible while the flood level in the creek is low and for the floodgates to then close and prevent backflow from the creek into the low lying areas behind the levee. Culverts have been added to the model at the following locations: • At the outfall of the government land south of Arden Street • At Bruce Street (western side of Moonee Ponds Creek) • At Gracie Street (eastern side of Moonee Ponds Creek) • At Macaulay Road (both eastern and western sides of Moonee Ponds Creek) • At Mark Street (eastern side of Moonee Ponds Creek) • At Stubbs Street, east of Robertson Street (western side of Moonee Ponds Creek) • At Stubbs Street, east of Smith Street (western side of Moonee Ponds Creek) • At Stubbs Street, east of Parsons Street (western side of Moonee Ponds Creek) • At Sutton Street (eastern side of Moonee Ponds Creek) • At Alfred Street (eastern side of Moonee Ponds Creek)
Deepening of Moonee Ponds Creek	Moonee Ponds Creek has been deepened by between 1-2 metres from Macaulay Road through to just north of Footscray Road. The channel has not been widened.
Additional levee	An additional levee has been added on along the east bank of Moonee Ponds Creek, from south of Arden Street to the first rail bridge.
Swales through government land	New swales or provision for overland flow paths have been added along Queensberry Street, Laurens Street and through the government land south of Arden Street.
Raised road	A section of Henderson Street near Fogarty Street has been raised by 300 millimetres.

7.2 Outputs

Appendix E provides the following flood maps for the review of the MMRA flood mitigation works:

- Figure E2: MMRA proposed works for existing flows 1% AEP flood map, Arden Macaulay Precinct
- Figure E3: MMRA proposed works for existing flows 1% AEP flood map, Arden Street Government Land
- Figure E4: MMRA proposed works for year 2100 flows 1% AEP flood map, Arden Macaulay Precinct
- Figure E5: MMRA proposed works for year 2100 flows 1% AEP flood map, Arden Street Government Land

- Figure E6: MMRA proposed works for year 2100 with planning controls flows 1% AEP flood map, Arden Macaulay Precinct
- Figure E7: MMRA proposed works for year 2100 with planning controls flows 1% AEP flood map, Arden Street Government Land
- Figure E8: Reduction in 1% AEP flood depth achieved by MMRA proposed works for existing flow conditions.

7.3 MMRA Proposal Discussion

The hydraulic modelling shows that the mitigation works proposed by AJM will reduce flooding in the precinct, but significant flood risks remain. With reference to Figure E6 in **Appendix E**, flood depths in Moonee Ponds Creek south of Macaulay Road are shown to be increasing due to the excavation proposed as part of MMRA mitigation works. The actual flood level in the creek is not increasing.

The modelling shows that the proposed box culverts draining the low lying areas of the precinct are reducing peak flood levels in these areas. Many of the 1800 millimetre pipe upgrades proposed are not operating at full capacity. These pipe upgrades either require further inlet capacity, additional connections to the existing drainage network or could be reduced in size.

The MMRA proposal includes deepening Moonee Ponds Creek downstream of Macaulay Road, but does not widen the channel. Downstream of Macaulay Road, Moonee Ponds Creek is partially inundated by the Port Phillip Bay tail water level under existing conditions. Excavating the channel below the tidal level provides limited benefits in terms of flow capacity. More benefit may be achieved by widening Moonee Ponds Creek, or by raising the low Dynon Road railway bridge.

While the MMRA proposal does achieve some reduction in flooding for the Arden Macaulay Precinct, further investigation of works is required to achieve a more effective solution.

8. FLOOD MITIGATION WORKS OPTIONS ANALYSIS

8.1 Identification of Mitigation Works

A wide range of flood mitigation works were identified for consideration. This included options already proposed under the MMRA mitigation strategy as well as an extensive list of further possibilities for managing drainage and flooding within the precinct.

The potential flood mitigation works were discussed at a workshop with key stakeholders, including representatives from the MPA, Melbourne Water, City of Melbourne and Engeny held on 16 February 2016. The likely benefits and limitations of each flood mitigation option were discussed in order for the group to come to a consensus on the works to be discounted and the works to be considered for further investigation, including detailed hydraulic modelling. **Appendix F** provides the summary of the meeting outcomes that was circulated to stakeholders, which includes the full list of works considered and whether they were chosen by the consensus of the stakeholders to proceed to further investigation.

Based on the outcomes of the meeting Engeny compiled the mitigation works identified for further investigation into four separate mitigation strategies, with each mitigation strategy consisting of a combination of flood mitigation measures. The following sections of this report provide details of and review these mitigation strategies.

Each flood mitigation strategy has been tested and refined in the TUFLOW model. At this stage, the design event (i.e. the runoff scenario that the precinct's development must satisfy flood prone development conditions for) has not been confirmed by Melbourne Water and so each strategy has been analysed for the following runoff conditions:

- Existing runoff conditions
- Year 2100 scenario
- Year 2100 with planning controls scenario

The year 2100 with planning controls scenario has been analysed in order to assess the benefits of implementing measures to control development within both the local catchments and the greater Moonee Ponds Creek catchment to ensure that there is no increase in runoff compared to existing conditions. The actual measures to achieve this aim could be quite diverse and include:

- Green roofs
- Rainwater tanks or on site detention
- Permeable paving
- Retarding basins

The potential impact of these measures has been reflected by maintaining the fraction imperviousness within the local catchment and greater Moonee Ponds Creek catchment year 2100 RORB models at existing levels. While this gives a good indication of the benefits of these options, an alternative approach could be adopted tailored to a specific option if any of the options are to be considered further. The year 2100 with planning controls scenario includes the impact of a 15.5 per cent increase in rainfall intensities and 0.8 metres sea level rise, as per the assumptions made for the year 2100 scenario.

Common for all flood mitigation strategies is the construction of flood gates on all existing and new pipe outfalls to Moonee Ponds Creek in order to prevent creek flows backing up into the local precinct catchment.

