South East Water & Melbourne Water

Fishermans Bend Integrated Water Management Strategy

Public Version of Options Evaluation Report, 2015

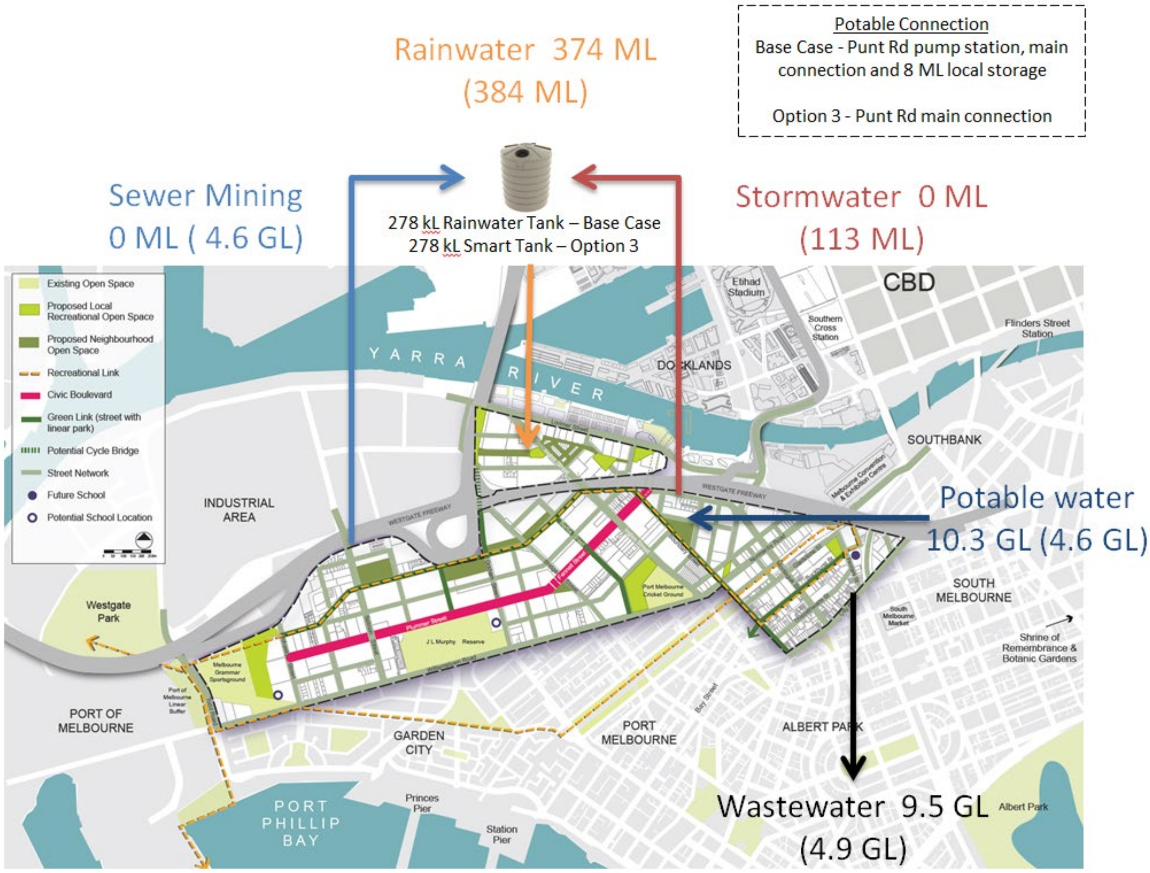
June 2020

Executive summary

Fishermans Bend is a large redevelopment area of around 258 ha which is expected to accommodate 120,000 residents and 60,000 employees within a wide range of enterprises over the next 40 years. It has been rezoned and the planning process is defined in the Strategic Framework Plan (SFP) (MPA, 2013), which includes requirements for third pipe supply and rainwater tanks in buildings.

A particular challenge in decision making now is that the future urban form is not yet determined, and will be driven to a significant extent by developer decisions, as many of the land holdings are large.

If serviced 'conventionally', the area will require around 10.3 GL per year of potable water, produce around 9.5 GL per year of wastewater and require significant upgrades to drainage to manage flooding. A high level water balance comparing Scenario 0 (Base case) with Scenario 3 (Interlinked Third Pipe Supply) is presented below.



Numbers quoted outside brackets – Base Case (Option 0)
Numbers quoted in brackets – Option 3

This study has examined the water cycle infrastructure required to service the area using the conventional approach and a range of innovative alternatives. The key conclusions are:

1. Rain harvesting does not provide a significant or reliable supply as high rise development has very high demands compared to roof areas.

2. Sewer mining is a practical possibility in the area as there are large sewers nearby, which have low salinity wastewater as a supply source. Sewer mining would reduce potable water demands by about 50% on an annual basis, and also reduce the peak potable demands. This means a significant reduction in the connection infrastructure from the main potable network.

3. Construction of conventional retarding basins for flood management is not favoured due to the low amount of open space, high land values and the potential for contaminated soil and groundwater to create issues and costs with excavation. Therefore, keeping rain and stormwater held in rainwater tanks above ground level in developments is preferred, and this approach can be made more efficient if the tanks are interconnected and actively controlled (subsequently referred to as 'Smart').
4. If the ‘Smart’ interconnected tanks are also used as part of the supply network for alternative water, further efficiencies are realised (reduced plant capacity and precinct storage), but with additional complication both technically and in the approach to management.
5. Economic analysis shows that these alternative approaches are typically within 10 to 15% of the NPV of the conventional approach. Since cost inputs include variables such as development timing, future land values, future costs of potable water and assumptions about technology over a 40 year time frame, it appears reasonable to see these costs as equivalent.
6. A practical implementation approach is available which moves progressively from a more standard third pipe solution in the medium term into a 'Smart' (actively controlled) system with interconnected tanks in the longer term.
7. A number of significant unknowns remain, particularly in relation to flood management, which will need ongoing investigation over time as the full details of the urban form are resolved, and as questions of policy in relation to flood management objectives and climate change are answered.

In summary, this report makes the following recommendations.

1. Adopt third pipe supply and assume the source will be a sewer mining plant in the area.
2. Undertake further investigations to identify the best site for sewer mining, noting possible opportunities just outside the area where land may be easier to obtain.
3. Develop an approach to manage funding of drainage infrastructure, which should include a method to maximise and encourage additional above ground tanks in new developments. Innovative market based instruments should be considered.
4. Develop flood mapping and mitigation on a catchment by catchment basis, with ‘sump and pump’ as the base case design.
5. Confirm the flood management standard including consideration of climate change. Undertake detailed flood modelling and localised design of solutions once urban form is confirmed.
6. Investigate the benefits and risks of different forms of 'Smart' and interconnected tanks, including how such a system would be managed given the dual function of supply and flood management.

Study Overview

Fishermans Bend offers an outstanding opportunity to consider how to provide effective and innovative water cycle infrastructure in a major inner city redevelopment. The fact that the majority of the water infrastructure will need to be designed and developed offers opportunities for integration of water cycle services.

There is a genuine opportunity to do things differently at Fishermans Bend. Due to the significant transformation required to transition to a precinct that accommodates 120,000 residents and 60,000 employees within a wide range of enterprises, all elements of infrastructure need significant attention: transport, energy, community requirements such as open space and the water cycle. The nature of the area means that most of the development will be multistorey and high rise. This kind of higher density development intensifies the infrastructure requirements.

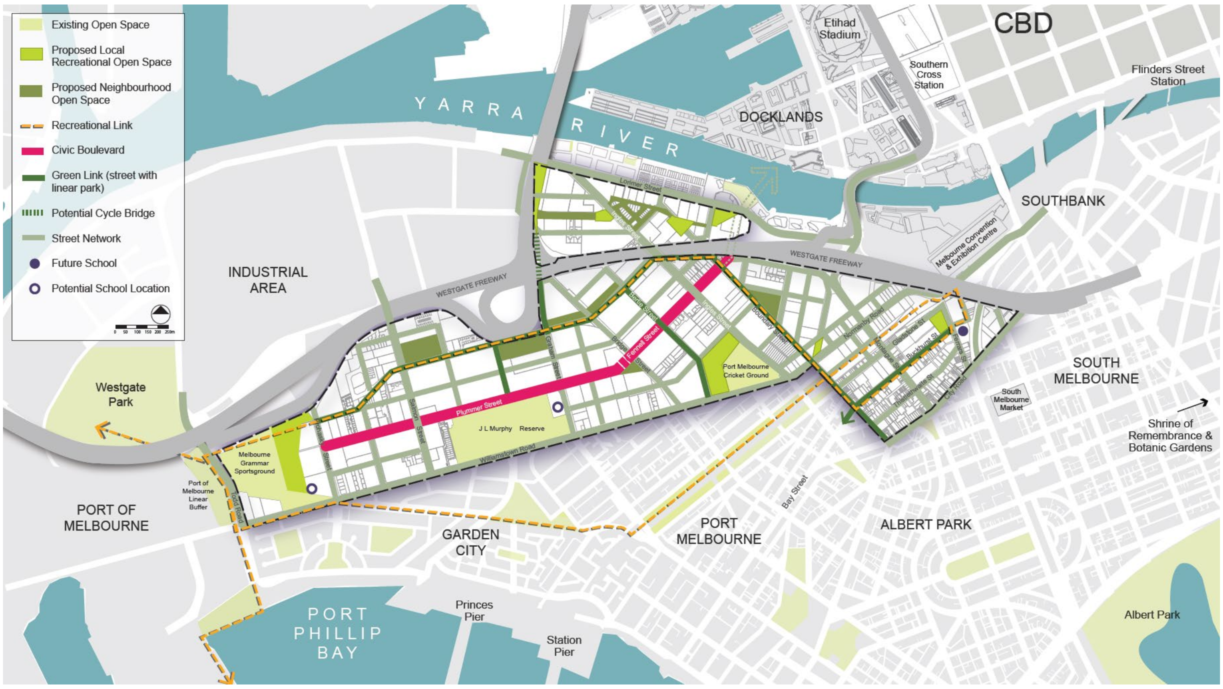
This study identifies a preferred Integrated Water Management (IWM) servicing strategy for the Fishermans Bend Urban Renewal Area, encompassing the Montague, Lorimer, Sandridge and Wirraway precincts.

Unique Characteristics

The Fishermans Bend precinct can be characterised as follows:

- Fishermans Bend is an area of around 258 ha, which is currently built out with commercial and industrial premises. The area has been rezoned as ‘Capital City Zone’, and is expected to transform over the next 40 years to become an extension of the CBD toward the Bay. This industrial commercial area is expected to be redeveloped into residential, offices, commercial and retail areas. Taken as a whole, it is a very large urban redevelopment.
- Due to the geology of the area, which discourages excavation, land values and proximity to the city, high rise buildings with raised podiums (set above projected climate change sea level rise level) are expected to characterise much of the development.
- The area is located on a peninsula between the lower reaches of the Yarra and Port Philip Bay. It is low lying, and in some circumstances is already subject to flooding. This flooding includes some incursions of salt water in high tide events, which will constrain some opportunities for harvesting or management of this water.
- The water table is close to the ground surface, with a range of implications. It is expected that the depth to the water table will reduce as a result of climate change and settlement. Further, there has been a long history of industrial activity in this area, much of which occurred in times when regulatory constraints and attitudes to pollution were different to today. As a result, it is possible there is contamination of soils and groundwater in the area (pending the completion of all soil and groundwater contamination investigations).
- There are existing potable water, waste water and drainage assets in the area. However, none will be entirely adequate to accommodate the needs of the development, unless all the development is self-contained from a water cycle viewpoint.

The Fishermans Bend Urban Renewal Area is presented below.



Purpose of This Study

The purpose of this study is to identify a preferred Integrated Water Management (IWM) servicing strategy for the Fishermans Bend Urban Renewal Area encompassing the Montague, Lorimer, Sandridge and Wirraway precincts.

Approach

The project used a collaborative approach with a range of stakeholders, including a number of meetings and workshops. These collaborative efforts progressively delivered the following outputs:

- Identification of levels of service the development will need to meet (i.e. level of flood protection, reliability of supply etc);
- A long list of options and concepts which were then assessed qualitatively against a set of functional criteria and opportunity/risk considerations
- A short list of options which drew on the best elements of the long list, and/or provided examination of key project questions;
- A cost and benefit analysis of the short listed options, based on further development and design; and
- Review of the outputs and broad agreement on the preferred options.

This report presents details of each of these steps.

WoWCM (Whole of Water Cycle Management) Scenarios

The scenarios that were assessed as part of this assessment are outlined below in Table 1.

Table 1 Summary of base case and alternative scenarios

Scenario	Description	Third Pipe	Primary Third Pipe Source	Third Pipe Back-up	Building Rainwater Tank Size	Drainage Approach
0 - Conventional Water, Sewer with (no minor or major drainage upgrades) – Base Case	Conventional servicing with rainwater tanks as per SFP (Strategic Framework Plan) and no precinct based drainage. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Rainwater tanks as per SFP with no new precinct drainage
1 - Conventional Water, Sewer & Drainage upgrades	Conventional servicing [no development wide third pipe]. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
2 - Sewer Mining in the Precinct	Sewer Mining with development wide third pipe. Slow release rainwater tank. Conventional drainage upgrades.	Development wide (SEW Managed)	Rainwater, Sewer Mining	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
3 - Interlinked Third Pipe Supply	Mix of lot & development scale initiatives. Harvested rainwater, stormwater and sewer mining mix to third pipe network. Smart quick release rainwater tank. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks). End of line retention and reuse.	Development wide – Building (SEW Managed)	Rainwater, Stormwater	Sewer Mining	Smart tank to maximise roof & podium collection (fitted with fast release)	Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse.
4 - Stormwater Harvesting in the Precinct	Precinct scale stormwater harvesting into third pipe. Slow release rainwater tank. End of line stormwater retention and reuse.	Development wide (SEW Managed)	Rainwater, Stormwater	Sewer Mining	As per SFP (capture roof only, fitted with slow release storage component)	End of line retention and reuse.
5 - Lot focus	Lot scale approach to minimise precinct infrastructure. Designated tolerable road flooding. Smart quick release rainwater tank. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens).	Building scale (Developer Managed) & Local Stormwater	Building - Rainwater, Greywater Local - Stormwater	Potable	Smart tank to maximise roof & podium collection (fitted with fast release)	Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens)

Key Design Considerations

The following unique features mean that 'typical' greenfield suburban thinking is unlikely to be appropriate for Fishermans Bend:

- Demands are not as variable, as there is proportionally much less open space;
- There is existing infrastructure which will meet requirements for some time, but eventually need upgrading;
- Development will occur gradually, so the whole area will be a mix of new and existing;
- It is low lying and flood prone;
- Underground excavations are not favoured due to ground conditions, the groundwater table and contaminated soil; and
- Demands very significantly exceed supply so that rainwater tanks empty very quickly and are mostly empty (providing capacity for a secondary or tertiary use).

Implications of Climate Change for Fishermans Bend

This section broadly addresses the implications of climate change for Fishermans Bend, as they relate to the water cycle.

Sea Level Rise

Note that the effects and impacts of rising sea levels will be widespread, and the surrounding areas, as well as other regions along the coast will all be affected. Therefore it would appear most appropriate for any response to this risk at Fishermans Bend to be part of a wider strategy.

Some potential technical considerations:

- Keeping buildings and infrastructure high;
- Minimising below ground level and in particular below sea level infrastructure;
- Keeping water high to provide a driving hydraulic grade;
- Keeping water high to maintain it with low salinity; and
- Considering the possibility of isolating drainage from sea level with one way valves, pumps and levees.

Increased Frequency of Higher Intensity Rain Events and/or Increased Intensity of Rain Events.

Rain events may become more intense more frequently, even if the overall climate is getting drier. The degree to which this might occur, and when it might occur are highly unpredictable.

Current flood management objectives aim for a convenient and safe standard of protection from events with 5 and 100 year Average Recurrence Interval (ARI). The size of event which will occur with this frequency might increase, and therefore catering [as one example] for a 20 year ARI event today might in effect lead to meeting a 5 year ARI standard in the future.

The advantage of considering the adoption of a higher standard is that it provides increased service now, and in time might reduce in performance, but back to a level considered to be the desirable minimum today.

The current SFP keeps most of the buildings high, which manages much of the impact of flooding. The flood risks to on street infrastructure, cars and access by pedestrians are some of the key risks not managed by the current SFP.

It may be that these risks can be better managed by unique very local responses such as urban design rather than precinct wide responses to provide a uniform flood response.

Some potential technical considerations include:

- More storage to manage larger events.
- Allow for bigger events in urban planning and design.
- Consider how to provide a risk level consistent with land use proposed in the area.

What are we aiming for?

From a ***water supply*** perspective the aim is for a resilient reliable supply, with the ability to support a changing pattern of water use over time, and with the flexibility to provide water to higher demands if concepts such as green walls are taken up much more widely than currently estimated.

From a ***wastewater management*** perspective the aim is for a reliable system removing wastewater generated with minimal to no spill potential. Minimise inflow of rainwater, groundwater and salinity. [Note: major sewers run through this area, and send wastewater to WTP. Currently, there is sufficient capacity in these systems to accommodate the projected loads.

From a ***flood management*** perceptive the aim is for

- 5 year ARI event – streets and private realm flood free; and
- 100 year ARI event – private realm flood free and streets meeting low risk velocity depth criteria.

Note there are a range of broader flood management objectives relating to climate change that are yet to be resolved:

- Do we account for climate change [additional rain fall intensity and frequency]?
- Do we account for sea level rise?
- Do we aim for a higher standard [such as 20 year vs 5 year ARI].

From an ***environmental and community*** beneficial uses perspective the area is just upstream of Port Philip Bay, and therefore there are no 'waterways' to impact. Flow regimes are likely to be less important; however contaminants such as nitrogen and pathogens are important.

What is the 'Base Case'?

For water supply and wastewater management it is technically credible, and potentially even economically attractive to supply all water demands with potable water, and to send wastewater to WTP for treatment and disposal.

For flood management due to a range of unresolved objectives relating to climate change, it is not clear what the 'base case' should be:

- Even with the requirement for tanks in the buildings, additional precinct systems are needed;
- Sump and pump approaches can work, but there may be concerns about reliability;
- Tanks in the buildings could be made bigger to reduce the need for works in the ground, but it is not clear what mechanism would be used to enforce, or fund this;

- Below ground storages could form part of the solution, but would require identification of suitable open land, and then the difficulty of construction in this area with high groundwater and potentially contaminated soils means that they are unlikely to be suitable. In any case, pumping is likely to be required from any ground level storage in some areas if sea level rise is considered;
- The approach is likely to need consideration of neighbouring areas, and may vary from precinct to precinct; and
- On balance, the current preferred approach is ‘sump and pump’.

Are 'Innovative' Options Available?

Several different concepts were developed, all of which could be implemented, and would assist with management of the water cycle in a different way.

The most attractive of these innovative alternative options has the following features:

- Tanks at buildings serve multiple purposes and are 'Smart'. Purposes are rain harvest, flood storage and peak supply storage.
- Tanks in buildings are interconnected through the third pipe network.
- The network is backed up with Class A recycled water from sewer mining.
- Flood management is a mix of sump and pump, and storages varying from area to area.
- This approach is close to the economics of the base approach but not the cheapest. This approach could be implemented progressively as follows:
  - Tanks and third pipe installed in the short term (not Smart or fully interconnected). Third pipe uses potable.
  - Tanks become smart and get interconnected.
  - Supply backed up with Class A from sewer mining commencing in 2030.

Preferred Approach

The selection of a preferred option is not clear cut. The following key conclusions have been drawn from the assessment of alternative WoWCM scenarios for Fishermans Bend:

- It appears that it is worthwhile investing in drainage infrastructure relative to Scenario 0 (the base case). Despite the already high level of protection afforded by the elevated buildings, the potential reduction in average annual flood damages is generally comparable to the additional infrastructure costs;
- Scenario 5 is less attractive than the other options due to the capital and operating expenditure that is associated with having a greywater treatment plant in every building.
- In economic terms (i.e. without a mandatory potable water substitution or wastewater reduction target), the base case (Scenario 0) is a marginally more attractive option under the current long run marginal cost, land value and sewer mining plant cost assumptions.
- Options 2, 3 and 4 (all have sewer mining as a key component) have slightly higher net present values than the base case (GHD, 2015)Due to the uncertainty in a number of the key assumptions, further detailed evaluation of sewer mining within Fishermans Bend is recommended as part of a business case process. Two key considerations are explored in the implementation decisions for Fishermans Ben section below, namely the viability of sewer mining viability and smart rainwater tanks.

- It does appear that a progressive approach based on Scenario 3 has merit, given that only small changes in the input parameters are needed for the sewer mining approach to be equivalent on an economic basis.
- The flood analysis suggests that a sump and pump approach is preferred to end of line storage, however this may vary on a catchment basis.

Implementation Decisions for Fishermans Bend

Fishermans Bend is in relatively early stages of urban design development, and the full details of how the different precincts will 'look' will depend on stakeholder inputs, and then a range of more detailed considerations as the individual developers put forward their proposals.

This is expected to happen over a relatively long time frame, and to some extent progressively as development moves broadly from the east to the west across the precincts.

There is existing water, waste water and stormwater cycle infrastructure in the area, which are outlined below.

Water Supply

The water supply system will be adequate for a number of years. In the longer term upgrades will be required to provide sufficient flow to accommodate the increased demand. The timing and extent of these upgrades depends on a number of factors including:

The degree to which water is supplied from alternative sources such as rain water and sewer mining.

1. The extent, nature and density of the development. At one extreme, if many high rise, high density residential developments occur early, then the upgrades will be required sooner. If development is slower and incorporates lower density and less residential, then the upgrades will be required much later.
2. The degree of 'greening' incorporated in the development. If features such as urban forest, green walls etc become prominent, this will increase the demand for water. So there is some uncertainty related to future urban design approaches.
3. The pressure and flow available from the central system, which will change over time as demand on the wider Melbourne system changes with growth generally, and particularly in areas which influence the transfer system from the Preston tanks to Punt Rd.

Note that works to construct pipes, tanks and other transfer infrastructure from the Punt Road system across to Fishermans Bend are likely to be expensive and disruptive as they will occur through a heavily developed part of the city, and also in areas where ground conditions may be problematic.

Overall, there are likely to be benefits from sourcing water locally, particularly if these alternative local approaches are sufficiently reliable so that expansions of the existing connections to the main Melbourne network can be deferred, avoided or minimised.

Wastewater

The wastewater supply system will be adequate for a number of years. The local system will need upgrading to accommodate the increased flows from development. Melbourne Water has currently indicated that the major sewers in the area have sufficient capacity to accommodate the flow, particularly if it is confined to dry weather flow, with minimal wet weather peaking.

Overall, this suggests there is limited value in reduced wastewater flows in relation to impact on the sewer network, based on the current advice.

Final discharge of wastewater to WTP will increase loads, and form a fraction of the growth in flows expected over time, which lead to a need for progressive upgrades.

One concept explored in this study is sewer mining. It is useful to consider how sewer mining as a concept might affect the wider sewer network and wastewater treatment.

Sewer mining plants are typically designed to provide a supply, not manage waste water. Therefore, the amount of flow they remove will vary from time to time based on the demands, and may drop quite low. If the sewer mining plant is designed to be cost effective and with downstream peak supply storage, it may even stop taking wastewater altogether from time to time. As a result, with typical sewer mining plants, little credit can be given to the reduction of wastewater flows on a day to day or hour to hour basis, which means little benefit in reducing the need for sewer system upgrades.

1. Sewer mining plants are typically designed to remove BOD and provide pathogen removal, not specifically to reduce all contaminants. For example, nitrogen removal may not be important. Further, the waste streams from the plant [such as biosolids and the like] are likely to be returned to the sewer system. In the case of an area like Fishermans Bend, the recycled water would largely be used in the buildings, and therefore non-removed contaminants [like nitrogen and salt], would then re-enter the sewer system and be sent on to WTP.
2. Taken as a whole, these points suggest that although sewer mining removes a net flow from the sewer system, it does not remove all of the load from the 'final' waste water treatment plant, and does not reliably remove peak flows from the sewer network. So limited credit can be given to the reduction in capacity for the downstream sewers and wastewater treatment plant. Further work is needed in this area to better understand the extent of any benefits.

Flooding and Waterway Health

There is an existing drainage network, which does not include any waterway health protection measures such as wetlands. This network does not adequately manage current flooding in some areas (assuming an objective is to meet the current 5 and 100 year ARI standards everywhere).

The area is currently highly developed and impervious, so the proposed developments are not going to increase imperviousness, and in fact the requirements in the SFP are likely to improve floodwater management from developments compared to the current situation.

Waterway health is a complex issue, as the drains in the area discharge into either Port Phillip Bay or into the lower reaches of the Yarra. So there are no 'sensitive' waterways downstream, but rather these large bodies of water. The inputs from these drains will have an influence on the health of these water bodies, generally as incremental contributions to wider problems. Some local influences such as pathogens on local beaches may be important; however no specific objectives have been set. The following points are relevant:

1. Current infrastructure needs upgrading or replacement to meet the current 'standard'. However, such an approach would need to be considered over a wider area than just Fishermans Bend, as the drainage network and the topography means that flood issues are not isolated to this area.

2. Due to the low elevation of the area, the hydraulics of the drains will be significantly impacted by sea level rise, and in particular by storm surge. The SFP has managed the risks to some extent by setting floor levels, but areas such as roads etc will still be flooded. This means that the bulk of risk mitigation has already been incorporated. Concepts which assist in managing this longer term risk would be attractive.
3. The SFP requires storage in the buildings ['rainwater tanks']. These provide an opportunity to assist in managing flood flows if configured with smart systems and a location to release water when heavy rain is forecast.
4. The high value of land, the potential for contaminated soil, the low elevation and high water tables and other factors suggest that in-ground storages or retarding basins in open space are less attractive.

Overall, there are three issues which need resolution before an approach to flood management can be confirmed:

1. The standard which must be met needs to be defined. Must all areas meet the 5 year ARI requirements? When? [Amongst other questions].
2. Does the approach need to manage sea level rise and/or increased intensity of rain events due to climate change? Or will this be handled on a more regional basis when needed?
3. Does the approach need to manage flood inputs from surrounding areas? [Or can all or parts of this area be physically isolated?]

Sewer Mining Viability

This project has examined different options and scenarios for water supply. As the precinct has a high density, the primary demands which can be serviced by alternative water are relatively constant, with a less than typical variation for watering of open space [there are no backyards].

Further, the roof area is relatively low versus demand, due to the tall buildings. So the most attractive source for alternative water seems likely to be wastewater, which is plentiful, as major sewers run through this area. Sewer mining doesn’t make sense on its own. There are advantages in capturing roof and podium runoff at the lot scale whilst the quality of water is still relatively good and so that downstream infrastructure requirements (within poor ground conditions and expensive land) are reduced. The primary economic benefit of sewer mining is the reduction in annual use of potable water, which has been considered in the analysis by evaluating the saving based on the Long Range Marginal Cost (LRMC) of potable water.

The net present value (NPV) analysis was conducted on the sewer mining option for supply of alternative water in the original Fishermans Bend IWM Strategy (GHD, 2015). In this analysis, the costs and benefits of various flood management concepts wereremoved, so the comparisons are based on the management of water supply and wastewater alone.

The following observations could be made:

1. The difference in the Net Present Values [NPVs] for the base input assumptions is about 12% higher for sewer mining through third pipe compared to potable alone supply.
2. An equivalent NPV is achieved with relatively small changes in the LRMC of potable water, plant cost, land cost and plant timing (Table 2 and Table 3).

Table 2 Sewer MininViability Sensitivity Test Paramters

Sensitivity Test	Description	Reduction from starting value
1	Cost of plant ($ per ML/d)	-5%
2	Cost of land ($/ha)	-5%
3	LRMC of potable water ($/ML)	+5%
4	Timing for plant	Timing modified from 25% in 2030, 2040, & 2050 to 20% in 2030, 40% in 2050 and 40% in 2060.

Table 3 Sewer Mining Viability Sensitivity Results

Sensitivity Tests Applied	NPV Difference (Scenario 3 - Base Case NPV)
None	12%
4	10%
3 & 4	8%
2, 3 & 4	7%
1, 2, 3 & 4	7%

Overall it appears that sewer mining is so close in cost to potable supply in this project that other factors are also important.

The non-costed factors which could influence the choice to pursue sewer mining include:

- Community views: There could be diametrically opposed views on this: on the one hand developers may support it, as it will assist in selling a 'green' image. On the other hand people may prefer to have other sources of water due to perception concerns. The community may prefer not to have a treatment plant in their neighbourhood, or they may like the idea of accessing a local resource.
- Energy use: collecting wastewater locally and treating for local use will have lower energy use than water supplied from the desalination plant [noting that the desalination plant is supplied with renewable energy through an offset arrangement].
- Construction of additional water mains from Punt road will cause cost and disruption outside this precinct, whereas dual pipe and sewer mining plant construction will have cost and disruption inside the precinct.
- This area does have a large sewer with relatively low salinity wastewater available, so the concept is technically feasible.

Overall it appears the arguments for and against sewer mining is too balanced to allow a simple decision at this time. GHD recommends the following approach:

1. Assume it may be viable and continue to require third pipe in buildings. Assume the plant itself will not in any case be required for many years: thus allowing time to consider the relative merits in more detail. Provide potable water in the meantime.
2. Plan to install dual supply pipes (third pipe).

3. Investigate community and developer views.
4. See if a site can be identified and at what cost.
5. Develop a more detailed concept design based on an identified site [or sites] to provide a more robust cost estimate.
6. Confirm the long range marginal cost (LRMC) for potable water.
7. Study the impact of upstream sewer mining on WTP in more detail to determine if there is any benefit.

Sewer Mining Plant Location

The selection of a suitable site for the sewer mining plant is not resolved, and needs consideration of a range of complex factors:

1. No land was originally set aside in the SFP.
2. The need for buffer distances would add significant land cost, and the alternative of 'in-building' or 'underground' would add significant construction and operation cost.
3. The 'Main Sewer' has more than enough flow, and currently acceptable salinity. So it is attractive to access. By contrast, the sewers further downstream to the west become more saline.

Overall then, it seems that the choice is either to locate the plant very close to the main sewer and the demand, which will be right in the middle of the expensive land, or to locate it well away [perhaps in industrial land more to the west] and then pay for longer transfer mains to and from the sewer and the demand.

There are too many factors which are currently unknown to reach a conclusion on this point, other than to emphasise the need to set aside land as quickly as possible.

Viability of In-Development Smart Rainwater Tanks

The value of smart rainwater tanks at the lot scale can potentially be four-fold:

1. Lot scale rainwater tanks can provide flood storage (potentially at a lower cost to precinct base storages. The uncertainty in the cost of implementing precinct scale storages is a clear driver for exploring the implementation of larger or smart rainwater tanks at the lot scale. This uncertainty relates to poor ground conditions (high water table and Coode Island silt), contaminated soils, cost of land as well as the uncertain time frame of development.
2. Lot scale rainwater tanks can provide a rainwater harvesting function;
3. Lot scale rainwater tanks can provide a short term storage alternative for potable water (after third pipe is installed and before recycled water plant is required due to a low population in the early years of development); and
4. Lot scale rainwater tanks can provide a long term storage alternative for potable water and/or recycled water.

Preston Potable Connection Upgrade

The development in Fishermans Bend, along with other development in the general area, is putting a gradually increased load on the Preston to Punt Road potable water supply system, and then from that system to this area.

In the longer term, this will be managed by a combination of additional storage and pumping to provide additional head and reduce peak hour demands on the core system. However, these works are not required until the demands in this area, and in other areas reach a level which constrains the wider system.

So it is difficult to determine the appropriate timing for the Fishermans Bend precincts need for such upgrades in isolation from consideration of the wider network.

For the purposes of this study, this infrastructure has been assumed to be required at around 25% of development, in approximately 15 years' time. Some points to note:

- Accelerated development in other areas connected to the Preston system could bring forward the need for this infrastructure.
- The need for earlier peak flows is related to other sensitivities such as the degree of penetration of water based cooling.
- One critical factor will be the identification of a suitable site for the storage tank.

Recommendations

The recommendations of this study are as follows:

- Adopt third pipe supply and assume the source will be a sewer mining plant in the area.
- Undertake further investigations to identify the best site for sewer mining, noting possible opportunities just outside the area where land may be easier to obtain.
- Develop an approach to manage funding of drainage infrastructure, which should include a method to maximise and encourage additional above ground tanks in new developments. Innovative market based instruments should be considered.
- Develop flood mapping and mitigation on a catchment by catchment basis, with 'sump and pump' as the base case design.
- Confirm the flood management standard including consideration of climate change. Undertake detailed flood modelling and localised design of solutions once urban form is confirmed.
- Investigate the benefits and risks of different forms of 'Smart' and interconnected tanks, including how such a system would be managed given the dual function of supply and flood management.

List of acronyms

Acronym	Definition
ARI	Average Recurrence Interval
BPEMG	Best Practice Environmental Management Guidelines
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CoM	City of Melbourne
CoPP	City of Port Phillip
CWW	City West Water
IWM	Integrated Water Management
kL	Kila-Litres
LoS	Levels of Service
LRMC	Long Range Marginal Cost
MCA	Multi-Criteria Assessment
ML	Mega-litres
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
MWC	Melbourne Water Corporation
NPC	Net Present Cost
NPV	Net Present Value
OPEX	Operational Expenditure
POS	Public Open Space
PSP	Precinct Structure Plan
RO	Reverse Osmosis
RWW	Class A Recycled Wastewater
SEPP	State Environmental Protection Policy
SEW	South East Water
SFP	Strategic Framework Plan (MPA, 2013)
WoWCM	Whole of Water Cycle Management
WTP	Western Treatment Plant

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Appendices

1. Introduction

The purpose of this study is to identify a preferred Integrated Water Management (IWM) servicing strategy for the Fishermans Bend Urban Renewal Area encompassing the Montague, Lorimer, Sandridge and Wirraway precincts. This report:

- Provides a contextual summary of the Fisherman's Bend vision;
- Explores how the vision can be implemented;
- Provides background on how the areas is presently serviced and the challenges presented by the region;
- Provides land use and growth projections;
- Provides water balance estimates;
- Outlines desired levels of service;
- Summarises key water and pollutant balance estimates;
- Provides a discussion on the key concept design considerations;
- Outlines the conceptual infrastructure and design intent of the short listed Whole of Water Cycle Management (WoWCM) scenarios;
- Presents staging considerations; and
- Recommends a preferred WoWCM scenario.

2. Fishermans Bend Vision

Fishermans Bend offers an opportunity to consider how to provide effective and innovative water cycle infrastructure in a major inner city redevelopment. The fact that the majority of the water infrastructure will need to be designed and developed offers opportunities for integration of water cycle services.

The development of this report was a collaborative process where a number of ideas were suggested by various contributors to workshops which were run in parallel by the CRC for Water Sensitive Cities

This section of the report discusses various concepts and ideas which could enhance the development.

Note: The concepts and ideas in this section of the report have been designed to be intentionally aspirational without constraint to stimulate innovation. As such they deliberately set aside the various constraints inherent in the planning schemes, roles of different entities, funding mechanisms and the like. The workshop process did not assume nor require commitment to these ideas.

The Fishermans Bend Urban Renewal Area is presented within Figure 1 below.

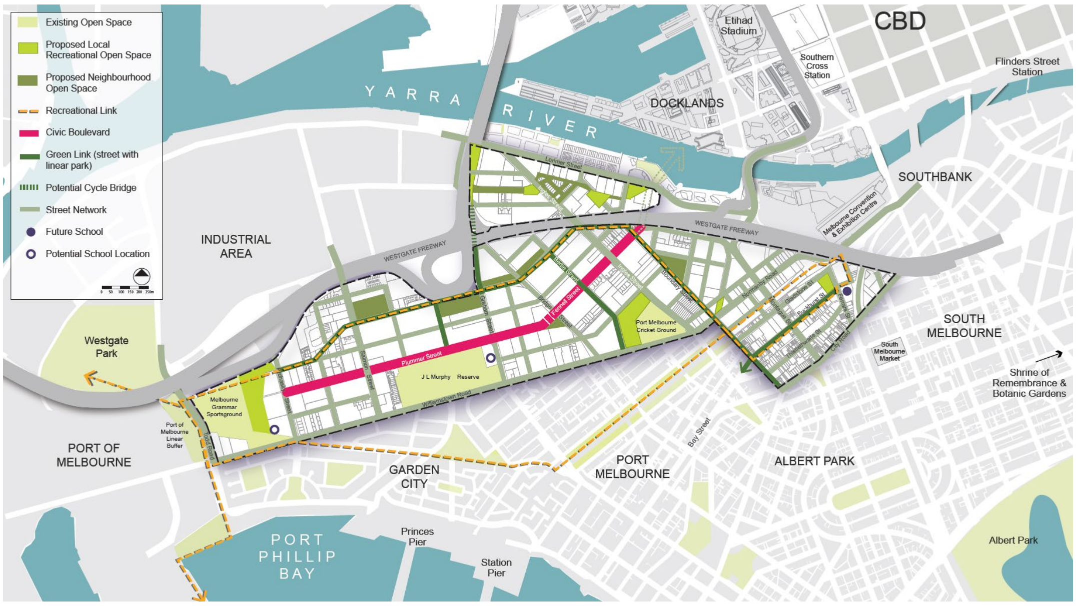


Figure 1 Fishermans Bend Urban Renewal Area*

**Source: Fishermans Bend SFP*

2.1 'Green' precinct vision for Fishermans Bend

The strategic plan for Fishermans Bend considers liveability of the urban environment and the many interrelated aspects this encompasses including how to incorporate green infrastructure, stormwater management, water in the landscape, walkability, canopy cover and urban form. One linking element of these is the use of greening along major roads and encouraging developers to incorporate green and open space.

Successful provision of a green precinct requires successful management of the water cycle. Water must be provided to the green areas, including during times when rainfall is low, and excess water must be removed when rainfall is high.

Such a vision will only be optimised if the developments and the precincts open space and public areas have a somewhat consistent approach.

Figure 2 and Figure 3 provide an interpretation of the Green Vision for Fisherman Bend. These are provided solely to illustrate how some of the concepts can interact.

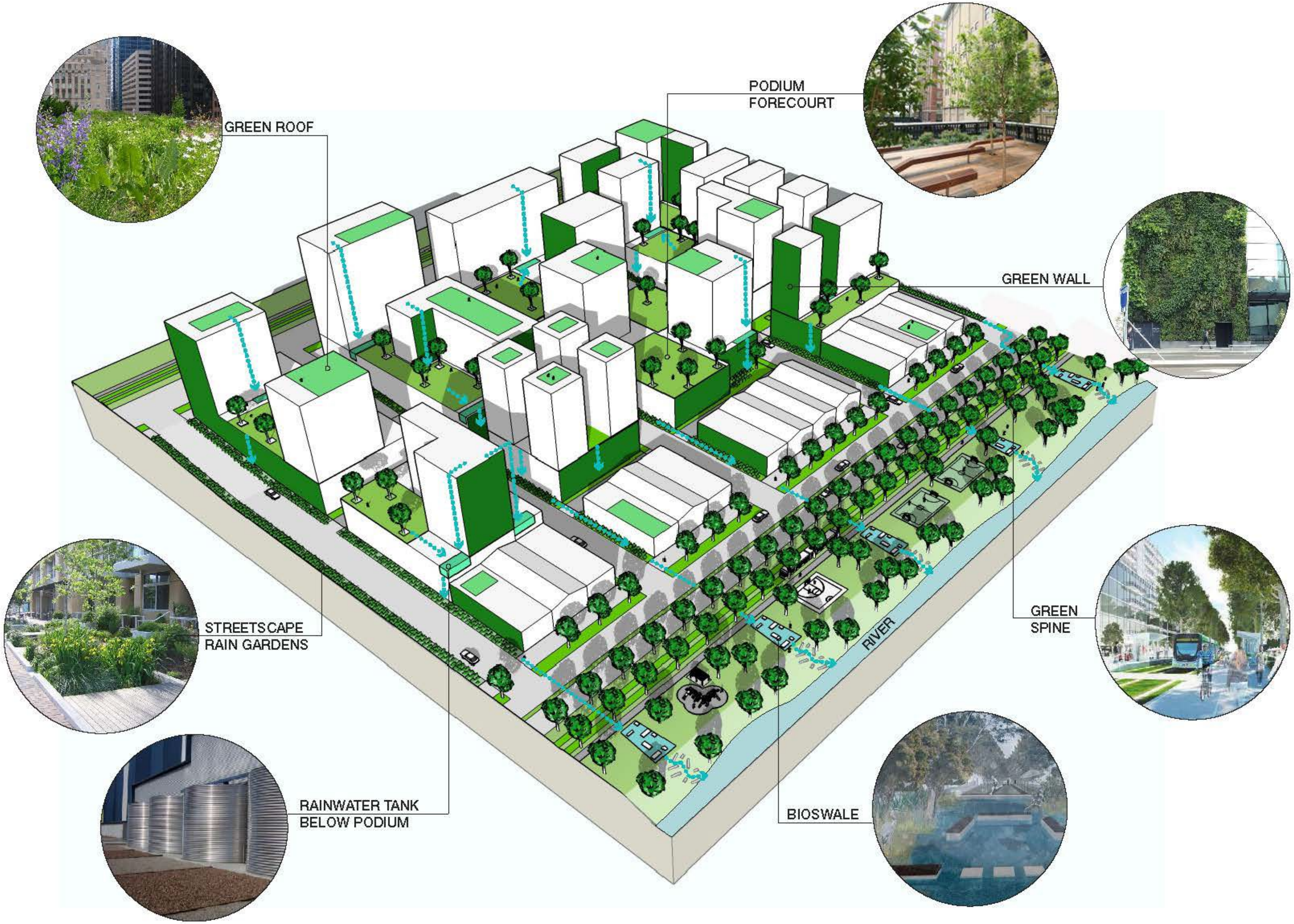


Figure 2 Green Vision for Fishermans Bend

Figure 3 Interpretation of a green vision for Fishermans Bend*

**Source: R.Pasman, Monash Art Design and Architecture and CRCWSC (Figures sourced from draft workshop presentation).*

2.2 What are the key ideas?

The following points summarise the key ideas.

- Consider the area on different scales, from the building level through to the precinct level and then through to the whole of development. Ideas need to be considered on all these scales and to integrate through the scales. For example, the best opportunity to capture water for use in green areas at the building scale is at the buildings, potentially backed up with sources from 'outside'.
- Water captured high in buildings [whether rain water in tanks, grey water in pipes or other water], has a high potential energy which could be captured to reduce energy used elsewhere. Many concepts were suggested, one simple example is to have a pressure pipe drainage system which uses the building head to drive stormwater over longer distances in smaller diameter pipes. All other factors being equal, this suggests maximising water retention and storage in the buildings and on podiums.
- Urban design concepts which combine open space, drainage and green areas along corridors can serve as both open space and also transport and treatment for stormwater. Plummer Street has been suggested for such a 'green spine'.
- The water used in this area significantly exceeds that which could be captured from roofs and the like, because high rise buildings put many more people under the same roof space. Therefore reuse of grey water and black water become more attractive to minimise potable water use. One innovative idea is to separate grey water and then treat it to a potable standard. If taken further, this would most likely be considered at a precinct scale to allow management of quality and minimise the number of complex treatment plants.
- The buildings and development will include storages such as rain tanks to manage peaks in rainfall and stormwater flow. These will often be empty, as peak rain events do not occur every day. A range of different ideas have therefore arisen to use this 'empty' space. For example, it could be used to balance peak demands in dry periods. The key challenge of these concepts is finding an acceptable 'sink' for the water in the storages when a rain event is expected, so that the storages can maintain their original function. Developing reliable operating regimes which take weather predictions into account would also be required.
- There is opportunity to explore the link between energy and water. Potential energy from elevated wastewater could be considered. Heat could potentially be recovered from the sewers. If local blackwater treatment occurs, anaerobic processes could be used to generate biogas.

2.3 Implementing innovative 'Green Precinct' ideas

Many of the servicing strategy scenarios presented within this study are flexible enough to compliment, support or facilitate a range of the innovative ideas that have been identified to date. These include:

- Green spines, green walls/facades and green roofs and podiums – there is flexibility within all scenarios to explore such initiatives. As noted within this report, these demands do not place significant pressure on the class A or potable network due to the nature of development at Fishermans Bend. A green vision will therefore not be held back by the proposed water servicing strategy. The additional demand has been explored in the sensitivity analysis.

- Sewer heat recovery - there is flexibility within scenarios 2, 3, 4 and 5 to explore this initiative in the future;
- Sophisticated flood approaches such as stratifying the development across a number of levels including green roofs, podium forecourts, green corridors and roadways that work in unison to collect, store and transport stormwater water across the site – there is flexibility within all scenarios to explore these initiatives. All scenarios explore ways in which to maximise on lot capture from the roof and podium. Scenario 3 and 5 specifically explore innovative ways to utilise the rainwater tanks (i.e. provide detention/retention overlap, share rainwater between buildings, provide balancing class A storage, supply different end uses etc) with Scenario 5 also exploring local streetscape retention and reuse.
- Sophisticated water quality approaches (i.e. a full green spine down Plummer St) – there is flexibility within scenarios 3, 4 and 5 to explore this initiative through precinct based stormwater treatment and flood storage initiatives;
- Buildings have 3rd pipe with option to convert from supply to collection system (i.e. greywater is treated for non- potable use while also sustaining vertical landscapes) – there is flexibility within scenario 5 to explore this initiative; and
- Smart technology for integrated water & energy management – there is flexibility within scenario 3 to explore this initiative.

Figure 4 provides an interpretation of the implementation of a green spine along Plummer Street.

Figure 4 Plummer Street Green Spine Interpretation*

**R.Pasman, Monash Art Design and Architecture and CRCWSC (Figures sourced from draft workshop presentation).*

2.4 Challenges in implementing a fully innovative vision

Discussion and analysis showed there are a range of challenges. The following list provides some key points.

- The development will occur progressively over many years, and therefore concepts and technology are likely to change over that time. Approaches seen as difficult today may become commonplace. Approaches seen as best practice today may become unacceptable. Therefore it seems critical that the approach is flexible.
- It is possible to conceive 'optimal' solutions for the water cycle. However other factors are also important such as transport, other infrastructure, and the commercial implications of development occurring on a large number of sites with different owners. So compromise is likely to be required in some areas.
- Some issues have a wider impact than just this precinct. For example, flooding is a consideration in the wider area, not just Fishermans Bend. So solutions are likely to need a catchment wide approach.
- Some benefits and risks are not currently the subject of legislation, or regulation, and do not therefore have a policy basis for pursuing them, unless they have lower cost. Or, in other words, there are externalities which could affect decisions, but these are not currently easily costed. This again highlights the need to retain flexibility.

2.5 Some lessons learnt for future Brown Field Development Planning

The following points are potentially of value for other future projects.

- It is useful to consider whether the development will be progressive, or happen as one large project. If the development is one large project it is likely to be easier to implement innovations, as they can be undertaken development wide. With progressive development, new ideas must be incorporated into the existing infrastructure and/or change gradually over time, which adds technical challenges, and can make economics less compelling;
- Brown field areas are likely to have many existing infrastructure elements, providing various water cycle services such as water supply, wastewater management and stormwater and flood management. In some areas, the brown field area may not have met the latest service standards, but this may have been tolerated due to the nature of land use. Patterns of use will vary once development occurs. The 'value' of the existing infrastructure, which may be ageing and not fully able to service the new development, may be difficult to determine. So this creates a challenge in considering innovative alternatives. The best approach here may be to separate the requirement from the solution. What service standard is actually needed? Then if the existing infrastructure does not meet that standard, it has limited value. This particular challenge is common in that it depends on avoiding the 'sunk cost' fallacy.
- Significant costs may arise to improve water cycle services to meet the requirements of the new development. However, finding acceptable methods to fund these may be a challenge, as the existing servicing will meet some needs, and a 'tragedy of the commons' issue may arise, where each development on its own is not an issue, but the overall impact is an issue. Here one suggestion is to develop a current technology solution which meets all standards and ensure this is funded. Then by comparison, some innovations may create a saving, providing an easier path to implementation.

- Buildings scale approaches can be effective in managing staged development if you are innovative in what you use them for (i.e. smart tanks that can provide a combination of flood detention and retention, share rainwater between buildings, provide balancing class A storage, supply different end uses etc). Whilst interlinking buildings can provide more efficiency it can introduce new challenges relative to conventional approaches to servicing and potentially funding arrangements.
- The impacts of development in this area will spread into the wider water cycle, through requirements for water, sewage and stormwater management in greater Melbourne. A key input into these analyses is a reliable avoided cost to allow the increased or decreased impacts on the wider system to be considered reasonably.

The key overarching lesson is to adopt approaches which are flexible and allow ongoing innovation at all scales.

2.6 Next steps in implementing the 'Green Precinct' vision

The logical next steps to implement a greener precinct vision at Fishermans Bend are:

- Acquiring land or seeking access to land through some form of agreement or other process with private owners (i.e. below podium level) for major above ground infrastructure.
- Setting aside easements for major trunk infrastructure (drainage (inclusive of green spines), water and wastewater infrastructure).
- Developing clear guidelines for developers on how to interpret the SFP requirements.
- Developing a green spine vision for Fishermans Bend.
- Exploring how to maximise green infrastructure within the private realm inclusive of podium and building facades.
- Explore the role integrated water and energy management can play in supporting the green vision.
- Explore the business case including incentive for decentralised multi-use smart tanks within buildings potentially for both detention and retention, share rainwater between buildings, provide balancing class A storage, and supply a range of different end uses.

2.7 Lessons learnt for future Brown Field Development Planning

The Fishermans Bend Urban Renewal Area is one of many brownfield urban renewal projects that will be explored within Melbourne over the course of the next 40 years. If there are lessons that can be learnt from Fishermans Bend from a water cycle planning perspective they are:

- Whether the development will be progressive, or happen as one large project. If the development is one large project it is likely to be easier to implement innovations, as they can be undertaken development wide. With progressive development, new ideas must be incorporated into the existing infrastructure and change gradually over time, which adds technical challenges, and can make economics less compelling.
- Brown field areas are likely to have many existing infrastructure elements, providing various water cycle services such as water supply, wastewater management and stormwater and flood management. In some cases, the brown field area may not have met the latest service standards, but this may have been tolerated due to the nature of land use. Patterns of use will vary once development occurs. The 'value' of the existing infrastructure, which may be ageing and not fully able to service the new development, may be difficult to determine. This creates a challenge in considering innovative alternatives.

- Significant costs may arise to improve water cycle services to meet the requirements of the new development. However, finding acceptable methods to fund these may be a challenge, as the existing servicing will meet some needs, and a 'tragedy of the commons' issue may arise, where each development on its own is not an issue, but the overall impact is an issue.
- Buildings scale approaches can be effective in managing staged development if you are innovative in what you use them for (i.e. smart tanks that provide a combination of flood detention and retention, share rainwater between buildings, provide balancing class A storage, supply different end uses etc). Whilst interlinking buildings can provide more efficiency it can introduce new challenges relative to conventional approaches to servicing and potentially billing.
- The acquisition of land by the Government before the land is re-zoned enables the Government to have ultimate control in the consistency of outcomes and staging of water cycle and other public infrastructure including roads, open space etc. The East Werribee Employment Precinct is a good model in this regard. A key challenge for Fishermans Bend relates to the fact that the land is currently owned by a variety of developers, which brings a great deal of uncertainty in regards to the rate of development and the ability of Government to influence large scale coordinated change within a defined timeframe.

3. Site background

Fishermans Bend is an area of around 258 ha, which is currently built out with commercial and industrial premises. The area has been rezoned as 'Capital City Zone', and is expected to transform over the next 40 years to become an extension of the CBD toward the Bay.

This industrial commercial area is expected to be redeveloped into residential, offices, commercial and retail areas. Taken as a whole, it is a very large urban redevelopment.

