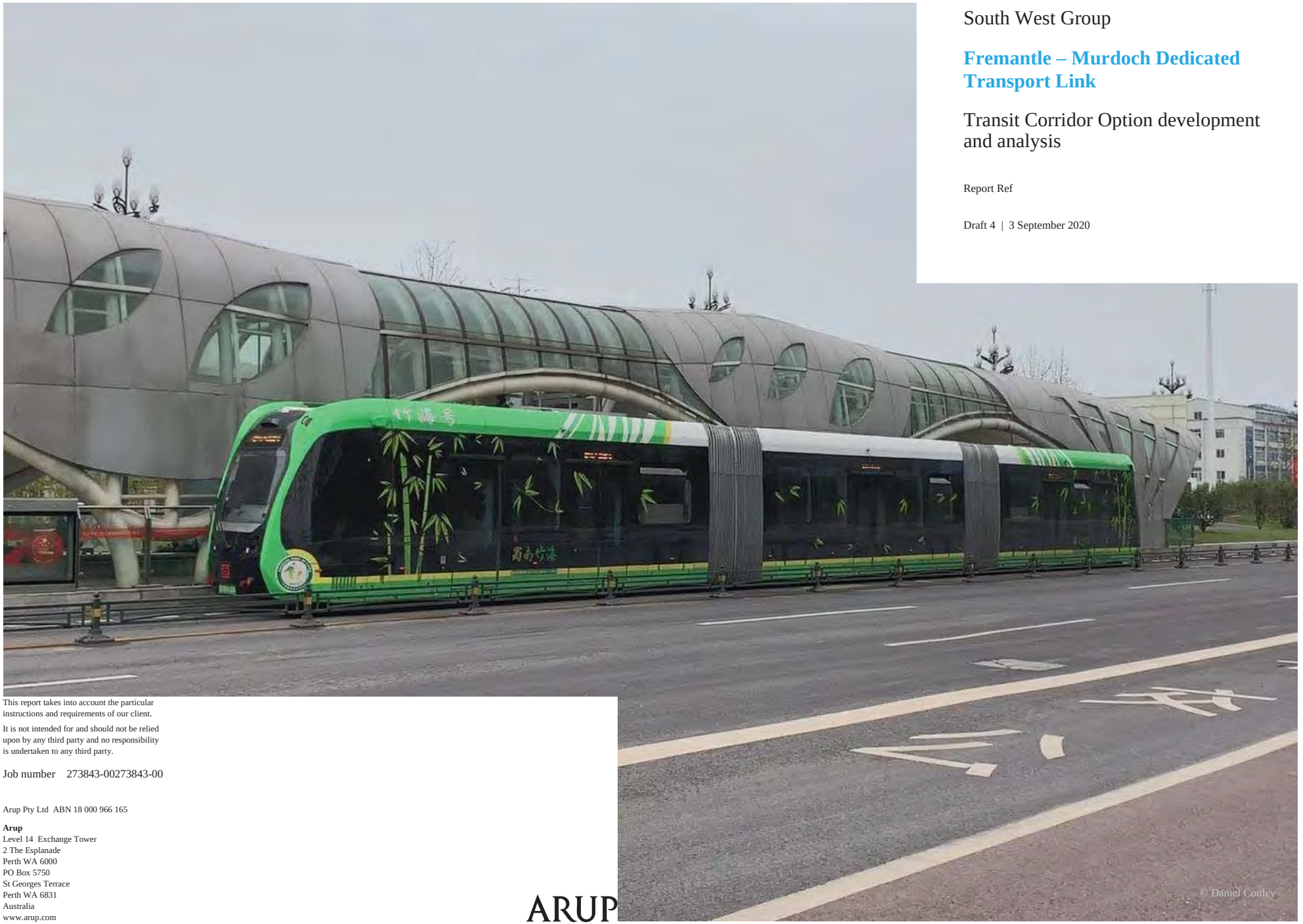
South West Group

Fremantle – Murdoch Dedicated Transport Link

Transit Corridor Option development and analysis

Report Ref

Draft 4 | 3 September 2020



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Contents

1 Introduction

1.1 Project overview

The South West Group (SWG), in collaboration with the City of Fremantle (CoF) and the City of Melville (CoM) is proposing a new infrastructure project that will create an opportunity to transform connectivity within the South West Metropolitan region of Perth. Through an expanded dedicated mass transit service between the Activity Centres of Fremantle and Murdoch, it will provide the opportunity for urban intensification while integrating with existing land uses and centres. A corridor of this description was identified in both the State's metropolitan growth strategy Perth and Peel @ 3.5 million (2018) and Transport for Perth and Peel @ 3.5 million (2018) as a 'proposed high-priority transit route', connecting Murdoch and Fremantle. It is the vision of the SWG, to advance the planning and Business Case development of the transit corridor and gain endorsement as part of the State Government's METRONET program, supporting the delivery of the State's growth frameworks.

SWG has engaged Arup to feed into a high-level advocacy document that will provide an indicative alignment, high level engineering feasibility and station design for the project as well as outline the recommended next steps to progress to a full Business Case and beyond. This work includes the identification and assessment of a range of potential alignments and transit stops for addressing the identified problems and meeting intended objectives. The deliberative process, which aligns with WA Government and Infrastructure Australia guidelines, progresses through a Long List evaluation to determine Short List options, using Multi-Criteria Analysis (MCA) and Rapid Cost Benefit Analysis (CBA) to inform development of a final Business Case. It should be noted that this piece of work *does not* constitute a full Business Case, it is a preliminary study that examines the opportunities, constraints at a feasibility level in order to provide context and advocate for the full Business Case development in line with Infrastructure Australia guidelines and requirements.

This report builds on extensive land use planning and project need analysis already undertaken by SWG that considered the broader transport needs within the South West Metropolitan Region (SWMR) shown in Figure 1. The study, compiled by SWG, was submitted to Infrastructure Australia on 30/08/2019 entitled South West Metropolitan Public Transport Network. A significant portion of the submission is the identification and recommendation of the Fremantle – Murdoch study area as a major connection to support substantial economic and population growth, particularly along the South Street corridor. The identified study area has been shown in Figure 2.

It should be noted that the project has been undertaken assuming that the future attitude towards public transport and subsequent demand for mass-transit infrastructure is unaffected by the 2020 outbreak of Covid-19. Given the case that this assumption is not realised in the post-pandemic transport environment and public transport is significantly impacted, it is expected that subsequent work will be re-thought in order to accommodate this change.

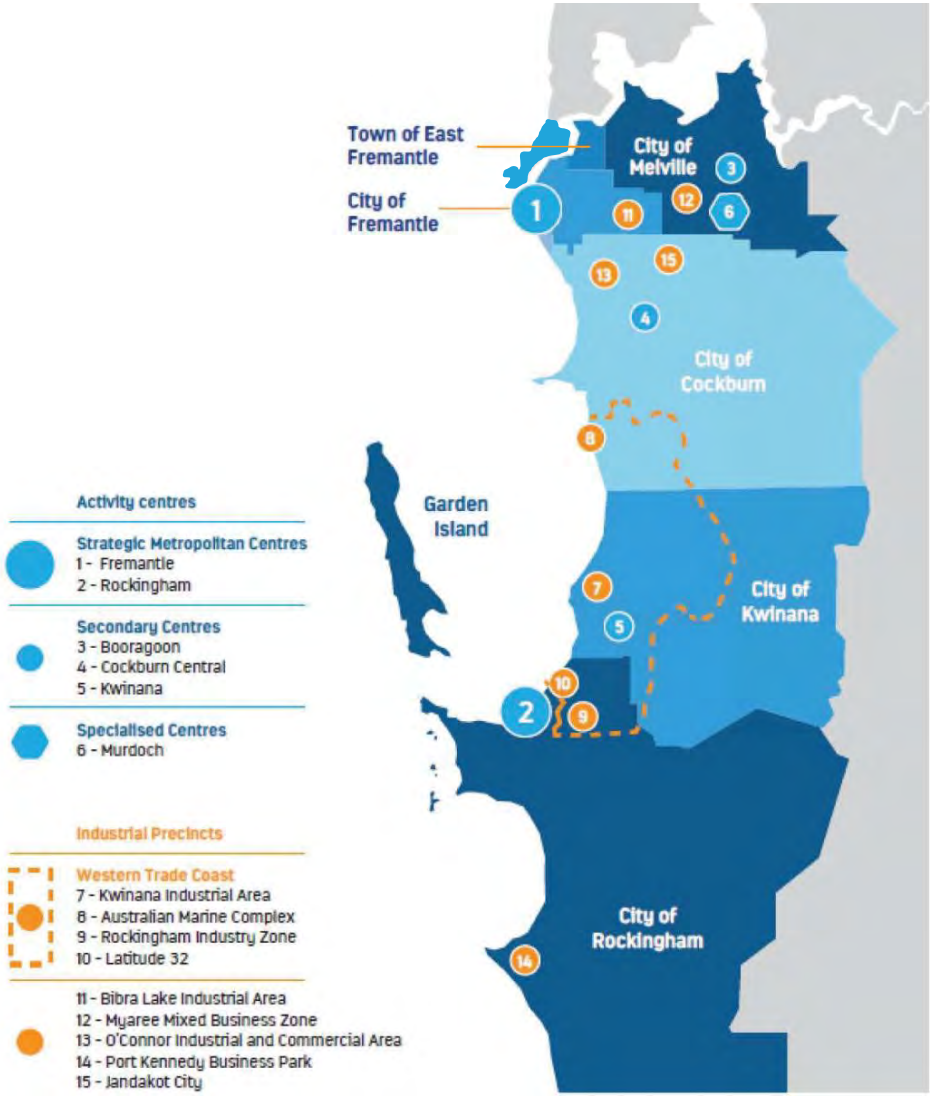


Figure 1 – The South West Metropolitan Region (SWMR) of local government areas (South West Metropolitan Public Transport Network, 2019)

Figure 2 – Fremantle – Murdoch study area

Serviced from the north by the Fremantle rail line, Fremantle station is currently Perth's busiest heritage line rail station with approximately 5,000 average weekday daily boardings (March 2019). Anchoring to the east, Murdoch Activity Centre is becoming a major specialised centre including Fiona Stanley Hospital and Murdoch University. Murdoch Station is the busiest rail station outside of the Perth CBD with over 9,500 average weekday daily boardings serviced by the Mandurah Line.

With the approximate combined growth of over 27,000 residents from 2020 to 2036, according to South West Group's Region Community Profile (2020), the introduction of a mass public transit corridor is important to achieving projected growth in a sustainable manner, capitalising on the land use opportunities and providing a key connector for the Fremantle and Murdoch Activity Centres to one another and the wider Perth area. In addition, the direct connection of strategic and specialised centres by appropriate modes is a catalyst for both encouraging metropolitan wide public transport use and facilitating development opportunities through the provision of high-quality public transit systems.

1.2 Abbreviations

A list of common abbreviations referenced throughout the report is tabulated below.

ASS	Acid Sulphate Soils	MLUFS	Metropolitan Land Use Forecasting System
ATOM	Australian Terminal Operations Management	MRWA	Main Roads WA
BP	Bus Priority	MU	Murdoch University
BRT	Bus Rapid Transit	SA2	Statistical Area 2
CoF	City of Fremantle	NBN	National Broadband Network
CoM	City of Melville	SWS	South Western Suburbs
DPLH	Department of Planning, Lands and Heritage	PDP	Project Definition Plan
DoT	Department of Transport	PTA	Public Transport Authority
IA	Infrastructure Australia	TOD	Transit Oriented Development
KnR	Kiss and Ride	VCR	Volume Capacity Ratio
LRT	Light Rail Transit	WAPC	Western Australian Planning Commission
MCA	Multi-Criteria Analysis		

1.3 Assumptions and disclaimers

The documentation, calculations and information contained in this report has been arrived at in consultation with relevant authorities and stakeholders. The information, conclusions and assumptions in the report are considered to be correct by the consultant team at the time the report was prepared. The preliminary concept designs are described as conceptual only and require significant further detailed analysis, including Safety in Design reviews, during the next stages of the project.

2 Acknowledgements

2.1 Summary of stakeholders

The overall team to deliver this project was proposed to operate as an integrated, tiered management team involving a core group of organisations, consultants and also wider stakeholders. This has provided a structure that allows the team to work closely with clear areas of focus and agree on key decisions quickly and responsibly over the option selection period.

The structure was built up by the following key groups:

1. Technical Reference Group (TRG)
2. Project Team (PT)
3. Transport consultant (TC)
4. Other stakeholders.

The roles and responsibilities of each of the groups is outlined in Figure 3 and in the following sections.

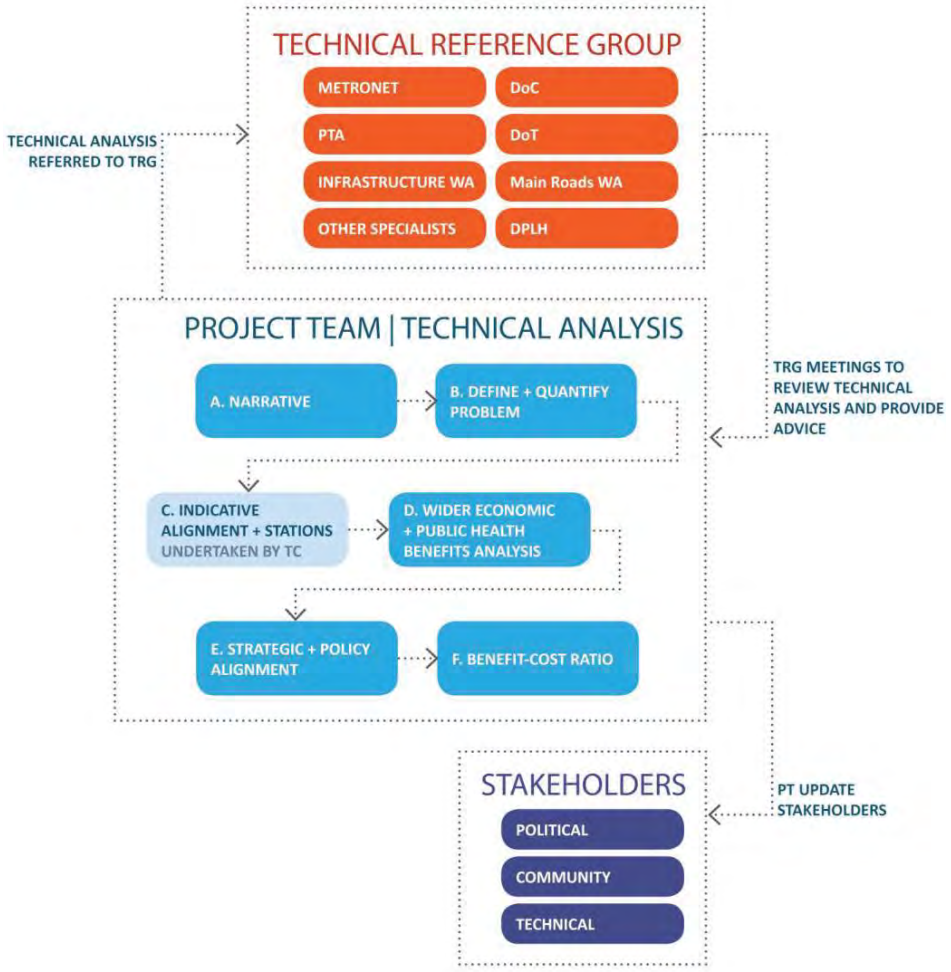


Figure 3 – Team structure

2.2 Technical Reference Group

The Technical Reference Group (TRG) has been established to provide high level guidance and input in the planning of the project. Each member has been selected for their unique expertise and knowledge of the Project's impact on land-use planning and transport as a whole to the context of Perth.

Key organisations engaged with as part of the TRG is shown below:

Table 1 – TRG members

Organisation
METRONET
PTA
DoT
DPLH
DoC
Infrastructure WA
Main Roads WA

Made up of a combination of representatives from State Government organisations, the TRG has been engaged with at key milestones throughout the project.

South West Group and Arup have conducted a series of meetings and half-day workshops with the TRG throughout the project to:

- Review and refine project objectives and assessment criteria
- Review and add to key opportunities and constraints (including supply of relevant datasets)
- Co-develop potential options for the alignment, modes and stations
- Review the option assessment against agreed criteria.

2.3 Project Team

The Project Team (PT) has been established to lead delivery of the Project Concept document and associated material. Each member has been selected based on their extensive knowledge and experience of the transport and land-use planning context of the study area and their potential of delivering the best outcome for the SWMR.

Key members of the PT and their respective organisations are shown below:

Table 2 – PT members and roles

Name	Position	Organisation
Tom Griffiths	Director	South West Group
Paul Garbett	Director of Strategic Planning & Projects	CoF
Phillida Rodic	Manager of Strategic Planning	CoF
Mick McCarthy	Director of Technical Services	CoM
Steve Cope	Director of Urban Planning	CoM
Chris Fitzhardinge	Director	Berkelium Consulting

The PT is responsible for delivering technical analysis that has fed into:

- Part A: Project narrative (context and background) – *Section 1.1*
- Part B: Define and quantify the problem (developed by SWG) – *Section 4*
- Part E: Strategic and policy alignment with Local, State and Federal Government - *Section 1.1*

2.4 Transport consultant

The Transport consultant (TC) has been engaged by SWG to work in collaboration within the Project Team (PT) to deliver the engineering component of the study including developing the indicative alignment and station designs as part of the overall project. Arup has been selected to undertake this role based on a long and demonstrated history of project work within the study area, experience delivering similar projects and experience working with the relevant key stakeholders for the project.

Key members of the TC and their respective role on the Project is shown below:

Table 3 – TC members and roles

Name	Role
Darryl Patterson	Project Director
Ben Haddock	Project Manager

Danya Mullins	Technical Advisor
Zoe Wilks	Transport Planning Lead
Miguel Monteiro	Civil Engineering Lead
Adam Rotapel	Senior Civil Engineer
Jason Hoad	Transport Planner

Comprised of a diverse team of engineers and planners, the TC has been responsible for delivering technical analysis that has fed into:

- Development of project objectives and assessment criteria
- Identification of key opportunities and constraints
- Long List option development and assessment
- Short List option development and assessment
- Preferred option feasibility design development
- Reporting.

2.5 Other Stakeholders

In addition to the TRG, PT and TC, the following wider stakeholders have been identified throughout the project. Consultant with these wider stakeholders has not yet been undertaken at this early stage of the project, however this is recommended to be progressed in the next stages of work as part of the development of the detailed Business Case:

- Utility providers such as Water Corporation, APA, Western Power and ATCO Gas
- Telecommunications providers such as NBN, Telstra, Optus, Vocus Communications
- BP refinery Kwinana Pty Ltd
- Western Australian Planning Commission (WAPC)
- Murdoch University
- St John of God Murdoch Hospital
- Fiona Stanley Hospital
- Fremantle Hospital
- Fremantle Ports
- Australian Terminal Operations Management (ATOM)
- PIPE Networks
- Nextgen
- AARNet.

3 Methodology

The overall methodology followed by the PT and TC throughout this study is set out in Figure 4 below.