8.2 Flood Mitigation Strategy A

8.2.1 Mitigation Measures

Flood mitigation strategy A includes:

- widening Moonee Ponds Creek on the western side of the creek
- extending the existing levee on the eastern bank of Moonee Ponds Creek at the government land south of Arden Street
- re-building some of the road and rail bridges over the creek to reduce the hydraulic constraint they impose on flows in the creek
- filling in low lying areas of the local catchment.

Figure G1 in **Appendix G** provides a concept layout plan of the works included in flood mitigation strategy A. Table 8.1 provides a description of the works included in this strategy.

Table 8.1 Mitigation works included in flood mitigation strategy A

Mitigation Works	Description
Widening of Moonee Ponds Creek	Moonee Ponds Creek has been widened by approximately 25 metres on the western side of the creek between Racecourse Road and the second rail bridge downstream of Arden Street. This is a total length of approximately 1.5 kilometres along Moonee Ponds Creek. This would include acquiring the currently developed land between Stubbs Street and Moonee Ponds Creek. Land acquisition of would also be required downstream of Macaulay Road. The extent of the widening of the creek has been reduced downstream of Arden Street so that the existing power substation would not be significantly affected and in order to provide a smooth transition back to the existing channel width at the downstream end of the creek widening.
Extended levee	The existing levee on the eastern bank of Moonee Ponds Creek has been extended south of Arden Street in order to provide protection to the government land. The levee will prevent 1 %

Mitigation Works	Description
	AEP flows from the creek flowing into the government land.
Re-building of road and rail bridges	The following bridges would be constructed at a higher elevation, with clear spans across the widened creek channel or hydraulically efficient piers: • Macaulay Road bridge • Arden Street bridge • First rail bridge downstream of Arden Street These works would reduce the hydraulic constraint that the bridges currently have on the conveyance capacity of Moonee Ponds Creek. The effectiveness of these works has been assessed in the model by removing the components of the model that reflected the bridges. This assumes that the re-built bridges would provide no constraint on creek flows.
Filling of low lying areas of the catchment	Filling in low lying areas of the catchment would involve raising building floor levels for all flood prone properties above the 1% AEP flood level, as well as raising roads so that the roads can act as overland flow paths draining into Moonee Ponds Creek. This requires road levels being above the 1% AEP flood level in Moonee Ponds Creek. Figure G1 in Appendix G shows the areas where roads have been raised and the approximate height that the roads have been raised. The maximum height that a road has been raised is just under 2.5 metres, which occurs in a short section of Stubbs Street and around Langford Street on the eastern side of Moonee Ponds Creek. Road levels have been raised based on year 2100 scenario flood levels in the widened Moonee Ponds Creek, as this scenario produces the highest flood levels. If the raised road levels were based on existing runoff conditions flood levels with the widened Moonee Ponds Creek then the road levels could be reduced by approximately 0.5 metres. Raised road levels at the discharge point to Moonee Ponds Creek have been set at the flood level in the creek (where possible) and then the road has been graded upstream at a typical longitudinal grade of 1 in 500 until the road can match back into existing levels. This requires raising roads beyond the Arden Macaulay Precinct boundary. On the western side of Moonee Ponds Creek it is possible to provide conveyance of overland flows along the roads and into Moonee Ponds Creek. This is more difficult on the eastern side of Moonee Ponds Creek due to the train line and CityLink. It has been assumed that it is not possible to alter the topography of the train line and it may not be possible to raise road levels beneath CityLink. Therefore, on the eastern side of Moonee Ponds Creek the existing road levels have been retained where Arden Street and Macaulay Road intersect with the train line, but road levels east of these locations have been raised. This reduces flood depths on the roads but creates a higher flood level on the roads than in the creek so that the underground drainage system can discharge flow into Moonee Ponds Creek under pressure. At the government land south of Arden Street, Laurens Street has been raised in order to reduce the flood hazard on the road. Two main overland flow paths have been provided through the crown land in order to convey overland flow from Laurens Street to the western side of the crown land. Buildings have been raised within the government land based on the MGS Architects preliminary master plan.

8.2.2 Hydraulic Modelling

Appendix G provides the following flood maps for the hydraulic review of flood mitigation strategy A:

- Figure G2: Flood mitigation strategy A for existing flows 1% AEP flood map
- Figure G3: Reduction in 1% AEP flood depth achieved by flood mitigation strategy A for existing flow conditions
- Figure G4: Flood mitigation strategy A for year 2100 flows 1% AEP flood map
- Figure G5: Reduction in 1% AEP flood depth achieved by flood mitigation strategy A for year 2100 flows
- Figure G6: Flood mitigation strategy A for year 2100 with planning controls scenario 1% AEP flood map
- Figure G7: Reduction in 1% AEP flood depth achieved by flood mitigation strategy A for year 2100 with planning controls scenario flows

8.2.3 Discussion and Potential Further Improvements

Initially, the hydraulic model was simulated with just the widened Moonee Ponds Creek and the hydraulically improved bridge crossings in order to understand the benefits that these works provide. Based on the model's results for existing flow conditions, the following conclusions can be made for the creek works (as stand-alone works, i.e. not including the raised roads and buildings):

- Just downstream of Racecourse Road flood levels in Moonee Ponds Creek are predicted to reduce by approximately 0.3 metres due to the increased capacity of the creek.
- Further downstream towards Macaulay Road the benefit of the improved bridge crossings becomes more apparent and flood levels in Moonee Ponds Creek are predicted to reduce by up to 0.8 metres.
- Towards the downstream end of the creek widening the hydraulic benefits start to dissipate, with reduced flood levels in Moonee Ponds Creek of approximately 0.1 metres at the location of the pipe outlets from the government land south of Arden Street.
- Downstream of the extent of creek widening flood levels in the Moonee Ponds Creek are predicted to increase above existing conditions due to the higher peak flow that the increased channel capacity conveys downstream.

- Within the developable areas of the precinct, the benefits of the creek widening and hydraulically improved bridges is less apparent, with peak flood depths typically reduced by approximately 0.1 metres.

