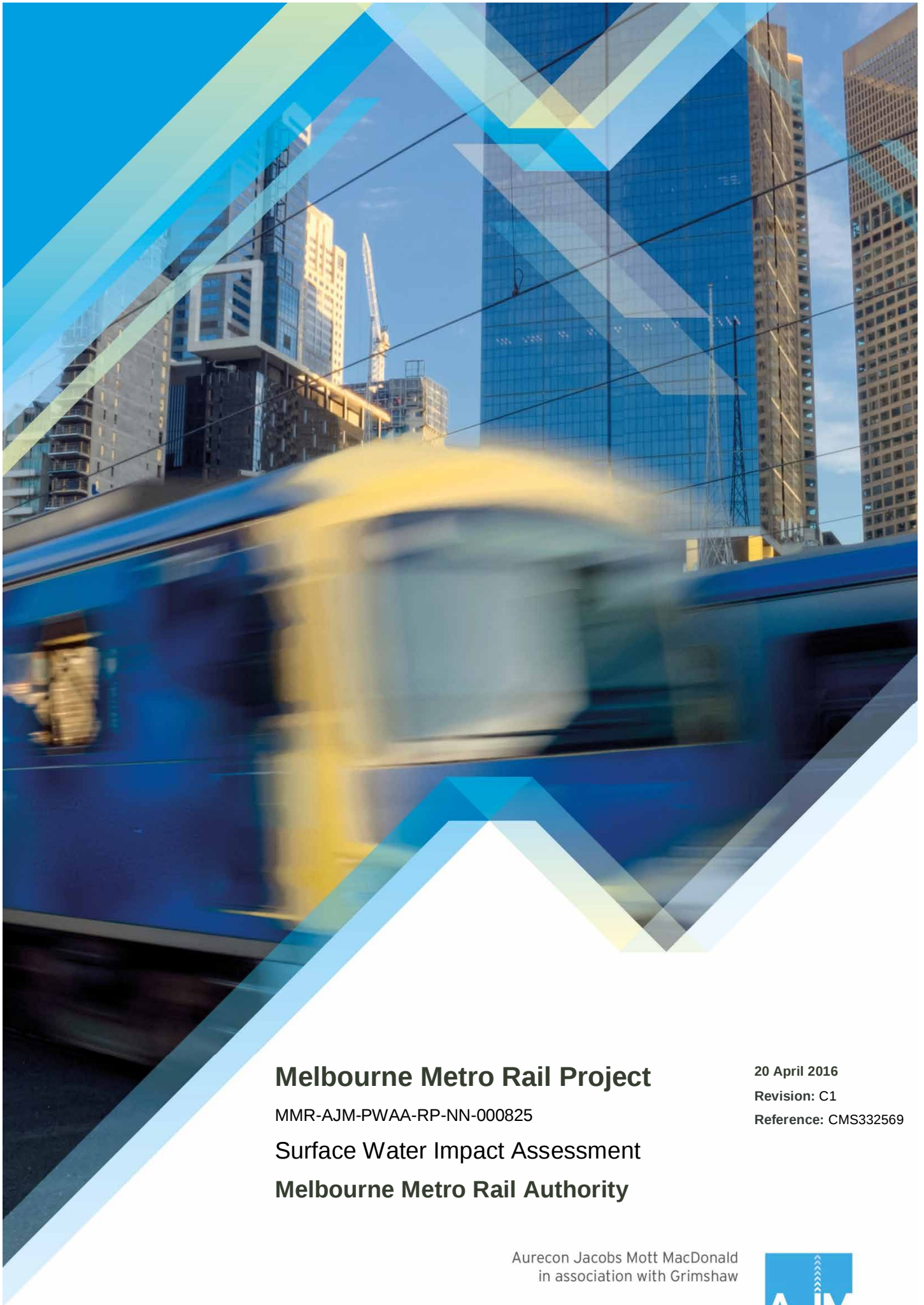




Melbourne Metro Rail Project

MMR-AJM-PWAA-RP-NN-000825

Surface Water Impact Assessment

Melbourne Metro Rail Authority

20 April 2016

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- Appendix A. Legislation, policy and guidelines**
- Appendix B. Technical details – flood levels and flows**
- Appendix C. Peer review report**



Glossary and Abbreviations

Abbreviation	Definition
AEP	Annual Exceedance Probability. The chance of a flood event being equalled or exceeded in any given year
AHD	Australian Height Datum
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval. The inverse of Annual Exceedance Probability
ARR	Australian Rainfall and Runoff. The Australian guideline for flood estimation
BoM	Bureau of Meteorology
CMA	Catchment Management Authority
Compensatory storage	Permanent water storage facility installed to offset loss of flood storage due to works. It would normally be dry (ie empty)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DDA	<i>Disability Discrimination Act 2002</i>
DELWP	Department of Environment, Land, Water and Planning
Flood gate	Automatic or manually operated structure to prevent inundation of tunnels or stations by floodwaters. If used, would be installed at tunnel portals and/or station entrances
FO	Floodway Overlay (in relevant Planning Scheme)
GSAM	Generalised Southeast Australia Method (for estimating PMP depths)
HCMT	High Capacity Metro Trains
IPCC	Intergovernmental Panel on Climate Change
IS	Infrastructure Sustainability
LSIO	Land Subject to Inundation Overlay (in relevant Planning Scheme)
MMBW	Melbourne and Metropolitan Board of Works
MTM	Metro Trains Melbourne
PMP	Probable Maximum Precipitation
SBO	Special Building Overlay (in relevant Planning Scheme)
VICSES	Victoria State Emergency Service
VPP	Victoria Planning Provisions



Executive Summary

This report provides an assessment of the surface water quantity-related aspects associated with the construction and operation of Melbourne Metro. These include drainage and flood-related issues, including risks and impacts associated with flood and overland drainage flows, levels and velocities. Other aspects, including water quality-related aspects, are covered in the following Technical Appendices:

- Technical Appendix O *Groundwater*
- Technical Appendix Q *Contaminated Land and Spoil Management*
- Technical Appendix U *Aquatic Ecology and River Health*.

Surface Water Context

The Melbourne Metro alignment and associated infrastructure potentially interface with a number of waterways and drainage systems. There is potential for infrastructure and construction works to impact on flood flows and levels along these systems. There is also potential for floodwaters and overland drainage flows to impact on project works. Relevant major drainage systems and waterways in the study area include:

- Maribyrnong River, which is approximately 500 m from the western portal
- Moonee Ponds Creek, which is approximately 100 m from Arden station
- Yarra River, which is approximately 120 m from CBD South station, and could also potentially impact on the eastern portal at South Yarra
- City of Melbourne drainage systems along Swanston Street, adjacent to CBD South station.

Methodology

The methodology for the surface water study included:

- Review of relevant previous studies and other available information, including relevant planning scheme overlays
- Review of relevant legislation and guidelines
- Where possible, use of hydraulic and hydrologic models to determine flood flows and levels for a range of flood events, including allowances for the impacts of climate change. This was then used to inform the environmental risk and impact assessments
- Site inspections
- Consultation with stakeholders including Melbourne Water, City of Melbourne, City of Stonnington and City of Port Phillip.

The report was also independently peer reviewed (the final peer review report is attached at Appendix C of this report).

Risk Assessment

The environmental risk assessment considered the following potential consequences across the study area, in the absence of specific mitigation measures:

- Flooding of tunnels and stations from tunnel portals or stations during construction or operation, potentially compromising the safety of construction workers, rail staff or commuters, and disrupting rail services. This could occur from riverine flooding, or overland flows in excess of the capacity of the underground drainage system.
- Temporary or permanent works obstructing riverine flood or overland drainage flows, or resulting in loss of flood storage. This could potentially increase flood levels or velocities, in turn resulting in an increased



flood risk to infrastructure and property. The performance criterion proposed for the project works are that they *'maintain or improve existing flooding functions and characteristics.'* This was assessed, where possible, on the basis of the *'magnitude of predicted changes to one per cent Annual Exceedance Probability (AEP) flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.'*

The environmental risk assessment informed the project design. Input to the design process focussed on Year 2100 flood levels (ie accounting for the impacts of climate change) for a range of AEPs. A range of potential design requirements need to be accounted for:

- Melbourne Water generally requires that major infrastructure be protected against a one per cent AEP flood, with a 600 mm freeboard allowance for riverine flooding, and a 300 mm freeboard allowance for local stormwater flooding. It requires this assessment to take account of the design life of the infrastructure. For Melbourne Metro this assessment was therefore based on Year 2100 conditions. Melbourne Metro Rail Authority (MMRA) is committed to providing this level of flood immunity as a minimum standard.
- MMRA may decide to adopt higher flood immunity standards than are required by Melbourne Water. This should be informed by an additional flood immunity risk assessment. This is quite separate to the environmental risk assessment discussed above and below and is not a requirement of the EES Scoping Requirements. It does not form part of the environmental approvals process. The flood immunity risk assessment would need to consider the operability and integrity of the rail network as determined by the network owner, and take account of the impacts of a range of flood events on factors such as damage and clean-up costs and the costs associated with any potential long-term disruption of the rail network.

The environmental risk assessment considered the likelihood and consequence of a range of different AEP flood events assuming no mitigation works or measures, and used this to assign initial risk. It then assessed the residual risk assuming potential mitigation works and measures are implemented to reduce the initial risk. The risk assessment concluded that mitigation measures could feasibly be implemented to reduce all residual risks to 'Low' or 'Very Low'. No 'Very High' initial risks were identified. Eight 'High' initial risks were identified. These relate to tunnels and stations that are potentially at risk of flooding during construction and/or operation from:

- The Maribyrnong River at the western portal
- Moonee Ponds Creek at Arden station
- The Yarra River from the existing City Loop tunnel portals near Federation Square through the underground cross connection at CBD North station, and at the eastern portal
- Overland flows along Swanston Street into the entrances to CBD South station.

All residual risks associated with potential for infrastructure and construction works to impact on flood flows and levels were assessed as 'Low' or 'Very Low'.

Maribyrnong River: The area around the existing rail embankment, in which the western portal (tunnel decline structure, and cut-and-cover section of tunnels) would be constructed, forms part of the Maribyrnong River floodplain. Under existing conditions, a one percent AEP flood would inundate Childers Street near JJ Holland Park to a depth of around a metre. There is potential for Maribyrnong River floodwaters to fill the tunnels within hours during a flood event. Up to a days warning would typically be available in advance of such an event. Works would be required to protect the portal from flooding during construction. It is unlikely to be feasible to protect the portal from flooding in an extreme flood event (say rarer than one per cent AEP) during construction, and emergency measures would need to be put in place to protect construction workers if such an event was to occur. These would include a flood warning system and evacuation procedures. In the absence of any additional mitigation works, the permanent portal would be protected against flooding from the Maribyrnong River in an estimated one per cent AEP (100 year Average Recurrence Interval (ARI)) event, under Year 2100 conditions, with a 600 mm freeboard allowance. This would be provided by a proposed retaining wall on the north side of the rail embankment along Childers Street. It is proposed that



automatic flood gates be installed during the project's operational phase to protect the portal against flooding from more extreme events. These gates would extend to the full height and width of the portal and thus provide protection against even the most extreme flood event.

Moonee Ponds Creek: The Arden station construction work site, and permanent entrances to Arden station, are in the Moonee Ponds Creek floodplain. The land around the station box and entrances is subject to flooding in events as frequent as 10 per cent AEP. Flood warning times in Moonee Ponds Creek are typically relatively short at only one to two hours. The flood risk to construction workers would need to be managed by erection of barriers around the station box to provide protection against at least the one per cent AEP flood event, and implementation of emergency management measures including a flood warning system and evacuation procedures, to mitigate the risk in more extreme flood events. The permanent station entrances in the Concept Design would be above 0.1 per cent AEP flood levels, including allowance for climate change impacts. The adequacy of this would need to be determined by flood immunity risk assessment.

Yarra River: The Melbourne Metro tunnels are potentially subject to flooding from the existing City Loop tunnels through the underground interconnection at CBD North station. Of the six City Loop tunnel portals in the area between Flinders Street and Richmond Stations, the portal on the line between Flinders Street and Parliament stations, near Federation Square, is at by far the greatest risk of riverine flooding, and is subject to flooding from the Yarra River in an event more frequent than a Year 2100 (ie including allowance for climate change impacts) one per cent AEP Yarra River flood. Up to three day's warning would typically be available in advance of such an event. The Melbourne Metro tunnels could fill within hours once inundation thresholds were exceeded. This could be mitigated by installation of flood gates on this City Loop tunnel portal to provide protection during both the construction and operational phases of the project. The other five portals in this area are all immune from flooding in a Year 2100 0.1 per cent AEP (1,000 year ARI) Yarra River flood event. A flood immunity risk assessment is required to determine whether this is acceptable.

In the absence of any additional mitigation works, the eastern portal would be subject to flooding from the Yarra River in an estimated Year 2100 0.1 per cent AEP (1,000 year ARI) event. A flood immunity risk assessment is required to determine whether this is acceptable. At a very minimum, it is recommended that a flood warning system be implemented, such that rail services could be suspended and the tunnels and stations evacuated in advance of an extreme flood. If the risk is not deemed to be acceptable, additional emergency management measures such as sandbagging or flood gates would need to be put in place to protect the tunnels from flooding in an extreme event during both the construction and operational phases of the project. It is currently proposed that the portal incorporate works to allow flood gates in the form of stop logs to be installed across the portal in advance of an extreme flood event. It is also proposed that stop logs be stored adjacent to the portal.

Overland flows along Swanston Street: The permanent entrances to CBD South station are subject to flooding from overland flows along Swanston and Flinders Streets. The Flinders Street Station entrance facing Swanston Street, in particular, is subject to some slight ponding of stormwater flows. All entrances would need to be elevated slightly to provide an appropriate level of flood protection to be determined by flood immunity risk assessment. Very little warning (tens of minutes) would typically be available in advance of a major overland flow event at this site.

Conclusions

Mitigation measures could feasibly be implemented to reduce all residual risks to 'Low' or 'Very Low'.

If the proposed works described above are put in place, the tunnels and all stations would be protected against flooding from the Maribyrnong River, Moonee Ponds Creek and the Yarra River in at least the 0.1 per cent AEP flood event under Year 2100 conditions (ie including allowance for the impacts of climate change) and the project would be consistent with the draft Environment Effects Statement (EES) evaluation objective for surface water drainage and flooding as it would result in negligible impact on existing flooding and drainage functions and characteristics. The project would also comply with Melbourne Water's flood immunity requirements.



Benefits and Opportunities

The majority of the project is to be located underground, and there are consequently few opportunities for surface water benefits to be derived from the works. There may be opportunities to enhance the flood protection of the existing City Loop tunnels and stations. Rainfall runoff from the tunnel decline structures at the portals could be pumped to the surface, and there may be opportunities to re-use some of this water for irrigation of parks, sports fields or gardens, with appropriate treatment.

Environmental Performance Requirements

The following Environmental Performance Requirements are recommended.

Environmental Performance Requirements

For all precincts (with the exception of the Western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows.

This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.

For all precincts:

- Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority
- Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority
- Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority
- Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.



1 Introduction

This report provides an assessment of the surface water impacts of Melbourne Metro. It covers the flooding and surface water drainage aspects of surface water. Related issues, such as water quality and aquatic ecology and river health, are covered in the following Technical Appendices:

- Technical Appendix O *Groundwater*
- Technical Appendix Q *Contaminated Land and Spoil Management*
- Technical Appendix U *Aquatic Ecology and River Health*.

1.1 Project Description

Melbourne Metro comprises two nine-kilometre-long rail tunnels from Kensington to South Yarra, travelling underneath Swanston Street in the Central Business District (CBD), as part of a new Sunbury to Cranbourne / Pakenham line to form the new Sunshine-Dandenong Line (refer to Figure 1-1).

The infrastructure to be constructed as part of the Melbourne Metro broadly comprises:

- Twin nine-kilometre rail tunnels from Kensington to South Yarra, travelling underneath Swanston Street in Melbourne's CBD, connecting the Sunbury and Cranbourne/Pakenham railway lines (with the tunnels to be used by electric trains)
- Rail tunnel portals (entrances) at Kensington and South Yarra
- New underground stations at Arden, Parkville, CBD North, CBD South and Domain with longer platforms to accommodate longer High Capacity Metro Trains (HCMT). The stations at CBD North and CBD South will feature direct interchange with the existing Melbourne Central and Flinders Street Stations respectively
- Train/tram interchanges at Domain station

Proposed construction methods involve bored and mined tunnels, cut-and-cover construction of station boxes at Arden, Parkville and Domain and portals, and cavern construction at CBD North and South stations. The project requires planning, environmental and land tenure-related approvals to proceed.

1.2 Purpose of the Report

The purpose of this report is to provide an understanding of the surface water flooding and drainage characteristics of the Melbourne Metro study area and to identify potential risks and impacts of Melbourne Metro, as they relate to surface water flooding and drainage. The outcome of this assessment provides information for inclusion in the project's Environment Effects Statement (EES) and guidance for the detail design phase of the project.

The focus for this assessment is the Yarra River, Maribyrnong River and Moonee Ponds Creek and local drainage systems in the vicinity of the tunnels alignment (Figure 1-1).

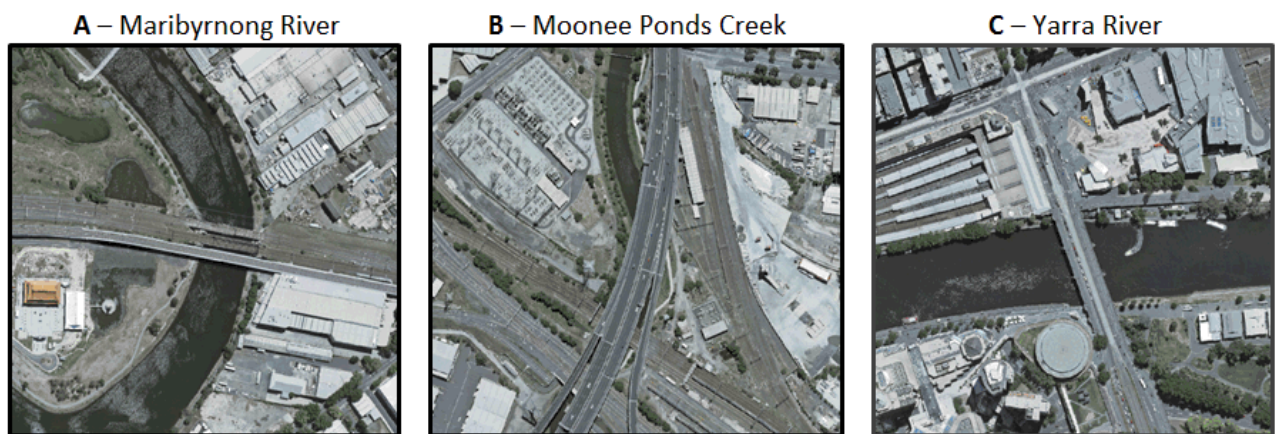
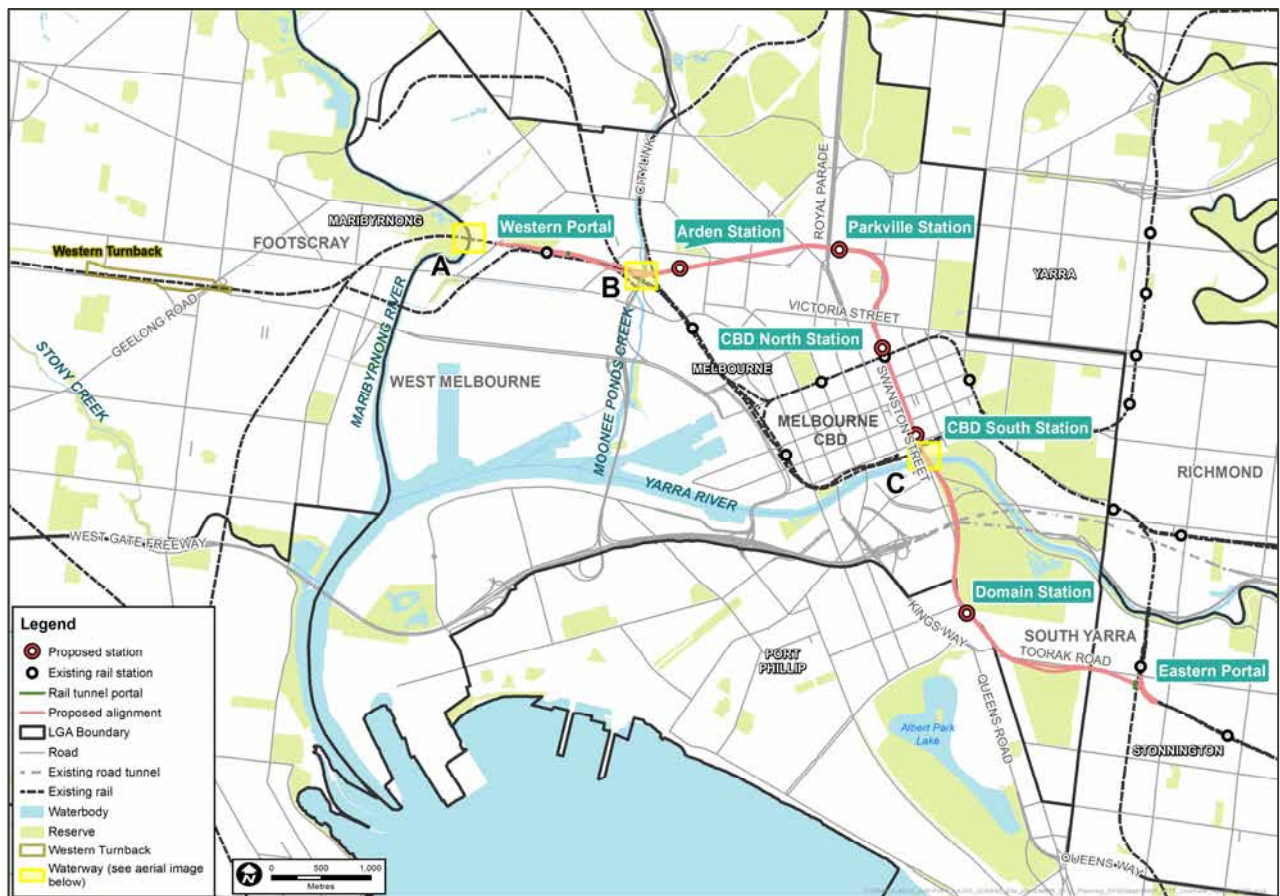


Figure 1-1 Site map showing Melbourne Metro alignment and five underground stations, and key waterways

1.3 Project Precincts

For assessment purposes, Melbourne Metro has been divided into precincts as outlined below. The precincts have been defined based on the location of the project components and required construction works, the potential impacts on local areas and the character of surrounding communities.

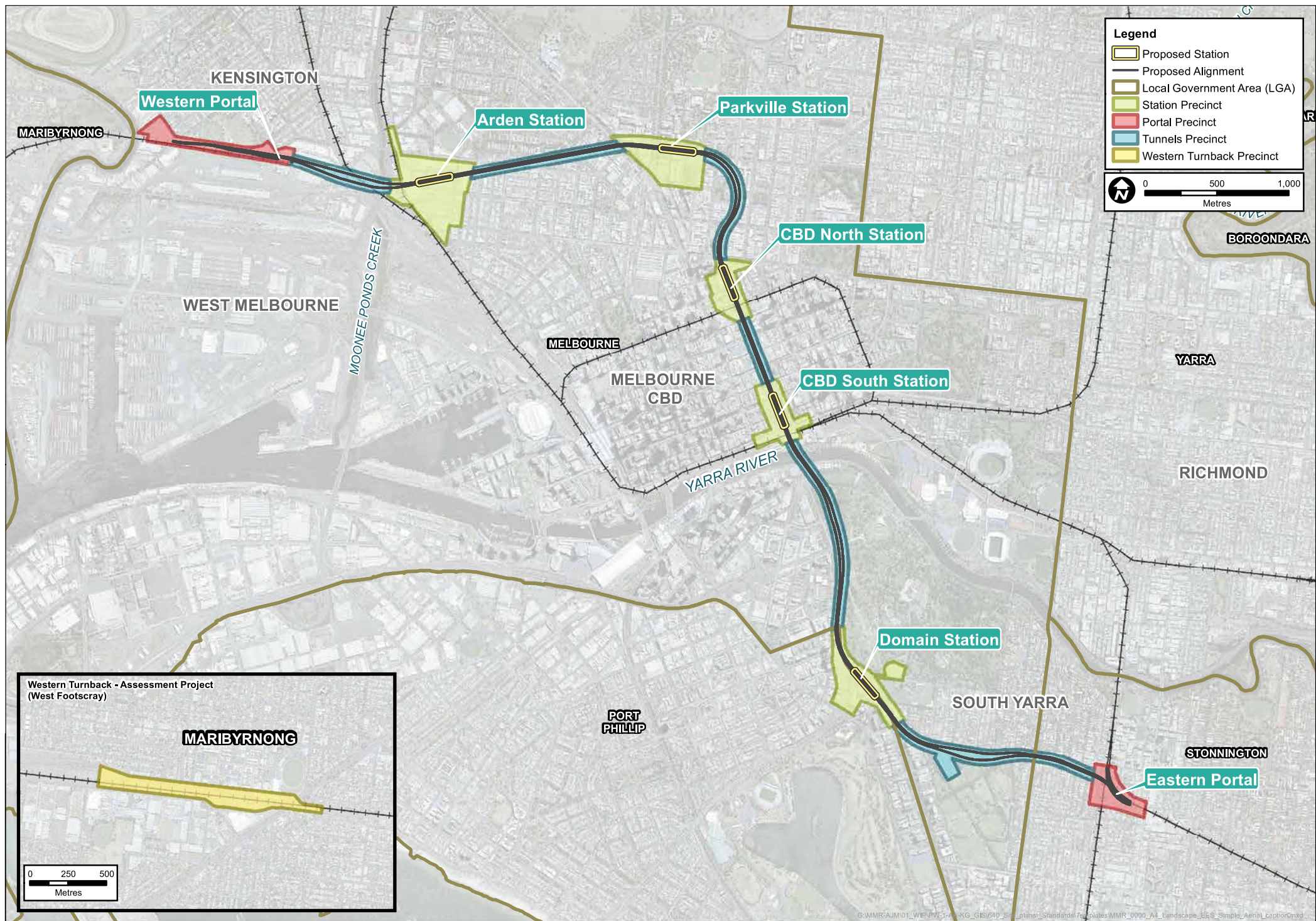
The precincts are:

- Precinct 1: Tunnels (outside other precincts)
- Precinct 2: Western Portal (Kensington)
- Precinct 3: Arden station (including substations)
- Precinct 4: Parkville station



- Precinct 5: CBD North station
- Precinct 6: CBD South station
- Precinct 7: Domain station
- Precinct 8: Eastern Portal (South Yarra)
- Precinct 9: Western Turnback.

The nine precincts are shown in Figure 1-2.





