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Fishermans Bend Arterial Road Feasibility Study
 12 June 2013



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Contents

	Page number
1. Background	1
1.1 Fishermans Bend urban renewal area	1
1.2 Study scope	1
2. Approach	3
2.1 Methodology	3
2.2 Assessment criteria	5
2.3 Report outline	6
3. Existing site issues and constraints	7
3.1 Global site issues	7
3.2 Existing utility services	8
3.3 Site visit	11
4. Treatment options	19
4.1 Study assumptions	19
4.2 Section 1 – Graham Street/Plummer Street intersection	19
4.3 Section 2 – Graham Street north of Plummer Street	20
4.4 Section 3 – Graham Street to Prohasky Street (Bypass route)	21
4.5 Section 4 – Prohasky Street intersection	21
4.6 Section 5 – Graham Street to Ingles Street (arterial connection)	22
5. Options assessment	24
5.1 Section 1	24
5.2 Section 2	26
5.3 Section 3	27
5.4 Section 4	29
5.5 Section 5	31
6. Multi criteria assessment	34
7. Conclusion	35
7.1 Key findings	35
7.2 Recommendations	35

1. Background

1.1 Fishermans Bend urban renewal area

The Fishermans Bend urban renewal area is located approximately 3km south west of Melbourne's central business district. It is geographically bound by the Yarra River to the north and west, Hobsons Bay to the south, the suburbs of South Melbourne to the east and Port Melbourne to the south.

The Fishermans Bend urban renewal area has four precincts. The Lorimer Precinct is located on the eastern side of the Bolte Bridge between Lorimer Street and the West Gate Freeway. The Montague Precinct is located between City Road, Boundary Street, Johnson Street and the West Gate Freeway. The Sandridge Precinct is located between Williamstown Road, Graham Street, the West Gate Freeway and Johnson Street. The Wirraway Precinct is located between Williamstown Road, Todd Road, West Gate Freeway and Graham Street. Figure 1.1 below shows the layout of each of the precincts within the urban renewal area.



Source: <http://www.dpod.vic.gov.au>

Figure 1.1 Fishermans Bend urban renewal map

1.2 Study scope

The scope of this study is to identify potentially feasible options for providing an arterial connection between Graham Street and the Prohasky Street/West Gate Freeway ramps intersection within the Wirraway Precinct of the Fishermans Bend urban renewal area. The road is intended to replace the existing heavy vehicle route along Plummer Street/Prohasky Street, and to remove this arterial traffic from the proposed Fishermans

Bend Wirraway Precinct redevelopment. As an extension to the above scope, options for an arterial connection from Graham Street to Ingles Street are to be investigated also.

It is proposed that the options will be evaluated using qualitative 'desktop' techniques providing high level but robust advice about what are potentially viable options for the route of the road connection with the preferred option undergoing further detailed assessment.

The options for the road connection will be assessed against a number of criteria:

- Functionality
- Traffic operations
- Impact to developable land
- Constructability
- Design and construction cost
- Construction risk
- Environmental impacts
- Future operation and maintenance

Identification of a preferred road connection route option will be the primary outcome of this study to form the basis for a road reservation as part of the Fishermans Bend redevelopment.

2. Approach

2.1 Methodology

The methodology used in this study involves the key steps listed in Table 2.1. The outcome sought from each step is also described.

Table 2.1 Steps in the methodology and desired outcomes

Step	Detail	Outcome
Step 1: Identification of issues and constraints	Identifies and assesses the potential issues and constraints within the study area such as existing bridge structures and City Link ramps which may inhibit potential routes for the road connections.	An understanding of existing site constraints which would enable identification of potentially realistic road connection routes for further assessment.
Step 2: Identification of assessment criteria	Identifies the assessment criteria that will be used to assess each option. The assessment criteria will be developed in consultation with DoT.	List of criteria to be used in a multi-criteria assessment of the potential route options.
Step 3: Development of route alignment options	Route alignment options will be developed taking into consideration the issues and constraints identified in Step 1. Potential treatments for the Plummer Street/Graham Street intersection to provide for a light rail along Plummer Street will also be commented at a high level but not assessed in detail during this step.	Identification of route options through the study area.
Step 4: Assessment of route alignment options	This step involves assessing the route options against the criteria identified in Step 2. Each option will be rated for each criteria based on a desktop assessment.	A clear understanding of the benefits and dis-benefits of each of the route options.
Step 5: identification of the preferred route alignment	Identification of the most feasible route option for both connection routes based on the preceding analysis. Both route alignments will be submitted to DoT for comment prior to development of the feasibility design layout.	Multi-criteria assessment resulting in a preferred route alignment option for the arterial bypass connection and arterial connection between Graham Street and Ingles Street.
Step 6: Feasibility design of the preferred route alignment	Undertake feasibility design of the chosen route alignment. The feasibility design will then inform a reservation boundary for the road connection within the Fishermans Bend redevelopment.	Feasibility design plans of the preferred route alignment and intersections including reservation boundary.

2.1.1 Sections of the connection road

The proposed arterial scheme has been divided into sections to identify portions of the route alignment that may have similar issues/constraints and geometric characteristics. This will enable route alignment options to be more easily identified, assessed and compared. On this basis the study area can be currently split into five sections, as illustrated in Figure 2.1, and summarised as follows:

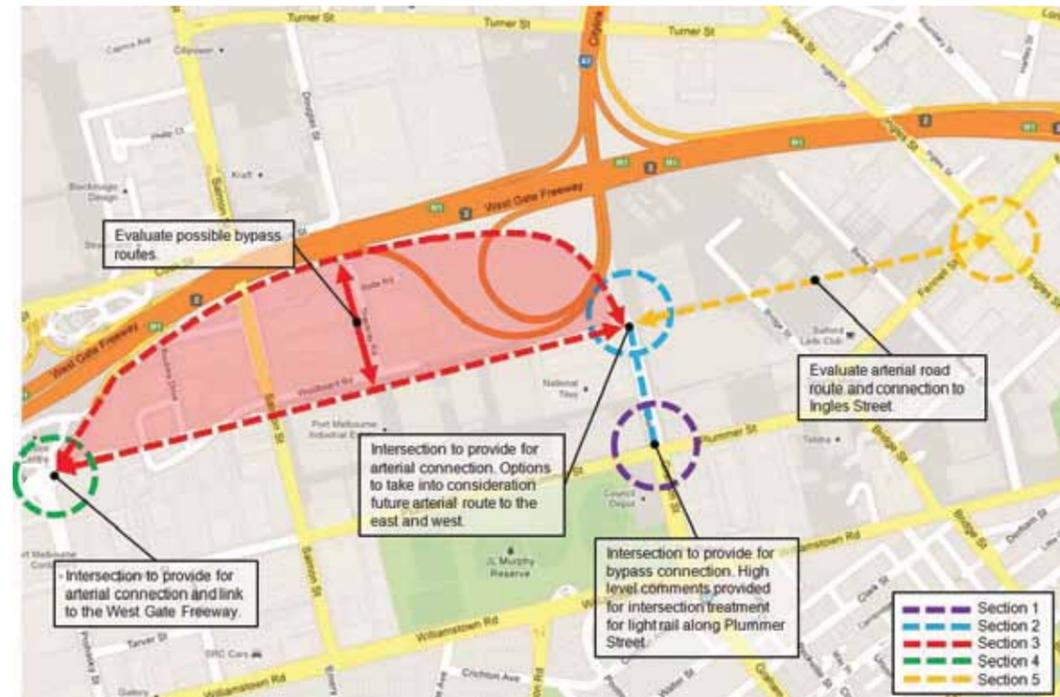


Figure 2.1 Study area sections

- Section 1: Graham Street from the Plummer Street intersection to the future intersection with Proposed Arterial connection.** This section of Graham Street can cater for a four-lane cross-section, with median and parking, although it has recently been downgraded to a two-lane roadway with angle parking and no median. It terminates as a cul-de-sac to the south of City Link. Currently heavy vehicles turn into Plummer Street from Graham Street and vice versa to access Prohasky Street and southern Melbourne. This section would also include the Graham Street/Plummer Street intersection comments on treatments to provide for a light rail down Plummer Street, such as grade separation of the intersection. It is noted that high level 'desktop' formulated options will be commented on and no design plans will be made for this intersection.
- Section 2: Graham Street intersection with Proposed Arterial connection to Graham Street connection.** We will examine layout options of the Graham Street / proposed Arterial intersection. We will also include an eastern leg to the intersection, to cater for a possible Arterial connection between Graham Street and Boundary Street / Brady Street in the east.
- Section 3: Route of the Proposed Arterial connection between Graham Street and the Prohasky Street/West Gate ramps intersection.** This section will have a number of possible route alignment options from potentially running under the City Link ramps along the side of the West Gate Freeway to along the existing Woolboard Road alignment. The number of realistic options for this section of the route would be reduced early in the study following identification of site issues and constraints.
- Section 4: Intersection of heavy vehicle connection with Prohasky Street/West Gate ramps.** This section of the route will look at options to link the bypass into the Prohasky Street/West Gate ramps intersection which would need to provide connections to the West Gate Freeway from the connection road.
- Section 5: Route of the proposed Arterial connection between Graham Street and Ingles Street.** This section may have a number of possible route alignment options between Graham Street and Ingles Street. The number of realistic options for this section of the route will depend on the most feasible location of the intersection of this route with Ingles Street.

2.2 Assessment criteria

A set of evaluation criteria will be used for assessing route alignment options for the proposed arterial route and the connection road to Ingles Street. Table 2.1 below outline the assessment criteria that have been developed to assess the options for each section of the study area.