The nature of the development is defined by the Strategic Framework plan, which is an incorporated document in related planning schemes. This document guides the layout expected, the nature of each precinct, and a range of specific requirements related to the water cycle.

The majority of the land is privately owned, and in some cases owned in large sections. Development will therefore occur as driven by the private sector, in accordance with the Strategic framework. *This is in contrast to some other large redevelopment projects where much of the land is owned by the government.*

The table below describes each of the four precincts of Fishermans Bend, summarising the key concepts set out in the Strategic Framework Plan. This is intended as contextual information only, so refer to the SFP if any specific information is required.

Table 4 Precincts

Precinct	Description
Lorimer	The Lorimer precinct is to the North of the Westgate Freeway, and continues toward the Yarra. It is located in the City of Melbourne. This area is expected to have a significant amount of high rise development, and includes a central 'green' spine along Lorimer Parkway. The Lorimer precinct is expected to develop earlier rather than later, due to its proximity to other development near the Yarra. Much of the development in this area is expected to be high rise. Some current planning applications confirm the interest in high rise in this area. This area is somewhat physically separated from the other precincts by the freeway, and may drain primarily north into the Yarra River. Therefore, solutions which are appropriate here may be unique to this area, and possibly isolated in some way from the other precincts.
Montague	This area is to the East closer to South Melbourne. It is expected to have early growth, particularly if key transport links go ahead. In this area there is again a green spine along the Buckhurst Street and high rise is expected. The Strategic plan effectively restricts high rise along the boundaries with the existing suburb, so there will be transitions in this area. This area has a number of flood prone zones.
Sandridge	The Sandridge precinct is to the west of Montague, and is effectively the central precinct. The area at its Eastern end is expected to be high rise including a significant number of commercial premises. The Civic Boulevard runs through the entire precinct and leads to the West. As for Montague, there are areas around the edge of the precinct where heights are effectively constrained to provide a transition from the existing areas.
Wirraway	This precinct is the furthest west, and in general is expected to be developed last. However, there are areas, particularly along the southern boundary where the Bay is close, and there could be development in these areas, which is likely to be less high rise than the other areas.

3.1 Geography

There are some key elements of geography which are important to the development of Fisherman's Bend.

The area is located on a peninsula between the lower reaches of the Yarra River and Port Philip Bay. It is ***low lying***, and in some circumstances is already subject to ***flooding***. This flooding includes some incursions of salt water in higher tide events, which will constrain some opportunities for harvesting or management of this water.

Over the next 40 years, this situation is expected to get worse, as ***sea level rise*** will increase the levels of both the Bay and lower reaches of the Yarra, the effects of consolidation on ground levels, and upstream development and or climate change may increase the peak flows along the Yarra, also contributing to the flooding potential.

The ***water table*** is close to the ground surface, with a range of implications. It is expected that this will also rise in response to the factors outlined above. Further, there has been a long history of industrial activity in this area, much of which occurred in times when regulatory constraints and attitudes to pollution were different to today. As a result, it is possible there is ***contamination*** of soils and groundwater in the area.

The ***geology*** in the area is challenging for construction, and is likely in some cases to require significant foundation works. This may lead to preferences for higher rise buildings to recoup the expense. It will also have implications for construction of community assets such as open space.

The above elements have a range of consequences.

- There are risks to human health and the environment from soil, soil vapour (and soil gas) and groundwater that need to be managed from both an infrastructure installation and operation perspective.
- Groundwater dewatering during construction and how this may be treated and disposed of due to potential and/or regional groundwater contamination
- Infrastructure involving significant excavation is not favoured.
- Above ground balancing tanks are favoured over underground balancing tanks for alternative water reuse purposes as underground tanks have been found to be prone to saline water intrusion within the neighbouring Docklands precinct.
- Reintroducing water into the groundwater (i.e. through WSUD infiltration approaches) may not be favoured as it could raise an already shallow groundwater table and mobilise contaminants.
- Extraction of groundwater may be necessary to treat it.
- There may be a need to capture or even replace groundwater from excavations.

There are investigations underway to regards to how these factors will be addressed, with large scale development and the potential of many different applications.

All scenarios presented consider the risk proposed by land and groundwater through the application of lined bioretention cells, the intent to minimise potable water augmentation requirements, as well as the use of rainwater/stormwater storages and alternative water balancing tanks at or above street level to minimise underground infrastructure requirements.

When cost estimation is undertaken, the sensitivity of options to high construction costs where any excavation is required will need to be considered.

3.2 Existing & future Water Cycle Infrastructure

There are existing potable water, waste water and drainage assets in the area. However, none will be entirely adequate to accommodate the needs of the development, unless all the development is self-contained from a water cycle viewpoint.

So there is a need to construct new potable, waste water and drainage systems, including upgrades to the connections from the networks in the Fisherman's Bend to wider systems. Under some options, the need to connect to the wider potable network may be reduced, with corresponding savings.

3.2.1 Potable water

Potable Water in the area is supplied via the Melbourne potable network. The area is generally serviced from the Preston Tanks, which supply into this area via the Punt Road main.

The supply into the area from Preston is likely to be constrained in the future as demand generally increases. So options which reduce the demand for peak flow may offset future costs.

3.2.2 Wastewater

Waste water is collected via a sewer network, which operates via gravity and discharges into the large main which transfers wastewater to WTP.

While the existing sewer system currently has excess capacity available, this may be constrained in the long term.

Maps of the existing water supply network and sewer network are provided within Appendix A.

3.2.3 Supply of Class A recycled water

This study has assumed that Class A recycled water would be sourced locally from within the precinct. The sourcing of class A recycled water from an external source such as Western Treatment Plant (WTP) has not been considered as it is not considered economically viable for Fisherman's Bend to source Class A recycled water from an external source such as WTP on its own (i.e. it would need for a CBD wide scheme to make such a scheme potentially economically viable).

However, if a scheme was developed with a nearby main containing sufficient alternative water, it is likely to be attractive, as finding and acquiring suitable land for a sewer mining plant is likely to be one of the major costs and challenges for the currently adopted approach.

3.2.4 Stormwater and flooding

The area is generally flat, and close to sea level, and there are limitations in the drainage system. As a result, and as illustrated in the current flooding maps, there are issues with flooding in the area. This flooding results from a range of factors, including water coming from outside the precinct, and constraints on downstream drainage into the bay and the Yarra, as well as water from rain and run-off within the precincts. In some circumstances the drainage system can back up and salty water can be found in the drains. The precincts are all currently developed, and therefore there are significant existing impervious surfaces. As a result, the Strategic Framework has requirements related to minimum floor heights to manage the risk of flooding.

The key issue with flooding is likely to be the desire to provide a higher level of service [less flood impacts] to the area once the redevelopment occurs.

A map of the existing drainage network is provided in Appendix A. A map of the future conditions flood extents (with no new street drainage infrastructure) in areas with flood depths exceeding 400 mm is attached (refer Appendix B).

3.2.5 Water Quality and Waterway Health

Surface water quality and waterway health are some of the key issues underlying the concept of Integrated Water Management. There are specific and unique considerations in Fisherman's Bend.

The drainage systems within most of the precinct area do not discharge to waterways, but effectively directly into Port Phillip Bay. So the considerations are different (i.e. there no high value streams in the precinct). Some issues which are important for streams are less important [for example phosphorus levels], but other considerations such as E Coli levels [which impact recreational use of the Bay beaches] may be more important. Further, the discharges are close to where the very significant flows from the Yarra enter the Bay, and some consideration may be given to the comparatively small contribution of these flows.

Because the area is low lying and close to the Bay, there are salt water incursions back into the drainage systems, which mean that the water quality in these systems is unlikely to be suitable for low cost stormwater reuse. So options which provide separation of rainfall from the local ground level stormwater are more likely to be attractive.

Overall, these unique considerations mean that appropriate analysis will be required rather than reliance on standard rules of thumb, or standard inputs into models and the like. As one pertinent example: WSUD design in this area will have different objectives and constraints from WSUD in the catchment of a local stream, and therefore can be expected to have a different character.

3.3 Future urban form

In some areas the urban form will be a few stories high, and in effect not alter significantly from the existing factories and warehouses in terms of the general density of buildings; although occupancy may vary significantly.

In other areas large high rise developments are likely. These have a range of characteristics which are relevant:

- The sites are likely to have three general areas after development; a lower open area, a podium, and one or more tall high rise buildings.
- The number of occupants and water users may be high, but roof area may be relatively low.
- Impervious surface considerations may be deceptive, as the podium areas may not have significant holding capacity, even if apparently filled with gardens and the like.
- High pressures are required to get water to the upper floors and waste water and rainwater can have high pressures when returning to ground level.

A future conditions base map providing a conceptual representation of the built form, showing a possible ground level breakdown of open space, podiums and buildings is provided in Appendix A.

3.4 Future road network

There is an existing road network which services the current development in the area. The current development includes a number of large blocks, and the Strategic Plan shows a new road network which is expected to be developed as the project continues. The road network will be developed over time on the various existing blocks. While the layout once complete is shown in the Strategic plan, the entire network will not be built at once, as it will occur as development occurs.

This has implications for water infrastructure as it is typically laid along the road network layout, but if the network is incomplete, the water infrastructure may have to supply into areas in a more roundabout way than along the final linear network (i.e. there may be isolated dead ends or inefficient elements of the network during the period before redevelopment is complete). Similar considerations will apply to any new drainage system.

The existing and proposed road network is represented in the future conditions base map, which is provided in Appendix A.

4. Key Integrated Water Management Design Considerations

The following is a discussion of a number of key WoWCM design considerations that were adopted as part of this study.

A detailed evaluation of design considerations is provided within Appendix E.

A range of future implementation considerations are provided within Section 16.

Sewer Mining

On balance a single sewer mining plant drawing from a single extraction points is considered the most appropriate configuration. The conceptual design logic proposed is as follows:

- Single extraction point to capture 90% of peak demand.
- Single wastewater treatment plant sized to treat 90% of peak demand (18.5 ML/d).
- Above ground balancing tank to hold one peak day of supply (20.6 ML).

It is proposed that the wastewater treatment plant would be staged to so that there is an opportunity to revisit the plant sizing based on real world experience. We have explored the salinity in the Melbourne Main Sewer and whilst the old sewer had periodic high salinity (TDS of 2,400 mg/L) the new sewer has a much lower prolife (TDS < 500 mg/L) – presumably due to a lot less groundwater intrusion.

If acquiring land was not a problem, the siting of the plant would ideally be situated in the vicinity of the Melbourne Main Sewer (i.e. close to an extraction point) and generally in the north east, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region. However, if a suitable site cannot be identified, the plant may need to be located in a more undeveloped precinct, leading to additional transfer main costs or constructed in a way that buffer distances can be reduced (i.e. underground such as the MCG sewer mining plant). Further discussion is provided below.

If acquiring land is a problem then the following alternatives need to be considered:

- Leasing land in the private realm (i.e. below building podium level).
- Acquiring land to the west of Fishermans Bend (i.e. in the new 205 ha employment precinct proposed to the west of Lorimer precinct). Land in this precinct is yet to be zoned capital city zone and may be more readily available and affordable.

A single wastewater treatment plant could be staged by building the plant in a modular fashion and also treat stormwater or a stormwater/wastewater mix. A single plant provides the following benefits relative to multiple plants:

- One asset to maintain.
- One site to acquire.
- Buffer requirements around one site.

Extraction from the Melbourne main sewer is proposed. Extracting from the future local sewer network rather than the Melbourne main sewer may be advantageous due to the potentially lower salinity in this network (as a result of the source of sewer inflows and groundwater infiltration). However, this approach has the disadvantage that sufficient flow must be available, and that flow may not grow simultaneously with demand, particularly if green spaces are developed early but people arrive later.

Further work is needed to determine the optimum sizing of peak supply from the Class A network from this option. In other projects it has proven to be more economically feasible to only supply between 50 and 80% of peak demand from the Class A (with the remainder of the peaks being supplied with potable or rainwater), due to the infrequent peaks and underutilised investment. However, that may not apply in these precincts, as the ratio of peak to average day is predicted to be less as the proportion of green space watering is less.

Further, in this area, there is a cost of supplying additional peak day capacity of any kind, so the trade-off against additional Class A plant capacity will be less obvious.

Given these points, the current approach adopts 90% of peak day, and allows for staging so the relative merit of different approaches can be considered when more data is available.

Based on the assumption of drawing from local sewer networks, the likely configuration of the sewer mining plant would be:

- Extraction from the Melbourne main sewer with a pump station designed to exclude rags and larger solids, and also to contain any odours.
- Degritting and the like near the sewer to allow returns at that point.
- A Membrane Bioreactor (MBR) or similar compact process located within a building. This will manage odours and noise.
- All waste streams returned to sewer. [The main sewer rather than the local network if possible].
- UV disinfection and addition of some form of chlorine based residual.

Note that the overall process will change over time as new technologies become available. If the salinity is not managed [for example because the new sewers have infiltration from the high salinity groundwater], then RO or similar will need to be added, which will increase cost, land needed and also the return and extraction volumes due to recovery constraints.

Lot Scale Greywater Treatment Plant

Another alternative for supplying Class A to the development is to source it from a from a building scale greywater plant. The approach differs for residential and commercial buildings as a result of their different characteristics.

Sending the shower, clothes washing and miscellaneous supplies to the greywater plant within residential buildings results in excess supply. For residential buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant.
- Greywater treatment plant sized to treat 100% of average demand (33 kL/d), which is equivalent to 71 L/person/d.
- Balancing tank within each building to hold one average day of demand (33 kL/d).
- Greywater distribution pump station within each building to supply one average day of demand (33 kL/d).

Sending the shower and potable supplies (no clothes washing) to the greywater plant within commercial buildings results in a supply constraint. As a result the commercial buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant.
- Greywater treatment plant sized to treat 100% of available supply (12 kL/d), which is equivalent to 27.2 L/person/d.

- Balancing tank within each building to hold one average day of supply (12 kL/d).
- Greywater distribution pump station within each building to supply one average day of supply (12 kL/d).

It is considered that supplying greywater based on an average day of demand or supply is appropriate in this instance (rather than peak day). Regardless of the class A from greywater supply regime, provision of potable back-up will be required due to the independent nature of these plants (i.e. operated by third parties) and their inherent reliability (i.e. SEW cannot control or guarantee the plants will be operating 100% of the time).

Greywater treatment for Class A reuse is not common. As a result it is not clear what treatment train might be required based on other projects, or the trains typically approved by DOH. The following train is therefore only a preliminary suggestion, and more consideration is required.

To some extent, the amount of treatment required will also depend on which of the uses in the dwelling are connected to the grey water system. The inclusion or exclusion of the laundry could be a significant factor. The likely configuration of the greywater plant would be:

- Some form of fine screening to remove hair, and other solids.
- Ultra-filtration, potentially with upstream chemical dosing to manage some organic constituents.
- Disinfection with UV and chlorine based residual.
- Waste returns to the sewer.
- Housed in a building to manage noise and any odour.

Note, this process should have a lower footprint, energy use and impact than a blackwater MBR.

However, this approach could share the risk seen with blackwater plants in each building: if the building managers in future see the operation of the plant to be problematic, costly, or both, they could stop operating, with the demand returned onto the central network.

This raises the possibility of considering larger schemes collecting greywater which are more district oriented and could then be operated by the water authority. This would require an additional street network of greywater collection pipes which has additional cost and complication.

Rainwater Tanks

Two alternative rainwater tank arrangements have been considered within the options, namely slow release rainwater tanks (as per SFP) and smart quick release rainwater tanks (to maximise third pipe supply). It is important to note that whilst the SFP does not specifically mention 'slow release' or ‘quick release’ tanks, it implies it in the sense that it requires that the tanks assist in managing stormwater flows (i.e. 100% of five year 72 hour storm event detained on-site with 50% retained on-site for reuse).

A slow release tank is considered a ***mandatory approach*** that developers need to adopt as a minimum, whilst a quick release tank is a ***non-mandatory approach***, which is being explored within two of the scenarios to confirm whether there is value in MW or SEW subsidising the cost of these tanks to offset the cost of streetscape/sub-surface flood storage and/or class A balancing storages.

Alternative A – Slow Release Rainwater Tanks Installed in Accordance with SFP (Mandatory Approach)

These tanks are designed to primarily detain flood peaks with an orifice (leaky tank) half way up the tank. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply) – bottom 50% of tank (139 kL on average).
- Have the ability to slowly release water to the Yarra River and Bay (after the flood peak has receded) – top 50% of the tank (139 kL on average).

Alternative B – Smart Quick Release Rainwater Tanks Installed To Maximise Third Pipe Supply (Non-Mandatory Approach)

These tanks are designed to maximise third pipe rainwater reuse within the building and podium by retaining the roof and podium runoff for as long as possible (i.e. before the next flood event). These tanks perform two functions, namely:

- Provide rainwater to the building scale and/or precinct wide third pipe network (in the case of scenario 3 - interlinked storages) by capturing roof and podium runoff.
- Have the ability to quickly release water to the stormwater drainage network, and thus to the Yarra River and Bay before subsequent flood events (thus maximising any harvesting potential without compromising the flood mitigation benefits).
- A quick release tank relies on having some accuracy of forecasting to allow tanks to be drained in anticipation of significant rain events. This adds an element of complication and risk in flood management, which may need further modelling and demonstration to satisfy stakeholders it is a robust approach.
- Note also that the need to empty the contents of the tank from time to time will have some impact on yield. However, with refinement of forecasting and decision algorithms, such reduction should be minor, given the lower likelihood of significant rain events.

On average a quick release tank needs to have a total volume of 278 kL, based on the current interpretation of the SFP.

A summary of alternative rainwater tank approaches adopted across the various scenarios and underlying assumptions are provided in Appendix E1.

Drainage

By agreement with Melbourne Water the target levels of service that has been adopted for our analysis of the drainage requirements is as follows:

- 5 yr ARI - no surface flooding in roads or private realm.
- 100 yr ARI - no surface flooding within property boundaries.
- 100 yr ARI - designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting a low safety risk in roads category where practical.

In accordance with the MW Flood Mapping Projects, Guidelines and Technical Specifications (MW, 2014) a low safety risk in roads is defined as having a velocity times depth <= 0.40 cumecs/m with a depth <= 0.40 m . In addition, flooding is defined as a depth greater than 50 mm depth.

Conventional Drainage Approach

It is proposed under a conventional drainage approach (applies to Scenarios 1 and 2) all areas will be piped either to the Bay or Yarra River. It is assumed that all pipes will be fitted with non-return valves (i.e. duck bills) to eliminate back-watering.

In low lying areas that do not free drain (i.e. where the tail water conditions present a significant impediment to drainage capacity), sump and pumps infrastructure is proposed. We have identified that sump and pump arrangement are confined to sub-catchments within the Lorimer, Montague and Sandridge precincts that drain to the Yarra (i.e. sub-catchments that drain to Port Philip Bay currently have sufficient elevation to not require pumping).

The sump and pump approach (refer Figure F10) has been considered to be the conventional approach or base case starting point for mitigating flooding. The pump and sump approach provides the ability to resolve flooding in areas where other options may not be feasible (i.e. limited free gravity outfall potential, large sub-surface approaches limited due to shallow groundwater table, contaminated land and a lack of open space to construct open storages), and provides flexibility to accommodate climate change conditions with little or no upgrade required.

In low lying areas, which are the most flood prone areas in or downstream of the precincts, volume is a driving factor rather than attenuating peaks. If volume is not removed by pumping from the system, large storage volumes are required. Given the ground conditions the application of traditional retarding basins is very difficult. In the past concern has been expressed over these occupying a large proportion of the public open space, particularly if the water takes an extended period of time to recede making the open space unusable during this time and potentially requiring grass to be reseeded.

Alternative Drainage Approaches

The three alternative drainage approaches that are applied across the scenarios include:

- Increasing the rainwater tank volume available for Flood Detention/Retention by utilising “Smart Tanks” which empty prior to rain event (Scenarios 3 & 5).
- Precinct Scale Flood Storage Approach (Scenario 3 & 4).
- Local Streetscape Flood Storage Approach (Scenario 5).

Further, it has been assumed that all pipes will be fitted with non-return valves (i.e. duck bills) to eliminate back-watering.

Flood Retention Storage - Stormwater Harvesting

Two alternatives have been considered for maximising the benefit of flood retention storages within the development.

The first alternative is to provide treated stormwater to the class A network (via the proposed sewer mining treatment plant). Under this scenario the stormwater retention storages are drawn down over a period of 24 hours.

The second alternative is to provide treated stormwater to a local public open space demand within close proximity to one of the proposed flood storages within the precinct. The conceptual design logic proposed is as follows:

- Storages below/adjacent selected raingardens (i.e. within proposed greenspines) capturing treated stormwater for future reuse.
- Pumping to sub-surface irrigation of public open space within close proximity to the selected raingardens.

Under this scenario the stormwater retention storages would exhibit a Smart ability to empty before subsequent flood peaks (as per the Smart rainwater tanks).

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. It is anticipated that this infrastructure will be distributed across both the private realm (i.e. podiums) and public realm (i.e. streetscape).

We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct. It has been assumed that stormwater harvesting, treatment and reuse initiatives will effectively improve the water quality beyond best practice.

We anticipate that 50% of the bioretention systems in the form of raingardens, tree pits (or equivalent) would be accommodated within the private realm (i.e. podiums). This equates to approximately 18 square metres of bioretention systems per podium. The remaining 50% of the bioretention systems would be accommodated within the public realm (i.e. streetscape) based on the fraction impervious make-up of the precinct.

Lot scale rainwater harvesting (from roof & podium) and stormwater harvesting (from precinct) contribute to a reduction in pollutant levels beyond BPEMG.

5. Proposed land use and growth

5.1 Land use

The future land use for the site is pivotal input information to a number of components of this servicing strategy. It will be used to determine the quantity and location of water demands and sewage generated, and as input to the drainage and flood modelling.

The proposed land use for the site has been provided by MPA, who indicated the best available information for use in this project is the PDF Plans in the SFP.

A base map of the proposed land use has been digitised based on these PDFs is attached to this memorandum (refer Appendix A). The map represents:

NOTE – It should be highlighted that land use is a primary input dataset to all modelling and currently is based on GHD's digitisation of MPA's PDF concept plans, as this was the best available information.

- The four precincts;
- Road layout, including new 12 m, 22 m and 30 m streets and Green Links;
- Open spaces (existing, proposed local recreational and proposed neighbourhood); and
- Parcel boundaries categorised by maximum development heights.

Figure 5 Interpretation of Open Space Linkages*

*R.Pasman, Monash Art Design and Architecture and CRCWSC (Images sourced from draft workshop presentation)

5.2 Growth forecasts

The residential and employment populations for which the water cycle will be planned are key assumptions for this project.

This study will plan for ultimate development, noting that recent WWCM strategy work for Water Future Central has planned to 2050 for consistency with both Plan Melbourne and Victoria in Future.

The SFP states that it will "guide future development of an inner city precinct for at least 80,000 residents, with commercial opportunities to create 40,000 jobs".

Based on our engagement with the project stakeholders, there is uncertainty in relation to projected draft dwelling and resident and employment population forecasts. As a result GHD propose three alternative growth scenarios to sensitivity test the impact of population. These are:

- **Low Sensitivity |** 2050/51 Scenario of 80,000 residents and 40,700 employees, corresponding to the populations stated in the SFP (50% below extra growth scenario).
- **Design Basis |** Ultimate Development Scenario of 120,000 residents and 61,050 employees.[1] These values are based on a draft for discussion, which forecasts between 44,132 – 52,080 dwellings for 2051, and 60,000 dwellings at ultimate development (i.e. approximate 120,000 residents). Note that it was assumed that there is an average 2.0 persons/dwelling.
- **High Sensitivity |** High Growth Scenario: 180,000 residents and 91,575 employees (50% above extra growth scenario).

Figure 6 illustrates the estimated rate of residential and commercial growth has been estimated below.

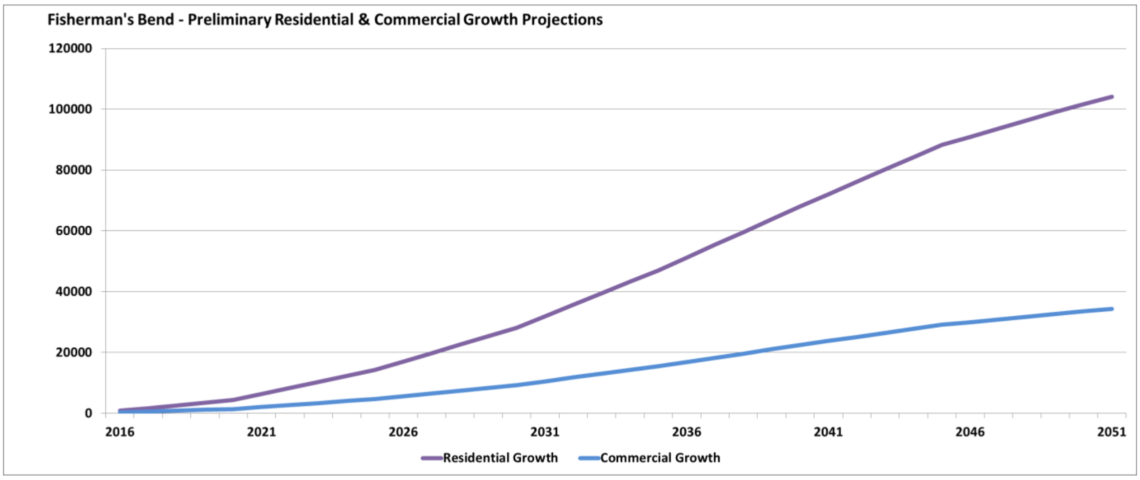


Figure 6 Project Rate of Growth

5.3 Land value

Land values are likely to be high in this area, and where land must be acquired for infrastructure (such as tanks or treatment plants), the land cost may be a significant factor.

Present land value estimates indicate that the value of land in the Montague precinct are in the order of $3,000/sq m, and approximately $1,000/sq m within the other precincts.

[1] Note that 61,050 employees is an assumed population at ultimate development, which was derived by scaling up the 40,700 stated in the SFP by 50%.

6. Water & pollutant balance summary

6.1 Water balance

The section below outlines the inputs and outputs for the preliminary water balance. The underlying water balance design basis assumptions are attached to this memorandum. For the purposes of water balance modelling, the substitutable (alternative water) demands consist of:

- Toilet
- Laundry
- Podium (outdoor)

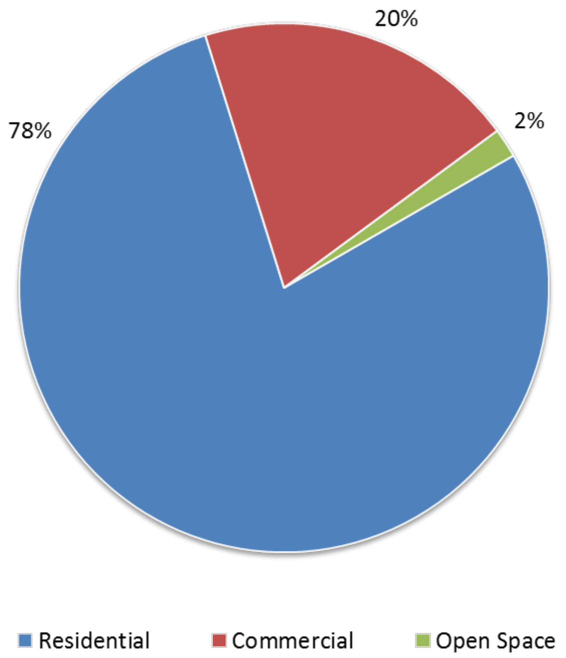


Figure 7 Demand category breakdown

Table 5 Potable vs. substitutable breakdown

Demand	Potable	Substitutable	Total	Unit
Residential	4,876	3,712	8,440	ML/yr
Commercial	8,96	1,221	2,117	ML/yr
Open Space	0	188	188	ML/yr
Total	**5,624**	**5,121**	**10,745**	**ML/yr**

Table 6 Demand sensitivity breakdown

Demand	Ultimate Development	Low Sensitivity (-50%)	High Sensitivity (+50%)	Unit
Residential	8,440	5,627	12,660	ML/yr
Commercial	2,117	1,411	3,175	ML/yr
Open Space	188	188	188	ML/yr
Total	**10,745**	**7,226**	**16,024**	**ML/yr**

6.2 Pollutant balance

Stormwater and wastewater pollutant loads are presented in Table 7 and Table 6.

A comparison of the pollutant loads from stormwater relative to wastewater is illustrated in Figure 8.

Wastewater Loads

The wastewater loads leaving WTP exceed the stormwater loads by a factor of 10.

Stormwater Loads & Pollutant Reductions

All scenarios achieve BPEMG through distributed bioretention initiatives totalling 11,200 sq m (identical across all options). A MUSIC model was developed to validate the achievement of BPEMG.

Accounting for WSUD and stormwater/rainwater harvesting initiatives total nitrogen is reduced by 62-68%, total phosphorous is reduced by 55-64% and total TSS is reduced by 81-86%.

Table 7 Stormwater Pollutant Balance

<table>
<tr><th colspan="2">Category</th><th>TN (kg/yr)</th><th>TP (kg/yr)</th><th>TSS (kg/yr)</th></tr>
<tr><td colspan="2">Raw Stormwater discharge to environment</td><td>2,359</td><td>278</td><td>117,267</td></tr>
<tr><td colspan="2">Stormwater discharge to environment (post WSUD to meet BPEMG)</td><td>1,298</td><td>153</td><td>23,453</td></tr>
<tr><td rowspan="6">Stormwater discharge to environment (post WSUD & Stormwater harvesting - beyond BPEM)</td><td>Scenario 0</td><td>886</td><td>126</td><td>21,957</td></tr>
<tr><td>Scenario 1</td><td>886</td><td>126</td><td>21,957</td></tr>
<tr><td>Scenario 2</td><td>886</td><td>126</td><td>21,957</td></tr>
<tr><td>Scenario 3</td><td>744</td><td>101</td><td>17,049</td></tr>
<tr><td>Scenario 4</td><td>752</td><td>101</td><td>17,003</td></tr>
<tr><td>Scenario 5</td><td>816</td><td>114</td><td>19,720</td></tr>
</table>

Table 8 Wastewater Pollutant Loads

Category	TN (kg/yr)	TP (kg/yr)	TSS (kg/yr)
Raw Wastewater	478,634	95,727	1,435,901
Treated Wastewater (WTP)	143,590	57,436	287,180

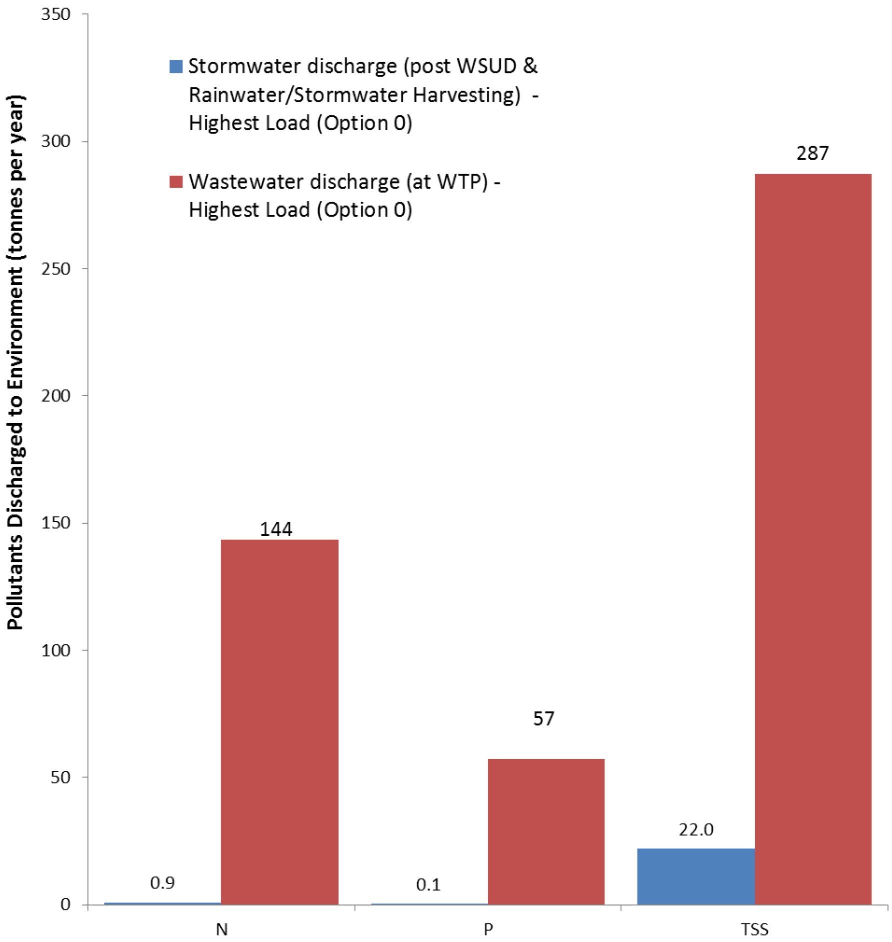


Figure 8 Comparison of Stormwater & Wastewater Pollutant Loads

7. Levels of service

A summary of the levels of service that have been adopted for this study are provided within the table below.

Table 9 Levels of Service

Design Elements	Level of Service
Potable Water Supply	Potable water network - Flow & Pressure to Deliver Peak Day Demand (PDD) and Peak Hour Demand (PHD). Fire supply in accordance with WSSA guidelines
Alternative Water Supply	Flow & Pressure to Deliver Peak Day Demand (PDD) and Peak Hour Demand (PHD) Stormwater/sewer mining treatment plant to provide 0.9 of Peak Day Demand (PDD) Class A balancing tank to provide 1 day of Peak Day Demand (PDD).
Sewer Network	Peak Dry Weather Flow (PDWF) does not exceed 70% full pipe flow and Peak Wet Weather Flow (PWWF) does not exceed 100% full pipe flow (no surcharging).
Drainage Network	5 yr event – streets and private realm flood free 100 yr – private realm flood free and streets meeting V*D <= 0.40 cumecs/m & D <= 0.4 m
Water Quality	Achievement of BPEMG requirements, TN 45%, TP 45% and TSS 80%
Building Rainwater Tanks	Building scale rainwater tanks – detain 100% of 5yr 72 hour runoff from the roof and the impervious fraction of the podium. Retain 50% of this volume for reuse.

8. Base case & alternative scenarios

A summary of the key points of difference between the scenarios is provided in Table 10 below (colours used to show common elements). This section explores the various scenarios under consideration. It sets these out at a higher level, as many sub-options remain available to allow more optimisation. It is important to emphasise that a preferred scenario at the completion of the study may be made up of components from respective scenarios below, considering respective costs and benefits (as well as geographical variances within the precincts (i.e. local stormwater harvesting may be more attractive at Montague relative to Sandridge).

Key design considerations associated with the IWM scenarios are presented within Appendix E.

8.1 Key terms used in defining base case & alternative scenarios

Key terms used in exploring the various scenarios are defined as follows:

- ***Conventional servicing*** – traditional trunk and reticulated infrastructure servicing the precinct;
- ***'No precinct based drainage'*** – Scenario 0 only uses the existing precinct drainage infrastructure (with exception of building rainwater tanks as prescribed by SFP);
- ***Tolerable flooding*** – flooding that is contained to the public realm and meets the required levels of service including a flood depth of < 0.4 m within the streetscape;
- ***Sump and Pump*** – high flow, low head pumps to manage flooding (as an alternative to underground storages or to supplement underground storages);
- ***End of line retention and reuse*** – utilisation of flood storage to temporarily retain stormwater before pumping direct to treatment plant (scenario 3 & 4) or above ground balancing tanks (scenario 5) for reuse;
- ***Interlinked Third Pipe Supply*** – utilising the third pipe supply into buildings as a means for sharing water collected off building roofs/.podiums and/or storage of class A within the buildings;
- ***Slow release tanks*** – These tanks are designed to primarily detain flood peaks with an orifice (leaky tank) half way up the tank (mandatory within SFP);
- ***Smart quick release tanks*** – designed to maximise third pipe rainwater reuse within the building and podium by retaining the roof and podium runoff for as long as possible, i.e. before the next flood event (included for economic evaluation purposes, not mandatory within SFP).

8.2 Strategic framework plan requirements

The mandatory requirements from the SFP that are included in all options include:

- Building third pipe and associated distribution pumps.
- Building rainwater tanks that captures the first 101 mm of rainfall on all roof tops and 70% of podium and retains 50% of this volume for reuse.

A summary of the guidelines in the Strategic Framework Plan (SFP) that directly or indirectly relate to this Integrated Water Management servicing strategy and how they have been interpreted are provided in Appendix D.

Table 10 Summary of Base Case and Alternative Scenarios

Scenario	Description	Third Pipe	Primary Third Pipe Source	Third Pipe Back-up	Building Rainwater Tank Size	Drainage Approach
0 - Conventional Water, Sewer with (no minor or major drainage upgrades) – Base Case	Conventional servicing with rainwater tanks as per SFP and no precinct based drainage. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Rainwater tanks as per SFP and no precinct based drainage.
1 - Conventional Water, Sewer & Drainage upgrades	Conventional servicing [no development wide third pipe]. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
2 - Sewer Mining in the Precinct	Sewer Mining with development wide third pipe. Slow release rainwater tank. Conventional drainage upgrades.	Development wide (SEW Managed)	Rainwater, Sewer Mining	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
3 - Interlinked Third Pipe Supply	Mix of lot & development scale initiatives. Harvested rainwater, stormwater and sewer mining mix to third pipe network. Smart quick release rainwater tank. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks). End of line retention and reuse.	Development wide – Building (SEW Managed)	Rainwater, Stormwater	Sewer Mining	Smart tank to maximise roof & podium collection (fitted with fast release)	Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse.
4 - Stormwater Harvesting in the Precinct	Precinct scale stormwater harvesting into third pipe. Slow release rainwater tank. End of line stormwater retention and reuse.	Development wide (SEW Managed)	Rainwater, Stormwater	Sewer Mining	As per SFP (capture roof only, fitted with slow release storage component)	End of line retention and reuse.
5 - Lot focus	Lot scale approach to minimise precinct infrastructure. Conventional potable back-up. Designated tolerable road flooding. Smart quick release rainwater tank. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens).	Building scale (Developer Managed) & Local Stormwater	Building - Rainwater, Greywater Local - Stormwater	Potable	Smart tank to maximise roof & podium collection (fitted with fast release)	Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens)

8.3 Conceptual Design Intent – Scenario 0: Conventional Water, Sewer with no Minor or Major Drainage Upgrades (Base Case)

8.3.1 Option definition

The make-up of scenario 0 is provided within Figure 9. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.3.2 Scenario characteristics

Potable water

In this scenario there is a rainwater tank servicing third pipe in each building. As rain tanks are not reliable in dry periods, there will be no reduction in the peak demand and as a result there will be no reduction in the design capacity of the potable water network.

Preston potable system upgrades will be required including a Punt Rd pump station (150 ML/d) and an on-site storage (6-8 ML) to manage peak hour demands. Based on feedback from Melbourne Water it is anticipated that this infrastructure would be staged as follows:

- Commissioning of 150 Ml/d pump station in 2030
- Commissioning of initial storage (3-4 ML) in 2030
- Commissioning of a further storage (3-4 ML) in 2045

Alternative water

Rainwater tanks in this scenario have been sized to meet the SFP requirements (tank captures the first 101 mm of rainfall on all roof tops and 70% of podium) and perform a dual function (i.e. provide rainwater to the building scale third pipe network and release water to the Yarra River and Bay before subsequent flood events). As a result rainwater harvested from each of the building roof tops will provide an alternative source of water to toilets, laundry and outdoor use within the podium.

Sewer

Sewer upgrades in the precinct are anticipated to include approximately 21 km of sewer upgrades proposed as part of this option.

Drainage

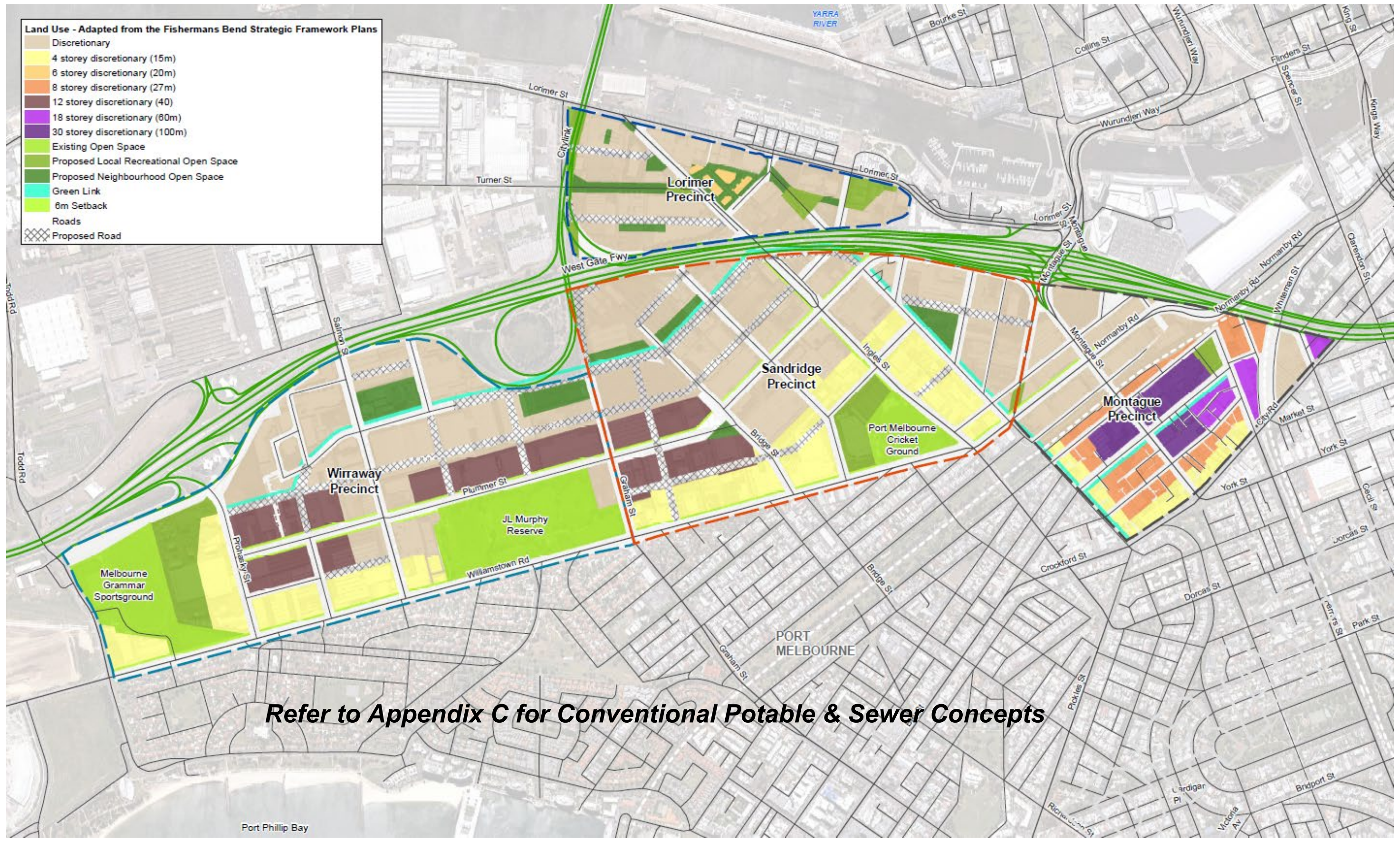
There are no minor or major drainage upgrades associated with this option.

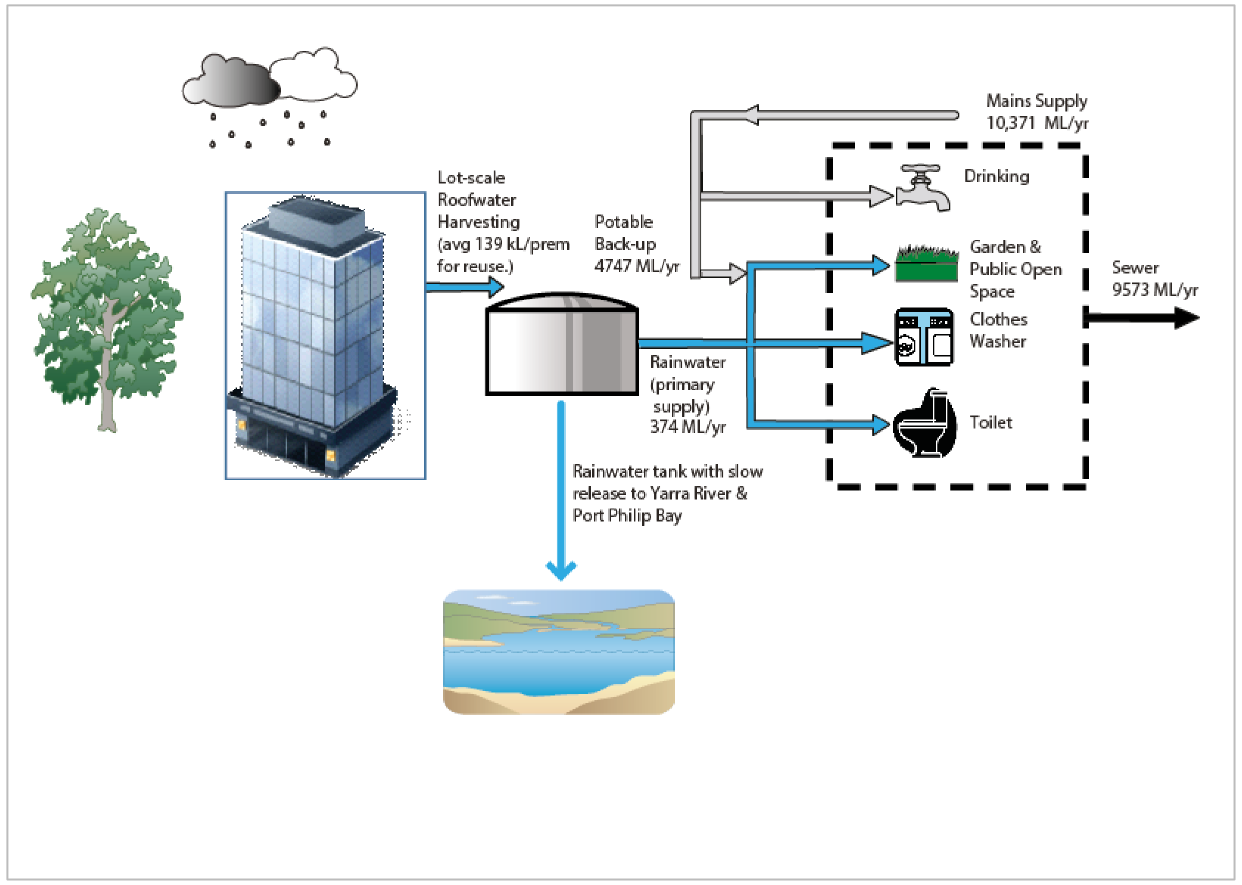
Rainwater tanks installed in accordance with the SFP are designed to capture the first 101 mm of rainfall off all roof tops and 70% of podium within the precinct. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply); and
- Have the ability to slowly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

- Conventional servicing with rainwater tanks as per SFP and no precinct based drainage)

Make-Up

- Augmentation of existing potable mains & new reticulation.
- Preston potable system upgrades including Punt Rd pump station & on-site storage.
- Some sewer upgrades in combination with new reticulation.
- Rainwater tank as per SFP requirements to building third pipe.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building (on average) with 139 kL for reuse.
- 11,200 sq m of podium (50%) & streetscape (50%) bioretention in the form of raingardens, tree pits (or equivalent) – TBC based on beyond BPEMG or account for RWH/SWH.
- 27 km of new or upgraded potable mains are required
- 21 km of new or upgraded sewers mains required
- 3rd pipe in building;

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage (limited), urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 9 Make-up of Scenario 0: Conventional Water, Sewer with no Minor or Major Drainage Upgrades

8.4 Conceptual Design Intent – Scenario 1: conventional water, sewer & drainage upgrades

8.4.1 Option definition

The make-up of scenario 1 is provided within Figure 10. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.4.2 Scenario characteristics

Potable water

In this scenario there is a rainwater tank servicing third pipe in each building. As rain tanks are not reliable in dry periods, there will be no reduction in the peak demand and as a result there will be no reduction in the design capacity of the potable water network (as per Scenario 0 – conventional servicing scenario with no drainage upgrades).

Preston potable system upgrades will be required including a Punt Rd pump station (150 ML/d) and an on-site storage (6-8 ML) to manage peak hour demands. Based on feedback from Melbourne Water it is anticipated that this infrastructure would be staged as follows:

- Commissioning of pump station in 2030
- Commissioning of initial storage (3-4 ML) in 2030
- Commissioning of a further storage (3-4 ML) in 2045

Alternative water

Rainwater tanks in this scenario have been sized to meet the SFP requirements (tank captures the first 101 mm of rainfall on all roof tops and 70% of podium) and perform a dual function (i.e. provide rainwater to the building scale third pipe network and release water to the Yarra River and Bay before subsequent flood events). As a result rainwater harvested from each of the building roof tops will provide an alternative source of water to toilets, laundry and outdoor use within the podium.

Sewer

Sewer upgrades in the precinct are anticipated to be in accordance with Scenario 0 – conventional servicing scenario with no drainage upgrades (i.e. there are approximately 21 km of sewer upgrades proposed as part of this option).

Drainage

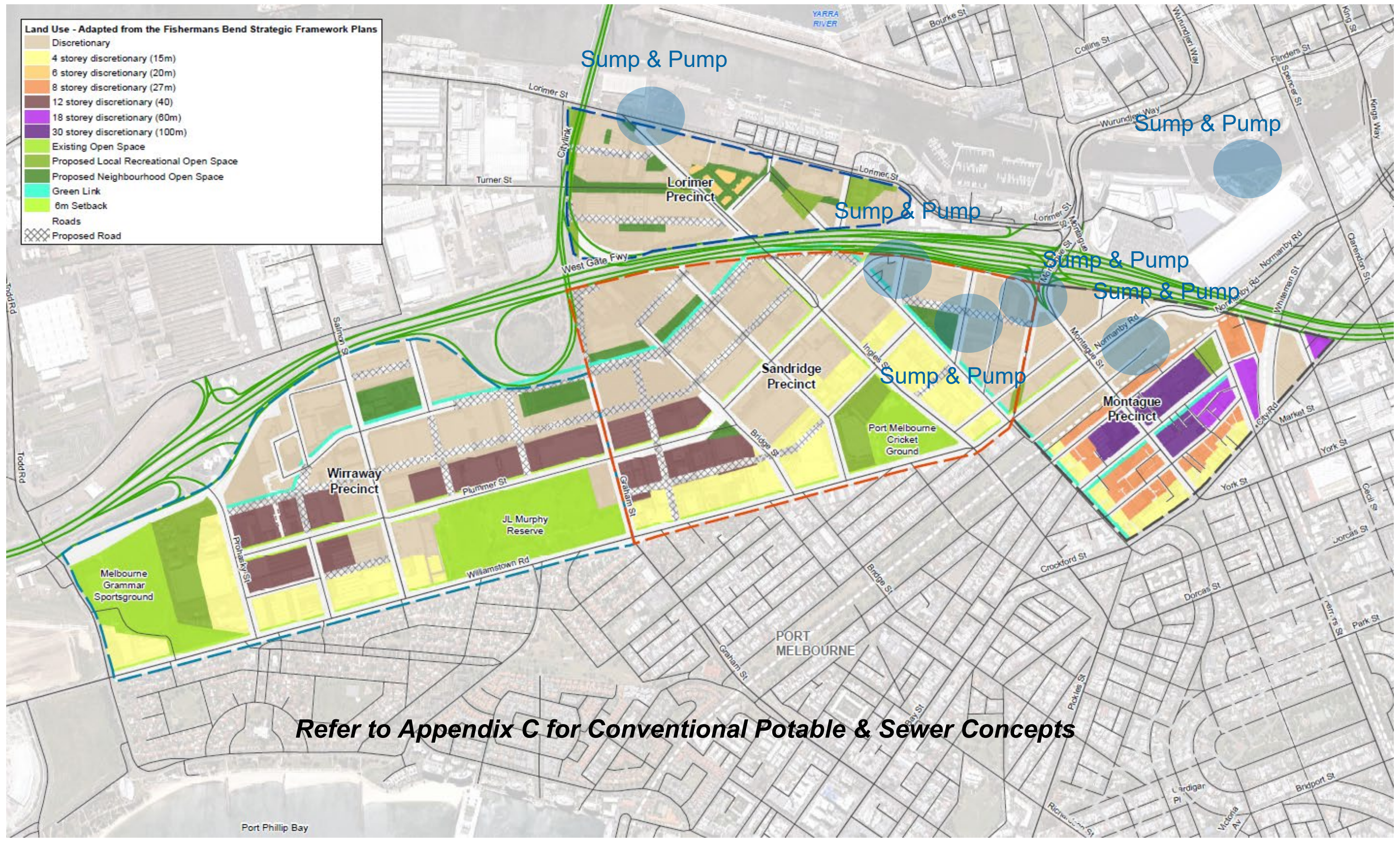
A conventional drainage approach applies to this option. This includes the application of underground drains and sump and pump infrastructure to provide a five year ARI minor street drainage standard and 100 year ARI major drainage protection to properties and designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting hazard criteria (i.e. low egress risk) where practical.