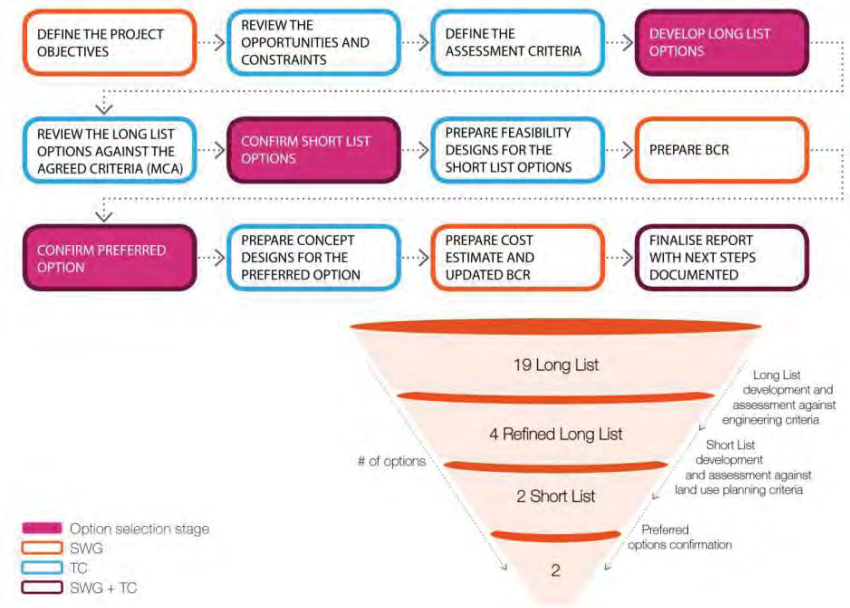


Figure 4 – Methodology (top) and option selection process (bottom)

1. **Problem definition** *(Section 1.1)*

The problem definition has been developed by SWG based on significant research and analysis undertaken to confirm the need for this study and a capital investment into the Business Case development.

2. **Opportunities and constraints review** *(Section 5)*

The first task involved the identification and appreciation of major opportunities and constraints within the study area that may influence choices and inspire alternative solutions.

3. **Project objectives and criteria confirmation** *(Section 6)*

The next task involved the identification of the project objectives and confirmation of the assessment criteria. In this task, a workshop was convened between representatives from the TCG, PT and TC. As an output from the workshop, the key project objectives were confirmed and the 'mapped' assessment criteria formalised in order to assess potential initiatives and solutions.

4. **Capital and non-capital option confirmation** *Section 7)*

As part of the Long List development described at Step 5, the TC presented on a range of capital options (i.e. transport modes and technologies) that could be considered in addressing the problem and satisfying key project objectives.

5. **Long List development and assessment** *(Section 8)*

The next task involved the development of a Long List of corridor route options for assessment against the agreed criteria. In this task, a workshop was convened between representatives from the TCG, PT and TC and involved a highly collaborative workshop session. In this session, attendees analysed the major opportunities and constraints within the study area and considered appropriate capital or non-capital Long List options to be progressed through to the MCA stage. 19 mode agnostic corridor route options were progressed through at this stage for assessment.

Following agreement of the Long List options, all were assessed against the already agreed assessment criteria as part of the Multi-Criteria Analysis (MCA). The first round of assessment included an MCA of the 19 options against the agreed purely engineering and transport planning criteria, refining the Long List to just 4 potential options. These remaining options were then assessed by SWG using the agreed land use planning, environmental and heritage criteria in a land use refinement process. An output of this assessment stage was the confirmed Short List options. A total of 2 options were confirmed as the Short List and were progressed to the next stage of assessment.

6. **Short List development and assessment** *(Section 9)*

A total of 2 options were considered as part of the Short List phase. The agreed Short List options were advanced to early feasibility concept designs prepared by Arup. This stage also included confirmation of station locations and hierarchy which were consistent for each of the options.

7. **Preferred option confirmation** *(Section 10)*

2 preferred options were identified based on their ability to satisfy the key project objectives in both an appropriate, purposeful and economic manner. The assessment of the Short List options including the preliminary designs were presented to stakeholders to collaboratively confirm the preferred options.

8. **Next steps** *(Section 11)*

Following inputs from stakeholders, a clear list of next steps will be compiled to help facilitate the advocacy for a full Business Case to be developed for this project in line with Infrastructure Australia processes and requirements.

4 Problem Definition

4.1 Context

This Problem Definition relates to a study area stretching from the Bull Creek Shopping Centre to the Port of Fremantle. It includes the area between Leach Highway and the southern boundary of the City of Melville as well as all of the City of Fremantle less North Fremantle.

The study area has a 2020 population of 75,000 people with a projected growth to 2036 of over 20,000 additional residents. The largest population growth is expected at Murdoch and in Fremantle (Table 4). The study area is located within the South West Metropolitan Region (SWMR) and sits within the Central Sub Region within the planning framework established under Perth and Peel @ 3.5 million.

Table 4 – Study area population

Location	2018 Population	2020 Population	2036 Population	Change 2018 to 2036
Leeming	8,354	8,569	8,956	602
Bull Creek	7,951	8,222	8,848	897
Murdoch	3,650	3,963	7,570	3,920
Bateman	3,699	3,949	4,105	406
Winthrop	5,970	6,129	6,319	349
Kardinya	9,177	9,147	10,295	1,118
Willagee	5,103	5,523	8,306	3,203
Sub Total City of Melville	43,904	45,502	54,399	10,495
Samson	2,072	2,107	2,109	37
Hilton-O'Connor	4,639	4,832	4,934	295
White Gum Valley	3,137	3,349	3,286	149
Beaconsfield	5,257	5,546	6,857	1,600
South Fremantle	3,249	3,393	3,950	701
Fremantle	8,719	10,358	15,895	7,176
Sub Total City of Fremantle	27,073	29,585	37,031	9,958
Study Area Total	70,977	75,087	91,430	20,453

Source: Forecast ID

The corridor between Murdoch and Fremantle is one of three major east west transport corridors traversing the City of Melville and linking to Fremantle (Figure 5). It is largely covered by Sections 1 and 2 in Corridor 19 in the Major Transport Corridor Review undertaken by the Public Transport Authority (PTA) in 2018.

The PTA Review of Corridor 19 identified slow bus average travel time (less than 30 kph) and low occupancy (7.94%) in the 130 buses that travel each day between Murdoch Train Station and the City of Melville western boundary (Section 2 in Figure 6). The PTA Review also identified that bus journey times are negatively impacted by the lack of priority at intersections and traffic congestion. The outcome of the Review was to propose bus priority lanes from Murdoch University to South Fremantle and bus priority at intersections where geometry allowed.

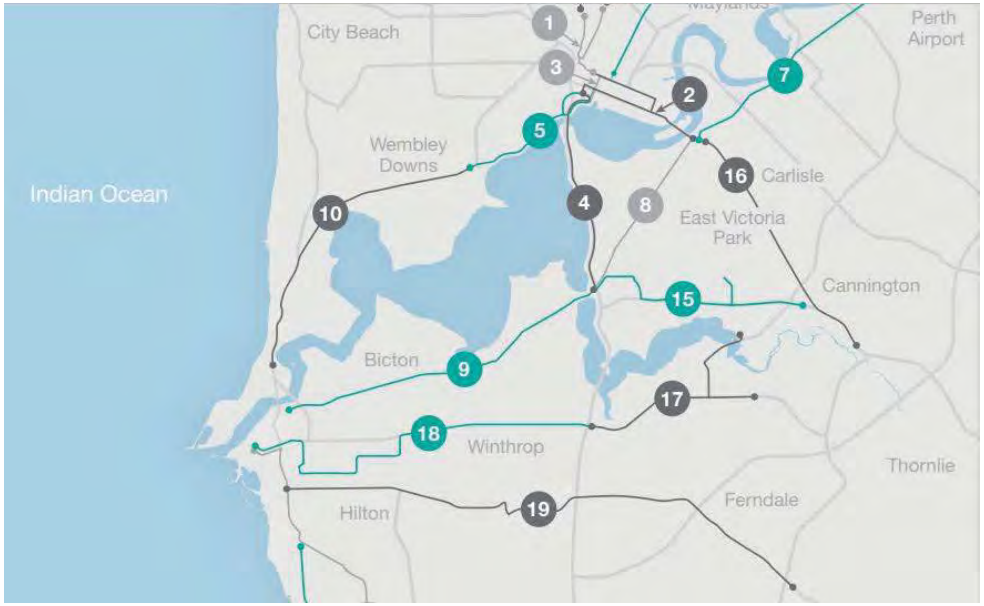


Figure 5 – Extract of major transport corridors assessed by PTA in 2018

Source: PTA Public Transport Major Road Corridor Review 2018

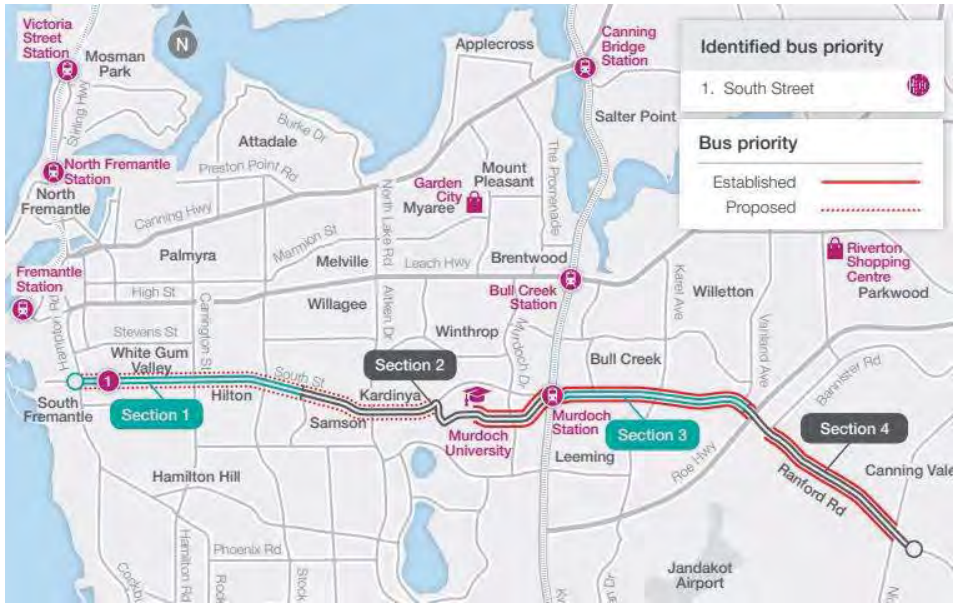


Figure 6 – South Street/ Ranford Road major transport corridor

Source: PTA Public Transport Major Road Corridor Review 2018

Development targets for infill have been set under Perth and Peel @ 3.5 million to support a sustainable and resilient city. These targets are a split of 47% infill and 53% greenfield development. Progress towards these targets is reported in the Department of Planning Urban Growth Monitor. The Central Sub Region has an infill target of 124,880 dwellings between 2011 to 2031 or 6,244 dwellings a year. The 2020 Urban Growth Monitor reports that performance to 2018 has been 4,534 dwellings a year well short of the target. Infrastructure Australia in their 2019 Audit Report state that 70% of Metropolitan Perth development has been greenfield development. This is consistent with the 2020

Urban Growth Monitor which reports of the 118,460 dwellings constructed between 2015 and 2018, 81,880 or 69% were constructed in greenfield areas.

Population growth in Australia relies heavily on overseas migration to supplement natural growth and internal migration. Overseas migration has changed dramatically over the past decade with India and China now the principal source countries (Figure 7).

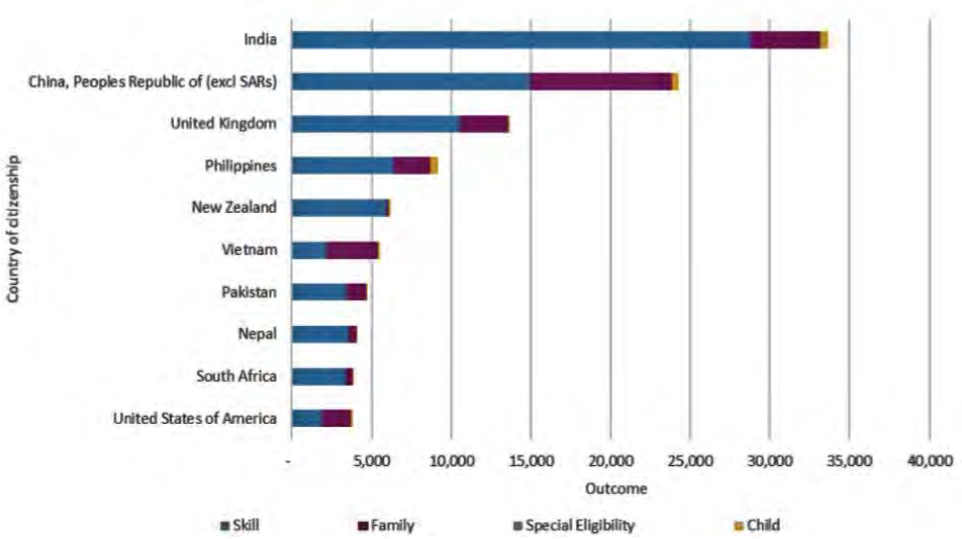


Figure 7 – 2018/19 migration program outcome: Top 10 countries of citizenship by stream

Source: Department of Home Affairs 2018-19 Migration Program Report

The City of Melville with its good access to universities and quality high schools is an attractive location for migrants from China, Malaysia, Hong Kong, Singapore and Indonesia. The City of Melville already has much higher proportions of overseas born residents from these countries than Greater Perth (Table 5) and with housing choice, liveable locations and improved public transport is likely to attract a much greater share of overseas migration.

Table 5 – Extract of City of Melville birthplace

City of Melville - Overseas born (Usual residence)	**2016**			**2011**			**Change**
Birthplace	Number	%	Greater Perth %	Number	%	Greater Perth %	2011 to 2016
Malaysia	3,150	3.2	1.5	3,048	3.2	1.4	+102
China	1,733	1.8	1.3	1,086	1.1	0.9	+647
Singapore	1,558	1.6	0.7	1,589	1.7	0.8	-31
Indonesia	1,436	1.5	0.5	1,575	1.6	0.5	-139
Hong Kong	663	0.7	0.3	605	0.6	0.3	+58

Source: Forecast ID

4.2 The problem

Public transport in the SWMR is not acting as a transformational infrastructure to promote coordinated corridor development, support the creation of local jobs, provide support for focussed nodal investment and meet the infill targets under Perth and Peel @3.5 million. The historic layout of the public transport system has meant that the region is poorly served with east west public transport links to connect the radial rail corridors. One of the transport links (Canning Highway West) is identified as one of the worst performing corridors in the PTA 2018 Public Transport Major Road Corridor Review.

Limitations on expansion of regional transport corridors and the projected high cost of regional congestion require intervention to support economic growth and regional amenity. The SWMR is growing faster than Metropolitan Perth (see South West Group At a Glance) and this growth is projected to continue for the next thirty years.

Well over 50% of Perth's population growth has been more than 20 kilometres from the Perth CBD. The Fremantle Murdoch corridor falls within a 20-kilometre radius for Perth where growth should be stimulated to constrain greenfield development and make development more sustainable (Figure 8).

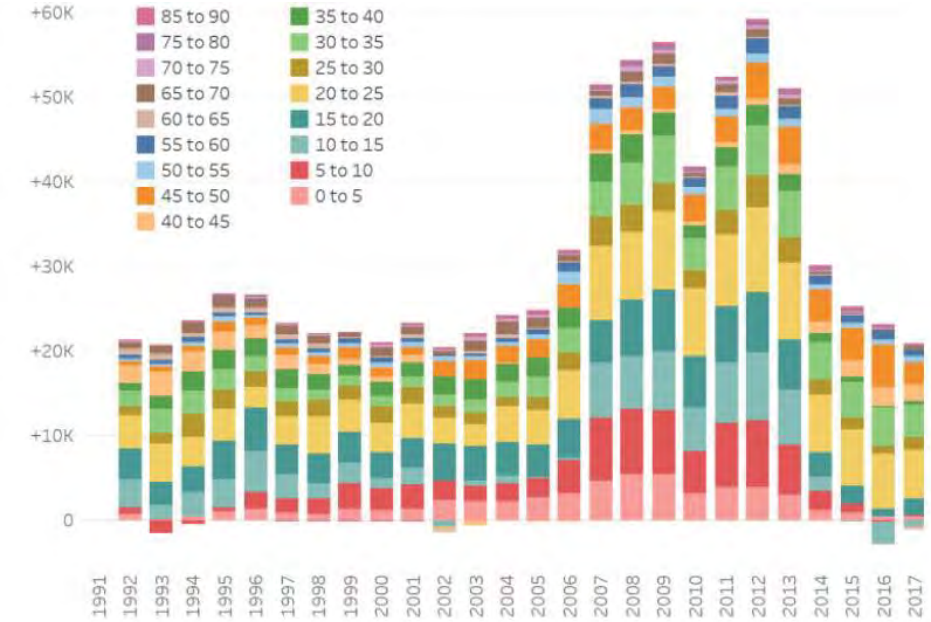


Figure 8 – Annual population change by distance (km) from the CBD, Perth

Source: Charting Transport

At a high-level Perth's public transport system is currently struggling to increase mode share and there is an unsustainable reliance on private motor vehicles. Vehicle Kilometres Travelled (VKT) are still over 9,000 per person (Table 6) which presents a challenge to managing congestion into the future.

Table 6 – Perth vehicle kilometres travelled compared to population

Year	Perth VKT (billion vehicle kilometres)	Perth Population (million people)	Ratio (billion VKT to million people)	VKT per person per year (kilometres)
2008/09	16.26	1.712	9.50	9,500
2009/10	16.30	1.753	9.30	9,300
2010/11	16.56	1.804	9.18	9,180
2011/12	16.96	1.862	9.11	9,110
2012/13	17.20	1.912	9.00	9,000
2013/14	17.61	1.941	9.07	9,070
2014/15	18.06	1.964	9.20	9,200
2015/16	18.68	1.982	9.42	9,420
2016/17	18.97	2.000	9.49	9,490
2017/18	19.04	2.019	9.42	9,420
2018/19	18.71	2.045	9.15	9,150
% Increase 2008/09 to 2018/19	15.06%	19.45%		

Source: BITRE Infrastructure Statistics Yearbook 2019

The largest contributor to VKT are journeys taken in private vehicles. In 2018/19 Perth had 25.30 Billion VKT passenger kilometres of which 20.69 Billion or 81.7% were undertaken in private vehicles. Only 1.73 Billion or 0.7% were on bus or heavy rail (2019 BITRE Yearbook). If emissions are to be managed the growth of the region should be used as an opportunity to promote travel by public transport (Figure 9).

Perth's public transport mode share is low at 6.8% (Figure 10). Infrastructure Australia only projects marginal mode share growth in public transport for Perth and crush capacity being reached in 2031 (Veitch Lister Consulting).