2 Scoping Requirements

2.1 EES Objectives

The following draft evaluation objectives (Table 2-1) are relevant to surface water and to identifying the desired outcomes in the context of potential project effects. The draft evaluation objectives provide a framework to guide an integrated assessment of environmental effects of the project, in accordance with the *Ministerial guidelines for assessment of environmental effects under the Environment Effects Act 1978*.

Table 2-1 Hydrology, water quality and waste management draft evaluation objective

Draft evaluation objective	Key legislation
Hydrology, water quality and waste management – To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	<i>Water Act 1989</i>

2.2 EES Scoping Requirements

The following extract from the Scoping Requirements, issued by the Minister for Planning, are relevant to the surface water impact assessment (Table 2-2).

Table 2-2 Scoping requirements relevant to surface water impact assessment

Aspect	Relevant responses
Key Issues	• Potential for project works to affect waterways and hydrology, including with respect to flooding
Priorities for characterising the existing environment	• Identify and map the natural and constructed surface water drainage system relevant to the geographic coverage of project works
Design and mitigation measures	• Identify measures to avoid or mitigate project effects on waterways and flood behaviour and management
Assessment of likely effects	• Assess potential for project works to affect waterways and hydrology, including with respect to flood behaviour and management
Approach to manage performance	• Describe principles to be adopted for setting programs for monitoring flooding events during construction (if they occur), surface water and groundwater quality and groundwater levels • Describe principles to be adopted for developing contingency measures to be implemented if unexpected adverse effects are identified.



3 Legislation, Policy and Guidelines

Table 3-1 summarises the relevant primary legislation that applies to the surface water (hydrology) aspects of the project, as well as the implications, required approvals and interdependencies, and information requirements associated with obtaining approvals. Primary legislation that applies to related issues such as water quality, aquatic ecology and river health is covered in other impact assessments. Descriptions of relevant legislation are contained in Appendix A of this report.

Table 3-1 Primary legislation and associated information

Legislation / policy	Key policies / strategies	Implications for this project	Approvals required	Timing / interdependencies
State				
Water Act 1989	Management of State's water resources. Delegates Catchment Management Authority responsibilities to Melbourne Water.	Designated waterways in the study area – Maribyrnong River, Moonee Ponds Creek and Yarra River. Works in proximity to Melbourne Water drains, water mains and other assets.	A Works on Waterways Permit would be required to undertake any works within or in proximity of designated waterways. A permit would be required to build over, or near, any of Melbourne Water's underground assets such as pipes, drains, water mains and easements.	Melbourne Water created two by-laws via this legislation. These by-laws create the obligations to obtain the permits.
Planning and Environment Act 1987	Framework for planning the use, development and protection of land in Victoria.	Surface water-related overlays, potentially triggering planning requirements – three overlays are potentially relevant to Melbourne Metro – Floodway Overlay, Land Subject to Inundation Overlay and Special Building Overlay.	Planning approval may be required to undertake works, subject to conditions.	Approvals must be in place prior to commencement of works.
Environment Effects Act 1978	Requirement for Environment Effects Statement (EES) to be prepared and submitted to the Minister for Planning. The Scoping Requirements issued for the project require specific consideration to be made in relation to		The outcomes of the Minister for Planning's assessment under this Act will inform decision-making under other legislation.	The outcomes of the Minister for Planning's assessment under this Act will inform decision-making under other legislation.



Legislation / policy	Key policies / strategies	Implications for this project	Approvals required	Timing / interdependencies
	hydrology.			
Victorian Coastal Strategy	Climate change induced mean sea level rise of at least 0.8 m by 2100.	Requires evaluation of climate change.	N/A	N/A
Other documents of relevance				
Australian Rainfall and Runoff	Guideline for determination of flood flows and levels.	Project should be undertaken in accordance with guideline.	N/A	N/A
Austroroads 'Guide to Road Tunnels' (2010)	Broad guideline for tunnel flood immunity standards.	Adoption of risk management approach.	N/A	N/A



4 Methodology

4.1 Overview

4.1.1 Objectives

A number of investigations were undertaken to establish baseline conditions. This comprised hydrologic and hydraulic modelling¹ or use of existing available information to determine flood levels along the following relevant watercourses and local stormwater systems:

- Maribyrnong River
- Moonee Ponds Creek and its eastern tributaries immediately to the north of Arden station (particularly the Arden Street Main Drain)
- Swanston Street Main Drains
- Yarra River
- Hannah Street Main Drain
- Major drains in the vicinity of the eastern tunnel portal (in particular the Yarra Street Outfall Drain and the Prahran Main Drain systems)
- Graingers Road Main Drain.

The investigations focussed on determining flood levels under both:

- Existing conditions
- Year 2100 conditions, taking account of increases in rainfall intensities and sea levels associated with climate change.

The objectives of this were two-fold, comprising support of the planning and impact assessment of Melbourne Metro, and as an input to the design process.

4.1.2 Planning and Impact Assessment Requirements

The planning and impact assessment focussed on assessing the impacts of early, temporary or permanent works associated with the project, on one per cent AEP flood levels. The one per cent AEP flood event is one which has a one per cent chance of being equalled or exceeded in any year (this is also sometimes referred to as the 100 year ARI flood event). Melbourne Water uses the one per cent AEP flood event as the reference event for delineating land affected by flooding and setting requirements for developers. The planning maps provided in this report show the location of the Land Subject to Inundation and Special Building Overlays, together with the watercourses and overland flow systems highlighted above.

Melbourne Water also uses the one per cent AEP event as the reference event against which to assess impacts associated with major infrastructure projects such as Melbourne Metro. In considering the impacts of Melbourne Metro works, consideration was given to the impact on one per cent AEP flood levels under both existing conditions and Year 2100 conditions. These impacts can be broadly subdivided into two categories:

- Works that increase flood levels by restricting the passage of flood and overland flows. The impacts (ie relative increase in flood levels) of these types of works would generally be greater for existing one per cent AEP flood conditions than for Year 2100 one per cent AEP flood conditions. This is because these types of impacts are generally greater when baseline flood levels are lower.

¹ Hydrologic modelling establishes estimates of flood and stormwater flows. Hydraulic modelling uses these flows to estimate flood levels and extents.



- Works that increase flood levels by reducing flood storage. The impacts of these types of works would generally be greater for Year 2100 one per cent AEP flood conditions than for existing one per cent AEP flood conditions. This is because these types of impacts are generally greater when baseline flood levels are higher.

Year 2100 conditions include allowance for increases in rainfall intensity and sea levels associated with climate change. Rainfall intensities are assumed to increase by 32 per cent. This is consistent with the rainfall intensity increase adopted by Melbourne Water to account for climate change, and is also broadly consistent with other rainfall intensity increase estimates that the project team is aware of. Sea level increases are based on CSIRO (2009) *The Effects of Climate Change on Extreme Sea Levels in Port Phillip Bay*. This is discussed in further detail in Section B.2. These estimates are considered appropriate for the purposes of the project. Further background to the adopted climate change parameters is provided in Technical Appendix W *Sustainability Assessment Report*.

4.1.3 Design Requirements

Input to the design process focussed on Year 2100 flood levels for a range of AEPs. A range of potential design requirements needs to be accounted for:

- Melbourne Water generally requires that major infrastructure be protected against a one per cent AEP flood, with a 600 mm freeboard allowance for riverine flooding, and a 300 mm freeboard allowance for local stormwater flooding. They require this assessment to take account of the design life of the infrastructure. For Melbourne Metro, this assessment was therefore based on Year 2100 conditions.
- MMRA may decide to adopt higher flood immunity standards than are required by Melbourne Water. This should be informed by an additional flood immunity risk assessment. This is quite separate to the Environmental Risk Assessment discussed in Section 4.3, and is not a requirement of the EES scoping requirements. It does not form part of the environmental approvals process. The flood immunity risk assessment would need to consider the impacts of a range of flood events on factors such as damage and clean-up costs, and the costs associated with any potential long-term disruption of the rail network.

4.1.4 Scope

The scope of the surface water assessment included:

- Review of relevant previous studies and other available information. This included relevant planning scheme overlays
- Review of relevant legislation and guidelines
- Use of hydraulic and hydrologic models to determine flood flows and levels for a range of flood events, including allowances for the impacts of climate change. This was undertaken for the three major riverine systems (Maribyrnong River, Moonee Ponds Creek and Yarra River), and for the two overland flow systems (Swanston Street and the Prahran Main Drain system in the area around Chapel Street) where flow depths could potentially be large enough to require anything other than very minor mitigation works. This modelling included consideration of a range of different duration storm events that would result in peak flood levels in different systems. For the larger riverine systems, these would typically be long duration storm events (several days). For stormwater systems these would typically be much shorter duration events (minutes to hours). This was then used to inform risk and impact assessments, and in particular:
 - Assess the impacts of temporary and permanent works on flood flows and levels
 - Inform requirements for mitigating unacceptable risk and impacts
 - Provide design advice to ensure an appropriate level of immunity of the project from inundation.
- Site inspections
- Consultation with relevant stakeholders, including Melbourne Water, City of Melbourne, City of Stonnington and City of Port Phillip.



Further details of previous studies and the hydrologic and hydraulic investigations undertaken in preparation of this report are included as Appendix B of this report.

This report covers the flooding and surface water drainage quantity aspects of surface water. Related issues, such as water quality and aquatic ecology and river health, are covered in the following Technical Appendices:

- Technical Appendix O *Groundwater*
- Technical Appendix Q *Contaminated Land and Waste Management*
- Technical Appendix U *Aquatic Ecology and River Health*.

4.2 Peer Review

This assessment has been independently peer reviewed by Mr David Fuller of Deep River Associates. The peer reviewer reviewed and provided feedback on drafts of this report. The peer reviewer's methodology is set out in his report, but in general terms it included a review of the assumptions, methodology, assessment criteria and scope applied in this report. It also addressed whether there were any additional matters which should be considered as part of the impact assessment in order to address the EES Scoping Requirements that are relevant to surface water/hydrology impacts or management. The peer reviewer was also required to consider whether there are any gaps or matters where they disagreed with this assessment. The final peer review report is attached at Appendix C of this report, which sets out the peer reviewer's conclusions in relation to a near final draft of this report.

4.3 Risk and Impact Assessment

4.3.1 Overview

An Environmental Risk Assessment has been completed for impacts of Melbourne Metro. The risk-based approach is integral to the EES as required by Section 3.1 of the Scoping Requirements for the EES. Importantly, an environmental risk is different from an environmental impact. Risk is a function of the likelihood of an adverse event occurring and the consequence of the event. Impact relates to the outcome of an action in relation to values of a resource or sensitivity of a receptor. Benefits are considered in impact assessment but not in risk assessment. Impact assessment must be informed by risk assessment so that the level of action to manage an impact relates to the likelihood of an adverse impact occurring.

The overall risk assessment process adopted was based on AS/NZS ISO 31000:2009, as illustrated in Figure 4-1.

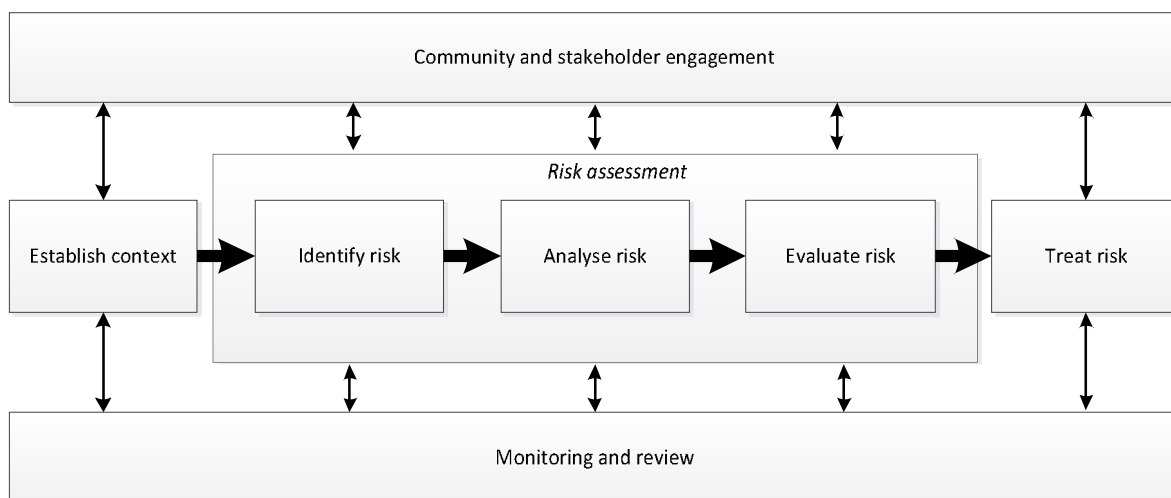


Figure 4-1 Overview of AS/NZS ISO 31000-2009 risk process



The following tasks were undertaken to determine the impact pathways and assess the risks:

- Setting of the context for the environmental risk assessment
- Development of consequence and likelihood frameworks and the risk assessment matrix
- Review of project description and identification of impact assessment pathways by specialists in each relevant discipline area
- Allocation of consequence and likelihood categories and determination of preliminary initial risks
- Workshops with specialist team members from different yet related discipline areas and focussing on very high, high and moderate initial risks to ensure a consistent approach to risk assessment and to identify possible interactions between discipline areas
- Follow-up liaison with specialist team members and consolidation of the risk register.

A more detailed description of each step in the risk assessment process is provided in Technical Appendix B *Environmental Risk Assessment Report*.

4.3.2 Context

The overall context for the risk assessment and a specific context for each specialist study are described in Technical Appendix B *Environmental Risk Assessment Report*. The context describes the setting for evaluation of risks arising from the Melbourne Metro. The specific context for the surface water impact assessment is provided below.

The Melbourne Metro alignment and associated infrastructure potentially interface with a number of waterways and drainage systems. Relevant major drainage systems and waterways in the study area include:

- *Maribyrnong River, which is approximately 500 m from the western portal*
- *Moonee Ponds Creek, which is approximately 100 m from Arden station*
- *Yarra River. This is approximately 120 m from CBD South station and could also potentially impact on the eastern portal at South Yarra*
- *City of Melbourne drainage systems along Swanston Street, adjacent to CBD South station*
- *Hannah Street Main Drain which is approximately 200 m west of Domain station*
- *Prahran Main Drain and Yarra Street Outfall Drain and their tributaries, in the area around the eastern portal*
- *Graingers Road Main Drain which crosses under West Footscray station at the western turnback.*

The Melbourne Metro would involve tunnelling under the Yarra River and Moonee Ponds Creek (bored tunnels), therefore there would be no direct interface with these waterways. However, the construction of some of the Melbourne Metro portals and stations could potentially interface with the floodplains of the Yarra River, Moonee Ponds Creek, Maribyrnong River and associated drainage systems. Each of these major waterways is subject to flood events of varying frequency and severity. Unobstructed overland flood paths are important to draining floodwaters and avoiding damage to property and infrastructure. Similarly, the availability of flood storage (where water is temporarily stored within the riverine floodplain) plays a critical role in ameliorating the effects of a flood event.

All of the potential impacts of Melbourne Metro on flood flows and storage and of flooding on Melbourne Metro would be required to comply with the relevant statutory requirements being the relevant planning scheme provisions and the Water Act 1989.

Surface water quality is addressed as part of the interrelated aquatic ecology and river health impact assessment.



The generic likelihood rating descriptions used in the risk assessment by all specialists are shown in Table 4-1.

Table 4-1 Generic likelihood rating criteria

Level	Description
Rare	The event is very unlikely to occur but may occur in exceptional circumstances.
Unlikely	The event may occur under unusual circumstances but is not expected.
Possible	The event may occur once within a five-year time frame.
Likely	The event is likely to occur several times within a five-year time frame.
Almost Certain	The event will occur one or more times a year.

For the surface water studies, the Descriptions listed in the first column of Table 4-1 have been redefined so that they align more closely with a layperson's interpretation of the meanings of the Level terms in the first column of the table. These redefinitions assume that the descriptions relate to the likelihood of an event occurring over the duration of the relevant phase of the project. This has been assumed to be 10 years for the construction phase and 100 years for the operational phase. These redefinitions are listed in Table 4-2.

Table 4-2 Surface water-specific likelihood rating criteria

Level	Description
Rare	The event is very unlikely to occur but may occur in exceptional circumstances.
Unlikely	The event may occur under unusual circumstances but is not expected.
Possible	The event has a one in five (20 per cent) chance of occurring.
Likely	The event has a 70 per cent chance of occurring.
Almost Certain	The event has a 95 per cent chance of occurring.

For the surface water studies, the likelihoods as defined in Table 4-2 have then been further defined in terms of the AEPs of flood events, as shown in Table 4-3.

Table 4-3 Relationship between likelihoods and flood event AEPs

Level	Flood event AEP (%)		Comments
	Construction	Operation	
Rare	0.1	0.01	Approximately one per cent chance of occurrence over duration – 10 years for construction, 100 years for operation
Unlikely	1	0.1	Approximately 10 per cent chance of occurrence over duration
Possible	2	0.2	Approximately 20 per cent chance of occurrence over duration
Likely	11	1.2	Approximately 70 per cent chance of occurrence over duration
Almost Certain	26	3	Approximately 95 per cent chance of occurrence over duration



The consequence criteria framework used in the risk assessment is presented in Table 4-4. Each specialist has used this framework to develop criteria specifically for their assessment.

Table 4-4 Consequence framework

Level	Qualitative description of biophysical / environmental consequence	Qualitative description of socio-economic consequence
Negligible	No detectable change in a local environmental setting.	No detectable impact on economic, cultural, recreational, aesthetic or social values.
Minor	Short-term reversible changes, within natural variability range, in a local environmental setting.	Short-term localised impact on economic, cultural, recreational, aesthetic or social values.
Moderate	Long-term but limited changes to local environmental setting that are able to be managed.	Significant and/or long-term change in quality of economic, cultural, recreational, aesthetic or social values in local setting. Limited impacts at regional level.
Major	Long-term, significant changes resulting in risks to human health and/or the environment beyond the local environmental setting.	Significant, long-term change in quality of economic, cultural, recreational, aesthetic or social values at local, regional and State levels. Limited impacts at national level.
Severe	Irreversible, significant changes resulting in widespread risks to human health and/or the environment at a regional scale or broader.	Significant, permanent impact on regional economy and/or irreversible changes to cultural, recreational, aesthetic or social values at regional, State and national levels.

The consequence rating criteria used in the risk assessment specifically for the surface water study are shown in Table 4-5.

Table 4-5 Consequence rating criteria

Level of consequence	Consequence criteria
Negligible	- Minor public nuisance - No disruption of operational rail activity - No increase in flood damage to property, infrastructure or the environment.
Minor	- Moderate public nuisance - Minimal disruption of operational rail activity - Negligible increase in flood damage to property, infrastructure or the environment.
Moderate	- Major public nuisance - Short term disruption of operational rail activity (hours) - Minor increase in flood damage to small numbers of property or infrastructure, or the environment (small and/or short-term increase in flood levels/velocities).
Major	- Injury to one or more people (construction workers, commuters, rail staff, other) - Moderate increase in flood damage to property, major infrastructure or the environment (moderate and/or medium-term increase in flood levels/velocities) - Longer-term disruption of operational rail activity (days).



Level of consequence	Consequence criteria
Severe	• Death of one or more people (construction workers, commuters, rail staff, other) • Serious injury to multiple people (construction workers, commuters, rail staff, other) • Major increase in flood damage to multiple properties, major infrastructure, or significant environmental assets (major and/or long-term increase in flood levels/velocities) • Major long-term disruption of operational rail activity (weeks or more).

The environmental risk assessment matrix used by all specialists to determine levels of risk from the likelihood and consequence ratings is shown in Table 4-6 below.

Table 4-6 Risk assessment matrix

		Consequence ratings				
		Negligible	Minor	Moderate	Major	Severe
Likelihood rating	Rare	Very Low	Very Low	Low	Medium	Medium
	Unlikely	Very Low	Low	Low	Medium	High
	Possible	Low	Low	Medium	High	High
	Likely	Low	Medium	Medium	High	Very High
	Almost Certain	Low	Medium	High	Very High	Very High

Section 6 provides a summary of the surface water risks assessed as part of the EES.

4.4 Assumptions

Assumptions relating to the surface water (hydrologic and hydraulic modelling) are documented in Appendix B of this report.

4.5 Stakeholder Engagement

As part of this assessment, specific engagement was undertaken with stakeholders as described in Table 4-7.



Table 4-7 Summary of stakeholder engagement

Activity	When	Matters discussed / issues raised	Consultation outcomes
Meeting – MMRA, Melbourne Water, AJM JV	26 March 2015	- Introduction and overview of the project provided to Melbourne Water - Broad overview of data and information held by Melbourne Water that might be useful to the project team.	Melbourne Water committed to providing the project with all relevant available information.
Meeting – Melbourne Water, AJM JV	28 April 2015	Further discussion of data and information held by Melbourne Water that might be useful to the project team.	Melbourne Water reiterated commitment to providing the project with all relevant available information.
Meeting – Melbourne Water, AJM JV	19 May 2015	Transfer of relevant available Melbourne Water flood and drainage information, including hydrologic and hydraulic models, and details of waterways and drainage systems.	Provision of Melbourne Water information to the project team.
Meeting – MMRA, City of Melbourne, Melbourne Water, AJM JV	5 June 2015	- Joint City of Melbourne / Melbourne Water hydraulic modelling of the CBD. - Availability of and access to flood and drainage data and information held by City of Melbourne. - Broad discussion of potential drainage issues and solutions along Swanston Street associated with CBD South station.	- Broad agreement with City of Melbourne to share information, including the hydraulic model of CBD being developed in conjunction with Melbourne Water for the project. - Agreement to work in consultation with City of Melbourne to develop solutions.
Meeting – MMRA, Melbourne Water, AJM JV	27 July 2015	Strategies to expedite Melbourne Water audit of hydraulic modelling on an ongoing basis to expedite approvals at completion of works.	Confirmed that Melbourne Water would undertake moving reviews of modelling to expedite outcomes.
Communication – MMRA, Melbourne Water	11 August 2015	Mitigation of construction impacts at Arden station.	Melbourne Water provided in-principle agreement to the concept of providing compensatory storage to offset loss of floodplain storage during construction.
Meeting – MMRA, City of Melbourne, City of Port Phillip, AJM JV	26 August 2015	Review of drainage proposals for Domain station.	Broad agreement on potential drainage diversions and protection levels.



Activity	When	Matters discussed / issues raised	Consultation outcomes
Meeting – MMRA, City of Melbourne, City of Port Phillip, AJM JV, Melbourne Water	25 September 2015	- Further review of drainage proposals for Domain station to take account of downstream restrictions. - Update to City of Melbourne for all other locations except for the eastern portal.	Broad agreement on potential drainage diversions and protection levels.
Meeting – MMRA, City of Stonnington, AJM JV	29 September 2015	Review of drainage issues at the eastern portal.	- Additional hydraulic assessment required to undertaken as part of impact assessment - Exchange of relevant supporting data between City of Stonnington and MMRA/AJM JV.
Meeting – Melbourne Water, AJM JV	6 October 2015	- Previous Melbourne Water hydraulic and hydrological models of Graingers Road Main Drain made available. - Discussion of flood impact mitigation of the western turnback (West Footscray station).	- Agreed the western turnback (West Footscray station) intersects existing Special Building Overlay (SBO) in the Maribyrnong Planning Scheme. - Need to check Melbourne Water hydraulic model results at West Footscray station, as these supersede existing (Special Building Overlay) in the Maribyrnong Planning Scheme.
Meeting – MMRA, Melbourne Water, AJM JV	7 October 2015	CBD drainage performance criteria.	Melbourne Water provided CBD drainage performance criteria for City of Melbourne.
Meeting – Melbourne Water, AJM JV	9 October 2015	- Review of flood planning overlays surrounding Domain station. - Discussion regarding Hannah Street Main Drain.	- Agreed Special Building Overlay in the Port Phillip Planning Scheme is outdated - Melbourne Water to provide Hannah Street Main Drain flood reporting and peak flood levels to be extracted from results.
Meeting – MMRA, City of Stonnington, Melbourne Water, AJM JV	19 October 2015	Review of drainage issues at the eastern portal.	- Need for additional hydraulic assessment of potential impacts of overland flows from the Prahran Main Drain system at the eastern portal - Exchange of relevant supporting data (hydraulic models and supporting reports, data on underground drainage systems).



In addition to the specific agency and Technical Reference Group engagement and the engagement listed in the table above, general engagement and consultation with the community was also conducted as part of this assessment. Written feedback was obtained through feedback forms and the online engagement platform, and face-to-face consultation occurred at the drop-in sessions (refer to Technical Appendix C *Community and Stakeholder Feedback Summary Report* for further information). Surface water specialists attended the drop-in sessions at Arden and Kensington where it was considered that flooding issues were likely to be raised due to the presence of flooding and overland flow overlays.

Feedback and concerns from the community relating to surface water were limited. The primary concern was that the project would increase flood risk within South Yarra, as the rail cutting has historically been subject to flooding. These concerns were addressed through research of archives of previous flood events and incorporating recommended Environmental Performance Requirements that ensure flood risk would not increase (refer to Section 17).

4.6 Limitations

The limitations associated with this assessment are as follows:

- Where flood levels, hydrological and hydraulic models and other information have been provided by others, including agencies such as Melbourne Water, these have generally been assumed to be correct, and have not been comprehensively reviewed. Models provided by third parties include:
 - Melbourne Water – Provision of a copy of the previously developed hydraulic and hydrologic models of the Maribyrnong River, Moonee Ponds Creek and the Yarra River, and a copy of the hydraulic model of the CBD drainage system.
 - MMRA – Provision of previously developed AECOM hydraulic and hydrologic models of the lower portion of the Moonee Ponds Creek.
 - City of Stonnington – Provision of a hydraulic model of the Prahran Main Drain system.

Elements of the models that were generally not reviewed in detail included the topography, bathymetry and other details of waterways, overland flow paths and floodplains, levee banks, pipes, bridges and other structures, etc. In general, none of the models have been calibrated or recalibrated to recorded flood levels or flows from historical events as part of the current investigation. In some cases, no evidence has been made available to demonstrate the calibration performance of the models that were provided. The models have been assumed to provide a reasonable representation of flows from the contributing catchments, and the hydraulic behaviour of the system, including bridges and other structures, for existing conditions. More details of the models and their limitations are discussed further in Appendix B of this report. Limitations are also discussed in background reports to models referenced in Appendix B of this report.

Despite these limitations, based on the author's experience the models are considered to be fit for purpose, as they are considered to provide an adequate representation of the flood events required to be investigated for the purposes of the assessment.

- The assessment was based on the Concept Design and the associated alternative design options as of January 2016.
- Station pedestrian entrance levels are based upon available station design information; however, Domain station levels were extracted from available aerial and ground-based survey data.