The flood maps in **Appendix G** show that there are significant benefits when the flood mitigation works to raise roads and buildings within flood prone areas are also included in flood mitigation strategy A. The works are most effective on the western side of Moonee Ponds Creek with the remaining flood hazard only within the low to medium range (flood depths less than 0.5 metres) in the year 2100 scenario. There are some higher flood depths at the low point of Lloyd Street, south of Arden Street. Lloyd Street has not been raised as the surrounding industrial property (including the power substation) is to be retained. Raising Lloyd Street is also constrained by the rail bridge over this street.

Flood mitigation strategy A is less effective on the eastern side of Moonee Ponds Creek. While raising the roads and buildings has provided considerable reduction in flood depths in flood prone areas around Langford Street, increased flooding is predicted along the train line under CityLink. This occurs as raising the previously flood prone areas on the eastern side of the creek has reduced flood storage and re-directed runoff towards the train line at Arden Street and Macaulay Road. The train line then prevents overland flow effectively draining into Moonee Ponds Creek. It should be noted that there is some uncertainty of model's definition of the topography of the train line as CityLink may have prevented reliable LiDAR in this area.

At the government land south of Arden Street, raising Laurens Street has reduced the flood depths and flood hazard on the road. There are still some significant flood depths through the site, with flood hazards approaching extreme in the year 2100 scenario.

A constraint of flood mitigation strategy A is how the works could be staged. It would be difficult to achieve the levels of fill required without raising large sections of the precinct at the same time so that appropriate road grades could be achieved and so that adverse impacts don't occur due to raising downstream areas which may worsen flooding of upstream areas yet to be filled.

While the widening of Moonee Ponds Creek and hydraulically improved bridge crossings as stand-alone works do not provide a significant reduction of flooding within the precinct, they do reduce the level to which the roads and buildings have to be raised to. As the flood levels within Moonee Ponds Creek are lower with the widened creek, the road levels do not have to be as high in order to drain into the creek.

8.3 Flood Mitigation Strategy B

8.3.1 Mitigation Measures

Flood mitigation strategy B includes:

- raising and extending the existing Moonee Ponds Creek levees

- constructing new pipes from higher areas within the precinct to discharge into Moonee Ponds Creek under pressure
- providing new and upgraded pump stations for the low lying areas of the precinct.

Figure H1 in **Appendix H** provides a concept layout plan of the works included in flood mitigation strategy A. Table 8.2 provides a description of the works included in this strategy.

Table 8.2 Mitigation works included in flood mitigation strategy B

Mitigation Works	Description
Raised and extended levees	The existing levees have been raised in order to prevent any flow from Moonee Ponds Creek overtopping the levees and flowing into the local catchment in a 1 % AEP event. The existing levee on the eastern bank of Moonee Ponds Creek has also been extended south of Arden Street in order to provide protection to the government land. In order to analyse the benefits of this option in the TUFLOW model, the levees in the model have been raised well above what is required. Depending on the flow scenario, not all sections of the levee would need to be raised. Based on the model's results, the following maximum increases in the crest level of the levees are required: • Existing conditions: 0.4 metres • Year 2100 scenario: 0.75 metres • Year 2100 with planning controls scenario: 0.9 metres
Pressure pipes	This is similar to a component of the MMRA flood mitigation strategy, with new pipes collecting flow from higher areas of the local catchment and discharging flow into Moonee Ponds Creek under pressure. These pipes have no inlet connections in the lower areas of the precinct so that flow cannot spill out of the pits / pipes. The difference in the setup of these pipes compared to the MMRA proposal is that several cross connections from the existing drainage network to the new pipes have been provided so that they are able to collect sufficient flow to be running full and reduce the flow in the existing drainage system.
Pump stations	The pressure pipes from the higher areas of the local catchment reduce the volume of flow that reaches the low lying areas of the catchment. However, there is still significant flooding within the low lying areas. Pump stations have been added to the model to facilitate the drainage of the low lying areas. This includes upgrading existing pump stations and several new pump stations, as showing in Figure H1 in Appendix H. It has been assumed that the pumps have automatic switch on mechanisms, a reliable or backup power supply and significant capacities of 2 m_3/s.

8.3.2 Hydraulic Modelling

Appendix H provides the following flood maps for the hydraulic review of flood mitigation strategy B:

- Figure H2: Flood mitigation strategy B for existing flows 1% AEP flood map
- Figure H3: Reduction in 1% AEP flood depth achieved by flood mitigation strategy B for existing flow conditions
- Figure H4: Flood mitigation strategy B for year 2100 flows 1% AEP flood map
- Figure H5: Reduction in 1% AEP flood depth achieved by flood mitigation strategy B for year 2100 flows
- Figure H6: Flood mitigation strategy B for year 2100 with planning controls scenario 1% AEP flood map
- Figure H7: Reduction in 1% AEP flood depth achieved by flood mitigation strategy B for year 2100 with planning controls scenario

8.3.3 Discussion and Potential Further Improvements

While raising the crest level of the Moonee Ponds Creek levees provides a reduction in flooding of the local catchment, these works result in increased flood levels within the creek. This is most apparent in the year 2100 scenario, with the increased flood levels in Moonee Ponds Creek having a significant tail water impact for the creek upstream of Racecourse Road. The model predicts increased flow spilling from the western bank of the Moonee Ponds Creek between Racecourse Road and Mt Alexander Road, and this overflow is then conveyed into the precinct around Stubbs Street. This reduces the effectiveness of the other works proposed under this strategy. The creek's levees have only been raised within the Arden Macaulay Precinct, but it may be possible to raise and extend the levees beyond the precinct as well to reduce this risk.

Under existing runoff conditions, flood mitigation strategy B provides a considerable reduction in peak flood depths in most parts of the precinct. As the peak rates and volume of flow increase in the year 2100 scenario the pumps become less effective and there are extensive areas of deep flooding with an extreme flood hazard.