Table 2.2 Multi criteria assessment

Criteria	Detail/Change
Functionality	<p>Degree to which the road serves its intended purpose e.g. through traffic (trucks etc.) verses local traffic.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> Accessibility of the bypass Potential for an effective pedestrian/cyclist facility Road safety Adaptability of the option for future change of use (i.e. bus route)
Traffic operation	<p>A high level of assessment of the operation and efficiency of traffic utilising the various options, based on the capacities of the potential network items.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> Efficient freight movement/maintaining traffic flow
Impact to developable land	<p>Certain route options within Section 3 of the study area may split the available developable land. Options will be evaluated and scored based on maximising the land for the Fishermans Bend development to the north and south of the arterial route alignment.</p>
Constructability	<p>A high level judgement will be made on the constructability of each route option. This may include an assessment of the constructability of changes to existing structures, tunnelling under existing roads and other related impacts such as traffic delays/closures during construction.</p>
Design and construction cost	<p>A high level judgement will be made about the relative cost of options.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> Structure costs Traffic signals Utility service relocations Local flood mitigation measures
Construction risk	<p>There may be a number of areas where risk may arise during construction. Some types of construction will be more risky such as structures and tunnels.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> Constructing structures under traffic Geotechnical issues
Environmental impacts	<p>A high level judgement will be made about the relative impact of options on the environment based on the available background reports and engineering judgement.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> Noise/air pollution Likelihood of disturbing contaminated land Visual impact

Criteria	Detail/Change
Future operation and maintenance	<p>A high level judgement will be made about the relative future operation and maintenance cost of options based on engineering judgement.</p> <p>In determining the rating for this criteria for each option the following factors will be considered:</p> <ul style="list-style-type: none"> ■ Structure maintenance ■ Pavement repair ■ Traffic signal maintenance ■ Future upgrading

2.3 Report outline

This report documents the options that have been developed for the Fishermans Bend Arterial Road Feasibility Study.

Table 2.3 provides an outline of the chapters in this report and the contribution they make to the development of the arterial road route options.

Table 2.3 Report outline

Chapter No.	Chapter title	Contribution
Chapter 1	Background	<ul style="list-style-type: none"> ■ Objectives of the study ■ Scope of work
Chapter 2	Approach	<ul style="list-style-type: none"> ■ Study methodology ■ Outlines assessment criteria ■ Report outline
Chapter 3	Existing site issues and constraints	<ul style="list-style-type: none"> ■ Identifies the existing issues and site constraints within the study area such as existing utility services, contaminated land and flooding which may impact the route alignment options.
Chapter 4	Treatment options	<ul style="list-style-type: none"> ■ Outlines potentially feasible treatment options for each section of the study area and key features of that option.
Chapter 5	Options assessment	<ul style="list-style-type: none"> ■ Each option is assessed based on the criteria set out in chapter 2. A summary of the identified positive and negative aspects of each option for each criterion is outlined in this chapter.
Chapter 6	Multi criteria assessment	<ul style="list-style-type: none"> ■ The positives and negatives of each option identified in chapter 5 are compared and then each option is rated against each other based on the criteria set out in chapter 2. ■ A tally for each option is provided with the highest scores potentially being the most feasible to develop further.
Chapter 7	Conclusion	<ul style="list-style-type: none"> ■ Lists the key findings of the study. ■ Lists recommendations in relation to the key findings.
	Appendix A	<ul style="list-style-type: none"> ■ Options layout plans

3. Existing site issues and constraints

3.1 Global site issues

3.1.1 Flooding

The land subject to inundation boundaries within the study area are shown in the figures below. The boundaries shown in the diagrams are classified as Special Building Overlay (SBO) which applies to land affected by flooding from the storm water system. The purpose of the SBO is to set appropriate conditions and building floor levels to address the flood risk and to ensure that flood waters are not obstructed or diverted by development. The design of roads crossing these areas will need to investigate flood levels and design the road level and drainage systems to suit.

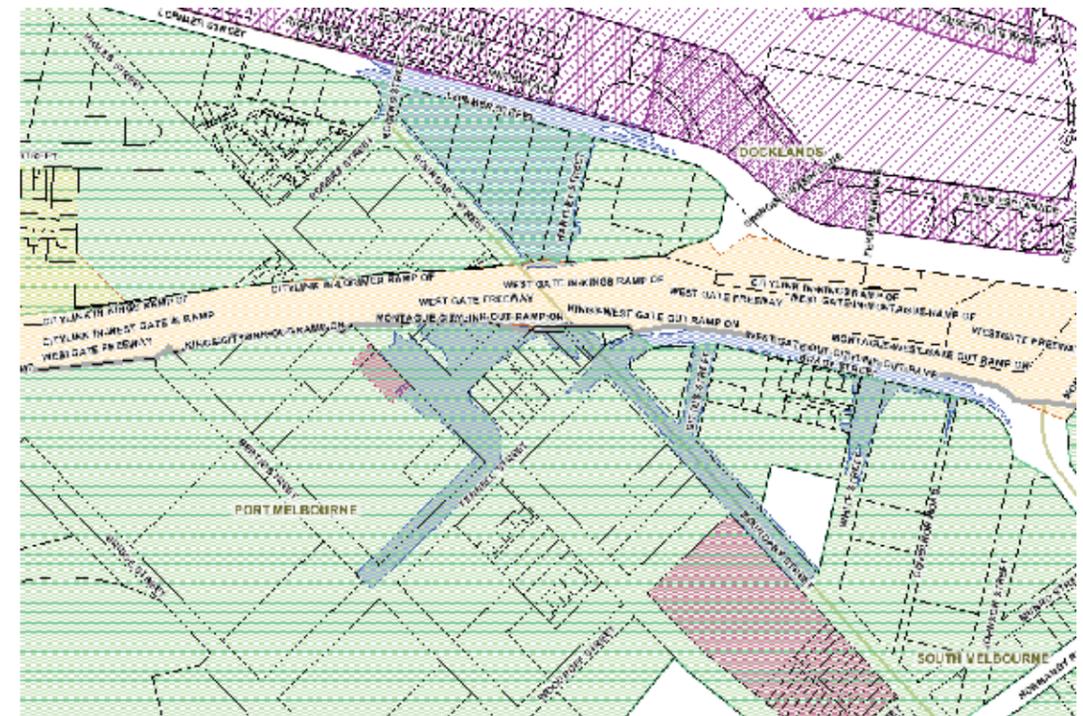


Figure 3.1 Sandridge SBO

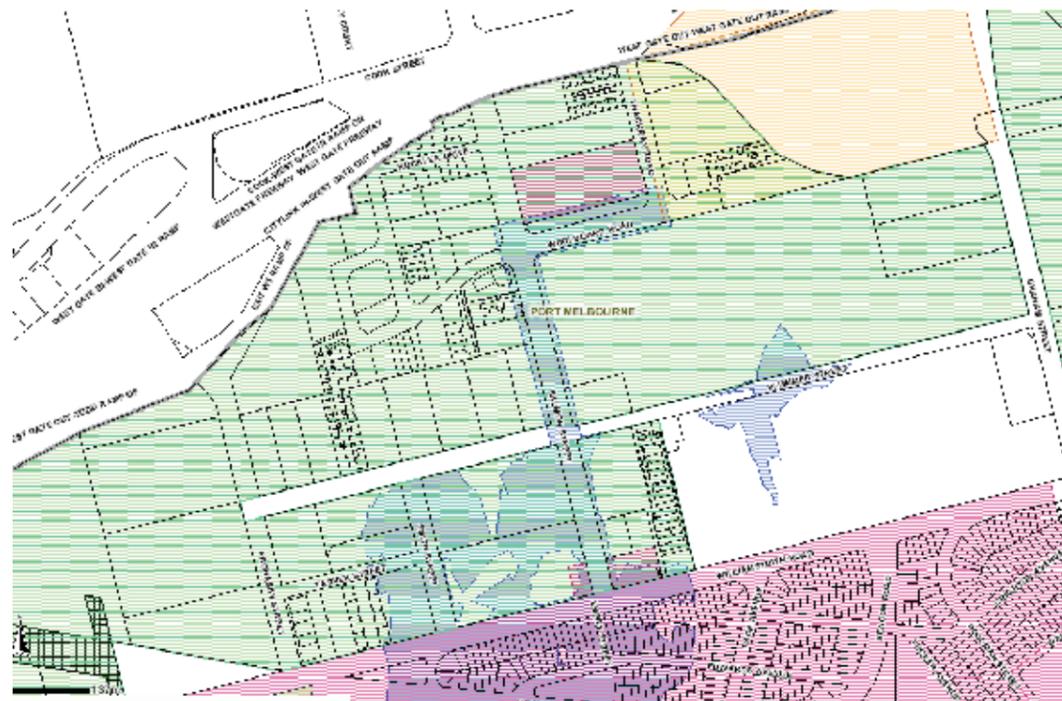


Figure 3.2 Wirraway SBO

3.1.2 Groundwater

The relative low ground level of the area and proximity of Fishermans Bend to the Yarra River and Hobsons Bay and Port Phillip Bay means that the ground water level in the area is relatively high. Any deep excavation in the area will most likely encounter groundwater.

3.1.3 Geological conditions

Due to the nature of the history of development in the area and that the area is underlain with Coode Island silt there is a high risk of encountering contaminated land and acid sulphate soils with any deep excavation in the area. This is further detailed in the report “Fishermans Bend Precinct – Preliminary Land Contamination Study” undertaken by Golders Associates for Places Victoria, June 2012.

3.1.4 Existing road layout

There are two distinct road grid systems within the study area. To the west of Bridge Street the grid system runs generally north/south, where to the east of Bridge Street the grid system runs generally northwest/southeast. Existing infrastructure below street level may be impacted if the existing road layout is changed during redevelopment of the area. This may only be of concern if existing businesses in the area remain operational during the redevelopment of the area.

3.2 Existing utility services

Table 3.1 below summarises the existing utility services within the project study area. The existing services information below is based on recent DBYD information and the findings from the report “Fishermans Bend Infrastructure Assessment” (Revision C) undertaken by GHD for Places Victoria, September 2012.