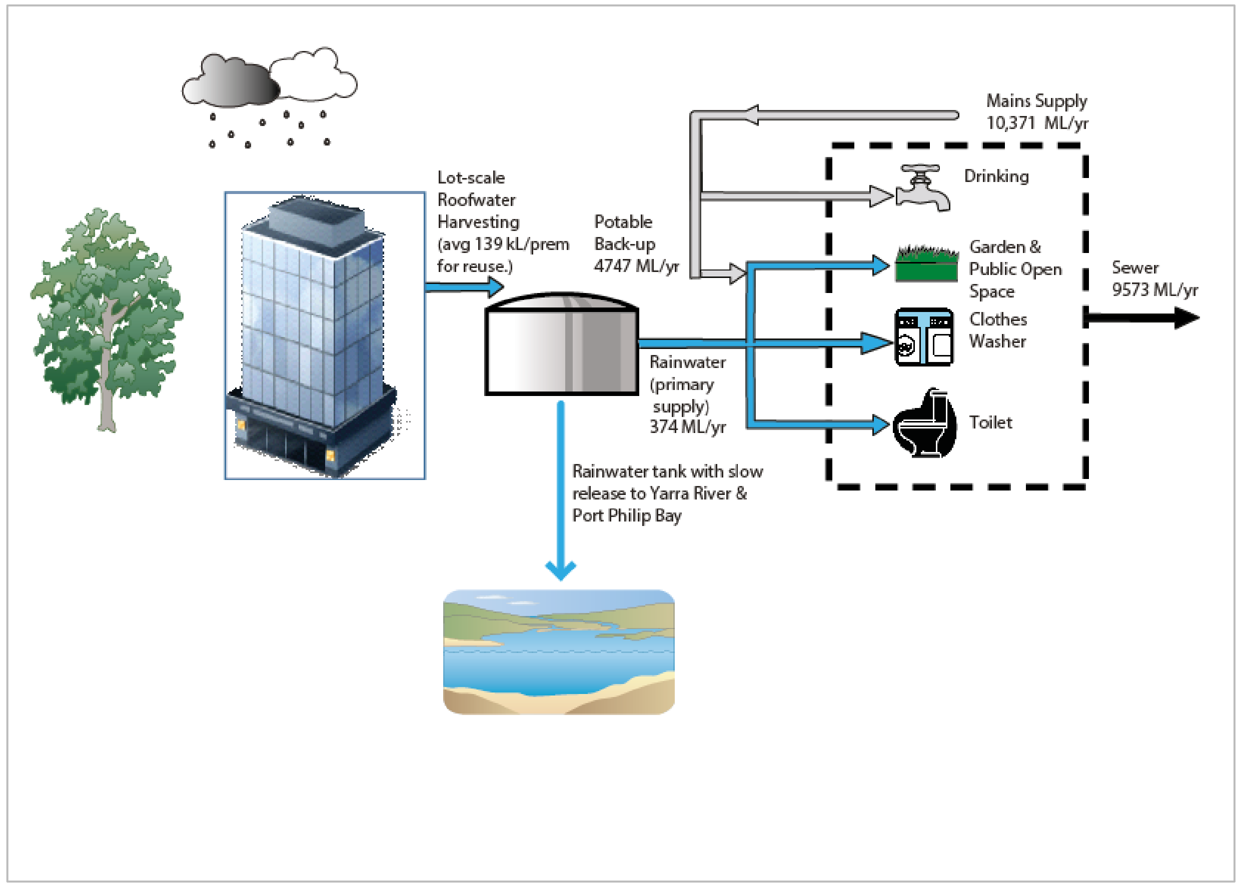
Rainwater tanks installed in accordance with the SFP are designed to capture the first 101 mm of rainfall off all roof tops and 70% of podiums within the precinct. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply).
- Have the ability to slowly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

Conventional servicing [no development wide third pipe]

Make-Up

- Augmentation of existing potable mains & new reticulation.
- Preston potable system upgrades including Punt Rd pump station & on-site storage.
- Some sewer upgrades in combination with new reticulation.
- Conventional upgrading of stormwater drains/swales, and sump/pump infrastructure as required to achieve a 5 year ARI minor flood standard in roads and 100 year ARI major flood standard for properties.
- Rainwater tank as per SFP requirements to building third pipe.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building (on average) with 139 kL for reuse.
- 28.6 km of new stormwater drains (pits and pipes) or swales
- 8 No. Stormwater sumps & pumps
- 11,200 sq m of podium (50%) & streetscape (50%) bioretention in the form of raingardens, tree pits (or equivalent) – TBC based on beyond BPEMG or account for RWH/SWH.
- 27 km of new or upgraded potable mains are required
- 21 km of new or upgraded sewers mains required
- 3rd pipe in building;

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage (limited), urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 10 Make-up of Scenario 1: Conventional Water, Sewer & Drainage Upgrades

8.5 Conceptual Design Intent - Scenario 2: Sewer Mining in the Precinct

8.5.1 Option definition

The make-up of scenario 2 is provided within Figure 10. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.5.2 Scenario characteristics

Potable water

As a result of the class A (sourced from a local sewer mining plant) precinct wide third pipe network, the average and peak day potable water demand requirements are approximately 50% of those presented within Scenario 0 – conventional servicing scenario with no drainage upgrades. It is anticipated that this will reduce the design capacity of potable infrastructure as follows:

- Elimination of Punt Road pump station and on-site Fisherman's Bend storage associated with Preston potable system upgrade.
- Downsizing of potable water reticulation in accordance with WSAA requirements.
- Potential deferment of future upgrades associated with the broader Preston Main system operated by Melbourne Water.

Alternative Water

Rainwater tanks in this scenario have been sized to meet the SFP requirements (tank captures the first 101 mm of rainfall on all roof tops and 70% of podium) and perform a dual function (i.e. provide rainwater to the building scale third pipe network and release water to the Yarra River and Bay before subsequent flood events). As a result rainwater harvested from each of the building roof tops will provide an alternative source of water to toilets, laundry and outdoor use within the podium.

In addition to rainwater, class A recycled water is proposed sourced from a local sewer mining plant drawing from the local or wider sewer network. On balance a single sewer mining plant drawing from a single extraction point along the Melbourne Main Sewer is considered the most appropriate configuration due to the constant supply available within this network. The conceptual design logic proposed is as follows:

- Single extraction point to capture 90% of peak demand;
- Single wastewater treatment plant sized to treat 90% of peak demand (18.5 ML/d);
- Balancing tank to hold 1 peak day of supply (20.6 ML/d); and
- Class A distribution pump station (20.6 ML/d).

An indicative centralised treatment plant and extraction points are shown within Figure 11. The siting of the plant is situated in the vicinity of the Montague precinct, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region.

A single wastewater treatment plant could be staged by building the plant in a modular fashion. A single plant provides the following benefits relative to multiple plants:

- One asset to maintain;
- One site to acquire;
- Buffer requirements around one site.

Sewer

Sewer upgrades in the precinct are anticipated to be in accordance with Scenario 0 – conventional servicing scenario with no drainage upgrades (i.e. the presence of a sewer mining plant cannot provide a reduction in upstream or downstream peak flow design capacity). As a result there are approximately 21 km of sewer upgrades proposed as part of this option.

Drainage

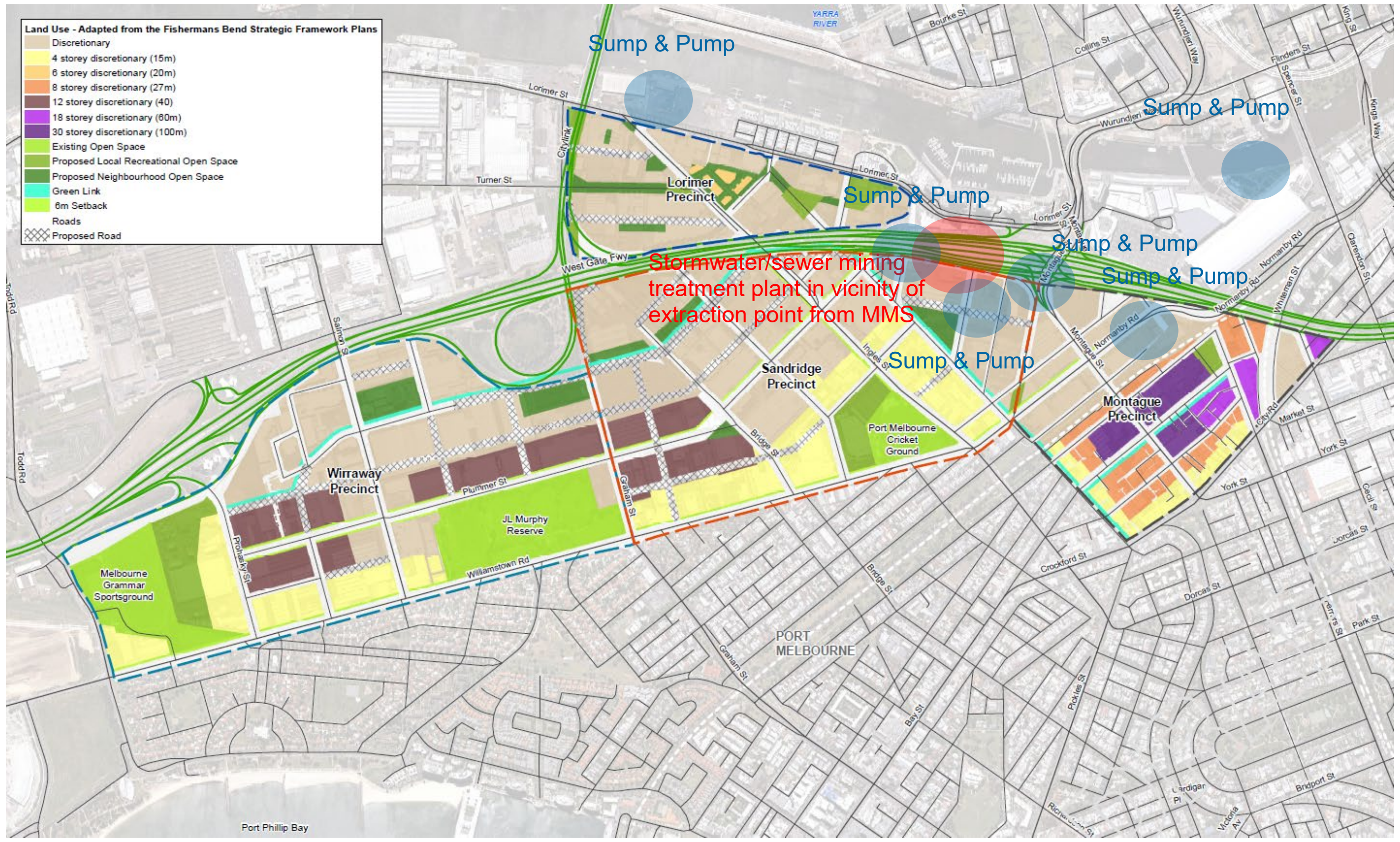
A conventional drainage approach applies to this option. This includes the application of underground drains and sump and pump infrastructure to provide a five year ARI minor street drainage standard and 100 year ARI major drainage protection to properties and designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting hazard criteria (i.e. low egress risk) where practical.

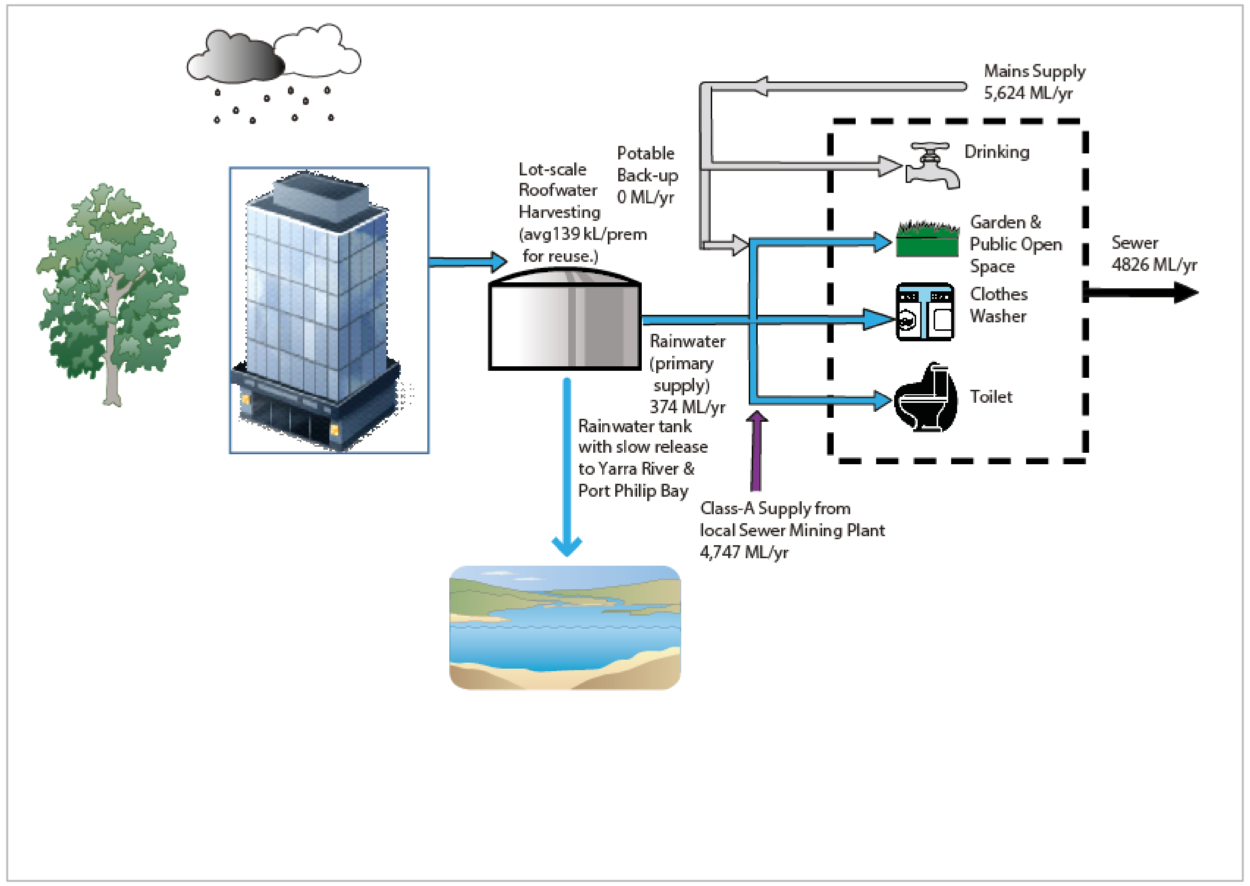
Rainwater tanks installed in accordance with the SFP are designed to capture the first 101 mm of rainfall off all roof tops and 70% of podiums within the precinct. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply); and
- Have the ability to slowly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

- Sewer mining with development wide third pipe. Conventional drainage upgrades.

Make-up

- Augmentation of existing potable mains & new reticulation.
- Some sewer upgrades in combination with new reticulation.
- Local sewer mining plant/s to precinct wide third pipe network.
- Rainwater tank as per SFP requirements to building third pipe.
- Conventional upgrading of stormwater drains/swales, and sump/pump infrastructure as required to achieve a 5 year ARI minor flood standard in roads and a 100 year ARI major flood standard for properties.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building (on average) with 139 kL for reuse.
- 28.6 km of new stormwater drains (pits and pipes) or swales.
- 8 No. Stormwater sumps & pumps.
- 11,200 sq m of podium (50%) & streetscape (50%) bioretention in the form of raingardens, tree pits (or equivalent) – TBC based on beyond BPEMG or account for RWH/SWH.
- 24.9 km of new or upgraded potable mains are required. It is anticipated that there will be reductions in potable trunk and reticulation sizes relative to Scenario 0 as a result of the precinct wide third pipe network.
- 21 km of new or upgraded sewers mains required;
- 29.3 km of new alternative water (third pipe) mains required;
- 3rd pipe in building;
- Sewer extraction pump;
- 1 sewer mining plant (18.5 ML/d);
- 20.6 ML class A balancing tank;
- Class A distribution pump station (20.6 ML/d);

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Single sewer mining plant	Single asset to maintain, less land acquisitions required. Can be staged using modular plant.	Siting near sewer with sufficient capacity to meet ultimate demands. Consistency of sewerage quality.	Alternative Water & Potable
Multiple sewer mining plants	Each plant can be introduced in a staged manner (each dedicated to a precinct)	Requires more land acquisitions, buffer distances problematic. Consistency of sewerage quality.	Alternative Water & Potable
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage, urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 11 Make-up of Scenario 2: Sewer Mining in the Precinct

8.6 Conceptual Design Intent - Scenario 3: Interlinked Third Pipe Supply

8.6.1 Option definition

The make-up of scenario 3 is provided within Figure 12. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.6.2 Scenario characteristics

Potable water

As a result of the class A (sourced from a local sewer mining plant) precinct wide third pipe network, the average and peak day potable water demand requirements are approximately 50% of those presented within Scenario 0 – conventional servicing scenario with no drainage upgrades. It is anticipated that this will reduce the design capacity of potable infrastructure as follows:

- Elimination of Punt Road pump station and on-site Fisherman's Bend storage associated with Preston potable system upgrade.
- Downsizing of potable water reticulation in accordance with WSAA requirements.
- Potential deferment of future upgrades associated with the broader Preston Main system operated by Melbourne Water.

Alternative water

Smart fast release rainwater tanks in this scenario have been sized to provide rainwater to the building scale third pipe network (back-up supply) by capturing the first 101 mm of rainfall on all roof tops and 70% of podium and have the ability to quickly release water to the Yarra River and Bay before subsequent flood events. Rainwater harvested will provide an alternative source of water to toilets, laundry and outdoor use within the podium.

It is also proposed in this scenario that the smart rainwater tank also provides storage for class A recycled water from the local sewer mining plant (when the tank is not full). Refer to Appendix E1 for further details on the smart quick release rainwater tank.

In addition to rainwater, stormwater is proposed to be sourced from end of line flood storages, backed up by class A sourced from a local sewer mining plant drawing from the Melbourne main sewer network (refer Appendix E4).

A single stormwater/sewer mining treatment plant could be adopted and staged by building the plant in a modular fashion. A single stormwater/wastewater plant provides the following benefits relative to multiple plants:

- One asset to maintain;
- One site to acquire;
- Buffer requirements around one site.

An indicative centralised treatment plant and sewer extraction points are shown within Figure 11. Extracting from the Melbourne main sewer is considered advantageous due to the constant supply available within this network. The siting of the plant is situated in the vicinity of the Montague precinct, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region.

The conceptual design logic proposed is as follows:

- Primary below ground flood storages to provide initial capture. Due to poor ground conditions and ability to drain the flood storages (due to tailwater levels), the end of line flood storages are proposed to provide short term flood detention prior to pump directly to the sewer mining/stormwater treatment plant (daily demand exceeds flood storage volume).
- Pump Station with rising main from flood storage to sewer mining/stormwater treatment plant (15.5 ML/d).
- Single sewer mining/stormwater treatment plant sized to treat 90% of peak demand (18.5 ML/d).
- Class A balancing within the building rainwater tanks to hold one peak day of supply (20.6 ML/d).
- Class A distribution pump station at each premises (52.6 kL/d on average).

Sewer

Sewer upgrades in the precinct are anticipated to be in accordance with Scenario 0 – conventional servicing scenario with no drainage upgrades (i.e. the presence of a sewer mining plant cannot provide a reduction in upstream or downstream peak flow design capacity). As a result there are approximately 21 km of sewer upgrades proposed as part of this option.

Drainage

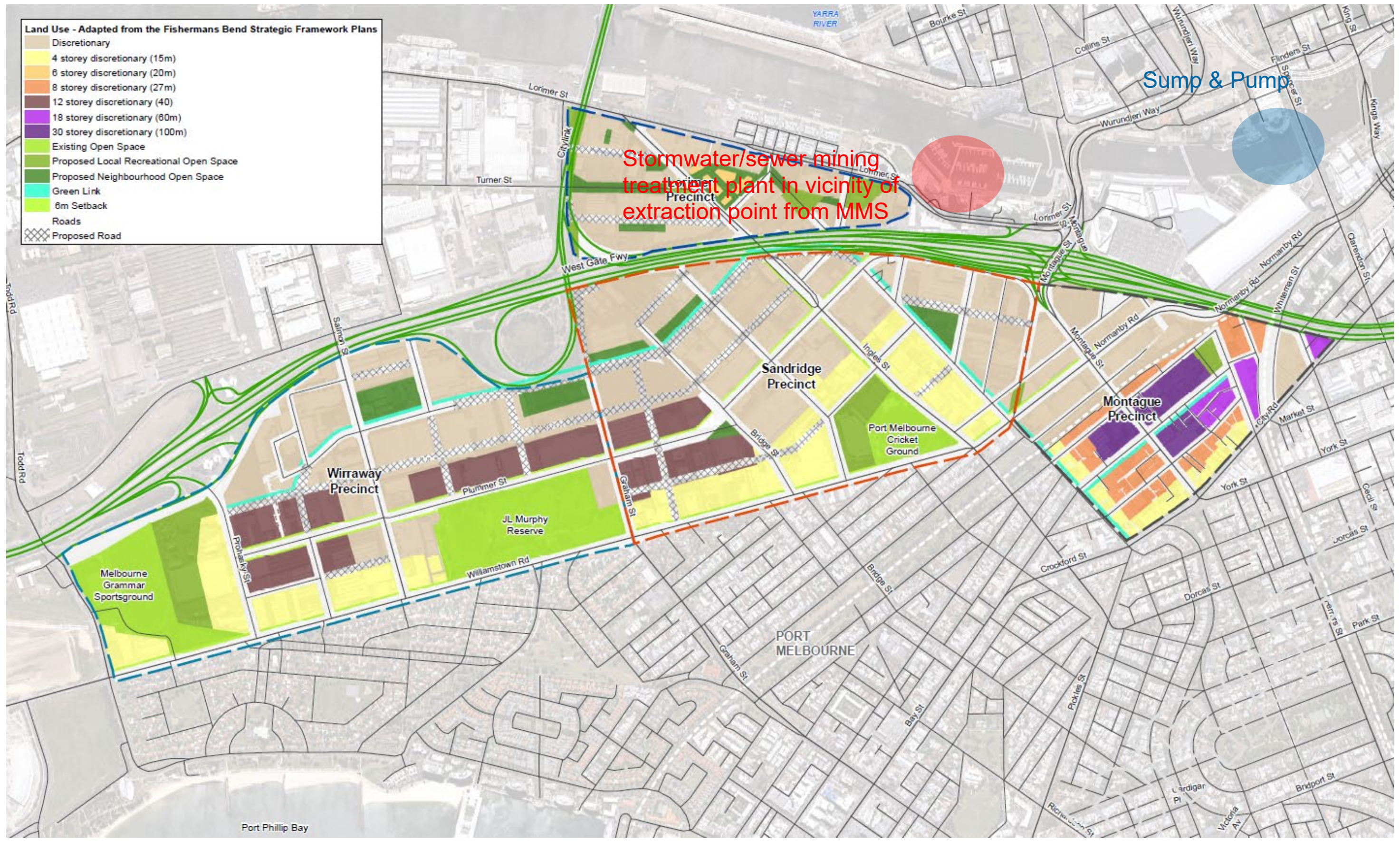
A non-conventional drainage approach applies to this option. This includes the application of smart rainwater tanks, augmentation of underground drains, and end of line sub-surface storages to provide a five year ARI minor street drainage standard and 100 year ARI major drainage protection to properties and designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting hazard criteria (i.e. low egress risk) where practical.

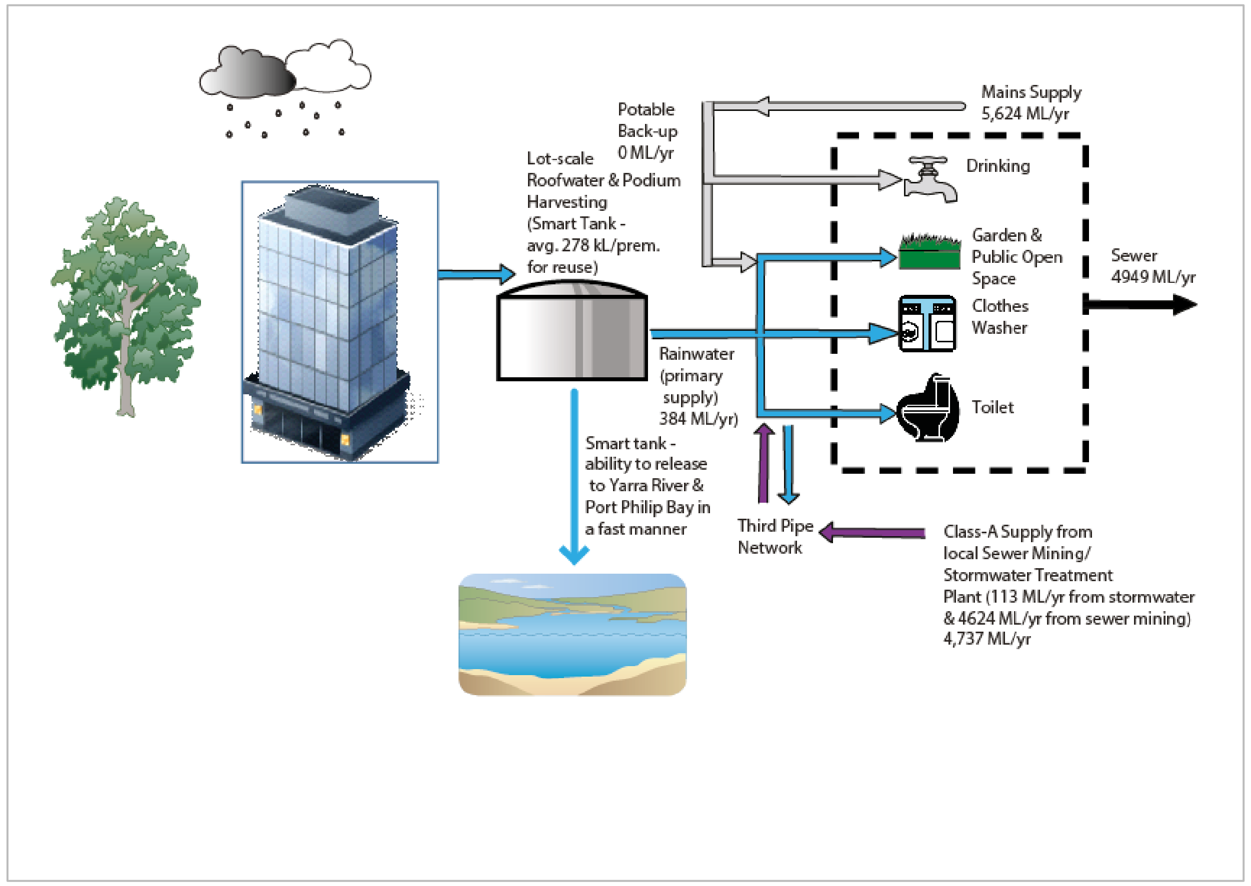
Smart fast release rainwater tanks in this scenario are sized to:

- Provide rainwater to the building scale and precinct wide third pipe network (primary supply) by capturing runoff from the roof and 70% of podiums.
- Have the ability to quickly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

Harvested rainwater and treated wastewater from local sewer mining plant to development wide third pipe.

Make-up

- Augmentation of existing potable mains & new reticulation.
- Some sewer upgrades in combination with new reticulation.
- Smart fast release rainwater tank with development wide third pipe sharing (in combination with Class A from sewer mining plant).
- On site retention & reuse to provide a 5 year ARI minor flood standard in roads. Smaller conventional development wide infrastructure to provide a 100 year ARI major flood standard for properties.
- Local stormwater/sewer mining treatment plant to development wide third pipe.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building capturing roof and podium (Smart Tank);
- New stormwater drains (pits and pipes) or swales;
- Flood/stormwater harvesting storages (4 no. totalling 10.9 ML);
- 1 No. stormwater sumps & pumps;
- 11,200 sq m of podium and streetscape bioretention in the form of raingardens, tree pits (or equivalent);
- 24.9 km of new or upgraded potable mains are required. It is anticipated that there will be reductions in potable trunk and reticulation sizes relative to Scenario 0 as a result of the development wide alternative water pipe;
- 21 km of new or upgraded sewers mains required;
- 29.3 km of new alternative water (third pipe) mains required;
- 3rd pipe in building;
- Sewer extraction pump (18.5 ML/d);
- 1 sewer mining/stormwater treatment plant (18.5 ML/d);
- Class A balancing within building rainwater tanks;
- Class A distribution pump station at each premises (52.6 kL/d on average).
- 29.3 km of new alternative water (third pipe) mains required

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Single sewer mining plant	Single asset to maintain, less land acquisitions required. Can be staged using modular plant.	Siting near sewer with sufficient capacity to meet ultimate demands.	Alternative Water & Potable
Multiple sewer mining plants	Each plant can be introduced in a staged manner (each dedicated to a precinct)	Requires more land acquisitions, buffer distances problematic	Alternative Water & Potable
Combined sewer mining and stormwater plant	Single asset to maintain, less land acquisitions required. Can be staged using modular plant.	Finding a location where stormwater can be stored close to sewer extraction points	
Greywater/blackwater separation	Reduce treatment requirements.	Additional fourth pipe costs	Alternative Water & Potable
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Create retarding basin storages in POS areas.	Lower CAPEX and OPEX relative to streetscape storages (some pumping required in case of climate change scenario likely)	Loss of POS after flood. Contaminated land and shallow groundwater table means excavated depths will be shallow.	Drainage
Create shallow retarding basin storages under podium level (i.e. tanks or landscaped basins at street level).	May allow most suitable location in the catchment to be utilised (low points), and help compensate or reduce impact of (assumingly solid) podiums blocking flood storage.	Need to create easement or similar to allow this to be a public asset.	Drainage
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage, urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 12 Make-up of Scenario 3: Interlinked Third Pipe Supply

8.7 Conceptual Design Intent - Scenario 4: Stormwater Harvesting in the Precinct

8.7.1 Option definition

The make-up of scenario 4 is provided within Figure 13. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.7.2 Scenario characteristics

Potable water

As a result of the treated stormwater and class A back-up (sourced from a local sewer mining plant) to the precinct wide third pipe network, the average and peak day potable water demand requirements are approximately 50% of those presented within Scenario 0 – conventional servicing scenario with no drainage upgrades. It is anticipated that this will reduce the design capacity of potable infrastructure as follows:

- Elimination of Punt Road pump station and on-site Fisherman's Bend storage associated with Preston potable system upgrade.
- Downsizing of potable water reticulation in accordance with WSAA requirements.
- Potential deferment of future upgrades associated with the broader Preston Main system operated by Melbourne Water.

Alternative water

Rainwater tanks in this scenario have been sized to meet the SFP requirements (tank captures the first 101 mm of rainfall on all roof tops and 70% of podium within the precinct) and perform a dual function (i.e. provide rainwater to the building scale third pipe network and release water to the Yarra River and Bay before subsequent flood events). As a result rainwater harvested from each of the building roof tops will provide an alternative source of water to toilets, laundry and outdoor use within the podium.

In addition to rainwater, stormwater sourced from local flood storages, backed up by class A sourced from a local sewer mining plant drawing from the Melbourne main sewer network (refer Section Appendix E4).

A single stormwater/sewer mining treatment plant could be adopted and staged by building the plant in a modular fashion. A single stormwater/wastewater plant provides the following benefits relative to multiple plants:

- One asset to maintain;
- One site to acquire;
- Buffer requirements around one site.

An indicative centralised treatment plant and sewer extraction points are shown within Figure 12. Extracting from the Melbourne main sewer is considered advantageous due to the constant supply available within this network. The siting of the plant is situated in the vicinity of the Montague precinct, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region.

The conceptual design logic proposed is as follows:

- Primary below ground flood storages to provide initial capture. Due to poor ground conditions and ability to drain the flood storages (due to tailwater levels), the end of line flood storages are proposed to provide short term flood detention prior to pump directly to the sewer mining/stormwater treatment plant (daily demand exceeds flood storage volume).
- Pump Station with rising main from flood storage to sewer mining/stormwater treatment plant (15.5 ML/d).
- Single extraction point to capture 90% of peak demand.
- Single stormwater/wastewater treatment plant sized to treat 90% of peak demand (18.5 ML/d).
- Balancing tank to hold 1 peak day of supply (20.6 ML/d).
- Class A distribution pump station (20.6 ML/d).

Sewer

Sewer upgrades in the precinct are anticipated to be in accordance with Scenario 0 – conventional servicing scenario with no drainage upgrades (i.e. the presence of a sewer mining plant cannot provide a reduction in upstream or downstream peak flow design capacity). As a result there are approximately 21 km of sewer upgrades proposed as part of this option.

Drainage

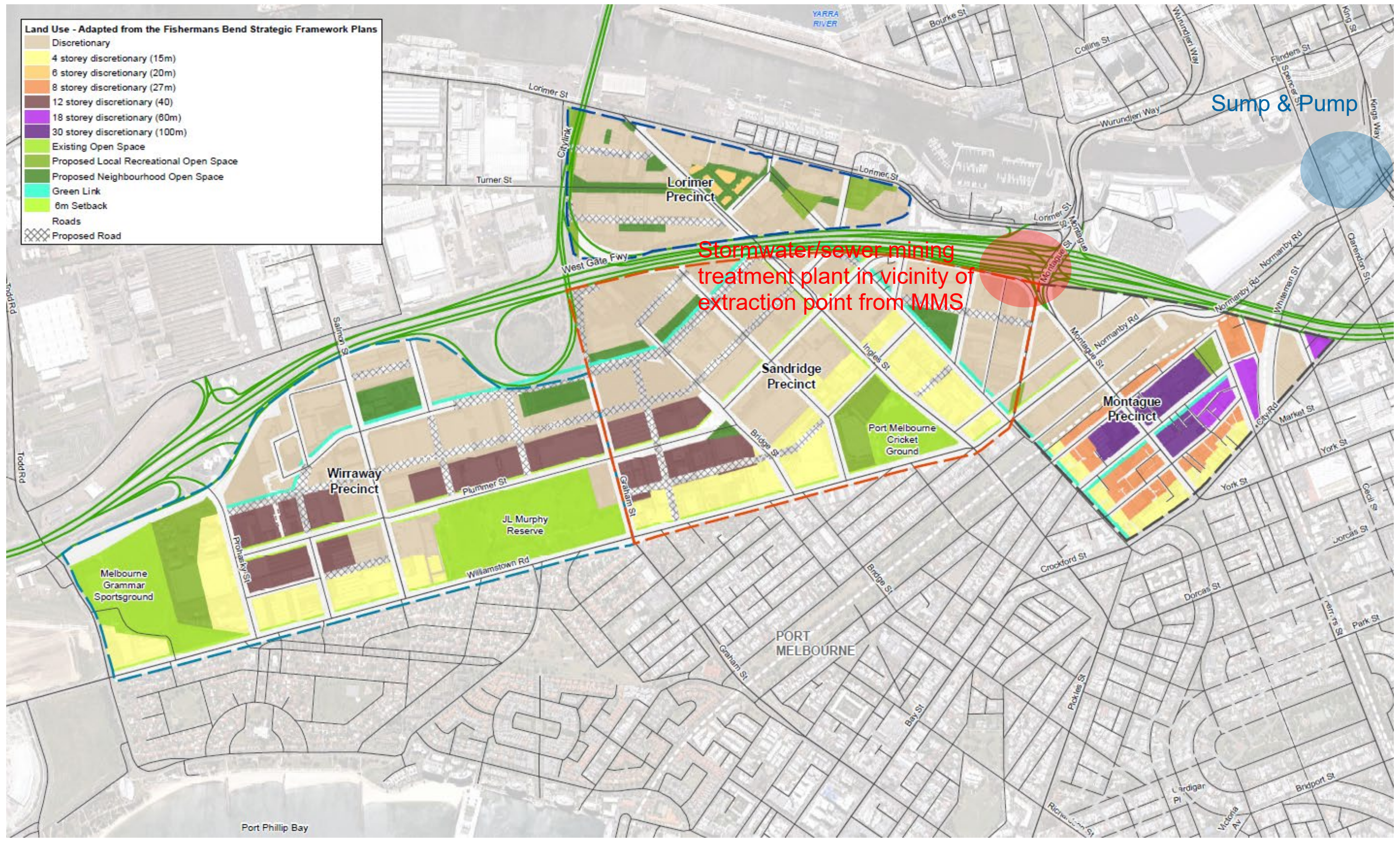
A non-conventional drainage approach applies to this option. This includes the application of rainwater tanks (as per SFP), augmentation of underground drains and end of line sub-surface storages to provide a five year ARI minor street drainage standard and 100 year ARI major drainage protection to properties and designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting hazard criteria (i.e. low egress risk) where practical. The end of line storages will also provide stormwater for reuse within the precinct.

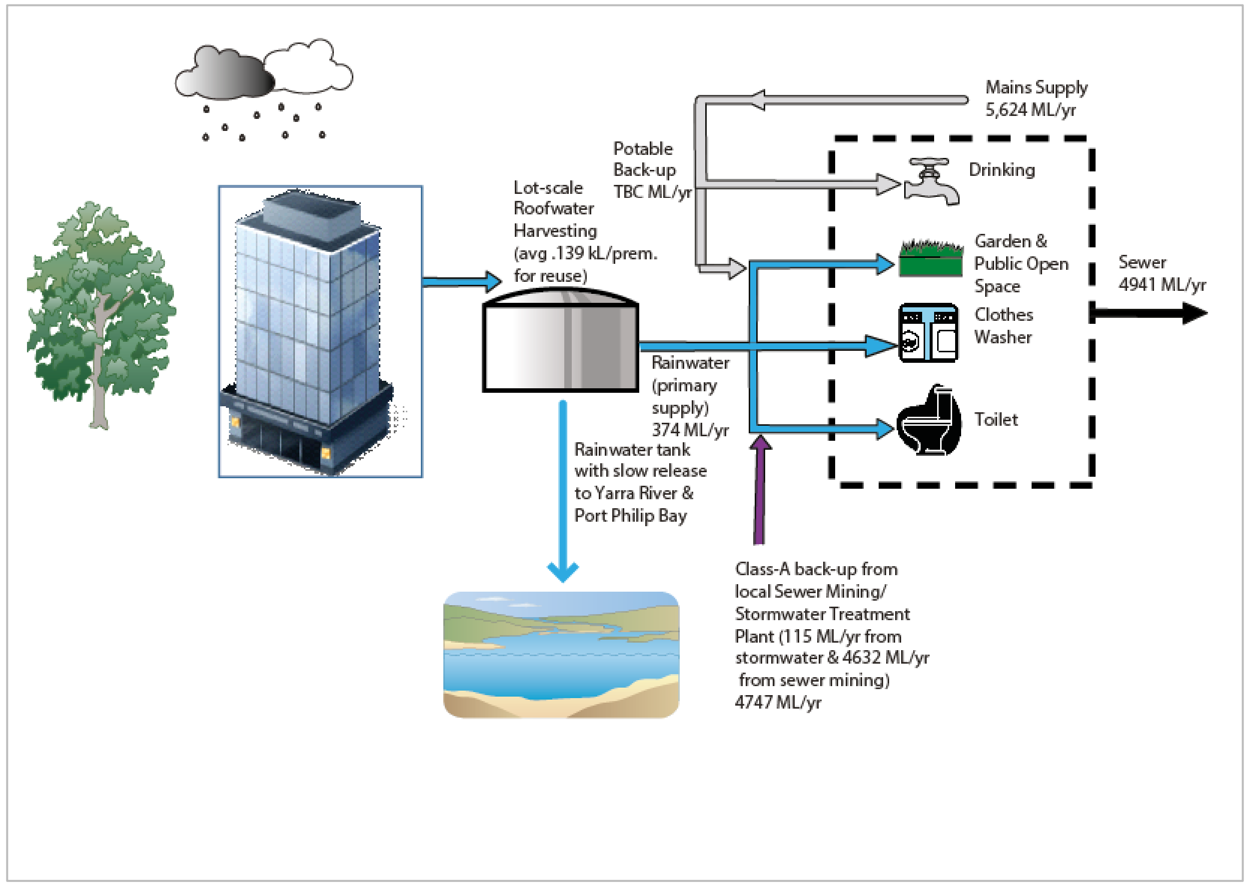
Rainwater tanks installed in accordance with the SFP are designed to capture the first 101 mm of rainfall off all roof tops and 70% of podiums within the precinct. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply); and
- Have the ability to slowly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

Precinct scale stormwater harvesting into third pipe with smaller conventional development wide drainage infrastructure.

Make-Up

- Augmentation of existing potable mains & new reticulation.
- Some sewer upgrades in combination with new reticulation.
- Developer managed precinct scale stormwater retention & reuse (to development wide third pipe) in combination with upgraded stormwater drains/swales, new retarding basins, and pumping as required to achieve a 5 year ARI minor flood standard in roads and a 100 year ARI major flood standard for properties.
- Rainwater tank as per SFP requirements to building third pipe.
- Local stormwater/sewer mining treatment plant to development wide third pipe.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building (on average) with 139 kL for reuse.
- 28.6 km of new stormwater drains (pits and pipes) or swales.
- Flood/stormwater harvesting storages (4 no. totalling 16 ML).
- 1 No. Stormwater sumps & pumps.
- 11,200 sq m of streetscape bioretention in the form of raingardens, tree pits (or equivalent)
- 24.9 km of new or upgraded potable mains are required. It is anticipated that there will be reductions in potable trunk and reticulation sizes relative to Scenario 0 as a result of the development wide alternative water pipe.
- 21 km of new or upgraded sewers mains required;
- 29.3 km of new alternative water (third pipe) mains required;
- 3rd pipe in building;
- Sewer extraction pump (18.5 ML/d);
- 1 sewer mining/stormwater treatment plant (18.5 ML/d)
- Class A balancing tank (20.6 ML/d);
- Class A distribution pump station (20.6 ML/d).

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Single sewer mining plant	Single asset to maintain, less land acquisitions required. Can be staged using modular plant.	Siting near sewer with sufficient capacity to meet ultimate demands.	Alternative Water & Potable
Multiple sewer mining plants	Each plant can be introduced in a staged manner (each dedicated to a precinct)	Requires more land acquisitions, buffer distances problematic	Alternative Water & Potable
Combined sewer mining and stormwater plant	Single asset to maintain, less land acquisitions required. Can be staged using modular plant.	Finding a location where stormwater can be stored close to sewer extraction points	Combined sewer mining and stormwater plant
Greywater/blackwater separation	Reduce treatment requirements.	Additional fourth pipe costs	Alternative Water & Potable
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Create retarding basin storages in POS areas.	Lower CAPEX and OPEX relative to streetscape storages (some pumping required in case of climate change scenario likely)	Loss of POS after flood. Contaminated land and shallow groundwater table means excavated depths will be shallow.	Drainage
Create shallow retarding basin storages under podium level (i.e. tanks or landscaped basins at street level).	May allow most suitable location in the catchment to be utilised (low points), and help compensate or reduce impact of (assumingly solid) podiums blocking flood storage.	Need to create easement or similar to allow this to be a public asset.	Drainage
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage, urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 13 Make-up of Scenario 4: Stormwater Harvesting in the Precinct

8.8 Conceptual Design Intent – Scenario 5: Lot Focus

8.8.1 Option definition

The make-up of scenario 5 is provided within Figure 14. This includes a scenario description, conceptual infrastructure requirements and the merits and relative importance (in servicing terms) of various implementation considerations that were identified by both the CRC and project stakeholders.

8.8.2 Scenario characteristics

Potable water

In this scenario there is building scale greywater and rainwater servicing third pipe in each building. As the building scale greywater systems cannot be assumed to be reliable (independently operated) there will be no reduction in the peak potable demand requirements and as a result there will be no reduction in the design capacity of the potable water network (as per Scenario 0 – conventional servicing scenario with no drainage upgrades).

Preston potable system upgrades will be required including a Punt Rd pump station (150 ML/d) and an on-site storage (6-8 ML) to manage peak hour demands. Based on feedback from Melbourne Water it is anticipated that this infrastructure would be staged as follows:

- Commissioning of pump station in 2030;
- Commissioning of initial storage (3-4 ML) in 2030; and
- Commissioning of a further storage (3-4 ML) in 2045.

Alternative water

Smart fast release rainwater tanks in this scenario have been sized to provide rainwater to the building scale third pipe network (back-up supply) by capturing the first 101 mm of rainfall on all roof tops and 70% of podium within the precinct and have the ability to quickly release water to the Yarra River and Bay before subsequent flood events. Rainwater harvested will provide an alternative source of water to toilets, laundry and outdoor use within the podium. Refer to Appendix E1 for further details on the smart quick release rainwater tank.

In addition to rainwater, building scale greywater is proposed to be sourced and treated on site (i.e. each building has an independent treatment plant).

Sending the shower, clothes washing and miscellaneous supplies to the greywater plant within residential buildings results in excess demand. For residential buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant;
- Greywater treatment plant sized to treat 100% of peak demand (33 kL/d), which is equivalent to 71 L/person/d;
- Balancing tank within each building to hold 1 peak day of supply (33 kL/d); and
- Greywater distribution pump station within each building to supply 1 peak day of supply (33 kL/d).

Sending the shower and potable supplies (no clothes washing) to the greywater plant within commercial buildings results in a supply constraint. As a result the commercial buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant;
- Greywater treatment plant sized to treat 100% of available supply (12 kL/d), which is equivalent to 27.2 L/person/d;
- Balancing tank within each building to hold one peak day of supply (12 kL/d); and
- Greywater distribution pump station within each building to supply one peak day of supply (12 kL/d).

A localised stormwater harvesting scheme has been incorporated into this scenario which will complement the flood mitigation approach and provide alternative water for the local public open space demands. It has been assumed that given the intended use for this option is limited to public open space, indirect controls (i.e. sub-surface irrigation or irrigation at night) rather than direct controls (advanced treatment) will be adopted in this instance. Local stormwater harvesting has been included for cost benefit comparative purposes.

Sewer

Sewer upgrades in the precinct are anticipated to be in accordance with Scenario 0 – conventional servicing scenario with no drainage upgrades (i.e. the presence of a sewer mining plant cannot provide a reduction in upstream or downstream peak flow design capacity). As a result there are approximately 21 km of sewer upgrades proposed as part of this option.

Drainage

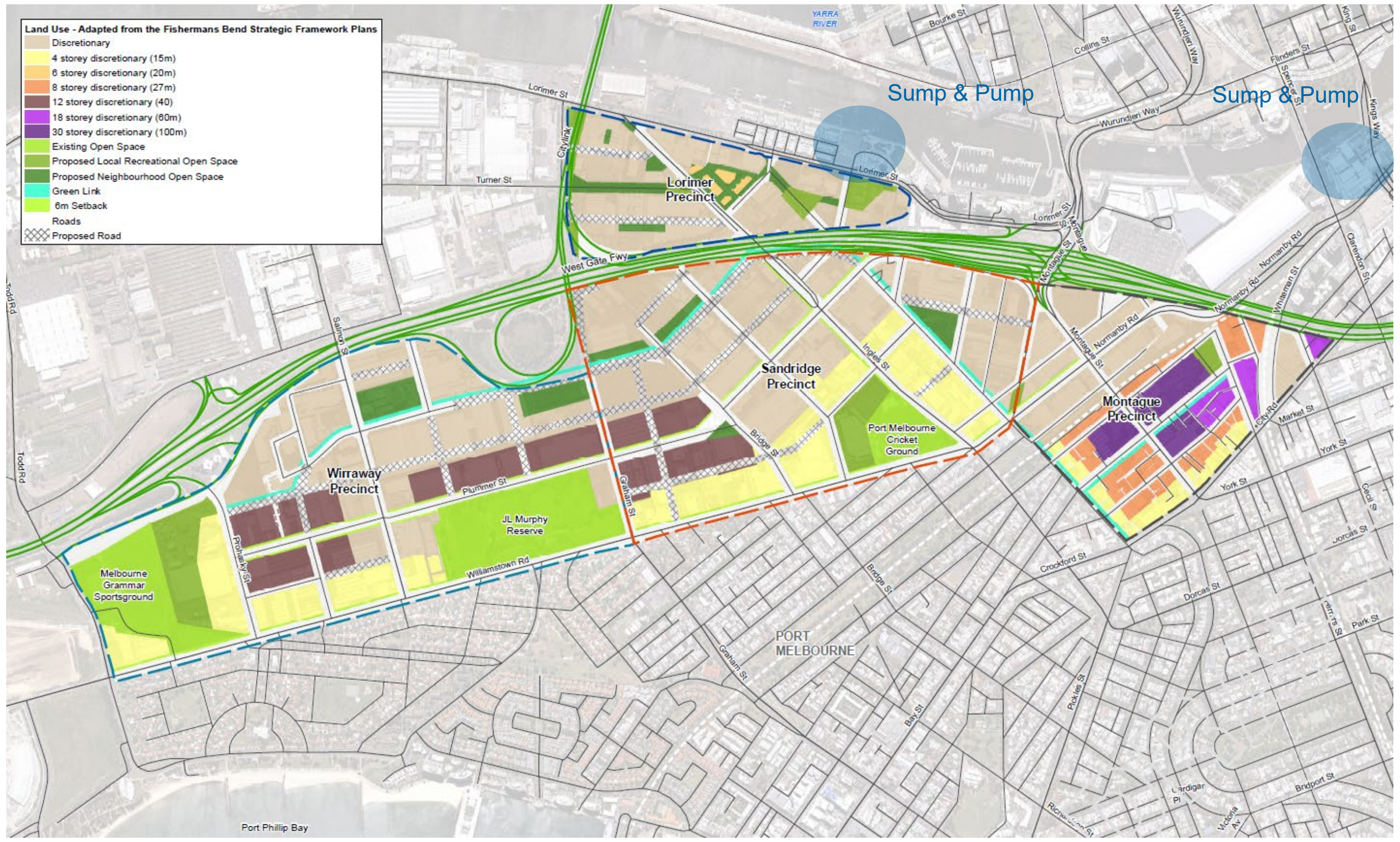
A non-conventional drainage approach applies to this option. This includes the application of smart rainwater tanks, augmentation of underground drains, podium and streetscape storages to provide a five year ARI minor street drainage standard and 100 year ARI major drainage protection to properties and designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting hazard criteria (i.e. low egress risk) where practical.