Raising the Moonee Ponds Creek levees also results in increased flows being conveyed to the creek downstream of the Arden Macaulay Precinct. This results in increased flooding of already flood prone land.

8.4 Flood Mitigation Strategy C

8.4.1 Mitigation Measures

Flood mitigation strategy C includes:

- raising and extending the existing Moonee Ponds Creek levees,
- constructing centralised flood storages (retarding basins)
- filling in low lying areas of the precinct so that roads act as overland flows path to convey runoff into the retarding basins.

Two alternatives setups of this option have been analysed, with the first option including a small retarding basin within the government land south of Arden Street and the alternative setup removing this retarding basin and instead raising Laurens Street in order to convey overland flow to the retarding basin proposed at Langford Street.

Figure I1 in **Appendix I** provides a concept layout plan of the works included in flood mitigation strategy C, while **Appendix J** provides a concept layout plan showing the works included in the alternative setup of flood mitigation strategy C. Table 8.3 provides a description of the works included in this strategy.

Table 8.3 Mitigation works included in flood mitigation strategy C

Mitigation Works	Description
Raised and extended levees	The Moonee Ponds Creek levees have been raised, with assumption consistent with flood mitigation strategy B. Refer to Table 8.1 for details.
Retarding basins	Retarding basins have been provided in low lying areas of the Arden Macaulay Precinct as the following locations: • Stubbs Street: 1.1 hectare footprint, approximate flood storage of 18,000 m^3 • Bent Street: 2.7 hectare footprint, approximate flood storage of 41,000 m^3 • Langford Street: 3.3 hectare footprint, approximate flood storage of 53,000 m^3 • Government land south of Arden Street: 0.8 hectare footprint, approximate flood storage of 11,000 m^3 Pipe Outlets have been provided from each of the retarding basins to Moonee Ponds Creek. The alternative setup of flood mitigation strategy C does not include the retarding basin within the government land south of Arden Street. Overland flow that would have been conveyed to this retarding basin has been re-directed to the proposed Langford Street retarding basin, as described below. It may be possible to achieve multiple benefits of the land identified for the retarding basins, such as improving water quality by constructing wetlands and/or communal passive open space.

Mitigation Works	Description
Filling of low lying areas of the catchment	Similar to flood mitigation strategy A, low lying areas of the catchment have been filled so that buildings on flood prone properties are above the 1 % AEP flood level and to reduce flood hazards on the roads. Under flood mitigation strategy C, the raising of the roads has been configured so that overland flows are conveyed to the retarding basins. Similar assumptions have been made, with typical roads grades of 1 in 500 and some sections of the raised roads extending beyond the Arden Macaulay Precinct in order to match back to existing roads levels. In the alternative setup of flood mitigation strategy C, sections of Laurens Street have been raised by up to 2.5 metres in order to convey overland flow to the proposed retarding basin at Langford Street. This would also require extensive raising of adjacent buildings so that the buildings are not below road level.

8.4.2 Hydraulic Modelling

Appendix I provides the following flood maps for the hydraulic review of flood mitigation strategy C:

- Figure I2: Flood mitigation strategy C for existing flows 1% AEP flood map
- Figure I3: Reduction in 1% AEP flood depth achieved by flood mitigation strategy C for existing flow conditions
- Figure I4: Flood mitigation strategy C for year 2100 flows 1% AEP flood map
- Figure I5: Reduction in 1% AEP flood depth achieved by flood mitigation strategy C for year 2100 flows
- Figure I6: Flood mitigation strategy C for year 2100 with planning controls scenario 1% AEP flood map
- Figure I7: Reduction in 1% AEP flood depth achieved by flood mitigation strategy C for year 2100 with planning controls scenario

Appendix J provides the following flood maps for the hydraulic review of flood mitigation strategy C under the alternative setup (no retarding basin within the government land south of Arden Street):

- Figure J2: Flood mitigation Strategy C (alternative) for existing flows 1% AEP flood map
- Figure J3: Reduction in 1% AEP flood depth achieved by flood mitigation Strategy C (alternative) for existing flow conditions
- Figure J4: Flood mitigation Strategy C (alternative) for year 2100 flows 1% AEP flood map

- Figure J5: Reduction in 1% AEP flood depth achieved by flood mitigation Strategy C (alternative) for year 2100 flows
- Figure J6: Flood mitigation Strategy C (alternative) for year 2100 with planning controls scenario 1% AEP flood map
- Figure J7: Reduction in 1% AEP flood depth achieved by flood mitigation Strategy C (alternative) for year 2100 with planning controls scenario

8.4.3 Discussion and Potential Further Improvements

The flood maps in Appendix I and Appendix J show significant reductions in flooding for both setups of flood mitigation strategy C.

Under existing runoff conditions, the Bent Street retarding basin is not quite filling to its maximum capacity. Under year 2100 scenario runoff conditions all retarding basins are full and are also utilising flood storage in surrounding roads. The flood depths in the roads exceed 1.2 metres in some locations and create an extreme flood hazard (these depths could be reduced with further adjustments to this option).

The retarding basin within the government land south of Arden Street is not very effective, with flood depths in the areas surrounding the retarding basin increased compared to existing conditions. While the alternative setup of flood mitigation strategy C would delete this retarding basin it would require significant earthworks and raising building levels on both sides of Laurens Street, to provide a high level of protection for the government land south of Arden Street.

If the footprints of the retarding basins were increased then additional flood storage could be provided and this may further reduce flooding in the precinct. Discussions with key stakeholders would be required to understand what area of land could be utilised.

Similar to flood mitigation strategy A, a constraint of flood mitigation strategy C is how the works could be staged. It would be difficult to achieve the levels of fill required without raising large sections of the precinct at the same time so that appropriate road grades could be achieved and so that adverse impacts don't occur due to raising downstream areas which may worsen flooding of upstream areas yet to be filled.