Table 3.1 Existing utility services (by Section refer figure 2.1)

Utility Description	Location
Section 1	
Stormwater Drainage and Flooding	<ul style="list-style-type: none"> Municipal drainage assets located along Graham Street and Plummer Street. No flood overlays identified.
Potable Water	<ul style="list-style-type: none"> Local reticulation 150mm pipes along Plummer Street and Graham Street.
Sewer	<ul style="list-style-type: none"> 300mm sewer main along Plummer Street east of the intersection with Graham Street. Local sewer pipe along Graham Street.
Electricity	<ul style="list-style-type: none"> SPI Powernet overhead fibre optic cable along Plummer Street. CitiPower underground and overhead assets along Plummer Street and Graham Street.
Gas	<ul style="list-style-type: none"> 150mm high pressure pipeline along Graham Street north of the intersection with Plummer Street. 150mm high pressure pipeline along Plummer Street west of the intersection with Graham Street. 100mm high pressure pipeline along Plummer Street east of the intersection with Graham Street.
Telecommunications	<ul style="list-style-type: none"> Telstra assets along Graham Street and Plummer Street. Optus underground assets along Graham Street. Optus aerial assets along Plummer Street.
Section 2	
Stormwater Drainage and Flooding	<ul style="list-style-type: none"> Municipal drainage assets located along Graham Street. No flood overlays identified.
Potable Water	<ul style="list-style-type: none"> Local reticulation 150mm pipe along Graham Street.
Sewer	<ul style="list-style-type: none"> No assets identified.
Electricity	<ul style="list-style-type: none"> CitiPower underground and overhead assets along Graham Street. DBYD plans supplied by CitiPower show old underground electricity assets crossing the Westgate Freeway under the City Link ramps.
Gas	<ul style="list-style-type: none"> 150mm high pressure pipeline along Graham Street north of the intersection with Plummer Street.
Telecommunications	<ul style="list-style-type: none"> Telstra assets along Graham Street.
Section 3	
Stormwater Drainage and Flooding	<ul style="list-style-type: none"> Municipal drainage assets located along Rocklea Drive, Salmon Street, Woolboard Road and Thackray Road. SBO (Special Building Overlay) along Woolboard Road from and including the intersection with Salmon Street to the intersection with Thackray Road.
Potable Water	<ul style="list-style-type: none"> Distribution main 300mm pipe along Salmon Street south from the intersection with Rocklea Drive 2x150mm pipes along Salmon Street north from the intersection with Rocklea Drive which cross under the West Gate Freeway connecting into 300mm pipes either side of the overpass. Local reticulation 150mm pipes along Rocklea Drive, Woolboard Road and Thackray Road.

Utility Description	Location
Sewer	<ul style="list-style-type: none"> 450mm sewer main along Salmon Street which crosses under the West Gate Freeway. Local sewer pipes along Rocklea Drive and Thackray Road.
Electricity	<ul style="list-style-type: none"> SPI Powernet 220kV transmission tower line. The alignment crosses Prohasky Street south of the intersection with the West Gate Freeway ramps continuing across to the intersection of Salmon Street/Woolboard Road along Woolboard Road then continuing north across the City Link westbound entry ramp to the West Gate Freeway and across the West Gate Freeway. SPI Powernet overhead fibre optic cable along Salmon Street north of Plummer Street and continues underground from the intersection with Rocklea Drive across the West Gate Freeway. CitiPower underground assets within the Rocklea Drive estate, overhead and underground assets along Salmon Street, Woolboard Road and Thackray Road. Underground assets cross the West Gate Freeway in the vicinity of the Salmon Street Bridge.
Gas	<ul style="list-style-type: none"> 150mm high pressure pipeline along Salmon Street which crosses under the West Gate Freeway 63mm high pressure pipeline line along Rocklea Drive.
Telecommunications	<ul style="list-style-type: none"> Telstra assets along Salmon Street which pass under the West Gate Freeway also along Rocklea Drive, Woolboard Road and Thackray Road. Optus underground assets along Salmon Street which pass under the West Gate Freeway and along Woolboard Road and Thackray Road. Uecomm underground assets along Salmon Street south of Rocklea Drive.
Section 4	
Stormwater Drainage and Flooding	<ul style="list-style-type: none"> Municipal drainage assets located along Prohasky Street No flood overlays identified
Potable Water	<ul style="list-style-type: none"> No assets identified.
Sewer	<ul style="list-style-type: none"> No assets identified.
Electricity	<ul style="list-style-type: none"> SPI Powernet 220kV transmission tower line. The alignment crosses Prohasky Street south of the intersection with the West Gate Freeway ramps.
Gas	<ul style="list-style-type: none"> No assets identified.
Telecommunications	<ul style="list-style-type: none"> No assets identified.
Section 5	
Stormwater Drainage and Flooding	<ul style="list-style-type: none"> 1500mm diameter Melbourne Water drain extends along Anderson Street from the intersection with Ingles Street under the West Gate Freeway. Municipal drainage assets located along Bertie Street and Ingles Street as well as a pipe between Bertie Street and Ingles Street along an extension of Anderson Street alignment through private land. SBO (Special Building Overlay) along Fennell Street between Bertie Street and Ingles Street, along Ingles Street between the West Gate Freeway and Fennell Street and the area bound by Ingles Street/Anderson Street/West Gate Freeway.
Potable Water	<ul style="list-style-type: none"> Local reticulation 150mm pipes along Bridge Street, Bertie Street Fennell Street and Ingles Street and an additional 180mm pipe along Bertie Street north of Fennell Street. The pipe along Ingles Street crosses under the West Gate Freeway.

Utility Description	Location
Sewer	<ul style="list-style-type: none"> 300mm sewer main along Ingles Street south of the intersection with Anderson Street. Local sewer pipes along Bridge Street, Bertie Street, Fennell Street and Ingles Street. Local sewer pipes cross the West Gate Freeway at Bertie Street and Ingles Street.
Electricity	<ul style="list-style-type: none"> SPI Powernet overhead fibre optic cable along Fennell Street. CitiPower underground and overhead assets along Fennell Street, Bertie Street and Ingles Street and underground assets along Bridge Street. Underground assets cross the West Gate Freeway in the vicinity of the Ingles Street Bridge.
Gas	<ul style="list-style-type: none"> 150mm high pressure pipeline along Bertie Street and Fennell Street. 150mm medium pressure pipeline line along Ingles Street which crosses under the West Gate Freeway.
Telecommunications	<ul style="list-style-type: none"> Telstra assets along Ingles Street which pass under the West Gate Freeway also along Bridge Street, Bertie Street and Fennell Street. Optus underground assets along Ingles Street which pass under the West Gate Freeway and along Bridge Street, Bertie Street and Fennell Street. Optus aerial assets along Bertie Street, Fennell Street and Ingles Street. Uecomm underground assets along Ingles Street which pass under the West Gate Freeway and along Bertie Street and Fennell Street.

3.3 Site visit

A site visit was undertaken on the 4 March 2013 to gain an understanding of the study area's existing issues and possible constraints that may limit route options. The figures and table below summarise the findings.

The assessment of the contaminated land is based on information contained within the report "Fishermans Bend Precinct – Preliminary Land Contamination Study" undertaken by Golders Associates for Places Victoria, June 2012.

The flooding assessment is based on the existing Special Building Overlay (SBO) which applies to land affected by flooding from the storm water system. The purpose of the SBO is to set appropriate conditions and building floor levels to address the flood risk and to ensure that flood waters are not obstructed or diverted by development. The existing SBO for the area has been sourced from City of Port Phillip online planning maps.

The utility services assessment is based on information contained in chapter 3.2. It is noted that there may be an 'interim' period during the redevelopment of Fishermans Bend where businesses may still be operating during construction and will require reticulation services to be maintained. Design and construction of the arterial connection road may need to consider the existing utility services during this possible 'interim' period.