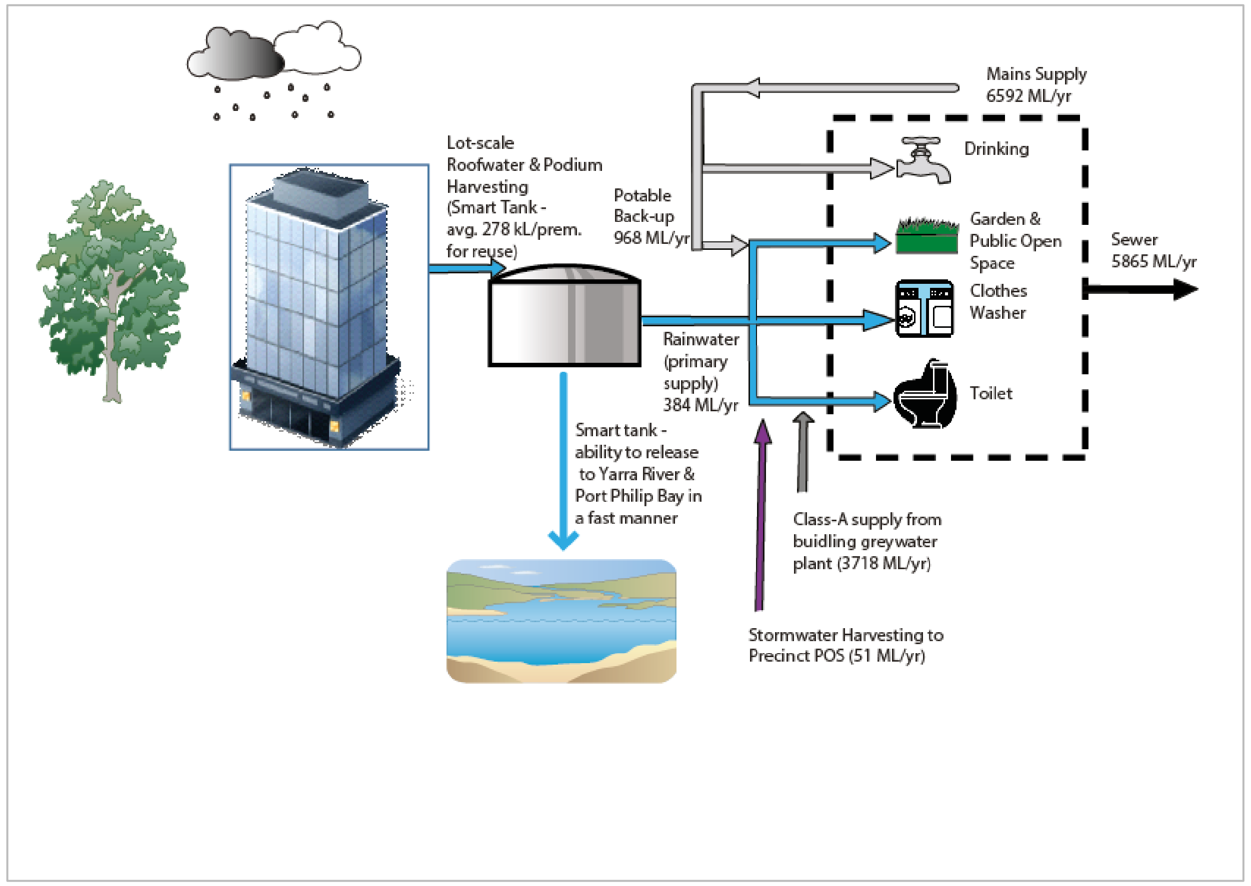
Smart fast release rainwater tanks in this scenario are sized to:

- Provide rainwater to the building scale and precinct wide third pipe network (primary supply) by capturing runoff from the roof and 70% of podiums; and
- Have the ability to quickly release water to the Yarra River and Bay before subsequent flood events.

WSUD

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) within the building podiums (50%) and streetscape (50%) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct.





Option Description

Lot scale approach to minimise precinct infrastructure. Tolerable flooding approach in the streetscape.

Make-Up

- Augmentation of existing potable mains & new reticulation.
- Preston potable system upgrades including Punt Rd pump station & on-site storage;
- Some sewer upgrades in combination with new reticulation.
- 4th pipe greywater collection.
- Building scale greywater plants to building third pipe
- Smart fast release rainwater tank to building third pipe sharing (in combination with building scale greywater system).
- On site retention & reuse.
- Designated tolerable flooding in roads. Smaller conventional development wide infrastructure to provide a 100 year ARI major flood standard for properties and local stormwater harvesting.

Conceptual Infrastructure Requirements

- 278 kL rainwater tank at each building (Smart Tank)
- New stormwater drains (pits and pipes) or swales
- 3 No. Stormwater sumps & pumps
- 11,200 sq. m of streetscape bioretention in the form of raingardens, tree pits (or equivalent)
- 24.9 km of new or upgraded potable mains are required. It is anticipated that there will be reductions in potable trunk and reticulation sizes relative to Scenario 0 as a result of the development wide alternative water pipe.
- Preston potable system upgrades including Punt Rd pump station & on-site storage;
- 21 km of new or upgraded sewers mains required;
- 3rd and 4th pipe in building
- Lot scale greywater plants (avg. 12 kL/d & 33 kL/d for commercial & residential)
- Lot scale greywater balancing tank (avg. 12 kL/d & 33 kL/d for commercial & residential)
- Lot scale greywater distribution pump station (avg. 12 kL/d & 33 kL/d for commercial & residential)

Implementation Considerations

Opportunities	Benefits	Risks	Implications on Infrastructure Requirements
Sub-precinct greywater plant (one every 10 buildings)	Reduction in number of plants relative to plant in every building	Management of a large number of plant and metering.	Alternative Water & Potable
Consider shallow gravity or pressure sewers where applicable	Mitigates contaminated soil and shallow groundwater table, and minimises infiltration inflow.	Additional operating costs associated with pressure sewer. Pump stations likely to be located within buildings.	Sewer
Create retarding basin storages in dedicated street/laneway/greenway low points with low head pumping	Egress maintained within dedicated streets. Public opens space not impacted. Minimal or no excavation (using fall of catchment).	Some streets will be inaccessible after flood. Higher CAPEX and OPEX relative to a traditional retarding basin.	Drainage
Create retarding basin storages in POS areas.	Lower CAPEX and OPEX relative to streetscape storages (some pumping required in case of climate change scenario likely)	Loss of POS after flood. Contaminated land and shallow groundwater table means excavated depths will be shallow.	Drainage
Create shallow retarding basin storages under podium level (i.e. tanks or landscaped basins at street level).	May allow most suitable location in the catchment to be utilised (low points), and help compensate or reduce impact of (assumingly solid) podiums blocking flood storage.	Need to create easement or similar to allow this to be a public asset.	Drainage
Add 'Green Elements' such as greenwalls/roofs and streetscapes.	Flood storage, urban cooling, aesthetics nutrient reduction	Adds additional demand in dry periods	None
Consider soil moisture beds above groundwater table.	Flood storage, urban cooling, aesthetics nutrient reduction, drought tolerant/wicking potential	Relative cost to seal above groundwater table	None

Figure 14 Make-up of Scenario 5: Lot Focus

9. Drainage

9.1 Need for a high level of service

Parts of the Fishermans Bend site are low lying and subject to frequent flooding. This frequent flooding has given the area a reputation as being subject to drainage issues / flooding with locations such as the York Street underpass adjacent the South Melbourne Market getting frequent media reports of closure due to flooding. Any development of the magnitude proposed at this site justifies a high standard of drainage to provide a convenient and safe flood free environment for the large number of people who will live, work and or visit the development during its design life. Given the public knowledge of flooding in this area, the need for a high standard of drainage is even greater, to not only meet the public and investor expectations for a project of this nature but also to offset preconceptions and instil confidence in the robustness of the drainage solutions.

The location of all habitable floors on podiums well above the flood level significantly limits the potential for flood damage and provides a level of protection and reassurance to occupiers and investors which will be required for the successful uptake of the opportunities within the site. The targeted drainage standard for the development is currently proposed to be:

1. 5 yr ARI - no surface flooding in roads or private realm (ie depths less than 50mm);
2. 100 yr ARI - no surface flooding within property boundaries[2]; and
3. 100 yr ARI - designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting a low safety risk in roads category where practical.

The conceptual design of the drainage system for the current urban form has been targeted to effectively achieve these standards. While these standards can be practically achieved for the majority of the development it is expected that some relatively small isolated locations will need to be treated differently, perhaps filled, designated as public open space or a range of other potential solutions.

Although there is recognition that this standard may not be possible to achieve everywhere, it is none the less considered a minimum objective and a higher target level of service should be considered. For instance the no surface flooding criteria (depth less than 50mm) currently required for a 5 year ARI event could potentially be upgraded to apply for a 10 or 20 year ARI event where it was found economic to do so.

9.2 Drainage Characteristics

9.2.1 Synergies with other solutions

The adoption of rainwater tanks, as defined in the SFP, results in a beneficial reduction in runoff volume (retention) and consequently a reduction in flooding. The reduction in runoff volumes varies with the size, reliability and efficiency of the provided storages however regardless of implementation as only part of the flooding results from local runoff, some of it being from backwatering of in particular the low lying areas, the storages will only ever provide part of the drainage solution.

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[2] It is probable that some properties will include ramps, stairs or possibly even foyers at a sub podium level to facilitate street level access. It has been assumed that such infrastructure will be designed in such a manner that it is not subject to flooding damage. It is also entirely possible that some flooding may result on the podiums themselves subject to the adopted design approach. Neither of these circumstances has been included in the assessment of flooding damage as these will be designed outcomes on private infrastructure with little or no damage, a minor allowance for clean-up cost has been included in the AAD estimates where appropriate . Guidelines for development of these unique areas may be required to avoid the potential for low design standards which may potential place the public or their assets at risk.

9.2.2 Low Lying areas and Climate Change

Low lying areas which are currently susceptible to flooding, and or may become so as a result of future climate change, cannot rely entirely on the reduction in local runoff volumes to provide adequate drainage. Hydraulic modelling results for Scenario 1 showing the maximum 100 year ARI depths indicate a number of regions which fall into this category and are identified in Figure 15 using red circles.

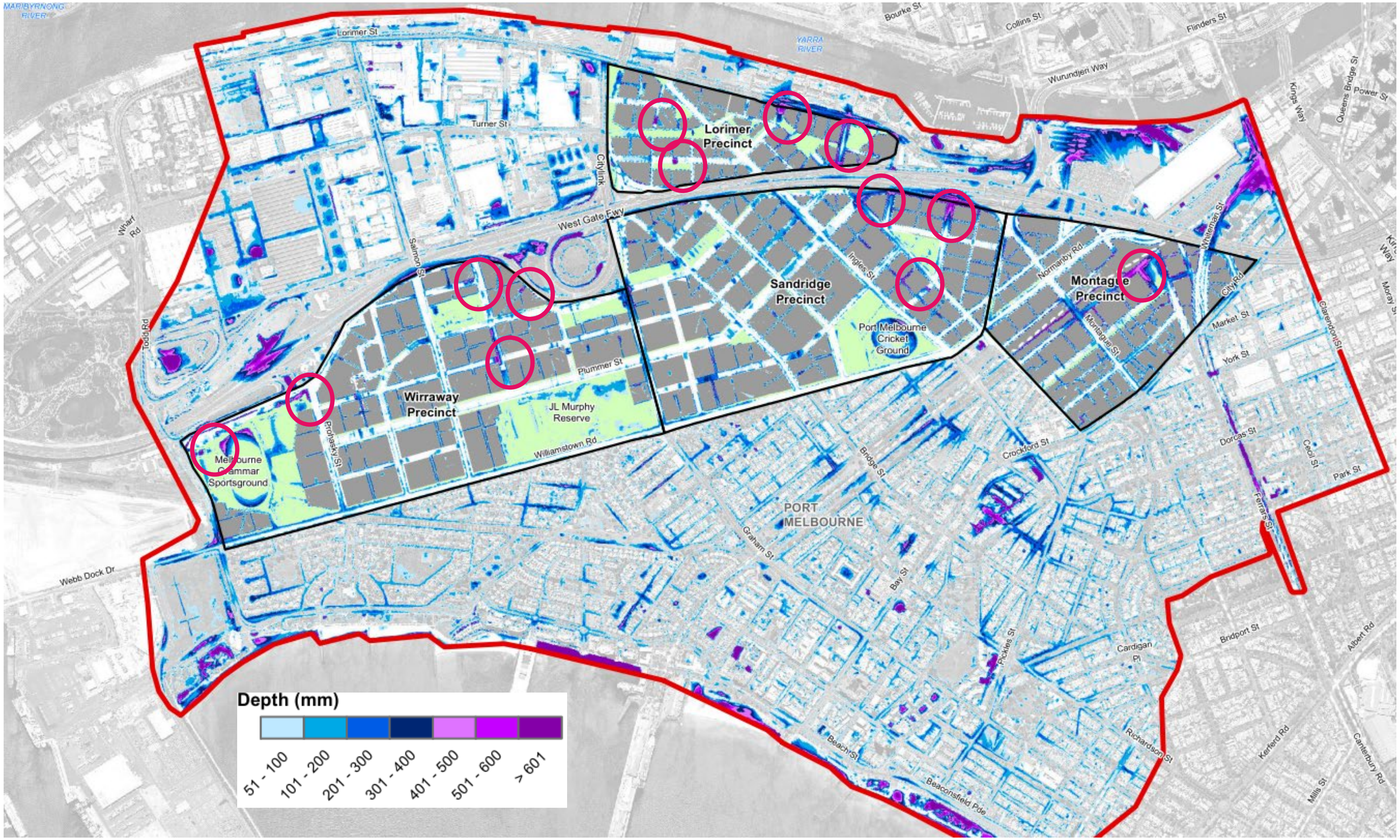

Figure 15 Low lying areas where regional drainage infrastructure assists but local controls are likely to be required to achieve performance criteria. (100 year ARI flood depths Scenario 1)

It should be noted that alternate development layouts and servicing plans are likely to result in the identification of similar areas as a result of their physical attributes the threshold for defining an area as requiring special consideration may change between scenarios and may need refinement as development concepts evolve.

In many of these areas achieving the desired drainage standard may require one or more of a range of measures including:

- Filling
- Flood tolerant development, both in terms of the adopted usage, building form, detailing and materials
- Levees
- Pumped sumps
- One-way valves and
- Storages

An increase in tail water levels due to climate change will increase the frequency and number of locations which require additional flood mitigation both within and external to the Fishermans Bend development. Subsequently where not needed for current conditions, these measures should be considered when required on a regional basis, rather than as a specific requirement of the Fishermans Bend development.

Sea level rise and increased rainfall intensities which may result from climate change should remain an important aspect of design decisions for the Fishermans Bend development however the current planning and design should focus more on providing a high level of drainage service for current conditions and a built in robustness, compatibility and tolerance to future requirements with an understanding that the future requirements will in many instances be shared and solved with a more regional approach.

9.3 Reduction in Flood Damage

A traditional approach to justifying drainage upgrades is to undertake a benefit cost analysis and demonstrate that the benefit in terms of reduction in flood damages justifies the expected costs. The potential for the drainage improvements within Fishermans Bend to reduce flood damages is significantly reduced by the fact that quantifiable flood damages are significantly controlled by the already adopted SFP which requires building the habitable floors on podiums well above expected flood levels. As part of this investigation the remaining quantifiable damage within the road reserves and associated indirect costs due to potential health impact, disruption of employment, commerce, transport and communication have been estimated. The relative difference in average annual damage NPV estimates for scenario 1 to 5 relative to scenario 0 are illustrated in Figure 16 and are based on the original estimates (GHD, 2015). These damage estimates are based on damage estimates for specific flood events from which an estimate of Average Annual Damage (AAD) and subsequently NPVs are derived. Drainage improvements for the Fishermans Bend precinct are a fundamental requirement of a successful development, the estimated benefit (reduction in flood damage) is a part justification for works which are fundamentally required to facilitate the development.

9.4 Summary of modelling methodology and interpretation.

Although the adopted flood modelling approach is largely representative of the currently anticipated characteristics of the Fishermans Bend development, there are a number of macro level limitations which need to be considered when interpreting the results.

Key amongst these limitations are a number of simplifications which include:

1. The model does not explicitly include any guttering or downpipes
2. There is a limited representation of road gutters (limited by terrain and grid resolution as well as the conceptual nature of the current development concept)
3. A finite number of inlet pits providing an indicative but suboptimal version of what will ultimately be designed. For instance it is likely that the final design will include saw tooth grading of the road gutters with side inlet pits at the sags. This type of detail is well beyond the current concept. The further detail and design consideration is expected to lead to further reductions in ponding and or more efficient outcomes.

All of the above limitations contribute to an overestimate of flooding depths, particularly for small flows. With a rain on grid model excess runoff from the surface of the podium runs off the edge of the podium down the vertical wall falling on the footpath and having to flow across the footpath and down the road (which may have little or no grade) until it encounters an inlet pit. This is different to the real situation where most of the water would be captured in internal guttering and drainage systems which deliver it directly to the piped drainage system via downpipes and local drainage infrastructure. For podiums in close proximity to an outlet the actual design may include drainage via a pressure main directly to a point of discharge such as the Yarra River, a situation which is even more different to the modelled process.

A significant challenge in this project was to try and achieve a somewhat uniform standard of drainage service between scenarios so that the costs of drainage works could be more directly compared. Although it is desirable to achieve a fairly uniform drainage standard across modelled scenarios it is not essential as it is the benefit cost ratios which are being compared and not just the costs. The depth plots provided in Appendix B show the degree to which the desired level of drainage system performance has been achieved. As development concepts and assumptions are firmed up and design concepts are refined it will become more important that the final overall drainage strategy broadly achieves the drainage objectives. While the details of the drainage servicing strategy are yet to be finalised it seems likely that a refined solution may use a mix of solutions and not necessarily stick with a single approach as has been done for the scenario assessments.

Further details of the modelling process are included in Appendix G.

9.5 Estimation of Flood Damages and Average Annual Damages

To enable assessment of AAD both within and in areas draining to the precincts, flood damages for a range of events have been estimated. The adopted method was based on the AAD assessment methodology that was being refined by Aither, GHD and MW at the time of writing in 2015. This method involves estimating damages for each type of asset for modelled events with various techniques to infill the remainder of the probability distribution curve and estimate AAD. The assumptions adopted for each asset category are summarised below.

9.5.1 General Assumptions

Buildings

Residential building damages are per building and estimated based on the depth of above floor flooding for the inundated floor with a stage damage curve defining the relationship between depth of flooding and damages. External damages are assumed to commence when flood levels reach an elevation 100 mm below the floor.

Commercial and Industrial building damages are estimated in a similar way to residential building damages with a different stage damage curve applied that relates to building area and depth of flooding relative to the floor level.

Properties

Damages to properties with no buildings (including the street level platforms around the podiums) are estimated as a cleanup rate of $1 per meter squared of property inundated.

Roads

It has been assumed that 15% of roads within the precinct will be major roads and 85% will be minor roads.

Damages to major roads are estimated as $105,000 per kilometer of road inundated above 50 mm and damages to minor roads are estimated as $33,000 per kilometer of road inundated above 50 mm.

Indirect Damages

Indirect damages[3] are estimated as a percentage of direct damages, for buildings and properties indirect damages are estimated as 30% of the direct damages, and for roads and motor vehicles indirect damages are estimated as 50% of the direct damages.

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[3] The following extract from Department of Water Resources, Division of Flood Management, State of California, *Flood Rapid Assessment Model Development (F-RAM)*, (URS November 2008) provides a useful description of indirect damages and a suggested means of evaluating them. Draft recomendations in recent (May 2015) work by Aither as part of the update of Melbourne Water's AAD tool still references the Department of Sustainability and Environment, *Review of Flood RAM Standard Values* (URS 2009) and have recommended that indirect damages are estimated based on 30% of direct damages to buildings including residential, commercial and industrial. While these relationships seem plausible, it is understood that they are based on limited information and are thus subject to large uncertainty.

Appendix C
F-RAM Documented Assumptions

Estimating Indirect Costs associated with Flooding

Indirect damages include the emergency responses to floods, as well as the disruption to normal social and commercial activities which occur subsequent to the direct damage of physical assets as follows:

- Emergency response including food and accommodation
- Health impacts
- Disruption of employment, commerce, transport and communication

Approach: Many of the components of indirect costs pertain to emergency food and accommodation in the post-flood period and as such are directly related to the population density in the inundated region.

Transport services are an important component of a functioning society and economy, and disruptions to these services impose an economic cost on society. The loss of transport services as a result of floods imposes economic costs in the form of lost time, or additional transport costs.

Flooding can cause health impacts for people in both direct and indirect ways. During flooding events, physical symptoms such as injuries and even death can result due to coming into contact with deep or rapidly flowing floodwaters. Flooding events can also cause emotional or psychological problems such as stress, exhaustion, nightmares, depression, despair, etc. The economic impacts of health issues manifest in medical costs and disruption to work activities.

The development of standard values for the various different categories of indirect damages is difficult. The overriding factor is the lack of available data, with which to formulate likely costs. Within the F-RAM, instead of using standard values for each category, we have chosen to represent indirect values as a proportion of direct values. There are a considerable amount of global literature that provides some basis and justification for using this approach.

Assumptions: The assumptions for estimating indirect costs are shown in Table C-6.

Estimating Total Damages for a Single Flood Event

The damages for a single flood are calculated as the probability of levee failure multiplied by the sum of losses to buildings, agriculture, roads, plus indirect losses.

Table C-6 Indirect Costs as a Percentage of Direct Damages

Type of Damage	Percentage of Direct Damages
Residential Buildings	25%
Industrial/Commercial Buildings	25%
Roads	50%

9.5.1 Precinct Specific Assumptions

Buildings

There are no building damages within the precinct as all buildings are located on podiums a minimum 600 mm above the flood level.

Motor Vehicles

Typically motor vehicle damage is considered to be included in the external damages associated with building damages, because of the special design of buildings within the precinct it is necessary to make a special allowance for potential motor vehicle damages

It is assumed that within the precinct parallel parking on both sides of the street will exist resulting in an estimated 163 cars per kilometer of road. Damages to motor vehicles are based on a stage damage curve with damages commencing at an inundation depth of 150 mm.

Motor vehicle damages are the largest component of damage for the Fishermans Bend precinct.

Public Open Space

Damage to public open space is estimated as $16 per square meter of property flooded above a threshold of 400 mm.

10. Summary of Flood Mitigation Outcomes

The following tables and figure outlines the flood mitigation outcomes that have been achieved for each of the respective scenarios.

The base infrastructure for underground drainage (300 mm diameter pipes to service new local streets in Scenarios 1-5 and no upgrades to existing underground network) is consistent between options.

It is important to note that the flood mitigation options documented in this report represent those explored in 2015. The flood mapping and associated mitigation options that were explored in 2015 were undertaken for strategic planning purposes and therefore undertake at a high level. Further flood assessment have been undertaken since 2015 and these studies have progressed looked at the flood mapping and associated mitigation options in increasing levels of detail (i.e. to inform planning scheme amendments etc).

Table 11 Flood Mitigation Outcomes

Scenario	Flood Mitigation Approach	Modelled infrastructure	Flooding outcomes
0 – Conventional Water, Sewer with no minor or major drainage upgrades	Rainwater tanks as per SFP and no precinct based drainage. Slow release rainwater tank.	• 278 kL slow release rainwater tank in each building (139 kL of flood detention)	2.2 km (29%) of major roads and 12.7 km (29%) of minor roads inundated (>= 50 mm) in 5 year ARI event 0.5 km (6%) of major roads and 2.8 km (6%) of minor roads inundated (>= 400 mm) in 100 year ARI event
1 – Conventional Water, Sewer and Drainage Upgrades	Slow release rainwater tanks Conventional drains/swales & pump & sump [Note: less land needs to be purchased as there are no storages required, and it is assumed the pump & sumps are accommodated in the streetscape. This cost saving is offset by reduced pumping infrastructure including reduction in operational and maintenance costs]	• 278 kL slow release rainwater tank in each building (139 kL of flood detention) • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 11 non-return valves • 8 sump and pumps within or downstream of precincts & associated rising mains. These are summarised in Table 12 below. • Sewer Mining Treatment Plant	1.4 km (19%) of major roads and 8.2 km (19%) of minor roads inundated (>= 50 mm) in 5 year ARI event 0.1 km (2%) of major roads and 0.8 km (2%) of minor roads inundated (>= 400 mm) in 100 year ARI event
2 – Sewer Mining in the Precinct	Slow release rainwater tanks Conventional drains/swales & pump & sump [Note: less land needs to be purchased as there are no storages required, and it is assumed the pump & sumps are accommodated in the streetscape. This cost saving is offset by reduced pumping infrastructure including reduction in operational and maintenance costs]	• 278 kL slow release rainwater tank in each building (139 kL of flood detention) • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 11 non-return valves • 8 sump and pumps within or downstream of precincts & associated rising mains. These are summarised in Table 12 below. • Sewer Mining Treatment Plant	1.4 km (19%) of major roads and 8.2 km (19%) of minor roads inundated (>= 50 mm) in 5 year ARI event 0.1 km (2%) of major roads and 0.8 km (2%) of minor roads inundated (>= 400 mm) in 100 year ARI event
3 – Interlinked Third Pipe Supply	Smart quick release rainwater tanks Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse. [Note: additional land needs to be purchased for storages, which is offset by reduced pumping infrastructure including reduction in operational and maintenance costs]	• 278 kL smart quick release rainwater tank in each building (278 kL of flood detention) • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 11 non-return valves • 1 x sump and pump at Clarendon St & associated rising mains. This is summarised in Table 12 below. Below ground storages as follows: • Lorimer Precinct – 1190 m3 • Montague Precinct –8320 m3 • Sandridge Precinct –1240 m3 • Wirraway Precinct – 170 m3	0.5 km (6%) of major roads and 2.7 km (6%) of minor roads inundated (>= 50 mm) in 5 year ARI event 0.3 km (4%) of major roads and 1.9 km (4%) of minor roads inundated (= 400 mm) in 100 year ARI event 0 km (0%) of major roads and 0 km (0%) of minor roads inundated (> 400 mm) in 100 year ARI event

Scenario	Flood Mitigation Approach	Modelled infrastructure	Flooding outcomes
		Above ground stormwater harvesting extraction pump stations and rising mains from flood storages to treatment plant. These are summarised in Table 13 below.	
4 – Stormwater Harvesting in the Precinct	Slow release rainwater tanks End of line stormwater retention and reuse. [Note: additional land needs to be purchased for storages, which is offset by reduced pumping infrastructure including reduction in operational and maintenance costs]	• 278 kL slow release rainwater tank in each building (139 kL of flood detention) • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 11 non-return valves • 1 x sump and pump at Clarendon St & associated rising main. This is summarised in Table 12 below. Below ground storages as follows: • Lorimer Precinct - 1920 m3 • Montague Precinct – 9930 m3 • Sandridge Precinct – 2360 m3 • Wirraway Precinct – 1780 m3 Above ground stormwater harvesting extraction pump stations and rising mains from flood storages to treatment plant. These are summarised in Table 13 below.	1.6 km (21%) of major roads and 9.2 km (21%) of minor roads inundated (>= 50 mm) in 5 year ARI event 0.4 km (5%) of major roads and 2.3 km (5%) of minor roads inundated (>= 400 mm) in 100 year ARI event
5 – Lot Focus	Smart quick release rainwater tanks Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens) [Note: additional land needs to be purchased for storages, which is offset by reduced pumping infrastructure including reduction in operational and maintenance costs]	• 278 kL smart quick release rainwater tank in each building (278 kL of flood detention) • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 11 non-return valves • 3 x sump and pump (Clarendon St, Lorimer 2 and Lorimer 3) & associated rising mains. These are summarised in Table 12 below. Local streetscape/bioretention flood storage as follows: • Lorimer Precinct – 130 m3 (other in road flooding needs to be pumped to allow egress) • Montague Precinct – 8320 m3 • Sandridge Precinct –	1.5 km (20%) of major roads and 8.6 km (20%) of minor roads inundated (> 50 mm) in 5 year ARI event 0.4 km (5%) of major roads and 2.1 km (5%) of minor roads inundated (> 400 mm) in 100 year ARI event

Scenario	Flood Mitigation Approach	Modelled infrastructure	Flooding outcomes
		1240 m3 • Wirraway Precinct – 170 m3 Above ground stormwater harvesting extraction pump station (Montague only) and rising mains from flood storage to treatment plant. These are summarised in Table 13 below.	

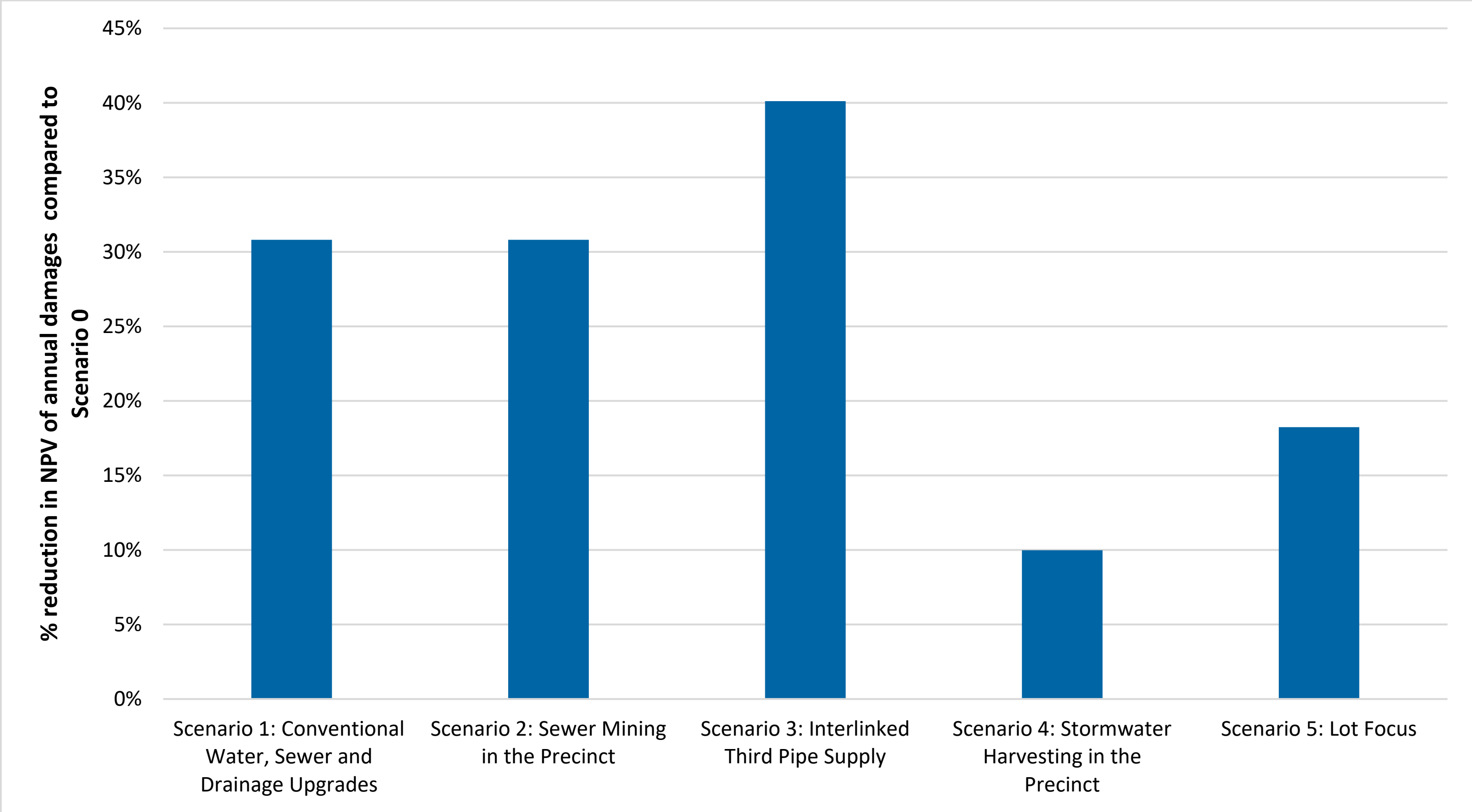


Figure 16 Percentage Reduction in Average Annual Damages NPV compared to scenario 0

Table 12 Proposed Sump & Pumps

Pump Location	Wet Well Diameter (m)	Wet Well Depth (m)	Pump Output – kW (2 Pumps at each location - 1 duty, 1 stand-by)
CLARENDON	6.6	2.1	16.0
LORIMER 1	5.8	2	10
LORIMER 2	7.2	2.3	30
LORIMER 3	7.4	2.5	43
SANDRIDGE 1	6.8	1.5	48
SANDRIDGE 2	10.6	2.3	28
MONTAGUE 1	6.4	2.9	113
MONTAGUE 2	9.6	2.1	130

Table 13 Stormwater Harvesting Above Ground Extraction Pump Stations (Flood Storage to Treatment Plant

Pump Location	Scenario 3 Pump Output – kW (2 Pumps at each location - 1 duty, 1 stand-by)	Scenario 4 Pump Output – kW (2 Pumps at each location - 1 duty, 1 stand-by)	Scenario 5 Pump Output – kW (2 Pumps at each location - 1 duty, 1 stand-by)
LORIMER 1	6	4	-
MONTAGUE 1	30	24	24
SANDRIDGE 2	7	4	-
WIRRAWAY 1	5	1	-

11. Summary of Land Take Requirements

The following table outlines land take requirements for major above ground infrastructure across the respective scenarios.

Table 14 Land Take Requirements

Scenario	Major Infrastructure Requiring Land	Estimated Land Take Required (sq m)	Basis for Land Take Estimate
0 – Conventional Water, Sewer with no minor or major drainage upgrades	New potable mains	Easement	
	New sewer mains	Easement	
1 – Conventional Water, Sewer and Drainage Upgrades	New potable mains	Easement	
	New sewer mains	Easement	
	Sump & Pumps	Accommodated in streetscape	
2 – Sewer Mining in the Precinct	New potable mains	Easement	
	New sewer mains	Easement	
	New third pipe	Easement	
	Sump & Pumps	Accommodated in streetscape	
	Sewer mining plant (18.5 ML/d)	Acquisition/lease of 12,000 sq m	Ravenhall Sewer Mining, CWW 2014
	20.6 ML class A balancing tank	Acquisition/lease of 1,300 sq m	Ravenhall Sewer Mining, CWW 2014
3 – Interlinked Third Pipe Supply	New potable mains	Easement	
	New sewer mains	Easement	
	New third pipe	Easement	
	Sump & Pumps	Accommodated in streetscape	
	Precinct scale stormwater flood storage	Acquisition/lease of 82,980 sq m	TUFLOW model
	Primary above ground stormwater harvesting storage & pumps	Accommodated above precinct scale flood storage	
	Stormwater/sewer mining treatment plant (18.5 ML/d)	Acquisition/lease of 12,000 sq m	Ravenhall Sewer Mining, CWW 2014
4 – Stormwater Harvesting in the Precinct	New potable mains	Easement	
	New sewer mains	Easement	
	New third pipe	Easement	
	Sump & Pumps	Accommodated in streetscape	
	Precinct scale stormwater flood storage	Acquisition/lease of 31,980 sq m	TUFLOW mode
	Primary above ground stormwater harvesting storage & pumps	Accommodated above precinct scale flood storage	

Scenario	Major Infrastructure Requiring Land	Estimated Land Take Required (sq m)	Basis for Land Take Estimate
	Stormwater/sewer mining treatment plant (18.5 ML/d)	Acquisition/lease of 12,000 sq m	Ravenhall Sewer Mining, CWW 2014
	20.6 ML class A balancing tank	Acquisition/lease of 1,300 sq m	Ravenhall Sewer Mining, CWW 2014
5 – Lot Focus	New potable mains	Easement	
	New sewer mains	Easement	
	New third pipe	Easement	
	Sump & Pumps	Accommodated in streetscape	
	In building greywater plant	Acquisition/lease of 100 sq m	Landcom, 2006.
	Streetscape/bioretention flood storage	Accommodated in streetscape	
	Local stormwater harvesting storage & pumps	Accommodated in streetscape	

12. Consolidated Summary of Scenario Concept Design Requirements

A consolidated summary of concept design requirements for all scenarios is provided in Table 15.

It should be noted that all infrastructure identified in this report (inclusive of design parameters and exact siting) is of a conceptual nature and requires further detailed analysis to explore the opportunities, risks and constraints.

In accordance with the SFP, the in development infrastructure includes rainwater tanks, distribution pumps and third pipes within each of the buildings. Whilst the different rainwater tank approaches are explored below, the distribution pumps and third pipes within buildings are not explored below (i.e. these are assumed to be mandatory across all scenarios). The public open space (POS) irrigation requirements (i.e. mains, sub-surface/above ground sprinklers etc.) throughout the precinct, which are consistent across all scenarios have not been estimated. Balancing tanks and distribution pump requirements (scenario dependent) have been estimated.

Table 15 Consolidated Summary of Concept Design Requirements

Scenario	Description	Utilisation of existing infrastructure (applicable to all scenarios)	Major New Infrastructure Requirements	Staging	Major Land acquisition requirements	Building-based regulations	Health requirements
0 - Conventional Water, Sewer (no minor or major drainage upgrades) – Base Case	Conventional servicing with rainwater tanks as per SFP and no precinct based drainage. Slow release rainwater tank	Upgrade of 10.4 km of potable mains Upgrade of 8.5 km of sewer mains	• 16.7 km of new potable mains • Preston potable system upgrades including Punt Rd pump station & on-site storage • 12.6 km of new sewers mains • 278 kL rainwater tank at each building (139 kL of flood detention and 139 kL of retention for reuse) • 11,200 m^2 of bioretention within podium (50%) and streetscape (50%).	Rainwater tanks come on line as buildings are completed	New potable mains New sewer mains	Provision of fire storage	Rainwater & Class A fit for purpose
1 - Conventional Water, Sewer & Drainage upgrades	Conventional servicing [no development wide third pipe] Slow release rainwater tank	Upgrade of 10.4 km of potable mains Upgrade of 8.5 km of sewer mains	In addition/relative to the infrastructure identified in Scenario 0 the following is required: • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 10 non-return valves • 8 sump and pumps within or downstream of precincts & associated rising mains	Rainwater tanks come on line as buildings are completed	New potable mains New sewer mains Flood storage, sumps& pumps	Provision of fire storage	Rainwater & Class A fit for purpose
2 - Sewer Mining in the Precinct	Sewer Mining with development wide third pipe. Slow release rainwater tank Conventional drainage upgrades.	Upgrade of 10.3 km of potable mains Upgrade of 8.5 km of sewer mains	In addition/relative to the infrastructure identified in Scenario 0 the following is required: • 2.1 km less potable mains (downsized relative to base case) • No Preston potable system upgrades including Punt Rd pump station & on-site storage • 29.3 km of new alternative water (third pipe) mains • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 10 non-return valves on Yarra River stormwater outlets • 8 sump and pumps within or downstream of precincts & associated rising mains • Sewer Mining Treatment Plant • 20.6 ML class A balancing tank • Class A distribution pump station (20.6 ML/d).	Rainwater tanks come on line as buildings are completed Modular sewer mining plant	New potable mains New sewer mains New third pipe Precinct scale flood storage, sumps& pumps Sewer mining plant (18.5 ML/d) 20.6 ML class A balancing tank	Provision of fire storage	Rainwater & Class A fit for purpose
3 - Interlinked Third Pipe Supply	Mix of lot & development scale initiatives. Harvested rainwater, stormwater and sewer mining mix to third pipe network. Smart quick release rainwater tank Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks). End of line retention and reuse.	Upgrade of 10.3 km of potable mains Upgrade of 8.5 km of sewer mains	In addition/relative to the infrastructure identified in Scenario 0 the following is required: • 2.1 km less potable mains (downsized relative to base case) • No Preston potable system upgrades including Punt Rd pump station & on-site storage • 29.3 km of new alternative water (third pipe) mains • 278 kL 'smart' quick release rainwater tank at each building (278 kL of combined flood detention/retention for reuse). It is proposed that in this scenario the tank also stores peak day class A in addition to rainwater. • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 10 non-return valves on Yarra River stormwater outlets • 1 x sump and pump at Clarendon St & associated rising main • Below ground storages as follows: - Lorimer Precinct- 1190 m3 - Montague Precinct -8320 m3 - Sandridge Precinct -1240 m3 - Wirraway Precinct -170 m3 • Above ground stormwater harvesting extraction pump stations and rising mains from flood storages to treatment plant • Combined Stormwater/Sewer Mining Treatment Plant • Class A distribution pump station at each premises (in-building cost).	Rainwater tanks come on line as buildings are completed Modular stormwater/ sewer mining treatment plant	New potable mains New sewer mains New third pipe Precinct scale stormwater flood storage & sumps/pumps Primary above ground stormwater harvesting storage & pumps Stormwater/sewer mining treatment plant (18.5 ML/d)	Provision of fire storage	Rainwater & Class A fit for purpose
4 - Stormwater Harvesting in the Precinct	Precinct scale stormwater harvesting into third pipe. Slow release rainwater tank End of line stormwater retention and reuse.	Upgrade of 10.3 km of potable mains Upgrade of 8.5 km of sewer mains	In addition/relative to the infrastructure identified in Scenario 0 the following is required: • 2.1 km less potable mains (downsized relative to base case) • No Preston potable system upgrades including Punt Rd pump station & on-site storage • 29.3 km of new alternative water (third pipe) mains • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry)	Rainwater tanks come on line as buildings are completed Modular stormwater/ sewer mining treatment plant	New potable mains New sewer mains New third pipe Precinct scale stormwater flood storage & sumps/pumps	Provision of fire storage	Rainwater & Class A fit for purpose

Scenario	Description	Utilisation of existing infrastructure (applicable to all scenarios)	Major New Infrastructure Requirements	Staging	Major Land acquisition requirements	Building-based regulations	Health requirements
			• 10 non-return valves on Yarra River stormwater outlets • 1 x sump and pump at Clarendon St & associated rising main • Below ground storages as follows: - Lorimer Precinct - 1920 m3 - Montague Precinct - 9930 m3 - Sandridge Precinct -2360 m3 - Wirraway Precinct -1780 m3 • Above ground stormwater harvesting extraction pump stations and rising mains from flood storages to treatment plant • Combined Stormwater/Sewer Mining Treatment Plant • 20.6 ML class A balancing tank • Class A distribution pump station (20.6 ML/d).		Primary above ground stormwater harvesting storage & pumps Stormwater/sewer mining treatment plant (18.5 ML/d) 20.6 ML class A balancing tank		
5 - Lot focus	Lot scale approach to minimise precinct infrastructure. Designated tolerable road flooding. Smart quick release rainwater tank Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens).	Upgrade of 10.4 km of potable mains Upgrade of 8.5 km of sewer mains	In addition/relative to the infrastructure identified in Scenario 0 the following is required: • 2.1 km less potable mains (downsized relative to base case) • 278 kL 'smart' quick release rainwater tank at each building (278 kL of combined flood detention/retention for reuse). • 28.6 km of new stormwater pipes, 470 new stormwater pits (grated or side entry) • 10 non-return valves on Yarra River stormwater outlets • 3 x sump and pump (Clarendon St, Lorimer 2 and Lorimer 3) & associated rising mains • Local streetscape/bioretention flood storage as follows: - Lorimer Precinct- 130 m3 (other in road flooding needs to be pumped to allow egress) - Montague Precinct -8320 m3 - Sandridge Precinct -1240 m3 - Wirraway Precinct -170 m3 • Above ground stormwater harvesting extraction pump station, balancing tank and distribution pump station (local Montague only). • Building scale Greywater Treatment Plant (avg. of 33 kL in residential and 13 kL in commercial). • Building scale Greywater balancing tank avg. of 33 kL in residential and 13 kL in commercial). • Class A distribution pump station at each premises (in-building cost). • 4th pipe within the building to collect greywater	Rainwater tanks and greywater systems come on line as buildings are completed	New potable mains New sewer mains New third pipe Streetscape/bioretention flood storage Local stormwater /harvesting storage & pumps	Provision of fire storage	Rainwater & Class A fit for purpose

13. Water Cycle Infrastructure Staging

The following should be noted in relation to the staging of infrastructure:

- The rate of population growth will influence both system wide and precinct infrastructure requirements. It is estimated that the Preston system upgrade will not be required until 2030 based in the current growth rate presented within Figure 17 below. If the rate of growth doubles, it is anticipated that the Preston upgrade would be required in 2022. However if the rate of growth is halved, the Preston upgrade would not be required until 2043;
- The renewal of existing assets should be taken into account when exploring future upgrade requirements (i.e. it is likely that there are many assets due to be replaced within Fishermans Bend within the next 25-50 years);
- Developers could undertake reticulation – pending timing and extent of precinct development;
- There is the potential to send potable or recycled water to rainwater tanks within building in the short term to delay the need to construct precinct based storages; and
- The sewer mining plant (if applicable) could be staged (refer section 4 for a detailed discussion).

Figure 17 illustrates the estimated rate of residential and commercial growth has been estimated below based on discussions with the MPA.

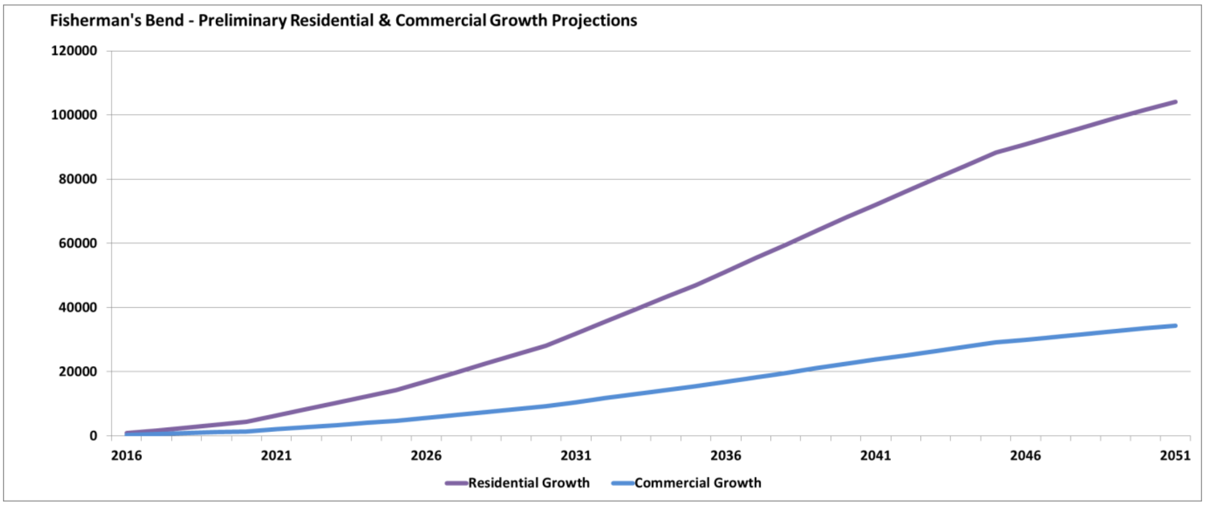


Figure 17 Project Rate of Growth

14. Supplementary Discussion – Innovative Decentralised Solution

A supplementary option was investigated at a high level. Table 16 summarises the characteristics of this option. This innovative decentralised solution involves significant lot and precinct scale attenuated storages and intelligent smart analytics within the potable and wastewater networks to reduce peak requirements in the respective network.

Capturing benefits in cost benefit analysis

It is anticipated that if attenuation of peak wet weather sewer flows is a future development requirement, then this option may be attractive depending on whether there are other smart ways to manage peak wet weather sewer flows. Benefits such as this cannot be captured in a CBA assessment at this point in time as they are not legislated.

Challenges in adopting this option

This option would require significant investment within the private realm and would require changes to the SFP and the exploration of complicated metering, and non-traditional market mechanisms to make this happen.

Table 16 Characteristics of an Innovative Decentralised Solution

Title	Local decentralised solution that spreads network attenuation across the private and public realm to minimise future trunk infrastructure requirement
Vision	In the short term potable use is significantly reduced with mains water to the kitchen and bathroom taps and non-potable to other uses. In the long term the potential for elimination of mains supply via potable polishing of alternative water [noting that potable reserve, neighbour leaning and squireling are all critical to achieving a water neutral or positive outcome].
Key Characteristics	Intelligent network approach where smart storages (blackwater, greywater, rainwater/other, precinct non-potable, precinct potable) are interconnected minimising inefficient empty storages. Attenuation storages are distributed across the private and public realm to minimise future trunk infrastructure requirements. These provide 72 hours attenuation of potable, non-potable, grey and blackwater across the network Greywater/Blackwater separation. In sink grinder in kitchen to blackwater clarifier & digester within building (optional biosolid energy generation). Multi-function treatment plants at precinct scale (multiple plants likely to be staged across the entire development within individual precincts). For greywater and for stormwater. Fire supply from non-potable source
Benefits	Reduces OPEX through reduce potable in and wastewater out. Reduces OPEX through off=peak transfer and treatment. Long term CAPEX trunk infrastructure deferment or elimination. Elimination of leakage through pressure sewer. Minimises lazy assets through smart tank connectivity technology to connect attenuation storages and lean on neighbours. Supplement neighbouring schemes during wet periods. Ability to stage and implement over a long period of time without prejudicing the final concept (i.e. approach can be modified with time as standards/approaches change).

Scale	City Block Scale (i.e. 4 high rise buildings surrounding a podium - equivalent to population of typical suburb)	Precinct Scale
Features	Smart rainwater storage (inclusive of non-potable reserve) - elevated at or above podium Greywater/Blackwater separation 3rd and 4th pipe in the building (non-potable supply & greywater collection) Greywater attention (up to 72 hours) - elevated at or above podium Blackwater attenuation (up to 72 hours) - elevated at or above podium. Blackwater and kitchen (in sink grinder) demand to clarifier and sludge digester with optional biosolid energy Recovery) - elevated at or above podium Fire Storage	Potable network reserve (up to 72 hours) Non-potable reserve (up to 72 hours) Short term/long term neighbour leaning for partial back-up Greywater multi-function treatment plant Pressure sewer from elevated blackwater storage to Melbourne Main Sewer (gravity feed). Stormwater multi-function treatment plant (could be combined with greywater treatment plant) Stormwater harvesting storage Yarra Skimming (optional)
Definitions	Potable/non-potable reserve – store excess supply (above average daily demand) in network and private realm to meet a portion of the peak day demand. Neighbour leaning – obtain a portion of the peak day demand from neighbours. Squireling – maximise use of excess water in wet periods (i.e. local stormwater harvesting or Yarra skimming) through priority use and neighbour sharing.	

15. Observations

15.1 Implications of Climate Change for Fishermans Bend

This section broadly addresses the implications of climate change for Fishermans Bend, as they relate to the water cycle.

Sea Level Rise

Sea level is predicted to rise gradually over time, which will lead to an increase in the level of both Port Phillip Bay and the lower estuarine reach of the Yarra River. Note that this increase may occur somewhat steadily over time and therefore relatively predictably.

Sea level rise could have the following effects:

- An increase in tail water levels, which will mean existing drainage systems will become increasingly ineffective, as the hydraulic grade they operate on decreases. Progressively the influence of high water levels, particularly at high tide, will result in the existing drainage infrastructure flowing backwards more frequently and contributing to, rather than alleviating, flooding of low lying areas.;
- The increasing frequency of low and reverse flows within the existing drainage network will increase the potential for debris accumulation and resulting performance and odour problems.
- The level of storm surge events will rise, leading to greater potential areas of inundation. [Note the link to later points on event frequency]; and
- The levels of saltiness in the groundwater table may rise. This could affect salinity in sewers, corrosion of assets and potentially salinity of stormwater harvested below ground level.