5 Regional Context

The Melbourne Metro project boundary potentially interfaces with a number of waterways and drainage systems. There is potential for infrastructure and construction works to impact on flood flows and levels along these systems. There is also potential for floodwaters and overland drainage flows to impact on project works. This could include potential inundation of the tunnels and stations, potentially compromising the safety of construction workers, commuters and rail staff, and disrupting rail services. Relevant drainage systems and waterways include:

- **Maribyrnong River.** This is approximately 500 m to the west of the western portal. Its catchment area upstream of the three parallel railway bridges to the west of the western portal is approximately 1,400 km². The area immediately surrounding the portal is subject to flooding from the Maribyrnong River.
- **Moonee Ponds Creek** and its tributary drainage systems. The area around Arden station is subject to flooding from one or both of (1) flows in excess of the capacity of the Moonee Ponds Creek channel, and/or (2) inflows from the local sub-catchments on either side of the Creek. The major inflows to the area are from Moonee Ponds Creek upstream of Mount Alexander Road. The catchment area of Moonee Ponds Creek to this point is 148 km². The areas of the local sub-catchments on the eastern and western sides of the Creek between Mount Alexander and Footscray Roads are six and three square kilometres respectively. Many of the drainage systems that service these local sub-catchments are equipped with pumped outfalls. Flows from the local sub-catchments are pumped into the creek at times when creek levels are too high to allow discharge by gravity. The most significant system servicing the local sub-catchment on the east side of the creek is Melbourne Water's Arden Street Main Drain.
- **Swanston Street Drains.** The CBD South station area is immediately adjacent to two existing City of Melbourne drains in Swanston Street. There are station entrances at City Square, Federation Square and close to Flinders Street. All these areas may be subject to flooding from overland flows. Flows in excess of the combined capacities of the Swanston Street drains and overland flow paths along Swanston Street, flow west into the Elizabeth Street Main Drain system. The drains in Elizabeth Street are the responsibility of Melbourne Water. Elizabeth Street is prone to regular and significant flooding. The most significant recent event was in 2010. Overland flows from the Swanston Street catchment are known to contribute to the Elizabeth Street flooding.
- **Yarra River.** The Yarra River is the largest waterway within the study area, with a catchment area of 4,080 km² and main stream length of 242 km. In its lower reaches the Yarra catchment becomes more densely urbanised before it flows through the Melbourne CBD and into Port Phillip Bay. Flooding of the Yarra River has the potential to impact on CBD South and Domain stations, and the eastern portal.
- **Hannah Street Main Drain.** The Hannah Street Main Drain system services the catchment around Domain station. The largest drain in the system, the Hannah Street Main Drain, runs approximately north south along Kingsway, and discharges to the Yarra River near Crown Casino. The system also includes outfalls to Albert Park Lake.
- **The Prahran Main Drain and Yarra Street Outfall Drain systems.** These service the area in the immediate vicinity of the eastern portal. The Prahran Main Drain services the catchment to the south and east of South Yarra station. The Prahran Main Drain outfalls to the Yarra River between Church Street Bridge and the Yarra River rail crossing to the north of South Yarra station. The upper reaches of the Yarra Street Outfall Drain run from south west to north and parallel to the Sandringham rail line cutting. North of Toorak Road, the Outfall Drain turns north east and crosses under the rail line at South Yarra station, before outfalling to the Yarra River immediately to the east of the Yarra rail bridge. Anecdotal evidence suggests that South Yarra station is subject to relatively frequent inundation as a result of overland flows from this system.



- **Graingers Road Main Drain.** The western turnback at West Footscray station crosses Melbourne Water's Graingers Road Main Drain. This flows from north to south across the rail alignment, and discharges to Stony Creek approximately one kilometre south of the station.



6 Risk Assessment

Table 6-1 presents the surface water risks associated with the project, on a precinct basis. The environmental risk assessment methodology is outlined in Section 4.3.

Existing performance requirements were identified to inform the assessment of initial risk ratings. These existing performance requirements are based on standard requirements that are typically incorporated into construction contracts for rail projects.

The potential impacts of the identified risks have been assessed, the findings of which are summarised in subsequent chapters. The impact assessment focusses on those risks that have been assessed as having a risk level of medium or above.

While many of the potential surface water risks associated with Melbourne Metro would have a rare or unlikely likelihood rating (such as 0.1 per cent AEP, or 0.01 per cent AEP flood events during the project's operational phase), the potential impacts of these hazardous events could be major, or severe. In a few instances, even flood events with a likelihood rating more frequent than 'unlikely' could have major or severe consequences. As a result, a number of initial risk ratings of medium or high were assigned.

As a result of the impact assessment, project-specific performance requirements ('Environmental Performance Requirements') have been proposed to reduce risks and hence determine the 'Residual Risk Rating'. The Environmental Performance Requirements are outlined in the following sections of the impact assessment and collated in Table 17-1. All Environmental Performance Requirements are incorporated into the Environmental Management Framework for the project (Chapter 23 of the EES).

In assigning likelihood and consequence ratings, the combination of those that would result in the most severe risk rating was used. In some instances this meant that the likelihood of the flood event used to determine the initial risk rating was different to the likelihood of the event used to determine the residual risk rating. For example, **Risk #SW019** relates to flooding of the tunnels from the Maribyrnong River through the western portal during the operational phase of the project. This could potentially result in death or serious injury to commuters or rail staff and long-term disruption to the rail network. Melbourne Water generally requires that all critical infrastructure be protected against flooding in a one per cent AEP flood event. This then constitutes the existing performance requirement. In the absence of any additional mitigation measures, the portal could, however, flood as a result of 0.2 per cent AEP flood event, which would be assigned a possible likelihood. The consequence of this would be severe. The initial risk rating is then high. Proposed mitigation measures include automated gates to protect the portal against even the most extreme flood event. Therefore, in assigning the residual risk, even a rare event would have negligible consequence and this combination has been used to assign a very low residual risk.

When combined with implementation of identified mitigation measures (such as portal flood gates and emergency procedures), all of the potential events have been assigned a residual risk rating of low or very low. Proposed flood mitigation works and measures that could be employed to reduce risks and achieve the Residual Risk ratings documented in Table 6-1 are outlined in subsequent Sections 7 to 16 inclusive. Proposed measures to mitigate flood risk often included emergency management measures. The feasibility of implementing these measures was also considered. Available flood warning times are generally much longer in systems with larger catchments, than for smaller overland flow systems. In the Yarra River, for example, two to three day's warning is likely to be available in advance of a flood peak. In smaller overland flow systems however, only ten of minutes warning might be available in advance of a flow peak. Where limited warning time is available, it is unlikely to be feasible, for example, to install temporary flood barriers such as sandbags in advance of a flood.



For further details, refer to Technical Appendix B *Environmental Risk Assessment Report*, which includes the full Risk Register, with existing performance requirements and Environmental Performance Requirements assigned to each risk.

For works required to protect construction workers, commuters, rail staff and rail services against flooding, a minimum flood immunity standard has often been specified. In cases where this has not been specified, it is feasible, in every instance, to implement works and measures that would reduce the 'Residual Risk Rating' to either low or very low, as documented in Table 6-1.

For works required to protect property and infrastructure in the vicinity of the project against flood impact, a one per cent AEP flood event benchmark has been assumed as the standard against which the impacts of the project need to be assessed. This is in accordance with Melbourne Water requirements, as outlined in Section 4.1.2 of this report.



Table 6-1 Risk register for impact assessment

Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Construction									
Flood event on Yarra River	Potential flooding of Melbourne Metro tunnels from the existing City Loop tunnels could potentially compromise the safety of construction workers.	1 - Tunnels	Severe	Rare	Medium	Negligible	Rare	Very Low	SW001
Rainfall/overland flow event in Fawkner Park	Potential flooding of TBM launch site and tunnels. This could result in injury to construction workers.	1 - Tunnels	Major	Rare	Medium	Negligible	Rare	Very Low	SW002
Flood event on Maribyrnong River	Potential flooding of the tunnels, from the western portal during construction which could potentially compromise the safety of construction workers if this occurred before the retaining walls had been built. Lesser consequence could arise due to inundation from local drainage.	2 - Western Portal	Severe	Possible	High	Negligible	Rare	Very Low	SW003
Flood event on Maribyrnong River or Moonee Ponds Creek	Minor potential increase in flood levels to surrounding properties, due to loss of flood storage.	2 - Western Portal 3 - Arden station	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW004
Flood event on Moonee Ponds Creek	Potential flooding of Arden station and tunnels could potentially compromise the safety of construction workers.	3 - Arden station	Severe	Unlikely	High	Negligible	Rare	Very Low	SW005
Flood event on Moonee Ponds Creek	Potential minor increases in flood levels during construction of the substation.	3 - Arden station	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW006



Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Rainfall/overland flow event in Parkville local catchment	Potential flooding of Parkville station and/or tunnels during construction could result in injury to construction workers.	4 - Parkville station	Major	Rare	Medium	Negligible	Rare	Very Low	SW007
Rainfall/overland flow event in Parkville, CBD North or CBD South local catchments	Minor potential increase in flood levels to surrounding infrastructure (expected to be confined to roads).	4 - Parkville station 5 - CBD North station 6 - CBD South station	Minor	Unlikely	Low	Minor	Unlikely	Low	SW008
Rainfall/overland flow event in CBD North local catchment	Potential flooding of CBD North station and/or tunnels during construction. This could result in injury to construction workers.	5 - CBD North station	Major	Rare	Medium	Negligible	Rare	Very Low	SW009
Rainfall/overland flow event in CBD South local catchment	Potential flooding of CBD South station and/or tunnels during construction. This could potentially compromise the safety of construction workers.	6 - CBD South station	Severe	Rare	Medium	Negligible	Rare	Very Low	SW010
Rainfall/overland flow event in Domain local catchment	Potential flooding of Domain station, TBM launch site and/or tunnels during construction could result in injury to construction workers.	7 - Domain station	Major	Rare	Medium	Negligible	Rare	Very Low	SW011
Rainfall/overland flow event in Domain local catchment	Potential increase in flood levels to surrounding properties.	7 - Domain station	Major	Unlikely	Medium	Minor	Unlikely	Low	SW012
Rainfall/overland flow event in eastern portal local catchments	Minor potential increase in flood levels to surrounding properties, due to construction infrastructure.	8 - Eastern Portal	Minor	Unlikely	Low	Minor	Unlikely	Low	SW013



Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Flood event on Yarra River	Potential flooding of the tunnels, from the eastern portal during construction. The level of the high point on the existing rail line between the Yarra River and the eastern portal in the current design is above the 0.1 per cent AEP existing flood level. If flood waters were to enter the tunnels from the portal, this could potentially compromise the safety of construction workers.	8 - Eastern Portal	Severe	Rare	Medium	Negligible	Rare	Very Low	SW014
Rainfall/overland flow event in eastern portal local catchments	Potential flooding of the tunnels from the eastern portal due to overland flows discharging to the rail cutting from either the Yarra Street Outfall Drain or Prahran Main Drain (from near Chapel Street) during construction could result in injury to construction workers.	8 - Eastern Portal	Major	Rare	Medium	Negligible	Rare	Very Low	SW015
Rainfall/overland flow event in drain system adjacent to West Footscray station	Potential minor increase in flood levels north of the track and platform works.	9 - Western Turnback	Minor	Unlikely	Low	Minor	Unlikely	Low	SW016
Rainfall/overland flow event in early works catchments	Potential minor increases in flood levels during construction.	All	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW017
Operation									
Flood event on Yarra River	Potential flooding of the Melbourne Metro tunnels from the existing City Loop tunnels could potentially compromise the safety of commuters or rail staff, and result in serious long disruption of rail operations.	1 - Tunnels	Severe	Unlikely	High	Negligible	Rare	Very Low	SW018
Flood event on Maribyrnong River	Potential flooding of the tunnels, from the western portal could potentially compromise the safety of commuters or rail staff, and result in serious long disruption of rail operations. Lesser consequences could arise due to inundation caused by runoff from the decline structure.	2 - Western portal	Severe	Possible	High	Negligible	Rare	Very Low	SW019



Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Flood event on Maribyrnong River or Moonee Ponds Creek	Minor potential increase in flood levels to surrounding properties, due to loss of flood storage.	2 - Western Portal 3 - Arden station	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW020
Rainfall event on tunnel decline structure	Pumped discharge may overload the local drainage system resulting in minor increase in flood levels to surrounding properties.	2 - Western Portal	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW021
Flood event on Moonee Ponds Creek	Potential flooding of Arden station and tunnels could potentially compromise the safety of commuters or rail staff, and result in serious long disruption of rail operations.	3 - Arden station	Severe	Unlikely	High	Negligible	Rare	Very Low	SW022
Flood event on Moonee Ponds Creek	Potential minor increases in flood levels due to substation infrastructure.	3 - Arden station	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW023
Flood event on Moonee Ponds Creek	Potential flooding of substation, resulting in loss of power to the rail system and disruption to service.	3 - Arden station	Major	Likely	High	Negligible	Unlikely	Very Low	SW024
Rainfall/overland flow event in Parkville, CBD North or Domain local catchments	Potential flooding of Parkville, CBD North and Domain stations, and tunnels, from station entrances at ground level could result in injury to commuters or rail staff, and disruption of rail operations.	4 - Parkville station 5 - CBD North station 7 - Domain station	Major	Unlikely	Medium	Negligible	Rare	Very Low	SW025
Rainfall/overland flow event in Parkville, CBD North or Domain local catchments	Minor potential increase in flood levels to surrounding properties, due to station infrastructure (raised entrances).	4 - Parkville station 5 - CBD North station 7 - Domain station	Minor	Unlikely	Low	Minor	Unlikely	Low	SW026



Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Rainfall/overland flow event in CBD South local catchment	Potential flooding of CBD South station and tunnels, from station entrances at ground level could potentially compromise the safety of commuters or rail staff, and result in disruption of rail operations.	6 - CBD South station	Severe	Unlikely	High	Minor	Rare	Very Low	SW027
Rainfall/overland flow event in CBD South local catchment	Minor potential increase in flood levels to surrounding properties, due to station infrastructure (raised entrances).	6 - CBD South station	Minor	Unlikely	Low	Minor	Unlikely	Low	SW028
Flood event on Yarra River	Potential flooding of CBD South station and tunnels, from station entrances at ground level could potentially compromise the safety of commuters or rail staff and result in serious long-term disruption of rail operations.	6 - CBD South station	Negligible	Rare	Very Low	Negligible	Rare	Very Low	SW029
Flood event on Yarra River	Potential flooding of Domain station and tunnels, from station entrances at ground level, could potentially compromise the safety of commuters or rail staff and result in serious long-term disruption of rail operations.	7 - Domain station	Negligible	Rare	Very Low	Negligible	Rare	Very Low	SW030
Rainfall/overland flow event in eastern portal local catchments	Potential flooding of the tunnels from the eastern portal due to overland flows discharging to the rail cutting from either the Yarra Street Outfall Drain or Prahran Main drains (from nearby Chapel Street) during operation. This could result in minor disruption of rail operations. Similar consequences could arise due to inundation resulting from runoff from the decline structure.	8 - Eastern Portal	Minor	Rare	Very Low	Minor	Rare	Very Low	SW031
Flood event on Yarra River	Potential flooding of the tunnels, from the eastern portal during operation. The level of the high point on the existing rail line between the Yarra River and the eastern portal in the current design is approximately the same as the Year 2100 (ie including allowance for climate change) 0.1 per cent AEP flood level. If floodwaters were to enter the tunnels from the portal, this could potentially compromise the safety of commuters or rail staff and result in serious long-term disruption of rail operations.	8 - Eastern Portal	Severe	Unlikely	High	Negligible	Rare	Very Low	SW032



Impact pathway		Precincts	Initial Risk			Residual risk			Risk no.
Category	Event		C	L	Risk	C	L	Risk	
Rainfall event on tunnel decline structure	Pumped discharge may overload the local drainage system resulting in minor increases in flood levels to surrounding properties.	8 - Eastern Portal	Minor	Unlikely	Low	Negligible	Unlikely	Very Low	SW033
Rainfall/overland flow event in drain system adjacent to West Footscray station	Potential minor increase in flood levels north of the track and platform works, and potential short-term disruption to rail services.	9 - Western Turnback	Minor	Unlikely	Low	Minor	Unlikely	Low	SW034



7 Precinct 1: Tunnels

7.1 Project Components

The components of the Concept Design, which are relevant to the surface water impact assessment, are:

- TBM Southern launch site in Fawkner Park open space and tennis courts
- Interconnection between the Melbourne Metro tunnels and existing City Loop tunnels at CBD North station
- The siting of the emergency access shafts:
 - Fawkner Park, located in the north east section of the park
 - Adjacent to Linlithgow Avenue, to be located in Queen Victoria Gardens (north of Linlithgow Avenue).

7.1.1.1 Alternative Design Options

The two alternative design options of relevance for the surface water impact assessment are the alternate emergency access shaft locations:

- Fawkner Park – utilising the location of the Fawkner Park TBM launch site
- Linlithgow Avenue – located in Toms Block, between Linlithgow Avenue and St Kilda Road.

7.1.2 Construction

The construction components of the Concept Design which are relevant to the surface water impact assessment are:

- Works associated with the interconnection between the Melbourne Metro tunnels and existing City Loop tunnels at CBD North station
- The siting of the Fawkner Park construction work site.

7.1.2.1 Alternative Design Options

The major construction activities for the alternative design options are very similar to those for the Concept Design.

7.2 Existing Conditions

Interconnection between Melbourne Metro and City Loop Tunnels at CBD North Station

The rail tunnels are potentially subject to flooding from the existing City Loop tunnels through the underground interconnection at CBD North station. Of the six City Loop tunnel portals in the area between Flinders Street and Richmond stations, the portal on the line between Flinders Street and Parliament stations, near Federation Square, is at by far the greatest risk of riverine flooding. The level of the decline structure at the entry to this portal is around 3.3 m AHD and thus subject to flooding from the Yarra River in a Year 2100 (ie including allowance for climate change impacts) one per cent AEP Yarra River flood event (flood level of 3.8 m AHD – refer to Section 12.2). The other five portals in this area are all above 6.0 m AHD, and thus above the Year 2100 0.1 per cent AEP Yarra River flood level.

TBM Southern Launch Site – Fawkner Park

There are no flooding overlays or major overland flow paths in the vicinity of the TBM southern launch site in Fawkner Park. The majority of overland flows originating in the small catchment to the north east of the site would be intercepted in Toorak Road and flow west away from the site. Therefore, the site is not subject to any major surface water inundation risk.



Emergency Access Shaft – North east corner of Fawkner Park

There are no flooding overlays or major overland flow paths in the vicinity of the emergency access shaft site in the north east corner of Fawkner Park. The site would be located on a minor ridgeline, and immediately south of a local high point on Toorak Road. Therefore the site would be subject to negligible surface water inundation risk.

Emergency Access Shaft – Linlithgow Avenue

There are no flooding overlays or major overland flow paths in the vicinity of the emergency access shaft site in Linlithgow Avenue. The site would be located approximately 50 m west of the high point in Linlithgow Avenue and the area draining to the site would be very small. Therefore, the site would be subject to negligible surface water inundation risk.

7.2.1 Alternative Design Options

Emergency access shaft – TBM launch site – Fawkner Park

As discussed in Section 7.2, this site would not be subject to any major surface water inundation risk.

Emergency access shaft – Tom's Block

There are no flooding overlays or major overland flow paths in the vicinity of the emergency access shaft site in Toms Block, between Linlithgow Avenue and St Kilda Road. The site would be close to a minor ridgeline, from which the topography falls away towards both Linlithgow Avenue and St Kilda Road. The majority of overland flows originating in the small catchment to east of Linlithgow Avenue would be intercepted in Linlithgow Avenue and flow north away from the site. Therefore, the site would be subject to negligible surface water inundation risk.

7.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 7-1.

Table 7-1 Key issues associated with the Concept Design

Concept Design	Issue	Risk no
Interconnection between Melbourne Metro and City Loop tunnels at CBD North station	Potential flooding of Melbourne Metro tunnels from Yarra River flood waters entering the City Loop tunnels during construction and operation.	SW001 SW018
TBM Southern launch site		
Fawkner Park open space and tennis courts	Potential flooding of the tunnels from local runoff to the TBM launch site during construction.	SW002

7.3.1 Alternative Design Options

Both of the alternative design options for the emergency access shaft locations would be subject to negligible surface water inundation risk.

7.4 Benefits and Opportunities

The opportunities associated with the Concept Design and the alternative design options relate to enhanced flood protection for the existing City Loop tunnels and stations, as a result of the mitigation measures that are proposed to protect the Melbourne Metro tunnels from flooding from the Yarra River.



7.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 7-2 Draft Evaluation objectives and assessment criteria for the tunnels

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

None of the works would have any adverse impacts on existing flooding functions and characteristics.

As discussed above, the Melbourne Metro tunnels are potentially subject to flooding from the existing City Loop tunnels through the underground interconnection at CBD North station (**Risks #SW001 and #SW018**). The flood level at which the lowest City Loop tunnel portal near Federation Square would commence to flood is approximately 3.3 m AHD. Investigations undertaken as part of Melbourne Metro (refer to Appendix B of this report) have concluded that this corresponds to an event more frequent than a Year 2100 one per cent AEP Yarra River flood. This would result in inundation of the Melbourne Metro tunnels in a relatively short time frame following initial inundation of the portal.

This could be mitigated by installing flood gates to prevent flooding of this City Loop tunnel portal during both the construction and operational phases of Melbourne Metro. These would comprise watertight gates at the ends of the cut-and-cover sections of the portals to prevent any floodwaters entering the tunnels in a flood event when the gates were closed. The gates would need to be permanently in place at the tunnel portals and would need to be periodically tested to ensure they were operating satisfactorily. They would be closed in advance of a potential flood event, based on flood warning advice from relevant authorities.

Melbourne Water has estimated that the Year 2100 one per cent AEP Yarra River flood level at the lowest City Loop tunnel portal is 2.9 m AHD. More detailed modelling, undertaken as part of Melbourne Metro (refer to Appendix B of this report), has estimated this level to be 3.8 m AHD. The difference in opinion regarding this flood level, although significant, does not contribute to an increased level of mitigated risk, as the proposed flood gates would provide flood immunity against even the most extreme Yarra River flood events. They would thus provide compliance with Melbourne Water's flood immunity requirements.

The other five portals in this area are all above 6.0 m AHD, and thus above the Year 2100 0.1 per cent AEP Yarra River flood level. A flood immunity risk assessment is required to determine whether this is acceptable. This would need to consider the operability and integrity of the rail network, as determined by the network owner, and take account of the impacts of a range of flood events on factors including damage and clean-up costs, and the costs associated with long-term disruption of the rail network.

There is potential for some inundation of the TBM launch site in Fawkner Park during construction, from minor overland flows reaching Fawkner Park across Toorak Road from the small catchment to the north and east (**Risk #SW002**). This could be relatively easily mitigated by construction of small barriers to intercept flows reaching the north side of the excavation and diverting these around the excavation. Diversion of these minor flows would have negligible impact on overland flow depths.



If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives, listed in Table 7-2, as it would result in negligible impact on existing flooding and drainage functions and characteristics.

7.5.1 Alternative Design Options

As noted above, both alternative design options emergency access shaft locations are subject to negligible surface water inundation risk.

The alternative design option for the precinct is consistent with the draft EES evaluation objective for surface water drainage and flooding as it would result in negligible impact on existing flooding and drainage functions and characteristics.



7.6 Environmental Performance Requirements

Table 7-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct. Note that the Environmental Performance Requirements for portals and stations are covered in chapters relating specifically to those assets. This includes the TBM launch site at Domain station.

Table 7-3 Environmental Performance Requirements for tunnels

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Potential flooding of the tunnels from the Yarra River from the City Loop tunnels during construction, potentially compromising the safety of construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Install flood gates on the City Loop tunnel portal near Federation Square. Ensure other five City Loop portals between Flinders Street and Richmond stations are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment.	SW001
Commuters, rail staff, rail services	Potential flooding of the tunnels from the Yarra River from the City Loop tunnels during operation, potentially compromising the safety of commuters and/or rail staff, and disrupting rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Install flood gates on the City Loop tunnel portal near Federation Square. Ensure other five City Loop portals between Flinders Street and Richmond stations are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment.	SW018
Construction workers	Flooding of the TBM launch site in Fawkner Park during construction, resulting in injury to construction workers.	For all precincts (with the exception of the Western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Construction of small barriers to prevent overland flow inundating the Fawkner Park TBM launch site during construction.	SW002



8 Precinct 2: Western Portal (Kensington)

8.1 Project Components

The components of the Concept Design which are relevant to the surface water impact assessment are:

- Twin track decline structure and retaining wall along Childers Street to carry the Melbourne Metro tracks from embankment level to below ground. This would result in widening of parts of the existing rail embankment. The gradient of the decline structure would be three per cent
- Twin track cut-and-cover tunnels from the decline structure to the driven (bored) tunnels entrances (ie tunnels precinct)
- The interface with the TBM driven tunnels would occur adjacent to the railway reserve on the eastern side of Tennyson Street in the 50 Lloyd Street Business Estate.

The Concept Design includes an emergency relief facility/TBM retrieval box located adjacent to the railway reserve on the eastern side of Tennyson Street in the 50 Lloyd Street Business Estate.

8.1.1.1 Alternative Design Option

The alternative design options to the Concept Design are:

- The location of the TBM retrieval box opposite the pavilion on Childers Street and a longer decline structure
- A substation adjacent to the western portal, although it is noted that this substation alternative design option is not possible in the event that the alternative design option for the TBM retrieval box, and longer decline structure, is selected.

8.1.2 Construction

Main construction activities at the site relevant to the surface water impact assessment would be:

- Establishment of construction work sites
- Construction of a piled structure alongside the current railway embankment to the east end of the skate park in JJ Holland Park
- Construction of decline structure to the centre of South Kensington station
- Construction of cut-and-cover tunnels to the east end of Childers Street, including an area of excavation of approximately 5,300 m²
- Construction of services and relief shaft in the west corner of the 50 Lloyd Street Business Estate
- Tunnels excavation and TBM retrieval (with the TBM driving first to the western portal from Arden station before being retrieved and relaunched from Arden station for the second drive to CBD North station).

A major construction work site is to be located at 1–39 Hobsons Road to support activities at the western portal. This site would be used for site offices and facilities, laydown areas and materials and equipment storage.

8.1.2.1 Alternative Design Option

The main construction activities associated with the alternative design options are similar to those associated with the Concept Design.

8.2 Existing Conditions

The area immediately to the west of the western portal precinct is subject to flooding from the Maribyrnong River. The Maribyrnong River is one of metropolitan Melbourne's most significant waterways. Its catchment



area upstream of the three parallel railway bridges to the west of the western portal is approximately 1,400 km².

The three existing railway bridges through the rail embankment form a significant constriction to flood flows. The floodplain upstream of the bridges is relatively wide, and includes Flemington Racecourse on the east bank and parkland on the west bank. The floodplain upstream of the railway bridges is of the order of 800 m wide, yet the span of railway bridges is only of the order of 100 m. While there is a large bank of culverts through the embankment that forms the right (west) abutment for two of the bridges (the third – the Regional Rail Link Bridge – is a series of bridge spans), the only opening in the left abutment is along Kensington Road. The rail embankment is relatively high and would only be overtopped by an extreme flood event.

Flood gradients along the Maribyrnong River are relatively flat. Consequently, any flood level increases due to works in the floodplain are likely to propagate upstream for a significant distance.

Residential developments and associated compensatory mitigation works have been undertaken along the floodplain upstream of the rail bridges in recent decades. These include, for example, the Edgewater Development. This development included landfilling to enable residential development and excavation of the floodplain to provide compensatory flood conveyance.