Figure 3.3 Site issues and constraints – Section 1 and 2

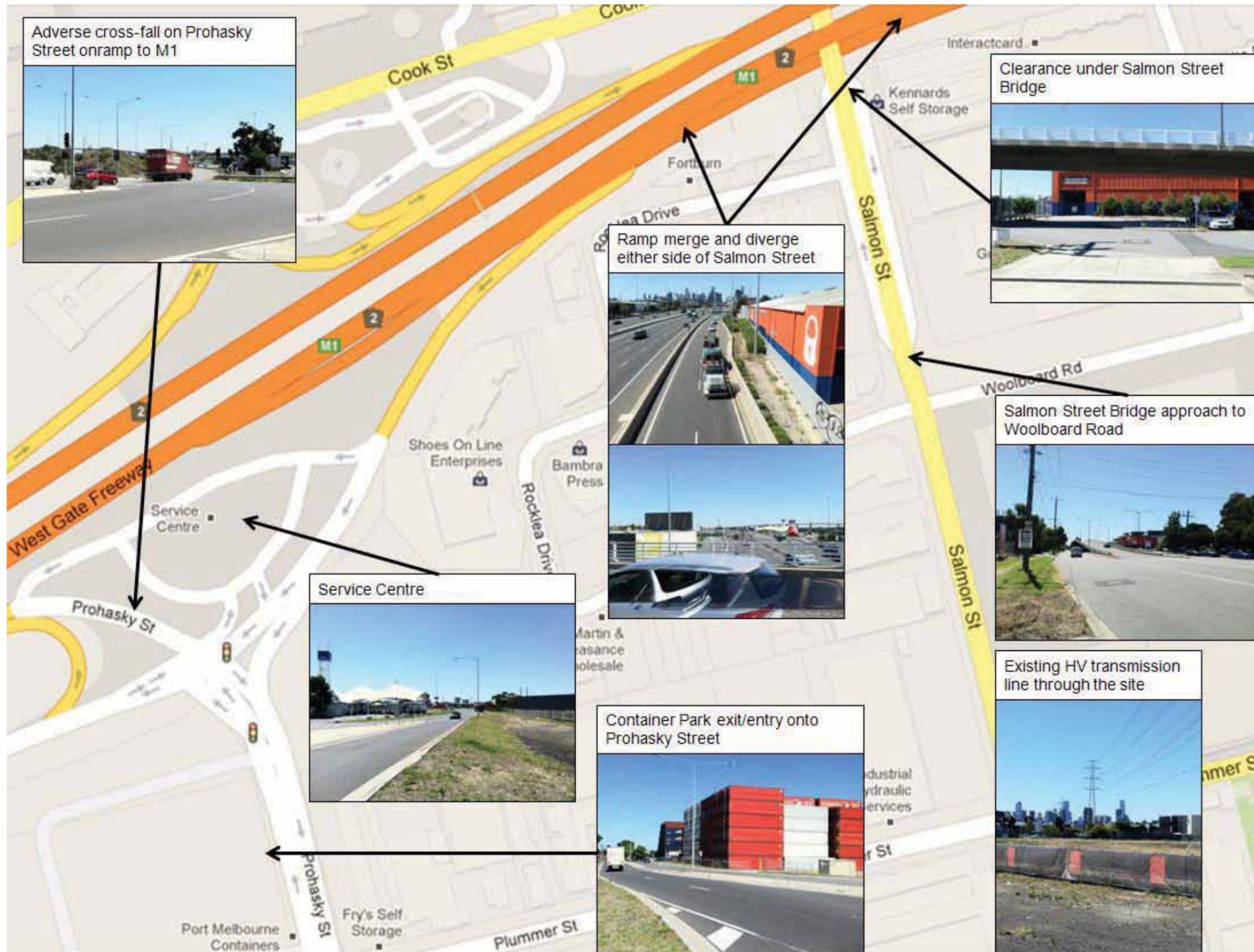


Figure 3.4 Site issues and constraints – Section 3 and 4



Figure 3.5 Site issues and constraints – Section 5

Table 3.2 Summary of existing site constraints and issues

Location	Summary of Site Constraints/Issues
Section 1	
Graham Street southern approach to Plummer Street	<ul style="list-style-type: none"> Approximately 240m to intersection with Williamstown Road may pose an issue with potential grade separation of the Graham Street/Plummer Street intersection. Site accesses along eastern side of Graham Street will need to maintain access via a service road in options that include grade separation of the Graham Street/Plummer Street intersection.
Plummer Street eastern approach to Graham Street	<ul style="list-style-type: none"> Approximate 20m road reserve width would most likely need to be widened to provide for a future tram line.
Plummer Street western approach to Graham Street	<ul style="list-style-type: none"> Approximate 20m road reserve width would most likely need to be widened to provide for a future tram line. Council depot on the south west corner of the Graham Street/Plummer Street intersection with access from Plummer Street. An increase in width of the road reserve south of Plummer Street may impact of the depot.
Utility Services	<ul style="list-style-type: none"> Utility services along Graham Street would be impacted in options that include grade separation of the Graham Street/Plummer Street intersection. Widening Plummer Street to provide for a tram route would impact utility services. Major utility services that may be impacted include: <ul style="list-style-type: none"> 300mm sewer along Plummer Street east of the intersection with Graham Street. SPI Powernet overhead fibre optic cable along Plummer Street.
Contaminated Land	<ul style="list-style-type: none"> 1 to 2 metres depth of fill along Graham Street and Plummer Street. Medium risk land contamination for properties fronting the eastern side of Graham Street to the north and south of Plummer Street. Council depot is classified as medium risk on the south western side of the Graham Street/Plummer Street intersection. Other areas fronting the western side of Graham Street are classified low risk of land contamination. Area classified as former quarry/landfill extends from the northern end of Graham Street down the eastern side of the road reserve approximately half the distance to Plummer Street. There may be potential remediation of soil and groundwater associated with excavation with medium risk areas. Options that include grade separation of the Graham Street/Plummer Street intersection may encounter contaminated land requiring remediation.
Section 2	
Graham Street north of Plummer Street	<ul style="list-style-type: none"> Site accesses along the eastern and western sides of Graham Street will need to be maintained via a service road in options that include grade separation of the Graham Street/Plummer Street intersection.
Utility Services	<ul style="list-style-type: none"> Utility services along Graham Street would be impacted in options that include tunnelling under the City Link ramps. No major utility services have been identified in the area.

Location	Summary of Site Constraints/Issues
Contaminated Land	<ul style="list-style-type: none"> 1 to 2 metres depth of fill along Graham Street. The two most northern properties fronting the western side of Graham Street south of the City Link ramps are classified medium risk of land contamination. Area classified as historic quarry/landfill extends from the northern end of Graham Street down the eastern side of the road reserve approximately half the distance to Plummer Street. There may be potential remediation of soil and groundwater associated with excavation with medium risk areas. Options that include tunnelling under the City Link ramps may encounter contaminated land requiring remediation.
Section 3	
Clearance under Salmon Street Bridge	<ul style="list-style-type: none"> Existing clearance under Salmon Street Bridge is approximately 4.3m at the lowest point. The option for passing under Salmon Street Bridge will require additional excavation to meet minimum clearance height to the underside of the bridge (5.4m for main and arterial roads, 5.9m for high clearance routes, Table 8.1 Austroads Guide to Road Design Part 3). Clearance between the piers under Salmon Street Bridge is approximately 26.8m. This should be adequate width for the bypass to pass through for the option to pass under Salmon Street Bridge.
Salmon Street Bridge approach to Woolboard Road	<ul style="list-style-type: none"> Existing downgrade of the bridge is approximately 6%. Options that include an intersection with Salmon Street may be impacted by the bridge approach with the location of the intersection determined by geometric design criteria such as truck stopping distance rather than the location of the existing intersection with Woolboard Road.
Ramp merge and diverge either side of Salmon Street	<ul style="list-style-type: none"> The location of the merge and diverge of the City Link westbound entry ramp to the West Gate Freeway and the Todd Road exit ramp respectively restricts the use of the service road for options passing under Salmon Street without realignment works.
Utility Services	<ul style="list-style-type: none"> Existing HV transmission line through the site may affect the alignment of options. For example the transmission tower closest to the West Gate Freeway between the City Link entry ramp and exit ramp may impact the alignment of the option to tunnel under the City Link ramps. It is expected that local distribution services along Rocklea Drive, Woolboard Road and Thackray Road would be made redundant with the redevelopment of the area and as such impacts of options that conflict with these services has been ignored. Major utility services along Salmon Street that may be impacted include: <ul style="list-style-type: none"> 300mm distribution water main south of Rocklea Drive. 450mm sewer main which crosses under the West Gate Freeway. SPI Powernet overhead fibre optic cable north of Plummer Street which continues underground from the intersection with Rocklea Drive across the West Gate Freeway. Telstra, Optus and Uecomm underground services.
Contaminated Land	<ul style="list-style-type: none"> Predominantly this section of the study area is classified as former quarry/landfill. Properties to the north of Woolboard Road and fronting Thackray Road are classified as medium and high risk of land contamination. The Rocklea Drive subdivision is classified as high risk of land contamination. There may be potential remediation of soil and groundwater associated with excavation in medium risk areas and likely remediation in high risk areas. The option to pass under Salmon Street may encounter contaminated land requiring remediation. Contaminated land mounds within City Link on and exit ramps would be impacted with option to tunnel under the ramps.

Location	Summary of Site Constraints/Issues
Flooding	<ul style="list-style-type: none"> There is a SBO (Special Building Overlay) along Woolboard Road from and including the intersection with Salmon Street to the intersection with Thackray Road. Future investigation into local flooding levels will need to be undertaken during preliminary/detail design if the option that includes an at grade intersection with Salmon Street is chosen and the road level and pipe network designed to suit.
Section 4	
Adverse cross-fall on Prohasky Street entry ramp to M1	<ul style="list-style-type: none"> Adverse cross-fall on the Prohasky Street entry ramp to the West Gate Freeway may impact options for the configuration of the intersection with Prohasky Street, in particular the right turn movement from the bypass onto the entry ramp.
Service Centre	<ul style="list-style-type: none"> The service centre north of the Todd Road exit ramp limits options for the configuration of the intersection with Prohasky Street.
Container Park exit/entry onto Prohasky Street	<ul style="list-style-type: none"> Access for the container park fronting Prohasky Street will need to be maintained as well as current truck access to/from Todd Road and the West Gate Freeway. This may impact the intersection configuration and location of the container park road access location.
Utility Services	<ul style="list-style-type: none"> SPI Powernet 220kV transmission tower line. The alignment crosses Prohasky Street south of the intersection with the West Gate Freeway ramps. Tower to the west of Prohasky Street may impact design.
Contaminated Land	<ul style="list-style-type: none"> This section of the study area is classified as former quarry/landfill. The parcel of land on the south east corner of the Prohasky Street/West Gate Freeway ramps intersection is classified as high risk of land contamination. Alterations to this intersection to accommodate the bypass would not likely require significant excavation.
Section 5	
Clearance under Ingles Street Bridge	<ul style="list-style-type: none"> Existing clearance under Ingles Street Bridge is approximately 3.5m at the lowest point. The option for passing under Ingles Street Bridge will require additional excavation to meet minimum clearance height to the underside of the bridge (5.4m for main and arterial roads, 5.9m for high clearance routes, Table 8.1 Austroads Guide to Road Design Part 3). Clearance between the piers under Ingles Street Bridge is approximately 56.6m. This should be adequate width for the bypass to pass through for the option to pass under Ingles Street Bridge.
Ingles Street Bridge approach to Fennell Street	<ul style="list-style-type: none"> Existing downgrade of the bridge is approximately 6%. The location of the intersection with Ingles Street may be impacted by the bridge approach and be determined by geometric design criteria such as truck stopping distance rather than where the existing intersection with Fennell Street is.
Utility Services	<ul style="list-style-type: none"> It is expected that local distribution services along Bridge Street, Bertie Street and Fennell Street would be made redundant with the redevelopment of the area and as such impacts of options that conflict with these services has been ignored. Major utility services along or near to Ingles Street that may be impacted include: <ul style="list-style-type: none"> 1500mm diameter Melbourne Water drain extending along Anderson Street from the intersection with Ingles Street. 300mm sewer main south of the intersection with Anderson Street. Telstra, Optus and Uecomm underground and aerial services.