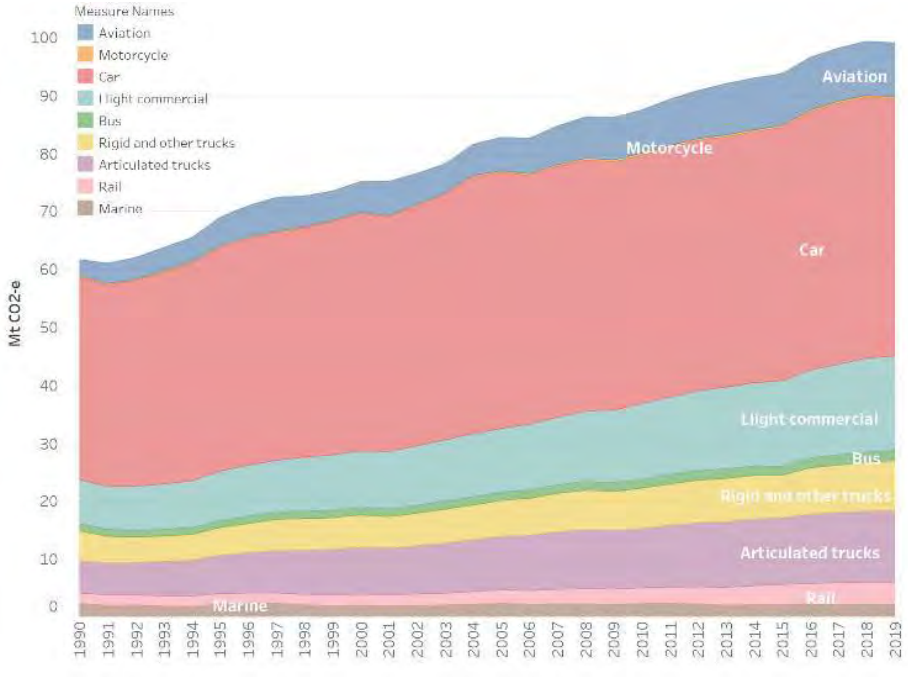


Figure 9 – Domestic non-electric transport emissions, Australia

Source: Charting Transport using data from the BITRE Yearbook 2019

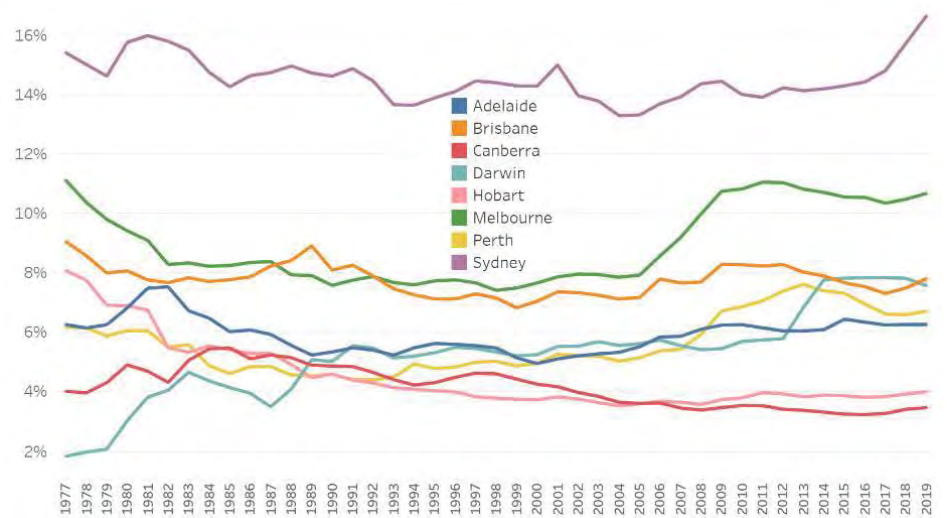


Figure 10 – Estimated mass transport share of motorised passenger kilometres

Source: Charting Transport using data from the BITRE Yearbook 2019

Murdoch Activity Centre is projected to grow to be the largest location of jobs outside of the Perth CBD with 35,000 workers, 44,000 students and 22,000 residents (LandCorp). The 2016 ABS Census identified over 50,000 workers travelled to the SWMR each day from outside of the region and only 56,000 lived in the same SWMR local government area as they were employed in (Table 7). Increasing the number of workers that live closer to their place of employment will impact congestion and encourage the use of public transport.

Table 7 – 2016 ABS residential location of SWMR workers

	Number of Workers	**Per Cent of Workers**
Lived and Worked in the SWMR	99,952	66.3%
Lived and Worked in the same SWMR LGA	56,274	37.6%
Lived in the SWMR but worked in a different LGA	43,228	28.7%
Worked in the SWMR but lived outside	50,862	33.7%
Total	150,814	100.0%

This project seeks to address the major regional problems listed in Table 8.

Table 8 – Problems addressed by the project and links to opportunities and benefits

Problem ID	Problem	KPIs or How Quantified	Links to Project Objective ID	Links to Benefit ID	Solution
P1	South Street is the second most congested major route in Perth	Annual Congestion Cost sourced from MRWA	O2, O5, O6		Promote local housing choice and availability and 10% public transport mode share
P2	High car dependency in the SWMR	Mode Share	O2, O5, O6		
P3	Inadequacy of existing transport system to cope with projected SWMR population and economic growth	Infrastructure Australia projections	O5		Take advantage of growth to use public transport as transformational infrastructure and create attractive living locations close to employment
P4	Most workers do not live locally	ABS Journey to Work	O3, O5		
P5	Poor east west public transport links	Public transport patronage and 2018 PTA Review	O1		Higher quality public transport link between Murdoch and Fremantle with competitive travel times, attractive station/stop precincts
P6	Murdoch Activity Centre failing to reach planned Public Transport Mode Share	Opening of Fiona Stanley Hospital and expansion of SJOG Murdoch only gave limited lift in Public Transport use	O1, O2, O6		
P7	Slow public transport travel times between Fremantle and Murdoch	PTA Timetables and 2018 PTA Review	O1		
P8	Poor resilience of existing public transport network	Chaos experienced with power failures, accidents and congestion	O1		Link the heavy rail stations of Fremantle and Murdoch and provide public transport priority to reduce the number of incidents that can impact public transport
P9	Sub optimal corridor development from incremental development along Fremantle Murdoch Corridor	Forecast ID shows most growth is at Fremantle and Murdoch with limited growth in between	O3		Focussed investment will be triggered by a commitment to develop nodes and upgrade public transport

The project objectives and the links to project problems and benefits are shown in Table 9.

Table 9 – Project objectives and links to problems and benefits

Objective ID	Objective	Links to Project Problem ID	Links to Benefit ID
O1	Improve the connectivity, reliability and resilience of the existing SWMR transport system	P5, P6, P7, P8	
O2	Reduce private car dependency and congestion, and change travel behaviours within the study area and within Greater Perth	P1, P2, P6	
O3	Improve liveability through creation of "places" and distinctive urban form that builds on the character and identity of the study area, encouraging urban consolidation in defined areas and giving both local employment and skills development opportunities	P4, P9	
O4	Mitigate project deliverability risks by minimising impacts where possible to major infrastructure, community infrastructure, amenity and the environment		
O5	Support the growth strategy outlined in Perth and Peel @3.5 million for the South West Metropolitan Region to diversify its economy, provide local employment, give housing choice and make the region attractive for visitors, new residents, investors and new businesses	P1, P2, P3, P9	
O6	Increase public transport mode share to 10% with a 20% target within Fremantle and Murdoch by 2031	P1, P2, P6	

5 Opportunities and constraints

Prior to the development of any initiatives to address the problem within the study area, it is essential to have a detailed understanding of any constraints and opportunities that may influence choices and highlight alternative solutions.

The TC, together with the PT, sought to map the key opportunities and constraints within the Study Area. A number of datasets were sourced with assistance from key stakeholders and compiled into one online GIS tool to provide a single source of layered information. The compilation of all the data into one bespoke layered digital tool, allowed the easy interrogation and identification of major opportunities and constraints that assisted throughout the option development process.

The key opportunities and constraints considered during this process included:

- Services/ utilities - *Section 5.1*
- Aboriginal and European heritage sites - *Section 5.2*
- Environmental sites - *Section 5.3*
- Land use (existing and future forecasts) - *Section 5.4*
- Public transport (existing and future networks and demand) - *Section 5.5*
- Roads (existing and future networks and demand) - *Section 5.6*
- Active transport (existing and future networks) - *Section 5.7*.

It should be noted that while a number of constraints exist in the study area, all projects of this size are prone to constraints and are examined at a high-level in order to identify big, compounding issues. Being a high-level assessment at this stage, constraints were able to be addressed in a fairly straightforward manner as communicated in the following sections.

5.1 Services/ utilities

Figure 11 – Existing services/ utilities (Data sources: Water Corporation, Western Power, DYBD, ATCO Gas)

Table 10 – Key utility/ service impacts

Location ID (shown in Figure 11)	Utility Service	Location of Impact	Constraint Description
1	132 kV Overhead Transmission Powerline (Western Power)	Crossing South Street at Taylor Street intersection.	Required vertical clearances may limit the adoption of transport modes requiring OLE infrastructure. Options incorporating an above ground vertical alignment would also be constrained. Construction working height below the transmission lines would also be restricted in accordance with Western Power requirements.
2	132 kV Overhead Transmission Powerline (Western Power)	Crossing Discovery Way at Murdoch Drive intersection.	Required vertical clearances may limit the adoption of transport modes requiring OLE infrastructure. Options incorporating an above grade vertical alignment would also be constrained. Construction working height below the transmission lines would also be restricted in accordance with Western Power requirements.
3	1650mm Diameter Reinforced Concrete Pipe Sewer Main (Water Corporation)	Crossing Discovery Way at Murdoch Drive intersection.	Water Corporation will likely require minimum cover to be maintained which will constrain options requiring below grade vertical alignments. Additional service protection measures may be required such as sleeving, concrete encasement or protection slabs. Given this is a gravity main, lowering of the service is not expected to be feasible.
4	100mm Diameter Steel 700kPa High Pressure Gas Main (ATCO Gas)	Intersection of South Street and Ladner Street	ATCO Gas will likely require minimum cover depths be maintained over the gas main. Strict conditions will be placed on construction operations in proximity to the gas main. Additional protection measures may be required where a future transport link generates consistent heavy vehicle movements over the gas main.
5	1050mm Diameter Concrete Pipe Stormwater Main (Water Corporation)	Crossing South Terrace at Henderson St intersection.	Water Corporation will likely require minimum cover to be maintained. Additional service protection measures may be required such as sleeving, concrete encasement or protection slabs. Given this is a gravity main, lowering of the service is not expected to be practical.
6	Fibre Optic Cable (AARNet)	Crossing Barry Marshall Parade at Murdoch Drive intersection.	Additional conduits may be required alongside the existing cables in accordance with asset owners requirements as a provision for future access below the crossing. Excavation and compaction works in close proximity to the cables will likely be prohibited within a set exclusion zone. Additional access pits will likely be required alongside the crossing.
7	Fibre Optic Cable (NBN)	Crossing South Street at Chamberlain Street intersection.	Additional conduits may be required alongside the existing cables in accordance with asset owners requirements as a provision for future access below the crossing. Excavation and compaction works in close proximity to the cables will likely be prohibited within a set exclusion zone. Additional cable access pits will likely be required alongside the crossing.
8	900mm Reinforced Concrete Pipe Stormwater Main (Water Corporation)	Intersection of South Street and Hampton Road	Water Corporation will likely require minimum cover to be maintained which will constrain options requiring below grade vertical alignments. Additional service protection measures may be required such as sleeving, concrete encasement or protection slabs. Given this is a gravity main, lowering of the service is not expected to be feasible.
9	66 kV Overhead Transmission Powerline (Western Power)	Intersection of South Street and Plane Tree Grove	Required vertical clearances may limit the adoption of transport modes requiring OLE infrastructure. Options incorporating an above grade vertical alignment would also be constrained. Construction working height below the transmission lines would also be restricted in accordance with Western Power requirements.

The presence of utility services within the study area, as highlighted in Figure 11 and listed in Table 10 can potentially result in significant constraints where the presence of services infrastructure result in physical clashes with the proposed alignment route, or where cover requirements are no longer achieved, resulting in the potential need for relocation or protection.

This does nevertheless provide an opportunity as the large number of services within the study area indicate that there could be station and precinct utility supply options with minor requirements for extensions or upgrades subject to further discussions with the service providers.

Transport government authorities and individual utility service authorities dictate specific requirements for existing utility assets in order to ensure they remain protected from damage, do not adversely interact with the surrounding environment and are accessible for ongoing operation and maintenance activities. Examples of these conditions include minimum cover depths, protection sleeves, overhead vertical clearances and special foundation requirements for new infrastructure.

Datasets from utility authorities have been reviewed spatially within the study area in order to identify the extent of potential encumbrance to future transport links. The spatial review was conducted using an FME process to corelate existing service locations from the available data sets with the potential wider alignment options for the future transport links. Data sets used include asset mapping data from Dial Before You Dig (DBYD) information as well as the most recent iterations of Government held spatial datasets sourced from *data.wa.gov.au*. Mapping data has been sourced from utility authorities and private asset owners including but not limited to Water Corporation, NBN, Optus, ATCO Gas, Western Power and AARNet.

5.1.1 Critical utility services

Our review has been focussed on identifying critical services within the study area which are of high importance to service distribution networks within the greater metropolitan area.

The study area includes significant existing commercial, light industrial and other special land use zones which corelate to a higher density of existing utility services. This is evidenced in our spatial data review which has yielded approximately 110 critical utility service potential impacts. Each of these represent a conflict point between an existing critical utility service and potential transit link alignment.

Considering the volume of potential impacts identified, we have consolidated the available data and represented critical service high risk areas diagrammatically in Figure 11. The high risk zones are centred around the following areas:

- South Fremantle
- Beaconsfield
- O'Connor
- Fiona Stanley Hospital.

As aforementioned, although the density of existing utility services presents a constraint in many areas there is also assumed to be opportunity to establish required service connections close to future land development and infrastructure associated with the transport link alignment.

Existing utility services are deemed critical where they meet one of the below criteria:

- Water mains (greater or equal to 300mm in diameter)
- Gravity sewers (greater or equal to 500mm in diameter)
- Pressurised sewers (all)
- Drainage pipes (greater or equal to 500mm in diameter)
- High pressure gas mains
- HV electrical transmission cables
- Open channel drains
- Fibre Optics.

The below table provides a sample of critical services identified within the study area and the likely constraints associated with these.

It should be noted that the list of key utility/ service impacts (Table 10) is not exhaustive and represents only a selection of high priority service impacts along the potential transport link alignments. A complete register of the identified critical service impacts can be provided in subsequent project phases.

A detailed review is recommended to undertaken as part of the detailed Business Case submission/ concept design phase in consultation with services authorities to verify the actual constraints imposed by each potential service impact.

Where major service crossings exist, discussions with respective asset owners and government authorities will be required to determine the appropriate course of action including any accommodation or protection requirements. It should be noted that minor services may still require protection or, removal and relocation under the direction of the asset owner, however significant costs and lead times are not anticipated.

5.1.2 Summary

Opportunities	Constraints	Unavoidable constraint
Identification early can result in better organised financial and programme implications associated with altering these assets Utility clash analysis is likely to highlight modes that are more appropriate for progressed alignments	High number of possible infrastructure constraints centred around South Fremantle, Beaconsfield, O'Connor and Fiona Stanley Hospital	Western Power's 132 kV Overhead Transmission Powerlines will increase difficulty of the solution progressing.

5.2 Aboriginal and Australian/ European heritage sites

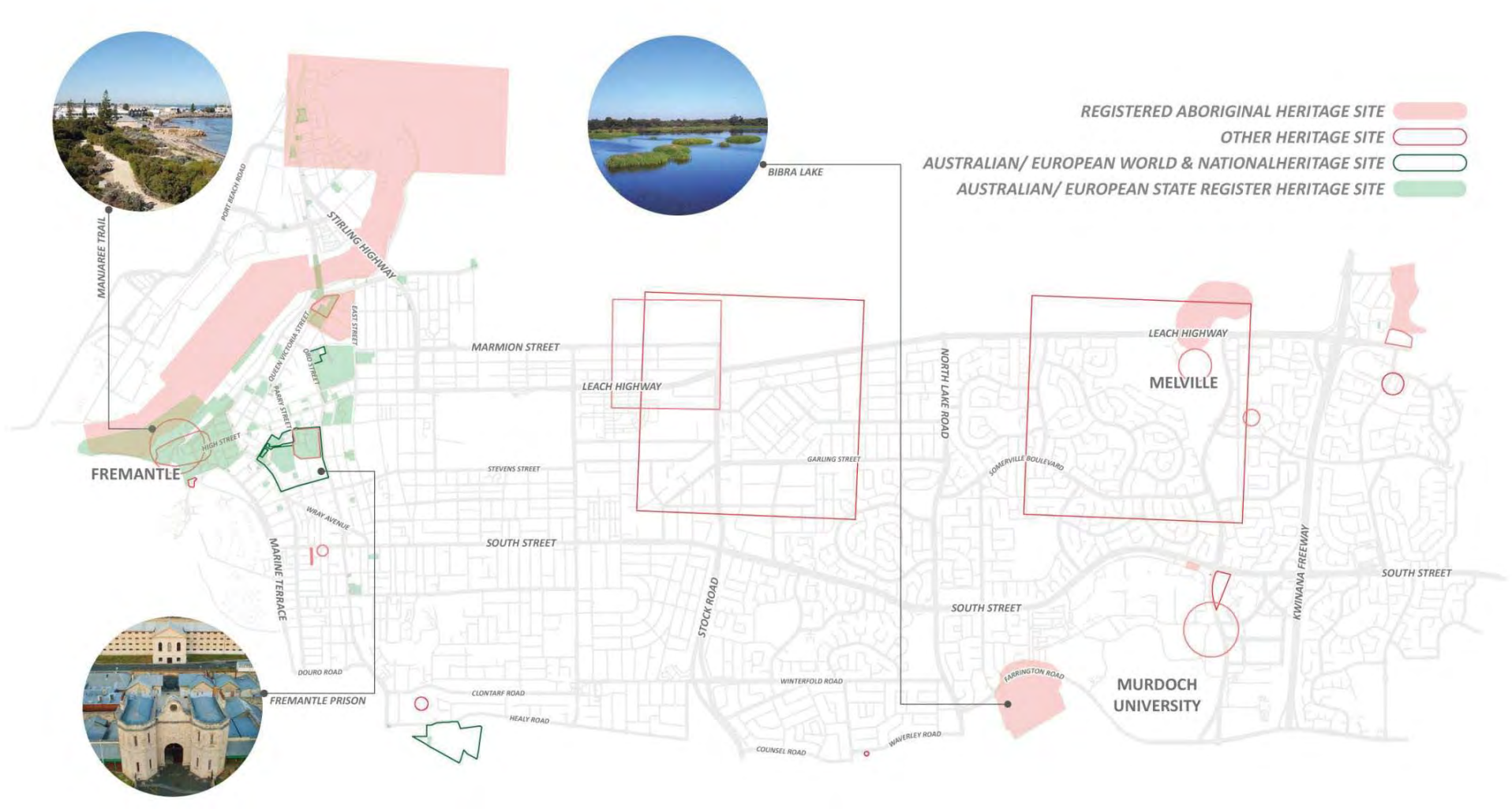


Figure 12 – Aboriginal and Australian/ European heritage sites (Data source: DPLH-001, DPLH-004, DPLH-006)

The existing Aboriginal and European/ Australia heritage attributes within the study area can inform the possible alignments and subsequent urban development, given the time, delay and costs associated in gaining approvals on heritage listed land. The most recent iterations of Government held spatial datasets have been displayed directly sourced from data.wa.gov.au.

These datasets have been reviewed spatially to identify where heritage sites are located within the study area. Relevant datasets include Aboriginal Heritage Sites and European/ Australian (World and National) Heritage Sites.

As shown in Figure 12, Aboriginal Heritage constraints are concentrated primarily on the western boundary of the study area, within and surrounding the Fremantle city centre. Several sites are scattered through the Fremantle area of high significance, including meeting places, ceremonial places, camps and trails, most notably the Manjaree Trail on the waterfront of Bather's Beach and Fremantle Prison. Other significant sites are found within the study area including Bibra Lakes, Booragoon Lake and an artefact/ scattering site on the north-eastern corner of the Murdoch University site. Adjacent to South Street, the Murdoch University site and other heritage site (Lodged site: S02772) on the eastern side of Murdoch Drive are significant sites recognised for numerous uses including a camp, burial ground, hunting place and plant/ water source.

European/ Australian heritage sites are concentrated in their entirety in the west of the study area, with a number of World and National registered sites existing within the Fremantle Town Centre and south of Healy Road. These include the Fremantle Prison, Fremantle Museum and Arts Centre and Hamilton Hill. It should be noted that 'The West End Heritage Area' of Fremantle extends over the entire city footprint west of Market Street and North of Collie Street. This heritage registered area also contains many individual buildings which are registered separately under the State Heritage Office. This area presents possible constraints to potential transport links given the existing road cross sections and existing heritage listed structures are largely inflexible.

5.2.1 Summary

Opportunities	Constraints	Unavoidable constraints
Low number of heritage listed areas within the middle and eastern portion of the study area.	Numerous heritage listed land parcels within the Fremantle Town Centre that will need to be avoided for any proposed alignments. Murdoch University aboriginal heritage site. Lodged site: S02772 Murdoch Drive camp.	North Lake and Bibra Lake have been defined as one of the most significant aboriginal heritage sites south of the Swan River and will likely stop the progression of options along this section of Farrington Road.