This suggests that the concepts for management of floodwater should consider the long term proposition of sea level rise and take it into account, at least in the sense of approaches which can be modified later to address rise as it occurs.

It further suggests that concepts for construction, reuse and other factors should consider the potential impacts of salinity.

Note that the effects and impacts of rising sea levels will be widespread, and the surrounding areas, as well as other regions along the coast will all be affected. Therefore it would appear most appropriate for any response to this risk at Fishermans Bend to be part of a wider strategy.

Some potential technical considerations:

- Keeping buildings and infrastructure high;
- Minimising below ground level and in particular below sea level infrastructure;
- Keeping water high to provide a driving hydraulic grade;
- Keeping water high to avoid contamination with saline waters; and
- Considering the possibility of isolating drainage from sea level.

Increased Frequency of Higher Intensity Rain Events and/or Increased Intensity of Rain Events.

Rain events may become more intense more frequently, even if the overall climate is getting drier. The degree to which this might occur, and when it might occur are highly unpredictable.

Current flood management objectives aim for a convenient and safe standard of protection from events with 5 and 100 year Average Recurrence Interval (ARI). The size of event which will occur with this frequency might increase, and therefore catering [as one example] for a 20 year ARI event today might in effect lead to meeting a 5 year ARI standard in the future.

The advantage of considering the adoption of a higher standard is that it provides increased service now, and in time might reduce in performance, but back to a level considered to be the desirable minimum today.

The current SFP keeps most of the buildings high, which manages much of the impact of flooding. The flood risks to on street infrastructure, cars and access by pedestrians are some of the key risks not managed by the current SFP.

It may be that these risks can be better managed by unique very local responses such as urban design rather than precinct wide responses to provide a uniform flood response.

Some potential technical considerations include:

- More storage to better manage larger events.
- Increased pumping capacity for pump and sump solutions.
- Allow for bigger events in urban planning and design.
- Consider how to provide a risk level consistent with land use proposed in the area.

15.2 Whole of System Contaminant Balance for Sewer Mining

In more 'typical' green-field Class A reuse schemes, a significant fraction of the waste water is sent to open space and backyard watering. This becomes a 'sink' for constituents still present in the Class A water. In Fishermans Bend, the predominant use of the Class A water will be for in-building use such as toilet flushing, and therefore the constituents will be sent to sewer downstream.

In addition, the most cost effective approach for the sewer mining plant is to avoid on-site biosolids management in this built-up area, and instead to return the waste sludge to the sewer.

The net result of these two factors is complex, the following points are a high level assessment:

- There is no specific need for the Class A water to have significant nitrogen removal, and as a result the nitrogen load to WTP will be roughly the same (i.e. waste/sludge from the sewer mining/greywater treatment plant has been assumed to be put back into the sewer system and hence the removal of pollutant load by sewer mining/ greywater plants are minimal, if any). There will be some minor reduction through the need to manage ammonia.
- There will be some reduction in the carbon load due to carbon which is converted to CO_2, but much of the carbon will still be present in the waste sludge. It will however have a different composition.
- The 'Net' Effect will mostly be a removal of water, and therefore a slight increase in the concentration of the effluent going to WTP.

As a result it is difficult to assign any benefit to downstream treatment at WTP from sewer mining at Fishermans Bend.

It is useful to note that if sewer mining became widespread in the future, it would have two effects worth considering:

1. The composition of the waste to be treated at the WWTPs would alter.
2. Upstream sewer mining plants could affect the viability of downstream recycling due to salinity increases.

Considering these wider effects is not within the scope of this study, but should be taken up if significant and widespread sewer mining is contemplated.

15.3 Implementation Decisions for Fishermans Bend

Fishermans Bend is in relatively early stages of urban design development, and the full details of how the different precincts will 'look' will depend on thinking underway among various stakeholders, and then a range of more detailed considerations as the individual developers put forward their proposals.

This is expected to happen over a relatively long time frame, and to some extent progressively as development moves broadly from the east to the west across the precincts.

There is existing water, waste water and stormwater cycle infrastructure in the area, which are explored below.

Water Supply

The water supply system will be adequate for a number of years. In the longer term upgrades will be required to provide sufficient flow to accommodate the increased demand. The timing and extent of these upgrades depends on a number of factors including:

1. The degree to which water is supplied from alternative sources such as rain water and sewer mining.
2. The extent, nature and density of the development. At one extreme, if many high rise, high density residential developments occur early, then the upgrades will be required sooner. If development is slower and incorporates lower density and less residential, then the upgrades will be required much later.
3. The degree of 'greening' incorporated in the development. If features such as urban forest, green walls etc become prominent, this will increase the demand for water. So there is some uncertainty related to future urban design approaches.
4. The pressure and flow available from the central system, which will change over time as demand on the wider Melbourne system changes with growth generally, and particularly in areas which influence the transfer system from the Preston tanks to Punt Rd.

Note that works to construct pipes, tanks and other transfer infrastructure from the Punt Road system across to Fishermans Bend are likely to be expensive and disruptive as they will occur through a heavily developed part of the city, and also in areas where ground conditions may be problematic.

Overall, there are likely to be benefits from sourcing water locally, particularly if these alternative local approaches are sufficiently reliable so that expansions of the existing connections to the main Melbourne network can be deferred, avoided or minimised.

Wastewater

The wastewater supply system will be adequate for a number of years. The local system will need upgrading to accommodate the increased flows from development. Melbourne Water has currently indicated that the major sewers in the area have sufficient capacity to accommodate the flow, particularly if it is confined to dry weather flow, with minimal wet weather peaking.

Overall, this suggests there is limited value in reduced wastewater flows in relation to impact on the sewer network, based on the current advice.

Final discharge of wastewater to WTP will increase loads, and form a fraction of the growth in flows expected over time, which lead to a need for progressive upgrades.

One concept explored in this study is sewer mining. It is useful to consider how sewer mining as a concept might affect the wider sewer network and wastewater treatment.

1. Sewer mining plants are typically designed to provide a supply, not manage waste water. Therefore, the amount of flow they remove will vary from time to time based on the demands, and may drop quite low. If the sewer mining plant is designed to be cost effective and with downstream peak supply storage, it may even stop taking wastewater altogether from time to time. As a result, with typical sewer mining plants, little credit can be given to the reduction of wastewater flows on a day to day or hour to hour basis, which means little benefit in reducing the need for sewer system upgrades.
2. Sewer mining plants are typically designed to remove BOD and provide pathogen removal, not specifically to reduce all contaminants. For example, nitrogen removal may not be important. Further, the waste streams from the plant [such as biosolids and the like] are likely to be returned to the sewer system. In the case of an area like Fishermans Bend, the recycled water would largely be used in the buildings, and therefore non-removed contaminants [like nitrogen and salt], would then re-enter the sewer system and be sent on to WTP.
3. Taken as a whole, these points suggest that although sewer mining removes a net flow from the sewer system, it does not remove all of the load from the 'final' waste water treatment plant, and does not reliably remove peak flows from the sewer network. So limited credit can be given to the reduction in capacity for the downstream sewers and wastewater treatment plant. Further work is needed in this area to better understand the extent of any benefits.

Sewer Mining Viability

This project has examined different options and scenarios for water supply. As the precinct has a high density, the primary demands which can be serviced by alternative water are relatively constant, with a less than typical variation for watering of open space [there are no backyards].

Further, the roof area is relatively low versus demand, due the tall buildings. So the most attractive source for alternative water seems likely to be wastewater, which is plentiful, as major sewers run through this area. Sewer mining doesn’t make sense on its own. There are advantages in capturing roof and podium runoff at the lot scale whilst the quality of water is still relatively good and so that downstream infrastructure requirements (within poor ground conditions and expensive land) are reduced.

The net present value analysis was conducted on the sewer mining option for supply of alternative water in the original Fishermans Bend IWM Strategy report (GHD, 2015). In this analysis, the costs and benefits of various flood management concepts wereremoved, so the comparisons are based on the management of water supply and wastewater alone.

The following observations couldbe made:

1. The difference in the Net Present Values [NPVs] for the base input assumptions is about 12% higher for sewer mining through third pipe compared to potable alone supply.
2. An equivalent NPV is achieved with relatively small changes in the LRMC of potable water, plant cost, land cost and plant timing (Table 17 and Table 18).

Table 17 Sewer Mining Viability Sensitivity Test Parameters

Sensitivity Test	Description	Reduction from starting value
1	Cost of plant ($ per ML/d)	-5%
2	Cost of land ($/ha)	-5%
3	LRMC of potable water ($/ML)	+5%
4	Timing for plant	Timing from 25% in 2030, 2040, 2050 pushed out to 20% in 2030, 40% in 2050 and 40$ in 2060

Table 18 Sewer Mining Viability Sensitivity Results

Sensitivity Test/s Applied	NPV Difference (Scenario 3 - Base Case NPV)
None	12%
4	10%
3 & 4	8%
2, 3 & 4	7%
1, 2, 3 & 4	7%

Overall it appears that sewer mining is so close in cost to potable supply in this project that other factors are also important.

The non-costed factors which could influence the choice to pursue sewer mining include

- Community views: There could be diametrically opposed views on this: on the one hand developers may support it, as it will assist in selling a 'green' image. On the other hand people may prefer to have other sources of water due to perception concerns. The community may prefer not to have a treatment plant in their neighbourhood, or they may like the idea of accessing a local resource.
- Energy use: collecting wastewater locally and treating for local use will have lower energy use than water supplied from the desalination plant [noting that the desalination plant is supplied with renewable energy through an offset arrangement].
- Construction of additional water mains from Punt road will cause cost and disruption outside this precinct, whereas dual pipe and sewer mining plant construction will have cost and disruption inside the precinct.
- This area does have a large sewer with relatively low salinity wastewater available, so the concept is technically feasible.

Overall it appears the arguments for and against sewer mining is too balanced to allow a simple decision at this time. GHD recommends the following approach:

1. Assume it may be viable and continue to require third pipe in buildings. Assume the plant itself will not in any case be required for many years: thus allowing time to consider the relative merits in more detail. Provide potable water in the meantime.
2. Plan to install dual pipe.
3. Investigate community and developer views.
4. See if a site can be identified and at what cost.
5. Develop a more detailed concept design based on an identified site [or sites] to provide a more robust cost estimate. This should include optimising the design capacity of the sewer mining plant (i.e. reduce from 90% to 60% of peak day demand) if sufficient precinct storage can be provided (i.e. provision of interconnected smart building tanks);
6. Study the impact of upstream sewer mining on WTP in more detail to determine if there is any benefit.

Sewer Mining Plant Location

The selection of a suitable site for the sewer mining plant is not resolved, and needs consideration of a range of complex factors. The Fishermans Bend specific considerations for the sewer mining plant are as follows:

1. No land was originallyset aside in the SFP.. There is a need to find a site which has an available area, near a sewer, no neighbours, good road access, easy to excavate and build. These things are not possible, so any site will be a compromise and more costly than in green field area;
2. The need for buffer distances would add significant land cost, and the alternative of 'in-building' or 'underground' would add significant construction and operation cost. Note that this still requires acquiring the 'space', either below public park, or under a building etc. Built 'underground' has other issues in this area due to high groundwater, likelihood of flooding and problems with contaminated soils;
3. The 'Main Sewer' has more than enough flow, and currently acceptable salinity. So it is attractive to access. By contrast, the sewers further downstream to the west become more saline.
4. Could identify land outside the precincts and pipe water to this location. Perhaps toward the west in the extended FB area. If sufficient land can be acquired/gifted etc, then costs of construction may be less, but need to add cost of pipelines; and
5. An access structure to the sewer for extraction also needs land. It is anticipated that there will be higher more than usual construction costs due to contaminated soil.

Overall then, it seems that the choice is either to locate the plant very close to the main sewer and the demand, which will be right in the middle of the expensive land, or to locate it well away [perhaps in industrial land more to the west] and then pay for longer transfer mains to and from the sewer and the demand.

There are too many factors which are currently unknown to reach a conclusion on this point, other than to emphasise the need to set aside land as quickly as possible.

Preston Potable Connection Upgrade

The development in Fishermans Bend, along with other development in the general area, is putting a gradually increased load on the Preston to Punt Road potable water supply system, and then from that system to this area.

In the longer term, this will be managed by a combination of additional storage and pumping to provide additional head and reduce peak hour demands on the core system. However, these works are not required until the demands in this area, and in other areas reach a level which constrains the wider system.

So it is difficult to determine the appropriate timing for the Fishermans Bend precincts need for such upgrades in isolation from consideration of the wider network.

For the purposes of this study, this infrastructure has been assumed to be required at around 25% of development, in approximately 15 years' time. So these upgrades are not required until that time. Some points to note:

- Accelerated development in other areas connected to the Preston system could bring forward the need for this infrastructure.
- The need for earlier peak flows is related to other sensitivities such as the degree of penetration of water based cooling.
- One critical factor will be the identification of a suitable site for the storage tank.

Flooding and Waterway Health

There is an existing drainage network, which does not include any waterway health protection measures such as wetlands. This network does not adequately manage current flooding in some areas (assuming an objective is to meet the current 5 and 100 year ARI standards everywhere).

The area is currently highly developed and impervious, so the proposed developments are not going to increase imperviousness, and in fact the requirements in the SFP are likely to improve floodwater management from developments compared to the current situation.

As the drains in the area discharge into either Port Phillip Bay or into the lower reaches of the Yarra River there are no 'sensitive' waterways downstream, but rather these large bodies of water. The inputs from these drains will have an influence on the health of these water bodies, often as an incremental contribution to a wider problem. Some local influences such as pathogens on local beaches may be important; however no specific objectives have been set.

The following points are relevant:

1. Current infrastructure needs upgrading or replacement to meet the current 'standard'. However, such an approach would need to be considered over a wider area than just Fishermans Bend, as the drainage network and the topography means that flood issues are not isolated to this area.
2. Due to the low elevation of the area, the hydraulics of the drains will be significantly impacted by sea level rise, and in particular by storm surge. The SFP has managed the risks to some extent by setting floor levels, but areas such as roads etc will still be flooded. This means that the bulk of risk mitigation has already been incorporated. Concepts which assist in managing this longer term risk would be attractive.
3. The SFP requires storage in the buildings ['rainwater tanks']. These provide an opportunity to assist in managing flood flows if configured with smart systems and a location to release water when heavy rain is forecast.
4. The high value of land, the potential for contaminated soil and ground water, the low elevation and other factors suggest that in-ground storages or retarding basins in open space are less attractive.

Overall, there are three issues which need resolution before an approach to flood management can be confirmed.

- The standard which must be met needs to be defined. Must all areas meet the 5 year ARI requirements? When? [Amongst other questions].
- Does the approach need to manage sea level rise and/or increased intensity of rain events due to climate change? Or will this be handled on a more regional basis when needed?
- Does the approach need to manage flood inputs from surrounding areas? [Or can all or parts of this area be physically isolated?]

Performance of Alternative Drainage Approaches

The relative performance of alternative drainage approaches cannot be assessed from an Average Annuual Damages (AAD) perspective alone (due to fact that majority of damages are mitigated through raised buildings) and needs to consider a variety of qualitative considerations. Table 19 provides a summary of the performance of alternative drainage approaches. It is clear from this qualitiative assessment that a pump and sump approach with building storage (rainwater tanks with initial storage and/or smart redundant capacity in case of pump failure) mitigates many of the risks.

Table 19 Performance of Alternative Drainage Approaches

Scenario	Base Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Drainage Approach	Rainwater tanks as per SFP, with no new precinct drainage	Conventional drains/swales & pump & sump	Conventional drains/swales & pump & sump	Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse.	End of line retention and reuse.	Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens)
Ability to manage high tail water levels		High	High	Moderate	Low	Low
Ability to manage power outages		Low	Low	High	High	High
Construction risk - ground conditions		Low	Low	High	High	High
Suitability to all precincts		High	High	Moderate	Low	Low
Robustness if development is out of sequence (relative ease to retro-fit)		High	High	Moderate	Low	Low

Alternative Flood Mitigation Approaches

Areas that do not meet the target flood standard either currently or in the future can be protected by a number of mechanisms which may include:

- Regional mitigation works such as:
  - Bunding and pumped sumps;
  - Floodwalls;
- Local works such as:
  - Raising road pavements;
  - Conventional increases to drainage systems;
  - Flood proofing and or flood tolerant designs and uses; and
  - Usage control and provision of alternate egress.

It is anticipated that a number of regional and/or local solutions could be implemented in a staged fashion to mitigate climate change (i.e. roads and parks could be raised in the future once the magnitude of climate change impacts become clearer (assuming podium levels have already been set at an appropriate level to protect buildings).

Sump and Pump Design Considerations

For maximum reliability sumps need to be relatively large, frequently used and serviced by a number of pumps both duty and standby. Large sumps provide a small amount of buffer storage and not only reduce pump cycles, they also provide additional time during an event to source alternative power and or enable power to be restored in the event that power is lost to the pump system. The need to frequently use a number of duty and stand by pumps on a rotating basis is to ensure that the pumps are well maintained and remain serviceable. Without frequent use there is reduced confidence that they will work when called upon.

Staging of Flood Mitigation Approaches

The staging of flood mitigation works for end of line systems is somewhat limited compared to at-source treatments, however some flexibility does exist for instance the number of duty and standby pumps can be increased at a later date and additional storages can be constructed if needed. Given the current impervious nature of the catchment it is unlikely that local flows will increase significantly as a result of development. What is more likely is that the tolerance for flooding will decrease as the site is redeveloped and local flows may increase as a result of climate change.

Pumps are likely to be of a submersible high volume low head variety but with appropriate selection and or by using standpipes should be able to function efficiently over a wide range of tail water conditions including those foreseeable as a result of sea level rise and storm surge. When well designed the pumped sump solution is well suited to adaption to cater for increased tail water levels expected as a result of climate change. With careful design such a system leads itself to the progressive development of perimeter floodwalls either via a perimeter wall, road embankment, and or suitably designed building walls or road and open space raising closer to building podium levels.

It is anticipated that progressive development of the urban form may include:

- Raising building podium levels – short term;
- Implementation of flood mitigation approaches in different precincts as population intensifies – medium term; and
- Climate change transition through perimeter floodwalls or road and open space raising closer to building podium levels - long term.

Viability of In-Development Smart Rainwater Tanks

The value of smart rainwater tanks at the lot scale can potentially be four-fold:

1. Lot scale rainwater tanks can provide flood storage (potentially at a lower cost to precinct base storages. The uncertainty in the cost of implementing precinct scale storages is a clear driver for exploring the implementation of larger or smart rainwater tanks at the lot scale. This uncertainty relates to poor ground conditions (high water table and Coode Island silt), contaminated soils, cost of land as well as the uncertain time frame of development.
2. Lot scale rainwater tanks can provide a rainwater harvesting function;
3. Lot scale rainwater tanks can provide a short term storage alternative for potable water (after third pipe is installed and before recycled water plant is required due to a low population in the early years of development); and
4. Lot scale rainwater tanks can provide a long term storage alternative for potable water and/or recycled water.

The following implementation considerations associated with rainwater tanks at the lot scale (larger or smart quick release) should be explored further:

- Clarification of the SFP rainwater tank requirements to assist developers;
- Identification of commercial models and mechanisms to encourage developers to implement a larger or smart rainwater tank relative to the SFP requirements; and
- Exploration of smart analytics that can be used to maximise the tank for both flood storage and rainwater/recycled water storage for reuse.

15.4 Key Risks

A summary of the key risks are provided in Table 20 below. The key risks fall into the following categories:

1. The assumptions on water demand rely on assumptions about the nature of future development, which are uncertain until planning and design are further progressed.
2. Several options create more complex plumbing at the lot than typical.
3. Underground excavations are not favoured due to ground conditions, the groundwater table, contaminated soil and land is low lying and subject to flooding.

Table 20 Summary of Key Risks

Risk	Risk Category	Applicable Options
Assumptions and unknowns in current strategy – development mix and timing	Design Basis	All
Management of 'Smart' and interconnected tanks, including how such a system would be managed given the dual function of supply and flood management.	Smart Rainwater Tanks & Building Plumbing	Options 3 & 5
Climate change implications (sea level rise and higher rainfall intensities) on building levels and drainage infrastructure	Drainage & Underground Infrastructure	All
Poor ground conditions (Coode Island Silt)	Underground Infrastructure	All
Saline groundwater table	Underground Infrastructure	All
Contaminated Soils	Underground Infrastructure	All
Land is low lying and subject to flooding	Drainage Approach & Underground Infrastructure	All
Uptake of in-building greywater/blackwater plants compete with sewer mining plant	Sewer Mining Plant	All
Land availability and cost – sewer mining plant	Sewer Mining Plant	Options 2-5
Land availability and cost –	Commercial	All
Power outage or pump failure	Drainage	Scenario 1-5
Construction risk - ground conditions	Construction cost	All
Construction risk – augmentation of pipelines through brownfield developments (including major disruptions from Punt Rd to Fishermans Bend)	Construction cost & Disruption	All
Rainwater tank maintenance at lot scale	Water Quality	All
Customer perception of alternative water supply.	Commercial	All

15.5 Preferred Approach

The selection of a preferred option is not clear cut. The following key conclusions have been drawn from the assessment of alternative WoWCM scenarios for Fishermans Bend:

- It appears that it is worthwhile investing in drainage infrastructure relative to Scenario 0 (the base case). Despite the already high level of protection afforded by the elevated buildings, the potential reduction in average annual flood damages is generally comparable to the additional infrastructure costs;
- Scenario 5 is less attractive than the other options due to the capital and operating expenditure that is associated with having a greywater treatment plant in every building.
- In economic terms (i.e. without a mandatory potable water substitution or wastewater reduction target), the base case (Scenario 0) is a marginally more attractive option under the current long run marginal cost, land value and sewer mining plant cost assumptions.
- Options 2, 3 and 4 (all have sewer mining as a key component) have slightly higher net present values than the base case. Due to the uncertainty in a number of the key assumptions, further detailed evaluation of sewer mining within Fishermans Bend is recommended as part of a business case process. Two key considerations are explored

in the implementation decisions for Fishermans Bend section, namely the viability of sewer mining viability and smart rainwater tanks.

- It does appear that a progressive approach based on Scenario 3 has merit, given that only small changes in the input parameters are needed for the sewer mining approach to be equivalent on an economic basis.
- The flood analysis suggests that a sump and pump approach is preferred to end of line storage, however this may vary on a catchment basis.

15.6 Preferred Approach – Timing of Investment

If the stakeholders choose to proceed with Options 2, 3 and 4, one consideration is the possibility of deferring much of the infrastructure until much later, and to supply the demand with potable water in the meantime. This would mean that South East Water would buy potable water in the meantime until the alternative water sources were developed at a time nearer to when major upgrades to the wider Melbourne system are required. This would take advantage of the lower future cost of money, while using the exiting lower cost potable supply as it is currently available.

Different ways of exploring this concept include:

- Install development wide third pipe in the short term and supply with potable water.
- The sewer mining plant (if applicable) could be staged (refer section 4 for a detailed discussion). The value of delaying the initial construction of the sewer mining plant until there are sufficient demands can provide significant economic benefits.
- There is the potential to send potable to rainwater tanks within building in the short term to delay the need to construct precinct based storages.
- There is the potential to send recycled water to rainwater tanks within the building in the medium to long term to delay or eliminate the need for a precinct scale recycled water storage.

15.7 Preferred Approach – Key Decision & Associated Timing

The review of Options 2, 3 and 4 suggests that it will be beneficial to delay major treatment works as long as possible. So it is useful to consider which decisions are required earlier or later in implementation.

A number of key decisions need to be made to progress the preferred servicing strategy. The timing of these decisions is paramount in providing flexibility to enable the servicing strategy to be staged and implemented over a long period of time. The relative timing of key decisions should consider:

- Explore the impact of varying the nature of the development mix if this is pursued by the Government;
- Confirm impacts impact of long run marginal costs on options;
- Confirm Preston system requirements and associated connection costs (we note Melbourne Water have committed to undertaking a system wide study);
- Refine the distributional analysis;
- Plan for various initiatives in the short to medium term. These are likely to include:
  - Third pipe network throughout the development;
  - Rainwater tanks in buildings;

  - Smart analytics and valving arrangements for rainwater tanks in buildings; and
  - Extent and location of stormwater harvesting/flood mitigation initiatives.

- Explore required changes to the SFP and opportunities to explore concepts as part of future neighbourhood planning work being undertaken by the MPA;
- Developing clear guidelines for developers on how to interpret the SFP requirements;
- Start acquiring land or seeking access to land through some form of agreement or other process with private owners (i.e. below podium level) for major above ground infrastructure; and
- Setting aside easements for major trunk infrastructure (drainage (inclusive of green spines), water and wastewater infrastructure).
- Develop an offset or drainage scheme to allow best for precinct flood outcomes to be designed. These are likely to be a blend of in-development storage and public sump and pump arrangements

16. Conclusions

16.1 Short Listed Options

A summary of the short listed options are provided in Table 21 below.

Table 21 Summary of Base Case and Alternative Scenarios

Scenario	Description	Third Pipe	Primary Third Pipe Source	Third Pipe Back-up	Building Rainwater Tank Size	Drainage Approach
0 - Conventional Water, Sewer with (no minor or major drainage upgrades) – Base Case	Conventional servicing with rainwater tanks as per SFP and no precinct based drainage. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Rainwater tanks as per SFP, with no new precinct drainage
1 - Conventional Water, Sewer & Drainage upgrades	Conventional servicing [no development wide third pipe]. Slow release rainwater tank	Building scale	Rainwater	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
2 - Sewer Mining in the Precinct	Sewer Mining with development wide third pipe. Slow release rainwater tank. Conventional drainage upgrades.	Development wide (SEW Managed)	Rainwater, Sewer Mining	Potable	As per SFP (capture roof only, fitted with slow release storage component)	Conventional drains/swales & pump & sump
3 - Interlinked Third Pipe Supply	Mix of lot & development scale initiatives. Harvested rainwater, stormwater and sewer mining mix to third pipe network. Smart quick release rainwater tank. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks). End of line retention and reuse.	Development wide – Building (SEW Managed)	Rainwater, Stormwater	Sewer Mining	Smart tank to maximise roof & podium collection (fitted with fast release)	Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse.

Scenario	Description	Third Pipe	Primary Third Pipe Source	Third Pipe Back-up	Building Rainwater Tank Size	Drainage Approach
4 - Stormwater Harvesting in the Precinct	Precinct scale stormwater harvesting into third pipe. Slow release rainwater tank. End of line stormwater retention and reuse.	Development wide (SEW Managed)	Rainwater, Stormwater	Sewer Mining	As per SFP (capture roof only, fitted with slow release storage component)	End of line retention and reuse.
5 - Lot focus	Lot scale approach to minimise precinct infrastructure. Conventional potable back-up.	Building scale (Developer Managed) & Local Stormwater	Building - Rainwater, Greywater Local - Stormwater	Potable	Smart tank to maximise roof & podium collection (fitted with fast release).	Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens)

16.2 Key findings

The key findings of this study are:

- Rain harvesting does not provide a significant or reliable supply as high rise development has very high demands compared to roof areas.
- Sewer mining is a practical possibility in the area as there are large sewers nearby, which have low salinity wastewater as a supply source. Sewer mining would reduce potable water demands by about 50% on an annual basis, and also reduce the peak demands. This means a significant reduction in the connection infrastructure from the main potable network.
- Construction of conventional retarding basins for flood management is not favoured due to the low amount of open space, high land values and the potential for contaminated soil and groundwater to create issues and costs with excavation. Therefore, keeping rain and stormwater held in rainwater tanks above ground level in developments is preferred, and this approach can be made more efficient if the tanks are interconnected and 'Smart'.
- If the interconnected tanks are also used as part of the supply network for alternative water, further efficiencies are realised, but with additional complication both technically and in the approach to management.
- Economic analysis shows that these alternatives are within around 10 to 15% of the NPV of the conventional approach. Since cost inputs include variables such as development timing, future land values, future costs of potable water and assumptions about technology over a 40 year time frame, it appears reasonable to see these costs as equivalent.
- A practical implementation approach is available which moves progressively from a more standard third pipe solution in the medium term into a 'Smart' system with interconnected tanks in the longer term.
- A number of significant unknowns remain, particularly in relation to flood management, which will need ongoing investigation over time as the full details of the urban form are resolved, and as questions of policy in relation to flood management objectives and climate change are answered.
- The preferred “base-case” for flood impact improvement is a “sump and pump” approach.

16.3 Recommendations

This report makes the following recommendations.

- Adopt third pipe supply and assume the source will be a sewer mining plant in the area.
- Undertake further investigations to identify the best site for sewer mining, noting possible opportunities just outside the area where land may be easier to obtain.
- Develop an approach to manage funding of drainage infrastructure, which should include a method to maximise and encourage additional above grade tanks in new developments. Innovative market based instruments should be considered.

- Develop flood mapping and mitigation on a catchment by catchment basis, with ‘sump and pump’ as the base case design.
- Confirm the flood management standard including consideration of climate change. Undertake detailed flood modelling and localised design of solutions once urban form is confirmed.
- Investigate the benefits and risks of different forms of 'Smart' and interconnected tanks, including how such a system would be managed given the dual function of supply and flood management.

17. References

CRC for Water Sensitive Cities (2015), Ideas for Fishermans Bend, March 2015

Department of Natural Resources & Environment (2000), Rapid Appraisal Method for Flood Plain Management, May 2000

Institute for Sustainable Futures (2013), Darling Quarter Case Study: Building Industry Capability to Make Recycled Water Investment Decisions, Prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the Australian Water Recycling Centre for Excellence, 2013

GHD (2013), Infrastructure Plan for Fishermans Bend, GHD on behalf of Places Victoria, June 2013

GHD (2015), Fishermans Bend Integrated Water Management Plan, GHD on behalf of South East Water & Melbourne Water 2015

Melbourne Water, 2014, Melbourne Water Flood Mapping Projects, Guidelines and Technical Specifications, 2014

MPA (2014), Fishermans Bend Strategic Framework Plan, July 2014

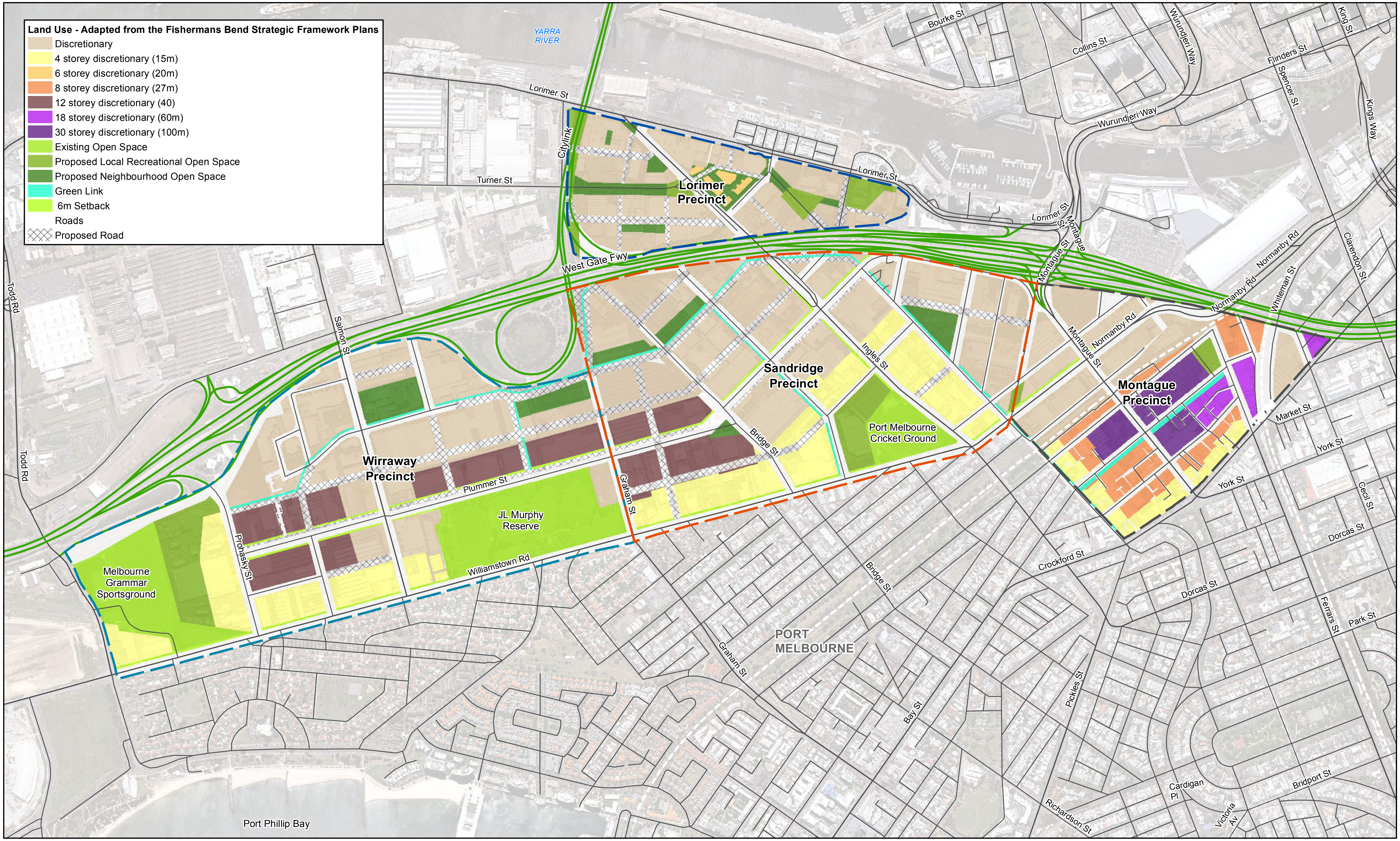
Transport & Infrastructure Council (2014), 2014 National Guidelines for Transport Systems Management in Australia – Road Parameters Values (PV2), December 2014

URS (2011), Flood Modelling – Updating Port Phillip Council Flood Modelling and Assessing the Impact of Climate Change, December 2011

Wastewater reuse in the Urban Environment: Selection of Technologies, Landcom, 2006.

Appendices

Appendix A – Key Maps



Paper Size A3

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Lorimer Precinct
- Montague Precinct
- Sandridge Precinct
- Wirraway Precinct
- Freeway
- Arterial
- Collector
- Tramway
- Railway

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South East Water
Fishermans Bend WoWCM

Job Number	31-32191
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Base Map

Figure 1

G:\31\32191\GIS\Maps\Working\3132191_02_BaseMap.mxd

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; South East Water, Drainage, 2014; Imagery, DEPI, 2013. Created by:kwilliams3

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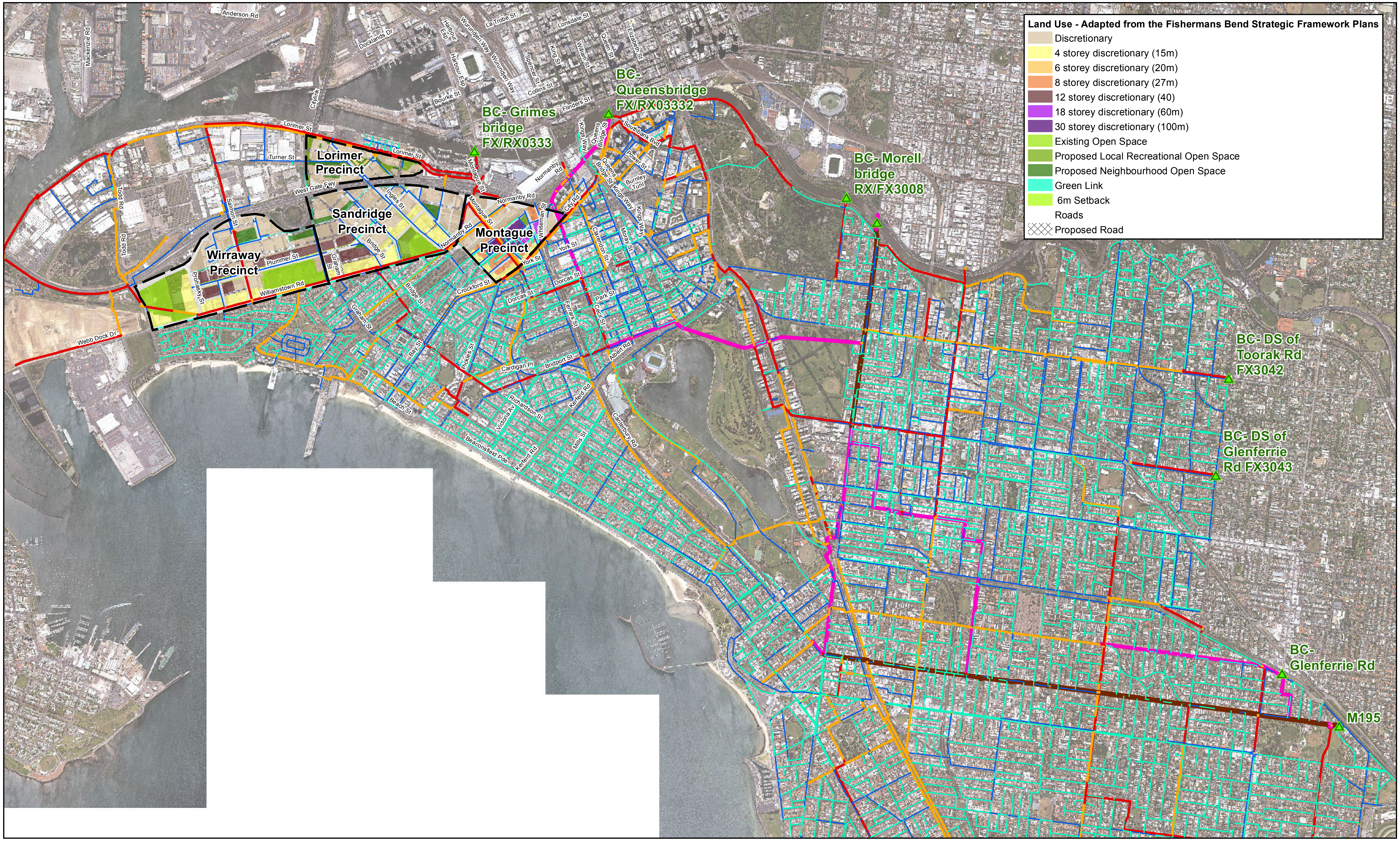

Paper Size A3

0 150 300 600 900 1,200 1,500
Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Precinct Boundaries
Existing Fixed Heads

Existing Pipes Diameter (mm)
20.0 - 110.0
110.1 - 170.0
170.1 - 250.0
250.1 - 450.0
450.1 - 750.0
750.1 - 2500.0

South East Water
Fishermans Bend WoWCM

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Water Supply

Figure 1

G:\31\32191\GIS\Maps\Working\3132191_01_WaterSupply_from_Steven.mxd

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; South East Water, Drainage, 2014; Imagery, DEPI, 2013. Created by:kwilliams3

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Paper Size A3

0 50 100 200 300 400 500
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Sewer Pipes Width (mm)			
80 - 150	301 - 450	Lorimer Precinct	
151 - 300	451 - 600	Montague Precinct	
	601 - 2700	Sandridge Precinct	
		Wirraway Precinct	

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Fishermans Bend WoWCM

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Sewer

Figure 1

G:\31\32191\GIS\Maps\Working\3132191_01_Sewer_from_MichaelT.mxd

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; South East Water, Drainage, 2014; Imagery, DEPI, 2013. Created by:kwilliams3

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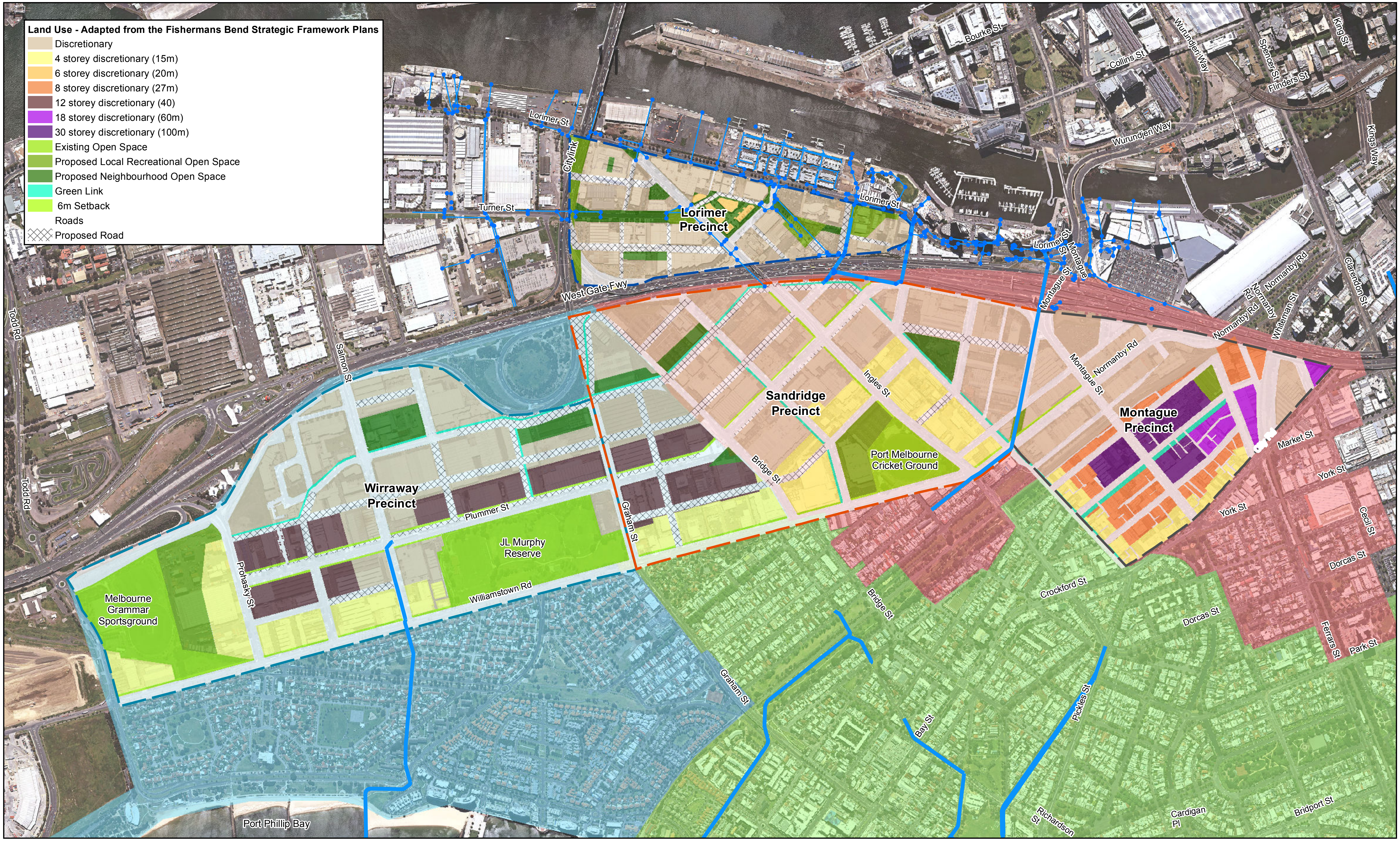

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND
- CoPP and CoM Drainage Pit
- CoPP and CoM Drainage Pipe
- MW Underground Drain
- Lorimer Precinct
- Montague Precinct
- Sandridge Precinct
- Wirraway Precinct
- Catch 1
- Catch 2
- Catch 3

Note: Drainage Dataset Incomplete

South East Water
Fishermans Bend WoWCM

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Drainage

Figure 1

G:\31\32191\GIS\Maps\Working\3132191_01_Drainage_from_Mardi.mxd

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; South East Water, Drainage, 2014; Imagery, DEPI, 2013. Created by:kwilliams3

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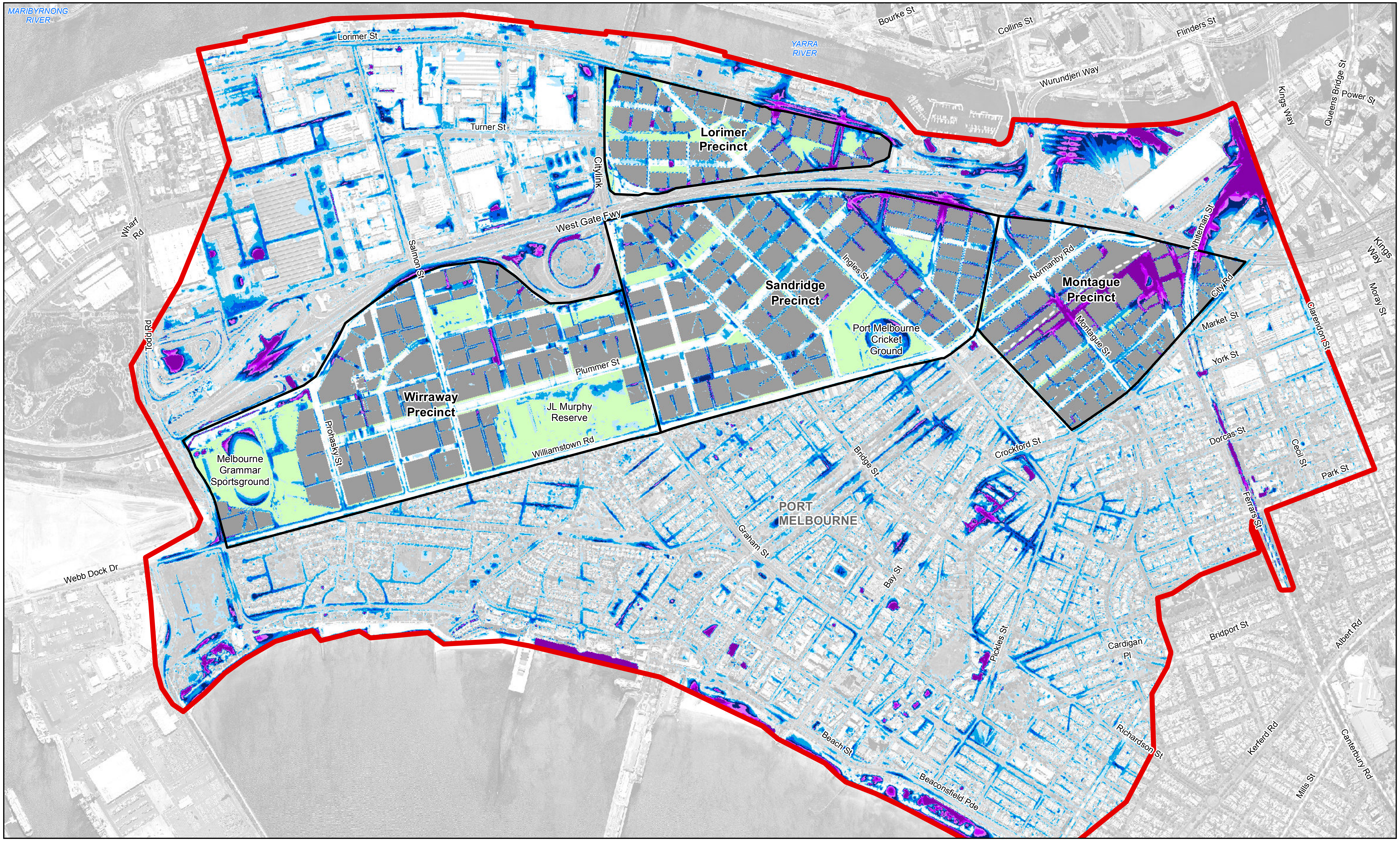
Appendix B – Flood Maps



Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100 | 101 - 200 | 201 - 300 | 301 - 400 | 401 - 500 | 501 - 600 | > 601

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Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
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Scenario 0 - 100 year ARI
Depth Plot

Figure 1A

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

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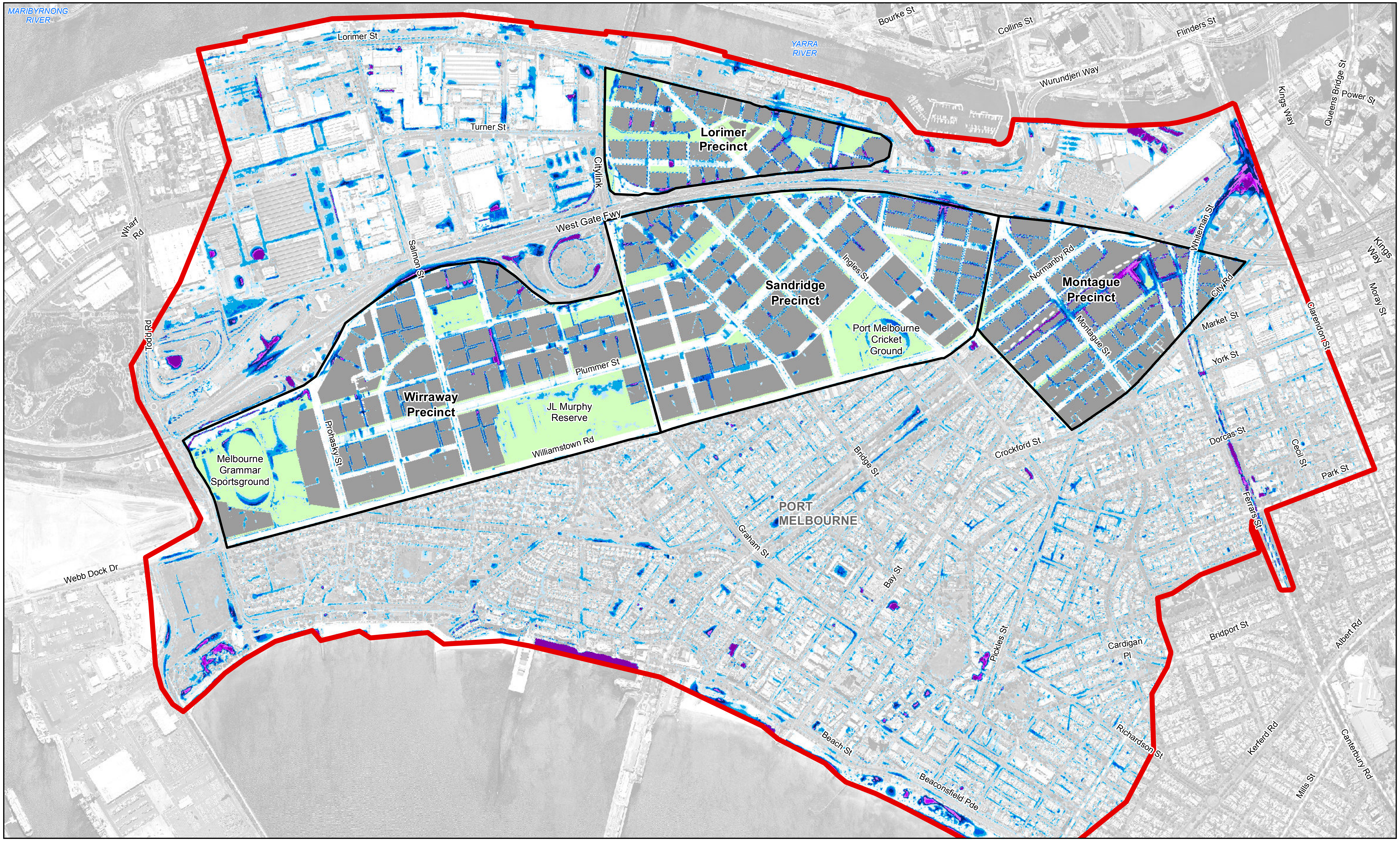

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

GHD

South East Water

Melbourne Water

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
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Scenario 0 - 5 year ARI Depth Plot