Location	Summary of Site Constraints/Issues
Contaminated Land	<ul style="list-style-type: none"> Less than 1 metre of fill in the area between Bertie Street and Ingles Street and 1 to 2 metres of fill in the area between Bridge Street and Bertie Street and the area east of Ingles Street. Area classified as historic quarry/landfill extends from the northern end of Graham Street down the eastern side of the road reserve approximately half the distance to Plummer Street and across to Bridge Street. Generally properties to the north of Plummer Street and Fennell Street are classified as medium risk of land contamination except for the properties to the north of Fennell Street between Bridge Street and Bertie Street and between Bertie Street and Ingles Street. There may be potential remediation of soil and groundwater associated with excavation in medium risk areas and likely remediation in high risk areas. The option to pass under Ingles Street may encounter contaminated land requiring remediation.
Flooding	<ul style="list-style-type: none"> SBO (Special Building Overlay) along Fennell Street between Bertie Street and Ingles Street, along Ingles Street between the West Gate Freeway and Fennell Street and the area bound by Ingles Street/Anderson Street/West Gate Freeway. Future investigation into local flooding levels will need to be undertaken during preliminary/detail design for the at grade intersection with Ingles Street and if the option to pass under Ingles Street is chosen, with the road level and pipe network designed to suit.

4. Treatment options

Refer to Appendix A for a layout plan of the section options and refer chapter 5 for identified issues with each option.

4.1 Study assumptions

The key study assumptions that have been made in developing the design options are:

- Existing building development, road layout and utility services in the area does not limit route options.
- Salmon Street and Ingles Street bridges will remain in their current location.
- Roads are designed to relevant VicRoads and Austroads design standards.
- Intersection design is based on engineering judgement as traffic volumes have not been provided for the study.

4.2 Section 1 – Graham Street/Plummer Street intersection

Four treatment options for the Graham Street/Plummer Street intersection have been developed to incorporate a tram service along Plummer Street. In all options it is assumed that Plummer Street would need to be widened to cater for a tram service running through the middle of the road. It is noted that options for this section would be developed based on a high level desktop assessment only and comments made on the feasibility of each without a multi criteria assessment being undertaken.

Table 4.1 Section 1 design options

Design option	Option description and key features
Option 1A	Maintain existing at grade intersection. Key features of this option are: <ul style="list-style-type: none"> Modify intersection layout to cater for change in through traffic from using Plummer Street to continuing north along Graham Street. Tram movements to be catered for in the traffic signal cycle timing.
Option 1B	Grade separated intersection with Graham Street going over Plummer Street. Key features of this option are: <ul style="list-style-type: none"> Bridge structure length of approximately 350m. Bridge maximum grade of 5.5%. Approximate bridge top of deck height of 8.0m. Bridge start/finish approximately 65m north of Graham Street/Williamstown Road intersection Service roads may be required for developments fronting Graham Street.

Design option	Option description and key features
Option 1C	Grade separated intersection with Graham Street going under Plummer Street. Key features of this option are: <ul style="list-style-type: none"> Underpass structure length of approximately 430m. Underpass maximum grade of 5.5%. Approximate maximum depth of underpass of 7.9m. Underpass start/finish approximately 35m north of Graham Street/Williamstown Road intersection Service roads may be required for developments fronting Graham Street.
Option 1D	Grade separate tram lines only under Graham Street and maintain at grade intersection of Graham Street with Plummer Street. Key features of this option are: <ul style="list-style-type: none"> Underpass structure length of approximately 500m. Underpass maximum grade of 6.0%. Approximate maximum depth of underpass of 7.6m. Modify intersection layout to cater for tram underpass and change in through traffic from using Plummer Street to continuing north along Graham Street.

4.3 Section 2 – Graham Street north of Plummer Street

Three treatment options for Graham Street north of Plummer Street have been developed. The three options that have been developed are specific to options within Section 3 and 5.

Table 4.2 Section 2 design options

Design option	Option description and key features
Option 2A	Graham Street continues north of Plummer Street at grade to a T-intersection with the bypass (options 3A, 3B and 3D) and arterial connection to Ingles Street (options 5A, 5B, 5C and 5D) near the existing cul-de-sac at the end of Graham Street. Key features of this option are: <ul style="list-style-type: none"> Intersection located approximately 225m north of Graham Street/Plummer Street intersection. Location of the intersection may preclude possible future ramp connections to city Link.
Option 2B	Graham Street continues north of Plummer Street at grade to a T-intersection with the bypass (options 3C) and arterial connection to Ingles Street (options 5A, 5B, 5C and 5D) south of the existing cul-de-sac at the end of Graham Street. For the purposes of this report submission the alignments for Section 5 options A to D have not been modified on the plan in Appendix A to show a connection to this possible intersection location. Key features of this option are: <ul style="list-style-type: none"> Intersection located approximately 150m north of Graham Street/Plummer Street intersection.
Option 2C	Graham Street continues north of Plummer Street at grade to a T-intersection with the arterial road (options 3D and 5E) north of the existing cul-de-sac at the end of Graham Street. Key features of this option are: <ul style="list-style-type: none"> Intersection located approximately 300m north of Graham Street/Plummer Street intersection.

4.4 Section 3 – Graham Street to Prohasky Street (Bypass route)

Four alignment options for the arterial bypass between Graham Street and Prohasky Street have been developed.

Table 4.3 Section 3 design options

Design option	Option description and key features
Option 3A	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continuing west just south of the existing Woolboard Road alignment and connecting into Prohasky Street just south of the existing intersection. Key features of this option are: <ul style="list-style-type: none"> ▪ A signalised intersection with Salmon Street.
Option 3B	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west north of the existing Woolboard Road alignment and is grade separated over Salmon Street then connecting into Prohasky Street just south of the existing intersection. The alignment is pushed as close as possible to the beginning of the Salmon Street/West Gate Freeway overpass to maximise developable land south of the alignment. This option may be modified to follow the option 3A alignment to maintain the existing grid layout. Key features of this option are: <ul style="list-style-type: none"> ▪ Bridge structure length of approximately 470m. ▪ Bridge maximum grade of 5.5%. ▪ Approximate bridge top of deck height of 7.9m.
Option 3C	The road continues north along Graham Street into a tunnel that goes under the existing City Link ramps and continues until just east of Salmon Street next to the West Gate Freeway. It then continues next to the freeway going under Salmon Street then following the Todd Road exit ramp connecting into Prohasky Street just south of the existing intersection. Key features of this option are: <ul style="list-style-type: none"> ▪ Tunnel length of approximately 620m under the City Link ramps ▪ Tunnel maximum grade of 5.5% ▪ Approximate 210m length of road lowering under Salmon Street with an approximately maximum 2m depth to top of pavement.
Option 3D	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west next to the City Link exit ramp and continues next to the freeway going under Salmon Street then following the Todd Road exit ramp connecting into Prohasky Street just south of the existing intersection. Key features of this option are: <ul style="list-style-type: none"> ▪ Approximate 240m length of road lowering under Salmon Street with an approximately maximum 2m depth to top of pavement

4.5 Section 4 – Prohasky Street intersection

Two treatment options for the Prohasky Street intersection have been developed.

Table 4.4 Section 4 design options

Design option	Option description and key features
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Design option	Option description and key features
Option 4A	Signalised intersection. Key features of this option are: <ul style="list-style-type: none"> ▪ Intersection location is moved south of the existing intersection to cater for the bypass connection. ▪ Realignment of Todd Road entry ramp approach to the intersection. ▪ Access to the service centre is currently not provided from the bypass.
Option 4B	Roundabout. Key features of this option are: <ul style="list-style-type: none"> ▪ Roundabout internal diameter of 50m to cater for all approaches. ▪ Access to the service centre from the roundabout.

4.6 Section 5 – Graham Street to Ingles Street (arterial connection)

Five alignment options for the arterial connection between Graham Street and Ingles Street have been developed.

Table 4.5 Section 5 design options

Design option	Option description and key features
Option 5A	At grade road from Graham Street at 90 degrees continuing east to Ingles Street connecting at the existing Ingles Street/Fennell Street intersection. There is a slight curve in the road on the approach to Ingles Street to remove any skew from the approach to the intersection with Ingles Street. Key features of this option are: <ul style="list-style-type: none"> ▪ Continues proposed grid system in the Wirraway Precinct through to Ingles Street. ▪ Arterial connection with potential for intersections with side roads.
Option 5B	At grade road from Graham Street skewing to the north as far as possible and connecting at the existing Ingles Street/Fennell Street intersection. There is a slight curve in the road on the approach to Ingles Street to remove any skew from the approach to the intersection with Ingles Street. Key features of this option are: <ul style="list-style-type: none"> ▪ To maximise developable land south of the alignment while maintaining connection into existing Fennell Street intersection. ▪ Does not follow existing grid system in the Wirraway or Sandridge precincts. ▪ Arterial connection with potential for intersections with side roads.
Option 5C	At grade road from Graham Street skewing to the north and continuing next to the West Gate Freeway passing under the Ingles Street West Gate Freeway overpass and connecting into Ingles Street via the existing services roads under Ingles Street. Key features of this option are: <ul style="list-style-type: none"> ▪ To maximise developable land south of the alignment. ▪ Approximate 340m length of road lowering under Ingles Street with an approximately maximum 2m depth to top of pavement. ▪ Alignment would perform as a bypass route rather than an arterial road.