5.3 Environmentally sensitive areas

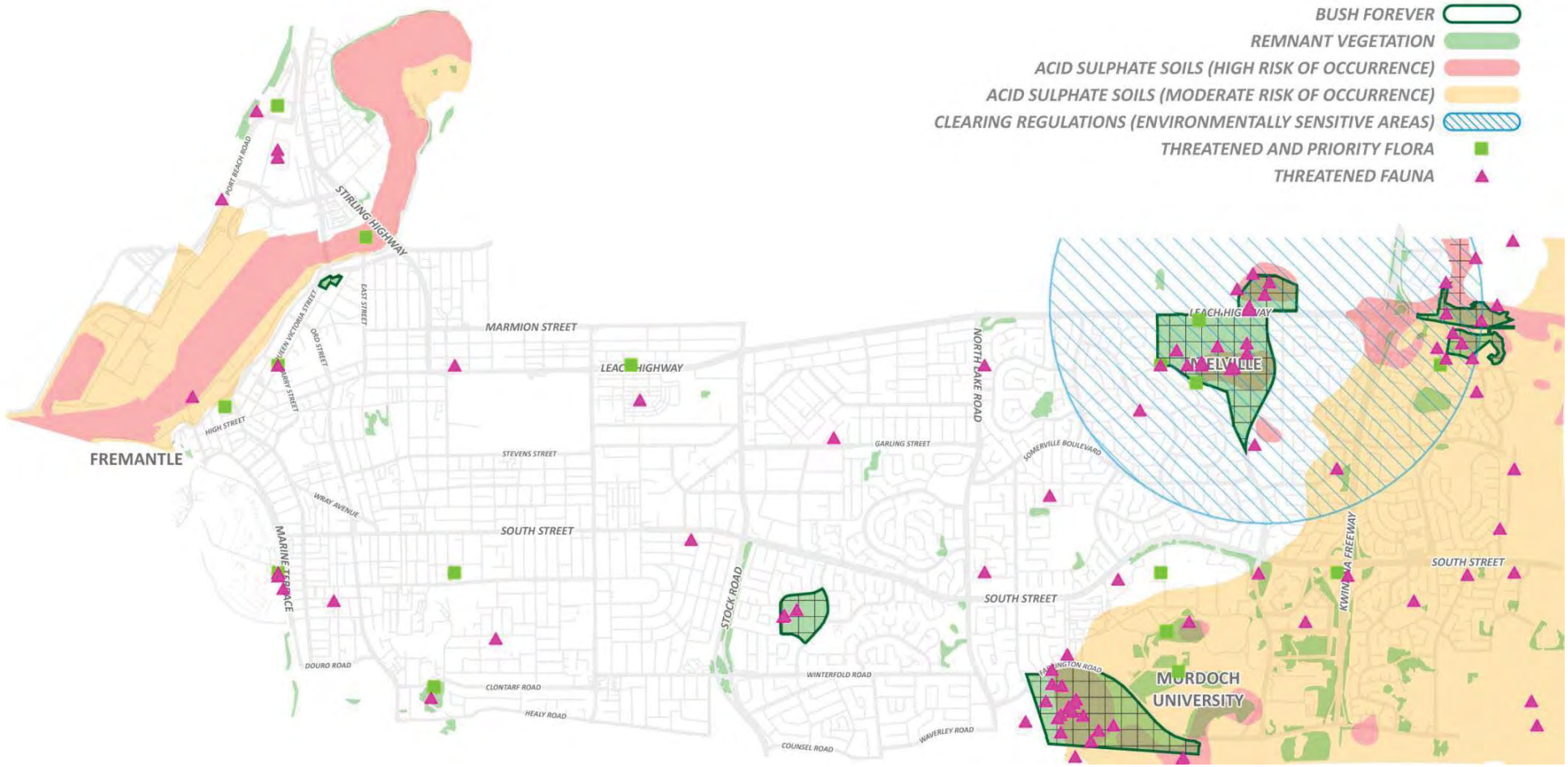


Figure 13 – Environmental constraints (Data sources: DBCA-036, DBCA-038, DPIRD005, DWER-055)

The existing environmental attributes within the study area will inform possible alignments and subsequent urban development. The most recent iterations of Government held spatial datasets have been displayed directly sourced from data.wa.gov.au.

These datasets have been reviewed spatially to identify where environmentally sensitive sites are located within the study area. Relevant datasets include Bush Forever, Environmentally Sensitive Areas, Threatened Flora and Fauna and Remnant Vegetation.

As shown in Figure 13, a high concentration of remnant vegetation is located in the eastern portion of the study area, particularly within the surrounds of Murdoch University between South Street and Farrington Road.

In the same respect, Bush Forever sites are also concentrated in the east, particularly around Bull Creek Station at Piney Lakes, Booragoon Lakes, Bateman Park and Richard Lewis Park.

Threatened Flora and Fauna sites have been recorded throughout the study area and are highly concentrated within and surrounding registered Bush Forever and Environmentally Sensitive Areas.

Besides the Bush Forever site of Sir Frederick Samson Park located south of South Street and East of Stock Road, the scarcity of environmentally sensitive sites in the western half of the study area suggest a high degree of clearing during the build-up of Fremantle.

It should also be noted that there is a high to moderate risk of encountering Acid Sulphate Soils (ASS) in close proximity to the Swan River. The datasets available indicate that this risk is significantly reduced in areas east of Elder Place which runs parallel with the Fremantle rail line north of central Fremantle.

Areas that have been identified as environmental constraints should be avoided where possible for potential land and corridor development due to its incompatibility with State visions of sustainability and relatively high risk of not gaining environmental and heritage approvals and/ or subsequent high costs of land clearing.

5.3.1 Summary

Opportunities	Constraints	Unavoidable constraint
Low number of environmentally sensitive land parcels within the western segment of the study area.	Highly biodiverse land parcels in CoM likely present constraint on approvals. ASS east of Murdoch University and in close proximity to the Swan River.	Bush Forever and high risk ASS area within North Lake and Bibra Lake likely to stop progression of options along this section of Farrington Road.

5.4 Land use

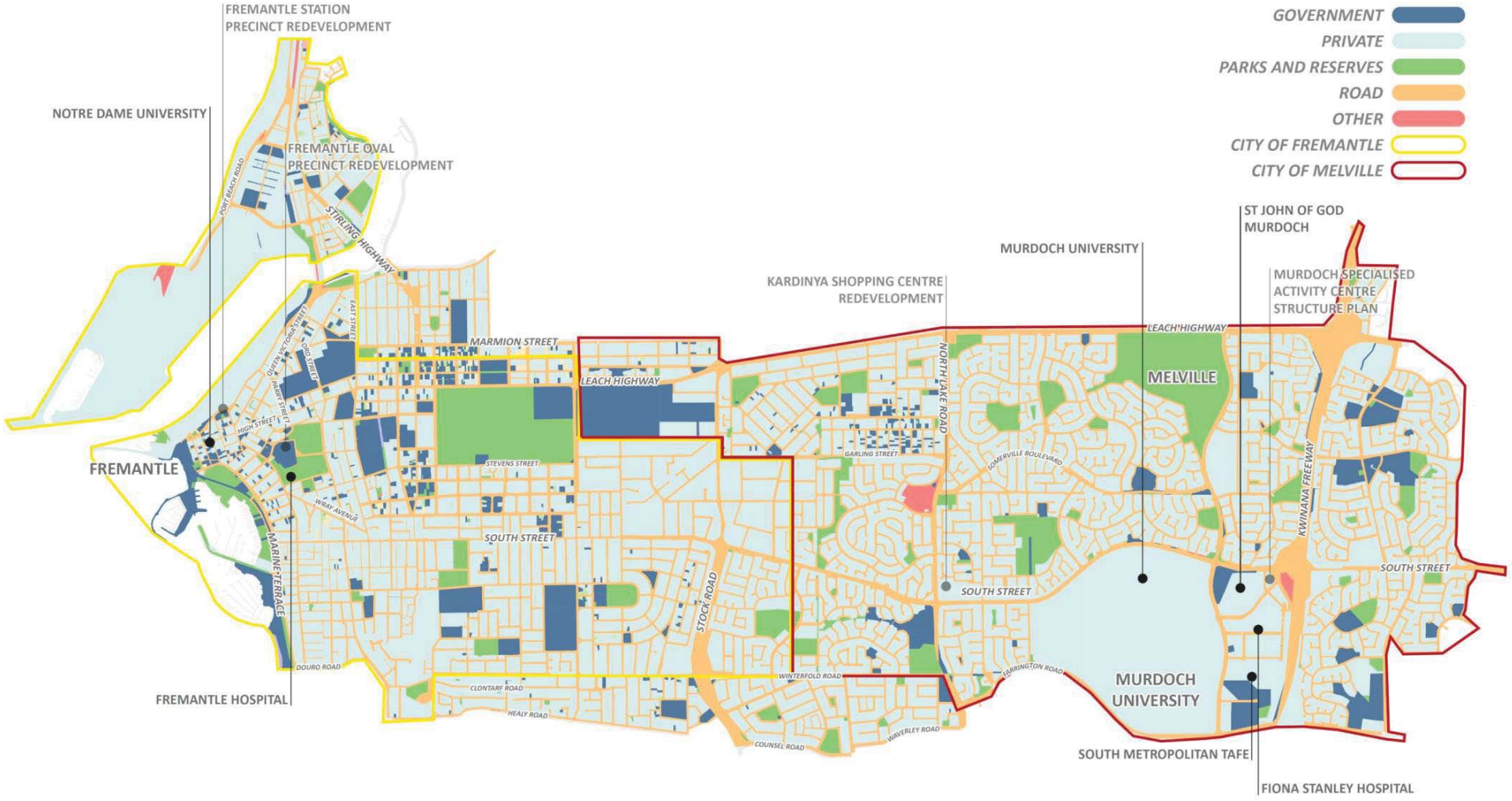


Figure 14 – Existing land ownership (Data sources: LGATE-217)

The study area currently spans across the CoF and the CoM and is anchored by the centres of Fremantle in the west, a Strategic Activity Centre, and Murdoch in the east, a Specialised Activity Centre, as outlined by Perth and Peel @ 3.5 million. The study area also contains a number of major industrial employment and service precincts including O'Conner Industrial and Commercial Area and Myaree Mixed Business Zone. These make up important destinations that are constantly evolving, diversifying their land use creating high-density housing, community, education, employment and services opportunities.

5.4.1 Land ownership

There are various areas of private and government owned land parcels across the study area as shown in Figure 14. The provision of new public transport infrastructure running through the study area has capacity to require the development of a large portion of land for the corridor itself, its stops and their access routes. For this exercise, it's worth considering opportunities adjacent to or near Government land or within the existing road reserve, rather than within privately owned land or land zoned for parks/ reserves. This will allow the possible optimisation of currently owned Government land and urban outcomes, while avoiding the time and complexities involved with claiming land from private land-owners. Where privately owned land is unavoidable, significant land will be considered that could be more attractive to developers should the quality of public transport improve.

5.4.2 Key destinations

Secondary and Tertiary education institutes are important to both centres, pulling students from the wider metropolitan area to their campus'. Most notable are Notre Dame University in Fremantle and Murdoch University and South Metropolitan TAFE campus' in Murdoch. The volume of district level movement and low level of mobility of student populations is a significant opportunity for the development of this project, with the potential of connecting facilities to wider facilities creating new typologies of 'urban' schools, contributing to a more compact and connected urban form outcome.

Hospitals and specialist health services are also important to both centres, drawing both staff and visitors to major destinations such as Fremantle Hospital, St John of God Murdoch Hospital and Fiona Stanley Hospital. Not only do hospitals play an important role in the development of the study area's general and specialised public and private health offering, but also offer a higher education role as well, attracting higher volumes of students and staff.

A number of key tourism and recreation attractions are also located within the study area. Highly concentrated in Fremantle, these include the Fremantle Prison, Markets, Fishing Boat Harbour and numerous café strips. Fremantle is also a major gateway to Rottnest Island, attracting just under 800,000 visitors each year (ABC, 2019). Murdoch, and the wider surrounds of CoM is known for its recreational and biodiversity attractions such as Beeliar Regional Park, Bibra Lake and Piney Lakes Reserve.

5.4.3 Existing population and journey to work

The study area currently encompasses the Fremantle, South Fremantle, O'Connor, Willagee, Winthrop, Murdoch-Kardinya and Bateman Statistical Area Level 2's (SA2). As recorded from the 2016 Census, these areas were home to approximately 57,400 people across 23,100 dwellings.

Journey to work (JTW) data from the 2016 Census recorded that 18,200 people commuted every day to work from inside the study area to outside the study area (assuming the wider SA2 boundary as a proxy). Of this sample, 67% of people commuted by vehicle and 12% commuted via public transport. On the contrary, 32,500 people commuted to the study area for work from outside the study area with 76% commuting by vehicle and 6% via public transport. Based on these findings, whilst the study area includes two major rail stations, the public transport mode share for this area both as an origin and destination is relatively low and compared to a Perth city average of 10.3%.

In addition, JTW data records show a total of 1,600 people commuting west from SA2 areas within the study area to Fremantle and 1,000 people in the other direction to Murdoch. Showing a total of 2,600 people commuting east-west every day for work purposes only.

It is noted that mode share by students is not captured in the JTW responses but recent surveys at Murdoch University indicate that existing mode share by public transport is relatively low.

5.4.4 Urban growth

The State Government's Perth and Peel @ 3.5 million Sub-regional Frameworks provide specific guidance on sustainable development over the next three decades to ensure the impact of urban growth on areas of environmental significance is minimised. This is to protect, heritage; and importantly, to maximise the benefits of available land and infrastructure.

Despite the study area encompassing a large land area zoned as low-density residential for the foreseeable future, the centres of Fremantle and Murdoch are envisaged to grow on a strategic level by the framework. Fremantle has been identified focussed on opportunities to build its mix of land uses, employment opportunities and housing choice and diversity. The Westport Taskforce, in charge of the planning, development and growth of both the Inner Harbour at Fremantle and the future Outer Harbour at Kwinana, could see the shift of most major port activities and facilities out of Fremantle, responding to WA's growing freight demands for the next 50 years. This is likely to see the large-scale redevelopment of Fremantle, particularly at the waterfront destination of Victoria Quay, generating an influx of visitors from the wider metropolitan region.

In Murdoch, new and upgraded health and education facilities are planned, responding to the Frameworks plans of instilling the centre as an engine-room for future growth in education, research, health and high-tech engineering and development services. The growth for this campus must be achieved with respect to the ratified parking cap for the wider Murdoch Activity Centre with minimal bays left for construction within this cap.

Growth of local centres within the study area is also planned within CoM and CoF structure plans, including:

- Murdoch Specialised Activity Centre
- Kardinya Shopping Centre redevelopment
- Heart of Beaconsfield
- Fremantle Oval precinct redevelopment.

5.4.5 Future land use

Population and land use forecasts have been undertaken independently by demographers' informed decisions for the SWG, taking into account their own forecasted residential development, net migration, dwelling numbers and birth and death rate assumptions. These forecasts were last updated in December 2017 and are available from 2016 to 2036 on Forecast ID (Table 11). It should be noted that these estimates were provided taking into account the entire City area, extending past the study area.

Population and dwelling projections were also supplied by DPLH using the Metropolitan Land Use Forecasting System (MLUFS) for the agreed study area. Two versions of MLUFS were supplied, MLUFS v1.4 and MLUFS v1.6.1. These numbers have also been supplied in Table 11.

Table 11 – Forecast population for City of Fremantle and City of Melville (Source: Forecast ID)

	Population		**Dwellings**	
Source	**2016**	**2036**	**2016**	**2036**
CoF	30,100	42,000	14,700	20,700
CoM	102,400	126,800	41,800	51,200
Total	***132,500***	***168,800***	***56,500***	***71,900***
% Change from 2016		***+27%***		***+27%***
MLUFS v1.4	50,800	56,762	21,400	24,100
% Change from 2016		*+12%*		*+12%*
MLUFS v1.6.1	49,900	57,400	20,000	24,900
% Change from 2016		*+15%*		*+24%*

5.4.6 Summary

Opportunities	**Constraints**	**Unavoidable constraint**
Diverse range of centres in Fremantle (Strategic) and Murdoch (Specialised). High number of Government owned land parcels. Significant urban development planned at a strategic level for both LGAs.	High number of private land parcels adjacent to major road reserves which may restrict widening opportunities along the corridor or space available for stations	The section immediately west of the freeway (hospitals and Murdoch University should align with the planning already done by Murdoch Activity Centre (MAC).

5.5 Public transport

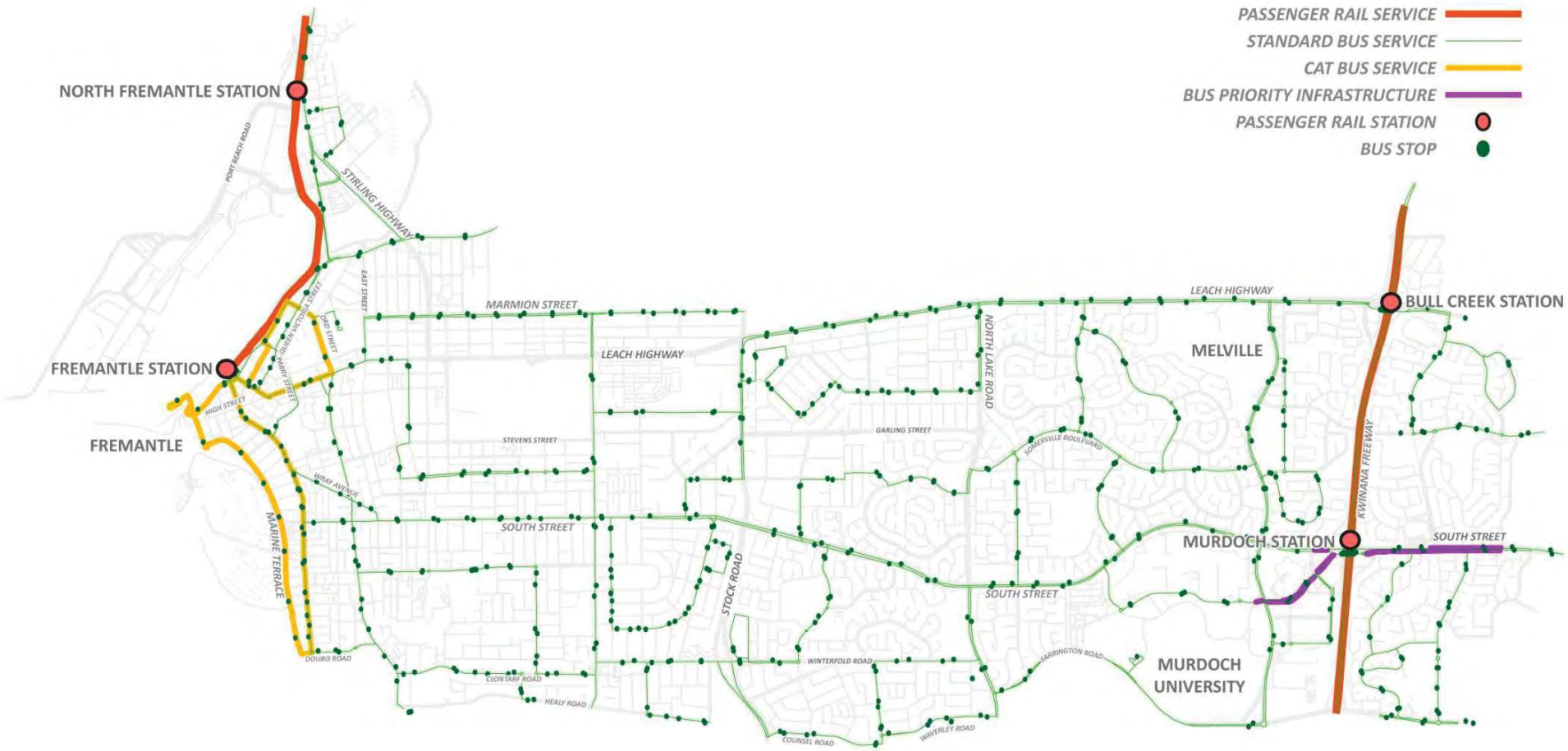


Figure 15 – Public transport provisions (Data sources: Transperth, PTA)

5.5.1 Existing network

There are a number of existing public transport services within the study area which have been considered from both a constraint and opportunity standpoint for this project. As shown in Figure 15, the study area is served by a number of public transport routes with two rail lines servicing the east and west in the Mandurah Line and the Fremantle Line and a total of 55 bus services operating in the area between the railways.