The Maribyrnong village, on the west bank of the River upstream of Maribyrnong Road, is particularly flood prone.

Areas covered by the Land Subject to Inundation Overlay (LSIO) of the Melbourne Planning Scheme and the Maribyrnong Planning Scheme associated with flooding from the Maribyrnong River are shown in Figure 8-1. The Maribyrnong River channel between Dynon and Footscray Roads is covered by a Floodway Overlay (FO) of the Maribyrnong Planning Scheme. Under existing conditions, a one per cent AEP flood would inundate Childers Street near JJ Holland Park to a depth of around a metre.

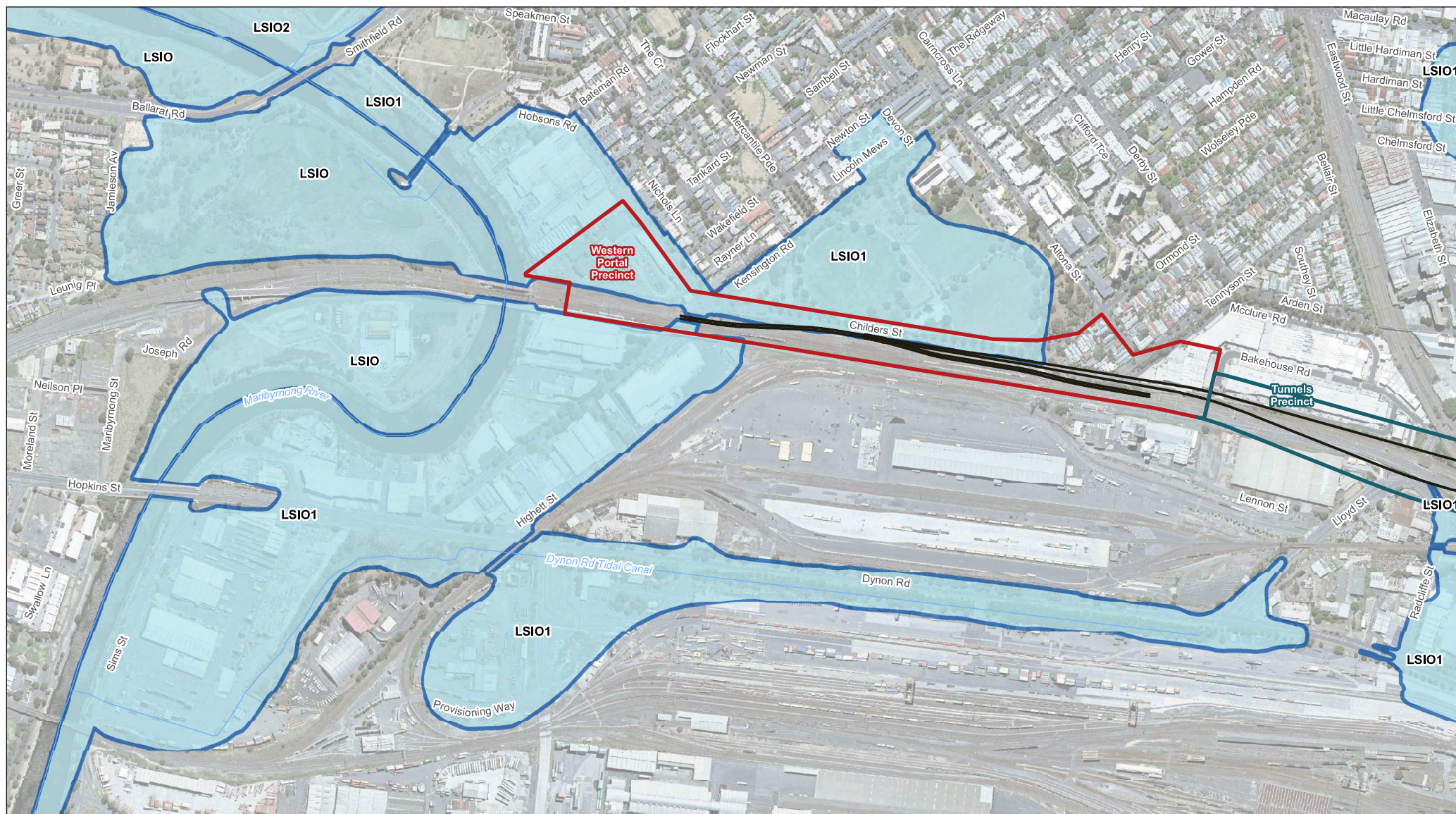
At least twelve hours warning would typically be available in advance of a flood peak on the Maribyrnong River at the western portal.

Flood warnings and notifications in Victoria are provided by the Bureau of Meteorology (BoM), Melbourne Water and the Victoria State Emergency Service (VICSES) (Victoria State Emergency Service, 2012). Melbourne Water acts as the flood prediction agency for some of the larger catchments in metropolitan Melbourne, including the Maribyrnong River.

Hydrologic and hydraulic flood modelling was undertaken to estimate a range of peak flood flows and levels on the upstream side of the existing rail embankment. These are summarised in Table 8-1. Further details of the modelling are provided in Appendix B of this report.

Table 8-1 Maribyrnong River flood flows and levels upstream of existing rail embankment

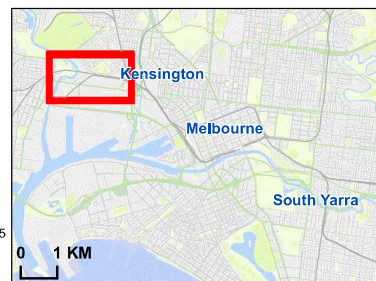
Flood event AEP (%)	Conditions	Peak flood level (m AHD)	Peak flood flow (m ³ /s)
1	Existing	3.1	1,000
1	Year 2100 (i.e. including allowance for climate change impacts)	4.7	1,650
0.1	Year 2100	Not determined	2,600
0.01	Year 2100	Not determined	4,100



Legend

- Proposed alignment
- LSIO - Land Subject to Inundation
- Environmental and Planning Precincts**
- Portal Precinct
- Tunnel Precinct

Data Sources:
 Proposed Infrastructure: AJM January 2015
 Contains Vicmap Information
 © State of Victoria 2015
 Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
 Maribyrnong River -
 Land Subject to Inundation Overlay

Drawing Number:
 MMR-AJM-UGAA-MP-NO-500142

Revision:
 P1

Drawn By:
 A. Berman

Approved By:
 D. Sheehan

Date:
 7/04/2016

Map Size:
 A4

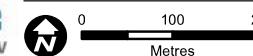


Figure 8-1 Maribyrnong River and Moonee Ponds Creek – Land Subject to Inundation Overlay (LSIO) (DELWP, 2016)



8.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 8-2.

Table 8-2 Key issues associated with Concept Design

Concept Design	Issue	Risk no.
Western portal and TBM retrieval box	Potential flooding of the tunnels from the Maribyrnong River from the western portal and/or the TBM retrieval box during construction	
	Construction works resulting in increased flood levels due to loss of flood storage	SW003
	Potential flooding of the tunnels from the Maribyrnong River from the western portal during operation	SW004
	Permanent embankment works resulting in increased flood levels due to loss of flood storage	SW019
	Increase in flood levels to adjacent properties due to overloading of the local drainage system resulting from pumped drainage from the decline structure during operation.	SW020 SW021

8.3.1 Alternative Design Option

The key issues associated with the alternative design options are similar to those associated with the Concept Design.

8.4 Benefits and Opportunities

The opportunities associated with the Concept Design relate to the collection and re-use of stormwater from decline structure drainage, with appropriate treatment.

8.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 8-3 Draft evaluation objectives and assessment criteria for the Western Portal precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

Potential flooding of the western portal during construction has the potential to cause significant inundation of the tunnels in a relatively short time frame (within hours). This could pose a significant risk to construction workers (**Risk #SW003**). The area on the north side of the rail embankment is currently subject to flooding in a one per cent AEP flood event. Measures need to be put in place to ensure the portal is protected from flooding in at least the one per cent AEP flood event during construction. The potential impacts associated with larger flood events should also be recognised. Floodwaters would generally be expected to rise relatively slowly in this floodplain area, consequently many hours warning would generally be available to



enable evacuation and other necessary emergency measures to be put in place in advance of a flood peak. Required measures would include a flood warning system that links to existing systems in place in the Maribyrnong catchment and emergency evacuation procedures.

Potential flooding of the tunnels from the portal during operation also has the potential to cause significant inundation of the tunnels in a relatively short time frame. This could pose a significant risk to commuters and rail staff, and significant disruption to rail services (**Risk #SW019**). Even relatively shallow overtopping of retaining walls or other barriers protecting the portal against flooding could result in major flooding of the tunnels in a relatively short time frame (tens of minutes to hours). In the absence of any additional mitigation works, the permanent portal would be protected against flooding from the Maribyrnong River in an estimated one per cent AEP (100 year ARI) event, under Year 2100 (ie including allowance for climate change impacts) conditions, with a 600 mm freeboard allowance. This would thus comply with Melbourne Water's flood immunity requirements. The protection would be provided by a proposed retaining wall along the north side of the rail embankment on the south side of Childers Street, with a minimum crest level of 5.3 m AHD. It would be proposed that automatic flood gates be installed to protect the portal against flooding from more extreme events. These gates would extend to the full height and width of the portal, and thus provide protection against even the most extreme flood event. Automation would require a gauge to measure flood levels and trigger the closure mechanism of the gates once flood levels have reached, say, 4.3 m AHD.

Major Maribyrnong River flood flow paths in this area are through the main channel rail bridges and along Kensington Road. None of the construction or infrastructure works would be located such that they would obstruct flows through any of these major flood flow paths. Construction of the western portal would, however, result in some loss of floodplain storage. In the absence of mitigation, this would result in minor increases in downstream flood flows and upstream and downstream flood levels (**Risks #SW004 and SW020**). This would need to be mitigated by provision of some compensatory flood storage. The volume of compensatory flood storage required is approximately 9,000 m³. A number of options have been considered, however the proposed location of the storage is still to be confirmed.

Drainage runoff from the decline structure would be pumped into the local drainage system during operation. As the decline structure would increase the overall paved area, there is potential for an increase in flood levels to adjacent properties due to overloading of the local drainage system (**Risk #SW021**). Hence, there is likely to be a need to control the discharge rate into the existing drainage system. Local drainage storage of around 180 m³ would be required. As is the case for the compensatory flood storage, a number of options have been considered, however the proposed location of the storage is still to be confirmed. It may be feasible to combine this with the compensatory storage requirements described above.

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 8-3, as it would result in negligible impact on existing flooding and drainage functions and characteristics.

8.5.1 Alternative Design Option

As with the Concept Design, construction of the western portal alternative design option would result in some loss of floodplain storage. In the absence of mitigation, this would result in minor increases in downstream flood flows, and upstream and downstream flood levels. This would need to be mitigated by provision of compensatory flood storage. The volume of compensatory flood storage required is approximately 7,000 m³. As with the Concept Design, a number of options have been considered, however the proposed location of the storage is still to be confirmed.

The alternative design option substation is not located within any areas covered by flood overlays.

If the proposed mitigation measures described above were put in place, the alternative design option for the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 8-3, as it would result in negligible impact on existing flooding and drainage functions and characteristics.



8.6 Environmental Performance Requirements

Table 8-4 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 8-4 Environmental Performance Requirements for the western portal

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Potential flooding of the portal from Maribyrnong River during construction, potentially compromising the safety of construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure retaining walls or similar barriers are in place to protect portal and TBM shaft during construction, in at least a one per cent AEP flood event. Emergency management measures in place – flood warning system evacuation of workers.	SW003
Commuters, rail staff, rail services	Potential flooding of the portal from Maribyrnong River during operation, potentially compromising the safety of commuters and/or rail staff and disrupting rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Install automatic gates to protect portal in events in excess of the one per cent AEP flood event.	SW019
Property and infrastructure on the Maribyrnong floodplain in the vicinity of the portal	Increase in flood levels in areas adjacent to the rail embankment during construction and operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Provision of compensatory flood storage (approx. 9,000 m ³).	SW004, SW020



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Property and infrastructure on the Maribyrnong floodplain in the vicinity of the portal	Pumped discharge from the decline structure may overload local drainage system resulting in increase in flood levels to surrounding properties.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Provision of balancing storage (approx. 180 m ³).	SW021



9 Precinct 3: Arden Station

9.1 Project Components

The Arden station precinct is dominated by the approximately 14 ha industrial site owned and leased out by VicTrack (a State-owned business and statutory manager owner of Victoria's railway land).

The station is to be located underground on a diagonal (from south west to north east), wholly within the VicTrack site. The key features of the station design include:

- An entrance on a ramp approximately 120 m south of Arden Street in line with a future southward extension of Fogarty Street
- A vent shaft and emergency access point adjacent to the Arden station entrance
- Two potential future entrances in the centre of the site currently owned by VicTrack, to service future development.

An intake substation would be required for the Melbourne Metro to provide power for the operation of the tunnels and stations. The Concept Design proposes the location of the substation north of Arden Street, between CityLink to the west and Langford Street to the east.

9.1.1.1 Alternative Design Options

Two potential alternative substation sites are located within the Arden station precinct and are:

- Co-location at Melbourne Metro Trains Melbourne (MTM) traction substation
- Southern section of the Arden precinct, between the rail lines to the west and Laurens Street to the east.

9.1.2 Construction

The station is to be constructed using the bottom up cut-and-cover construction method. Main construction activities at the site would include:

- Establishment of construction work sites
- Tunnels excavation and TBM launch (with the TBM driving first to the western portal before being retrieved and re-launched from Arden station for the second drive to CBD North station)
- Station structural works, including an area of excavation of approximately 6,250 m².

In addition to the station, the VicTrack land would be the major staging area for the Melbourne Metro western section works, and would include site offices and staff amenities, precast concrete segment facility, fabrication sheds, major storage areas and spoil extraction and handling facilities. A tunnels construction water treatment plant and water tanks, and a tunnels air ventilation and extraction plant, would also be located on the site.

The construction method assumes that the eastern end of the station box requires an access shaft to be kept open, as two TBMs would be re-launched from the site towards CBD North station (via Parkville station) following their boring from Arden station to the western portal.

9.2 Existing Conditions

The area around Arden station is subject to flooding from one or both of two sources:

- Flows in excess of the capacity of the Moonee Ponds Creek channel
- Inflows from the local sub-catchments on either side of the Moonee Ponds Creek.

The major inflows to the area are from Moonee Ponds Creek upstream of Mount Alexander Road. The catchment area of Moonee Ponds Creek to this point is 148 km².



The areas of the local sub-catchments on the eastern and western sides of the Creek between Mount Alexander and Footscray Roads are six and three square kilometres respectively. Many of the drainage systems that service these local sub-catchments are equipped with pumped outfalls. Many of the pumps are old and unreliable. Flows from the local sub-catchments are pumped into the Creek at times when Creek levels are too high to allow discharge by gravity. The most significant system servicing the local sub-catchment on the east side of the creek is Melbourne Water's Arden Street Main Drain.

Moonee Ponds Creek itself in this area is a heavily modified man-made channel. Between Footscray and Macaulay Roads it comprises a large permanent waterway, typically about 30 m wide and approximately two metres deep, with relatively small overbank areas to a total typical width of around 60 m. It is tidal up to Macaulay Road. Upstream of Macaulay Road, it comprises a small low flow channel, typically two metres wide and one metre deep, and larger overbank areas to a typical total width of around 50 m.

The Creek has levees along one or both banks through much of the reach of interest, in particular the reach between Arden Street and Racecourse Road.

For much of the duration of major flood flows, flood levels in the Creek are typically higher than those in the local sub-catchments behind the levees. Floodwaters pond in the areas behind the levees due to the capacities of the pump stations being insufficient to discharge peak flood flows. These ponded flows are eventually pumped to the Creek, or discharge by gravity from piped systems as Creek flood levels recede.

The hydraulic capacity of the Creek channel is constrained by a number of:

- Bridges – Mount Alexander Road, Racecourse Road, Macaulay Road, Arden Street, Dynon Road, Footscray Road, a number of rail bridges between Arden Street and Footscray Road, and a number of pipe bridges
- Bridge piers, which support the Melbourne CityLink elevated roadway, and its entry and exit ramps.

Areas covered by the Land Subject to Inundation Overlay and Special Building Overlay (Melbourne Planning Scheme) associated with flooding from Moonee Ponds Creek and the Arden Street Main Drain are shown in Figure 9-1 and Figure 9-2.

Hydrologic and hydraulic flood modelling was undertaken to estimate a range of peak flood flows and levels in the vicinity of the station. These are summarised in Table 9-1. Further details of the modelling are provided in Appendix B of this report.

Flood events on Moonee Ponds Creek typically occur relatively quickly and only one to two hours warning would typically be available in advance of a flood peak at the Arden station site.

Table 9-1 Moonee Ponds Creek flood flows and levels

Flood event AEP (%)	Conditions	Peak flood level (m AHD)		Peak flood flow at Mount Alexander Road (m ³ /s)
		Corner of Queensberry and Laurens Streets	Corner of Laurens and Arden Streets	
1	Existing	3.1	3.3	220
1	Year 2100 (ie including allowance for climate change impacts)	3.4	3.4	310
0.1	Year 2100	4.4	4.4	460
0.01	Year 2100	5.1	5.2	730



The Arden-Macaulay Structure Plan (City of Melbourne, 2012) identifies the Arden station precinct for future expansion of Melbourne's Central City, including high-density residential development, complemented by commercial activities, and tertiary education facilities.

The substation is within the Moonee Ponds Creek floodplain. It is however largely on a small strip of slightly elevated ground surrounded by the LSIO in the Melbourne Planning Scheme.

9.2.1 Alternative Design Options

The first alternative design option substation site (co-location at Melbourne MTM traction substation) is also within the Moonee Ponds Creek floodplain, and wholly within an area covered by an Land Subject to Inundation Overlay.

The second alternative design option substation site (southern section of the Arden precinct, between rail to the west and Laurens Street to the east) is also partly within the Moonee Ponds Creek floodplain. The western section of this site is covered by a Land Subject to Inundation Overlay.

9.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 9-2.

Table 9-2 Key issues associated with the Concept Design

Concept Design	Issue	Risk no.
Arden station – aligned between the alignment of Arden and Queensberry Streets, in the VicTrack land	• Potential flooding of the station box during construction • Construction works resulting in increased flood levels due to loss of flood storage • Potential flooding of the station and tunnels from Moonee Ponds Creek during operation • Permanent works resulting in increased flood levels due to loss of flood storage.	SW005 SW004 SW022 SW020
Substation north of Arden Street, between CityLink to the west and Langford Street to the east	• Construction works resulting in increased flood levels due to loss of flood storage • Flooding of the substation during operation • Permanent works resulting in increased flood levels due to loss of flood storage.	SW006 SW024 SW023

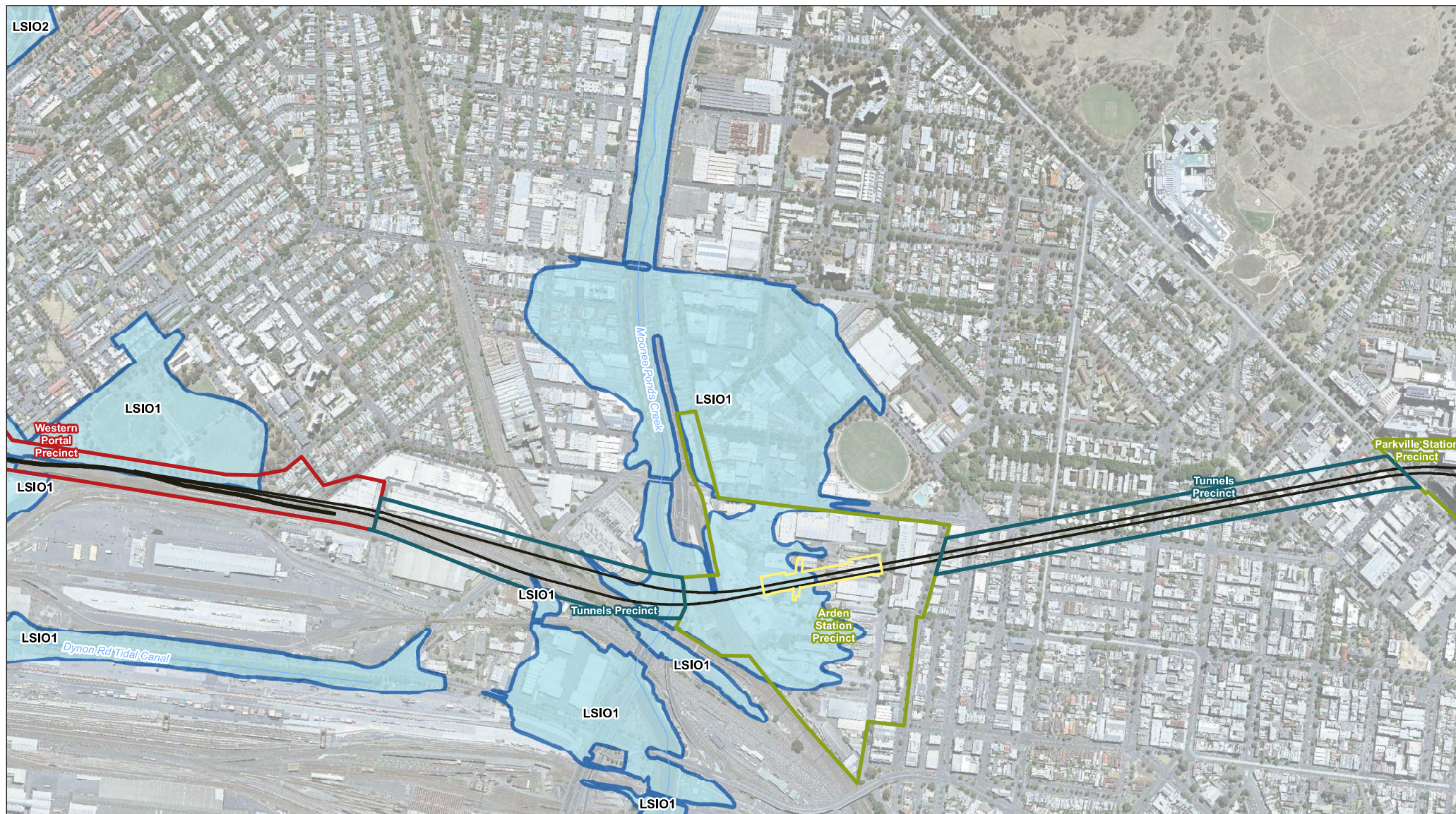
9.3.1 Alternative Design Options

Both alternative substation locations are within the Land Subject to Inundation Overlay and are subject to flooding from Moonee Ponds Creek. The key issues associated with both alternative design options substations are:

- Substation construction works resulting in increased flood levels due to loss of flood storage
- Flooding of the substation during operation
- Permanent substation works resulting in increased flood levels due to loss of flood storage.

9.4 Benefits and Opportunities

The opportunities associated with the Concept Design and the alternative design options relate to stormwater treatment, collection and/or re-use from compensatory flood storages.



Legend

- Proposed alignment
- Proposed station footprint
- Environmental and Planning Precincts**
 - Station Precinct
 - Portal Precinct
 - Tunnel Precinct
- LSIO - Land Subject to Inundation

Data Sources:
 Proposed Infrastructure: AJM January 2015
 Contains Vicmap Information
 © State of Victoria 2015
 Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
 Moonee Ponds Creek -
 Land Subject to Inundation Overlay

Drawing Number: MMR-AJM-UGAA-MP-NO-500143
 Revision: P1

Drawn By: A. Berman	Approved By: D. Sheehan	Date: 7/04/2016	Map Size: A4
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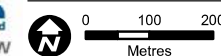
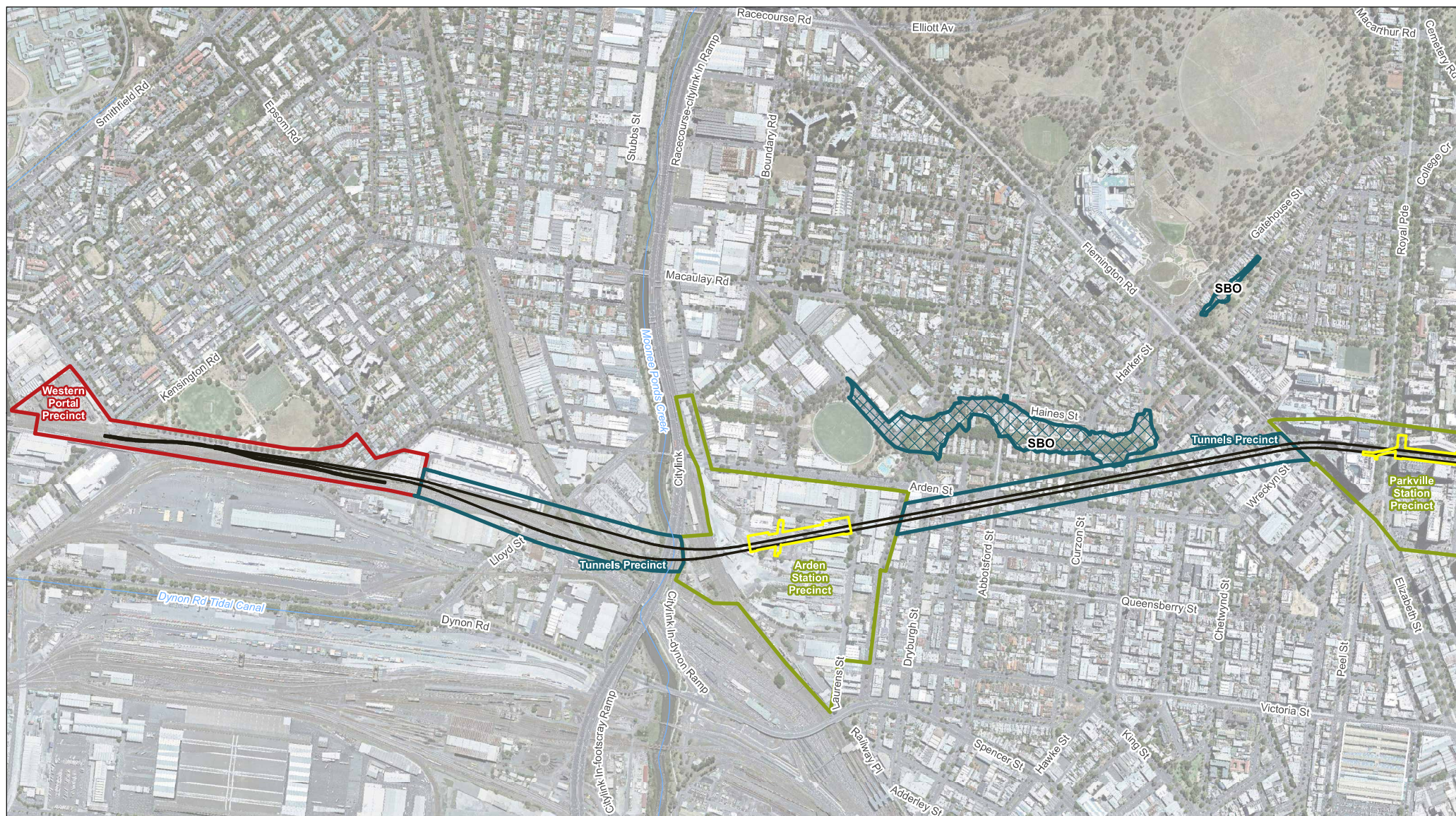


Figure 9-1 Moonee Ponds Creek – Land Subject to Inundation Overlay (LSIO) (DELWP, 2016)

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Legend

— Proposed alignment

— Proposed station footprint

Environmental and Planning Precincts

— Station Precinct

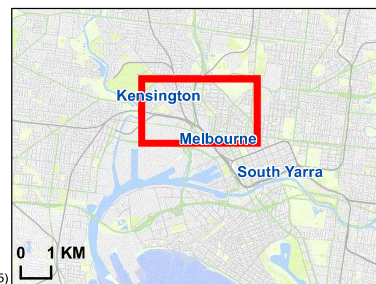
— Portal Precinct

— Tunnel Precinct



SBO - Special Building Overlay

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2016
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
Moonee Ponds Creek -
Special Building Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500144

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

Date:
6/04/2016

Map Size:
A4

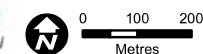


Figure 9-2 Moonee Ponds Creek – Special Building Overlay (SBO) (DELWP, 2016)

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9.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 9-3 Draft evaluation objectives and assessment criteria for the Arden station precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

Potential flooding of the station box during construction has the potential to cause significant inundation of the box and adjacent sections of tunnels in a relatively short time frame (within hours). This could pose a significant risk to construction workers (**Risk #SW005**). Much of the area in the vicinity of the station box is subject to flooding in a one per cent AEP flood event. Measures need to be put in place to ensure the station box is protected from flooding in at least the one per cent AEP flood event during construction. The potential impacts associated with larger flood events should also be recognised and emergency management measures put in place to ensure evacuation of construction workers in advance of such an event. Floodwaters could be expected to rise relatively quickly in this floodplain area and little warning would generally be available to enable sandbagging or similar temporary protection measures to be put in place in advance of a flood peak. A flood warning system should be put in place that links to and, if necessary, builds on existing flood warning systems in place in the catchment.