Design option	Option description and key features
Option 5D	<p>At grade road from Graham Street skewing to the south to Bridge Street and following the existing Fennell Street alignment to the Intersection with Ingles Street.</p> <p>Key features of this option are:</p> <ul style="list-style-type: none"> Continues proposed grid system in the Wirraway Precinct through to Bridge Street then shifts to the existing grid system east of Bertie Street. Arterial connection with potential for intersections with side roads.
Option 5E	<p>At grade road connecting from Option 3D following the alignment of the City Link exit ramp to the north of Graham Street and continuing next to the West Gate Freeway then skewing to the south to the east of Bertie Street on a similar alignment and connecting into Ingles Street at the existing intersection with Fennell Street.</p> <p>Key features of this option are:</p> <ul style="list-style-type: none"> Continues the idea of the bypass alignment in option 3D east of Graham Street i.e. following as closely as possible to the West Gate Freeway. To maximise developable land south of the alignment. Alignment would perform as a bypass route rather than an arterial road.

5. Options assessment

An assessment of the positives and negatives of the route and treatment options for each section of the study area was undertaken using the criteria in chapter 2. The purpose of this assessment is to identify the key opportunities, issues and constraints associated with the options. The desired outcome of this study is to define one route option based on using the most feasible option from each section within the study area.

A summary of the positives and negatives of each of the options is contained in the tables below.

5.1 Section 1

Table 5.1 Section 1 option assessment

		Design Option 1A	Design Option 1B	Design Option 1C	Design Option 1D
Criteria		At grade intersection with tram movements catered for in the signal timing.	Grade separated intersection with Graham Street going over Plummer Street.	Grade separated intersection with Graham Street going under Plummer Street.	Grade separate tram lines only under Graham Street and maintain at grade intersection of Graham Street with Plummer Street.
POSITIVES	Functionality	Maintains accessibility for properties fronting Graham Street. Has the potential for cyclist and pedestrian facilities.	Improves road safety by removing signalised intersection.	Improves road safety by removing signalised intersection.	Maintains accessibility for properties fronting Graham Street and Plummer Street. Has the potential for cyclist and pedestrian facilities.
	Traffic operation		Provides free flow conditions for Graham Street and Plummer Street. Provides priority for tram movements.	Provides free flow conditions for Graham Street and Plummer Street. Provides priority for tram movements.	Removes tram from intersection operation.
	Impact to developable land	Option should have least impact on developable land.			
	Constructability	No significant excavation or impacts to existing structures would be required.			
	Design and construction cost	Lowest relative construction cost. Option least likely to affect existing services.			
	Construction risk	Lowest relative construction risk as no structures are proposed.			
	Environmental impacts		Reduced noise/air pollution compared to at grade intersection options.	Reduced noise/air pollution compared to at grade intersection options.	
	Future operation and maintenance	Relatively low future operation and maintenance costs.			
NEGATIVES	Functionality		Unfriendly for cyclists and pedestrians.	Unfriendly for cyclists and pedestrians.	
	Traffic operation	Increased delays for north/south vehicles due to signal priority phasing for trams.			

	Design Option 1A	Design Option 1B	Design Option 1C	Design Option 1D
Criteria	At grade intersection with tram movements catered for in the signal timing.	Grade separated intersection with Graham Street going over Plummer Street.	Grade separated intersection with Graham Street going under Plummer Street.	Grade separate tram lines only under Graham Street and maintain at grade intersection of Graham Street with Plummer Street.
Impact to developable land	Plummer Street road reserve width would need to be increased to accommodate tram service.	Plummer Street road reserve width would need to be increased to accommodate tram service. Option would require service lanes for access either side of Graham Street unless access was gained from Williamstown Road or Plummer Street	Plummer Street road reserve width would need to be increased to accommodate tram service. Option would require service lanes for access either side of Graham Street unless access was gained from Williamstown Road or Plummer Street	Plummer Street road reserve width would need to be increased to accommodate tram service. May require localised widening of intersection to facilitate tram underpass.
Constructability		May be impacts to Graham Street traffic during bridge construction.	May be impacts to Graham Street traffic during underpass construction. Groundwater impacts on tunnel/underpass structures.	May be impacts to Graham Street/Plummer street traffic during underpass construction. Groundwater impacts on tunnel/underpass structures.
Design and construction cost		Relatively high construction cost with bridge structure.	Relatively high construction cost with underpass structure.	Relatively high construction cost with underpass structure.
Construction risk		Relatively high risk of encountering geological issues with bridge foundations.	Relatively high risk of encountering geological issues with depth of underpass construction. May need to be constructed under traffic.	Relatively high risk of encountering geological issues with depth of underpass construction. May need to be constructed under traffic.
Environmental impacts	Increased noise/air pollution with high volume of trucks travelling through the precinct as well as requiring to brake/accelerate from the intersection.	Visual impacts with highly trafficked road through the precinct. Possibly an unsightly structure for medium/high density living.	Possible contaminated land and groundwater would be encountered with excavation under Plummer Street which would require treatment.	Increased noise/air pollution with high volume of trucks travelling through the precinct as well as requiring to brake/accelerate from the intersection. Possible contaminated land and groundwater would be encountered with excavation under Graham Street which would require treatment.
Future operation and maintenance	Cost with future maintenance of traffic signals.	Future maintenance and operational cost associated with bridge.	Future maintenance and operational cost associated with underpass.	Cost with future maintenance of traffic signals. Future maintenance and operational cost associated with underpass.

5.2 Section 2

Table 5.2 Section 2 option assessment

	Design Option 2A	Design Option 2B	Design Option 2C	
Criteria	Graham Street continues north of Plummer Street at grade to the T-intersection with the bypass and arterial connection to Ingles Street near to the City Link ramps.	Graham Street continues north of Plummer Street at grade to an intersection approximately 100m south of the location proposed in Option 2A. This would be required to facilitate Option 3C and possible future connection from the City Link off ramp.	Graham Street continues north of Plummer Street at grade to a T-intersection with the arterial road (options 3D and 5E) north of the existing cul-de-sac at the end of Graham Street.	
POSITIVES	Functionality			
	Traffic operation	Provides approximately 250m distance to Graham Street/Plummer Street intersection.	Provides approximately 275m distance to Graham Street/Plummer Street intersection.	
	Impact to developable land	Option maximises developable land by placing intersection with bypass as far north as possible.		Option maximises developable land by placing a majority of the intersection with the bypass within current City Link land.
	Constructability	No significant excavation or impacts to existing structures would be required.	No significant excavation or impacts to existing structures would be required.	No significant excavation or impacts to existing structures would be required.
	Design and construction cost	Similar for all options		
	Construction risk	Similar for all options		
	Environmental impacts	Similar for all options		
	Future operation and maintenance	Similar for all options		
	NEGATIVES	Functionality		
Traffic operation			Provides approximately 150m distance to Graham Street/Plummer Street intersection which is not desirable in terms of signalised intersection spacing.	
Impact to developable land			Impacts developable land to the south of the City Link ramps.	
Constructability				
Design and construction cost		Similar for all options		
Construction risk		Similar for all options		
Environmental impacts		Similar for all options		
Future operation and maintenance		Similar for all options		

5.3 Section 3

Table 5.3 Section 3 option assessment

		Design Option 3A	Design Option 3B	Design Option 3C	Design Option 3D
Criteria		At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continuing west just south of the existing Woolboard Road alignment and connecting into Prohasky Street just south of the existing intersection. This option includes a signalised intersection with Salmon Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west north of the existing Woolboard Road alignment and is grade separated over Salmon Street and connecting into Prohasky Street just south of the existing intersection. The alignment is pushed as close as possible to the Salmon Street West Gate Freeway overpass.	The road continues north along Graham Street into a tunnel that goes under the existing City Link ramps and continues until just east of Salmon Street next to the freeway. It then continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection. This option requires the bypass to begin grading downwards approximately 150m north of Plummer Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west next to the City Link exit ramp and continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection.
POSITIVES	Functionality	Provides accessibility to the development and can be adapted to future requirements easily e.g. bus route or increased capacity. Has the potential for cyclist and pedestrian facilities.	Provides a direct route for the bypass. Improved road safety compared to Option 3A as signalised intersection is removed.	Provides a bypass outside/on the edge of the development.	Provides a bypass on the edge of the development. Improved road safety compared to Option 3A, 3B and 3C as there is no signalised intersections, bridge or tunnel structures.
	Traffic operation		Maintains efficient traffic flow.	Maintains efficient traffic flow.	Maintains efficient traffic flow.
	Impact to developable land			This option maximises the developable land for the precinct and does not bifurcate the precinct.	This option maximises the developable land for the precinct and does not bifurcate the precinct.
	Constructability	No significant excavation or impacts to existing structures would be required. Option allows for future staged construction if appropriate.	No significant excavation or impacts to existing structures would be required.		
	Design and construction cost	Lowest relative construction cost. Option least like to affect existing services.	Less likely to be impacted by local flooding. Less likely to impact underground services along Salmon Street.		Relatively low construction cost with no structures. Not likely to be impacted by local flooding.
	Construction risk	Relatively low construction risk as no structures.			Relatively low construction risk as no structures.
	Environmental impacts	Less likely to encounter contaminated land.	Less likely to encounter contaminated land.	Reduced noise/air pollution compared to options 3A and 3B. Visual impact would be minimal.	Reduced noise/air pollution compared to options 3A and 3B. Visual impact would be minimal.
	Future operation and maintenance	Relatively low future operation and maintenance costs.			Relatively low future operation and maintenance costs.