Rail

The study area is serviced by two passenger rail lines in the Fremantle Line and Mandurah Line. The Fremantle Line, which originates at Fremantle Station, is one of Perth's remaining heritage lines servicing the study area directly northbound to the Perth CBD. The Mandurah Line, which is accessed via Murdoch Station, services the study area directly southbound to Mandurah and northbound to the Perth CBD.

Provided in the table below are existing frequencies of passenger rail services operating from Fremantle and Murdoch Station to the Perth CBD in both directions.

Service	Peak frequency	Inter-peak frequency	Off-peak frequency
Fremantle Line	6 services per hour (in each direction)	4 services per hour (in each direction)	2 services per hour (in each direction)
Mandurah Line	12 services per hour (in each direction)	4 services per hour (in each direction)	2 services per hour (in each direction)

Buses

Amongst these bus services is a CAT service that operates within the Fremantle Town Centre and extend along Marine Terrace towards Douro Road. The CAT bus services are high frequency, circular and free routes that operate in key Activity Centres in Perth.

It should also be noted that Bus Priority infrastructure currently exists to the east of Murdoch University, extending through the hospital precinct and eastbound on South Street.

Provided in the table below are existing frequencies of bus services operating between Fremantle and Murdoch Stations along South Street. It is noted there are a number of additional services that utilise South Street and travel within the study area – these routes are less direct and travel within the surrounding suburb local streets.

Table 12 – South Street bus service frequencies (Source: Transperth website, accessed March 2020)

Service no.	Route	Peak frequency	Intra-peak frequency	Off-peak frequency
511	Fremantle to Murdoch Station via Winterfold Road and South Street	3 services per hour (in each direction)	1 service per hour (in each direction)	1 service per hour (in each direction)
513	Fremantle to Murdoch Station via Coolbellup	5 services per hour (in each direction)	1 service per hour (in each direction)	1 service per hour (in each direction)
998	Circle Route (clockwise)	10 services per hour (in each direction)	5 services per hour (in each direction)	2 services per hour (in each direction)
999	Circle Route (anti-clockwise)	10 services per hour (in each direction)	5 services per hour (in each direction)	2 services per hour (in each direction)

5.5.2 Existing demand

Smartrider data was provided by Transperth in March 2020. The data encapsulates boardings and alightings within the study area on a typical weekday in October 2019, in this case Tuesday 22nd and Thursday 24th of October.

Rail

Table 13 shows the average capacity of passenger rail rolling stock at Fremantle and Murdoch station. As shown, during the busiest time on the Mandurah Line heading north towards the Perth CBD, trains approaching Murdoch Station were almost at capacity on average, and leaving Murdoch Station over capacity, presenting a major constraint on the existing public transport network. Fremantle station does not experience these issues given it is an end of the line station, passengers are the first ones on the empty trains in the AM peak period heading towards the Perth CBD.

Capacity issues on the Mandurah Line, specifically at Murdoch Station, suggest that issues are heavily driven by public transport demand heading northbound from south of the study area, as services are close to full once arriving at Murdoch Station.

Table 13 – Average available capacity at Fremantle and Murdoch Station (Smartrider data, October 2019)

Line	Highest occupancy service time	Average occupancy	Planning capacity*	Available capacity
Fremantle Line (between Fremantle Station and North Fremantle station heading towards Perth CBD)	7:28am	120	620	81%

Line	Highest occupancy service time	Average occupancy	Planning capacity*	Available capacity
Mandurah Line (between Cockburn Station and Murdoch Station heading towards Perth CBD)	7:25am	885	1,000	13%
Mandurah Line (between Murdoch Station and Bull Creek Station heading towards Perth CBD)	7:25am	1,060	1,000	-6%

*N.B. planning capacity of rolling stock does not take into account possible crush loading.

Buses

The capacity of existing bus services within the study area has been reviewed, with particular attention given to the east-west bus services operating between Fremantle and Murdoch, and the passenger rail services departing Fremantle and Murdoch Station heading towards the CBD. Smartrider data for these routes have been provided by Transperth for days between 21st October to 31st October 2019. A breakdown of this data has been provided in Table 14. As shown, provided data has been broken down by proportion of concession boardings and alightings, busiest service during the time period where maximum passengers on board was detected, licensed capacity per service and available capacity.

It should be noted that following investigation into the provided Smartrider data, an obvious peak commute time by bus was not identified across all service routes, with demand for buses spread throughout the day. This is likely due to the high average proportion of patronage using the services under a concession ticket, and therefore likely to have varied commute times throughout the day. Therefore, occupancies have been shown for the busiest service times across each individual route.

It should also be noted that while Circle Routes 998 and 999 operate both inside and outside the study area, data shown only reflects the busiest sections within the study area at their busiest commute time. The purpose of this study, these sections have been identified between Fiona Stanley Hospital and Murdoch Station for both 998 and 999 services.

Table 14 – Average available capacity on east-west bus services during AM peak (Smartrider data, October 2019)

Service no.	% concession boarding in study area (daily average)	% concession alighting in study area (daily average)	Highest occupancy service time	Highest recorded occupancy	Planning capacity (per vehicle)*	Available capacity (average per vehicle)
511	64%	61%	3:08pm, 29 October	59	76	22%
513	71%	68%	8:26am, 22 October	34	76	18%
998	72%	67%	10:12am, 23 October	75	82	9%
999	69%	72%	3:27pm, 23 October	23	82	26%

*Planning capacities for all services are varied during the day, operating with capacities of 76, 82 and 110 (articulated bus) persons.

As shown, relatively high service capacities were experienced during the data capture period, experienced at varying points throughout the day. Significant capacity constraints were experienced on the 998 service, with available capacities on the service reaching 9%.

5.5.3 Proposed future network

Rail

In line with announced projects as part of the METRONET taskforce, the Mandurah Line is to undergo upgrades including the inclusion of two stations at Karnup and Lakelands. Whilst new stations may spread some demand across the line to these stations, it is likely to also increase overall demand of the service, putting more pressure on the already constrained rail network, specifically on the approach to Murdoch Station.

Additional upgrades include frequency and rolling stock upgrades, expected to be implemented from 2022. These upgrades would see the increase in capacity on the Fremantle and Mandurah Lines when new rolling stock and High Capacity Signalling (HCS) arrives, including the subsequent cascading of existing rolling stock.

Buses

As advised directly by Transperth, there are no major service upgrades planned for bus network within the study area, besides investigations into frequency upgrades to the Circle Route between Fremantle and Murdoch Stations. Depending on available funding, investigations into upgrading the frequency to 12 buses per hour during the peak periods and 6 buses per hour during the off-peak (to match train frequency on the Mandurah Line) are currently taking place.

Additionally, Transperth have advised that the redevelopment of Fremantle Station will have subsequent impact on bus access to the station precinct, spurring the possible implementation of Bus Priority infrastructure on new access routes such as Queen Street and Cantonment Street.

While requiring further investigation and collaboration with Transperth, future public transport infrastructure plans should be considered in optimising and increasing connectivity either to, or with, a new public transport corridor within the study area.

Murdoch University

As part of the Murdoch University Perth Campus Strategic Masterplan, Discovery Way has been identified as an intended primary gateway for public and private transport, with provisioning for future BRT/ LRT.

It is intended that the service will operate as a median running service which enters the campus off South Street on a future realigned segment of road connecting to Discovery Way. The service is then intended to traverse Discovery Way eastbound towards the University, with its first stop outside the Murdoch Student Guild building. It is this intended to follow Discovery Way, with a second stop adjacent to the future Southern Plaza, until it reaches Murdoch Drive, where it continues through the intersection towards Fiona Stanley and St John of God Murdoch Hospital. Despite intended as a median running service, provisioning for the service and associated space proofing has been undertaken assuming a more conservative marginal (kerbside) service to assure the provision of sufficient space in the event a median running outcome is not realised.

For the purpose of this investigation, the alignment and stops through Murdoch University have already been defined and confirmed, with associated work undertaken.

A depiction of the alignment including stops is included in Figure 16.

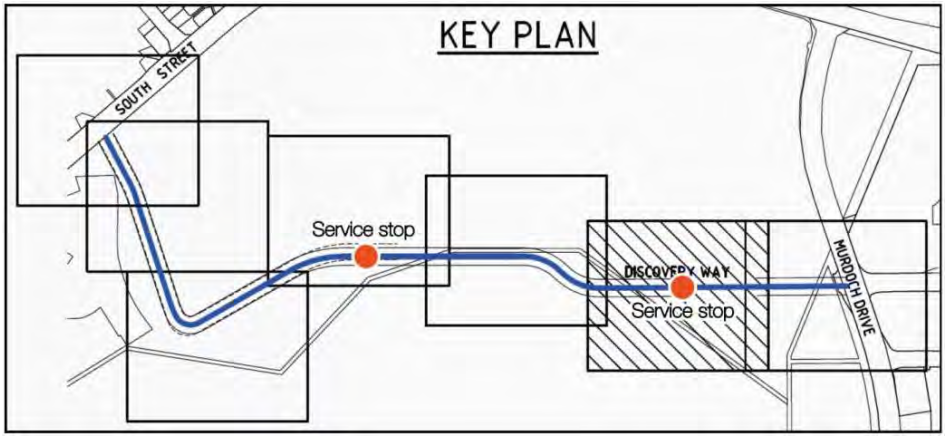


Figure 16 – Proposed Murdoch University BRT/ LRT alignment and stops (Arup, 2020)

5.5.4 Estimated future demand

Future public transport demand was not included within this stage however it is recommended that STEM data is requested from DoT and used to assess the potential options in later stages.

5.5.5 Summary

Opportunities	Constraints	Unavoidable constraint
Existing bus routes operating under capacity allowing potential for consolidation of services. Space proofing of BRT/ LRT already undertaken within Murdoch University. Future planned Bus Priority infrastructure.	Capacity constraints already evident at Murdoch station. Limited existing bus priority leading to relatively slow services connecting east-west between Fremantle and Murdoch Activity Centres.	Limited existing capacity on rail services at Murdoch Station during peak hours unavoidable as patronage is generated from outside of the study area.

5.6 Roads

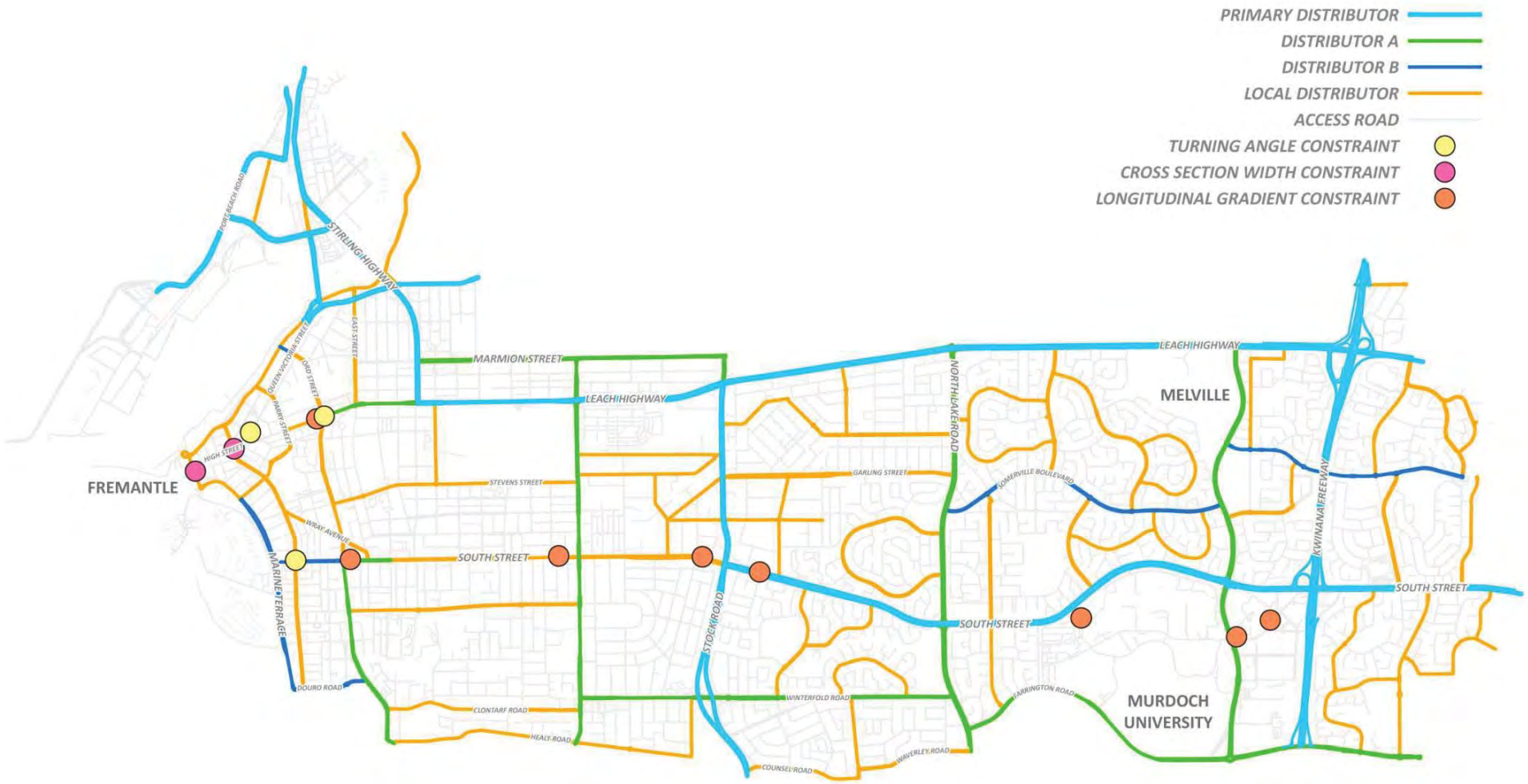


Figure 17 – Existing road hierarchy (Data sources: Main Roads WA Road Information Mapping System)

5.6.1 Existing network

The existing road network within the study area presents a number of constraints in regards to both current and future capacity constraints along key corridors, proposed future network changes and also physical constraints within the road reserves in consideration of cross section widths and turning radii.

As shown in Figure 17, the current study area is serviced by a number of Primary Distributors in east-west corridors of South Street and Leach Highway and north-south corridor of Stock Road as defined by the Main Roads WA Road Information Mapping System. Supporting these corridors are a number of north-south Distributor A roads, east-west Distributor B roads and a network of Local Distributors. Major movement corridors are common in the eastern, CoM portion of the study area yet roads within the CoF are of a lower movement hierarchy, directing a majority of through-traffic away from the Fremantle city centre.

This is also reflected in the character of streets and cross-sections observed across the study area. Identified as a key constraint in the introduction of any new mass transit infrastructure is the existing characteristics and profile of major corridors connecting the east and west. This is particularly evident along South Street, which is identified as a preferable alignment option for the service providing the most direct connection and reserved land between the two key Activity Centres. For instance, ample space for new infrastructure currently exists within the 30m cross section width of the Primary Distributor segment between the Kwinana Freeway and Stock Road. West of Stock Road, as the hierarchy of South Street changes to a Local Distributor, available space reduces significantly for alterations to the corridor with a cross section width as low as 12m before the Hampton Road/ South Street intersection. Figure 18 indicate the difference in street character and cross section at two points along South Street, east of Gilbertson Road and west of Hines Road.

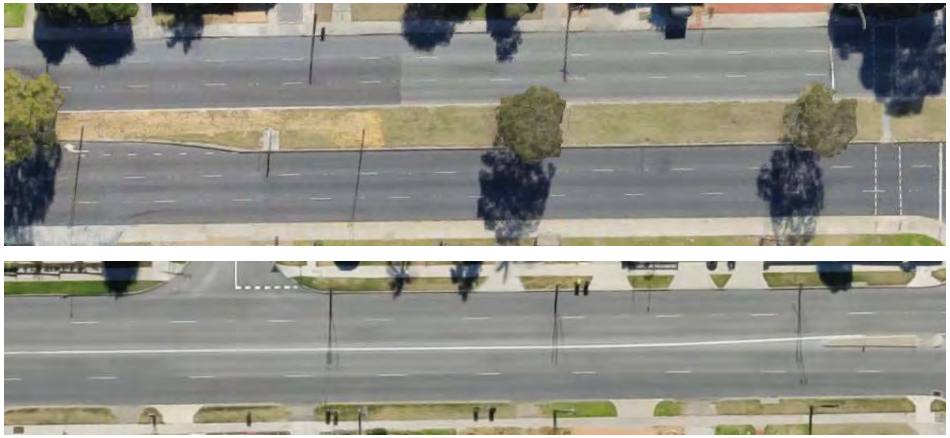


Figure 18 – South Street cross section east of Gilbertson Road (top) and west of Hines Road (bottom)

5.6.2 Existing traffic and congestion

The existing peak hour traffic conditions within the study area are shown in Figure 19, as sourced from Google Maps traffic data for a typical Tuesday AM peak hour at 8:30am. As shown, moderate congestion is currently experienced in both directions along major east-west corridors of South Street and Leach Highway, including high congestion on the approach to the Fremantle town centre at Leach Highway and South Terrace. Moderate to high congestion is also observed at key intersections including:

- South Street/ Carrington Street
- South Street/ Stock Road
- South Street/ South Terrace
- South Street/ North Lake Road.

Despite moderate to high congestion at these locations, low congestion along major midblock sections of South Street may present opportunities for better utilisation of the road area without detrimental impacts to the road network. This could include possible reallocation of traffic lanes for other uses such as Bus Priority, active transport and/ or a new east-west public transport corridor.

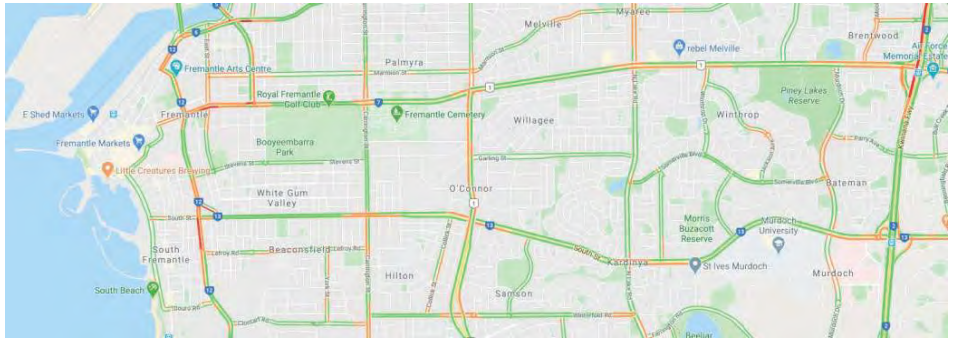


Figure 19 – Typical weekday (Tuesday 8:30am) traffic congestion within study area (Google Traffic, 2020)

5.6.3 Existing crashes

Crash data compiled over the last 5 years shows a concentration of crashes at each major intersection along South Street (over 51 crashes) with crashes exceeding 100 reports at the South Street/ Murdoch Drive and South Street/ Stock Road intersection. Table 15 shows a breakdown of major intersection crashes along South Street as recorded by CARS (2020).

Table 15 – Last 5 years crash reports at major intersections on South Street (CARS crash data, 2020)

Intersection	State ranking (by number of crashes)	State ranking (by cost of crashes based on the Willingness to pay approach)	Total crashes	Casualties
South Street/ Murdoch Drive	22	34	151	25
South Street/ North Lake Road	104	190	86	12
South Street/ Carrington Street	269	429	53	10
South Street/ Stock Road	21	45	155	27

5.6.4 Existing geometric constraints

Physical constraints in the road network have been identified as geometrical constraints based on existing low turning angles, insufficient cross section widths and steep longitudinal gradients associated with some potential routes highlighted for the purpose of this opportunities and constraints study. These major constraint locations have been shown in Figure 17.