8.5 Flood Mitigation Strategy D

8.5.1 Mitigation Measures

Flood mitigation strategy D includes:

- raising and extending the existing Moonee Ponds Creek levees
- raising flood prone buildings with the precinct but constructing them on piers or stilts and providing flood storage or conveyance beneath the building

- raising roads.

Figure K1 in **Appendix K** provides a concept layout plan of the works included in flood mitigation strategy D. Table 8.3 provides a description of the works included in this strategy.

Table 8.4 Mitigation works included in flood mitigation strategy D

Mitigation Works	Description
Raised and extended levees	The Moonee Ponds Creek levees have been raised, with assumption consistent with flood mitigation strategies B and C. Refer to Table 8.1 for details.
Buildings on piers or stilts	Buildings on flood prone properties could be raised above the flood level by elevation the building on stilts or piers. In this option, flood storage and conveyance would be provided beneath the buildings. The key benefit of this is that no flood storage is lost by raising the buildings. No changes are required to the TUFLOW to represent the raised buildings. Where properties within the Arden Macaulay Precinct are shown to be flood prone on the flood maps in Appendix K, it can be assumed that the buildings on these properties would be raised.
Raised roads	Roads have also been raised in order to reduce the flood hazard on the road. The raised roads would not act as overland flow paths, with runoff on the road draining to the flood storage / conveyance areas under the raised buildings. A series of culverts have been added to the model to facilitate runoff being conveyed under roads from areas beneath raised buildings. All culverts have been assumed to be five 2400 x 900 millimetre box culverts. The sizes of the culverts could potentially be reduced with further modelling. At the low lying areas of the precinct, a culvert outlet has been provided from the flood storage areas beneath the raised building to Moonee Ponds Creek.

8.5.2 Hydraulic Modelling

Appendix K provides the following flood maps for the hydraulic review of flood mitigation strategy D:

- Figure K2: Flood mitigation strategy D for existing flows 1% AEP flood map
- Figure K3: Reduction in 1% AEP flood depth achieved by flood mitigation strategy D for existing flow conditions
- Figure K4: Flood mitigation strategy D for year 2100 flows 1% AEP flood map
- Figure K5: Reduction in 1% AEP flood depth achieved by flood mitigation strategy D for year 2100 flows

- Figure K6: Flood mitigation strategy D for year 2100 with planning controls scenario 1% AEP flood map
- Figure K7: Reduction in 1% AEP flood depth achieved by flood mitigation strategy D for year 2100 with planning controls scenario

8.5.3 Discussion and Potential Further Improvements

While the flood maps in Appendix K show deep flooding within the developable areas of the precinct, it can be assumed that buildings in these areas would be raised above the flood level and would not be flooded above floor level in a 1 % AEP event. Flood depths on the roads are generally improved for all runoff condition scenarios.

Similar to flood mitigation strategies B and C, raising the levees increases flood levels in Moonee Ponds Creek and this has a significant tail water impact for the creek upstream of Racecourse Road. In the year 2100 scenario, the model predicts increased flow spilling from the western bank of the Moonee Ponds Creek between Racecourse Road and Mt Alexander Road, and this overflow is then conveyed into the precinct around Stubbs Street.

As for flood mitigation strategies B and C, there may be some difficulty in staging works to raise roads. Additionally, the flood conveyance and storage areas beneath raised buildings could be a safety and/or maintenance issue. The design of these under floor areas will need to be strictly managed to prevent their future use in ways that are incompatible with their flood storage function.

9. SUMMARY

Key outcomes and recommendations from stages 1 and 2 of the investigation of drainage and flooding of the Arden Macaulay Precinct are summarised below:

- There is improved confidence in the accuracy of the hydraulic model's outputs. A key revision made to the model was the updated pipe dimensions and network connectivity using GIS data from the City of Melbourne obtained by Engeny in 2016. This data was particularly useful to update the model's representation of sections of the piped drainage where previously modelled details appeared to be incorrect. Engeny believes that the model is appropriate to be used as a planning tool for the Arden Macaulay Precinct.

- The results of the hydraulic modelling show that large areas of the Arden Macaulay Precinct are significantly impacted by flooding in a 1% AEP event under existing conditions. This is consistent with historical records of flooding and the findings of previous studies. Extreme flood hazard (where flood depth exceeds 1.2 metres) is predicted in the low lying areas of the precinct adjacent to Moonee Ponds Creek.

- The modelling shows that predicted increases in fraction impervious, rainfall intensity and sea level rise will have a significant impact on flooding of the precinct by the year 2100. In some areas of the catchment flood depths are predicted to increase by in excess of one metre compared to existing conditions.

- The government land south of Arden Street is not significantly flood prone under existing conditions. The City of Melbourne land north of Arden Street is more flood prone and presents a greater challenge in achieving development with a satisfactory flood hazard.

- The MMRA proposal achieves some reduction in flooding for the Arden Macaulay Precinct but extreme flood hazards remain that may prevent Melbourne Water approving development within the precinct.

- A range of flood mitigation strategies have been analysed. Mitigation works that reduce flooding in one section of the precinct are not necessarily as effective or appropriate in other sections of the precinct. There is no one solution that solves all flooding issues within the precinct and the best solution may be a combination of works from the mitigation strategies that have been analysed in this report.

- The benefits and constraints of the investigated flood mitigation strategies should be discussed among key stakeholders and mitigation works should be identified for further consideration, refinement and costing.

- Each flood mitigation strategy has been analysed for three runoff conditions which are existing conditions, year 2100 conditions (including climate change) and year 2100 with planning controls. Engeny recommends that Melbourne Water reviews these

scenarios and selects an appropriate design event. Flood mitigation works can then be tailored to the requirements of the design event.

10. 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.