		Design Option 3A	Design Option 3B	Design Option 3C	Design Option 3D
Criteria		At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continuing west just south of the existing Woolboard Road alignment and connecting into Prohasky Street just south of the existing intersection. This option includes a signalised intersection with Salmon Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west north of the existing Woolboard Road alignment and is grade separated over Salmon Street and connecting into Prohasky Street just south of the existing intersection. The alignment is pushed as close as possible to the Salmon Street West Gate Freeway overpass.	The road continues north along Graham Street into a tunnel that goes under the existing City Link ramps and continues until just east of Salmon Street next to the freeway. It then continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection. This option requires the bypass to begin grading downwards approximately 150m north of Plummer Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west next to the City Link exit ramp and continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection.
NEGATIVES	Functionality	Does not provide a true bypass outside of the development and rather provides an arterial connection instead. Signalised intersection with Salmon Street decreases road safety compared to other options.	Provides limited accessibility opportunities to the development. Does not provide a true bypass outside of the development. Would be difficult to adapt the road to future changes in use. Bridge structure would limit the ability to implement an effective cycle/pedestrian facility.	Provides limited accessibility opportunities to the development. Would be difficult to adapt the road to future changes in use. Tunnel structure would limit the ability to implement an effective cycle/pedestrian facility. Potentially reduced road safety within tunnel.	Provides limited accessibility opportunities to the development. Would be difficult to adapt the road to future changes in use. Lowered road under Salmon Street would limit the ability to implement an effective cycle/pedestrian facility.
	Traffic operation	Impacts traffic flow with signalised intersection with Salmon Street.	Grades of bridge may impact truck speeds.	Minimal distance between where the tunnel would daylight on Graham Street to the existing Plummer Street intersection to locate a new intersection for the arterial connection to Ingles Street.	
	Impact to developable land	Impacts developable land by bifurcating the precinct. Option may require service lanes for side street connection to improve traffic flow increasing width of the required road reserve.	Impacts developable land by bifurcating the precinct.		
	Constructability	May be impacts to Salmon Street traffic during construction of signalised intersection.	May be impacts to Salmon Street traffic during construction of the overpass.	Difficulty with constructing a tunnel under the City Link ramps which would more than likely require no traffic closures. Difficulty with constructing bypass under existing Salmon Street West Gate Freeway overpass. Groundwater impacts on tunnel/underpass structures.	Difficulty with constructing bypass under existing Salmon Street West Gate Freeway overpass.
	Design and construction cost	Cost with installing traffic signals. May need to raise road level near Woolboard Road as alignment traverses the Special Building flood overlay.	Relatively high construction cost associated with Salmon Street overpass.	Highest relative construction cost. May impact services under Salmon Street.	May impact services under Salmon Street.

	Design Option 3A	Design Option 3B	Design Option 3C	Design Option 3D
Criteria	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continuing west just south of the existing Woolboard Road alignment and connecting into Prohasky Street just south of the existing intersection. This option includes a signalised intersection with Salmon Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west north of the existing Woolboard Road alignment and is grade separated over Salmon Street and connecting into Prohasky Street just south of the existing intersection. The alignment is pushed as close as possible to the Salmon Street West Gate Freeway overpass.	The road continues north along Graham Street into a tunnel that goes under the existing City Link ramps and continues until just east of Salmon Street next to the freeway. It then continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection. This option requires the bypass to begin grading downwards approximately 150m north of Plummer Street.	At grade road from Graham Street at 90 degrees passing as close as possible to the City Link ramps and continues west next to the City Link exit ramp and continues next to the freeway going under Salmon Street then following the Todd Road off ramp connecting into Prohasky Street just south of the existing intersection.
Construction risk		Uncertainty of bridge foundations on the former quarry/landfill area.	Relatively high risk with tunnel construction including construction under traffic. Risk with pavement design under Salmon Street overpass as uncertainty of subgrade material.	Risk with pavement design/depth under Salmon Street overpass as uncertainty of subgrade material.
Environmental impacts	Increased noise/air pollution with high volume of trucks travelling through the precinct as well as requiring to brake/accelerate from the intersection with Salmon Street. Visual impacts with highly trafficked road through the precinct.	Increased noise/air pollution with high volume of trucks travelling through the precinct as well as requiring to accelerate/brake on up/down grade of bridge. Visual impacts with highly trafficked road through the precinct. Possibly an unsightly structure for medium/high density living.	Contaminated soil from mounds in between the City Link ramps and groundwater from the tunnel construction would need to be treated. Possible contaminated land and groundwater would be encountered with excavation under Salmon Street which would require treatment. May impact water table with tunnel construction.	Possible contaminated land and groundwater would be encountered with excavation under Salmon Street which would require treatment.
Future operation and maintenance	Some cost with future maintenance of the traffic signals at Salmon Street.	Future maintenance and operational cost associated with bridge.	Future maintenance and operational cost associated with tunnel.	

5.4 Section 4

Table 5.4 Section 4 option assessment

	Design Option 4A	Design Option 4B
Criteria	Signalised intersection	Roundabout
POSITIVES	Functionality	Reduced number of vehicle conflict points.
	Traffic operation	During off peak periods intersection may have lower delays compared to Option 4A.
	Impact to developable land	
	Constructability	No significant excavation or impacts to existing structures would be required.
	Design and construction cost	May be able to re-use some of the existing intersection pavement.

	Design Option 4A	Design Option 4B
Criteria	Signalised intersection	Roundabout
NEGATIVES	Construction risk	Relatively low construction risk as no structures.
	Environmental impacts	
	Future operation and maintenance	Relatively low future operation and maintenance costs.
	Functionality	Unfriendly for cyclists and pedestrians.
	Traffic operation	Varying traffic flows on approaches to the roundabout may cause long delays to other approaches. Queuing from freeway ramp meters likely to back through intersection and interrupt flow frequently.
	Impact to developable land	Slightly larger intersection footprint.
	Constructability	
	Design and construction cost	Relatively high construction cost with signal infrastructure.
	Future operation and maintenance	Cost with future maintenance of the traffic signals.

5.5 Section 5

Table 5.5 Section 5 option assessment

	Option 5A	Option 5B	Option 5C	Option 5D	Option 5E	
Criteria	At grade road from Graham Street at 90 degrees continuing east to Ingles Street connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north as far as possible and connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north and continuing next to the West Gate Freeway passing under the Ingles Street West Gate Freeway overpass and connecting into Ingles Street via the existing services roads under Ingles Street.	At grade road from Graham Street skewing to the south to Bridge Street and following the existing Fennell Street alignment to the Intersection with Ingles Street.	At grade road connecting from Option 3D following the alignment of the City Link off ramp to the north of Graham Street and continuing next to the West Gate Freeway then skewing to the south to the east of Bertie Street on a similar alignment and connecting into Ingles Street at the existing intersection with Fennell Street.	
POSITIVES	Functionality	Provides accessibility to the development and can be adapted to future requirements easily e.g. bus route or increased capacity. Has the potential for cyclist and pedestrian facilities.	Provides accessibility to the development and can be adapted to future requirements easily e.g. bus route or increased capacity. Has the potential for cyclist and pedestrian facilities.	Provides a bypass route.	Provides accessibility to the development and can be adapted to future requirements easily e.g. bus route or increased capacity. Has the potential for cyclist and pedestrian facilities.	Provides a bypass route.
	Traffic operation			Maintains traffic flow.		Maintains traffic flow.
	Impact to developable land	Creates a large block of developable land north of the alignment.			Maintains existing road grid layout east of Bertie Street utilising existing Fennell Street road reserve.	
	Constructability	No significant excavation or impacts to existing structures would be required.	No significant excavation or impacts to existing structures would be required.		No significant excavation or impacts to existing structures would be required.	No significant excavation or impacts to existing structures would be required.
	Design and construction cost	Lowest relative construction cost as shortest most direct route.	Relatively low construction cost.		Relatively low construction cost.	Relatively low construction cost.
	Construction risk	Relatively low construction risk as no structures or significant excavation.	Relatively low construction risk as no structures or significant excavation.		Relatively low construction risk as no structures or significant excavation.	Relatively low construction risk as no structures or significant excavation.
	Environmental impacts			Reduced noise/air pollution compared to options 5A, 5B and 5D. Visual impact would be minimal.		Reduced noise/air pollution compared to options 5A, 5B and 5D. Visual impact would be minimal.
	Future operation and maintenance	Relatively low future operation and maintenance costs.	Relatively low future operation and maintenance costs.	Relatively low future operation and maintenance costs.	Relatively low future operation and maintenance costs.	Relatively low future operation and maintenance costs.

	Option 5A	Option 5B	Option 5C	Option 5D	Option 5E	
Criteria	At grade road from Graham Street at 90 degrees continuing east to Ingles Street connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north as far as possible and connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north and continuing next to the West Gate Freeway passing under the Ingles Street West Gate Freeway overpass and connecting into Ingles Street via the existing services roads under Ingles Street.	At grade road from Graham Street skewing to the south to Bridge Street and following the existing Fennell Street alignment to the Intersection with Ingles Street.	At grade road connecting from Option 3D following the alignment of the City Link off ramp to the north of Graham Street and continuing next to the West Gate Freeway then skewing to the south to the east of Bertie Street on a similar alignment and connecting into Ingles Street at the existing intersection with Fennell Street.	
NEGATIVES	Functionality		Does not perform as an arterial connection road. Would be difficult to adapt the road to future changes in use. Lowered road under Ingles Street would limit the ability to implement an effective cycle/pedestrian facility.		Does not perform as an arterial connection road.	
	Traffic operation	Delays associated with connecting side roads.	Delays associated with connecting side roads.	Inefficient intersection layout of bypass road with Ingles Street.	Delays associated with connecting side roads.	
	Impact to developable land	Maintains the road grid system that is west of Bridge Street through to Ingles Street. May require service roads for access to property fronting road.	Impacts the ability to make a road grid system. May require service roads for access to property fronting road. Creates an awkward shaped block of land to the east of the City Link ramps.	Creates an awkward shaped block of land to the east of the City Link ramps.	May require service roads for access to property fronting road.	Creates an awkward parcel of land between the route and Ingles Street.
	Constructability			Difficulty with constructing bypass under existing Ingles Street West Gate Freeway overpass.		
	Design and construction cost	May need to raise road level along Fennell Street at the intersection with Ingles Street as alignment traverses the Special Building flood overlay.	May need to raise road level along Fennell Street at the intersection with Ingles Street as alignment traverses the Special Building flood overlay.	Highest relative construction cost. May be issues with road drainage going under Ingles Street as this alignment traverses the Special Building flood overlay. May impact services under Ingles Street.	May need to raise road level along Fennell Street as alignment traverses the Special Building flood overlay.	May need to raise road level along Fennell Street as alignment traverses the Special Building flood overlay.
	Construction risk			Risk with pavement design/depth under Ingles Street overpass as uncertainty of subgrade material.		