As shown, geometrical constraints are found generally within the western portion of the study area, apart from longitudinal gradient constraints. Existing topography within the study area generates steep longitudinal gradients of greater than 10% in several locations along South Street as well as High Street and Ord Street in central Fremantle. The portion of Barry Marshall Parade west of the Murdoch Road intersection is significantly constrained by an existing longitudinal gradient in excess of 40%.

Existing roads within the CoF present another major constraint, due to the historical and predominantly unchanged road network that combines low cross section widths with small turning radii particularly evident on South Terrace, High Street and Queen Street.

Nevertheless, potential routes that intersect these constraints can be overcome by engineered solutions however are likely to require a greater degree of difficulty associated with construction, including intrusion to the existing transport flow and higher associated capital costs.

5.6.5 Proposed future network

Future road network upgrades have been proposed by Main Roads WA and are currently under construction. These upgrades include:

- Extension of Murdoch Drive from Farrington Road to Roe Highway
- Grade separation of Farrington Road/ Murdoch Drive
- Grade separation of Hope Road under Murdoch Drive extension
- Bibra Drive/ Murdoch Drive east-west connection.

There are currently no identified future network modifications for the study area as determined by the CoF and CoM.

5.6.6 Estimated future demand

The Regional Operations Model (ROM) is a strategic model developed by Main Roads WA that projects road network volumes based on a series of network assumption inputs as defined by the operator including movement networks and land use assumptions. For the purpose of assessing the road network's estimated future demand within the study area, the ROM was produced and supplied by Main Roads WA for the years 2016, 2021, 2031 and 2041. Model assumptions were as a 'business as usual' scenario for the study area, assuming only known and funded road network and public transport upgrades included in the model. The land use inputs for this scenario are consistent with MLUFS v 1.4 (based on Perth and Peel at 3.5 million but not yet updated for the recently released WA Tomorrow forecasts).

The future expected demand for the two east-west Primary distributors: South Street and Leach Highway have been reviewed as part of this study. A summary of future demand growth between 2016 to 2041 on South Street and Leach Highway is shown below. Note, all data was supplied as projected 24-hour traffic volumes.

Table 16 – ROM 24-hour traffic volumes South Street and Leach Highway 2016-2041

Road	Location	2016 demand (in both directions)	2041 demand (in both directions)	% increase
South Street	Between Murdoch Drive and Kwinana Freeway	52,200	74,800 (3-lanes)	43%
	Between North Lake Road and Gilbertson Road	39,400	57,100 (3-lanes)	45%
	Between Stock Road and Yarrick Street	33,100	38,200 (2-lanes)	15%
	Between Solomon Street and Edmund Street	19,100	26,300 (1-lane)	38%
Leach Highway	Between Moolyeen Road and Kwinana	74,300	97,100 (3-lanes)	31%

Road	Location	2016 demand (in both directions)	2041 demand (in both directions)	% increase
	Freeway northbound off-ramp			
	Between North Lake Road and Norma Road	48,200	64,500 (3-lanes)	34%
	Between Stock Road and Webber Street	45,200	67,600 (3-lanes)	50%
	Between Stirling Highway and Montreal Street	31,200	59,800 (1-lane)	92%

As shown by ROM data, there is a high projected increase in traffic volumes between Fremantle and Murdoch along South Street and Leach Highway. This growth is particularly evident on Leach Highway between Stirling Highway and Montreal Street showing a 92% increase in traffic volumes either travelling northbound onto Stirling Highway from Leach Highway or eastbound on Leach Highway towards the Kwinana Freeway. High growth is also projected on South Street east of Gilbertson Road towards Murdoch, with a growth of up to 45% from 2016 to 2041. Although not supplied, an increase in traffic volumes along these corridors is directly correlated to an increase in vehicle kilometres travelled. This is necessary in considering costs of carbon emissions, fuel and road maintenance costs and the potential savings involved in the opportunity of changing mode choice behaviour within the study area.

5.6.7 Summary

Opportunities

High cross section widths of Primary Distributors and Distributor A roads between Kwinana Freeway and Stock Road potentially allowing for introduction of a new mass rapid transit connection.

Mode choice behaviour change potential with the introduction of a new frequent mass rapid transit mode.

Constraints

High projected traffic volumes and associated congestion which could be potentially relieved with a mode shift towards public transport.

Existing congestion issues at key signalised intersections on South Street.

Numerous geometric constraints within historical road network of Fremantle.

Unavoidable constraint

High Street between Stirling Street and Carrington Street is ‘out of play’ and cannot be considered as part of an alignment (under development already as part of the WA governments “congestion busting” plan to improve efficiencies for freight traffic).

Longitudinal gradient constraints within Murdoch University and along South Street.

5.7 Active transport

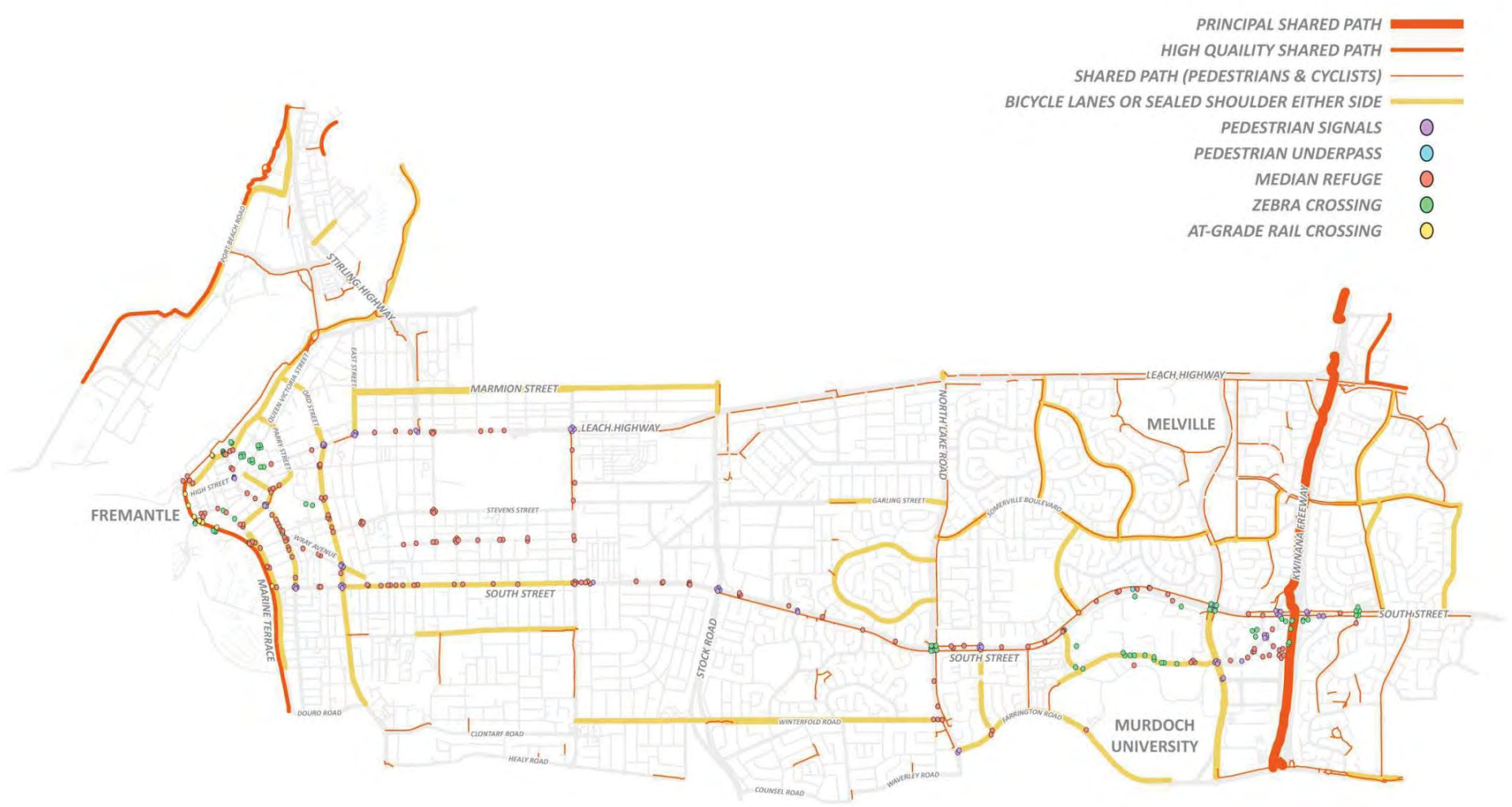


Figure 20 – Existing active transport (Data sources: DoT Perth Bike Maps)

5.7.1 Existing network

The existing provisions of active transport infrastructure is considered as both an opportunity and constraint for the introduction of any new mass transit infrastructure given the lack of connections and protected crossings throughout the study area. This infrastructure will be vital to facilitate access to any new stations and encourage ridership.

As shown in Figure 20, existing active transport infrastructure is provided through a combination of predominantly shared paths (pedestrians and cyclists) and on-street bicycle lanes, plus the provision of a Principal Shared Path (PSP) north-south along the Kwinana Freeway. As shown, infrastructure exists primarily within and in the surrounds of the Fremantle town centre, Murdoch and Bull Creek Stations and the corridor of the Kwinana Freeway.

A key constraint lies in between the CoF and CoM LGA boundaries, with particular focus along and surrounding the South Street corridor. Most evident, is a complete lack of active transport connections to South Street from both the north and south between Hampton Road in the west and North Lake Road in the east. In addition, east-west active transport infrastructure is currently fragmented in the same area, limiting viable and safe travel options for pedestrians and cyclists between the east and west. This creates a service gap and undesirable active transport environment for patrons accessing a potential alignment within the vicinity of the South Street corridor.

An assessment of existing crossing points for pedestrians and cyclists within the study area, particularly within the CoF and along the South Street corridor, has also been considered. Most notable, is a lack of safe crossing points along South Street between the northern and southern portions of the study area. Currently, signalised intersections offering a signal phase for pedestrians and cyclists are only offered at intersections of major corridors in Hampton Road, Stock Road, North Lake Road and Murdoch Drive. For the latter three, pedestrians and cyclists are required to cross at multiple points, including crossing the vehicle left turn lanes without protection before reaching the signalised crossing. A typical arrangement example is shown in Figure 21 at South Street/ North Lake Road intersection.

Figure 21 – South Street/ North Lake intersection (Google Maps, 2020)

In between these intersections, key crossings are identified by pedestrian refuges in the median of South Street, forcing pedestrians and cyclists to cross 3-lane carriageways at a time along some segments of busy and relatively high-speed roads. An example of this treatment at South Street east of Windelya Road is shown in Figure 22.

Figure 22 – South Street east of Windelya Road pedestrian refuge

Not only does this arise as a constraint but also an opportunity for the CoF and CoM to better integrate their active transport networks between their LGA boundaries, improving access throughout the entire study area and greater increase the access potential to a new public transport service.

5.7.2 Proposed future network

Proposed future active transport network upgrades within the study area have been provided by the CoF and CoM within their respective Bike Plans. It is recognised that the Department of Transport is in the process of developing a Perth wide coordinated cycle plan in conjunction with all LGAs that is intended to supersede all current bike plans. However, the outcomes of this study and relevant plans are not yet available at the time of undertaking this project. It is recommended that this planning is utilised for all future stages of planning and design.

The CoF 2019-2024 Bike Plan proposes the advocation of an extension of the existing Fremantle Line PSP southbound, either as a PSP or a Primary Route (fully separated bicycle lane) from North Fremantle Station to Fremantle Station and beyond along Marine Terrace. Within the town centre, the plan also outlines an upgrade of the existing bicycle lanes on Ord Road/ Hampton Road to a Secondary Route, involving the separation of cyclists from general traffic by a form of partial buffer treatment.

The CoM 2012 Bike Plan proposes the filling in of service gaps that currently exist within their network. This includes the upgrade of bicycle lanes on Murdoch Dr between Farrington Road and South Street and the introduction of infrastructure on Stock Road between Leach Highway and Winterfold Road.

Consistent across either Bike Plan are the planned introduction and upgrade of existing north-south active transport infrastructure within the middle portion of the study area on the boundaries of both LGA's. This includes the introduction of partially separated on-street cycle lanes on Carrington Street, Stock Road and North Lake Road. Connections east-west between each LGA is also considered, with upgrades suggested on Marmion Street, South Street and Winterfold Road.

5.7.3 Summary

Opportunities	Constraints	Unavoidable constraint
Potential to integrate with existing and proposed planning undertaken by the LGAs & DoT.	Lack of north-south protected crossing points for pedestrians and cyclists along South Street. Significant gaps in active transport infrastructure along South Street. Low integration of infrastructure between LGAs.	Active transport infrastructure likely to be implemented in line with prepared CoM and CoF Bike Plans. Alignment may lead to slight alterations however.

5.8 Summary

Table 17 shows a summary of the key opportunities and constraints that have been identified within the study area.

Table 17 – Identified opportunities and constraints

Theme/ mode	Opportunity	Constraint	Unavoidable constraint
Services/ utilities	• Identification early can result in better organised financial and programme implications associated with altering these assets	• High number of possible infrastructure constraints centred around South Fremantle, Beaconsfield, O'Connor and Fiona Stanley Hospital	• Western Power's 132 kV Overhead Transmission Powerlines will increase difficulty of the solution progressing.
Aboriginal and Australian/ European heritage	• Low number of heritage listed areas within the middle and eastern portion of the study area	• Numerous heritage listed land parcels within the Fremantle Town Centre that will need to be avoided for any proposed alignments	• North Lake and Bibra Lake have been defined as one of the most significant aboriginal heritage sites south of the Swan River and will likely stop the progression of options along this section of Farrington Road.
Environmental sites	• Low number of environmentally sensitive land parcels within the western segment of the study area	• Highly biodiverse land parcels in CoM likely present constraint on approvals • ASS east of Murdoch University and in close proximity to the Swan River	• Bush Forever and high risk ASS area within North Lake and Bibra Lake likely to stop progression of options along this section of Farrington Road.
Land use	• Diverse range of centres in Fremantle (Strategic) and Murdoch (Specialised) • High number of Government owned land parcels • Significant urban development planned at a strategic level for both LGAs	• High number of private land parcels adjacent to major road reserves which may restrict widening opportunities along the corridor or space available for stations	• The section immediately west of the freeway (hospitals and Murdoch University should align with the planning already done by Murdoch Activity Centre (MAC).
Public Transport	• Existing bus routes operating under capacity allowing potential for consolidation of services • Space proofing of BRT/ LRT already undertaken within Murdoch University • Future planned Bus Priority infrastructure	• Capacity constraints already evident at Murdoch station • Limited existing bus priority leading to relatively slow services connecting east-west between Fremantle and Murdoch Activity Centres	• Limited capacity on rail services at Murdoch Station during peak hours unavoidable as patronage is generated from outside of the study area.
Roads	• High cross section widths of Primary Distributors and Distributor A roads between Kwinana Freeway and Stock Road potentially allowing for introduction of a new mass rapid transit connection • Mode choice behaviour change potential with the introduction of a new frequent mass rapid transit mode	• Numerous geometric constraints within historical road network of Fremantle • Longitudinal gradient constraints within Murdoch University and along South Street • High projected traffic volumes and associated congestion which could be potentially relieved with a mode shift towards public transport • Existing congestion issues at key signalised intersections on South Street	• High Street between Stirling Street and Carrington Street is 'out of play' and cannot be considered as part of an alignment (under development already as part of the WA governments "congestion busting" plan to improve efficiencies for freight traffic) • Longitudinal gradient constraints within Murdoch University and along South Street.
Active Transport	• Potential to integrate with existing and proposed planning undertaken by the LGAs & DoT	• Lack of north-south protected crossing points for pedestrians and cyclists along South Street • Significant gaps in active transport infrastructure along South Street • Low integration of infrastructure between LGAs	• Active transport infrastructure likely to be implemented in line with prepared CoM and CoF Bike Plans. Alignment may lead to slight alterations however.

6 Project objectives and assessment criteria

In developing the assessment criteria to be used in evaluating the Long List options, the PT considered that the criteria should be a measure of how well a potential solution can satisfy any objectives for the Project. Accordingly, our initial focus was to develop and agree a suite of clear and measurable Project Objectives. In order to align with the State's METRONET Program, potential project objectives were therefore considered in line with the METRONET Program Objectives and their key themes. The METRONET Program Objectives are to:

1. Support economic growth with better connected business and greater access to jobs
2. Deliver infrastructure that promotes easy and accessible travel and lifestyle options
3. Create communities that have a sense of belonging and support Perth's growth and prosperity
4. Plan for Perth's future growth by making the best use of our resources and funding
5. Lead a cultural shift in the way government, private sector and industry work together to achieve integrated land use and transport solutions for the future of Perth.

A workshop was convened on 27 March 2020, where stakeholders were briefed on the background and purpose of the study, findings of the opportunities and constraints analysis, and finally, the potential Project Objectives. The PT and TRG then discussed, refined and agreed the Project Objectives during the workshop session.

The Project Objectives as endorsed by the SWG were agreed as:

1. Improve the connectivity, reliability and resilience of the existing transport system
2. Reduce private car dependency and congestion, and change travel behaviours within the study area and within Greater Perth
3. Improve liveability through creation of "places" and distinctive urban form that builds on the character and identity of the study area, encouraging urban consolidation in defined areas and giving both local employment and skills development opportunities
4. Mitigate project deliverability risks by minimising impacts where possible to major infrastructure, community infrastructure, amenity and the environment
5. Support the growth strategy outlined in Perth and Peel @3.5 million for the South West Metropolitan Region to diversify its economy, provide local employment, give housing choice and make the region attractive for visitors, new residents, investors and new businesses.

Following agreement on the Project Objectives, PT tabled key themes and metrics for potential MCA criteria and bottom-line assessment framework, which resulted in the identification of 12 key criteria. These key criteria involved considerations surrounding the key themes of Urban Planning and Community, Economics, Transport Planning, Engineering and Environmental/ Heritage.

The workshop materials including agenda, slides and minutes are contained in **Appendix A.**

7 Solutions for consideration

7.1 Capital options

As part of the Long List development, the TC presented on a range of capital options (i.e. transport modes and technologies) that could be considered in addressing the problem and satisfying key project objectives. As part of this presentation, key stakeholders were provided information on the key characteristics and performance parameters for each option, as described in Table 18 and Table 19. These sources were provided in order to show an extensive review of commercially available transit modes and emerging rolling stock and understand key differentiators for the modes for consideration in this project. The following mode options and technologies were covered:

- Bus Priority (BP)
- Bus Rapid Transit (BRT)
- Trackless Tram (TT)
- Light Rail Transit (LRT).

It is noted that heavy passenger rail was not considered as part of this study given grade separation requirements meaning the route would likely need to be completely underground or elevated. The CAPEX and likely disruption to the existing network for a project like this is regarded as extremely unlikely to be justified for this corridor. The decision to exclude this option was discussed with and supported by the TRG.

In addition, given the similarities between both the BP and BRT services, a combination of both modes may be considered as a possible solution. For instance, some segments of the preferred corridor may not be suitable for a full BRT service and may only be able to facilitate BP principles such as bus lanes and priority signalling. This however should not disallow other segments of the corridor to operate as a fully BRT corridor.

Table 18 – Capital investment options (mass rapid transit mode options)

Mode	Definition	Example
Bus priority (BP)	Bus priority is a name attributed to bus transit which employs various techniques that improve operation and reduce service delay within lanes and at intersections (includes bus lanes and bus priority signals aka “B-lights”)	
Bus Rapid Transit (BRT)	Bus Rapid Transit is a high quality, cost effective, fast and comfortable bus-based system operating entirely on a bus-only corridor. It provides a comparable service to heavy rail at a metropolitan scale.	 