Figure 1B

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Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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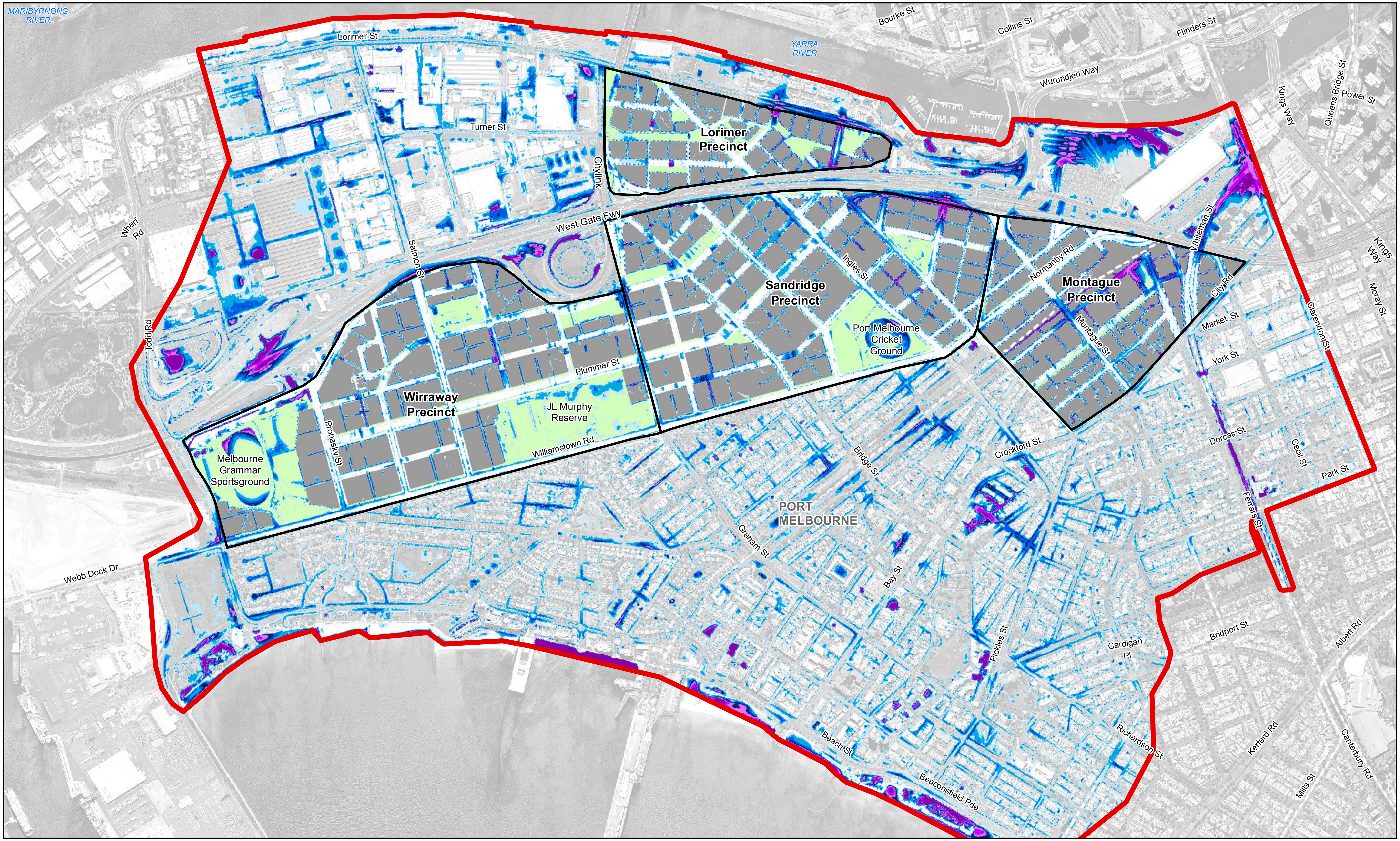

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

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Scenario 1 - 100 year ARI Depth Plot

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Date	04 Sep 2015

Figure 2A

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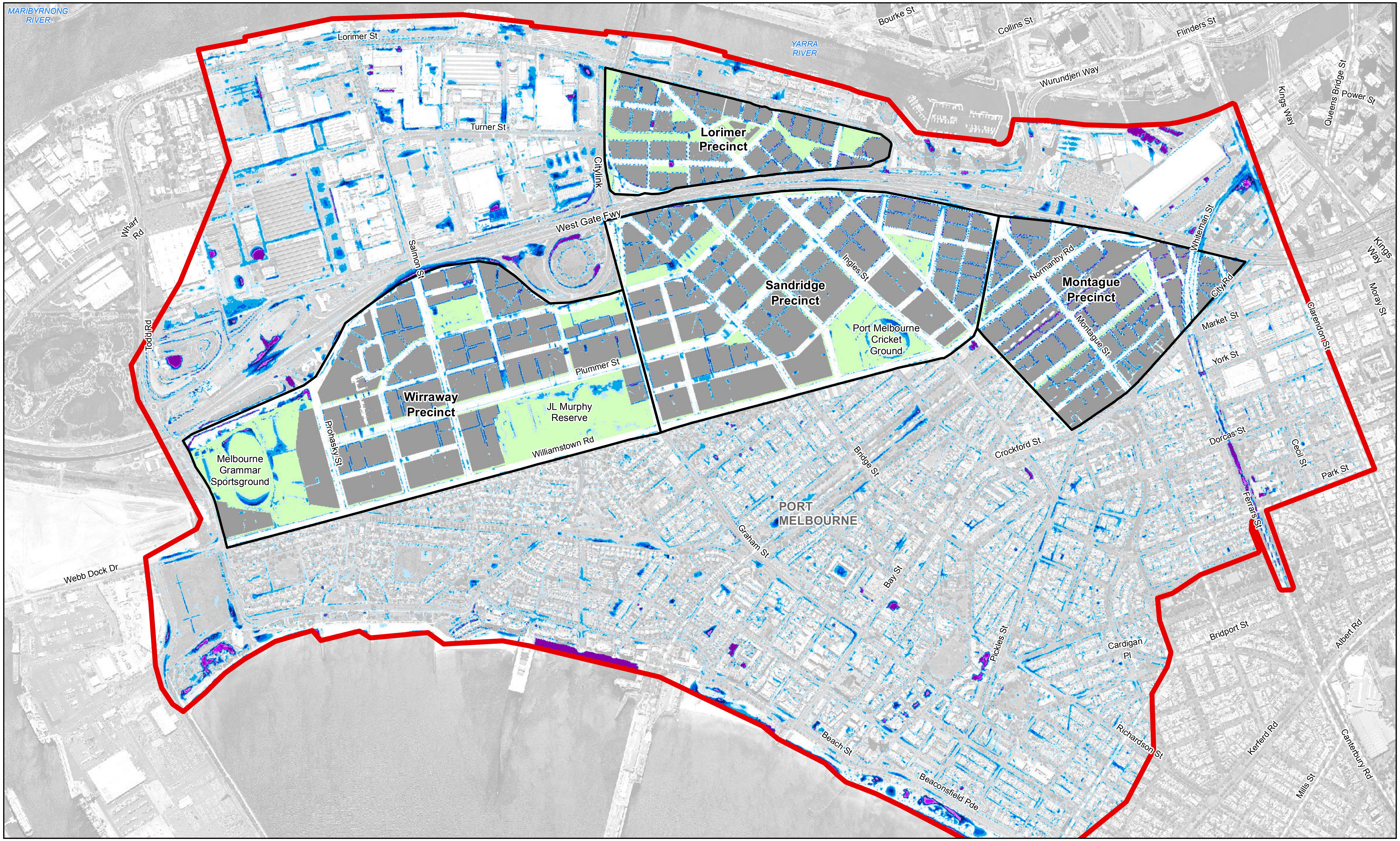

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

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Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number 31-32191
Revision A
Date 04 Sep 2015

Scenario 1 - 5 year ARI
Depth Plot

Figure 2B

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

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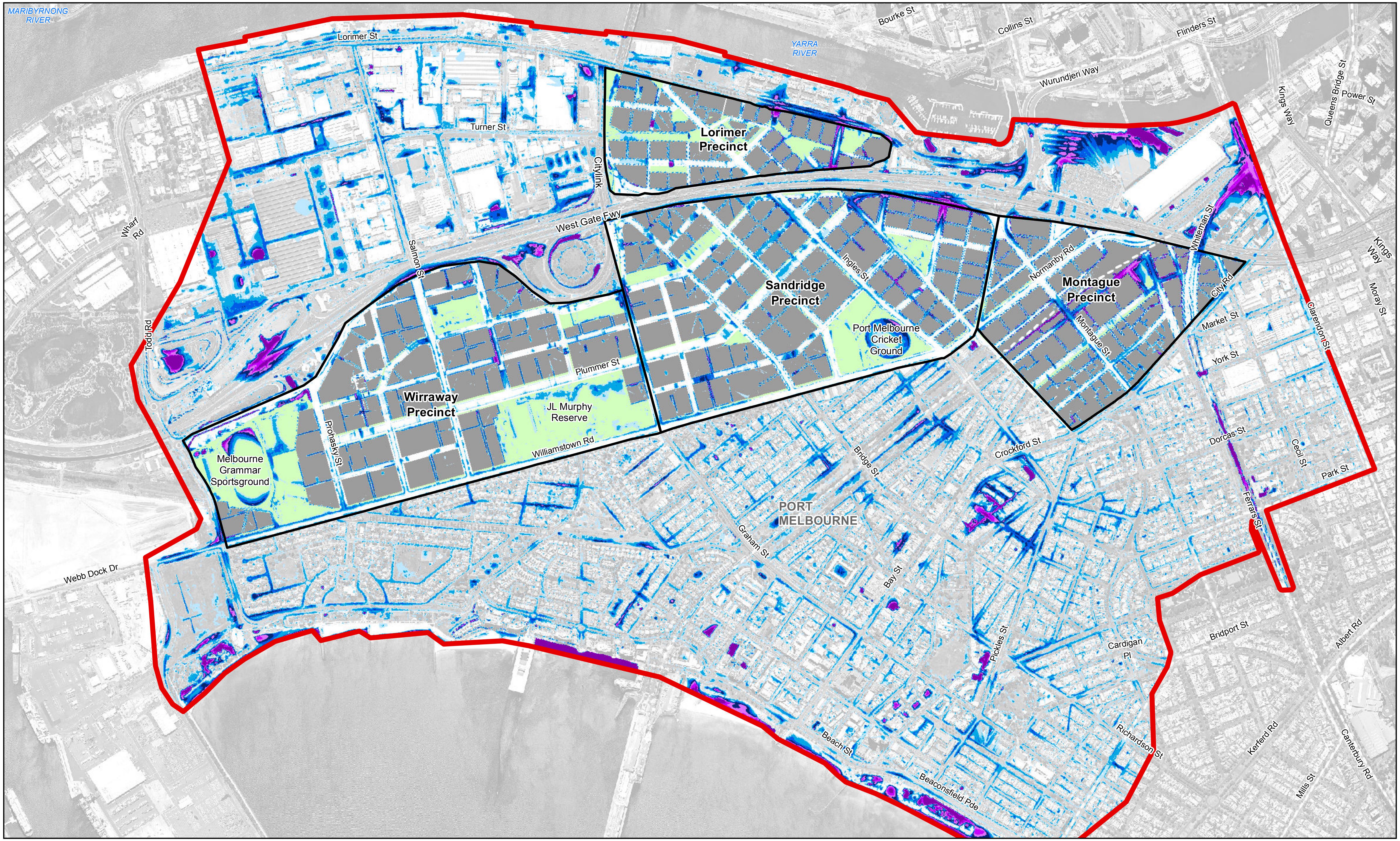

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Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100 | 101 - 200 | 201 - 300 | 301 - 400 | 401 - 500 | 501 - 600 | > 601

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Fisherman's Bend WoWCM

Job Number 31-32191
Revision A
Date 04 Sep 2015

Scenario 2 - 100 year ARI Depth Plot

Figure 3A

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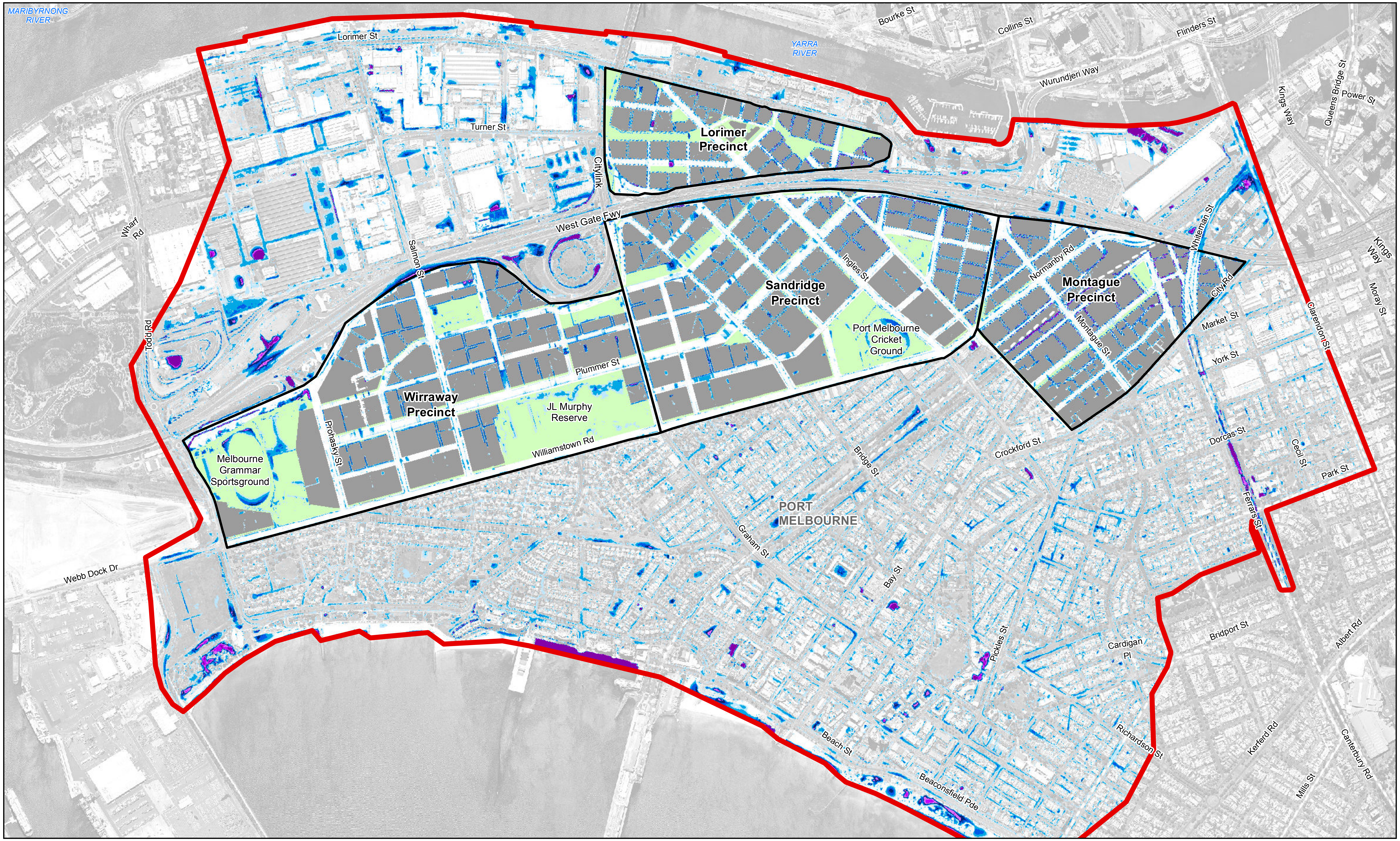

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100 | 101 - 200 | 201 - 300 | 301 - 400 | 401 - 500 | 501 - 600 | > 601

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Melbourne Water and South East Water
Fisherman's Bend WoWCM

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Scenario 2 - 5 year ARI
Depth Plot

Figure 3B

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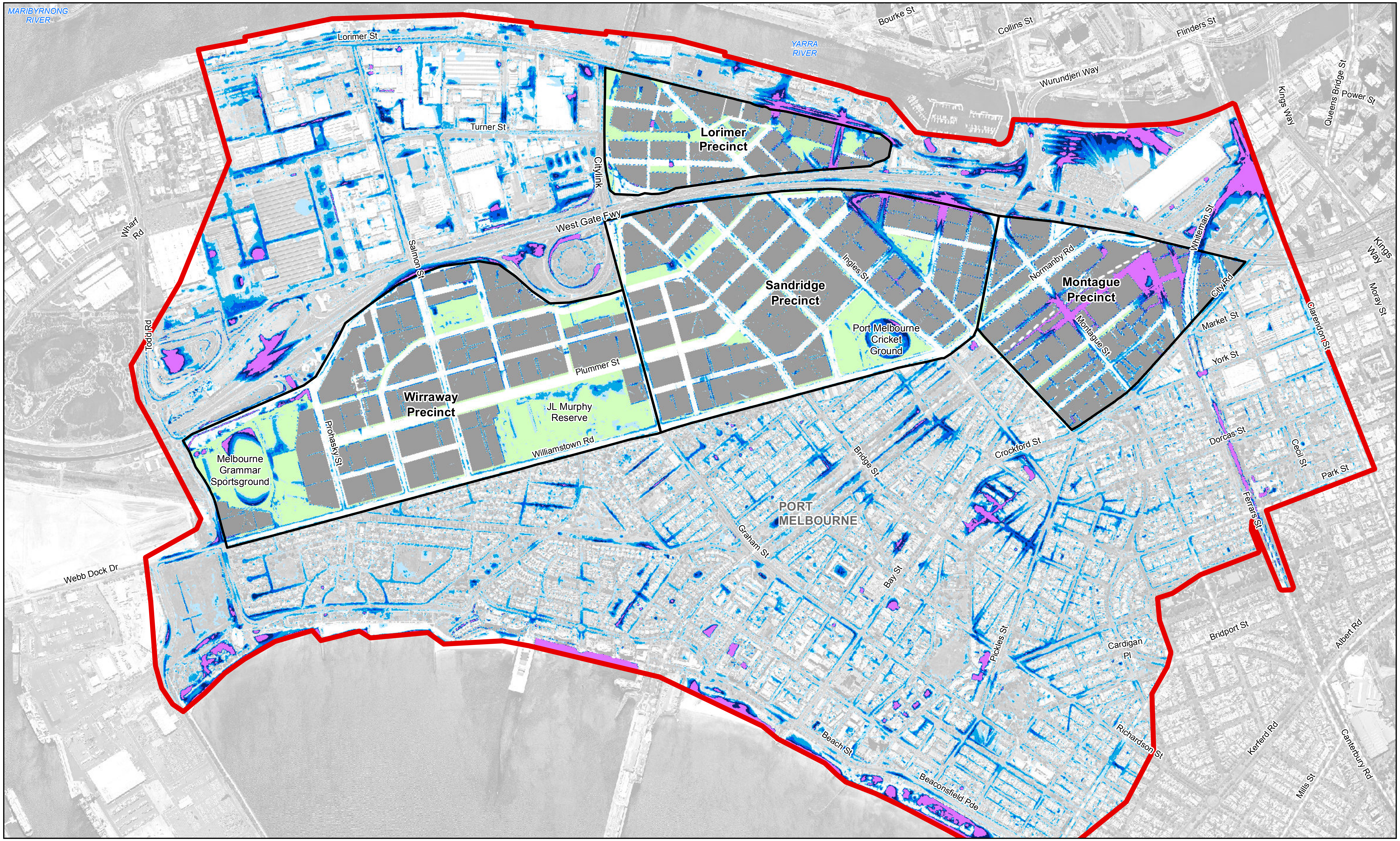

Paper Size A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
Revision	A
Date	04 Sep 2015

GHD South East Water Melbourne Water

Scenario 3 - 100 year ARI Depth Plot

Figure 4A

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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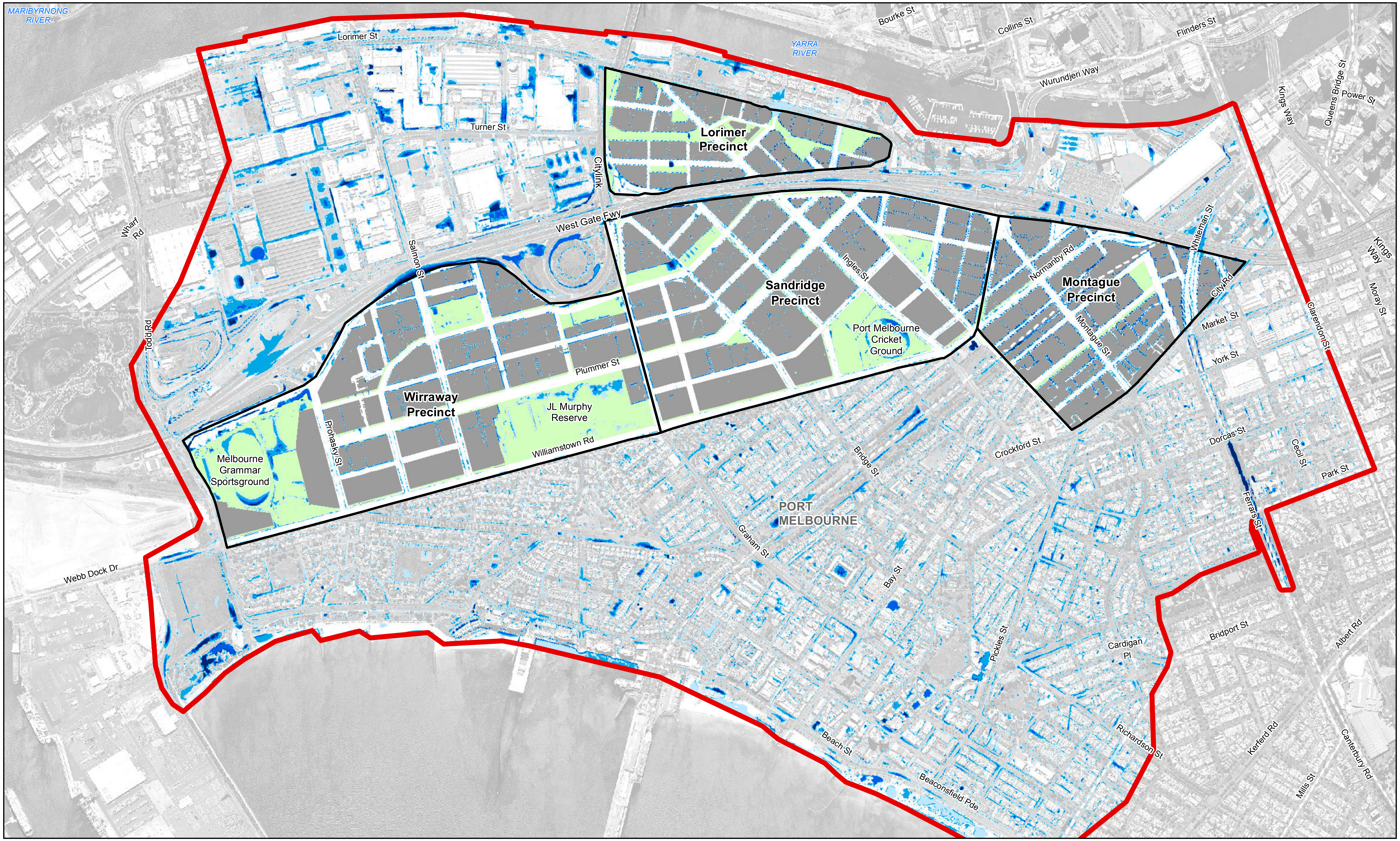

Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

GHD | South East Water | Melbourne Water

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Scenario 3 - 5 year ARI
Depth Plot

Figure 4B

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

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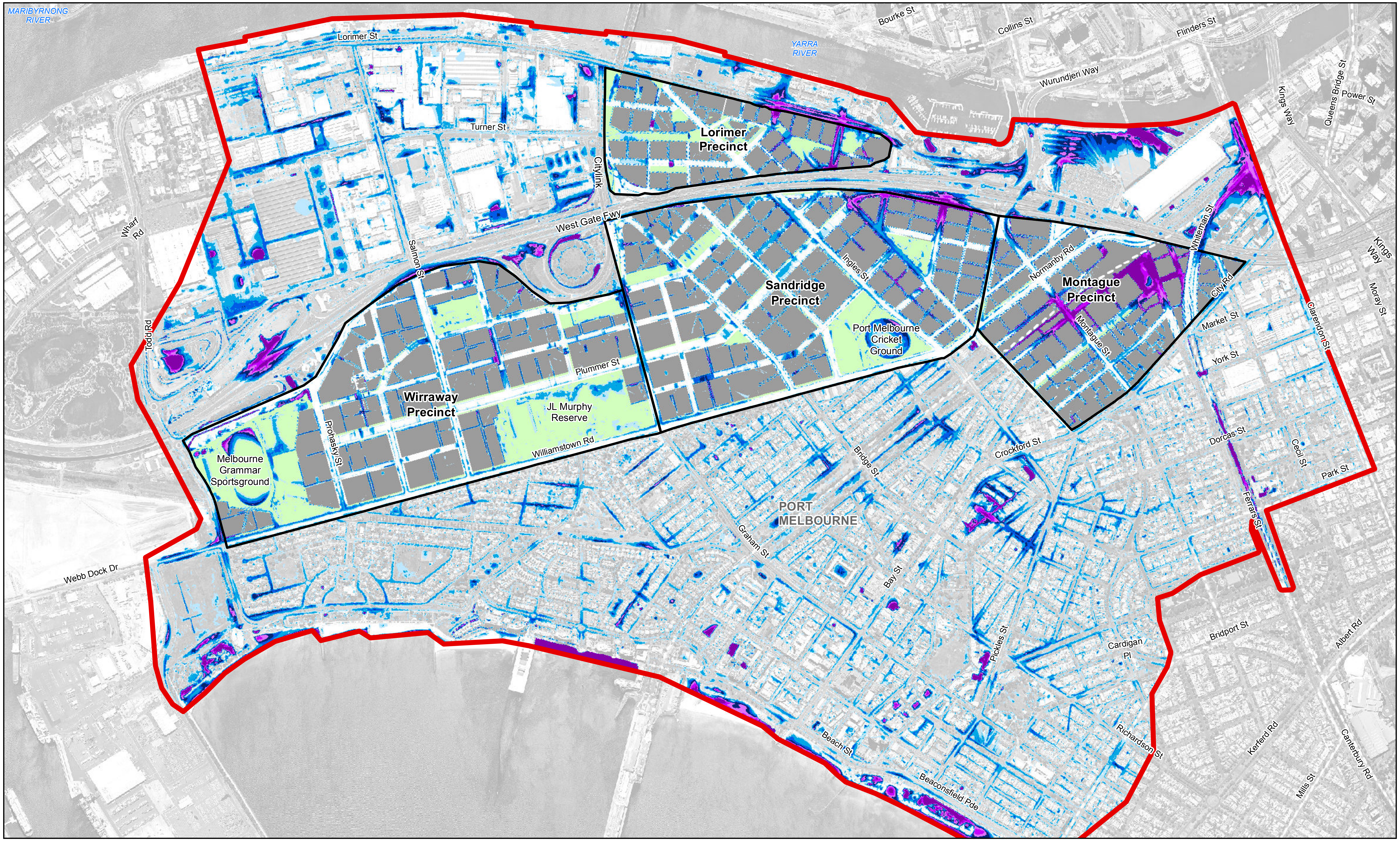

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Scenario 4 - 100 year ARI Depth Plot

Figure 5A

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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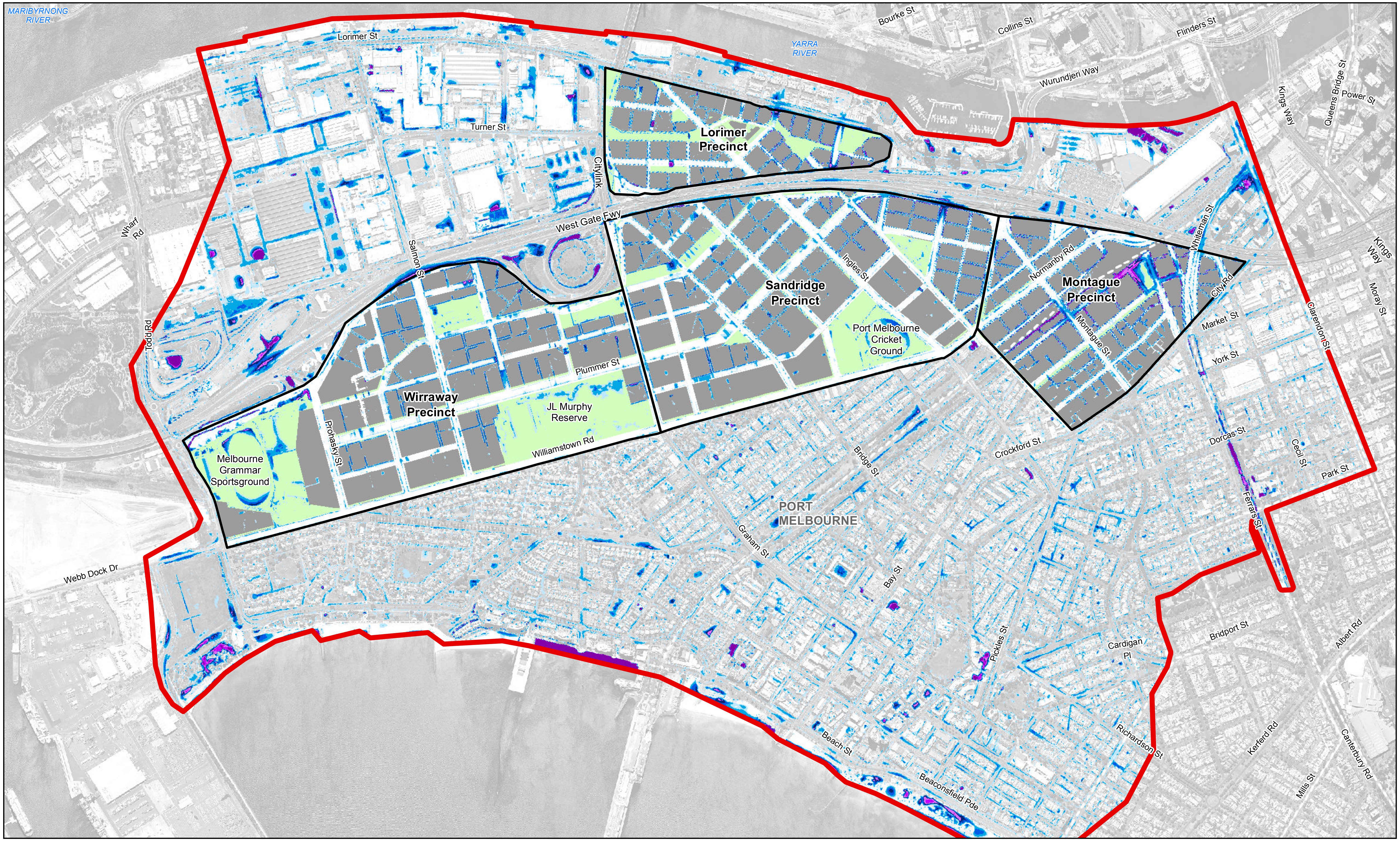

Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Scenario 4 - 5 year ARI Depth Plot

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Figure 5B

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Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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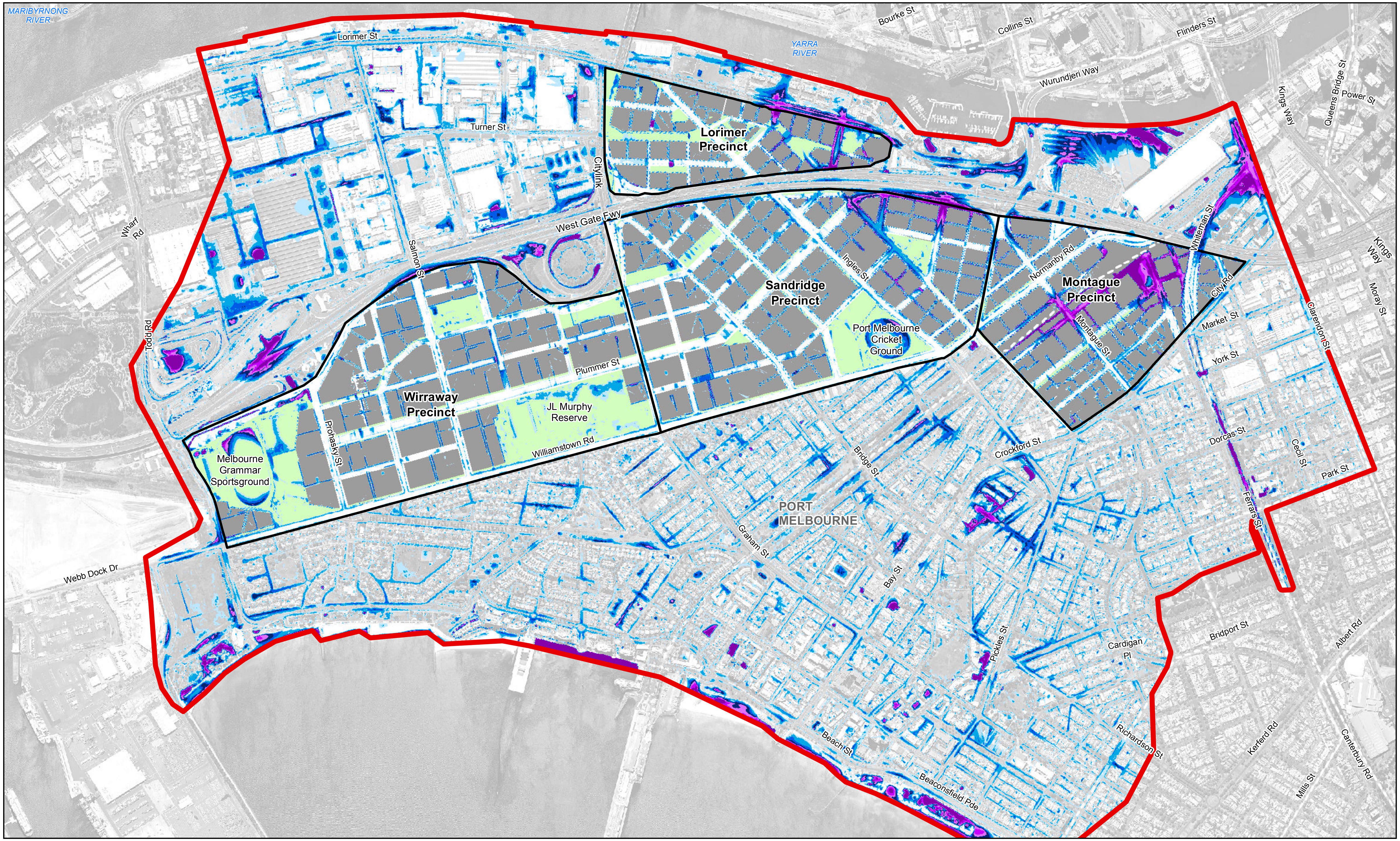

Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100 | 101 - 200 | 201 - 300 | 301 - 400 | 401 - 500 | 501 - 600 | > 601

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Melbourne Water and South East Water
Fisherman's Bend WoWCM

Scenario 5 - 100 year ARI
Depth Plot

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Figure 6A

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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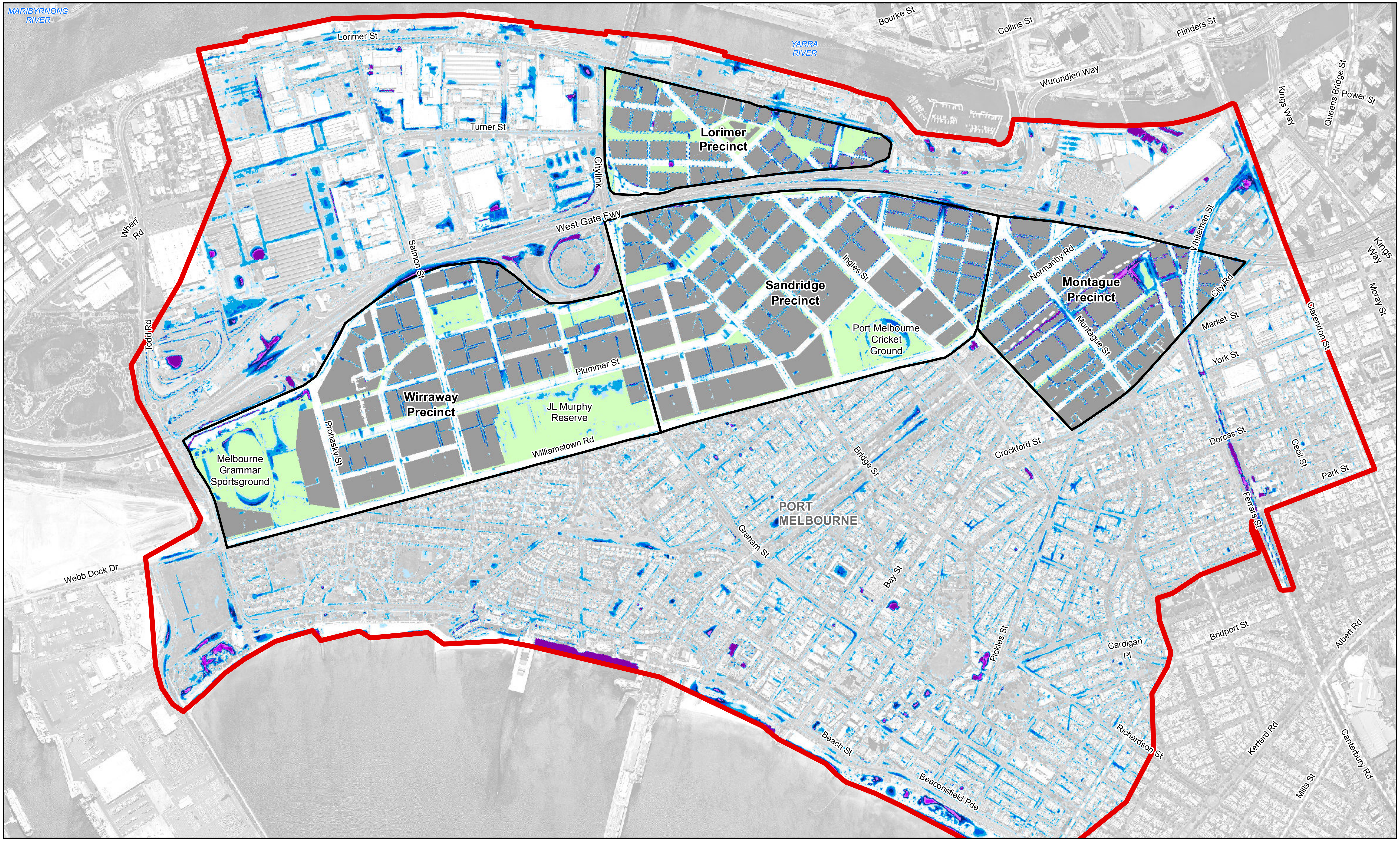
180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com



Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Scenario 5 - 5 year ARI Depth Plot

Figure 6B

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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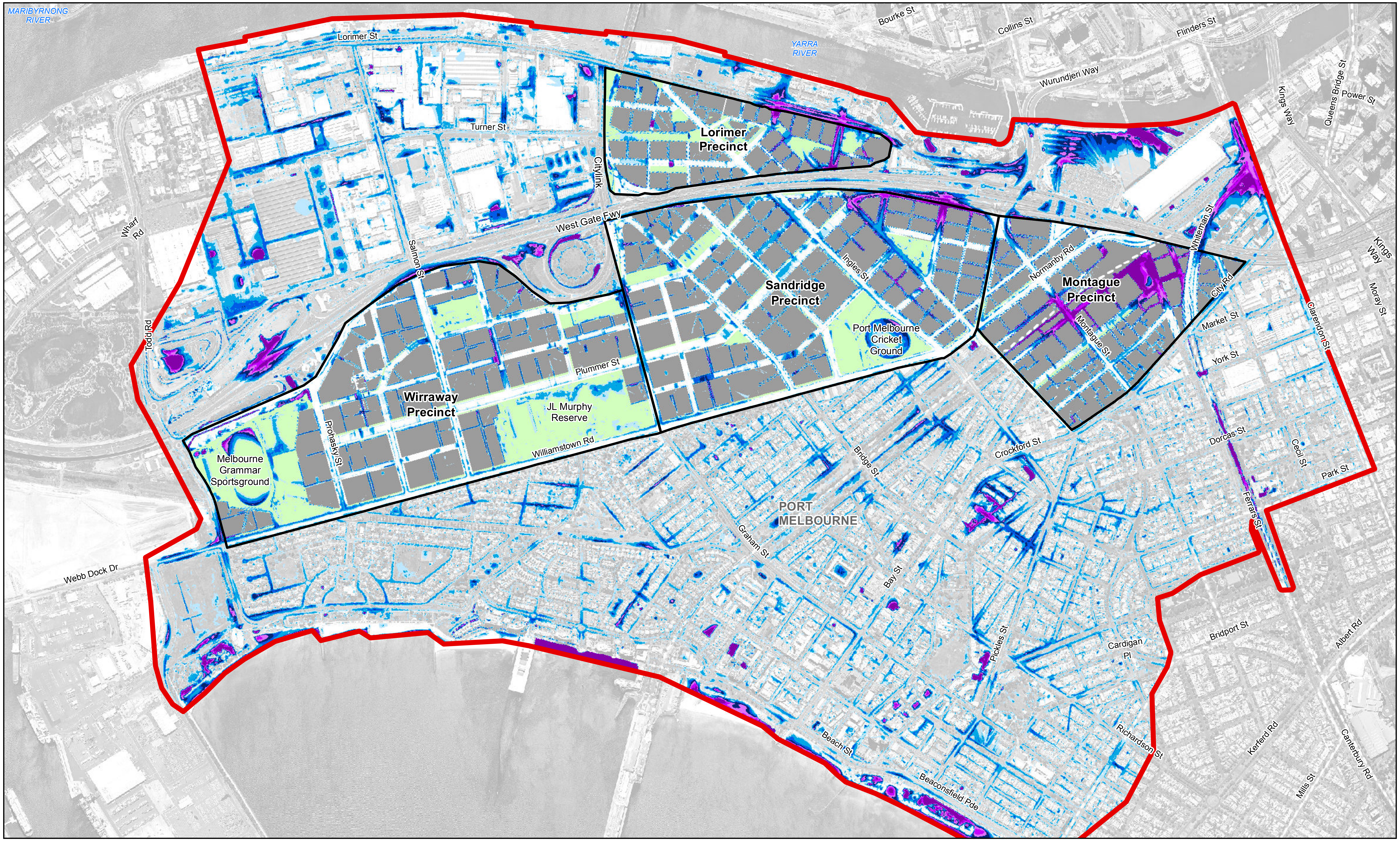

Paper Size A3

0 62.5 125 250 375 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Precinct Boundary
- Discretionary
- Open Space
- Model boundary

Depth (mm)

51 - 100, 101 - 200, 201 - 300, 301 - 400, 401 - 500, 501 - 600, > 601

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number	31-32191
Revision	A
Date	04 Sep 2015

Scenario 6 - 100 year ARI Depth Plot

Figure 7A

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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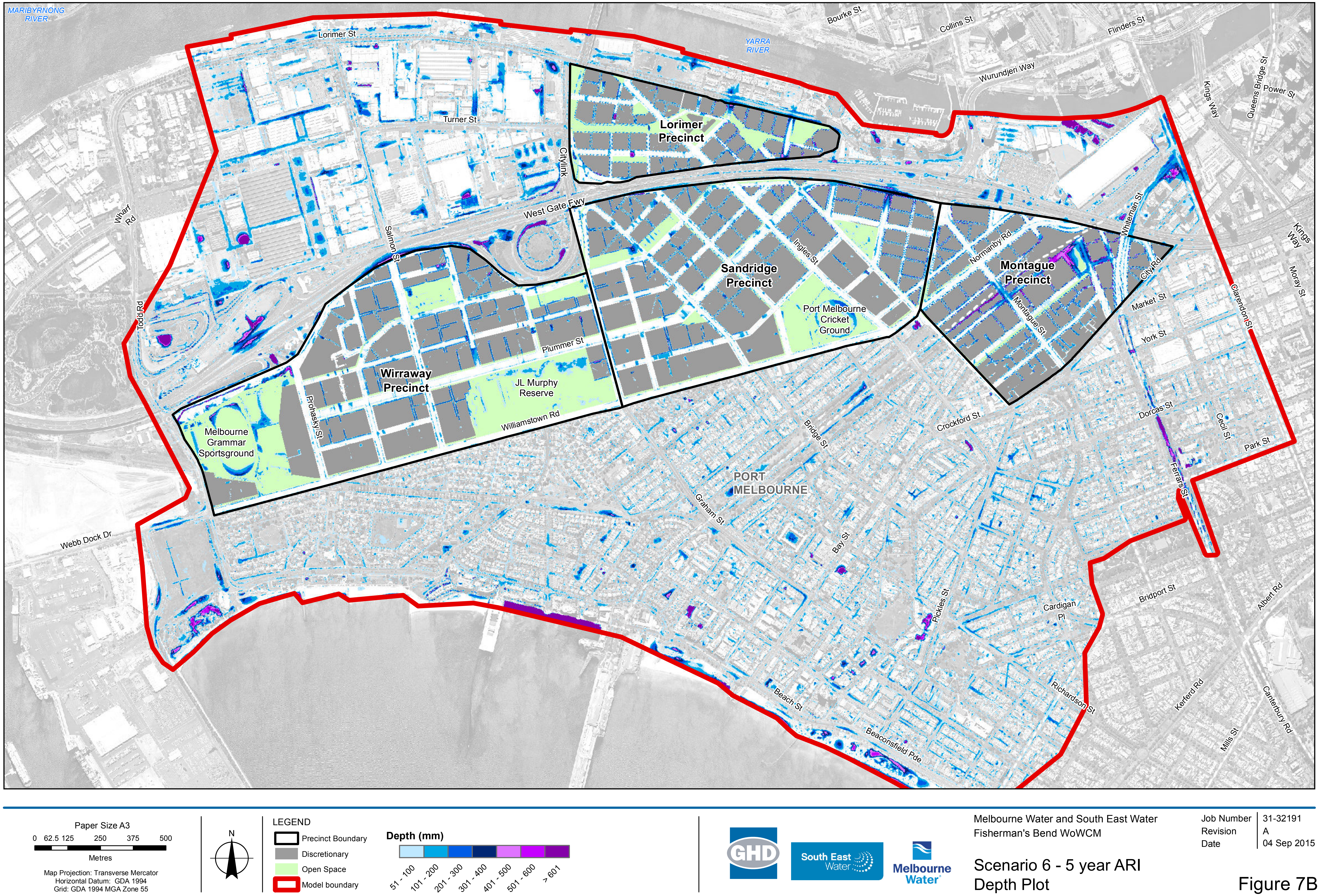

Melbourne Water and South East Water
Fisherman's Bend WoWCM

Job Number 31-32191
Revision A
Date 04 Sep 2015

Scenario 6 - 5 year ARI Depth Plot

Figure 7B

G:\31\32191\GIS\Maps\Deliverables\3132191_Model_Results_BulkMapping.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: PSP Landuse and Flood Data, GHD, 2014; Vicmap, DEPI, 2014; Imagery, DEPI, 2013. Created by:scowan

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Appendix C – Concept Design of Conventional Potable Water & Sewer Mains

Paper Size A3

0 250 500 1,000 1,500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Lorimer Precinct	Existing Fixed Heads	Potable - Upgrade/New Diameter
Montague Precinct		20.0 - 110.0
Sandridge Precinct		110.1 - 170.0
Wirraway Precinct		170.1 - 250.0
		250.1 - 450.0
		450.1 - 750.0
		750.1 - 2500.0

South East Water
Fishermans Bend WoWCM

Job Number 31-32191
Revision C
Date 08 Dec 2014

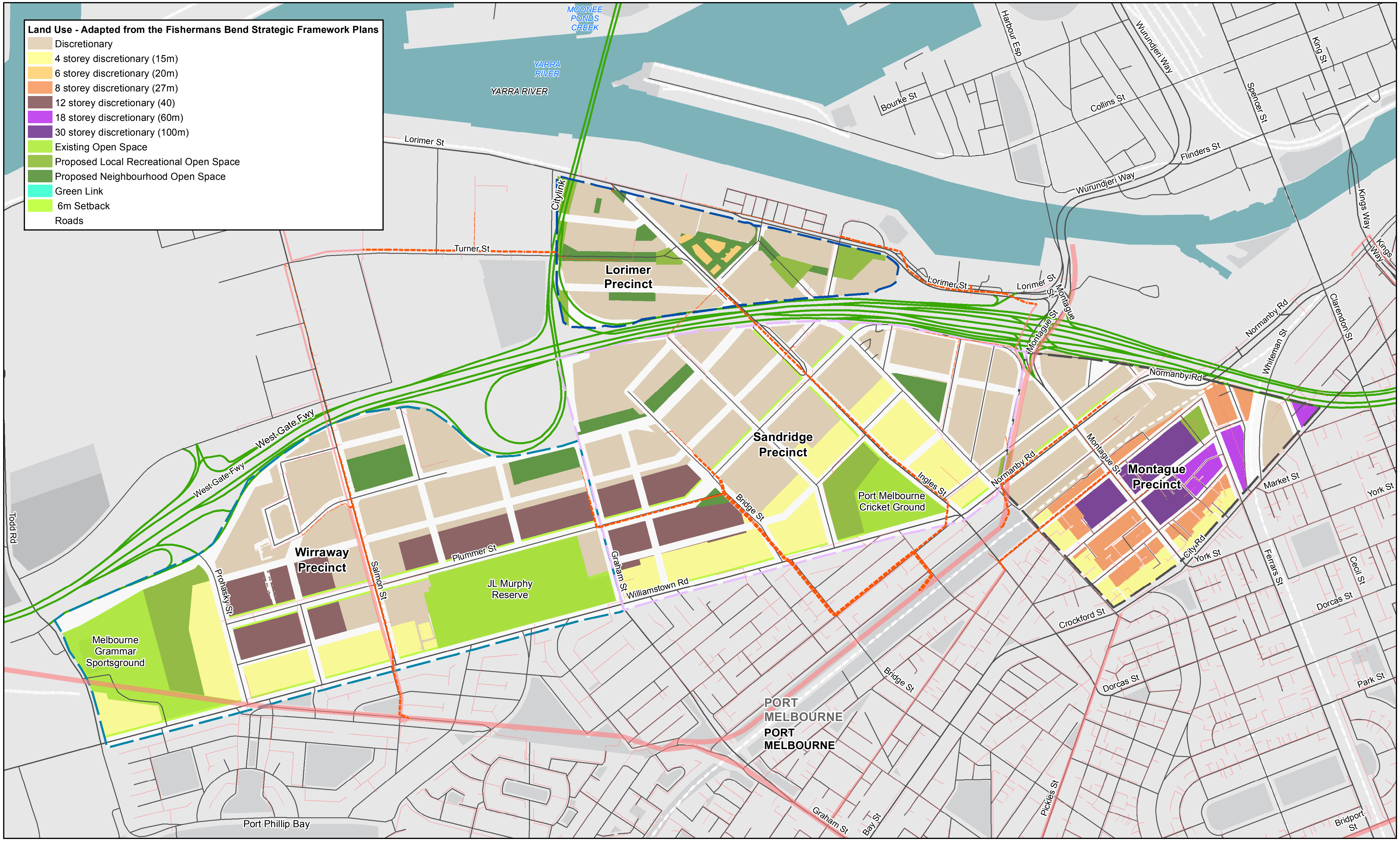
Potable Conventional

Figure 1

Level 8, 180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 E mwlmail@ghd.com W www.ghd.com

G:\31\32191\GIS\Maps\Working\3132191_004_PotableBaseCase.mxd

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; Potable, Melbourne Water, 2014; Imagery, DEPI, 2013. Created by:kwilliams3



Paper Size A3

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

Base Case Sewer Width	Existing Sewers Width			
0 - 350	0 - 350	Lorimer Precinct	Freeway	Tramway
351 - 500	351 - 500	Montague Precinct	Arterial	Railway
501 - 650	501 - 650	Sandridge Precinct	Collector	
	651 - 7900	Wirraway Precinct		

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South East Water
Fishermans Bend WoWCM

Job Number 31-32191
Revision B
Date 08 Dec 2014

Base Case Sewer

Figure 1

G:\31\32191\GIS\Maps\Working\3132191_004_SewerBaseCase.mxd

Level 8, 180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 E mwlmail@ghd.com W www.ghd.com

Data source: PSP Landuse Data, GHD, 2014; Vicmap, DEPI, 2014; Sewer Main, Melbourne Water, 2014; Imagery, DEPI, 2013. Created by:kwilliams3

Appendix D – Interpretation of the Strategic Framework Plan (SFP)

The guidelines in the Strategic Framework Plan (SFP) that directly or indirectly relate to this Integrated Water Management servicing strategy are listed in the table below.