		Option 5A	Option 5B	Option 5C	Option 5D	Option 5E
Criteria		At grade road from Graham Street at 90 degrees continuing east to Ingles Street connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north as far as possible and connecting at the existing Ingles Street/Fennell Street intersection.	At grade road from Graham Street skewing to the north and continuing next to the West Gate Freeway passing under the Ingles Street West Gate Freeway overpass and connecting into Ingles Street via the existing services roads under Ingles Street.	At grade road from Graham Street skewing to the south to Bridge Street and following the existing Fennell Street alignment to the Intersection with Ingles Street.	At grade road connecting from Option 3D following the alignment of the City Link off ramp to the north of Graham Street and continuing next to the West Gate Freeway then skewing to the south to the east of Bertie Street on a similar alignment and connecting into Ingles Street at the existing intersection with Fennell Street.
Environmental impacts		Increased noise/air pollution with high volume of vehicles travelling through the middle of the precinct.	Increased noise/air pollution with high volume of vehicles travelling through the middle of the precinct.	Possible contaminated land would be encountered with excavation under Ingles Street which would require treatment.	Increased noise/air pollution with high volume of vehicles travelling through the middle of the precinct.	
Future operation and maintenance						

6. Multi criteria assessment

A multi criteria assessment has been undertaken for each option within each section. The rating for each option has been based on the assessment summarised in chapter 5.

A rating system of 1 to 5 has been used for each criteria, where a score of 1 is a unfavourable outcome for the option and a score of 3 is neither unfavourable or favourable and a score of 5 is a favourable outcome.

Table 6.1 below outlines the scores of the multi criteria assessment. It is noted that Section 1 – Graham Street/Plummer Street intersection treatment has not been assessed.

Table 6.1 Multi criteria assessment results

		Section 2			Section 3				Section 4		Section 5				
Option		A	B	C	A	B	C	D	A	B	A	B	C	D	E
MULTI CRITERIA ASSESSMENT	Functionality	3	3	3	2	3	3	4	3	2	4	3	1	4	2
	Traffic operation	4	2	3	2	3	4	5	4	1	3	2	4	2	4
	Impact to developable land	3	2	4	1	2	5	4	3	2	4	1	4	3	4
	Constructability	3	3	3	5	2	1	3	2	3	4	4	2	4	3
	Design and construction cost	3	3	3	5	2	1	3	3	2	5	4	2	5	3
	Construction risk	3	3	3	5	3	1	3	5	5	5	5	3	5	4
	Environmental impacts	3	3	3	2	1	2	4	3	2	3	3	3	3	3
	Future operation and maintenance	3	3	3	4	2	1	5	2	4	4	4	3	4	4
TOTAL	25	22	25	26	18	18	31	25	21	32	26	22	30	27	

7. Conclusion

7.1 Key findings

- Options that involve deep excavation are likely to encounter contaminated land, acid sulphate soils and groundwater which would significantly impact the construction cost of these options.
- Section 2 intersection locations score relatively similar with option 2B scoring the worst due to its proximity to the existing Graham Street/Plummer Street intersection affecting potential traffic operations and the impact to developable land.
- Within section 3, option 3D scores the highest primarily due to the alignments functionality and traffic operation whilst also not rating poorly with the construction related criteria.
- The section 4 option 4A intersection treatment scores the highest primarily due to the traffic operation of this option being significantly better than option 4B.
- Within section 5, option 5A and 5D score the best primarily due to the functionality, impact to developable land and rating highly with the construction related criteria. Whilst both options are feasible option 5A would simplify the road grid system through to Ingles Street.

7.2 Recommendations

It is recommended that a combination of option 2A, 3D, 4A and 5A be chosen as the preferred arterial road route option and developed further during the feasibility design stage.



Appendix A

Section options plans



2175020A-CIV-0001



LEGEND	
—	DESIGN OPTION 3A
—	DESIGN OPTION 3B
—	DESIGN OPTION 3C
—	DESIGN OPTION 3D
—	DESIGN OPTION 5A
—	DESIGN OPTION 5B
—	DESIGN OPTION 5C
—	DESIGN OPTION 5D

GENERAL NOTES
1. OPTIONS DESIGNED FOR 60km/hr DESIGN SPEED



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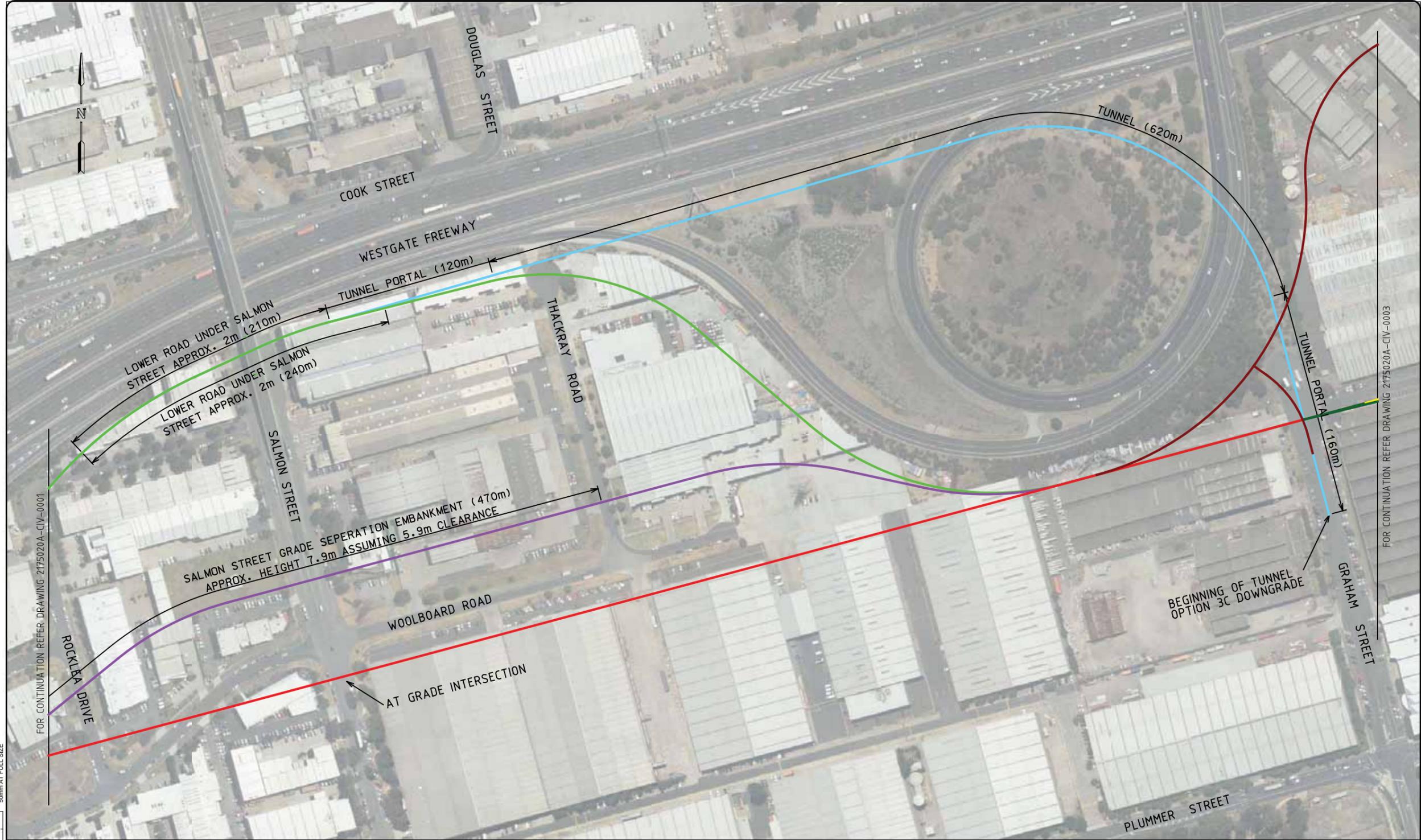
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LEGEND

DESIGN OPTION 3A	DESIGN OPTION 3B	DESIGN OPTION 3C	DESIGN OPTION 3D	DESIGN OPTION 3E	DESIGN OPTION 3A	DESIGN OPTION 3B	DESIGN OPTION 3C	DESIGN OPTION 3D	DESIGN OPTION 3E
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INTERSECTION AT GRADE

LEGEND	
DESIGN OPTION 3A	DESIGN OPTION 5A
DESIGN OPTION 3B	DESIGN OPTION 5B
DESIGN OPTION 3C	DESIGN OPTION 5C
DESIGN OPTION 3D	DESIGN OPTION 5D
DESIGN OPTION 3E	DESIGN OPTION 5E

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LEGEND	
Red line	DESIGN OPTION 3A
Blue line	DESIGN OPTION 3B
Yellow line	DESIGN OPTION 3C
Green line	DESIGN OPTION 3D
Dark Blue line	DESIGN OPTION 5A
Light Blue line	DESIGN OPTION 5B
Orange line	DESIGN OPTION 5C
Purple line	DESIGN OPTION 5D
Brown line	DESIGN OPTION 5E

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—	DESIGN OPTION 3C
—	DESIGN OPTION 3D
—	DESIGN OPTION 5A
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—	DESIGN OPTION 5C
—	DESIGN OPTION 5D

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