Trackless Tram (TT)	TTs are an emerging rapid transport technology that adopts hybrid characteristics from LRT and BRT modes. The rolling stock adopts pavement marking and optical guidance technology in lieu of traditional, physical track infrastructure	
Light Rapid Transit (LRT)	LRT is a form of urban public transport using rolling stock often operating on an exclusive LRT-only corridor/ route	 

Table 19 – Mass transit mode comparison of key statistics and features

Typical characteristic	Bus priority		Bus rapid transit		Light rail transit/ tram		Trackless tram	
	Specification	Source/ Reference	Specification	Source/ Reference	Specification	Source/ Reference	Specification	Source/ Reference
Vehicle type	Volgren Optimus and Volgren Optimus articulated	Volgren, 2018- (based on existing Transperth fleet)	Volgren built Volvo articulated bus	Volgren, 2018- (based on existing Transperth fleet)	Bombardier Flexity	Based on MAX Light Rail	Autonomous Rail Rapid Transit CRRC vehicle	CRRC,2019. *ART Integration Application*
Vehicle length	11.9m standard, 18m articulated	Volgren, 2018- (based on existing Transperth fleet)	18m	Volgren, 2018- (based on existing Transperth fleet)	45m	Based on MAX Light Rail	31.64m	CRRC,2019. *ART Integration Application*
Capacity	80 (49 seated) standard, 100 (57 seated) articulated	Volgren, 2018- (based on existing Transperth fleet)	100 per vehicle (57 seated)	Volgren, 2018- (based on existing Transperth fleet)	300 per vehicle	Based on MAX Light Rail	300 per vehicle	CRRC,2019. *ART Integration Application*
Average operating speed	20-50 km/h	Dependent on local street speed limits and level of priority provided	20-50 km/h	Currie G; Delbosc, A; Assessing bus rapid transit system performance in Australasia Varies depending on density and spacing of stops/ stations, noting that higher speeds and larger spacing of stops/ stations are possible in fringe areas.	20-50kph	Canberra Light Rail, Gold Coast Light Rail Note that LRT is typically used in urban environments with relatively close station spacing which restricts their operating speed due to acceleration and deceleration times.	40-50km/h	Observed from study tour participants in Yibin, Sichuan Province, China
Max speed	70 km/h	Typical speed limit for separated busways (Source: APTA RP-BRT-003-10 | Designing Bus Rapid Transit Running Ways). Standing passengers not typically allowed past this speed limit.	70kph	Typical speed limit for separated busways (Source: APTA RP-BRT-003-10 | Designing Bus Rapid Transit Running Ways). Standing passengers not typically allowed past this speed limit.	70kph	Based on MAX Light Rail - Typical speed limit for separated busways (Source: APTA RP-BRT-003-10 | Designing Bus Rapid Transit Running Ways). Standing passengers not typically allowed past this speed limit.	70km/h	CRRC,2019. *ART Integration Application*
Optimum frequency	4-10 minutes	PTA Bus Priority Flyer, PTA Bus Planning and Design Guidelines for Efficient People Movement	3-5 minutes	Brisbane busway (difficult to maintain service reliability due to factors such as bunching beyond this frequency)	5-minutes	Based on MAX Light Rail	4-5 minutes	Vuchic V, 2007 Urban Transit Systems and Technology Based on review of frequencies on Sydney light rail

Typical characteristic	Bus priority		Bus rapid transit		Light rail transit/ tram		Trackless tram	
	Specification	**Source/ Reference**	**Specification**	**Source/ Reference**	**Specification**	**Source/ Reference**	**Specification**	**Source/ Reference**
Typical cross section required	3.65m per lane (desirable) 3.5m min	Source: NACTO BUS RAPID TRANSIT SERVICE DESIGN GUIDELINES	10m corridor assuming separation between general traffic	Brisbane Busway	8m for main line Will vary on side vs centre ole 11 -15m Depending on median or center platforms.	Canberra Light Rail	13m	Based on 3.83m minimum lane widths and assuming separation between TT and barrier to general traffic.
Maximum turning radius	Single: 12.5m Articulated: 19m	Austroads	Single: 12.5m Articulated: 19m	Austroads	N/A	N/A	15m	CRRC,2019. *ART Integration Application*
Maximum gradient	13%	Affordable Mass Transit Guidance (Commission for Integrated Transport, 2005)	13%	Affordable Mass Transit Guidance (Commission for Integrated Transport, 2005)	10%	Affordable Mass Transit Guidance (Commission for Integrated Transport, 2005)	13%	CRRC,2019. *ART Integration Application*
Optimum stop spacing	300-400m*	Department of Transport, Public Transport Guidelines for land use and development	800-1000m*	Currie G; Delbosc, A. (2013) Assessing bus rapid transit system performance in Australasia	250-1000m*	Canberra Urban and Regional Futures, University of Canberra Vuchic V, 2007 Urban Transit Systems and Technology	250-1000m*	Inferred from other mode comparisons.
Case study/ recommended example	Beaufort Street Bus Priority Infrastructure Program TfNSW	N/A	Auckland North Shore busway, Brisbane busways, Sydney North west Transitways	N/A	MAX LRT, Gold Coast Light Rail Stage 2	N/A	Trialled in Yibin, China Zhuzhou, China (trials) Qatar (trials)	N/A
Walkable catchment/ Zone of influence	400m	TfNSW, Integrated Public Transport Service Planning Guidelines, Table 9	Higher density potential compared to standard bus service but less than LRT	DoPLH, Perth Light Rail Study, 2007	Higher density and placemaking potential than BRT due to provision of more permanent infrastructure	DoPLH, Perth Light Rail Study, 2007	800-1000m (similar to Trams/BRT)	Inferred from other mode comparisons.

Typical characteristic	Bus priority		Bus rapid transit		Light rail transit/ tram		Trackless tram	
	Specification	**Source/ Reference**	**Specification**	**Source/ Reference**	**Specification**	**Source/ Reference**	**Specification**	**Source/ Reference**
Precinct density	Lower density	DoPLH, Perth Light Rail Study, 2007	Higher density potential compared to standard bus service but less than LRT	DoPLH, Perth Light Rail Study, 2007	Higher density and placemaking potential than BRT due to provision of more permanent infrastructure	DoPLH, Perth Light Rail Study, 2007	Higher density and placemaking potential than BRT due to provision of more permanent infrastructure and accessibility.	Inferred from other mode comparisons and assessment
Pros: Cons:	Flexibility, relatively low capital cost Capacity, low potential for development surrounding stop, speed		Speed, flexibility Low potential for development and density,		Reliability, potential for development and surrounding density Flexibility		Reliability, potential for low capital cost transit corridor and positive land use benefits. High flexibility and ride quality. There are still a large number of items that need refinement and further technical understanding prior to application in an Australian context these are: - Pavement impacts and costs - Depot and stabling requirements - Platform gap (currently not DDA compliant and not sure if the vehicle has technical capacity to close this gap). - Only one manufacturer CRRC. - Further information on inertia management system and ride quality, indicative that ride quality is highly dependent on pavement surface quality. Arup are currently in conversations with CRRC's technical division and are hoping to facilitate further discussion to work through outstanding issues for application of this technology in an Australian context.	

*dependent on context i.e. networks operating within high density metropolitan areas may be more efficient with closer stops, while within low density regions stops further apart increase efficiency.

7.2 Non-capital-intensive options

Non-capital-intensive initiatives were also considered to address the defined problems and capture opportunities within the study area along with complementing the chosen capital option. Given the size, complexity and sheer nature of the problems and opportunities related to connectivity and congestion within the study area, it was considered unlikely that any single non-capital initiative would address all of the objectives, especially when deliverability is taken into account. Therefore, the assessment was designed to sift through a long list of potential non-capital initiatives and determine a shorter list that could be implemented as complementary measures to the Short List of capital options. It should be noted however that non-capital options and their complementary benefits to the capital options proposed have not been investigated in detail at this stage and are recommended for future stages.

Numerous non-capital initiatives were considered within the study, including regulatory reforms, governance reforms and better asset use reforms as per the Infrastructure Australia Assessment Framework presented in the table below.

Non-capital-intensive options		
Regulatory reform:	**Governance reform:**	**Better asset use reform:**
• Regulatory or access regimes • Market structures and frameworks • Safety and environmental standards • Licensing • Land use and planning controls.	• Administrative and institutional frameworks • Project appraisal and selection processes • Public service delivery processes • Approval processes • Coordination processes • Contractual provisions • Funding agreements.	• Active management systems • Intelligent transport systems • Smartcards • Smart metering • Economic charging • Demand management.

8 Long List development and assessment

8.1 Summary

Following agreement of the project objectives and criteria and a review of the key opportunities and constraints in the study area, a Long List of corridor route options was developed and assessed collaboratively with stakeholders.

Following agreement of the Long List options, all were assessed against the already agreed assessment criteria as part of the Multi-Criteria Analysis (MCA). An output of this assessment stage was the confirmed Short List options. A total of 2 options were confirmed as the Short List and were progressed to the next stage of assessment.

8.2 Long List option development

On 21 April 2020, a workshop was undertaken with the TRG, PT and CT to develop a list of potential corridors/ alignments for assessment – referred to as the *Long List options*. For the purposes of the Long List, stakeholders were asked to consider alignment options and provide commentary on the justification for these routes based on land use outcomes, unlocking of potential catchments and physical corridor constraints, noting that modes would be considered at the Short List stage. Therefore, the identified potential Long List options were deemed as 'mode agnostic'.

The workshop materials including agenda, slides and minutes are contained in **Appendix B.**

In addition to providing the project objectives to guide the option development, the following key guiding principles were provided to stakeholders for this process:

- Travel time should be favourable when compared to private motor vehicle use
- The end points are not completely fixed – though desirable to connect Fremantle train station & Murdoch train station
- It is assumed that private vehicle access must be maintained where it is currently provided
- High Street between Stirling Street and Carrington Street is 'out of play' and cannot be considered as part of an alignment (under development already as part of the WA governments "congestion busting" plan to improve efficiencies for freight traffic)
- The section immediately west of the freeway (hospitals and Murdoch University should align with the planning already done by Murdoch Activity Centre (MAC)
- Where reasonable, locations with high density or up zoning potential should be incorporated into the alignment (e.g. St Ives, Knutsford, Beaconsfield).

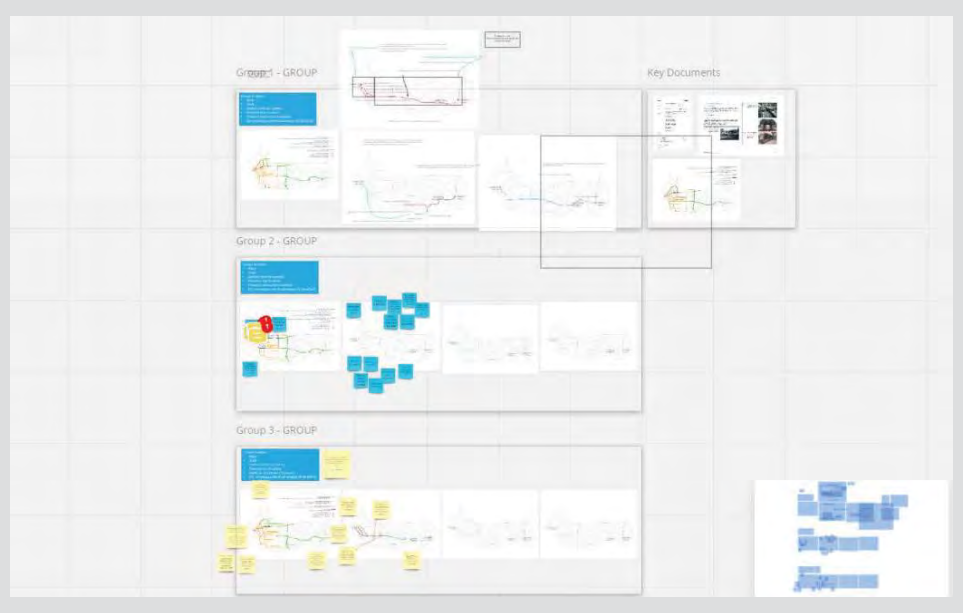


Figure 23 – Workshop 2 photo – Long List option development

A total of 19 Long List infrastructure options were assessed against the defined MCA metrics. The confirmed Long List options for assessment are shown in Table 20 and Figure 24.

Table 20 – Long List options (mode agnostic)

Option #	Description
1	Murdoch - Kardinya - Fremantle, Marine Terrace alignment via South Street
2	Murdoch - Kardinya - Fremantle, South Terrace alignment via South Street
3	Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via South Street
4	Murdoch - Kardinya - Fremantle, Marine Terrace alignment via Murdoch University & South Street
5	Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University & South Street
6	Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University & South Street

7	Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, Carrington Street, Marmion Street, Vale Street, James Street & Beach Street
8	Murdoch - Kardinya - Fremantle, Marine Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street
9	Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street
10	Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street
11	Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street & Lefroy Road
12	Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Lefroy Road & Solomon Street
13	Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Lefroy Road & York Street
14	Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Marmion Street, Vale Street, James Street & Beach Street
15	Murdoch – Kardinya – Fremantle, South Terrace alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Brennan Street & Wray Avenue
16	Murdoch - Kardinya - Fremantle, Queen Street alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Knutsford Street & Holdsworth Street
17	Murdoch - Kardinya - Fremantle, Queen Street alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Hampton Road, Knutsford Street & Holdsworth Street
18	Murdoch – Fremantle, Marine Terrace alignment via Murdoch University, Farrington Street, North Lake Road, Winterfold Road, Carrington Street & South Street
19	Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Hampton Road, James Street & Beach Street

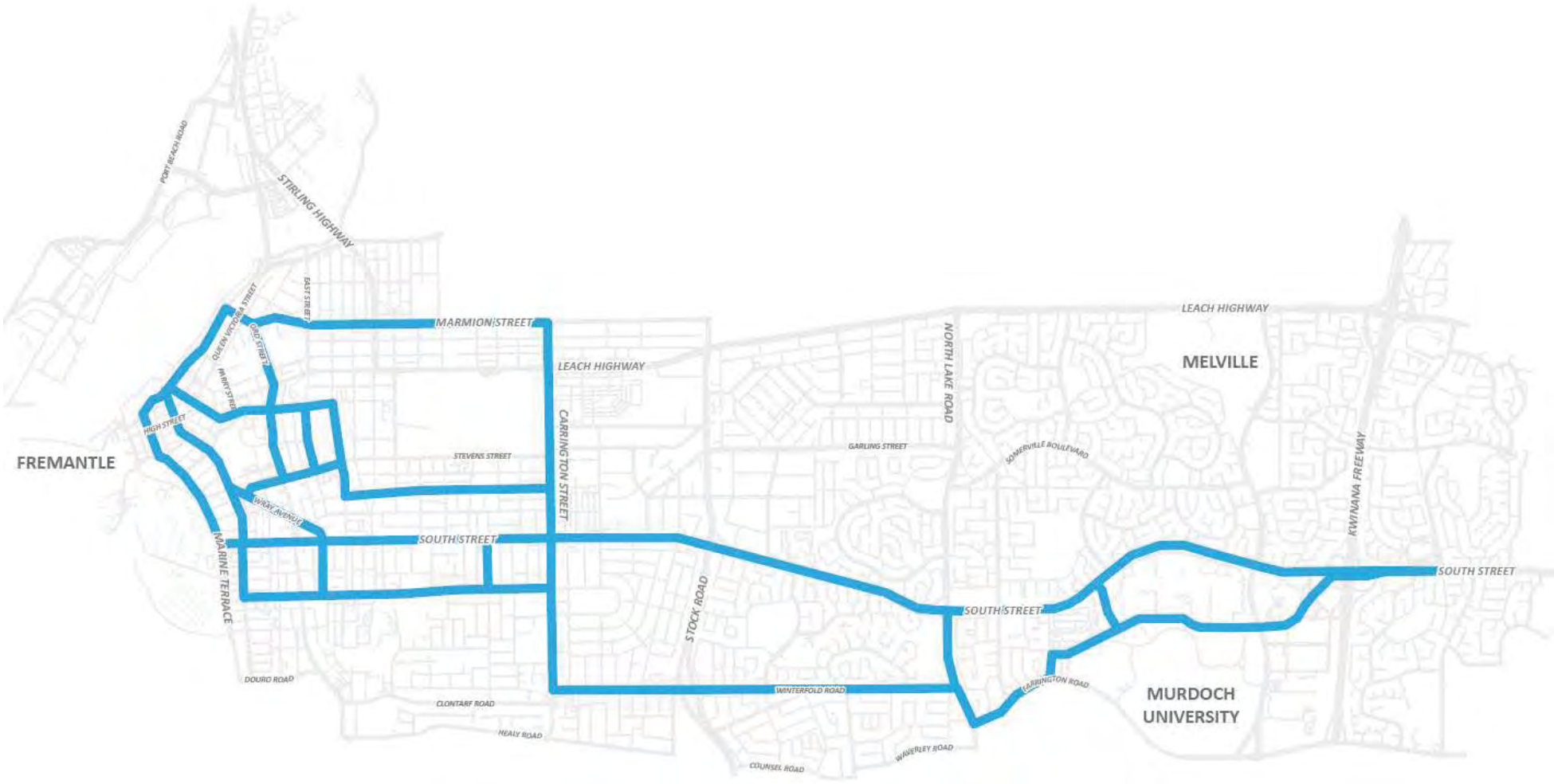


Figure 24 – Study area coverage of the 19 agreed Long List options

8.3 Multicriteria analysis (MCA)

Multi-Criteria Assessment for the 19 Long List options was undertaken concurrently across two separate streams, with Arup completing the Engineering and Transport Planning criteria assessment and the PT undertaking the Urban Planning and Community, Economics and Environmental/ Heritage criteria. Given the extent and contrast in context across the study area, the assessment for each alignment was divided into three sections, defined below and shown in Figure 25:

Section 1: Eastern (Bull Creek Shopping Centre to North Lake Road)

Section 2: Central (North Lake Road to Carrington Street)

Section 3: Western (Carrington Street to Fremantle Station).

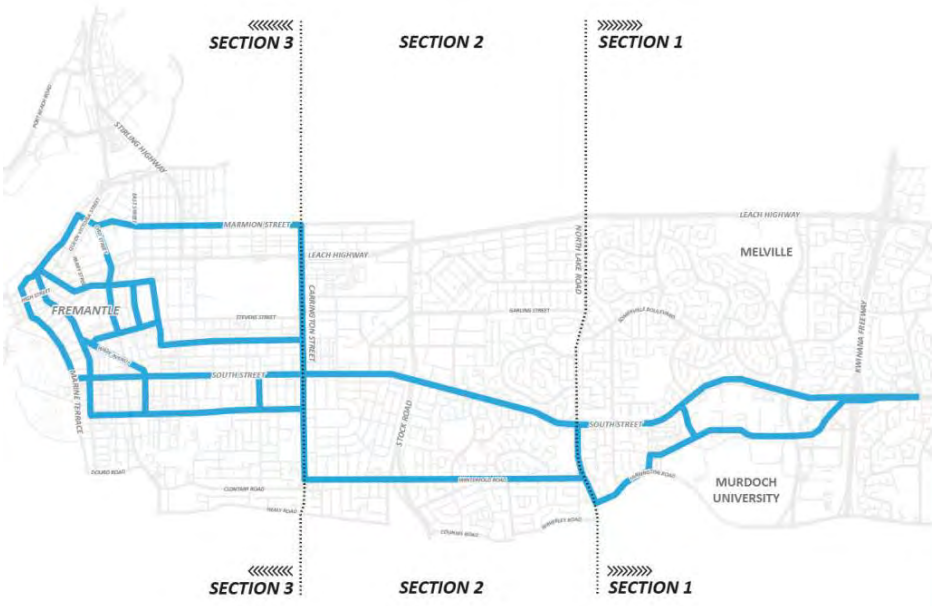


Figure 25 – Assessment sections

The TC undertook the initial assessment, refining the 19 Long List options against purely engineering criteria down to 4 options. The MCA was agreed and finalised by stakeholders to arrive at these remaining 4 options, interpolated from the results shown in Table 21.