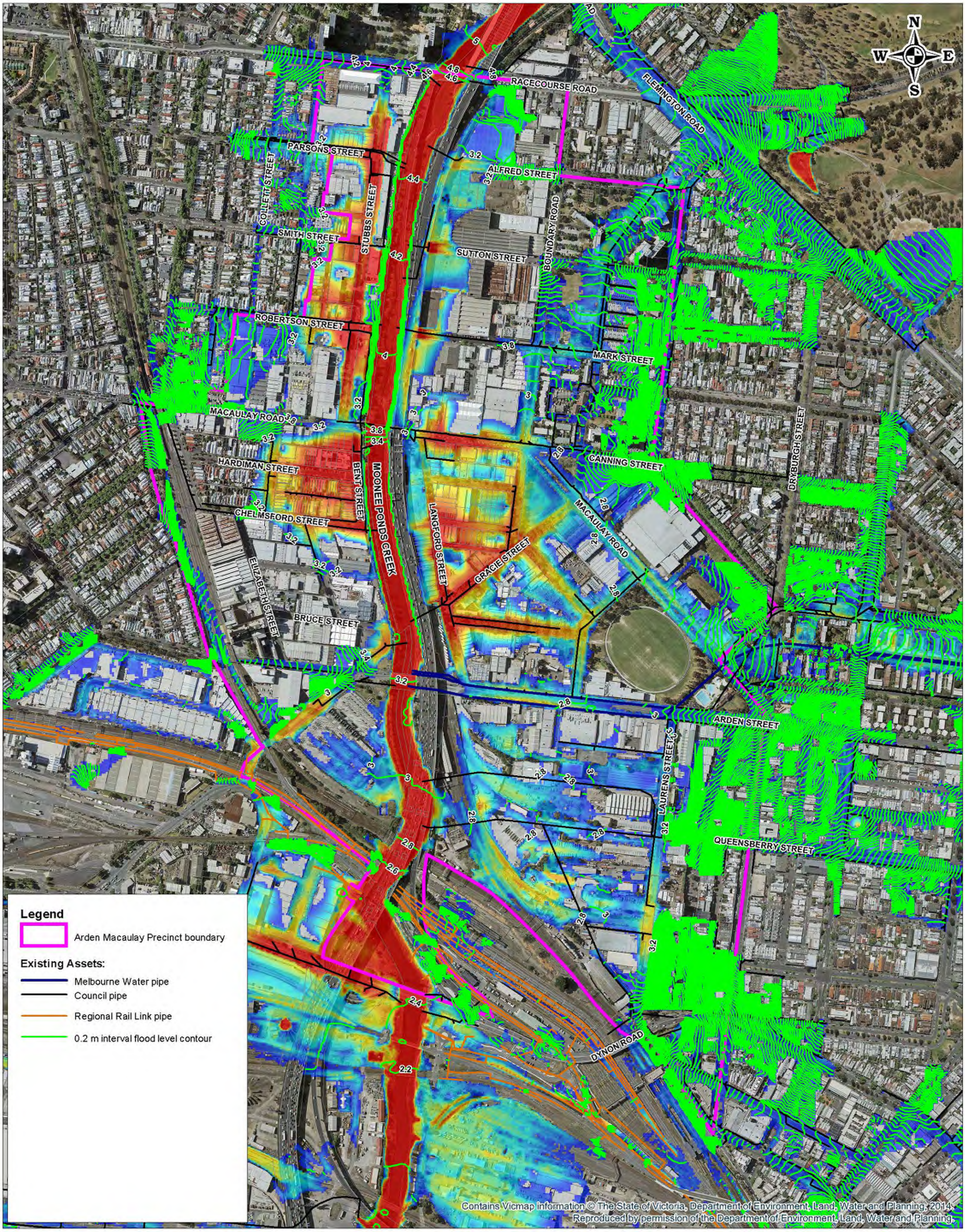
e. This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this report.

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.

APPENDIX A

Existing Conditions Flood Maps



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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 A1
1% AEP Flood Map - Existing Conditions

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 29 Feb 2016

BENT STREET
MOONEE PONDS CREEK
LANGFORD STREET
GRACIE STREET
CANNING STREET
MACAULAY ROAD
DRYBURGH STREET
BRUCE STREET
ARDEN STREET
LAURENS STREET
QUEENSBERRY STREET
DYNON ROAD

N
W
E
S

Legend

- Arden Macaulay Precinct boundary

Existing Assets:

- Melbourne Water pipe
- Council pipe
- Regional Rail Link pipe
- 0.2 m interval flood level contour

Flood Depth (m)