Table D1 SFP elements relating to WWCM

Design Guidelines			Key Information		
Section	**Objective**	**Guideline**	**Prescriptive**	**Relevant authorities**	**Comments**
5. Public Spaces and Landscaping	5.1 To achieve high precinct amenity through open space provision.	GUIDELINE 1: Where the site is large enough (generally over 6,000 sqm) or where the site contribution can clearly be co-located with an existing or proposed open space consistent with Plan 3, the contribution may be required in the form of land transferred to council. GUIDELINE 2: A public open space contribution in the form of land will only be required where the outcome fulfils a clear open space role and is more than just a pedestrian link. Generally, the resulting space should be at least 500 square metres with a minimum dimension of 20 metres and be in a location consistent with Plan 3.	No	NA	Is the amount of public open space contingent on these contributions? Is it possible there will be more public open space? If provided as open space: will it be actively irrigated? **MPA: Open space is not contingent on these contributions.**
	5.2 To ensure private landscaping, communal and rooftop gardens (generally on podiums) form an integral part of larger proposals.	GUIDELINE 1: On-site, communal open space and gardening opportunities should be provided in addition to the specified contribution for public open space. GUIDELINE 2: Developments should consider available rooftop space for garden and recreation areas. GUIDELINE 7: Green walls, facades and roofs should be supported by a robust maintenance regime and sustainable irrigation system.	No	NA	Private open space is not mandatory. What amount to assume for demand calcs? Green walls, facades, roofs and rooftop gardens are not mandatory. What amount to assume for demand calcs? **SEW: Adopt per capita irrigation rates with sensitivity for greening the precinct.**

Design Guidelines			Key Information		
		GUIDELINE 8: Landscaping of public open space must address requirements for managing the quality and quantity of stormwater generated.	Yes	NA	Does this add any additional requirement? How will MWC interpret this requirement when reviewing applications? **MWC Response: The development must not make flooding condition any worse for surrounding area, and must meet BPEM standards as applicable for the area.** **MW would encourage developers to maximize water retention on site/ in precinct, but may not be able to enforce it.**
	5.3. To develop streets as high amenity public spaces.	GUIDELINE 1: All streets must be formally planted with **canopy trees**.	Yes	NA	What to allow for water demand? Just during establishment (i.e. not at 2050)? **SEW: Happy with GHD suggestion that actively managed open spaces have elite turf allowance. Street tree densities need to be considered elsewhere.**
7. Water and Energy Management	7.1 To make efficient use of stormwater, not overload existing drainage and create green urban environments which protect the environmental health of urban waterways and Port Phillip Bay	GUIDELINE 4: To contribute to the creation of green urban environments, development should maximise **permeability, water infiltration and passive irrigation** of all public and private landscaped areas.	No	NA	How will MWC interpret this requirement when reviewing applications? **MWC Response: It will be up to developers to demonstrate that these requirements are met by the development proposals. It is not a mandatory requirement but MW will encourage the developers to meet this guideline. (We will know which areas can support this guideline condition after we have more information on the groundwater and soil contamination status).**
		GUIDELINE 2: To avoid overloading existing drainage infrastructure and exacerbating flood risk, each building should **capture runoff from** 100% of the **roof** area and successfully **retain on-site** at least 50% of the volume of runoff derived from a 5 year 72 hour storm event.	No	NA	It is assumed rainwater tanks need to be designed to capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) of roof runoff and retain a minimum of 50% of this volume for reuse.
		GUIDELINE 1: Provision should be made to **manage stormwater generated** on-site within the development footprint. Advice should be sought from Melbourne Water and council for determining an optimal stormwater management strategy.	No	**MWC Council**	How will MWC interpret this requirement when reviewing applications? **MWC Response: Developer will have to demonstrate this by modelling the proposed stormwater management**

Design Guidelines			Key Information		
		GUIDELINE 3: **Stormwater captured onsite** must be re-used in toilet flushing and irrigation or, as a **last option, controlled release**.	Yes	NA	Does this in effect just require that stormwater captured onsite must be "controlled release"? How is this different than Guideline 5? **SEW Response: In a SEW/MW' supplementary guideline, we would be incorporating this part with the RW provisions.**
		GUIDELINE 5: **Stormwater** generated from surfaces such as car parks, pavements and open space, must be **managed on-site**. Reducing the impervious area through measures such as rain gardens, permeable pavements, green roofs and other onsite detention systems can improve stormwater management outcomes.	Yes	NA	Stormwater runoff must be "managed" on-site. How is this different than Guideline 3? **MWC Response: My take on it is guideline 3 is more or less lot scale requirement and guideline 5 is for the precinct scale. I agree it is not clear.** **Regarding reuse, controlled release is the last option, meaning the developer would have to satisfy that reuse is not practical/possible.**
		GUIDELINE 6: Development must meet or exceed **best practice stormwater quality treatment standards** prior to discharge to receiving waterways, to the satisfaction of Melbourne Water and council.	Yes	MWC Council	Development must meet BPEM (onsite or offsite). **Runoff from podium level open spaces will be considered as roof water**
	7.2 To reduce the need to augment potable water supplies	GUIDELINE 1: New buildings **must install a third pipe** to supply non potable uses within the development, including for toilet flushing, fire services, irrigation and cooling, unless otherwise agreed by South East Water. Installing third pipe during building construction is more cost effective than retrofitting in the future.	Yes	SEW	Third pipe installation is mandatory. **SEW Response: We have already expanded this in our replies to developers in area. We have been saying that the 3rd pipe must be plumbed as if it is RW (purple pipe not green pipe used for rainwater).** **From the 1 Jan all RW areas are to be plumbed to laundry as well.**
		GUIDELINE 3: Provision of third pipe should include a **building connection point** that ensures readiness to connect to future precinct-scale alternative water supply. South East Water should be consulted to identify a suitable location for the building connection.	No	SEW	…. a building connection point for third pipe is not mandated. **SEW Response: The work we are doing now should hopefully tell us if we need to push this harder.**
		GUIDELINE 2: The design of new development should reduce consumption of potable water by adopting **best practice water efficient** fixtures and appliances.	No	NA	None.

Design Guidelines			Key Information		
		GUIDELINE 4: **Storage**, such as rainwater tanks with a capacity of 0.5 cubic m per 10 sqm of roof area and equipped with power and water management telecommunications will be required. Such roof top runoff should be stored independently of runoff from other impervious surfaces such as car parks.	?	NA	This may be ambiguous. 1. It is assumed the term "will be required" is prescriptive. Is this correct? **MWC Response: Yes** **SEW Response: Expect podium to be included in roof area** 2. If so, then is the following required for all development: a. Storage (with min capacity of 0.5 m^3 per 10 m^2 of roof area) b. Water management telecommunications (what does this mean?)
		GUIDELINE 5: **Grey water** collection and re-use is expected for all larger developments (over 200 dwellings).	?	NA	It is assumed the term "is expected" is non-prescriptive. Is this correct? Or do we need to assume that greywater systems are required for all developments over 200 dwellings? **MWC Response: Yes, non prescriptive** **SEW Response: Depending on the outcomes of our work SEW would issue a "supplementary guideline" saying that this will be unnecessary if street RW is provided.** **So the base case should not include it. The RW options should not include it but a theoretically decentralize option would.**
	7.3. To protect key building access points and uses from current and forecast flooding impacts.	GUIDELINE 1: So that the extent and impact of drainage and flooding issues can be accurately determined, Melbourne Water and council should be consulted early, at the concept design stage, for all new developments. **Unless lower levels are approved** by the responsible authority, **minimum floor levels should be set at** 3.0 metres AHD or 0.3 metres above the local overland flow flood level, whichever is the higher.	No	**MWC** **Council**	

Design Guidelines			Key Information		
		GUIDELINE 3: Creative design responses will be needed to accommodate raised ground floors which pose a threat to visual interaction with the street. An appropriate design response may include an entry at footpath level, with level changes internally to achieve the minimum AHD floor levels or raised level of access ways and laneways. GUIDELINE 4: Basements may be constructed provided access points comply with site safety requirements such as entry/exit routes incorporating a continuous apex that is at least 0.6 metres above 3.0 metres AHD.	No	NA	What does this mean for the flood modelling scenario? **MWC Response; Non-living areas will be permitted below 3m AHD, down to 2.4m AHD. Please see the diagram and explanation included in Bruce Rush's e-mail.**

Appendix E – Key Design Considerations

E1 Alternative rainwater tank properties

Two alternative rainwater tank arrangements have been considered within the options, namely slow release rainwater tanks (as per SFP) and smart quick release rainwater tanks (to maximise third pipe supply). It is important to note that whilst the SFP does not specifically mention 'slow release' or ‘quick release’ tanks, it implies it in the sense that it requires that the tanks assist in managing stormwater flows (i.e. 100% of five year 72 hour storm event detained on-site with 50% retained on-site for reuse).

A slow release tank is considered a ***mandatory approach*** that developers need to adopt as a minimum, whilst a quick release tank is a ***non-mandatory approach***, which is being explored within two of the scenarios to confirm whether there is value in MW or SEW subsidising the cost of these tanks to offset the cost of streetscape/sub-surface flood storage and/or class A balancing storages.

There are many different ways in which the SFP requirements can be interpreted. These include:

- The definition of a ‘roof’ for the purposes of these requirements of the SFP. With high rise buildings on podiums, there may be some areas where impervious surfaces occur well above ground level, but are not the ‘roof’ of any actual building structure.
- The role of the tank in providing flood detention and reuse functions simultaneously (i.e. do the detention and retention functions be treated separately or do they overlaps.

Further guiding documentation to clarify these issues could be useful in future to accompany the SFP.

We understand that the rainwater tanks need to capture the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and any podium hardstand, and retain a minimum of 50% of this volume. It is assumed that given the tanks are typically drawn down reasonably fast (i.e. with 24-48 hours) there is no requirements to separate the retention and detention elements of a rainwater tank (given this is how a developer may interpret the SFP and therefore challenge the SFP at VCAT).

For illustrative purposes the average a building scale rainwater tank needs to be 278 kL with 50% for reuse (139 kL) and 50% for slow release (139 kL). The average size of 278 kL is based on:

- An average building roof area of 1903 sq m.
- An average contributing podium area of 853 sq m (representing 70% of the podium, based on the land use assumptions derived by GHD in collaboration with MPA).

In practice the size of the rainwater tanks will vary from site to site.

Alternative A – Slow Release Rainwater Tanks Installed in Accordance with SFP (Mandatory Approach)

These tanks are designed to primarily detain flood peaks with an orifice (leaky tank) half way up the tank. These tanks perform two functions, namely:

- Provide rainwater to the building scale third pipe network (primary supply) – bottom 50% of tank (139 kL on average).
- Have the ability to slowly release water to the Yarra River and Bay (after the flood peak has receded) – top 50% of the tank (139 kL on average).

Alternative B – Smart Quick Release Rainwater Tanks Installed To Maximise Third Pipe Supply (Non-Mandatory Approach)

These tanks are designed to maximise third pipe rainwater reuse within the building and podium by retaining the roof and podium runoff for as long as possible (i.e. before the next flood event). These tanks perform two functions, namely:

- Provide rainwater to the building scale and/or precinct wide third pipe network (in the case of scenario 3 - interlinked storages) by capturing roof and podium runoff; and
- Have the ability to quickly release water to the stormwater drainage network, and thus to the Yarra River and Bay before subsequent flood events (thus maximising any harvesting potential).
- A quick release tank relies on having some accuracy of forecasting to allow tanks to be drained in anticipation of significant rain events. This adds an element of complication and risk in flood management, which may need further modelling and demonstration to satisfy stakeholders it is a robust approach.
- Note also that the need to empty the contents of the tank from time to time will have some impact on yield. However, with refinement of forecasting and decision algorithms, such reduction should be minor, given the lower likelihood of significant rain events.

On average a quick release tank needs to have a total volume of 278 kL, based on the current interpretation of the SFP.

[Note that some alternative interpretations of the SFP could lead to larger tanks.]

A summary of alternative rainwater tank approaches adopted across the various scenarios is provided in Table F1 below.

Table E1 Alternative Rainwater Tank Approaches Adopted

Scenario	Tank Type	Tank Description	Tank Approach	Tank Size[1]
0 – Conventional Water, Sewer with no minor or major drainage upgrades	**A**	Slow Release Rainwater Tanks Installed in Accordance with SFP	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 50% of this volume for reuse.***	278 kL (139 kL for slow release and 139 kL for reuse).
1 – Conventional Water, Sewer and Drainage Upgrades	**A**	Slow Release Rainwater Tanks Installed in Accordance with SFP	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 50% of this volume for reuse.***	278 kL (139 kL for slow release and 139 kL for reuse).
2 – Sewer Mining in the Precinct	**A**	Slow Release Rainwater Tanks Installed in Accordance with SFP	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 50% of this volume for reuse.***	278 kL (139 kL for slow release and 139 kL for reuse).
3 – Interlinked Third Pipe Supply	**B**	Smart Quick Release Rainwater Tanks Installed To **Maximise Third Pipe Supply**	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 100% of this volume for reuse.***	278 kL (278 kL for reuse with ability to empty entire tank before storm event).

Scenario	Tank Type	Tank Description	Tank Approach	Tank Size[1]
4 – Stormwater Harvesting in the Precinct	**A**	Slow Release Rainwater Tanks Installed in Accordance with SFP	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 50% of this volume for reuse.***	278 kL (139 kL for slow release and 139 kL for reuse).
5 – Lot Focus	**B**	Smart Quick Release Rainwater Tanks Installed To **Maximise Third Pipe Supply**	Capture and detain the first 101 mm (equivalent to the total rainfall from a 5 year 72 hour storm event) from the building roof and 70% of the podium and ***retain a minimum of 100% of this volume for reuse.***	278 kL (278 kL for reuse with ability to empty entire tank before storm event).

1 Based on average roof size of 1901 sq. m and average podium of 1218 sq. m

E2 Evaluation of Rainwater Harvesting Yield

An evaluation of the rainwater harvesting yield and volumetric reliability of supply for alternative water supply (to meet toilet, laundry and outdoor podium building demands totalling approximately 21 ML/yr on average per building) was undertaken for a variety of tank retention volumes to ascertain where the diminishing point of return on the yield curve occurs.

Key assumptions include:

- Average building roof of 1900 sq. m;
- Average podium area of 1300 sq. m;
- 100% of average roof area (1900 sq. m) connected to the tank;
- 50% of average podium area (650 sq. m) connected to tank (scenarios as noted in graphs below);
- Climatic period (average conditions) 1961 – 72 (daily time step adopted for water balance purposes).
- Rainwater tank demand is 100% of the outdoor (podium), toilet and clothes washer demands for each building (refer to design basis assumptions attached); and
- Average residential population of 460(equivalent to 12 story building with a density of 1 person/50 sq. m) and average employment population of 460 (equivalent to 5 story building with a density of 1 person/20 sq. m). An average population of 460 was adopted in both cases as this is equivalent to the total ultimate development population of 181,050 (design basis) distributed over 392 buildings. In reality the residential and employment precinct building heights, rood areas and use types (i.e. mixed use) will vary across the precinct;

The following can be concluded from the graphs (refer Figure F1, F2 and F3) provided below:

- Employment and residential yield curves are similar due to demand being much higher than supply in both cases (10.4 ML/yr and 14.2 ML/yr employment and residential demand relative to 0.88 ML/yr supply;
- The diminishing point of return is at a retention volume of approximately 25-50 kL per building tank;

- The volumetric reliability almost doubles from 6.1 to 12.0% if the projected building population is 50% lower than base population forecast (based on a 50 kL retention volume); and
- Given the flood storage requirements are the key driver for sizing the tanks (and not the volumetric reliability) the amount of rainwater harvested from a tank capturing roof & podium runoff is likely to be approximately to be:
  – 956 kL/yr/building tank or ***374 ML/yr*** for the total precinct for a slow release tank (50% or 139 kL retained for reuse);
  – 979 kL/yr/building tank or ***384 ML/yr*** for the total precinct for a smart quick release tank (all 278 kL retained for reuse);

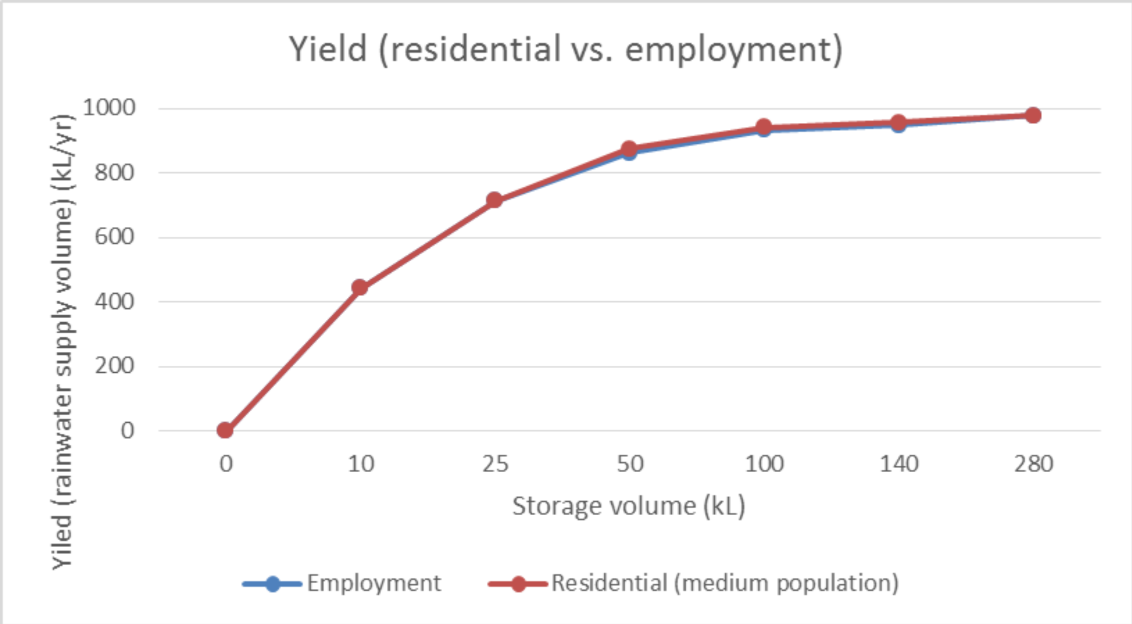


Figure E1 Employment & Residential Rainwater Harvesting Yields

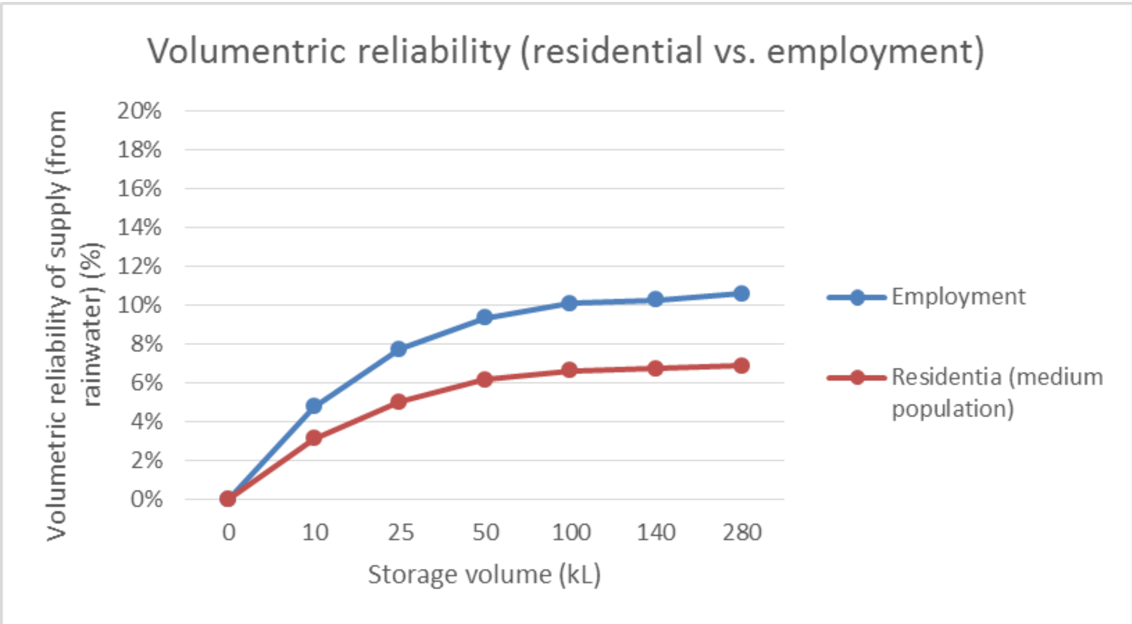


Figure E2 Residential Rainwater Harvesting Reliability

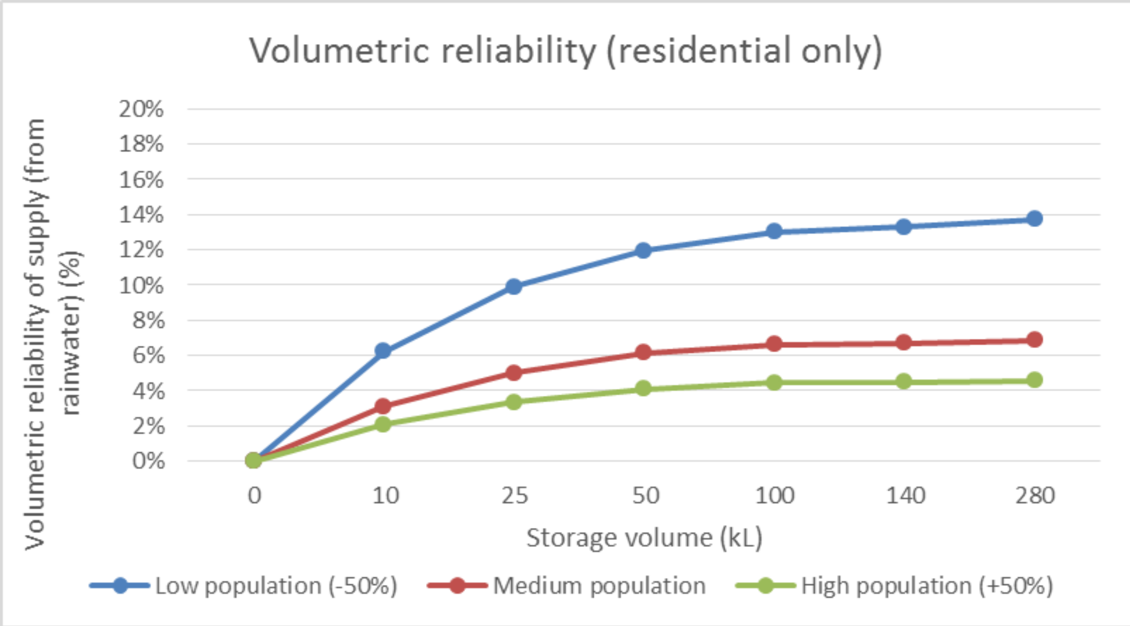


Figure E3 Residential Rainwater Harvesting Yield (Alternative Population Projections)

Innovative Idea – *Point of Discharge from Slow or Smart Fast Release Tanks*

An additional idea is to let this excess rainwater into the sewer after the peak wet weather flow has passed (or before subsequent flood events). It would help with dilution of salts.

Innovative Idea – *Use of Tanks for Class A Peak Day Storage (Scenario 3)*

Given there is projected to be approximately 109 ML of storage available within the building scale rainwater tanks there is the potential to use these storages to provide balancing storage for the Class A recycled water peak day demand (20.6 ML/d).

This concept has some complications, as if the tanks are to retain a function for managing stormflows, the Class A water in the tanks would need to be 'dumped' if a significant rain event was forecast. There are two obvious places to send this Class A water:

1. To the sewer system. This could occur with sufficient forecast warning while flows in the sewer system remain below peak wet weather flows.
2. To the stormwater system. This would need further detailed consideration to confirm no environmental concerns with Class A water release to the waterways. [Noting the likely dilution with stormwater].

SEW and MWC have approved in principle storing Class A Recycled Water within building rainwater tanks in scenario 3 with smart release to stormwater drains. It is noted that this concept is subject to further consideration and approvals by EPA and MWC in the future.

The idea of releasing residual amounts of Class A water which is stored in tanks so that the tanks can then be used to provide flood storage has several challenges:

- The need to forecast rain events and make the decision to release the tank contents;
- The need to release the tank contents quickly enough;
- The need to find a suitable end destination for the Class A water that is released;

- Accounting for the cost of producing Class A water which is then released; and
- The need to provide back up given the possibility of rain not occurring and the need to still meet demand but the tank is empty.

There is an interaction between these points. If forecasts are accurate some days in advance, then the tanks can be drawn down slowly by demand, and the need to 'dump' will be minimised.

However, there will be a need to allow for dumping. Two alternatives suggest themselves:

1. Sending the water to sewer [assuming the sewer system remains oversized to manage wet weather events, and since a rain event has not yet happened, spare capacity should be available];
2. Sending the water to the storm water system.

It is interesting to consider the second option. In this case, the Class A water will have lower pathogen content than the typical storm water flows, but higher nutrient content. Note that this water would then be diluted by the subsequent rain event. Note also that it would be entering the Bay, where the resulting concentration change is likely to be negligible. Note finally that if sent to sewer, the load will eventually enter the Bay, but lower down at WTP. Going to WTP will require pumping and then treatment, with the related energy cost.

These factors cannot be compared without significant further research, but it is apparent that there is some merit in either option. This point requires further research if this option is adopted.

Overall, a key element here is the likely ongoing improvement in forecasting accuracy and system control over time, which will reduce the livelihood of such releases. If this scenario proves to be attractive, there is an opportunity for significant refinement of the concept in terms of Class A treatment plant design (ramping up/down), network capacity and integration of smart tanks within the buildings. This is likely to occur as part of a future functional or detailed design.

E3 Third pipe characteristics

Two alternative third pipe arrangements have been considered within the options, namely building and precincts scale third pipe systems.

E3.1 Building Scale Third Pipe

Building scale third pipe arrangements have been considered in several options where rainwater supply is the only source of alternative water. For these schemes there is no third pipe within the street (i.e. there is no external supply or sharing of water between buildings).

Scenarios 0, 1 and 5 have a building scale third pipe (supplied with rainwater or building scale greywater), which only accommodates podium outdoor demands (i.e. does not accommodate public open space areas within the public realm). It is assumed that potable water will provide a source of irrigation to public open space areas in these scenarios.

On exception is the presence of a localised stormwater harvesting scheme has been incorporated into Scenario 5, which will complement the flood mitigation approach and provide alternative water for the local public open space demands. This has been included for cost benefit comparative purposes.

E3.2 Development Scale Third Pipe

Development scale third pipe arrangements have been considered in several options where there is a development wide source of alternative water (i.e. class A from local sewer mining plant) in addition to building scale rainwater harvesting. For these schemes there is a third pipe within the street (i.e. there is an external supply and/or sharing of water between buildings).

Scenarios 2, 3 and 4 have a development wide third pipe, which accommodates public open space areas both within the private and public realms (i.e. podiums, streetscapes and sports fields).

E4 Class A Supply from Local Sewer Mining Plant

One alternative for supplying Class A to the development is to source it from a local sewer mining plant drawing from the local or wider sewer network. On balance a single sewer mining plant drawing from a single extraction points is considered the most appropriate configuration. The conceptual design logic proposed is as follows:

- Single extraction point to capture 90% of peak demand;
- Single wastewater treatment plant sized to treat 90% of peak demand (18.5 ML/d); and
- Above ground balancing tank to hold 1 peak day of supply (20.6 ML).

It is proposed that the wastewater treatment plant would be staged to so that there is an opportunity to revisit the plant sizing based on real world experience. We have explored the salinity in the Melbourne Main Sewer and whilst the old sewer had periodic high salinity (TDS of 2,400 mg/L) the new sewer has a much lower prolife (TDS < 500 mg/L) – presumably due to a lot less groundwater intrusion.

If acquiring land was not a problem, the siting of the plant would ideally be situated in the vicinity of the Melbourne Main Sewer (i.e. close to an extraction point) and generally in the north east, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region. However, if a suitable site cannot be identified, the plant may need to be located in a more undeveloped precinct, leading to additional transfer main costs or constructed in a way that buffer distances can be reduced (i.e. underground such as the MCG sewer mining plant). Further discussion is provided below.

If acquiring land is a problem then the following alternatives need to be considered:

- Leasing land in the private realm (i.e. below building podium level); and
- Acquiring land to the west of Fishermans Bend (i.e. in the new 205 ha employment precinct proposed to the west of Lorimer precinct). Land in this precinct is yet to be zoned capital city zone and may be more readily available and affordable.

A single wastewater treatment plant could be staged by building the plant in a modular fashion. A single plant provides the following benefits relative to multiple plants:

- One asset to maintain;
- One site to acquire;
- Buffer requirements around one site.

Extraction from the local sewer network (capacity to be upgraded) is proposed. Extracting from the local sewer network rather than the Melbourne main sewer is considered advantageous due to the lower salinity in this network (as a result of the source of sewer inflows and groundwater infiltration). However, this approach has the disadvantage that sufficient flow must be available, and that flow may not grow simultaneously with demand, particularly if green spaces are developed early but people arrive later.Further work is needed to determine the optimum sizing of peak supply from the Class A network from this option. In other projects it has proved to be more economically feasible to only supply between 50 and 80% of peak demand from the Class A (with the remainder of the peaks being supplied with potable or rainwater), due to the infrequent peaks and underutilised investment. However, that may not apply in these precincts, as the ratio of peak to average day is predicted to be less as the proportion of green space watering is less.

Further, in this area, there is a cost of supplying additional peak day capacity of any kind, so the trade-off against additional Class A plant capacity will be less obvious.

Given these points, the current approach adopts 90% of peak day, and allows for staging so the relative merit of different approaches can be considered when more data is available.

Based on the assumption of drawing from local sewer networks, the likely configuration of the sewer mining plant would be:

- Extraction from the Melbourne main sewer with a pump station designed to exclude rags and larger solids, and also to contain any odours;
- Degritting and the like near the sewer to allow returns at that point;
- An MBR or similar compact process located within a building. This will manage odours and noise;
- All waste streams returned to sewer. [The main sewer rather than the local network if possible]; and
- UV disinfection and addition of some form of chlorine based residual.

Note that the overall process will change over time as new technologies become available. If the salinity is not managed [for example because the new sewers have infiltration from the high salinity groundwater], then RO or similar will need to be added, which will increase cost, land needed and also the return and extraction volumes due to recovery constraints.

General Considerations

The general consideration for the sewer mining plant are as follows:

1. The plant would be best if located near to a major sewer with low salinity.
2. The function of the plant is to make Class A water and not to 'treat' wastewater. So it does not need to manage wet weather peaks.
3. Wastes will be produced: WAS and filtrate and grits etc. Can these be returned to the main sewer?
4. What reliability is needed? If can be fully backed up with other source [Potable?], then does not need to be as reliable?
5. Will need connections for energy, and delivery of chemicals, and possibly need to take wastes away.
6. With variable demand, will operate at different rates from day to day. This creates a challenge for biological processes.
7. Operation needs monitoring to high level to ensure meets risk management requirements for Class A supply.
8. What is the source? Is it currently there, or will it occur once development happens? How to decouple these?
9. Salinity is added through use in house. So if source is from houses already supplied with Class A [or a 'loop' is proposed], then salinity in the system can rise.
10. Extraction point needs careful consideration. Could be an odour source. Must have safe access. Best to design to minimise sediments and ragging on extraction point infrastructure.

11. If majority of flow is removed from sewer, then there can be downstream effects due to low flow. Odour? Corrosion? Settling?
12. Removal of water and BOD from system, and then return of WAS etc means some form of new [trade waste?] licence may be needed for the waste return.
13. Operation costs relate to people, energy, chemicals, membrane replacement, monitoring and verification, maintenance and asset replacement. Many of these become cheaper as plant gets bigger on a per ML per day basis, as you need as many people etc for small plants.
14. Operation costs also relate to utilisation when quoted on a per ML basis. Peaking capacity plant is not fully utilised.
15. Some current uncertainty about whether UF is needed in addition to MBR. This makes some difference to the cost estimates.

Fisherman's Bend Specific Considerations

The Fishermans Bend specific considerations for the sewer mining plant are as follows:

1. Need to find a site which has area, near sewer, no neighbours, good road access, easy to excavate and build. These things are not possible, so any site will be a compromise and more costly than in green field area.
2. Could build a plant 'underground'. Or 'in a building', with extensive odour management etc. This will increase costs. Note that this still requires acquiring the 'space', either below public park, or under a building etc. Built 'underground' has other issues in this area due to high groundwater, likelihood of flooding and problems with contaminated soils.
3. Could [try to] find land outside the precincts and pipe water in. Perhaps toward the west in the extended FB area? If sufficient land can be acquired/gifted etc, then costs of construction may be less, but need to add cost of pipelines.
4. Access structure to the sewer for extraction also needs land. It is anticipated that there will be higher more than usual construction costs due to contaminated soil.
5. If not 'reliable', then need to consider whether avoided costs can be fully utilised.
6. How much saving on downstream infrastructure and operation? Not taking peak out? Not always taking load out? Still need near similar final WWTP??

E4.1 Land Take Requirements

The land take requirements associated with a local sewer mining plant (18.5 ML/d) are estimated to be in the order of 7,000 sq m. The land take requirements have been derived from recent work undertaken on the Ravenhall sewer mining plant.

E4.2 Basis for Capital and Operating Costs

The capital and operating costs have been derived from recent work undertaken on the Ravenhall sewer mining plant.

E5 Class A Supply from a Building Scale Greywater Treatment System

Another alternative for supplying Class A to the development is to source it from a from a building scale greywater plant. The approach differs for residential and commercial buildings as a result of

Sending the shower, clothes washing and miscellaneous supplies to the greywater plant within residential buildings results in excess demand. For residential buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant;
- Greywater treatment plant sized to treat 100% of average demand (33 kL/d), which is equivalent to 71 L/person/d;
- Balancing tank within each building to hold 1 average day of demand (33 kL/d); and
- Greywater distribution pump station within each building to supply 1 average day of demand (33 kL/d).

Sending the shower and potable supplies (no clothes washing) to the greywater plant within commercial buildings results in a supply constraint. As a result the commercial buildings the conceptual design logic proposed is as follows:

- Introduction of fourth pipe carrying greywater to building treatment plant;
- Greywater treatment plant sized to treat 100% of available supply (12 kL/d), which is equivalent to 27.2 L/person/d;
- Balancing tank within each building to hold 1 average day of supply (12 kL/d); and
- Greywater distribution pump station within each building to supply 1 average day of supply (12 kL/d).

It is considered that supplying greywater based on an average day of demand or supply is appropriate in this instance (rather than peak day). Regardless of the class A from greywater supply regime, provision of potable back-up will be required due to the independent nature of these plants (i.e. operated by third parties) and their inherent reliability (i.e. SEW cannot control or guarantee the plants will be operating 100% of the time).

Greywater treatment for Class A reuse is not common. As a result it is not clear what treatment train might be required based on other projects, or the trains typically approved by DOH. The following train is therefore only a preliminary suggestion, and more consideration is required.

To some extent, the amount of treatment required will also depend on which of the uses in the dwelling are connected to the grey water system. The inclusion or exclusion of the laundry could be a significant factor. The likely configuration of the greywater plant would be:

- Some form of fine screening to remove hair, and other solids;
- Ultra-filtration, potentially with upstream chemical dosing to manage some organic constituents;
- Disinfection with UV and chlorine based residual;
- Waste returns to the sewer; and
- Housed in a building to manage noise and any odour.

Note, this process should have a lower footprint, energy use and impact than a blackwater MBR.

However, this approach could share the risk seen with blackwater plants in each building: if the building managers in future see the operation of the plant to be problematic, costly, or both, they could stop operating, with the demand returned onto the central network.

This raises the possibility of considering larger schemes collecting greywater which are more district oriented and could then be operated by the water authority. This would require and additional street network of greywater collection pipes which has additional cost and complication.

[Note: Another idea has been brought up: that the grey water be captured and then treated to potable standard. This would eliminate a number of additional pipes. This is unlikely to be welcomed by the current regulators given the current limitations on knowledge, but is likely to be worth consideration in the longer term.]

E5.1 Land Take Requirements

We estimate the land take requirements for greywater treatment plant infrastructure to be relatively small in each building. Based on an average 12 kL/d plant in commercial buildings, it is estimated that 15 sq m of footprint will be required in each building. Based on an average 33 kL/d plant in residential buildings, it is estimated that 30 sq m of footprint will be required in each building.

E5.2 Basis for Capital and Operating Costs

A variety of building scale greywater and blackwater systems were identified within the following two studies:

- Wastewater reuse in the Urban Environment: Selection of Technologies, Landcom, 2006.
- Institute for Sustainable Futures (2013), Darling Quarter Case Study: Building Industry Capability to Make Recycled Water Investment Decisions, Prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the Australian Water Recycling Centre for Excellence.

The capital costs identified in these studies were estimated to be in the order of approximately $17,000-34,000/kL.

E6 Stormwater Harvesting Plant Characteristics

Stormwater harvesting is proposed to provide a source of alternative water for precinct public open space and building demands (Scenarios 3 and 4) through the development wide third pipe network and at a local scale network based on flood mitigation storage siting and nearby public open space demands (Scenario 5).

E6.1 Precinct Based Approach (applies to Scenarios 3 and 4)

One alternative for supplying treated stormwater to the development is to source it from proposed end of line flood storages within the precinct and back-up with class A recycled water sourced from a local sewer mining plant. On balance a combined stormwater/sewer mining treatment plant makes sense. A single stormwater/wastewater treatment plant could be adopted and staged by building the plant in a modular fashion. A single stormwater/sewer mining treatment plant provides the following benefits relative to multiple plants:

- One asset to maintain;
- One site to acquire;
- Buffer requirements around one site.

The conceptual design logic proposed is as follows:

- Low flow diversions into flood storage (equivalent to 3 month ARI flow);
- Primary below ground flood storages to provide initial capture. Due to poor ground conditions and ability to drain the flood storages (due to tailwater levels), the end of line flood storages are proposed to provide short term flood detention prior to pump directly to

the sewer mining/stormwater treatment plant (daily demand exceeds flood storage volume).

- Pump Station with rising main from flood storage to sewer mining/stormwater treatment plant (15.5 ML/d);
- Single sewer mining/stormwater treatment plant sized to treat 90% of peak demand (18.5 ML/d);
- Class A balancing within the building rainwater tanks to hold 1 peak day of supply (20.6 ML/d) or shared storage in building rainwater tanks in the case of Scenario 3; and
- Class A distribution pump station (20.6 ML/d) or building scale distribution pump 52 Kl/d in the case of scenario 3).

The siting of the plant is situated in the vicinity of the Montague precinct, which is considered to be sensible given that this precinct is likely to be redeveloped relatively early relative to the urban renewal of the entire Fishermans Bend region and is likely to require some form of flood storage.

The treatment plant requirements would be similar (some refinements possible) to those proposed in the case of a standalone (refer Section F4) and include:

- Degritting and the like near the sewer to allow returns at that point;
- An MBR or similar compact process located within a building. This will manage odours and noise;
- All waste streams returned to sewer. [The main sewer rather than the local network if possible]; and
- UV disinfection and addition of some form of chlorine based residual.

Note that the overall process will change over time as new technologies become available. If the salinity is not managed [for example because the new sewers have infiltration from the high salinity groundwater], then RO or similar will need to be added, which will increase cost, land needed and also the return and extraction volumes due to recovery constraints. The treatment plant would also be able to draw upon additional stormwater storages within the other precincts as they come on line. Stormwater would be transferred from the flood storages to the treatment plant using pumps.

The land take requirements and basis for capital and operating costs associated with the treatment plant are explored within Section F4. The land take requirements and basis for capital and operating costs associated with the primary storage and pumps are explored within Section F8.

Evaluation of Development Wide Stormwater Harvesting Yield

An evaluation of the stormwater harvesting yield and volumetric reliability of supply for alternative water supply to meet (a) outdoor public open space demands outside the podium (b) outdoor public open space demands outside the podium and building alternative water demands inclusive of the podium. This assessment was undertaken for a variety of tank retention volumes to ascertain where the diminishing point of return on the yield curve occurs.

Key assumptions include:

- Total contributing impervious catchment of 32.9 ha when both roof and 70% of podium are connected to the rainwater tank (i.e. not available for stormwater harvesting);
- Climatic period (average conditions) 1961 – 72 (daily time step adopted for water balance purposes);

- Stormwater demand (273.4 ML/yr) has been split into two components and includes:
  - 100% of the public open space demands (excluding podium demands supplied from building rainwater tanks), which is equivalent to 191 ML/yr based on different irrigation application rates for active/passive open space and streetscapes (refer to design basis attached);
  - 100% of the outdoor (podium), toilet and clothes washer demands for each building (refer to design basis assumptions attached)), which is equivalent to 82.4 ML/yr; and
- Average residential population of 460(equivalent to 12 story building with a density of 1 person/50 sq. m) and average employment population of 460 (equivalent to 5 story building with a density of 1 person/20 sq. m). An average population of 460 was adopted in both cases as this is equivalent to the total ultimate development population of 181,050 (design basis) distributed over 392 buildings. In reality the residential and employment precinct building heights, rood areas and use types (i.e. mixed use) will vary across the precinct;

The following can be concluded from the graphs provided below:

- The diminishing point of return is at a storage volume of approximately 20 ML;
- The volumetric reliability is approximately 38.5% (equivalent to a yield of 74 ML/yr) of the total precinct public open space demand of 192 ML/yr (based on a 20 ML storage size and assuming tanks only capture roof runoff);
- The volumetric reliability is approximately 2.4% (equivalent to a yield of 116 ML/yr) of the total precinct public open space and podium/in building alternative water demand of 4,928 ML/yr (based on a 20 ML storage size and assuming tanks only capture roof runoff);
- The return on investment (i.e. yield relative to tank size) for stormwater harvesting is significant lower relative to rainwater harvesting (i.e. rainwater tank volume is typically turned over 2.5 times more than the stormwater storages). This is largely due to the fact that the stormwater yields are diminished in all scenarios by the presence of rainwater tanks in all buildings capturing roof or roof and 70% of the podium.

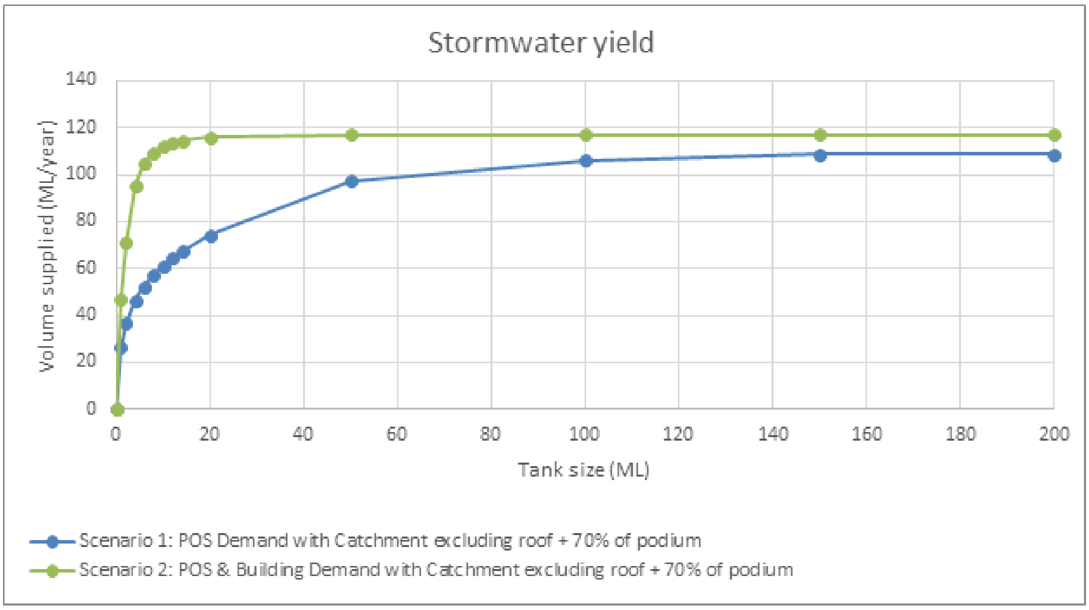


Figure E4 Stormwater Harvesting Yield to meet POS & POS/Building Alternative Water Demands

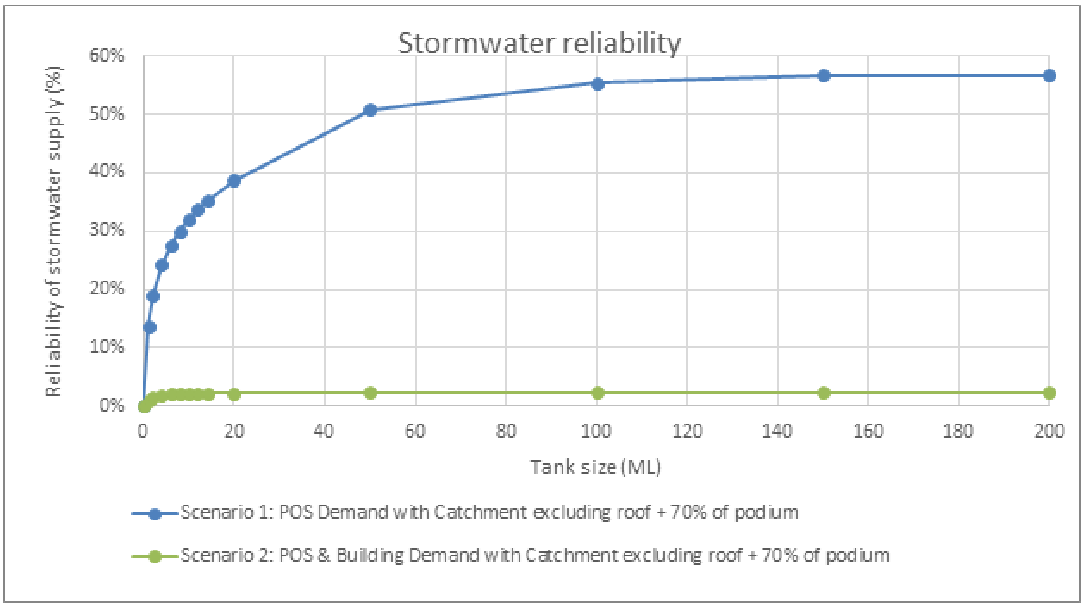


Figure E5 Stormwater Harvesting Yield to meet POS & POS/Building Alternative Water Demands

E6.2 Local Approach (applies to Scenario 5)

One alternative is to provide treated stormwater to a local public open space demand within close proximity to one of the proposed flood storages within the precinct. The conceptual design logic proposed is as follows:

- Storages below/adjacent selected raingardens (i.e. within proposed greenspines) capturing treated stormwater for future reuse; and
- Pumping to sub-surface irrigation of public open space within close proximity to the selected raingardens.

Currently, there is no mandatory requirement that dictates what stormwater can be used for or what quality standards stormwater must meet. A risk based approach is typically adopted whereby the more likely it is that stormwater will place people or the environment at risk, the higher the water quality requirements and more stringent the management controls. The Australian Guidelines for Water Recycling specifically call for a management plan to be developed. A risk management plan typically includes stormwater sampling (catchment and event based contaminant profiles can be highly variable) and direct (i.e. advanced treatment) or indirect controls (i.e. sub-surface irrigation or irrigating at night in an areas fenced off from public use during irrigation periods). Given the intended use for this option is limited to public open space we have assumed that indirect controls will be adopted in this instance.

The land take requirements and basis for capital and operating costs associated with the local storages and pumps are explored within Section F8.

Evaluation of Localised Stormwater Harvesting Yield – Montague Precinct

An investigation of a local scheme within the Montague precinct that sources stormwater from the Montague flood storage (8.3 ML) and pumped directly to an above ground balancing tank (8.3 ML) before distributing to POS within the precinct would provide a yield of approximately 45 ML/yr. Whilst the overall yields are lower relative to a scheme that supplies to buildings the level of treatment required reduces the cost and difficulty.

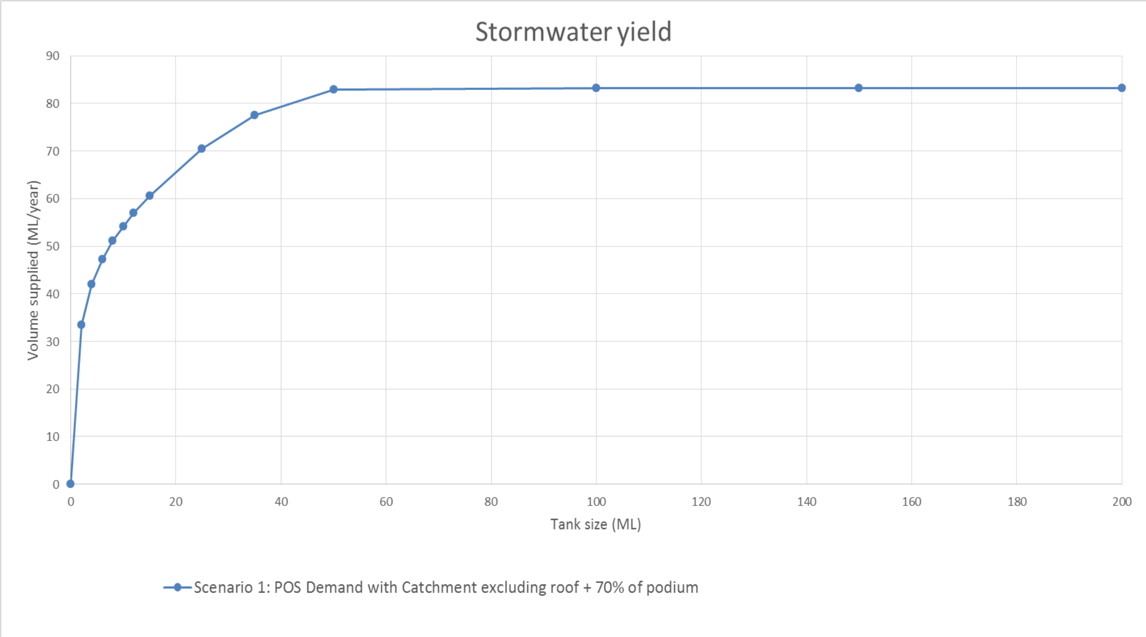


Figure E6 Stormwater Harvesting Yield to meet Local Alternative Water Demands

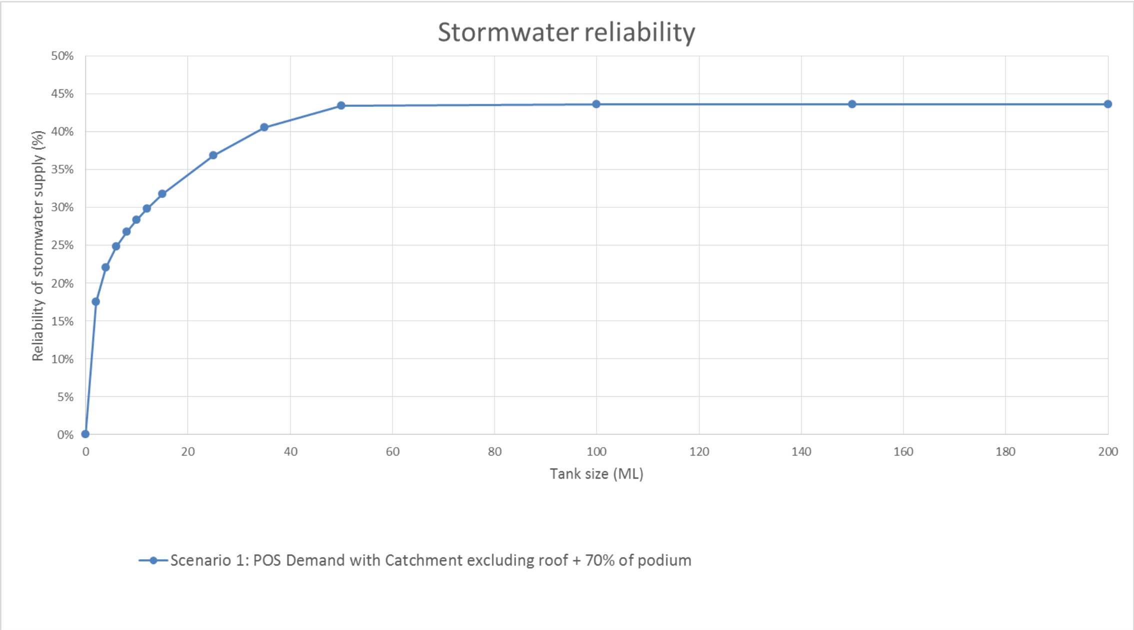


Figure E7 Stormwater Harvesting Reliability to meet Local Alternative Water Demands

E7 Water sensitive urban design (WSUD)

Water sensitive urban design (WSUD) infrastructure consists of precinct wide infrastructure to meet the best practice environmental management guidelines (BPEMG) and SFP. It is anticipated that this infrastructure will be distributed across both the private realm (i.e. podiums) and public realm (i.e. streetscape).