Potential flooding of the station and tunnels from the station entrances and other surface openings (eg ventilation shafts) during operation also has the potential to cause significant inundation of the project's underground assets in a relatively short time frame. This could pose a significant risk to commuters and rail staff and significant disruption to rail services (**Risk #SW022**). Even relatively shallow inundation of the station entrances has the potential to cause major flooding of the station and tunnels in a relatively short time frame (tens of minutes to hours).

The Arden station entrance and emergency access point are both to be raised 2.2 m above the adjacent Laurens Street footpath level, to provide flood protection. This equates to a level of 4.7 m AHD and is thus above the Year 2100 (ie including allowance for climate change impacts) 0.1 per cent event flood level, and 1.3 m above the Year 2100 one per cent AEP event flood level. This would thus comply with Melbourne Water's flood immunity requirements. A flood immunity risk assessment would nevertheless be required to determine whether this level of flood immunity is acceptable. This would need to take account of the impacts of a range of flood events on factors including damage and clean-up costs, and the costs associated with potential long-term disruption of the rail network. It should take account of the potential for floodwaters to enter the station through any surface openings, including, for example, ventilation shafts. As noted above, flood warning times available to enable emergency management measures to be put in place in advance of a flood would be expected to be relatively short. In addition to suspension of rail services, emergency management measures could include, for example, emergency sandbagging or automated flood gates on the station entrances.

Major Moonee Ponds Creek and overland flow paths in this area are generally along the main Creek channel and along Arden Street and other roads to the north of the station site. None of the construction or



permanent infrastructure works would be located such that they would obstruct flows through any of these major flood flow paths. Construction of the station (station box and precast concrete segment facility) would however, result in some loss of floodplain storage. In the absence of mitigation, this would result in minor increases in downstream flood flows and upstream and downstream flood levels (**Risk #SW004**). This would need to be mitigated by provision of compensatory flood storage. The volume of flood storage required is approximately 6,000 m³ (based on existing one per cent AEP flood level). Melbourne Water has provided in-principle agreement to this concept. It is currently proposed that this be provided by lowering surface levels in a car park at the southern end of the VicTrack land on which the construction site would be located.

The permanent station works are predominantly underground, and would thus have no impact on surface flows. The only exceptions to this are the station entrance, emergency egress point, chillers and vent shaft. The areas occupied by these are, however, very small, and would result in a required flood storage of approximately 1,600 m³ (based on Year 2100 one per cent AEP flood level) to mitigate minor increases in downstream flood flows, and upstream and downstream flood levels (**Risk #SW020**). Melbourne Water has provided in-principle agreement to this concept. This volume is significantly less than required during the construction stage and could be readily accommodated within the VicTrack land.

The substation would need to be protected (**Risk #SW024**) against flooding to an acceptable level of flood immunity to be determined by a flood immunity risk assessment. This would need to take account of the impacts of a range of flood events on factors including repair costs and disruption to rail services. Flood protection could be achieved by either bunding, or raising critical components of the substation to an appropriately high level.

Major Moonee Ponds Creek and overland flow paths in the area of the substation are also generally along the main Creek channel and along Arden Street and other roads to the north of the Arden station site. The substation would not obstruct flows along any of these major flood flow paths. Construction of the substation would however, result in some very minor loss of floodplain storage. In the absence of mitigation, this would result in minor increases in downstream flood flows and upstream and downstream flood levels (**Risks #SW006 and #SW023**). This would need to be mitigated by provision of compensatory flood storage. The volume of flood storage required is very small – less than 200 m³ – and could be readily incorporated within the much larger compensatory storages discussed above, required to offset loss of floodplain storage associated with Arden station.

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 9-3 above as it would result in negligible impact on existing flooding and drainage functions and characteristics.

9.5.1 Alternative Design Options

As was the case for the Concept Design, location of the substation at either of the two alternative design option sites would not obstruct flows along any major flood flow paths. Construction of either of the alternative design option substations would, however, result in some minor loss of floodplain storage. In the absence of mitigation, this would result in minor increases in downstream flood flows and upstream and downstream flood levels. This would need to be mitigated by provision of compensatory flood storage. The volumes of flood storage required are approximately:

- Substation co-located at Melbourne MTM traction substation – 400 m³ (approximately)
- Substation located in southern section of the Arden precinct, between rail lines to the west and Laurens Street to the east – approximately 250 m³.

As for the Concept Design, these volumes are relatively small and could be readily incorporated within the much larger compensatory storages discussed above, required to offset loss of floodplain storage associated with Arden station. If the proposed mitigation measures described above were put in place, the alternative design options for the precinct would then comply with the surface water elements of the draft EES



evaluation objectives listed in Table 9-3 as they would result in negligible impact on existing flooding and drainage functions and characteristics.



9.6 Environmental Performance Requirements

Table 9-4 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 9-4 Environmental Performance Requirements for the Arden station precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of station from Moonee Ponds Creek during construction, potentially compromising the safety of construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure retaining walls or similar barriers are in place to protect station box during construction in at least a one per cent AEP flood event. Emergency management measures in place – flood warning system for evacuation of workers.	SW005
Commuters, rail staff, rail services	Flooding of station from Moonee Ponds Creek during operation, potentially compromising the safety of commuters and/or rail staff and disrupting rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure station entrances and other surface openings are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, flood warning system, evacuation procedures, suspension of rail services.	SW022
Property and infrastructure on the Moonee Ponds Creek floodplain in the vicinity of the station	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority	Provision of compensatory flood storage (approx. 6,000 m ³).	SW004



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure on the Moonee Ponds Creek floodplain in the vicinity of the station	Increase in flood levels in areas adjacent to the station during operation resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Provision of compensatory flood storage (approx. 1,600 m ³).	SW020
Property and infrastructure in the vicinity of the substation	Increase in flood levels in areas adjacent to the substation during construction and operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Provision of compensatory flood storage (200 m ³ for Concept Design substation).	SW006, SW023
Rail services	Flooding of substation from Moonee Ponds Creek during operation, resulting in disruption of rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure substation is protected against flooding, by either bunding, or setting it at a sufficiently high level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment.	SW024



10 Precinct 4: Parkville Station

10.1 Project Components

Parkville station would be located under the Grattan Street road reserve, to the east of Royal Parade. The station's footprint would occupy the full width of Grattan Street and would extend from the intersection of Grattan Street and Royal Parade to the east side of University Square. The key surface features of the Parkville station design include:

- The above-ground components of the entrances at the following locations:
 - North side of Grattan Street opposite the north end of Barry Street; there is also a lift shaft immediately adjacent to this entrance to the north west
 - East side of Royal Parade immediately north of Grattan Street; there is also a lift shaft immediately adjacent to this entrance to the south east
 - South side of Grattan Street, immediately west of Royal Parade; there is also a lift shaft immediately adjacent to this entrance to the south east
- Up to five vent shafts and other similar equipment on the south side of Grattan Street, between Barry and Leicester Streets, and along Barry Street
- A *Disability Discrimination Act* (DDA)-compliant tram stop with side platforms, on Royal Parade.

10.1.1 Construction

The station is to be constructed using the 'top down' cut-and-cover construction method. The main construction activities at the site would be:

- Tunnel excavations through the station box
- Station structural works and station entrance connections across Royal Parade, including an excavation area of approximately 6,700 m²
- Construction of underground access between the station and the western side of Grattan Street (west of Royal Parade) is expected to be through cut-and-cover or mined tunnels, pending finalisation of the design.

The cut-and-cover method would also be used for the underground pedestrian connection across Royal Parade to the health facilities.

10.1.1.1 Alternative Design Option

The alternative design option involves construction using a bottom up cut-and-cover method.

10.2 Existing Conditions

The area in the immediate vicinity of Parkville station is not subject to any major surface water inundation risk, nor is it covered by any flooding overlays or major overland flow paths.

The reach of Grattan Street within which the station would be located slopes from east to west, from a high point near the east end of the station, sloping towards Royal Parade (refer to Figure 10-1). The slope of Grattan Street in this area is relatively steep at around 2.5 per cent. There is a small drainage catchment to the north of the station within the University of Melbourne. This is estimated to be of the order of six hectares. The majority of overland flows reaching Grattan Street from this catchment would discharge west along Grattan Street, across Royal Parade and away to the west towards Moonee Ponds Creek.

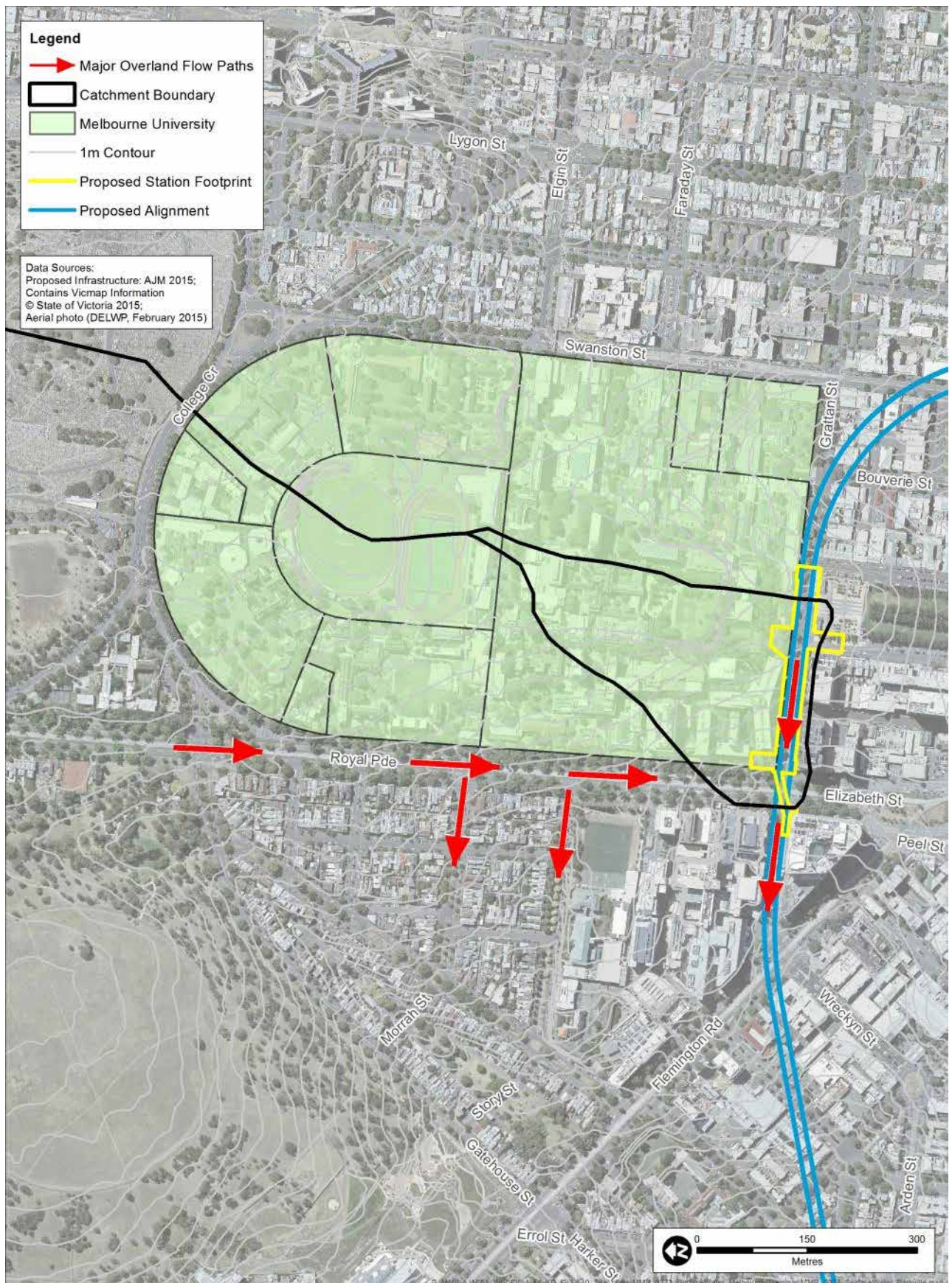


Figure 10-1 Overland flow paths in the vicinity of Parkville station



Royal Parade slopes gently towards Grattan Street from the north. The surface topography along this section of Royal Parade drops away relatively sharply to the west. The majority of any overland flows in excess of the capacity of the gutters on either side of Royal Parade would therefore flow away to the west from the streets on the west side of the Parade. Only relatively minor flows would reach Grattan Street from Royal Parade and these would then discharge away along Grattan Street to the west to Moonee Ponds Creek.

10.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 10-1.

Table 10-1 Key issues associated with the Concept Design

Concept Design	Issue	Risk no.
Parkville station – located under Grattan Street, to the east of Royal Parade	• Potential flooding of the station box during construction • Construction works resulting in increased flood levels due to obstruction of overland flows • Potential flooding of the station during operation • Permanent works resulting in increased flood levels due to obstruction of overland flows.	SW007 SW008 SW025 SW026

10.3.1 Alternative Design Option

The key issues associated with the alternative construction method are similar to those associated with the Concept Design and are:

- Potential flooding of the station box during construction
- Construction works resulting in increased flood levels due to obstruction of overland flows
- Potential flooding of the station during operation.

10.4 Benefits and Opportunities

No benefits and opportunities associated with the project in this precinct have been identified in relation to surface water.

10.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 10-2 Draft evaluation objectives and assessment criteria for the Parkville station precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

As noted above, the area in the immediate vicinity of Parkville station is not subject to any major overland stormwater flows.



There is potential for some inundation of the station box during construction, from minor overland flows reaching Grattan Street from the small catchment within the University of Melbourne and from the north from Royal Parade (**Risk #SW007**). This could be relatively easily mitigated by constructing small barriers to intercept flows reaching the north side of the station box, and diverting these away to the west. Diversion of these minor flows would have negligible impact on overland flow depths (**Risk #SW008**).

There is also potential for some inundation of the station from the entrances and other surface openings (eg ventilation shafts) during operation (**Risk #SW025**). This could pose a risk to commuters and rail staff, and disrupt rail services. This could again be easily mitigated by minor elevation of the station entrances and other surface openings above adjacent ground levels. This would have negligible impact on overland flow depths (**Risk #SW026**).

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 10-2, as it would result in negligible impact on existing flooding and drainage functions and characteristics.

10.5.1 Alternative Design Option

As with the Concept Design, there is potential for some inundation of the station box during construction, from minor overland flows reaching Grattan Street from the small catchment within the University of Melbourne and from the north from Royal Parade. This could be relatively easily mitigated by construction of small barriers to intercept flows reaching the north side of the station box and diverting these away to the west. Diversion of these minor flows would have negligible impact on overland flow depths.

As with the Concept Design, there is also potential for some inundation of the station from the entrances during operation. This could again be easily mitigated by minor elevation of the station entrances above adjacent ground levels. Diversion of these minor flows would have negligible impact on overland flow depths.

If the proposed mitigation measures described above were put in place, the alternative design option for the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 10-2, as it would result in negligible impact on existing flooding and drainage functions and characteristics.



10.6 Environmental Performance Requirements

Table 10-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 10-3 Environmental Performance Requirements for the Parkville station precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of station box from local catchment inflows during construction, resulting in injury to construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure small retaining walls or similar barriers are in place to protect station box during construction.	SW007
Commuters, rail staff, rail services	Flooding of station from local catchment inflows during operation, resulting in injury to commuters and/or rail staff and disruption of rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure station entrances and other surface openings are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, suspension of rail services.	SW025
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW008



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW026



11 Precinct 5: CBD North Station

11.1 Project Components

The components of the Concept Design which are relevant to the surface water impact assessment are:

- The La Trobe Street entrance would be on the site of an existing building on the north west corner of La Trobe and Swanston streets
- The Franklin Street entrance (located to the east of Swanston Street) would be located in a cut-and-cover box, extending east beyond Bowen Street to near Victoria Street (the box would be excavated from the eastern property boundary of Swanston Street)
- A vent shaft is on the north side of Franklin Street immediately to the west of Victoria Street
- Ventilation and fire egress and maintenance access would be provided in Franklin Street on the west side of Swanston Street and also in A'Beckett Street between Stewart Street and Swanston Street. This would require surface construction.

11.1.1 Construction

The station is to be constructed under Swanston Street using the mined cavern construction method. The main construction activities would include:

- Establishment of construction work sites
- Station structural works
- Construction of station entrances and connection to Melbourne Central Station, including an excavation area of approximately 6,450 m².

11.2 Existing Conditions

There are no planning scheme flooding overlays or major overland flow paths in the vicinity of CBD North station.

La Trobe Street slopes moderately steeply from east to west at the location of the La Trobe Street station entrance, and there is a small catchment east of the entrance that originates at Russell Street. Some minor overland flows would discharge west along La Trobe Street in a major storm event (refer Figure 11-1). There is a minor high point in Swanston Street between La Trobe and Franklin Streets, so very little overland flow would reach the corner of La Trobe and Swanston Streets from Swanston Street to the north. Therefore, the station entrance and construction access points are not subject to any major surface water inundation risk.

Franklin Street at the station entrance slopes steeply from east to west, and there is a small catchment upstream of the entrance to the east. While some minor stormwater runoff would discharge overland along Franklin Street during a major storm event, flow depths would be shallow due to the steep slope of the street. The station entrance and construction access points are not therefore subject to any significant surface water inundation risk.

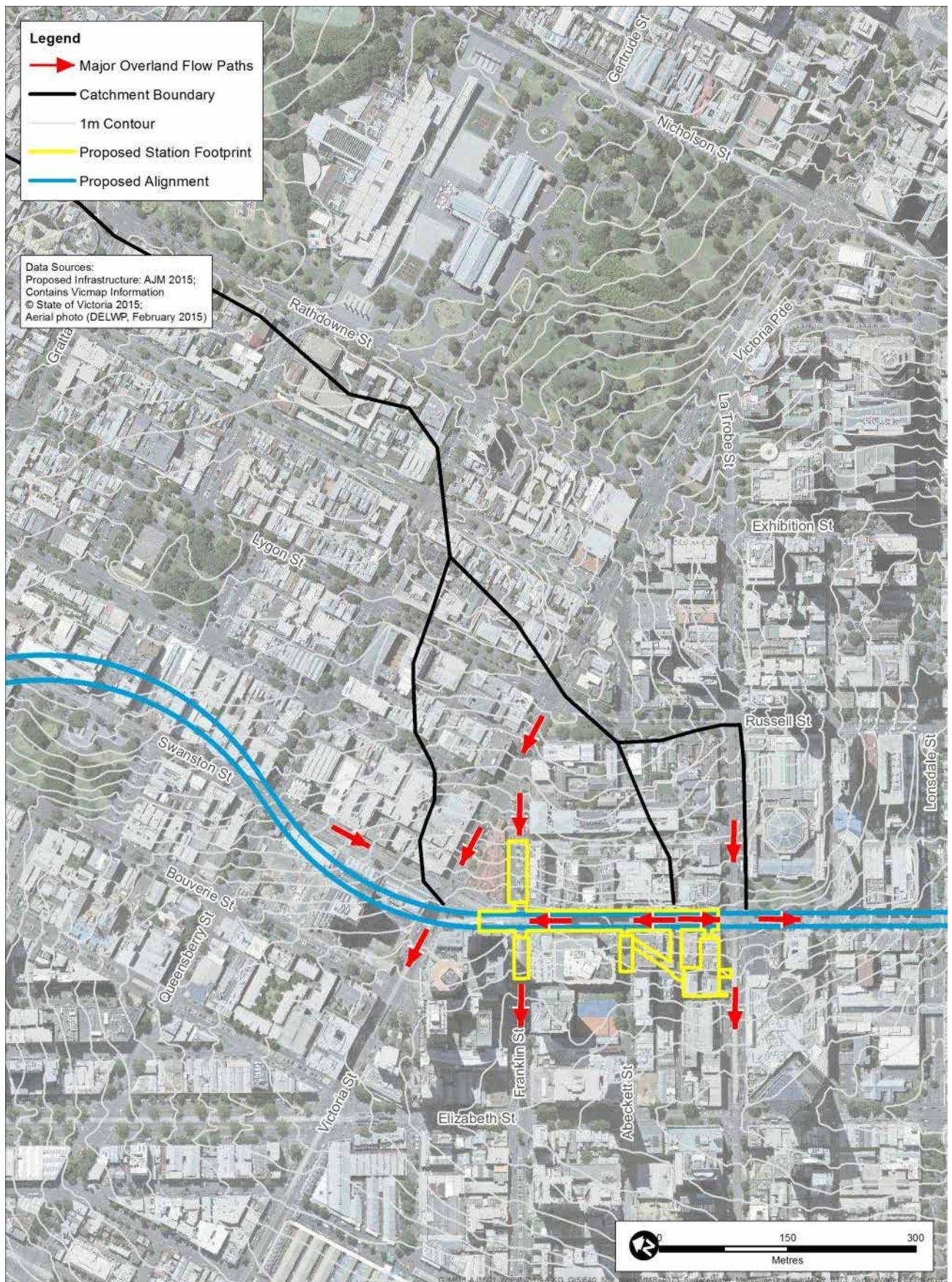


Figure 11-1 Overland flow paths in the vicinity of CBD North station



11.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are:

- Potential flooding of the station box from local drains during construction and operation – **Risks #SW009 and #SW025**
- Potential increase in flood risk to surrounding properties during construction and operation due to obstruction of overland flow paths – **Risk #SW008 and #SW026**.

11.4 Benefits and Opportunities

No benefits and opportunities associated with the Concept Design have been identified in relation to surface water in this precinct.

11.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 11-1 Draft evaluation objectives and assessment criteria for CBD North station precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

As noted above, the area in the immediate vicinity of CBD North station is not subject to any major overland stormwater flows.

There would be potential for some inundation of the station box during construction, from minor overland flows along Franklin Street, La Trobe Street and Lonsdale Street (**Risk #SW009**). This could easily be mitigated by constructing low height barriers to protect cavern entrances. Any minor diversion of these small flows would have negligible impact on overland flow depths (**Risk #SW008**).

There would also be potential for some inundation of the station from the entrances and other surface openings during operation (**Risk #SW025**). This could pose a risk to commuters and rail staff, and disrupt rail operations. This could again be easily mitigated by minor elevation of the station entrances and other surface openings above adjacent ground levels. This would have negligible impact on overland flow depths (**Risk #SW026**).

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 11-1 as it would result in negligible impact on existing flooding and drainage functions and characteristics.



11.6 Environmental Performance Requirements

Table 11-2 below provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 11-2 Environmental Performance Requirements for the CBD North station precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of station box from local catchment inflows during construction, resulting in injury to construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure small retaining walls or similar barriers are in place to protect station box during construction.	SW009
Commuters, rail staff, rail services	Flooding of station from local catchment inflows during operation, resulting in injury to commuters and/or rail staff and disruption of rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure station entrances and other surface openings are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, suspension of rail services.	SW025
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW008



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		authority Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW026



12 Precinct 6: CBD South Station

12.1 Project Components

The components of the Concept Design which are relevant to the surface water impact assessment are:

- A Collins Street station entrance at the northern end of the City Square
- A Flinders Street station entrance facing both Swanston and Flinders Streets
- A station entrance with underground connections to the Melbourne Visitors Centre at Federation Square, and the existing Flinders Street Station concourse.

12.1.1 Construction

The station is to be constructed under Swanston Street using the mined cavern construction method. Main construction activities would include:

- Establishment of work sites
- Establishment of site offices, materials storage and laydown at City Square
- Construction of the twin interconnecting tunnels between the two CBD stations
- Construction of station entrances and connections to Flinders Street Station and Federation Square, including an excavation area of approximately 4,400 m².

12.2 Existing Conditions

The Yarra River is the largest waterway within the study area, with a catchment area of 4,080 km² and main stream length of 242 km. In its lower reaches the Yarra catchment becomes more densely urbanised before it flows through the Melbourne CBD and into Port Phillip Bay. Flooding of the Yarra River has the potential to impact on CBD South station.

There are numerous crossings of the Yarra River along its length, with 16 bridges located in the vicinity of the study area, from Church Street to the Webb Pedestrian Bridge. The rail tunnel would cross under the Yarra River partly under and just upstream of Princes Bridge.

Between Dights Falls in Kew and the mouth of the river, the Yarra bed slope is relatively flat with moderately sloped banks. Downstream of South Yarra the channel widens and deepens substantially, providing increased conveyance to Port Phillip Bay. Low-lying areas in the city such as Southbank frequently experience minor flooding during severe weather events, caused by any one or a combination of storm rain generated flooding, high tides or strong winds.

Areas covered by the Land Subject to Inundation Overlay of the Melbourne Planning Scheme associated with flooding from the Yarra River are shown on Figure 12-1.

Two to three days warning would typically be available in advance of a flood peak on the Yarra River at these locations.