1.2
0.9
0.6
0.3
0

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0 80 160

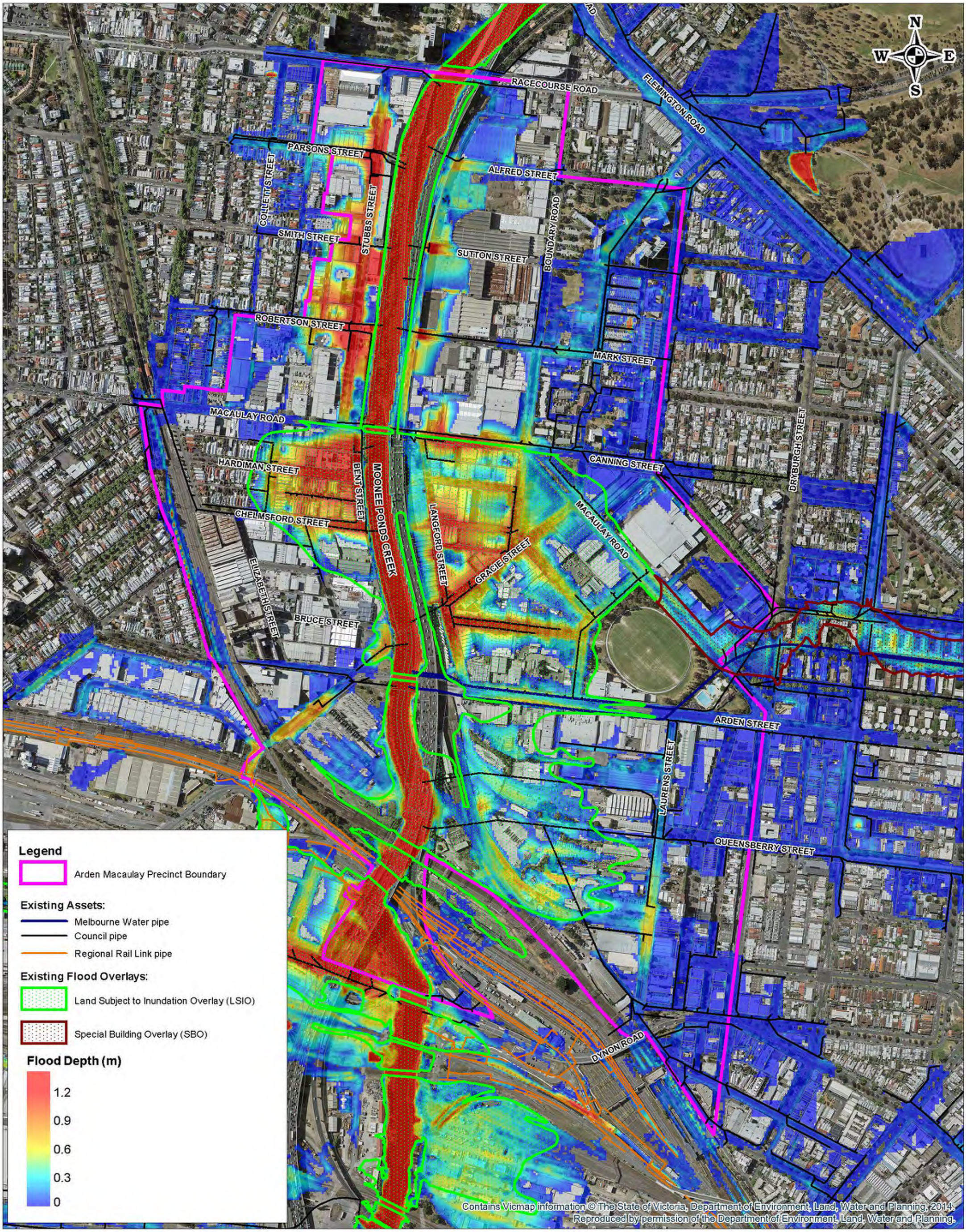
Scale in metres (1:4,000 @ A3)

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 A2
1% AEP Flood Map - Existing Conditions Government Land

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 29 Feb 2016



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Melbourne Water

0 130 260

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

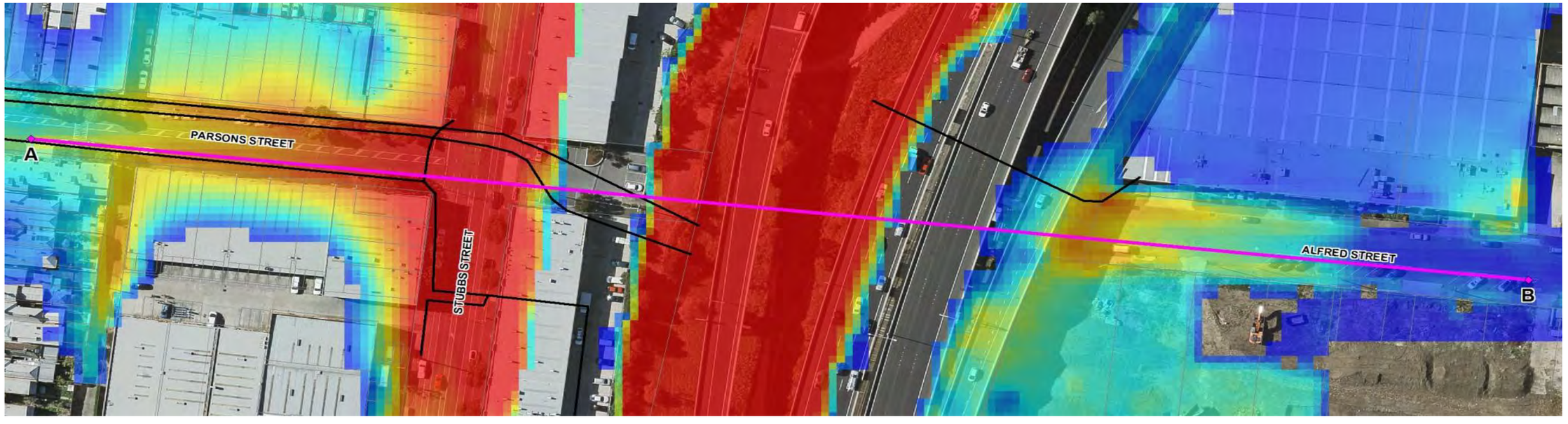
Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994. (GDA94)
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Arden Macaulay Precinct

Figure A3
Comparison of Predicted Flooding (1 % AEP Existing Conditions) with Current Planning Scheme Overlays

Job Number: V3000_052
Revision: 0
Drawn: PC
Checked: AP
Date: 29 Feb 2016

Figure A4: Cross Section - Parsons Street to Alfred Street
Existing Conditions, 1 % AEP Flood Event