We have determined that 11,200 sq m of bioretention systems in the form of raingardens, tree pits (or equivalent) will be required to meet the BPEMG and SFP requirements based on MUSIC modelling of the precinct. It has been assumed that stormwater harvesting, treatment and reuse initiatives will effectively improve the water quality beyond best practice.

We anticipate that 50% of the bioretention systems in the form of raingardens, tree pits (or equivalent) would be accommodated within the private realm (i.e. podiums). This equates to approximately 18 square metres of bioretention systems per podium. The remaining 50% of the bioretention systems would be accommodated within the public realm (i.e. streetscape) based on the fraction impervious make-up of the precinct.

It is proposed that these assets are relatively shallow and lined (i.e. do not infiltrate to groundwater) to minimise impacts to an already shallow groundwater table and mobilisation of contaminants.

E8 Drainage

Drainage infrastructure consists of infrastructure to manage flooding to nominally meet the desired levels of service. This may include different scale storages and conveyance infrastructure such as a combination of pipes, channels, swales and, pumps It is anticipated that with the exception of rainwater tanks this infrastructure will be largely located in the public realm (i.e. streetscape, public open space or land acquired to accommodate infrastructure in required locations). A brief overview of key flooding characteristics affecting the drainage analysis is given in the following sections. Further details on the drainage characteristics and flood modelling methodologies and assumptions can be found in Appendix F.

E8.1 Regional drainage features and characteristics

Flat terrain and cross-connections in underground drainage networks.

Much of the area is relatively flat, which means that underground drainage does not always follow the surface slope. There are multiple cross-connections and bifurcations in both the Council and Melbourne Water underground drainage networks. This means that catchments interact with each other via surface flows, underground drainage networks and a combination of both to varying degrees in different events.

Catchments draining to Yarra and modelling of Clarendon Street precinct.

As previously mentioned, the area draining to the Yarra is low-lying and particularly susceptible to tailwater at both the prescribed 5-year (1.1 m AHD) and 100-year (1.42 m AHD) levels. There is an existing stormwater pumping station at Crown Casino, which is fed by the Hanna Street Main Drain on the eastern side of Clarendon Street. The Hanna Street Main Drain is a large catchment (421 ha) located outside the Fisherman's Bend precincts stretching from Albert Park Lake to the Yarra. Whilst the underground drainage systems on the western and eastern sides of Clarendon Street are separate, near the outlet, the catchments interact via overland flow resulting in ponding when one or both systems surcharge into the large depressed area.

When ponding from Clarendon Street reaches a level of approximately 0.80 – 0.95 m AHD and stretches back down the south western branch of Whiteman Street, it flows into the 525 mm Council drain southwest into the Montague precinct. To isolate flow originating from the external catchment an additional pump station at Clarendon Street will be sized and included in all Scenarios except Scenario 1 (Conventional servicing with rainwater tanks as per SFP and no precinct based drainage).

This additional pump station will be sized to limit flooding originating from the system on the western side of the road so that ponding on Whiteman Street does not drive flow into the 525 mm Council drain. The limitation of this approach is that it does not account for the additional flood storage or pipe capacity which may be available on the eastern side of the road, or for any flows which may be crossing the road from east to west from the Hanna St drain catchment if this is experiencing greater surcharging. There is potential to provide additional capacity for the Hanna St catchment if desired, subject to detailed investigation in the future.

Port Melbourne Pump Station

The existing Port Melbourne Pump Station located on the Esplanade West Main Drain has been included in all scenarios. The Esplanade West Main Drain catchment borders on the southern side of the Montague Precinct (refer to map in Appendix B).

The pump station and bypass channels are understood to include non-return valves which isolate the upstream catchment from high Bay levels, providing additional storage within the underground drainage network and in low lying surface areas compared to if these were not present. This is particularly important in longer duration, volume dominated events.

E8.2 Target Levels of Service

By agreement with Melbourne Water the target levels of service that has been adopted for our analysis of the drainage requirements are as follows:

- 5 yr ARI - no surface flooding in roads or private realm;
- 100 yr ARI - no surface flooding within property boundaries; and
- 100 yr ARI - designated overland flow paths (inclusive of minor and/or major thoroughfares) meeting a low safety risk in roads category where practical.

In accordance with the MW Flood Mapping Projects, Guidelines and Technical Specifications (MW, 2014) a low safety risk in roads is defined as having a velocity times depth <= 0.40 cumecs/m with a depth <= 0.40 m . In addition, flooding is defined as greater than 50 mm depth.

Given this is a preliminary assessment of development concepts which are likely to be refined, details of the drainage system have not been optimised to achieve the above design objectives. Pipe sizes have been selected using minimum underground drainage requirements (i.e. 300 mm diam. pipes in accordance with CoM requirements) and an understanding of the infrastructure required to achieve the objectives. Variations in performance between development scenarios have influenced the major asset requirements such as pump stations and storages, however are not reflected in the underground drainage network. It is recognised that there will be differences between the assessed infrastructure and future detailed designs. The adopted approach and modelled system characteristics will in places over and or under achieve the design objectives. Importantly the adopted approach enables a comparison of the effect of various development scenarios via the reduction in AAD and variation in flood mapping outputs whilst minimising the potential distortion in apparent performance which would occur with resizing and optimisation of collection assets between scenarios. This is a more direct method of assessing the drainage benefits of a particular scenario rather than optimizing the drainage system for each scenario in an attempt to match performance objectives and subsequently comparing infrastructure costs of systems with similar but non identical performance characteristics.

E8.3 Scenario 0 (Conventional servicing with rainwater tanks as per SFP and no precinct based drainage) Flood Characteristics

Terrain is one of the most dominant factors in determining flooding characteristics. To approximate the assumed future urban form podiums and building footprints are raised to 3 m AHD, or 0.6 m above the existing terrain levels in higher areas. New streets are assumed to tie into existing road levels, with profiles in line with those given in the Strategic Framework document. Kerb heights of 150 mm have been assumed for all new streets, including laneways, and cross fall has been determined by existing levels on either side of the new streets. Whilst application of minimum and maximum grades and cross-falls could affect the flooding observed in the modelling, design of roads is outside the scope of this study, and the actual form of future roads is expected to vary.

A map of the future conditions flood extents (with no new street drainage infrastructure) in low lying areas with flood depths exceeding 400 mm in the 100 year ARI event is attached (refer Appendix B).

This flood mapping shows that areas within the Montague, Lorimer and parts of Sandridge precinct have flood depths exceeding 400 mm, which will require mitigation works. A significant cause of the flooding is the downstream tailwater levels, which backwater through the drainage system.

There is also wide spread flooding in the 5 yr ARI event, which is largely less than 400 mm and constrained to the streets. It is proposed that traditional drainage upgrades and servicing of new roads will largely mitigate this flooding.

It is also useful to consider that this new flood extent is similar to that without development, as the current area is in fact heavily developed with significant impervious surface.

E8.4 Important Design Considerations

All conventional and alternative drainage approaches need to consider that there is a stormwater quality-quantity trade-off. As stormwater drains from roof to podium and eventually to street level the quantity available to harvest (and to be managed to mitigate flooding) increases whilst the quality of stormwater diminishes. This occurs because the closer to ground level water is captured the more there is generally available, but the quality is generally diminished due to the greater number of contaminant sources the stormwater has passed. This concept is captured within Figure F8.

In addition, due to the relative level of tailwater conditions adopted for the Yarra River and Port Phillip Bay in accordance with Melbourne Water requirements, it is recognised that new underground drainage infrastructure will not allow Fishermans Bend to free drain under a variety of flood scenarios (from high to low frequency events). Further, a traditional drainage approach of constructing large underground drains is not in keeping with the principles of integrated water cycle management. As a result four alternative approaches to flood mitigation are explored below. These flood management options might vary from precinct to precinct.

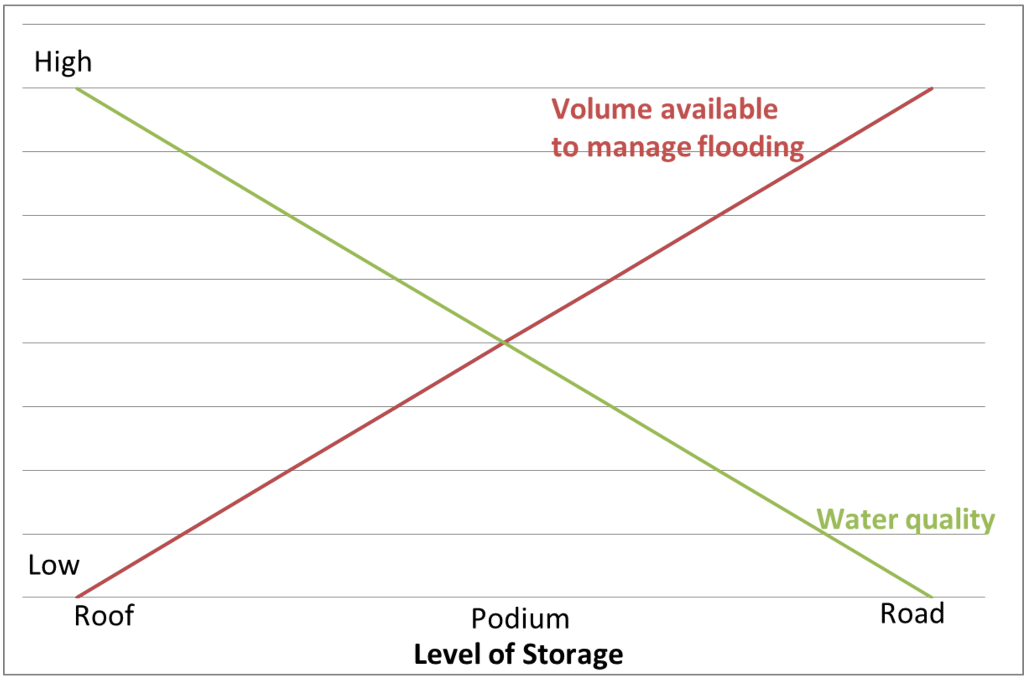


Figure E8 Trade-off between volume available to manage flooding and diminishing water quality

Benefit of Non-Return Valves on all Drainage Outlets

The existing Port Melbourne Pumping Station acts to isolate the part of the system draining to the Bay located upstream from the effects of tailwater.

There is a benefit in installing non-return valves (i.e. duck bills) on pipes to the Yarra River to prevent backflow up the pipes and into low lying areas within the Montague, Lorimer and Sandridge precincts. By installing non-return valves there is additional storage both at surface level and within the underground drainage system. Once the tailwater levels drop, the floodwaters within these storages will recede accordingly.

We anticipate that between 10 and 15 non-return valves would provide benefits to these precincts for base climate conditions.

The City of Melbourne have highlighted many pipes have flap valves that are not functioning. Another alternative that could be explored is the application of duck bills, angled in the direction of outfall flow and protected by wing walls. Duck bills have proven to be less prone to blockage from debris or fusing shut. The City of Melbourne have confirmed that this is anecdotally the case based on their work at Birrarung Marr.

Building Rainwater Tanks for Flood Detention/Retention at Building Podium Level (Applies to all Scenarios)

Alternative rainwater tank approaches are explored within Section F1. It is anticipated that a podium level approach would involve the installation of a rainwater tank just below the podium level. Roof runoff would be directed into the tank (in accordance with the SFP), whilst podium level runoff (non-trafficable impervious) would run through bioretention systems (raingardens) before entering the tank. The concept is illustrated within Figure F9.

The advantage of having storages at podium level is twofold. There is a supply of alternative water in close proximity to the external water demands (i.e. greening the podiums and building facades) as well as the embedded energy of the elevated tanks relative to building and street level (i.e. tanks can gravity drain to meet green spine demands at street level or meet in building demands such as toilets, requiring less energy to pump into the building).

With its limited catchment, collection at podium level may not provide an opportunity to completely mitigate flooding within the precinct; it provides an opportunity to harvest a higher quality of supply (as captured within Figure F9).

The building scale rainwater tanks provide approximately 54-108 ML of detention/flood storage (depending on the scenario). For scenarios involving streetscape or precinct based detention/flood storage (Scenarios 3, 4 & 5) it is estimated that the rainwater tanks provide between 77 and 87 % of the overall detention requirements for flood mitigation.

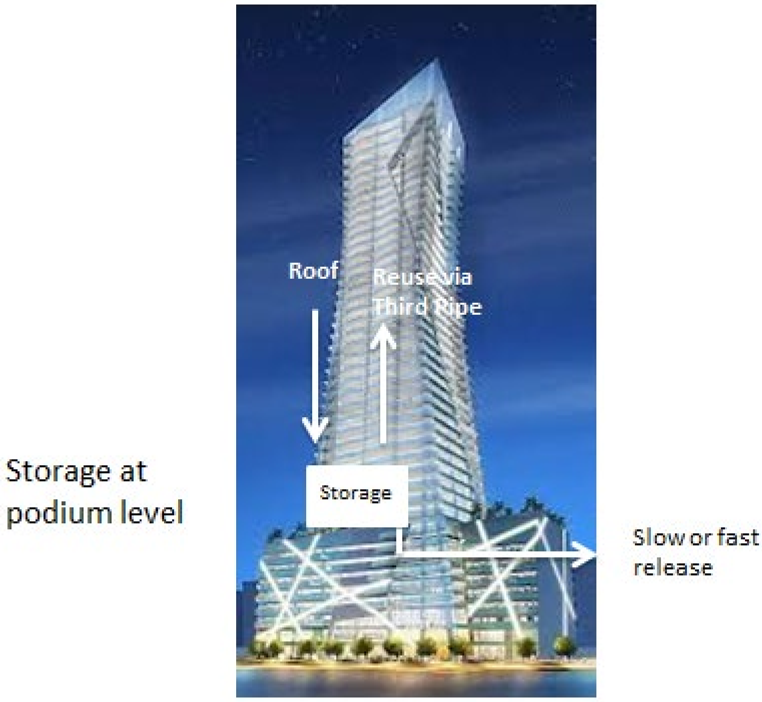


Figure E9 Podium Level Flood Mitigation Approach

E8.5 Conventional Drainage Approach

It is proposed under a conventional drainage approach (applies to Scenarios 1 and 2) all areas will be piped either to the Bay or Yarra River. It is assumed that all pipes will be fitted with non-return valves (i.e. duck bills) to eliminate back-watering.

In low lying areas that do not free drain (i.e. where the tail water conditions present a significant impediment to drainage capacity), sump and pumps infrastructure is proposed. We have identified that sump and pump arrangement are confined to sub-catchments within the Lorimer, Montague and Sandridge precincts that drain to the Yarra (i.e. sub-catchments that drain to Port Philip Bay currently have sufficient elevation to not require pumping).

The sump and pump approach (refer Figure F10) has been considered to be the conventional approach or base case starting point for mitigating flooding. The pump and sump approach provides the ability to resolve flooding in areas where other options may not be feasible (i.e. limited free gravity outfall potential, large sub-surface approaches limited due to shallow groundwater table, contaminated land and a lack of open space to construct open storages), and provides flexibility to accommodate climate change conditions with little or no upgrade required.

In low lying areas, which are the most flood prone areas in or downstream of the precincts, volume is a driving factor rather than attenuating peaks. If volume is not removed by pumping from the system, large storage volumes are required. Given the ground conditions the application of traditional retarding basins is very difficult. In the past concern has been expressed over these occupying a large proportion of the public open space, particularly if the water takes an extended period of time to recede making the open space unusable during this time and potentially requiring grass to be reseeded.

As a result, sumps and pumps have been located at low points/ land locked areas within or downstream of the precincts where tailwater conditions (with non-return valves in place) prevent free drainage. Non-return valves were fitted in areas where not doing so would cause new pipes to be significantly filled from the bay level, or to pipes draining areas where the surface level was below the 100-year tailwater level

In order for all overland flow paths (inclusive of minor and major thoroughfares) to meet the 100 yr ARI hazard criteria, it is estimated that 128 ha of the total precinct area (258 ha) will require sump and pump arrangements to achieve the above levels of service, whilst the remaining 130 ha will be serviced by conventional drainage.

In order for all overland flow paths (inclusive of minor and major thoroughfares) to meet the 100 yr ARI hazard criteria, it is estimated that 128 ha of the total precinct area (258 ha) will require sump and pump arrangements to achieve the above levels of service, whilst the remaining 130 ha will be serviced by conventional drainage.

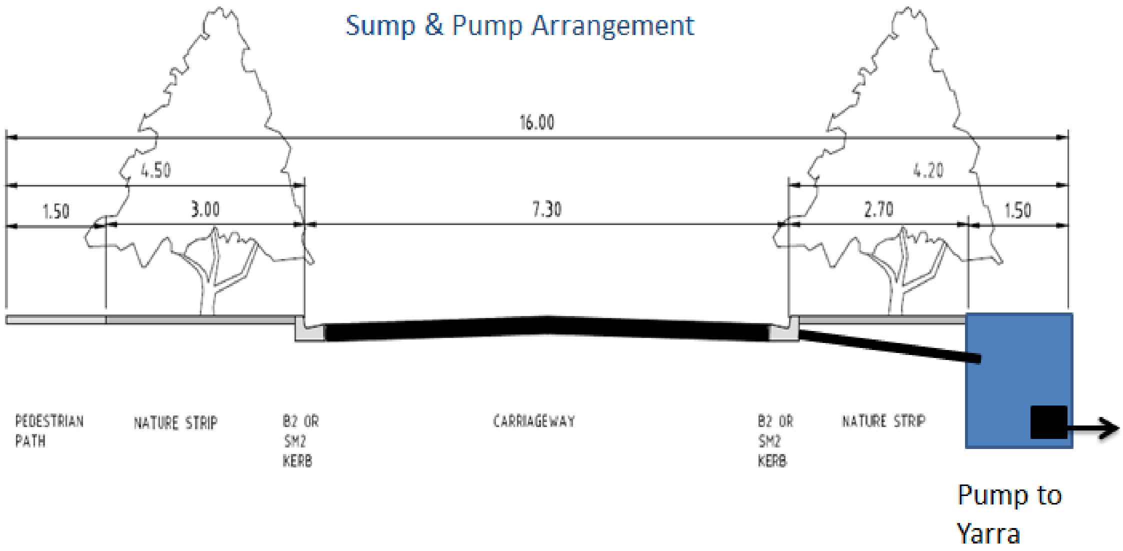


Figure E10 Sump & Pump Flood Mitigation Approach

E8.6 Alternative Drainage Approaches

The three alternative drainage approaches that are applied across the scenarios include:

1. Increasing the rainwater tank volume available for Flood Detention/Retention by utilising "Smart Tanks" which are sufficiently empty prior to a flooding event (Scenarios 3 & 5) ;
2. Precinct Scale Flood Storage Approach (Scenario 3 & 4); and
3. Local Streetscape Flood Storage Approach (Scenario 5).

The smart rainwater tanks are explored in Appendix F1. The precinct and local streetscape storage approaches are explored in further detail below;

Precinct Scale Flood Storage Approach (Scenario 3 & 4)

A precinct scale flood approach (refer Figure F11) would involve the capture of road, open space and pipe runoff within an underground storage.

It is anticipated that a precinct scale flood approach would involve constructing storages either directly below the road (through the use of shallow grated storages or structural soil) or in open space areas (i.e. along green spines, setbacks, parks etc.). These systems could be configured in a number of ways including:

- Connected directly to the road through grates (applicable to storages directly below the road -);
- Connected to the road and/or open space areas via pipes;
- Connected to streetscape bioretention systems (raingardens), which provide pre-treatment.

A gravity and/or sump and pump arrangement would then drain the storage to the Yarra River or Bay (depending on the relative level within the precinct) or to local treatment plant for reuse within the precinct.

This option is also likely to be more attractive where brand new roads are being constructed due to redevelopment, rather than on existing heavily used roads.

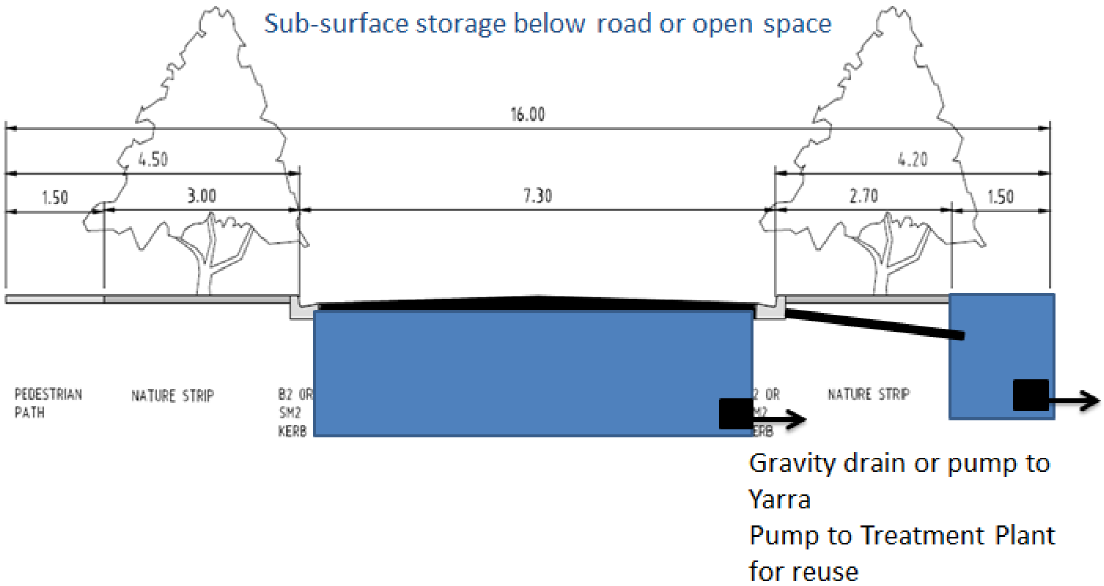


Figure E11 Sub-Surface Flood Mitigation Approach

E8.7 Local Streetscape Flood Storage Approach (Scenario 5)

A local streetscape approach (refer Figure F12) would involve the capture of road runoff within the road profile or adjacent raingardens (fitted with designated flood detention). It is anticipated that a street level approach would involve modifying the road profile by either flattening and deepening the profile or dropping the crown. A gravity and/or sump and pump arrangement would then drain the street as the flood peak recedes (depending on the relative level within the precinct). .

Collection at street level may not provide an opportunity to completely mitigate flooding within the precinct; however it provides an opportunity to mitigate flooding in areas where some other approaches are not feasible (i.e. sub-surface approaches limited due to shallow groundwater table, contaminated land and a lack of open space to construct open storages). A street level approach could be applied to designated streets so that egress can be maintained along key splines and certain streets are designed to provide temporary flood storage (a living with flooding approach).

This approach is also likely to be more attractive where brand new roads are being constructed due to redevelopment, rather than on existing heavily used roads.

This approach is proposed to be implemented in conjunction with a local stormwater harvesting scheme to provide additional water to the surrounding public open space areas during dry periods. An approach similar to that adopted by the City of Melbourne at Darling St, Fitzroy Gardens and Birrarung Marr using designated detention zone/streetscape (rather than a primary tank) to capture runoff before filtering through a bioretention system and storing (potentially above ground) for use during dry periods. This approach allows for the capture of runoff before it goes into the underground drainage network, which mitigates the need for significant deep sub-surface infrastructure requirements and the need for pumping above tailwater levels.

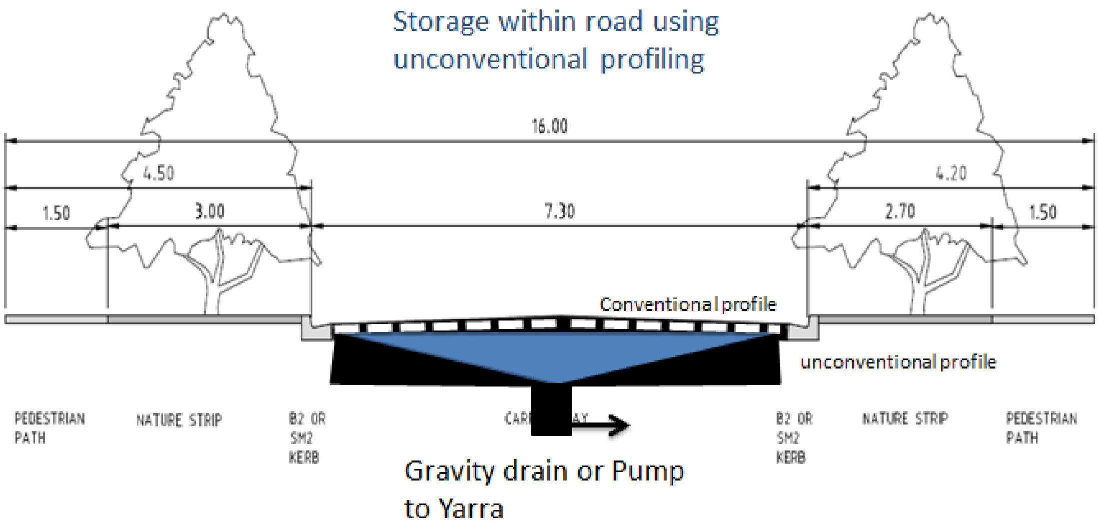


Figure E12 Local Streetscape Approach

E8.8 Summary of Drainage Approaches

The drainage approach adopted for each of the respective scenarios is summarised in Table F2Table below. Outcomes achieved by each of the scenarios are explored within Section 9.

Table E2 Summary of Drainage Approaches

Scenario	Description	Lot Scale Tank Approach[1][4]	Precinct Scale Approach
0 - Conventional Water, Sewer with (no minor or major drainage upgrades) – Base Case	Conventional servicing with rainwater tanks as per SFP and no precinct based drainage. Slow release rainwater tank	Slow Release 278 kL rainwater tank (139 kL of flood storage)	Rainwater tanks as per SFP and no precinct based drainage.
1 - Conventional Water, Sewer & Drainage upgrades	Conventional servicing [no development wide third pipe]	Slow Release 278 kL rainwater tank (139 kL of flood storage)	Conventional drains/swales & pump & sump Non-return valves on all outlets to Bay/Yarra.
2 - Sewer Mining in the Precinct	Sewer Mining with development wide third pipe. Conventional drainage upgrades.	Slow Release 278 kL rainwater tank (139 kL of flood storage)	Conventional drains/swales & pump & sump Non-return valves on all outlets to Bay/Yarra.
3 - Interlinked Third Pipe Supply	Mix of lot & development scale initiatives. Harvested rainwater, stormwater and sewer mining mix to third pipe network. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and end of line retention and reuse.	Enhanced on site retention and reuse through Smart Fast Release 278 kL rainwater tank (278 kL of flood storage)	Conventional drains/swales Smaller development wide infrastructure with end of line retention and reuse (as a result of Smart Fast Release rainwater tank). Non-return valves on all outlets to Bay/Yarra.
4 - Stormwater Harvesting in the Precinct	Precinct scale stormwater harvesting into third pipe. End of line stormwater retention and reuse.	Slow Release 278 kL rainwater tank (139 kL of flood storage)	Conventional drains/swales End of line retention and reuse. Non-return valves on all outlets to Bay/Yarra.
5 - Lot focus	Lot scale approach to minimise precinct infrastructure. Designated tolerable road flooding. Smaller development wide infrastructure through enhanced on site retention and reuse (smart tanks) and distributed streetscape storage (within street and raingardens).	Enhanced on site retention and reuse through Smart Fast Release 278 kL rainwater tank (278 kL of flood storage)	Conventional drains/swales Designated tolerable road flooding. Smaller distributed streetscape storages (as a result of Smart Fast Release rainwater tank). Non-return valves on all outlets to Bay/Yarra.

[4] [1] Tank size provided for illustrative purposes and is based on an average roof of 1903 sq m and an average podium hardstand of 853 sq m. In practice the tanks will vary from site to site.

Appendix F - Flood modelling methodology and assumptions

Model extent

The model extends from the Yarra in the north to Port Phillip Bay in the south, and broadly Todd Road in the west to Clarendon Street in the east.

Software

TUFLOW version 2013-12-AC-iDP-w64 was used for flood modelling of all scenarios. Utilising linked 1d (estry) and 2d (TUFLOW) domains.

Rainfall and storage volumes

The critical durations are expected to change between the development scenarios due to changes in available storages and discharge capacity.

The tanks connected to the podiums and rooves in the precincts are designed to capture up to the first 101 mm, although for modelling purposes they have been assumed to start half full (and retain 50.5 mm) in the slow release tank scenarios (0, 1, 2 & 4), or completely empty (and retain 101 mm) in the “smart tank” scenarios (scenarios 3 and 5). Therefore the buildings and podiums will not create runoff in events shorter than these. The durations at which the buildings and impervious podium areas will begin contributing are tabulated below.

Table F1 Threshold Storm Durations

ARI	Event Duration for shich rainfall total exceeds 50.5 mm. This is the amount required to fill the 139 kL of available storage per building as assumed for Scenarios 0, 1, 2, and 4	Event Duration for shich rainfall total exceeds 101 mm. This is the rainfall amount required to fill the 278 kL of available storage per building as assumed for Scenarios 3 and 5.
5-year	12 hour (55 mm)	NA
100-year	1.5 hour (54 mm)	12 hour (105 mm)

Peak levels in the streets and other local areas may peak in events of shorter duration due to the contribution of local catchments without connections to empty rainfall ranks.

The relative contributions of the areas connected to tanks and other local areas such as streets, open space and podium rain garden areas, external catchment flows and tail water effects will vary from catchment to catchment. Predicting a critical duration for the each ARI and scenario is therefore not easy to estimate without detailed modelling. URS time of concentration calculations estimated approximately a one hour duration for the outlets in base case (existing) conditions. This relates to peak flows and does not account for the fact that volume is a critical factor in determining maximum flood levels particularly in ponded areas. Ponded areas include areas which are pumped and or where flow is retained for any significant period of time.

Modelling approach

Much of the modelling approach (e.g. use of rain on grid) was continued from the TUFLOW model URS prepared for the City of Port Phillip in 2011, which GHD was asked to adopt and make only necessary adjustments to. Key changes were generally made only where substantial errors were found. Melbourne Water advised a single large model with longer run times was preferred over multiple smaller, quicker models. To make it practical to run the model for the entire area and durations up to 72 hours it was necessary to change to a 4 m grid cell.

Key changes made included:

- Modelling additional durations to the two durations (45 minute and 1.5 hour) modelled by URS.
- Further dividing land use categories into 10% impervious fraction ranges to represent differing losses.
- Changing a single rainfall polygon to multiple rainfall polygons based on impervious fractions with appropriate factors to replicate the RORB runoff co-efficients prescribed by Melbourne Water.
- Adoption of variable depth Manning's "n" values on areas such as buildings which behave differently when primarily acting in runoff mode vs conveyance mode.
- Changing inverts on pipes which had negative slopes or were above the inverts of incoming pipes, except where these are at bifurcation locations where they are likely to form a high level relief system, or where Melbourne Water GIS layer inverts indicated that slopes were negative, or there was a step up.
- Changing pipes from circular to rectangular where Melbourne Water GIS layers indicated these were not circular.
- Changing inverts on pipes which had no cover (were effectively sticking out of the ground).
- Increasing the tail water levels to those provided by Melbourne Water.
- Adding additional City of Port Phillip pipes and pits from Council's GIS layers which were located within or close to the precincts and not present in the URS model
- Adding City of Melbourne pits and pipes in areas the model was extended and connecting the City of Port Phillip network to these as appropriate.
- Representing Melbourne Water's Port Melbourne Pumping Station in the model.

Where elaboration is required these changes are further described in the following sections.

2d model setup and base data

The 2d model is a 4 m grid, with elevations assigned from the 2009 coastal LiDAR data set. Changing the underlying terrain was necessary as the URS models did not provide the full extent required, and were on different orientations from model to model.

"Z shapes" have been used to alter the terrain in the model in areas where holes were observed in key areas (such as where large buildings were under construction and significant excavation was seen in the data set within or upstream of the precincts), or in areas where bridges had caused obstructions to flow in the DEM.

Rain on grid application

- To represent differing initial losses and runoff coefficients due to different impervious fractions, land use was divided into impervious fraction ranges (10% brackets) e.g. 60-70%, 70-80% etc, with values adopted corresponding to the upper end of the range.
  - Variable depth Mannings 'n' to differentiate between runoff and conveyance. A smooth Mannings n was adopted for shallow depths of less than 50 mm to better represent the relatively rapid runoff from the roof, gutters and downpipes. Above this depth a rougher Mannings n was adopted to represent the resistance experienced by overland flows.

Events modelled

- Standard durations from 10 minutes to 72-hours. Results in many areas of the models are volume driven, therefore a time of concentration approach is not valid in estimating the longest duration which needs to be modelled. This is due to the fact that tail water conditions prevent free draining in some areas of the model, and storages are key features of the options being assessed.

Underground drainage network

- Data sources – The existing underground drainage network was mostly sourced from the original modelling and supplemented with information from MW provided GIS data
- Global assumptions
  - Modelled inlet pits have typically been generously sized to enable the pipes to be more easily filled in recognition of the fact that other directly connected drainage systems are not explicitly modelled.
  - Inlet losses were generally based on typical design values. These values were sometimes reduced using engineering judgement where they were considered too conservative (large).
  - Manning's n pipe roughness values of 0.015 were adopted for existing concrete pipes for consistency with the URS base model. New and proposed pipes were assumed to be in better condition and assigned a roughness coefficient of 0.013
- Although many of the underground assets are reasonably well documented, a number of assumptions have been made in building and or updating the model, these typically include assumptions regarding invert levels and sometime even connectivity. These assumptions and others which may remain from the original URS source model are not considered sufficiently representative for the current modelling purposes however they may not be appropriate for other objectives. It is recommended that any future modelling considers the potential significance of these assumptions and refers to the original drawings, GIS databases and survey to confirm key characteristics.

Adopted tail water levels as advised by Melbourne Water

The levels below were provided by Melbourne Water for both the Yarra and Port Phillip Bay.

Table F2 Summary of Tail Water Level Assumptions

ARI	Scenario	Adopted level
5-year	Base (current) climate	1.1 m AHD
5-year	Climate change sea level rise – 2100 planning horizon	1.9 m AHD
100-year	Base (current) climate	1.42 m AHD
100-year	Climate change sea level rise – 2100 planning horizon	2.22 m AHD

Clarendon Street boundary/ Hanna Street Main Drain catchment approach

A "glass wall" boundary was modelled at the Clarendon Street boundary in areas below 2.22 m AHD. The limitation of this approach is that it does not account for the additional flood storage or pipe capacity which may be available in the large depressed area on the eastern side of the road, or conversely any flows which may be crossing the road from east to west from the Hanna St drain catchment if this is experiencing greater surcharging. Overcoming this limitation would involve extensive model extension The Hanna St drain has a catchment area of 421 ha according to the 'DR_MW_Catchment tab ' the Crown Casino Pumping Station is also located at the end of the Hanna St main drain.

Only between half and two thirds of the Hanna St Main Drain catchment shown in the DR_MW_Catchment tab was included in the URS Catchment 4 model, stopping at the CoPP boundary. The pipe continues to the Yarra in the 1d only without further inflows and the Crown Casino Pump Station is not included.

An additional pump station at Clarendon Street was sized to limit flooding originating from the system on the western side of the road for all scenarios except Scenario 0 (Conventional servicing with rainwater tanks as per SFP and no precinct based drainage) so that ponding on Whiteman Street does not drive flow into the 525 mm Council drain southwest into the Montague precinct (somewhere between approximately 0.8m and 0.95 m AHD). There is potential to provide additional capacity for the Hanna St catchment if desired, subject to detailed investigation in the future.

Port Melbourne Pumping Station representation

The Port Melbourne Pumping Station was represented as a single variable speed pump with start and stop levels based on the target set point diagram. To represent the operating controls referencing a location other than the pump station a number of discreet steps in pump capacity were used, as tabulated below. A pump curve could only be utilised if referring to levels at the pump station itself.

Table F3 Port Melbourne Pump Station Representation

Level at offtake pit	Pump Capacity (m3/s)	Comment
-1.25	0	Stop level
-1.24	1.10	
-1.2	1.27	
-1.15	1.43	
-1.09	1.60	Start level
-1.05	1.72	
-1	1.84	
-0.95	1.96	
-0.9	2.08	
-0.85	2.20	
-0.8	2.32	
-0.75	2.44	
-0.7	2.56	
-0.65	2.68	
-0.6	2.80	
-0.55	2.92	
-0.5	3.04	
-0.45	3.16	
-0.4	3.28	
-0.35	3.40	
-0.3	3.52	
-0.25	3.64	
-0.2	3.76	
-0.15	3.88	

Level at offtake pit	Pump Capacity (m3/s)	Comment
-0.1	4.00	
-0.05	4.12	
0	4.24	
0.05	4.36	
0.1	4.48	
0.11	4.50	
0.15	4.90	
0.2	5.40	
0.25	5.90	
0.3	6.40	
0.35	6.90	
0.36	7.00	Maximum pump capacity

Conventional drainage basis and model representation (pipes and sumps and pumps)

City of Melbourne advised that the minimum pipe size for new stormwater pipes in the area should be 300 mm diameter on maintenance grounds (communication with Ralf Pfleiderer).

Accordingly 300 mm pipes were modelled in all streets in the precincts which did not have existing underground drainage. Pits will be required at nominally 60 m intervals, however as the cross-fall/ profile of the roads is unknown at this stage these pits were not modelled explicitly as their exact location is uncertain. Flow was applied to pipes at approximately 60 m intervals by splitting pipes and connecting three cells to each weir pit.

In low lying areas, which are the most flood prone areas in or downstream of the precincts, volume is a driving factor rather than attenuating peaks. If volume is not removed by pumping from the system large volumes of storage are required.

Conditions in the area such as the high water table, soil types and potential contamination issues make the application of traditional retarding basins in Fisherman's Bend difficult. In the past concern has been expressed over these occupying a large proportion of the public open space, particularly if the water takes an extended period of time to recede making the open space unusable during this time and potentially requiring grass to be reseeded.

Sumps and pumps have been located at low points/ land locked areas within or downstream of the precincts where tailwater conditions (with non-return valves in place) prevent free drainage. Non return valves were fitted in areas where not doing so would cause new pipes to be significantly filled from the bay level, or to pipes draining areas where the surface level was below the 100-year tailwater level

Preliminary pump sizing was based on a maximum of 12 pump starts per hour and a pump capacity of twice the maximum inflow. Required start levels were set based on the ground levels in low points, with stop levels (600 mm above the existing pit inverts, except for the small single pump SA1, which was set to 300 mm above the pit invert).

Table F4 Summary of Sump & Pump Assumptions

Pump name	Capacity (both pumps running)	Standby start level	Standby stop level	Rising Main diameter	Rising Main length
LO1	0.322	0.8	-0.114	0.3	20
LO2	0.66	0.8	-0.42	0.45	80
LO3	0.754	0.8	-0.532	0.45	90
SA1	0.1	0.4	0.191	0.15	260
SA2	0.484	0.4	-0.012	0.45	260
MO1	0.236	0.4	-0.155	0.3	380
MO2	0.708	0.4	-0.331	0.45	520
CLAR	0.484	0.7	-0.363	0.45	70

Podium Impervious and Pervious areas

Podiums were assumed to be 70% impervious, and 30% raingardens. Whilst the raingardens are rougher, once the initial storage depth is full they will behave as impervious, given that the underlying surface is impervious (they are not on natural ground).

Modelling methodology

A challenge in this analysis was to create a realistic representation of a conceptual development. Much of the required terrain manipulation was undertaken using Z Shapes within TUFLOW.

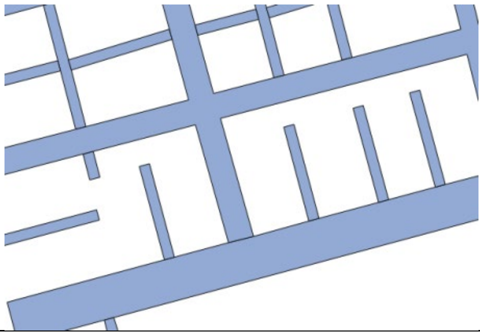
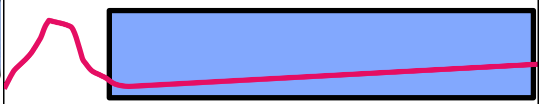
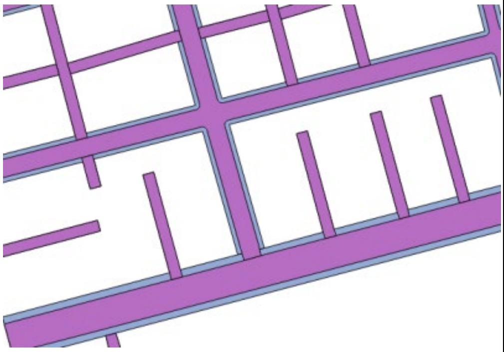
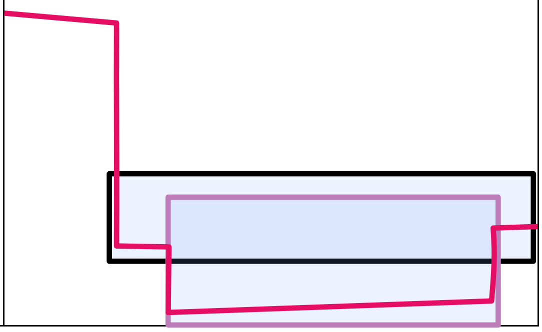
The following changes relating to the creation of the podiums were common to all scenarios.

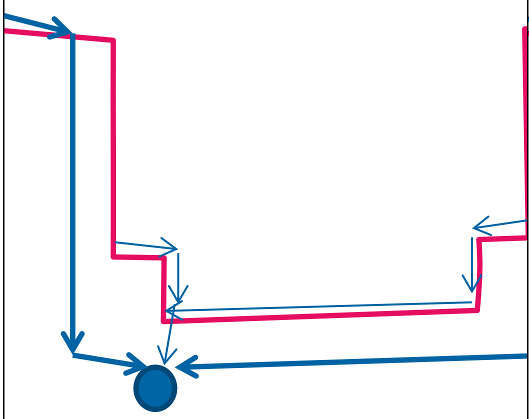
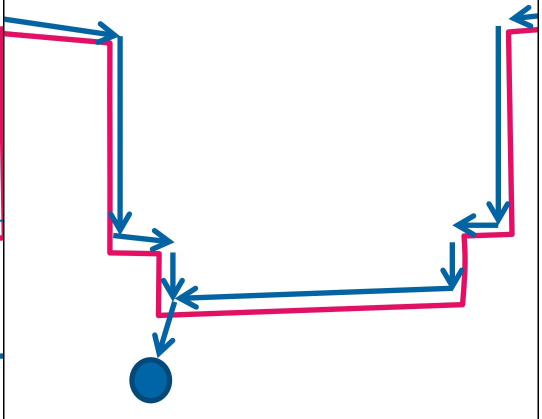
Polygons were used to define the extent of podiums within which:

1. Podium levels were raised to 600 mm above existing flood levels
2. Any raised podium levels less than 3 mAHD were raised to 3 mAHD
3. Roughness in the terrain was smoothed using the Merge All command

The alignment, elevation and connectivity of the modelled laneways is conceptual in nature and almost certain to be different to what will actually be built. As a result the modelled flood levels and associated drainage infrastructure are almost certain to be indicative but different to those adopted for the final detailed design solution.

Other changes were scenario specific for instance Scenario 5 relies on above ground storage with an acceptance of ponding in the streets to provide more storage. The method of achieving this was to create polygons of the new streets. These polygons were then used to smooth the ground surface within the new lanes, streets and roads and to lower the road pavement by 150 mm (footpaths retained at existing levels except in narrow lanes). This is shown diagrammatically in the following stylized cross sections.

Plan showing 2D_zsh polygons applied in TUFLOW to represent the conceptual roads and laneways.	**Cross sectional representation**
Typical cross section of existing surface	A typical existing conditions cross section 
typical smoothing polygons applied to conceptual laneways. 	Smoothing the road surface using a “Merge All” command. 
Plan Showing the polygons used to create the street storage 	The creation of street storage by lowering the road by 150 mm using a dz command. 
	With raised podium levels the cross section subsequently looks similar to the following (NTS). 

When constructed the runoff from the podiums is expected to be collected by roof guttering and podium level inlets feeding downpipes which will transfer the runoff to the underground drainage system with minimal overland flows for events which do not exceed the capacity of the underground drainage system. Minor surface runoff in the streets will lead to shallow sheet flow.	In the model runoff from the podiums falls down the building face and runs across the pavements, along the road to the nearest downstream pit which allows it into the underground drainage system. As a result in line with many urban models and in particular most rain on grid models the surface depths are typically over estimated particularly for the smaller events such as the 5 year ARI.
	

The limited time frame for this project combined with the exceptionally long run times and the conceptual nature of this investigation made it unfeasible to optimize and run a complete new simulation for Scenario 3 where surface flooding is no longer acceptable and additional underground storage is provided.

The results of scenario 5 have been interpreted to determine the necessary outcomes for scenario 3 using the following approach.

1. The additional storage added to the streets in scenario 5 was removed with the following process:
   i) The polygons used to create the street storage in scenario 3 were used to ‘fill’ the depressed roadways and effectively reduce the depth of flooding in these regions by 150 mm
   ii) Additional underground storage equal to the area of these polygons by the 0.15 m is allowed for as well as an allowance for inlets and connectivity to these storages.[5]
2. A comparison was made between the 100 year and the 400 mm criteria and the 5 year and the 50 mm depth criteria. It was decided that an adjustment would be made to achieve widespread compliance with the 100 year ARI criteria. The location and amount of fill required to achieve the 100 year ARI criteria was estimated. This set of conceptual adjustments was also applied to the 5 year ARI results.

The five year ARI results are generally considered compliant with the criteria although as noted previously modelling limitations result in an overestimate of flood depth in a number of locations particularly along the edge of the podium. A number of low lying areas exist for which the drainage criteria cannot be effectively met by regional drainage infrastructure without some local action most likely in the form of filling but potentially in terms of careful choice of land use and or some form of development control.

[5] Conceptually although this underground storage will typically be at a lower level, if the height of the storage inlet is nominally at ground level the reality is that the underground storage will remain empty for longer reserving the available storage for later in the design event.

Other modelling limitations include:

1. The alignment and level of overland flow paths may change significantly from what has been assumed and this would in turn affect the estimated flood extents.
2. Although the underground drainage scenarios are considered indicative of the likely outcomes changes to the preliminary estimates will almost certainly occur and may result in changes to the estimated flood extents and other flooding characteristics.

As a result of the above the following recommendations are made:

1. Flood depths and extents should be considered indicative and useful for comparison of options. Revised estimates are required during the detailed design process.
2. While these preliminary estimates of drainage characteristics are useful for gaining an understanding of drainage requirements under no circumstances should absolute flood levels from this preliminary and hypothetical analysis be used for design purposes. As a result such levels have not been provided.
3. The suggested podium levels are considered appropriate for the currently proposed concept although they will need to be reviewed to ensure that they remain compatible with the development concept as it develops.
4. In general the flat terrain in this area will result in mostly low velocities with safety risk categories dominated by flood depth alone. Velocity x Depth information has also not been provided as at this preliminary stage it is considered that for the current purposes depth is generally a good indicator of flood risk. Local detailing has the potential to result in locally high velocities of greater than 1 m/s and as a result the velocity depth product should be checked during subsequent design stages.
5. There are a number of localized regions which by virtue of their low lying topography will only be partially protected by regional drainage infrastructure. Flood risks in these locations are expected to be more efficiently / effectively controlled by site specific treatments rather than distorting a regional drainage infrastructure solution. These low lying areas should be carefully considered. Although some of these areas may have limited uses, it is probable that they will be readily developable with sufficient filling to remove the extreme low points. While these areas are typically small enough that changes in their treatment will typically have only a minor impact on the overall performance of the system like any changes which occur between this preliminary concept assessment and construction the potential for flooding impacts should be considered for instance filling of the low regions will reduce available storage and potentially increase tail water levels to adjacent areas.
6. There are a large number of potential drainage solutions which could provide the high level of service required. The challenge in terms of facilitating a good outcome is that development will be undertaken over an indeterminate timeframe with a range of proponents. Although providing a large degree of design freedom to individual developers would be a nice objective, drainage infrastructure cannot be considered in isolation and while rainwater tanks have the potential to locally reduce drainage requirements in a practical sense they are unlikely to eliminate them. On this basis the role of Council and Melbourne Water in directing the development of an appropriate regional drainage solution is critical. The concepts developed as part of this project should be reviewed by the stakeholders and their comments fed into a decision process by Melbourne Water which considers the following aspects:

   a. Development timing, in particular the start, intensity and duration

b. Completeness of development, how much will be developed and by when

c. Funding mechanisms and risks

d. Cost distribution private and public risks and rewards

e. Timing of key infrastructure

f. Risks of climate change and interaction with neighboring regions

g. Robustness to variability in timing, development form, climate, demand.

h. Environmental issues including both aesthetic and sustainability

i. Relationship with and interface with adjoining region

While there are a large range of potential drainage solutions all involve some compromise and the challenge will be balancing the risks to identify and secure an acceptable balance and subsequently guide a suitable outcome.

Thoughts about future design optimisation

As the development concepts are further developed it is likely that the conceptual drainage works will be refined. It is probable that some design efficiencies will be identified which may include:

1. Different sump and pump combinations which are better suited to the more detailed adopted development outcomes
2. Additional storage perhaps within the podiums

While it is likely that the level of performance may be improved, the potential for significant cost savings is less likely. Given that this is a brown fields area it is likely that existing services, contaminated land, shallow ground water and staged development are some of a number of project characteristics with the potential to increase costs. Both the performance and the cost of the currently considered scenarios are reasonable estimates useful for understanding the likely development outcomes however they are conceptual and in many ways uncertain.

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https://projectsportal.ghd.com/sites/pp17_01/updatetofishermansbe/ProjectDocs/12531442-REP-Fishermans-Bend-IWM-Strategy.docx

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