As noted previously, flood warnings and notifications in Victoria are provided by the Bureau of Meteorology (BoM), Melbourne Water and the Victoria State Emergency Service (VICSES) (Victoria State Emergency Service, 2012). Melbourne Water acts as the flood prediction agency for some of the larger catchments in Metropolitan Melbourne, including the Yarra River.

Hydrologic and hydraulic flood modelling was undertaken to estimate a range of peak flood flows and levels on the upstream side of Princes Bridge. These are summarised in Table 12-1. Further details of the modelling are provided in Appendix B of this report.



Table 12-1 Yarra River flood flows and levels upstream of Princes Bridge

Flood event AEP (%)	Conditions	Peak flood level (m AHD)	Peak flood flow (m ³ /s)
1	Existing	2.3	850
1	Year 2100 (ie including allowance for climate change impacts)	3.8	1,300
0.1	Year 2100	5.4	2,000
0.01	Year 2100	7.2	3,500

The CBD South station area directly impacts on two existing City of Melbourne drains in Swanston Street; a 1,220 mm diameter concrete pipe and a 1,950 mm x 1,350 mm brick ovoid drain. Both drains are over 100 years old. The station entrances at City Square and close to Flinders Street may both be subject to flooding from overland flows. Surface water flooding issues are known to exist at the junction of Swanston and Flinders Streets. Flows in excess of the combined capacities of the Swanston Street drains and overland flow paths along Swanston Street flow west into the Elizabeth Street Main Drain system (refer to Figure 12-3).

The drains in Elizabeth Street are the responsibility of Melbourne Water. Elizabeth Street is prone to regular and significant flooding. The most significant recent event was in 2010. Overland flows from the Swanston Street catchment are known to contribute to the Elizabeth Street flooding. Areas covered by the Melbourne Planning Scheme Special Building Overlay associated with flooding from the Elizabeth Street Main Drain are shown in Figure 12-2.

Very little warning (tens of minutes) would typically be available in advance of a major overland flow event at this site.

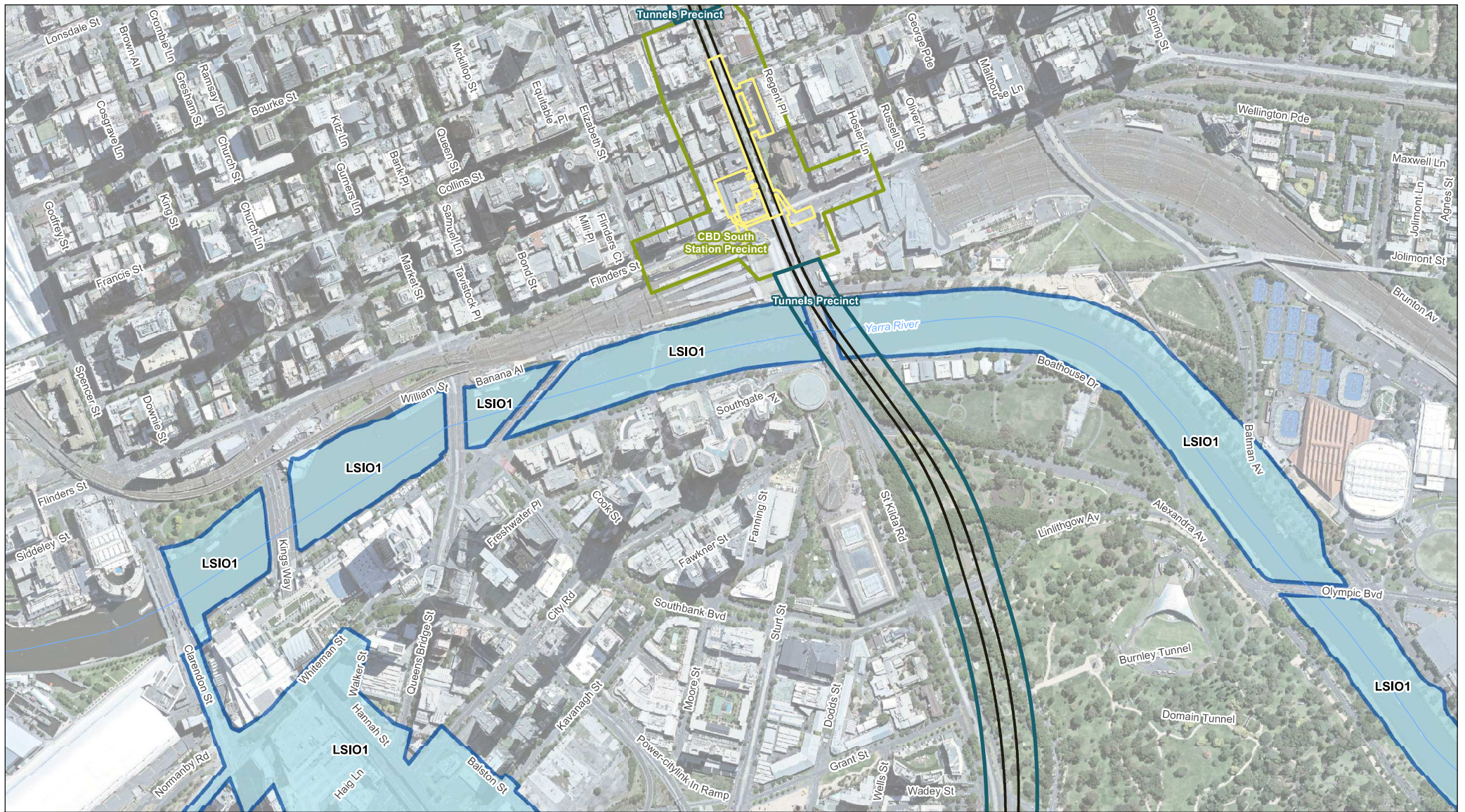
12.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are:

- Potential flooding of the station and tunnels from either the Yarra River or local drains, from station entrances, during operation – **Risks #SW027 and #SW029**
- Potential flooding of the station and tunnels from local drains, from cavern entrances, during construction – **Risk #SW010**
- Potential increase in flood risk to surrounding properties during construction or operation due to obstruction of overland flow paths – **Risks #SW008 and #SW028**.

12.4 Benefits and Opportunities

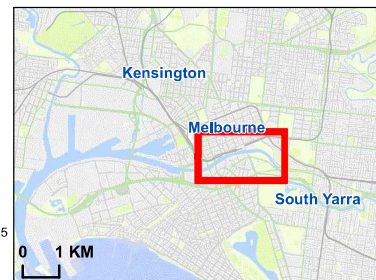
The opportunities associated with the Concept Design relate to improved stormwater drainage in the vicinity of the Swanston Street/Flinders Street intersection.



Legend

- Proposed alignment
 - Proposed station footprint
 - LSIO - Land Subject to Inundation
 - Station Precinct
 - Tunnel Precinct
- Environmental and Planning Precincts**

Data Sources:
 Proposed Infrastructure: AJM January 2015
 Contains Vicmap Information
 © State of Victoria 2015
 Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
 Yarra River -
 Land Subject to Inundation Overlay

Drawing Number:
 MMR-AJM-UGAA-MP-NO-500145

Revision:
 P1

Drawn By:
 A. Berman

Approved By:
 D. Sheehan

Date:
 7/04/2016

Map Size:
 A4

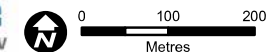
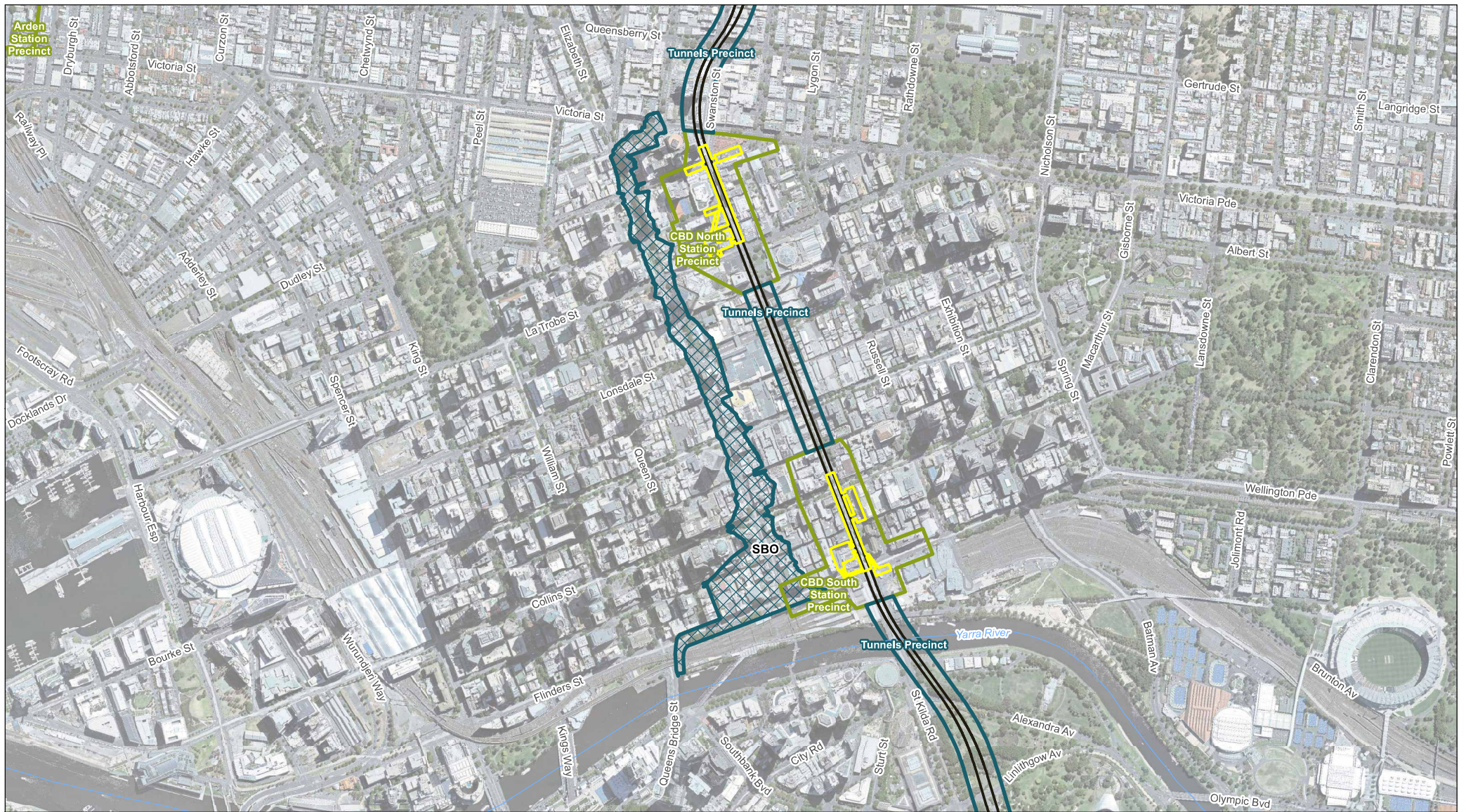


Figure 12-1 Yarra River – Land Subject to Inundation Overlay (LSIO) (DELWP, 2016)

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Legend

— Proposed alignment

— Proposed station footprint

Environmental and Planning Precincts

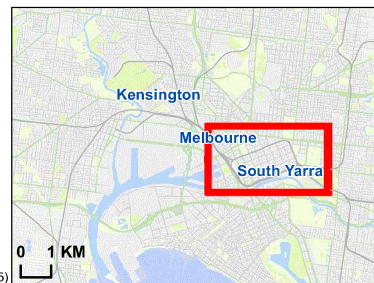
— Station Precinct

— Tunnel Precinct



SBO - Special Building Overlay

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2016
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
Elizabeth Street Main Drain -
Special Building Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500146

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

Date:
6/04/2016

Map Size:
A4

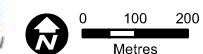


Figure 12-2 Elizabeth Street Main Drain – Special Building Overlay (SBO) (DELWP, 2016)

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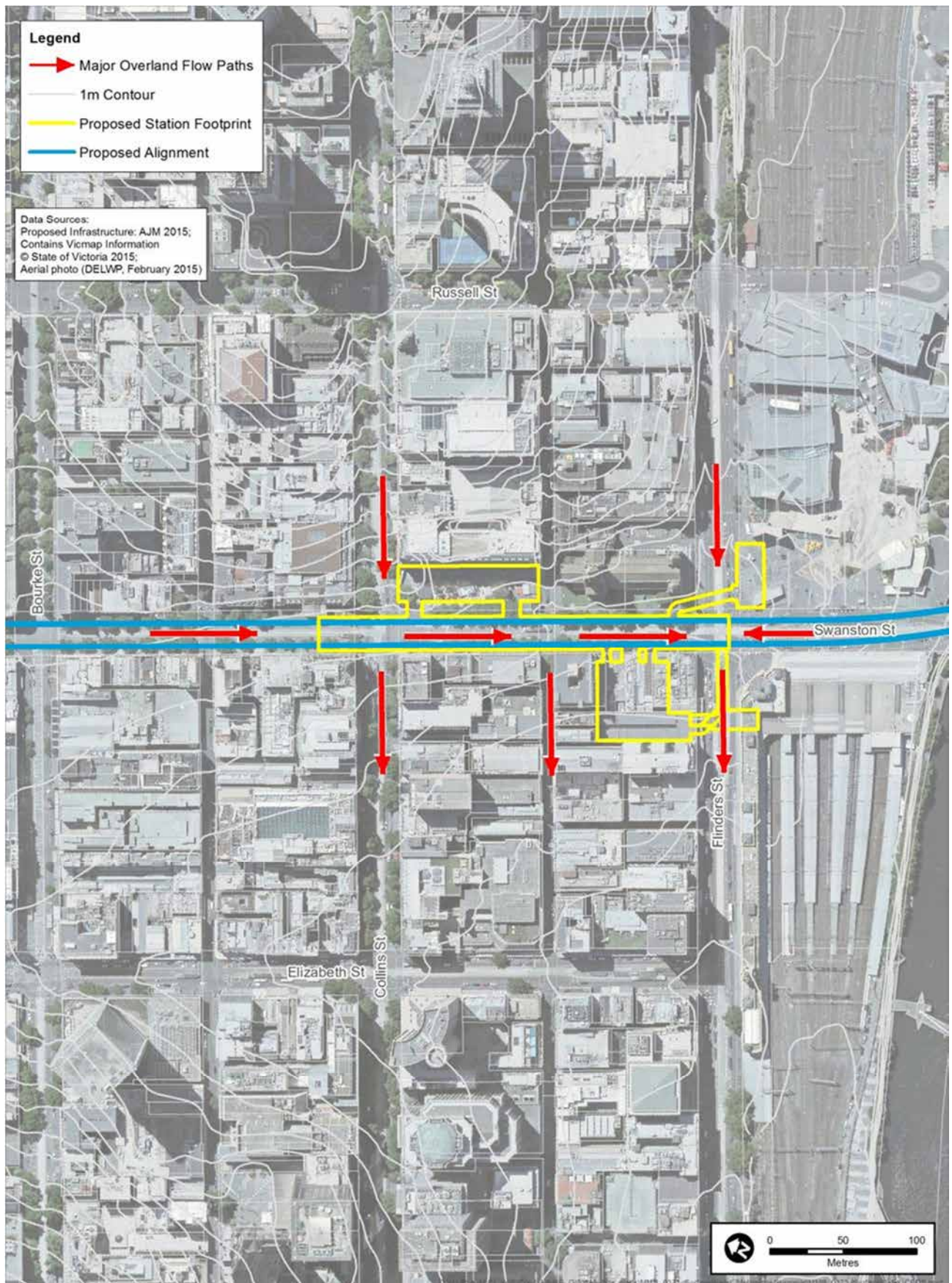


Figure 12-3 Overland Flow Paths in the vicinity of CBD South station



12.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 12-2 Draft evaluation objectives and assessment criteria for the CBD South station precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

Potential flooding of CBD South station and adjoining sections of the tunnels from the Yarra River from the station entrances during construction or operation (**Risk #SW029**) has the potential to cause significant inundation of the tunnels in a relatively short time frame. This could pose a significant risk to construction workers, commuters and rail staff, and significant disruption to rail services. Even relatively shallow inundation of the entrances could cause major flooding of the station and tunnels in a relatively short time frame (tens of minutes to hours) once flood levels that first inundated the station entrances were reached.

The ground levels at the station entrances under the Concept Design are all above 6.9 m AHD. These are all therefore very close to or above the estimated Year 2100 (ie including allowance for climate change impacts) 0.01 per cent AEP Yarra River flood level of 7.2 m AHD upstream of Princes Bridge, and 3.1 m above the Year 2100 one per cent AEP flood level of 3.8 m AHD. This would thus comply with Melbourne Water's flood immunity requirements. The risk of flooding of the station entrances and other surface openings from the Yarra River during either construction or operation is therefore very low. As noted above, many hours warning time would generally be available to implement emergency management measures to be put in place in advance of a more extreme flood to reduce the risk of station flooding and inundation of tunnels. In addition to suspension of rail services and station evacuation, these could include, for example, automated flood gates or emergency sandbagging.

The cavern entrances would need to be protected against flooding from local stormwater flows during construction (**Risk #SW010**). This could be readily achieved by constructing small barriers around the cavern entrances. This would have negligible impact on adjacent flood levels (**Risk #SW008**).

The levels of station entrances and other surface openings would need to be raised to provide an appropriate level of flood immunity to be determined by flood immunity risk assessment (**Risk #SW027**). The entrance at greatest risk is to the laneway next to the Nicholas Building (Flinders Street station entrance facing Swanston Street), which is subject to some slight ponding of stormwater flows, to a level of approximately 8.0 m AHD in a 0.5 per cent AEP event. None of the other entrances are subject to ponding to the same extent and no other flood protection measures would be expected to be required, other than some very minor raising of the entrances above ground levels. This would also have negligible impact on adjacent flood levels (**Risk #SW028**).

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 12-2 as it would result in negligible impact on existing flooding and drainage functions and characteristics.



12.6 Environmental Performance Requirements

Table 12-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 12-3 Environmental Performance Requirements for the CBD South station precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of station box from local catchment inflows during construction, resulting in injury to construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure small retaining walls or similar barriers are in place to protect station box during construction.	SW010
Commuters, rail staff, rail services	Flooding of station from Yarra River and/or local catchment inflows during operation, resulting in injury to commuters and/or rail staff and disruption of rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure station entrances and other surface openings are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, suspension of rail services.	SW027, SW029
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW008



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during operation, resulting in increased flooding of property and infrastructure	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW028



13 Precinct 7: Domain Station

13.1 Project Components

The components of the Concept Design which are relevant to the surface water impact assessment are:

- The footprint of the station would be 320 m long and 22 m wide, extending approximately from Park Street in the north to Bowen Crescent in the south
- Three entrances:
 - From the Shrine Parklands
 - From the triangular park located on the corner of Albert Road and St Kilda Road; this would include a sunken plaza within the park
 - From the Domain tram interchange in the centre of St Kilda Road
- A new super tram stop in St Kilda Road between Domain Road and Bowen Lane
- Access hatch, fire egress shaft and overhead track exhaust /tunnel ventilation system in the centre of St Kilda Road between Bowen Lane and Bowen Crescent
- TBM southern launch site.

13.1.1 Construction

The station is to be constructed using the cut-and-cover construction method. The main construction activities are:

- Establishment of construction work sites
- TBM operations (with the TBM driving to CBD South station)
- Structural works, including an excavation area of approximately 19,400 m².

The construction site footprint would extend along St Kilda Road approximately from Dorcas Street to Kingsway, along Albert Road from St Kilda Road to Kingsway and along Domain Road east from St Kilda Road for approximately 150 m.

13.2 Existing Conditions

The northern end of the Domain station box extends across the western end of Domain Road at its intersection with St Kilda Road. Domain Road would act as an overland flow path for stormwater flows in excess of pipe capacity from a moderate sized catchment (approximately 40 ha) on the north side of Domain Road extending east to approximately Punt Road (refer to Figure 13-1). These flows would then discharge across St Kilda Road and away to the south and west along Park Street, Albert Road and Bowen Lane, towards Albert Park Lake. Depending on the size of the storm event, overland flow of up to moderate depth would occur across St Kilda Road at the low point between Albert Road and Bowen Lane. Shallower overland flow would occur across St Kilda Road in the area around Park Street and Albert Road.

The area around the intersection of Albert Road and Kingsway is subject to overland flooding from Melbourne Water's Hannah Street Main Drain. The major overland flow path from this drain is north along Kingsway towards the Yarra River. The system also includes outfalls to Albert Park Lake. This area is also subject to flooding from breakaway flows from the Yarra River downstream of Princes Bridge – this is discussed further below. The Special Building Overlay in the Port Phillip Planning Scheme covering this area is shown in Figure 13-2 and is understood to represent the approximate extent of the one per cent AEP flood in this area. It is unclear whether this includes allowances for overflow flooding from the Yarra River, or is based purely on overland flows in the Hannah Street Main Drain system. Melbourne Water has advised that



the estimated one per cent AEP flood level at the intersection of Albert Road and Kingsway, consistent with the Special Building Overlay, is 2.62 m AHD.

Hydrologic and hydraulic flood modelling was undertaken to estimate a range of peak flood levels at the intersection of Albert Road and Kingsway, resulting from breakaway flows from the Yarra River. These are summarised in Table 13-1. Further details of the modelling are provided in Appendix B of this report.

Table 13-1 Yarra River breakaway flood levels – Albert Road/Kingsway intersection

Flood event AEP (%)	Conditions	Peak flood level (m AHD)
1	Existing	N/A ¹
1	Year 2100 (ie including allowance for climate change impacts)	3.3
0.1	Year 2100	4.1
0.01	Year 2100	5.2

Note 1: Yarra breakaway flooding does not extend to this location.

Modelling of Yarra River flows indicates that the area surrounding the Domain station, including the station entrances, is not subject to flooding from this source for events up to and including the Year 2100 (ie including allowance for climate change impacts) 0.01 per cent AEP event. The volume of runoff that would be generated during extreme events (greater than 0.1 per cent AEP) in the Hannah Street Main Drain system would be significantly less than generated by Yarra River overflows. Consequently the area around Domain Station, including the station entrances, would also not be subject to flooding from this source for events up to and including the 0.01 per cent AEP event including allowance for climate change. This would thus comply with Melbourne Water's flood immunity requirements.

13.3 Key Issues

As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 13-2.

Table 13-2 Key issues associated with the Concept Design

Concept Design	Issue	Risk no.
Domain station – located under St Kilda Road, adjacent to Albert Road	• Potential flooding of the station box and TBM launch site during construction from local drains • Construction and permanent works resulting in increased flood levels due to obstruction of overland flow paths • Potential flooding of the station and tunnels during operation, from local drains or Yarra River.	SW011, SW012 SW026, SW025 SW030

13.4 Benefits and Opportunities

No benefits and opportunities associated with each part of the Concept Design have been identified in relation to surface water in this precinct.

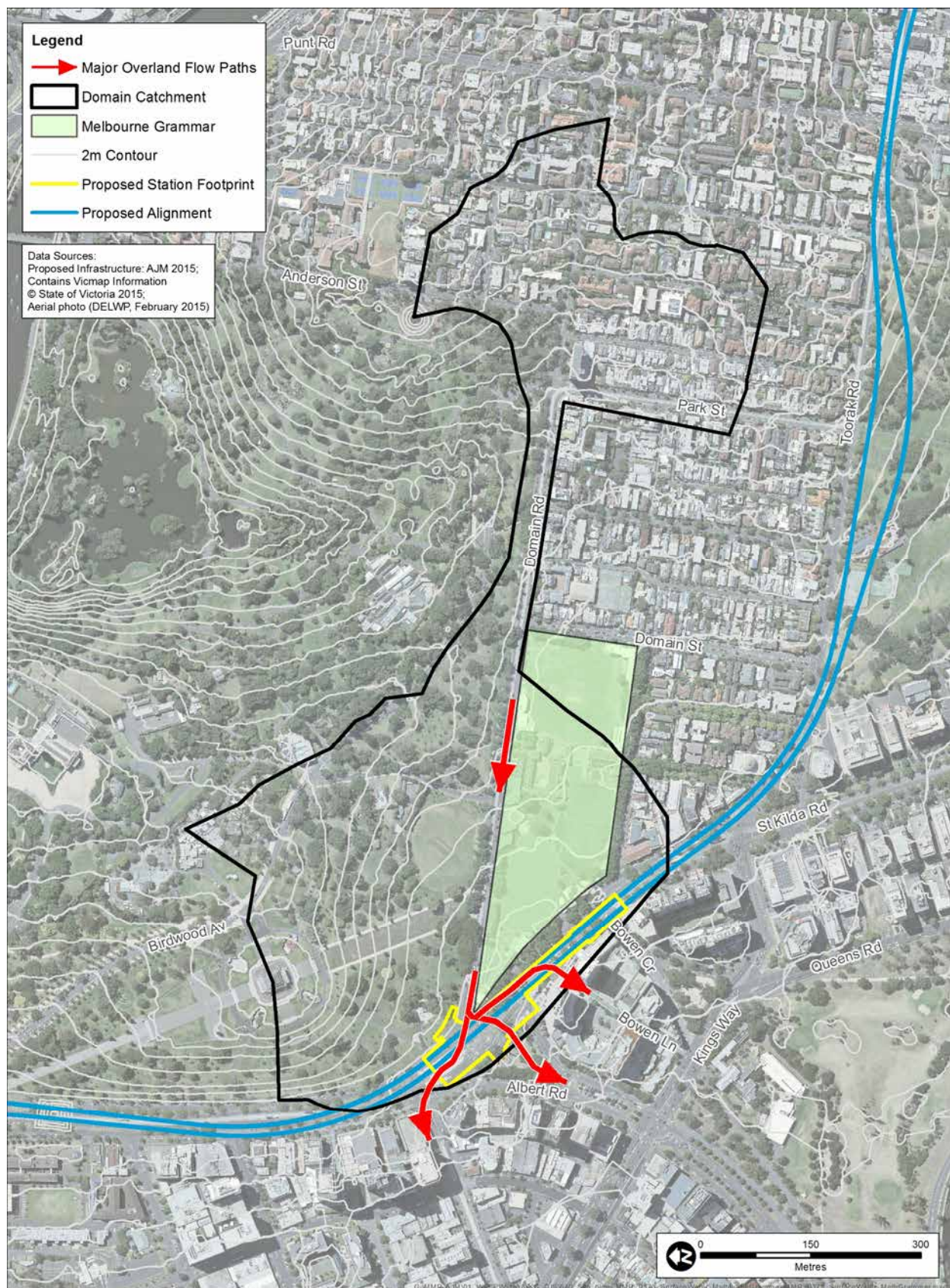
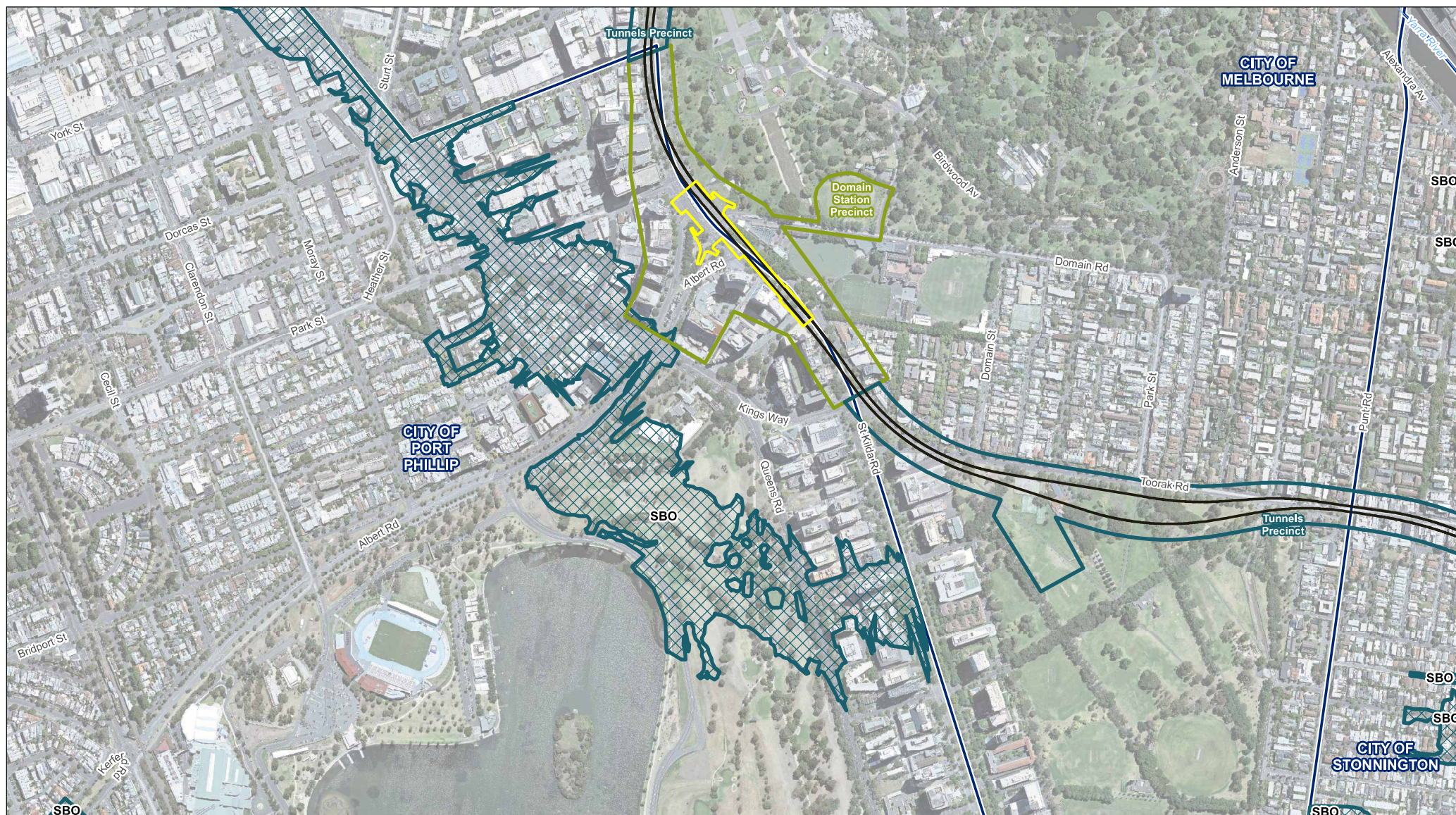