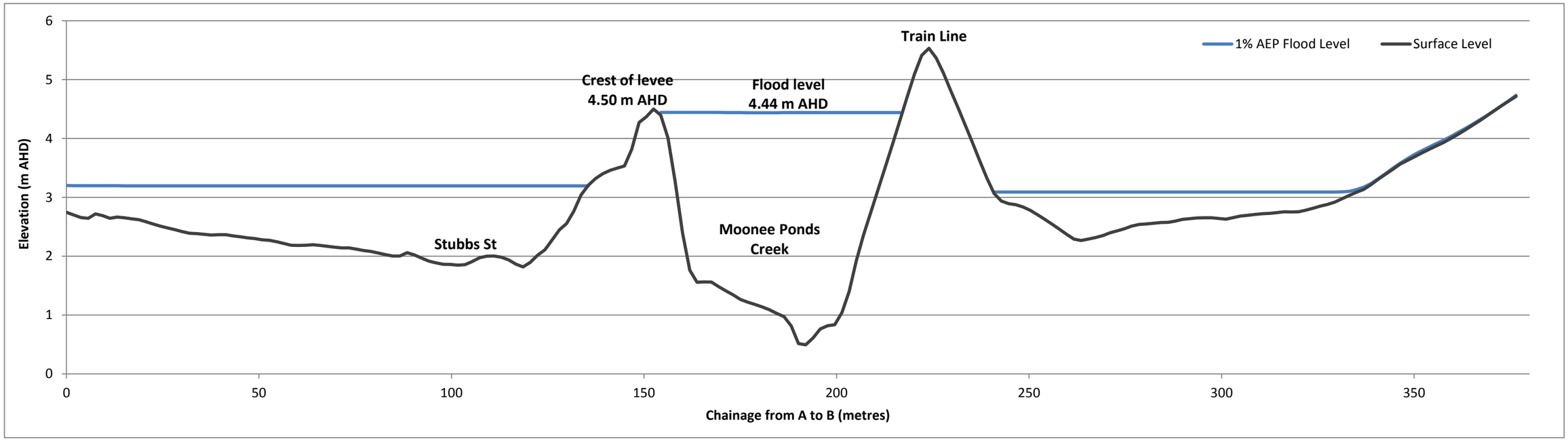
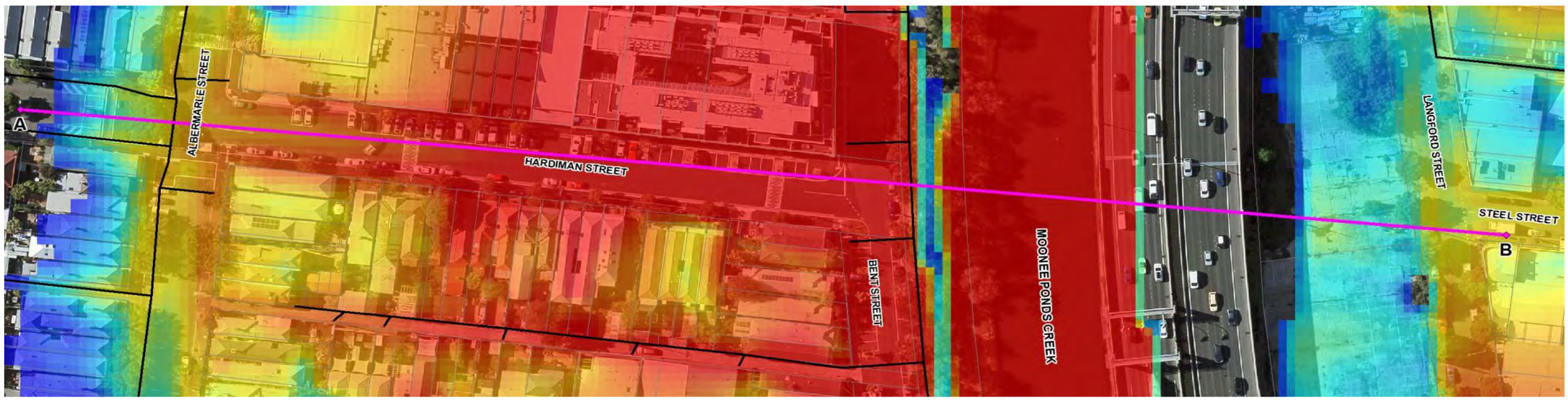


Figure A5: Cross Section - Hardiman Street to Steel Street
Existing Conditions, 1 % AEP Flood Event



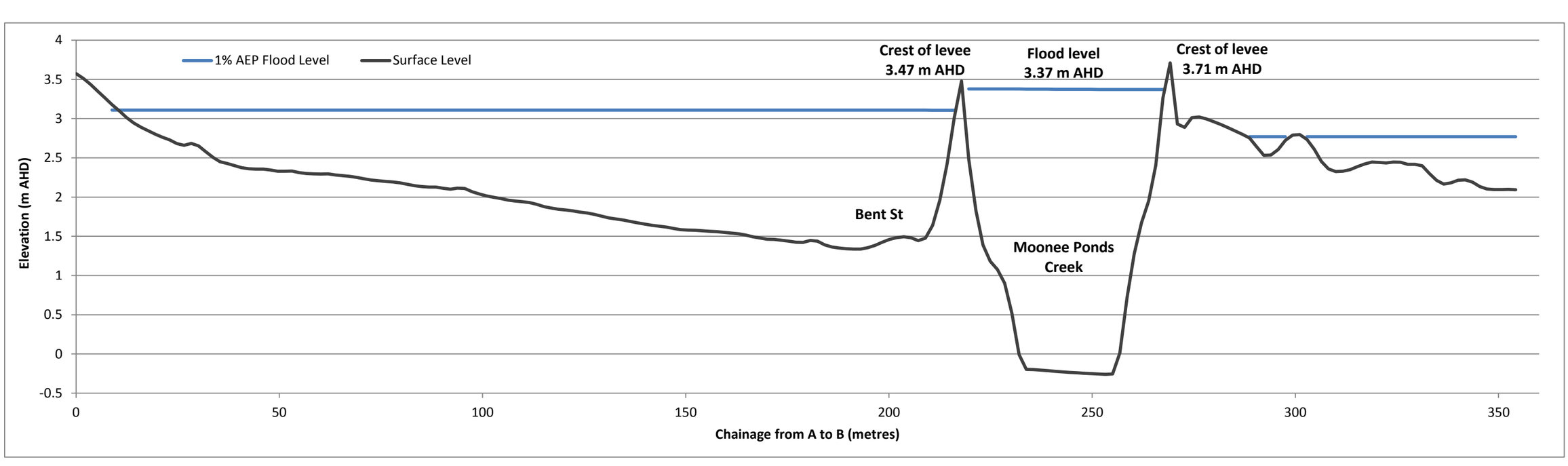


Figure A6: Cross Section - Government Land South of Arden Street
Existing Conditions, 1 % AEP Flood Event