Figure 13-1 Overland flow paths in vicinity of Domain station



Legend

— Proposed alignment

— Proposed station footprint

Environmental and Planning Precincts

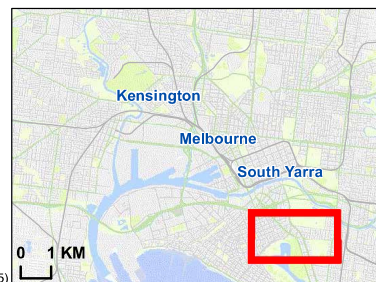
— Station Precinct

— Tunnel Precinct



SBO - Special Building Overlay

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2016
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
Hannah Street Main Drain -
Special Building Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500147

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

Date:
6/04/2016

Map Size:
A4

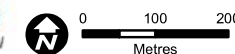


Figure 13-2 Hannah Street Main Drain vicinity – Special Building Overlay (SBO) (DELWP, 2016)

G:\MMR-AJM\01_WIP\PIW-1-AA-KG_GIS\640_Site_plans\MMR_0256_SurfaceWater_EES\MMR_0256_SBO_PlanningMaps_EES.mxd



13.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 13-3 Draft evaluation objectives and assessment criteria for the Domain station precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

Construction of barriers would be required to prevent inundation of the Domain station box and TBM launch site from overland flows from the catchment around Domain Road to the east during construction (**Risk #SW011**). Larger storm events in excess of the capacity of any underground drains and overland flow paths around the station box and TBM launch site could overtop the barriers and flood the station box and TBM launch site. Only tens of minutes warning would typically be available in advance of such an event and this could pose a risk to construction workers. Depending on the height of barriers, these flows could also back up into Melbourne Grammar School during larger storm events. This could be mitigated during construction, if necessary, by an appropriate combination of barrier heights and flow diversion works capacities. Any proposed flow diversion works could result in an increase in flows along Bowen Crescent. However, Bowen Crescent is relatively steep and this would only result in negligible increases in flow depths (**Risk #SW012**).

There is some potential for inundation of the station during operation from overland flows (**Risk #SW025**). However, as noted above, overland flow depths at the station entrances would be relatively shallow and could be mitigated by the minor elevation of the entrances and other surface openings (eg ventilation shafts) above surrounding ground levels. This would have negligible impact on overland flow depths (**Risk #SW026**).

The level at the top of the stairs leading to the station entrance in the Albert Road Reserve, located on the corner of Albert Road and St Kilda Road, is approximately 6.0 m AHD. This level is well above the predicted peak water surface elevation for the 0.01 per cent AEP event from both the Yarra River and Hannah Street Main Drains (including allowance for climate change) (**Risk #SW030**).

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 13-3 above as it would result in negligible impact on existing flooding and drainage functions and characteristics.



13.6 Environmental Performance Requirements

Table 13-4 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 13-4 Environmental Performance Requirements for the Domain station precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of station box and TBM launch site from local catchment inflows during construction, resulting in injury to construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure barriers are in place to protect station box and TBM launch site from local catchment inflows during construction.	SW011
Commuters, rail staff, rail services	Flooding of station from local catchment inflows or Yarra River during operation, resulting in injury to commuters and/or rail staff and disruption of rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure station entrances and other surface openings are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, suspension of rail services.	SW025 SW030
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of	If necessary, provide appropriate combination of barrier heights and flow diversion capacity to avoid backing up flooding into Melbourne Grammar.	SW012



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure in the vicinity of the station	Increase in flood levels in areas adjacent to the station during operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority - Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW026



14 Precinct 8: Eastern Portal (South Yarra)

14.1 Project Components

The eastern portal precinct is to connect the two tunnels to the existing Dandenong rail corridor just west of Chapel Street. The portal includes the approach to the tunnels and the tunnel works that connect to the tunnels precinct. The portal alignment design for the Concept Design includes a cut-and-cover structure (under the Sandringham line, Frankston line and freight and regional line) and a decline structure (open to air) which would bring the Melbourne Metro tracks to the same vertical level as the existing rail corridor.

The William Street bridge, South Yarra Siding Reserve, Osborne Street Reserve and Lovers Walk would be impacted during construction and largely reinstated following construction.

14.1.1 Construction

Main construction activities at the site would be:

- Establishment of construction work sites
- Demolition of William Street bridge
- Cut-and-cover excavation of the tunnel box, including an excavation area of approximately 720 m²
- Widening of the existing rail corridor and construction of retaining walls
- Construction of ventilation shaft, emergency access shaft and substation in Osborne Street Reserve
- Retrieval of the TBM from a box in the rail reserve adjacent to Osborne Street
- Reinstatement of William Street bridge
- Reinstatement of South Yarra Siding Reserve and Lovers Walk.

The South Yarra Siding Reserve and Osborne Street Reserve, generally bordered by William Street to the east and Osborne Street to the west, would be occupied as major sites for the eastern portal construction. This area would house site offices, amenities, and materials laydown and equipment storage. An area in Osborne Street to the south of the portal site would also be required for materials laydown and manoeuvring of equipment.

14.2 Existing Conditions

The Prahran Main Drain and Yarra Street Outfall Drain systems service the area in the immediate vicinity of the eastern portal. Areas covered by the Land Subject to Inundation Overlay and Special Building Overlay of the Stonnington Planning Scheme associated with flooding from these systems are shown in Figure 14-1 and Figure 14-2. The City of Stonnington is in the process of updating its Special Building Overlay as part of amendment C221 to be exhibited in early 2016.

The Prahran Main Drain system services the catchment to the south and east of South Yarra station. The lower catchment (northern) trunk system is under Melbourne Water's jurisdiction. The upper catchment trunk system and tributary drains are under the jurisdiction of the City of Stonnington. The Prahran Main Drain outfalls to the Yarra River between the Church Street bridge and the Yarra rail bridge immediately to the north of South Yarra station. As is evident from Figure 14-2, the area covered by the Special Building Overlay includes much of the area abutting the south side of the Caulfield line rail cutting between Chapel Street and Surrey Road. The northern border of the Special Building Overlay abuts the rail cutting at Chapel Street. There is therefore potential for flow resulting from severe storm events to enter the rail cutting at or close to this location.

The Yarra Street Outfall Drain system is under the jurisdiction of the City of Stonnington. The upper reaches of the Outfall Drain run from south west to north and parallel to the Sandringham rail line cutting. North of



Toorak Road, the Outfall Drain turns north east, and crosses under the rail line at South Yarra station, before outfalling to the Yarra River immediately to the east of the Yarra rail bridge. Anecdotal evidence suggests that South Yarra station is subject to relatively frequent inundation as a result of overland flows from this system, in excess of the capacity of the piped system.

There is also potential for the portal to be flooded by an extreme event on the Yarra River. Hydrologic and hydraulic flood modelling was undertaken to estimate a range of peak flood flows and levels on the upstream side of the existing rail bridge across the Yarra. These are summarised in Table 14-1. Further details of the modelling are provided in Appendix B of this report.

Table 14-1 Yarra River flood flows and levels upstream of existing South Yarra bridge

Flood event AEP (%)	Conditions	Peak flood level (m AHD)	Peak flood flow (m ³ /s)
1	Existing	3.5	850
1	Year 2100 (ie including allowance for climate change impacts)	5.2	1,300
0.1	Year 2100	7.3	2,000
0.01	Year 2100	10.1	3,500

14.3 Key Issues

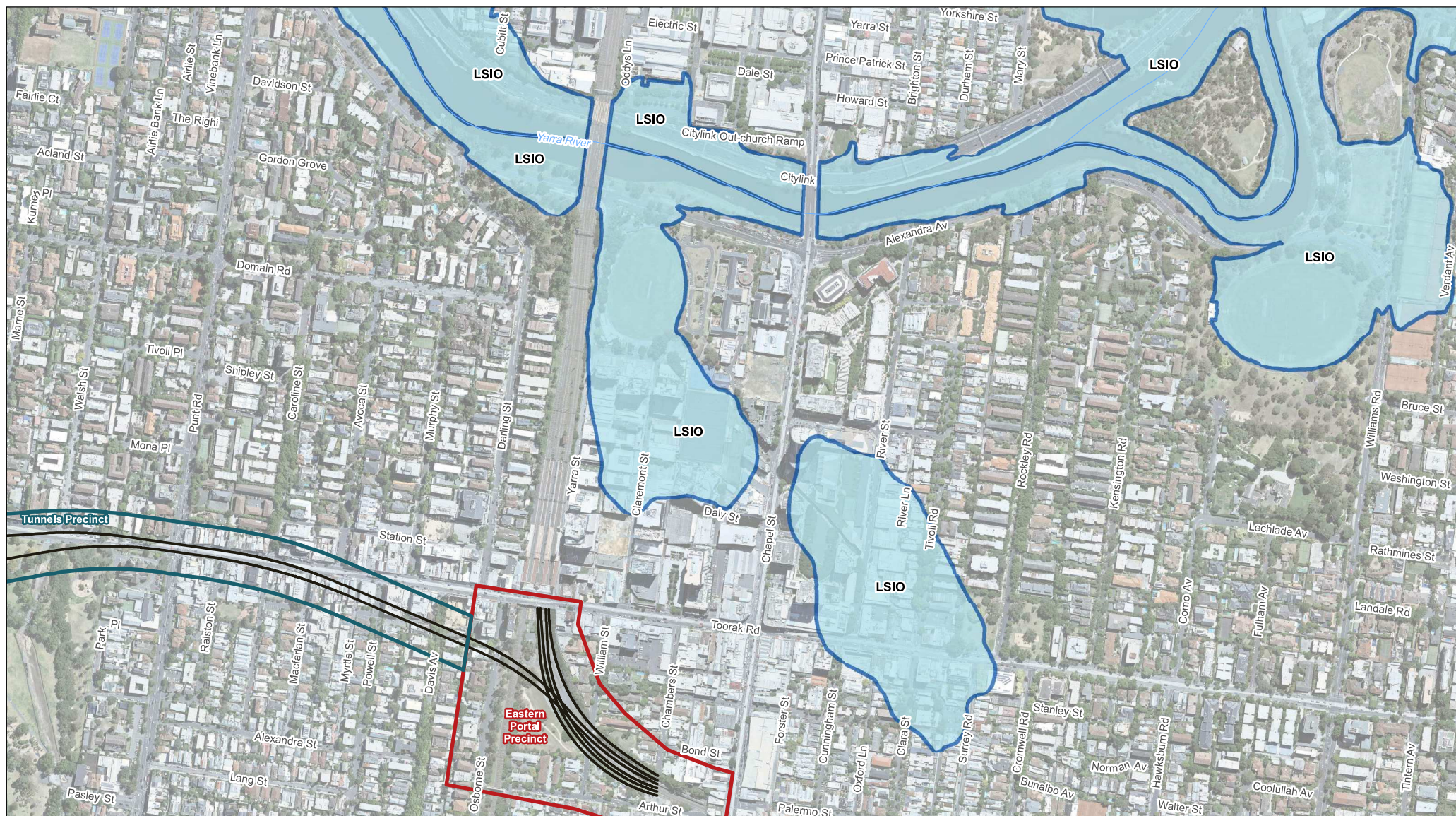
As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are:

- Potential flooding of the tunnels from the portal from the Yarra River or runoff from local drains into the rail cutting, during construction – **Risks #SW014 and #SW015**
- Potential flooding of the tunnels from the portal from the Yarra River, or runoff from local drains into the rail cutting, during operation – **Risks #SW031 and #SW032**
- Potential increase in flood levels to adjacent properties due to overloading of the local drainage system resulting from pumped drainage from the decline structure during operation – **Risk #SW033**
- Potential increase in flood risk to adjacent properties during construction due to obstruction of overland flow paths – **Risk #SW013**.

14.4 Benefits and Opportunities

The opportunities associated with the Concept Design project include:

- Possible collection and re-use of stormwater from the decline structure, with appropriate treatment
- Possible enhancement to parks by introduction of a wetland.



Legend

- Proposed alignment
- LSIO - Land Subject to Inundation
- Environmental and Planning Precincts**
- Portal Precinct
- Tunnel Precinct

Data Sources:
Proposed Infrastructure: AJM January 2015
Contains Vicmap Information
© State of Victoria 2015
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
Yarra River & Prahran Main Drain -
Land Subject to Inundation Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500149

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

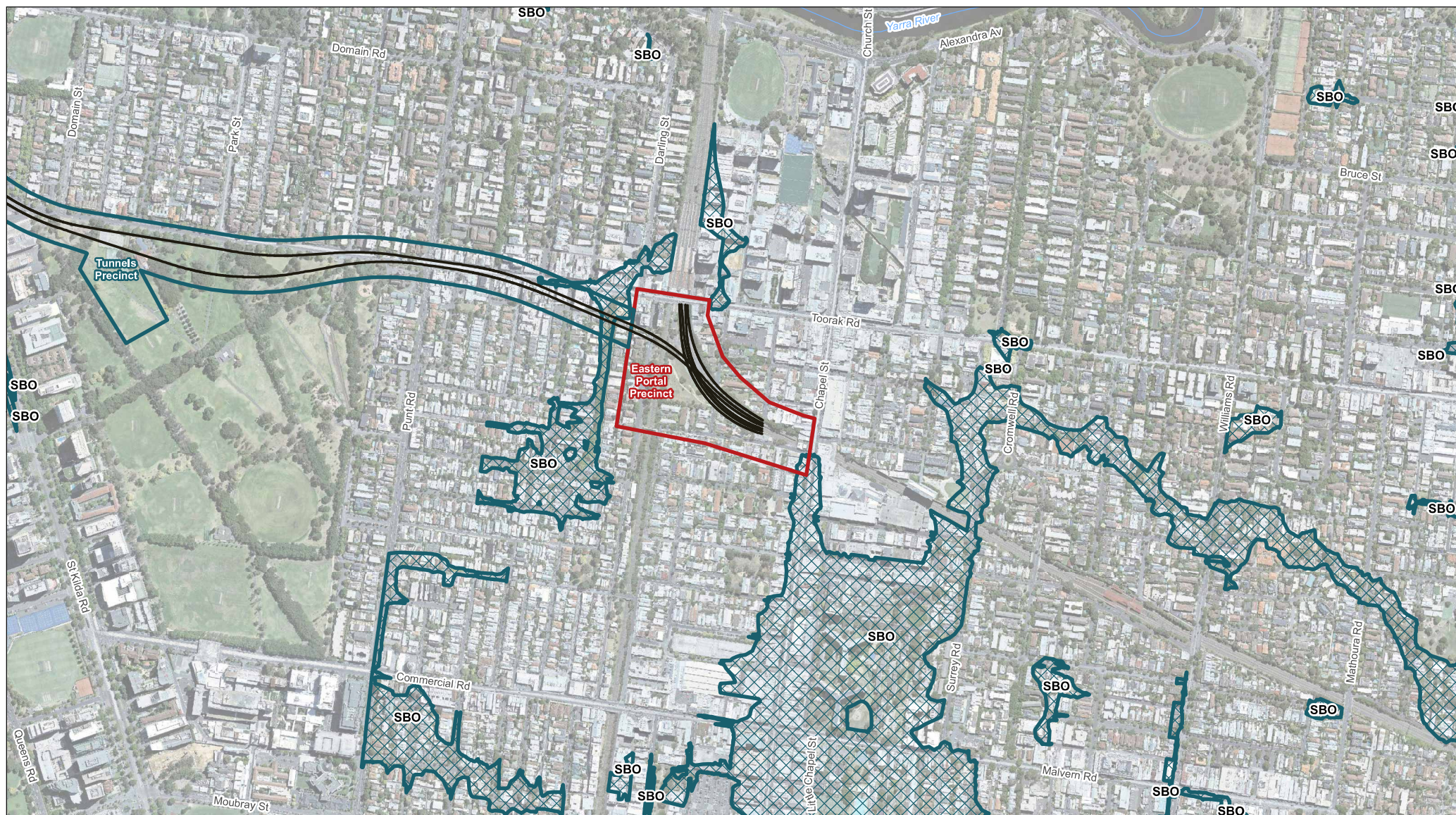
Date:
7/04/2016

Map Size:
A4



Figure 14-1 Prahran Main Drain – Land Subject to Inundation Overlay (LSIO) (DELWP, 2016)

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Legend

— Proposed alignment

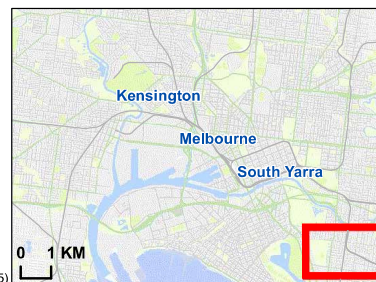
 SBO - Special Building Overlay

Environmental and Planning Precincts

 Portal Precinct

 Tunnel Precinct

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2016
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
South Yarra & Prahran Main Drains -
Special Building Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500148

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

Date:
6/04/2016

Map Size:
A4



Figure 14-2 Prahran Main Drain and Yarra Street Outfall Drain systems – Special Building Overlay (SBO) (DELWP, 2016)

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14.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 14-2 Draft evaluation objectives and assessment criteria for the eastern portal precinct

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

Potential flooding of the tunnels from the Yarra River from the portal during construction or operation has the potential to cause significant inundation of the tunnels in a relatively short time frame. This could pose a significant risk to construction workers, commuters and rail staff, and significant disruption to rail services. Even relatively shallow inundation of the portal could cause major flooding of the tunnels in a relatively short time frame (tens of minutes to hours).

The ground level of the highest point along the rail cutting between the eastern portal and the Yarra River is approximately 7.15 m AHD, immediately south of Toorak Road. The portal would therefore be immune from flooding from the Yarra River in approximately a Year 2100 (ie including allowance for climate change impacts) 0.1 per cent AEP event (1,000 year ARI event) (**Risks #SW014** and **#SW032**), and 1.95 m above the Year 2100 one per cent AEP Yarra River flood level. This would thus comply with Melbourne Water's flood immunity requirements. A flood immunity risk assessment would nevertheless be required to determine whether this level of flood immunity is acceptable. This would need to take account of the impacts of a range of flood events on factors including damage and clean-up costs, and the costs associated with long-term disruption of the rail network. Up to three day's warning is likely to be available in advance of such an event because it relates to floodwaters emanating from the Yarra River. At a very minimum, it is recommended that a flood warning system be implemented, such that rail services could be suspended and the tunnel and stations evacuated, in advance of an extreme flood. This system should link to existing systems in place in the Yarra catchment. If the risk associated with more extreme floods is not deemed to be acceptable, emergency management measures, such as sandbagging or flood gates and emergency evacuation procedures, would need to be put in place to protect the tunnel from flooding in these more extreme events. It is currently proposed that the portal incorporate works to allow flood gates in the form of stop logs to be installed across the portal in advance of a flood event. It is also proposed that stop logs be stored adjacent to the portal.

A flood warning system, emergency evacuation procedures and provision for installation of temporary barriers such as sandbags should also be in place during the construction phase.

Melbourne Water has estimated that the Year 2100 one per cent Yarra River flood level adjacent to the eastern portal is 4.85 m AHD. The level at which the portal would flood from the Yarra River (7.15 m AHD) is therefore well above the Melbourne Water requirement that it be above the one per cent AEP flood level, with a 600 mm freeboard allowance.

It appears unlikely that any Melbourne Metro works would significantly impact on flood flows or flood levels in either of the Prahran Main Drain or Yarra Street Outfall Drain systems (**Risk #SW013**). These systems are therefore likely to be of more relevance for their potential to inundate the rail cutting, and thence potentially



impact on the portal and tunnels during either construction or operation (**Risks #SW015 and #SW031**). As noted above, the most likely locations for this are:

- From overland flows in the Prahran Main Drain system in the area around Chapel Street immediately to the south of the Caulfield line rail cutting
- From overland flows from the Yarra Street Outfall Drain at South Yarra station.

There is a localised low point on the existing rail line under Chapel Street that could potentially flood in extreme rainfall events due to lack of capacity in the underground piped drainage system. Modelling (refer to Section B.7.2 of this report) indicates that the portal would be immune from flooding from any of these local systems in the Year 2100 0.5 per cent AEP flood event. More extreme events could potentially inundate the portal, but the impact would be negligible and represents a very low risk.

Drainage runoff from the decline structure would be pumped into the local drainage system (**Risk #SW033**). As the decline structure would increase the overall paved area, there is likely to be a need to control the discharge rate into the existing drainage system. Local drainage storage of around 60 m³ is likely to be required. It is currently envisaged that this would be located in the South Yarra Siding Reserve adjacent to the portal.

If the proposed mitigation measures described above were put in place, the precinct would then comply with the surface water elements of the draft EES evaluation objectives listed in Table 14-2 as it would result in negligible impact on existing flooding and drainage functions and characteristics.



14.6 Environmental Performance Requirements

Table 14-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 14-3 Environmental Performance Requirements for the eastern portal precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Construction workers	Flooding of portal from local drainage or Yarra River during construction, potentially compromising the safety of construction workers.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Emergency management measures in place – sandbagging or other barriers to floodwaters, flood warning system, evacuation of workers.	SW014, SW015
Commuters, rail staff, rail services	Flooding of portal from local drainage or Yarra River during operation, potentially compromising the safety of commuters and/or rail staff and disrupting rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Ensure portal is at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in place in the event of a larger flood, including flood warning system, evacuation procedures for tunnel and station, suspension of rail services, and, if deemed necessary, sandbagging or flood gates to protect the portal. Currently proposed that the portal incorporate works to allow flood gates in the form of stop logs to be installed across the portal in advance of a flood event, and that stop logs be stored adjacent to the portal.	SW031 SW032
Property and infrastructure in the vicinity of the portal	Increase in flood levels in areas adjacent to the portal during construction, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW013



Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
		flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.		
Property and infrastructure in the vicinity of the portal	Pumped discharge from the decline structure may overload local drainage system resulting in increase in flood levels to surrounding properties.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Provision of balancing storage (approx. 60 m ³).	SW033



15 Precinct 9: Western Turnback

15.1 Project Components

The Concept Design includes a western turnback at West Footscray, with a third platform and track at West Footscray station, and modifications to the existing concourse. The scope for this includes:

- Realigning regional, suburban and freight lines
- Construction of new track and turnouts
- Construction of a new passenger platform and alterations to the existing concourse.

15.1.1 Construction

There is no construction activity of particular relevance to surface water for the Concept Design.

15.2 Existing Conditions

Much of the area in the vicinity of the existing West Footscray station is covered by an Special Building Overlay in the Maribyrnong Planning Scheme (refer to Figure 15-1). This is associated with overland flows in excess of the capacity of underground drains in the Graingers Road Main Drain system. Graingers Road Main Drain passes under the western end of Footscray West station, and flows from north to south. This system outfalls to Stony Creek, downstream of Somerville Road.

15.3 Key Issues

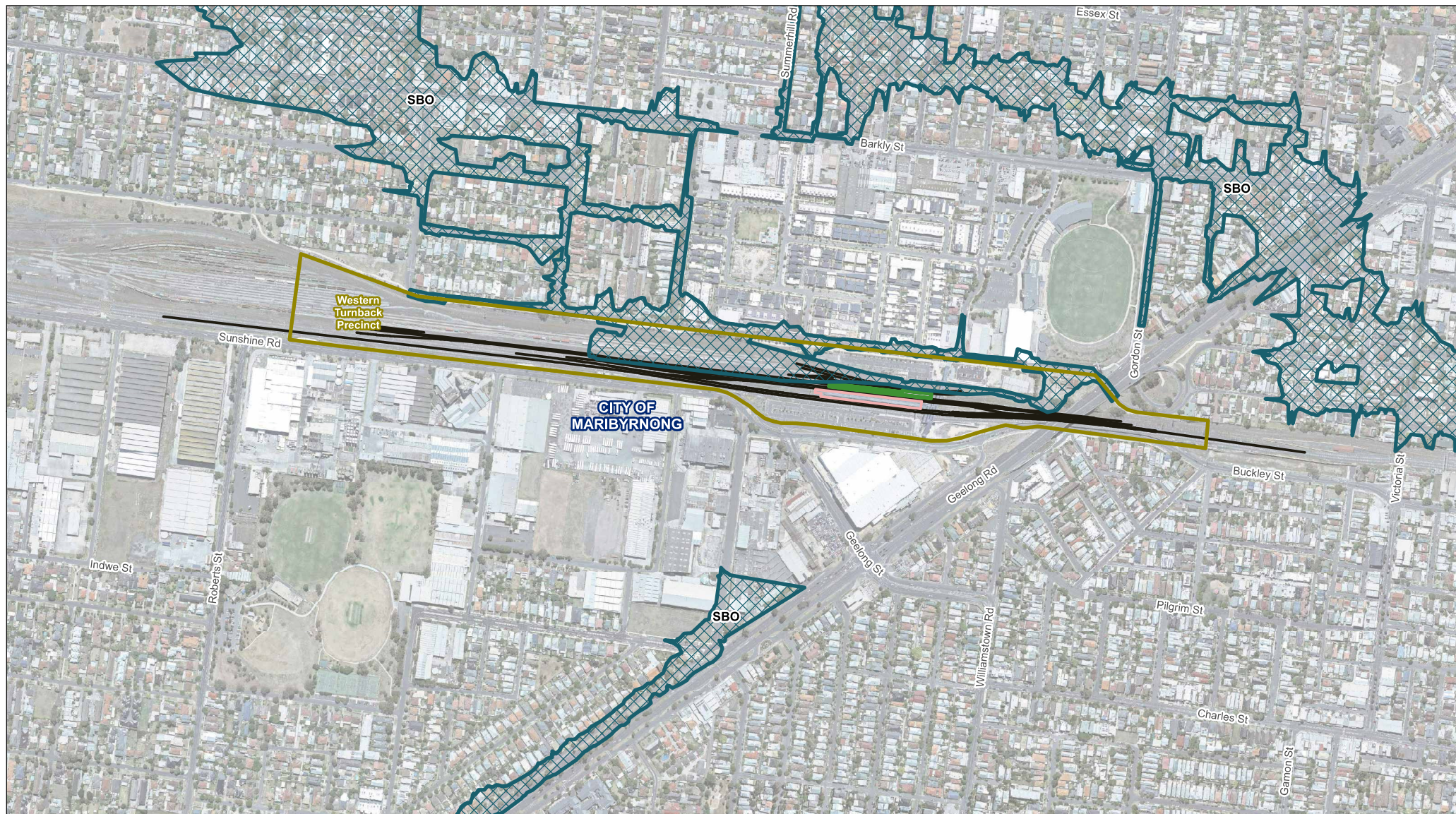
As identified in the risk assessment (Table 6-1), the key issues associated with the Concept Design are listed in Table 15-1.

Table 15-1 Key issues associated with Concept Design

Concept Design	Issue	Risk no.
West Footscray – a third platform and track at Footscray station, with modifications to existing concourse.	• Construction works resulting in increase in flood levels due to obstruction of overland flow paths and/or loss of flood storage • Permanent works resulting in increase in flood levels due to obstruction of overland flow paths and/or loss of flood storage.	• SW016 • SW034

15.4 Benefits and Opportunities

No benefits and opportunities associated with the Concept Design have been identified in relation to surface water in this precinct.



Legend

Proposed Turnback Design - West Footscray  SBO - Special Building Overlay

 Existing platform

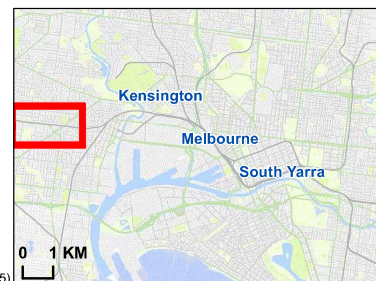
 Proposed platform

 Proposed alignment

Environmental and Planning Precincts

 Western Turnback Precinct

Data Sources:
Proposed Infrastructure: AJM 2016
Contains Vicmap Information
© State of Victoria 2016
Aerial photo (DELWP, February 2015)



Melbourne Metro Rail Project

Title:
Graingers Road Main Drain -
Special Building Overlay

Drawing Number:
MMR-AJM-UGAA-MP-NO-500150

Revision:
P1

Drawn By:
A. Berman

Approved By:
D. Sheehan

Date:
6/04/2016

Map Size:
A4



Figure 15-1 Graingers Road Main Drain – Special Building Overlay (SBO) (DELWP, 2016)

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15.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 15-2 Draft evaluation objectives and assessment criteria for the western turnback

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

The Special Building Overlay in the vicinity of West Footscray station does not extend continuously across the existing rail reserve. This indicates that there is no overland flow across the rail reserve in a one per cent AEP flood event under existing conditions. Therefore any works within the rail reserve would not obstruct overland flows, as there are none.

There is some potential for works within the rail reserve to result in loss of floodplain storage (**Risk #SW016** and **#SW034**). The platform works are suspended decks and thus hollow underneath. This would therefore result in negligible loss of flood storage.

The precinct is consistent with the surface water elements of the draft EES evaluation objectives listed in Table 15-2, as it would result in negligible impact on existing flooding and drainage functions and characteristics.



15.6 Environmental Performance Requirements

Table 15-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 15-3 Environmental Performance Requirements for the Western Turnback precinct

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Property and infrastructure in the vicinity of West Footscray.	Increase in flood levels in areas adjacent to the station during construction, resulting in increased flooding of property and infrastructure.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW016
Property and infrastructure in the vicinity of West Footscray.	Increase in flood levels in areas adjacent to the station during operation, resulting in increased flooding of property and infrastructure.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Unlikely to be required, as temporary and permanent works should be able to be designed to ensure negligible impact.	SW034



16 Early works

16.1 Project Components

A number of early works are required prior to the commencement of the main construction works. The early works predominantly comprise modifications, temporary works, relocations or new works associated with existing utilities and services as follows:

- Electrical
- Sewer
- Gas
- Water
- Stormwater
- Communications
- Tram works.

The only utility and services works of relevance to surface water are those relating to stormwater. These comprise realignment of stormwater drains and manholes to enable construction of other Melbourne Metro works, while maintaining or improving the current level of drainage service. They are:

- Western portal. Works associated with existing:
 - 525 mm and 300 mm diameter drains in Childers Street, east of Ormond Street. These are under cut-and-cover section of the project alignment and through the portal structure. The works would comprise construction of a new parallel 525 mm diameter drain adjacent to the existing drains and through the western extent of existing industrial estate, with connections to the existing downstream drain. This would include revised incoming connections to existing drains.
- Arden station. Works associated with:
 - Northern branch of an existing 750 mm diameter drain bifurcation across the station box extent. A new manhole would be constructed upstream of the station box on the existing drain, with flows intercepted and diverted by a new drain along Laurens Street and Barwise Street on the northern side of the station box. The downstream connection of the new drain would be at a manhole on the existing drain.
 - Multiple small diameter local connections on the northern side of the existing 750 mm diameter drain across the station box location, south of Barwise Street, across VicTrack property.
- Parkville station.
 - Abandonment of existing stormwater drain on the south side of Grattan Street.
- CBD North station. Works associated with existing:
 - 375 and 300 mm diameter drain on the south side of Franklin Street across Swanston Street. The exact nature of the works is still to be determined.
 - 375 and 300 mm diameter drain on the north side of Franklin Street across Swanston Street. This drain would be relocated to the north side of the north station entrance.
 - 100 mm diameter drain on the northern side of A'Beckett Street, west of the Swanston Street intersection. This drain would be relocated northwards outside the station cut-and-cover excavation area.
- CBD South station. Works associated with existing:
 - 1,200 mm diameter drain along the west side of Swanston Street. This would be abandoned, and a new 1,200 mm diameter drain constructed in Swanston Street between Flinders Lane and Flinders Street. This would then continue west into Flinders Street to a new manhole east of Degraves Street.



- 300 mm diameter drain along the north side of Flinders Street, west of the Swanston Street intersection. This would be abandoned during construction of the pedestrian link and then reinstated prior to completion.

While no other specific stormwater works are proposed for other precincts, any works involving modification to the ground surface could impact on surface water and drainage characteristics in the area, although for the works proposed the impact is expected to be negligible.

Access shafts in the City Square, Franklin Street and A'Beckett Street would be established as part of an early works program, to assist in accelerating construction upon appointment of the successful contractor.

16.2 Existing Conditions

The stormwater works described in Section 16.1 for the western portal and Arden station are in the Maribyrnong River and Moonee Ponds Creek floodplains, and parts of the works are in areas covered by a Land Subject to Inundation Overlay.

16.3 Key Issues

There are no key issues associated with the Concept Design involving miscellaneous stormwater relocation and realignment works in the western portal, Arden station, Parkville station, CBD North station and CBD South station precincts. The works are all routine, small-scale drainage works to maintain or improve the current level of drainage service. Any potential surface water issues of increasing flood levels in areas adjacent to the works (**Risk #SW017**) could be readily managed by standard construction measures.

16.4 Benefits and Opportunities

Table 16-1 provides the benefits and opportunities associated with the early works.

Table 16-1 Benefits and opportunities associated with Concept Design

Concept Design	Benefits	Opportunities
Miscellaneous stormwater relocation and realignment works – western portal, Arden station, Parkville station, CBD North station and CBD South station.	Maintenance of existing drainage service.	Improvement of existing drainage service.

16.5 Impact Assessment

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Table 16-2 Draft evaluation objectives and assessment criteria for early works

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

The objective of all the early drainage works is to maintain or improve the existing drainage service. The works are all routine, small-scale drainage works to maintain or improve the current level of drainage service.



Any potential surface water issues could be readily managed by standard construction methods. As such, these are unlikely to result in any significant surface water impacts (**Risk #SW017**).

There is potential for some inundation of the CBD North and CBD South station boxes during construction from overland flows into the construction shafts. This could be easily mitigated by constructing low height barriers to protect the shafts. This would have negligible impact on overland flow depths. The impacts associated with these shafts are adequately captured by the impact assessment conducted on the cavern entrances in the corresponding precincts (CBD North and CBD South), as discussed in Sections 11.5 and 12.5.

The precinct is consistent with the surface water elements of the draft EES evaluation objectives listed in Table 16-2 as it would result in negligible impact on existing flooding and drainage functions and characteristics.



16.6 Environmental Performance Requirements

Table 16-3 provides the recommended Environmental Performance Requirements and proposed mitigation measures for the precinct.

Table 16-3 Environmental Performance Requirements for the early works

Asset / value	Impact	Environmental Performance Requirements	Proposed mitigation measures	Risk no.
Property and infrastructure in the vicinity of early works.	Increase in flood levels in areas adjacent to early works during construction, resulting in increased flooding of property and infrastructure.	For all precincts: • Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority • Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority • Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Standard construction measures	SW017



17 Environmental Performance Requirements

This section provides a comprehensive list of the recommended Environmental Performance Requirements and proposed mitigation measures identified as a result of this impact assessment. Table 17-1 provides the Environmental Performance Requirements which apply across the project and on a precinct basis, linked to the draft EES evaluation objective.

Table 17-1 Environmental Performance Requirements

Draft EES evaluation objective	Impact	Environmental Performance Requirements	Proposed mitigation measures	Precinct	Timing
Hydrology, water quality and waste management objective: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects	Potential flooding of permanent and temporary portal, tunnel and station works, from local surface drainage or riverine flows, during construction or operation, potentially compromising the safety of construction workers, commuters and/or rail staff and disrupting rail services.	For all precincts (with the exception of the western turnback) design permanent and temporary works and, if necessary, develop and implement emergency flood management measures for the tunnels, tunnel portals, access shafts, station entrances and Arden electrical substation to provide appropriate protection against floodwaters and overland stormwater flows. This would be informed by a flood immunity risk assessment that considers a range of events, and to the requirements and satisfaction of the responsible authority.	Stations Entrances (all) - Ensure station entrances and other surface openings (eg ventilation shafts) are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Emergency management measures in the event of a larger flood, eg automatic flood gates, flood warning system, evacuation procedures, suspension of rail services. Tunnels (where not otherwise covered under station entrances and portals) - Install flood gates on the City Loop tunnel portal near Federation Square. - Ensure other five City Loop portals between Flinders Street and Richmond stations are at an appropriate level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. - Construction of small barriers to prevent overland flow inundating the Fawkner Park TBM launch site	All (except Western Turnback and Early Works)	Construction and Operation



Draft EES evaluation objective	Impact	Environmental Performance Requirements	Proposed mitigation measures	Precinct	Timing
resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.			during construction. Western portal • Ensure retaining walls or similar barriers are in place to protect portal and TBM shaft during construction. • Emergency management measures in place during construction – flood warning system, evacuation of workers. • Install automatic gates to protect portal in events in excess of the 100 year ARI event during operation Arden • Ensure retaining walls or similar barriers are in place to protect station box during construction. • Emergency management measures in place during construction – flood warning system for evacuation of workers. • Ensure substation is protected against flooding, by either bunding or setting it at a sufficiently high level to provide an acceptable level of flood immunity. Acceptability to be determined by flood immunity risk assessment. Parkville, CBD North and CBD South • Ensure small retaining walls or similar barriers are in place to protect station box during construction. Domain • Ensure barriers are in place to protect station box and TBM launch site from local catchment inflows during construction. Eastern portal • Emergency management measures in place during construction – sandbagging or other		



Draft EES evaluation objective	Impact	Environmental Performance Requirements	Proposed mitigation measures	Precinct	Timing
			barriers to floodwaters, flood warning system, evacuation of workers. - Ensure portal is at an appropriate level to provide an acceptable level of flood immunity during operation. Acceptability to be determined by flood immunity risk assessment. - Emergency management measures in place in the event of a larger flood during operation, including flood warning system, evacuation procedures for tunnel and station, suspension of rail services and, if deemed necessary, sandbagging or flood gates to protect the portal. Currently proposed that the portal incorporate works to allow flood gates in the form of stop logs to be installed across the portal in advance of a flood event, and that stop logs be stored adjacent to the portal.		
	Increase in flood levels in areas adjacent to permanent and temporary portal, station and tunnel works, during construction or operation, resulting in increased flooding of property and infrastructure.	For all precincts: - Maintain existing flood plain storage capacity potentially impacted by the project, to the requirements and satisfaction of the responsible authority - Permanent and associated temporary construction works must not increase flood levels that result in an additional flood risk to the requirements and satisfaction of the responsible authority - Ensure permanent and associated temporary works do not increase flow velocities that would potentially affect the stability of property, structures or assets, and/or result in erosion during	Western portal - Provision of compensatory flood storage (approx. 9,000 m³). - Provision of balancing storage (approx. 180 m³). Arden - Provision of compensatory flood storage during construction (approx. 6,000 m³). - Provision of compensatory flood storage during operation (approx. 1,600 m³). Domain - If necessary, provide appropriate combination of barrier heights and flow diversion capacity to avoid backing up flooding into Melbourne Grammar during construction.	Western portal, Arden, Domain, Eastern portal	Construction and Operation



Draft EES evaluation objective	Impact	Environmental Performance Requirements	Proposed mitigation measures	Precinct	Timing
		operation or construction, to the requirements and satisfaction of the responsible authority • Undertake modelling of the design of permanent and temporary works to demonstrate the resultant flood levels and risk profile to the satisfaction of the responsible authority.	Eastern portal • Provision of balancing storage (approx. 60 m³).		



18 Conclusion

This report covers the surface water quantity-related aspects associated with the construction and operation of Melbourne Metro. These include drainage and flood-related issues, including risks and impacts associated with flood and overland drainage flows, levels and velocities. Other aspects, including water quality-related aspects, are covered in the following Technical Appendices:

- Technical Appendix O *Groundwater*
- Technical Appendix Q *Contaminated Land and Spoil Management*
- Technical Appendix U *Aquatic Ecology and River Health*.

18.1 Relevant EES Objectives

The following draft EES evaluation objectives and assessment criteria (and indicators where relevant) are relevant to this assessment.

Draft EES evaluation objectives	Assessment criteria
Hydrology, water quality and waste management: To protect waterways and waterway function and surface water and groundwater quality in accordance with statutory objectives, to identify and prevent potential adverse environmental effects resulting from the disturbance of contaminated or acid-forming material and to manage excavation spoil and other waste in accordance with relevant best practice principles.	Criterion – maintain or improve existing flooding functions and characteristics. Indicator – magnitude of predicted changes to 1 per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.

18.2 Risk Assessment Summary

The environmental risk assessment considered the following potential consequences across the study area, in the absence of specific mitigation measures:

- Flooding of the tunnels and stations from tunnel portals or stations during construction or operation, potentially compromising the safety of construction workers, rail staff or commuters and disrupting rail services. This could occur from riverine flooding or overland flows in excess of the capacity of the underground drainage system.
- Temporary or permanent works obstructing riverine flood or overland drainage flows, or resulting in loss of flood storage. This could potentially increase flood levels or velocities, in turn resulting in an increased flood risk to infrastructure and property. The performance criterion proposed for the project works are that they '*maintain or improve existing flooding functions and characteristics.*' This was assessed, where possible, on the basis of the '*magnitude of predicted changes to one per cent AEP flood and overland flow extents, flows, levels and velocities caused by temporary and permanent project works.*'

The risk assessment informed the project design. Input to the design process focussed on Year 2100 flood levels (ie accounting for the impacts of climate change) for a range of AEPs. A range of potential design requirements need to be accounted for:

- Melbourne Water generally requires that major infrastructure be protected against a one per cent AEP flood, with a 600 mm freeboard allowance for riverine flooding and a 300 mm freeboard allowance for local stormwater flooding. It requires this assessment to take account of the design life of the infrastructure. For Melbourne Metro, this assessment was therefore based on Year 2100 conditions. MMRA is committed to providing this level of flood immunity as a minimum standard.



- MMRA may decide to adopt higher flood immunity standards than are required by Melbourne Water. This should be informed by a flood immunity risk assessment and this is not part of the environmental approvals process. The flood immunity risk assessment would need to consider the operability and integrity of the rail network as determined by the network owner and take account of the impacts of a range of flood events on factors including damage and clean-up costs, and the costs associated with any potential long-term disruption of the rail network.

18.3 Impact Assessment Summary

The environmental risk assessment considered the likelihood and consequence of a range of different AEP flood events assuming no mitigation works or measures and used this to assign initial risk. It then assessed the residual risk assuming potential mitigation works and measures are implemented to reduce the initial risk. The risk assessment concluded that mitigation measures could feasibly be implemented to reduce all residual risks to 'Low' or 'Very Low'. No 'Very High' initial risks were identified. Eight 'High' initial risks were identified. These relate to tunnels and stations that are potentially at risk of flooding during construction and/or operation from:

- The Maribyrnong River at the western portal
- Moonee Ponds Creek at Arden station
- The Yarra River, from the existing City Loop tunnel portals near Federation Square through the underground cross connection at CBD North station, and at the eastern portal
- Overland flows along Swanston Street into the entrances to CBD South station.

All residual risks associated with potential for infrastructure and construction works to impact on flood flows and levels were assessed as 'Low' or 'Very Low'.

Maribyrnong River: The area around the existing rail embankment, in which the western portal (tunnel decline structure and cut-and-cover section of tunnels) would be constructed, forms part of the Maribyrnong River floodplain. Under existing conditions, a one per cent AEP flood would inundate Childers Street near JJ Holland Park to a depth of around a metre. There is potential for Maribyrnong River floodwaters to fill the tunnel within hours during a flood event. Up to a day warning would typically be available in advance of such an event. Works would be required to protect the portal from flooding during construction. It is unlikely to be feasible to protect the portal from flooding in an extreme flood event (say rarer than one per cent Annual Exceedance Probability (AEP)) during construction and emergency measures would need to be put in place to protect construction workers if such an event was to occur. These would include a flood warning system and evacuation procedures. In the absence of any additional mitigation works, the permanent portal would be protected against flooding from the Maribyrnong River in an estimated one per cent AEP (100 year Average Recurrence Interval (ARI)) event, under Year 2100 conditions, with a 600 mm freeboard allowance. This would be provided by a proposed retaining wall on the north side of the rail embankment along Childers Street. It is proposed that automatic flood gates be installed during the project's operational phase to protect the portal against flooding from more extreme events. These gates would extend to the full height and width of the portal and thus provide protection against even the most extreme flood event.

Moonee Ponds Creek: The Arden station construction site, and permanent entrances to Arden station, are in the Moonee Ponds Creek floodplain. The land around the station box and entrances is subject to flooding in events as frequent as 10 per cent AEP. Flood warning times in Moonee Ponds Creek are typically relatively short at only one to two hours. The flood risk to construction workers would need to be managed by erection of barriers around the station box to provide protection against at least the one per cent AEP flood event, and implementation of emergency management measures including a flood warning system and evacuation procedures to mitigate the risk in more extreme flood events. The permanent station entrances in the Concept Design are above the 0.1 per cent AEP flood event, including allowance for climate change impacts. The adequacy of this would need to be determined by flood immunity risk assessment.



Yarra River: The Melbourne Metro tunnels are potentially subject to flooding from the existing City Loop tunnels through the underground interconnection at CBD North station. Of the six City Loop tunnel portals in the area between Flinders Street and Richmond stations, the portal on the line between Flinders Street and Parliament Stations, near Federation Square, is at by far the greatest risk of riverine flooding, and is subject to flooding from the Yarra River in an event more frequent than a Year 2100 (ie including allowance for climate change impacts) one per cent AEP Yarra River flood. Up to three day's warning would typically be available in advance of such an event. The Melbourne Metro tunnels could fill relatively quickly once inundation thresholds were exceeded. This could be mitigated by installation of flood gates on this City Loop tunnel portal to provide protection during both the construction and operational phases of the project. The other five portals in this area are all immune from flooding in a Year 2100 0.1 per cent AEP Yarra River flood event. A flood immunity risk assessment is required to determine whether this is acceptable.

In the absence of any additional mitigation works, the eastern portal would be subject to flooding from the Yarra River in an estimated Year 2100 0.1 per cent AEP (1,000 year ARI) event. A flood immunity risk assessment is required to determine whether this is acceptable. At a very minimum, it is recommended that a flood warning system be implemented, such that rail services could be suspended and the tunnels and stations evacuated in advance of an extreme flood. If the risk is not deemed to be acceptable, additional emergency management measures, such as sandbagging or flood gates, would need to be put in place to protect the tunnels from flooding in an extreme event during both the construction and operational phases of the project. It is currently proposed that the portal incorporate works to allow flood gates in the form of stop logs to be installed across the portal in advance of an extreme flood event. It is also proposed that stop logs be stored adjacent to the portal.

Overland flows along Swanston Street: The permanent entrances to CBD South station are subject to flooding from overland flows along Swanston and Flinders Streets. The Flinders Street Station entrance facing Swanston Street, in particular, is subject to some slight ponding of stormwater flows. All entrances would need to be elevated slightly to provide an appropriate level of flood protection to be determined by flood immunity risk assessment. Very little warning (tens of minutes) would typically be available in advance of a major overland flow event at this site.

Conclusions

Mitigation measures could feasibly be implemented to reduce all residual risks to 'Low' or 'Very Low'.

If the proposed works described above are put in place, the tunnels and all stations would be protected against flooding from the Maribyrnong River, Moonee Ponds Creek and the Yarra River in at least the 0.1 per cent AEP flood event under Year 2100 conditions (ie including allowance for the impacts of climate change).

If the proposed mitigation measures described above were put in place, the project would then comply with the surface water hydrology elements of the draft EES evaluation objectives for surface water drainage and flooding, as it would result in negligible impact on existing flooding and drainage functions and characteristics. The project would also comply with Melbourne Water's flood immunity requirements.

Benefits and Opportunities

The majority of the project is to be located underground and there are consequently few opportunities for surface water benefits to be derived from the works. There may be opportunities to enhance the flood protection of the existing City Loop tunnels and stations. Rainfall runoff from the tunnel decline structures at the portals could be pumped to the surface and there may be opportunities to re-use some of this water for irrigation of parks, sports fields or gardens, with appropriate treatment.



References

- Aurecon (2014), Metro Rail Capacity Project: Catchment Drainage Investigation Study Stage 1.
- Austrorads (2010), Guide to Road Tunnels.
- CSIRO (2009), The Effect of Climate Change on Extreme Sea Levels in Port Phillip Bay, November 2009. Available online at http://www.climatechange.vic.gov.au/_data/assets/pdf_file/0010/152488/CSIROReportPortPhillipBayv2.pdf
- City of Melbourne (2012), Arden Macaulay Structure Plan 2012, <http://www.melbourne.vic.gov.au/BuildingandPlanning/FutureGrowth/StructurePlans/ArdenMacaulay/Pages/ArdenMacaulayStructurePlan.aspx>
- Department of Environment, Land, Water and Planning (2015), Planning Schemes Online, Available online at <http://planningschemes.dpcd.vic.gov.au/>
- Department of Environment, Land, Water and Planning, Victorian Planning Provisions, Available online at <http://planningschemes.dpcd.vic.gov.au/schemes/vpps>
- Department of Transport (2010), Melbourne Metro Stage 1, Tunnel and Underground Station Drainage, Technical Discipline Report, 15 October 2010, by Aurecon, Mott MacDonald, SKM and Grimshaw.
- Department of Transport, Planning and Local Infrastructure (2013), Arden Street and E Gate, Hydrologic and Hydraulic Modelling, Draft report by Aecom, 10 September 2013.
- Engineers Australia (2013), Australian Rainfall and Runoff, Available online at <http://www.arr.org.au/>
- Government of Victoria (1989), *Water Act 1989*. Available online at: [http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/LTObjSt7.nsf/DDE300B846EE D9C7CA257616000A3571/3972EF36E12C9F68CA257A3700149F8E/\\$FILE/89-80a105bookmarked.pdf](http://www.legislation.vic.gov.au/Domino/Web_Notes/LDMS/LTObject_Store/LTObjSt7.nsf/DDE300B846EE D9C7CA257616000A3571/3972EF36E12C9F68CA257A3700149F8E/$FILE/89-80a105bookmarked.pdf)
- Melbourne Water (2010), Yarra River Flood Mapping Hydrologic and Hydraulic Study Report, by S P Goh and Associates.
- Melbourne Water, (2015) Available online at <http://www.melbournewater.com.au/aboutus/historyandheritage/History-of-our-rivers-and-creeks/Pages/History-of-the-Yarra-River.aspx>.
- Melbourne Water (2015), Flood Mapping Projects, Guidelines and Technical Specification, March 2015, Draft – Review in Progress.
- Melbourne Water, http://www.melbournewater.com.au/aboutus/whoweare/Legislationandpolicies/Documents/By-law_No_2_-_Waterways_Land_and_Works_Protection_and_Management.pdf
- MMBW (1986), Maribyrnong River Flood Mitigation Study Report.
- Victoria State Emergency Service (2012), State Flood Emergency Plan, Available online at <http://www.ses.vic.gov.au/em-sector/em-planning/em-partners-resources/state-flood-emergency-plan>
- Victorian Coastal Council (2014), Victorian Coastal Strategy 2014, Available online at http://www.vcc.vic.gov.au/assets/media/menu_files/VCS_2014.pdf