Following the external assessment period, the MCA was merged and further assessment and scoring of the remaining 4 options was undertaken during a 2-hour workshop between the PT and TC on 4 June 2020. This final assessment was based purely on land use, which further refined the progressed options to a final and agreed 2 Short List options. The sifting processes to arrive at the Short List options is depicted in Figure 26

Results of this analysis is shown in Table 23.

The agreed criteria used in the assessment of all options has been provided in **Appendix C**.

Figure 26 – Process for sifting and refining Long List options

Table 21 – Long List Multi-Criteria Analysis (MCA)

Option	Section 1 (Bull Creek Shopping Centre to North Lake Road)	Section 2 (North Lake Road to Carrington Street)	Section 3 (Carrington Street to Fremantle Station)	Progression to land use refinement process
Option 1: Murdoch - Kardinya - Fremantle, Marine Terrace alignment via South Street				✗ Eliminated at Long List Stage
Option 2: Murdoch - Kardinya - Fremantle, South Terrace alignment via South Street				✗ Eliminated at Long List Stage
Option 3: Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via South Street				✗ Eliminated at Long List Stage
Option 4: Murdoch - Kardinya - Fremantle, Marine Terrace alignment via Murdoch University & South Street				✓ Proceed to land use refinement process
Option 5: Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University & South Street				✓ Proceed to land use refinement process
Option 6: Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University & South Street				✓ Proceed to land use refinement process
Option 7: Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, Carrington Street, Marmion Street, Vale Street, James Street & Beach Street				✗ Eliminated at Long List Stage
Option 8: Murdoch - Kardinya - Fremantle, Marine Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street				✗ Eliminated at Long List Stage
Option 9: Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street				✗ Eliminated at Long List Stage
Option 10: Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University, South Street, North Lake Road, Winterfold Road & Carrington Street				✗ Eliminated at Long List Stage
Option 11: Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street & Lefroy Road				✗ Eliminated at Long List Stage

Option	Section 1 (Bull Creek Shopping Centre to North Lake Road)	Section 2 (North Lake Road to Carrington Street)	Section 3 (Carrington Street to Fremantle Station)	Progression to land use refinement process
Option 12: Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Lefroy Road & Solomon Street				✗ Eliminated at Long List Stage
Option 13: Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Lefroy Road & York Street				✗ Eliminated at Long List Stage
Option 14: Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, North Lake Road, Winterfold Road, Carrington Street, Marmion Street, Vale Street, James Street & Beach Street				✗ Eliminated at Long List Stage
Option 15: Murdoch – Kardinya – Fremantle, South Terrace alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Brennan Street & Wray Avenue				✗ Eliminated at Long List Stage
Option 16: Murdoch - Kardinya - Fremantle, Queen Street alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Knutsford Street & Holdsworth Street				✓ Proceed to land use refinement process
Option 17: Murdoch - Kardinya - Fremantle, Queen Street alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Hampton Road, Knutsford Street & Holdsworth Street				✗ Eliminated at Long List Stage
Option 18: Murdoch – Fremantle, Marine Terrace alignment via Murdoch University, Farrington Street, North Lake Road, Winterfold Road, Carrington Street & South Street				✗ Eliminated at Long List Stage
Option 19: Murdoch - Kardinya - Fremantle, Elder Place alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Stevens Street, Hampton Road, James Street & Beach Street				✗ Eliminated at Long List Stage

8.3.1 Key refinement areas

As shown in the MCA process, the refinement process was undertaken in each of the three sections based on distinguishing factors unique to each Long List option. In the refinement of the Long List options and the selection of Short List options, the following distinguishing factors, as listed below, were considered:

- Murdoch University or South Street alignment (Section 1)
- South Street or Farrington Road and/ or Winterfold Road alignment (Section 2)
- Travelling through the Fremantle Activity Centre or approaching Fremantle Station from the north (Section 3)
- Marine Terrace or South Terrace and Wray Avenue approach to Fremantle Station (Section 3).

8.3.1.1 Murdoch University, South Street or Farrington Road alignment (Section 1)

Options that travelled through the Murdoch University campus tended to score higher in the MCA process than options with a South Street or Farrington Road alignment due to a number of factors. These factors include:

- Previous work has already been undertaken in futureproofing and securing the university campus as a corridor for a potential mass transit solution
- A university alignment would capitalise further on student patronage by providing central stops/ stations
- Based on the agreed options, a university alignment secures a corridor through the St John of God/ Fiona Stanley hospital precinct
- Avoids impacts to the aboriginal heritage site listed on the northern boundary of Murdoch University and Lodged site: S02772 Murdoch Drive camp
- A Murdoch University or South Street alignment would avoid the environmentally sensitive area of Beeliar Regional Park and extents of Bibra Lake.

Based on these metrics, with particular consideration to the potential impact to both the culturally and environmentally sensitive areas of Beeliar Regional Park and Bibra Lake, all alignments that were proposed to operate on Farrington Road were not progressed to Short List stage. Options along South Street were also not progressed, being less desirable due to the limited potential of capturing future residential and commercial land uses within the Murdoch University campus and not aligning with the City's vision.

8.3.1.2 South Street or Winterfold Road alignment (Section 2)

Options that ran along South Street tended to score higher in the MCA process than the options with a Winterfold Road alignment due to a number of factors. These factors include:

- Limited space available within the Winterfold Road corridor compared to a more generous cross section within the South Street cross section
  - Winterfold Road unlikely to accommodate all mode's cross-sectional requirements without total reallocation of existing traffic lanes and disruption to the network (significantly between Anglesey Drive and North Lake Road and between Stock Road and Carrington Street) for the development of better stop/ station outcomes, amenity for waiting passengers and complementary active transport linkages.
  - 2041 ROM volume/ capacity forecasts suggest that Winterfold Road will be operating at high or over-capacity during both the AM and PM peaks compared to South Street's operation, as shown in the table below.

    Table 22 – Winterfold Road and South Street 2041 peak hour and daily volume/ capacity constraints

	AM peak hour		PM peak hour		Daily
Location	**East**	**West**	**East**	**West**	
South Street (W of Plane Tree Grove) Options: 1, 2, 3, 4, 5, 6, 7, 15, 16, 17, 19	71%	61%	71%	61%	68%
Winterfold Road Options: 8, 9, 10, 11, 12, 13, 14, 18	101%	87%	100%	87%	97.8%

    Based on these forecasts, reallocation of traffic lanes and associated disruption would likely result in capacity issues on the network on and surrounding Winterfold Road. On the contrary, a South Street alignment is likely to allow full operation of the service within the median with no or limited reallocation of the existing traffic lanes or disruption. Despite the capacity of the service to convert vehicle trips to public transport on Winterfold Road, it is likely that a South Street alignment would incur less capacity constraints along its corridor while improving the condition of Winterfold Road by converting vehicle trips to public transport.
- A South Street alignment is likely to lead to the consolidation of a number of existing bus routes, allowing the services to be better utilised on other parts of the PTA network
- Despite a Winterfold Road alignment servicing a higher number of existing dwellings within a 400m catchment, a South Street alignment would secure a stop/ station adjacent to the proposed

Kardinya Activity Centre and associated patronage, leading to a better land use outcome and accompanied precinct activation.

Based on these metrics, all alignments that were proposed to operate on Winterfold Road were not progressed to Short List stage.

8.3.1.3 Travelling through the Fremantle Activity Centre or approaching Fremantle Station from the north (Section 3)

Options that approached Fremantle Station through the Fremantle Activity Centre tended to score higher in the MCA process than the options that approached the terminus from the north due to a number of factors. These higher scoring options were those that approached either along Marine Terrace, South Terrace (and Wray Avenue) and Queen Street rather than those proposed on Beach Street/ Elder Place. Factors impacting the refinement process included:

- Alignments that approached through the Fremantle Activity Centre achieved a more direct route with less complex, 90-degree manoeuvres through already constrained intersections and scored higher in the Long List MCA process
- Alignments running through the Fremantle Activity Centre likely to lead to higher precinct activation, value uplift and patronage forecasts, scoring higher in the Long List MCA process
- Relatively flat gradient achieved through the activity centre, leading to higher accommodation potential for various modes.

Based on these metrics, all alignments that approached Fremantle Station from the north, via James Street and Elder Place, were not progressed to Short List stage.

8.3.1.4 Marine Terrace or South Terrace and Wray Avenue approach to Fremantle Station (Section 3)

Options that approached Fremantle Station on South Terrace and Wray Avenue tended to score higher in the MCA process than options that approached the terminus on Marine Terrace due to the following factors:

- Higher potential patronage catchment achieved on a South Terrace and Wray Avenue in comparison to Marine Terrace. A Marine Terrace alignment, while it offers a higher availability of space within the existing cross section, has a limited catchment due to the proximity of the coastline and land uses typically not associated with public transport such as private sailing clubs and maritime services
- Based on the City of Fremantle vision, the Marine Terrace alignment was considered undesirable as it does not capitalise on and service the development opportunities at Fremantle Hospital and Fremantle Oval.

Given these reasons, all options that included a Marine Terrace alignment, while still considered for Short List progression, were considered undesirable to a South Terrace or South Terrace/ Wray Avenue approach.

8.3.2 Land use refinement process

Following the progression of 4 Long List options based on a purely engineering constraints assessment process, a land use refinement process was undertaken to further refine the options to a suitable Short List for further investigation.

The MCA was agreed and finalised by stakeholders to arrive at these remaining 4 options, interpolated from the results shown in Table 23.

Table 23 – Land use refinement process

Option	Section 1 (Bull Creek Shopping Centre to North Lake Road)	Section 2 (North Lake Road to Carrington Street)	Section 3 (Carrington Street to Fremantle Station)	Progression to land use refinement process	Key reasoning/ justification
Option 4: Murdoch - Kardinya - Fremantle, Marine Terrace alignment via Murdoch University & South Street				✗ Eliminated at Long List Stage	Option 4 was not progressed to Short List stage as it: • Does not align with the City of Fremantle vision of servicing land development opportunities at Fremantle Oval and Fremantle Hospital • Is likely to capture a smaller catchment due to its coastline alignment.
Option 5: Murdoch - Kardinya - Fremantle, South Terrace alignment via Murdoch University & South Street				✓ Proceed to Short List Stage	Agreed to progress through to Short List Stage as it: • Likely to be supported by Murdoch University and City of Fremantle as it aligns with preferred and planned routes within the campus and adjacent to development opportunities at Fremantle Oval and Hospital • Likely to lead to desired land intensification along corridor • Likely to incur limited number of private property acquisitions adjacent to the corridor.
Option 6: Murdoch - Kardinya - Fremantle, South Terrace (Wray Avenue) alignment via Murdoch University & South Street				✓ Proceed to Short List Stage	Agreed to progress through to Short List Stage as it: • Likely to be supported by Murdoch University and City of Fremantle as it aligns with preferred and planned routes within the campus and adjacent to development opportunities at Fremantle Oval and Hospital • Likely to lead to desired land intensification along corridor • Likely to incur limited number of private property acquisitions adjacent to the corridor.
Option 16: Murdoch - Kardinya - Fremantle, Queen Street alignment via Murdoch University, South Street, Carrington Street, Watkins Street, Edmund Street, Knutsford Street & Holdsworth Street				✗ Eliminated at Long List Stage	While considered as a less intrusive and of a lower capital cost compared to the progressed options, Option 16 has not progressed through to Short List stage as it: • Does not provide certainty from a transport and land development perspective with the introduction of less permanent public transport infrastructure • Does not provide a step towards high quality public transport such as LRT or TT due to its geometry constraints.

9 Short List development and assessment

9.1 Summary

Following the Long List MCA process, 2 Short List options were identified for further consideration as shown below.

Option 5

This alignment proposes a service that runs westbound on South Street from Bull Creek Shopping Centre across the Kwinana Freeway bridge before turning into Barry Marshall Parade and entering the Murdoch University campus on Discovery Way, following the Murdoch University Perth Campus Strategic Masterplan alignment before re-entering South Street and heading westbound towards Fremantle. At South Terrace, the service then proposes to head north towards Fremantle Station, dissecting the Fremantle "Cappuccino Strip" and entering the station precinct via Market Street.

Option 6

This alignment proposes a service that runs westbound on South Street from Bull Creek Shopping Centre across the Kwinana Freeway bridge before turning into Barry Marshall Parade and entering the Murdoch University campus on Discovery Way, following the Murdoch University Perth Campus Strategic Masterplan alignment before re-entering South Street and heading westbound towards Fremantle. The service then proposes to head north on Wray Avenue, before connecting with South Terrace and running along the Fremantle "Cappuccino Strip" and entering the station precinct via Market Street.

The agreed Short List options were then advanced to early feasibility concept designs prepared by Arup. This stage also included confirmation of station locations and hierarchy which were consistent for each of the modes as agreed with the TRG.

High-level costs benefits were developed by SWG for each of the Short List options in order to prepare preliminary BCRs.

9.2 Mode type

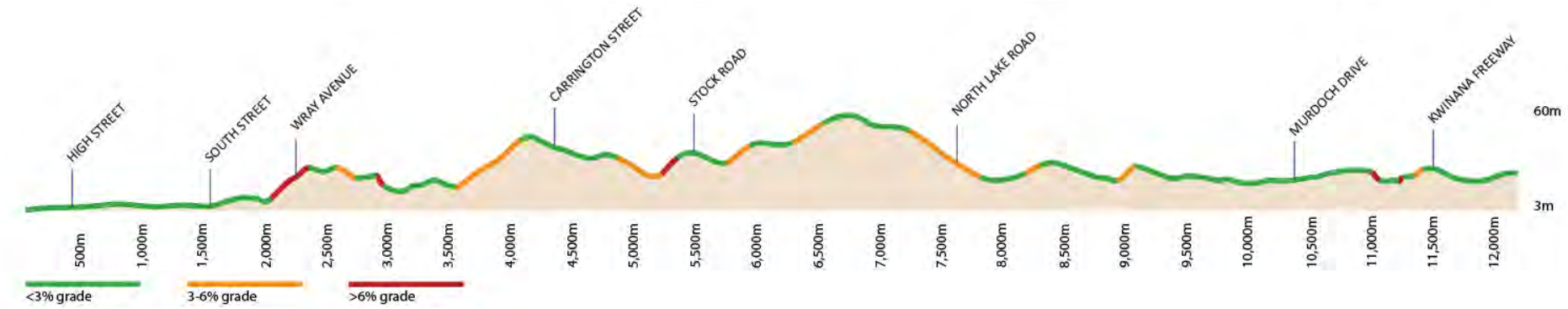
As discussed in Section 7.1, two mode options have been considered for the service:

- TT
- LRT.

Given the similarities in characteristics respective to both TT and LRT (refer to Table 19), including associated catchment and land development potential, both modes are recommended to be considered further for each Short List option.

Based on existing corridor use, corridor width, constructability of intersections and vertical gradient, an assessment of each option based on their suitability to facilitate TT and LRT is provided below.

9.2.1 Option 5



Maximum road corridor width:

37m (South Street east of Windelya Road).

Minimum road corridor width:

11m (Market Street).

Length of route:

12.2km

Intersection/ geometric constraints:

Turning angle constraints have been identified at: South Street/ South Terrace intersection.

Recommended mode:

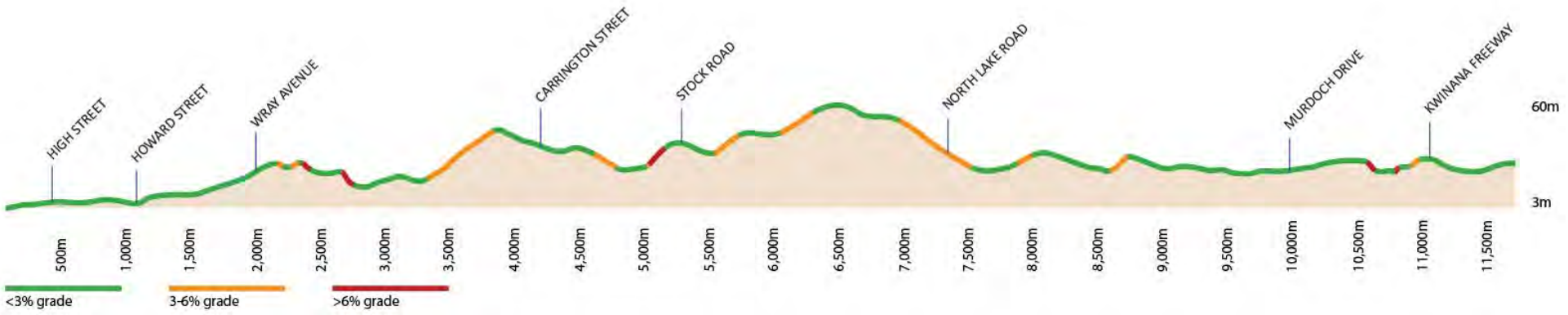
TT or LRT

Option 5 consists of a generally straight alignment within a wide road corridor for the majority of the route (Section 1 and Section 2). With the additional benefit of consisting of only two 90-degree angle turns (Murdoch University/ South Street and South Street/ South Terrace) the constructability and operational difficulty of a TT or LRT vehicle would be minimised. It is likely however that given existing corridor constraints within Fremantle, particularly along Market Street between High Street and Bannister Street, a TT or LRT service would require reallocation of existing traffic use to other parts of the network. Despite the existing corridor and intersection constraints, the land use outcome potential of a TT or LRT service would likely bring additional benefits and outweigh problems associated with the redistribution of traffic and constructability.

Given gradient constraints have not yet been fully investigated as part of this stage, it cannot be determined whether TT or LRT is more suitable for the corridor. This should be investigated in more detail further to this stage. However, based on initial investigation, while the majority of the route remains under a 3% grade, those sections identified above this grade will require further investigation of potential solutions.

It should also be noted that a BP or BRT solution, or a combination of both modes, would also be suitable for this corridor. However, the lower capital cost associated with these modes are unlikely to generate the desired land use outcomes that would be expected from this corridor in comparison to a TT or LRT solution.

9.2.2 Option 6



Maximum road corridor width:

37m (South Street east of Windelya Road).

Minimum road corridor width:

11m (Market Street).

Length of route:

12km

Intersection/ geometric constraints:

No geometric constraints have been identified for intersections within this section.

Recommended mode:

TT or LRT

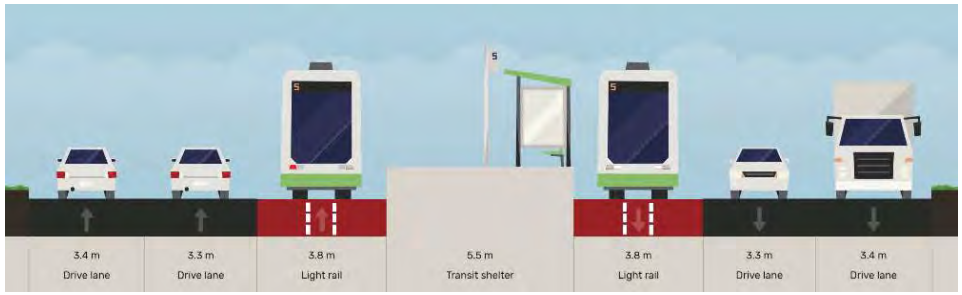
The Option 6 alignment is generally consistent with Option 5 but instead avoids the potentially constrained South Street/ South Terrace intersection and uses Wray Avenue between South Street and South Terrace. Given the same characteristics and the additional benefit of including the potentially less constrained intersections requiring a lower turning radius, it is recommended that this option is considered as a TT or LRT service.

Given gradient constraints have not yet been fully investigated as part of this stage, it cannot be determined whether TT or LRT is more suitable for the corridor. This should be investigated in more detail further to this stage. However, based on initial investigation, while the majority of the route remains under a 3% grade, those sections identified above this grade will require further investigation of potential solutions.

It should also be noted that a BP or BRT solution, or a combination of both modes, would also be suitable for this corridor. However, the lower capital cost associated with these modes are unlikely to generate the desired land use outcomes that would be expected from this corridor in comparison to a TT or LRT solution.

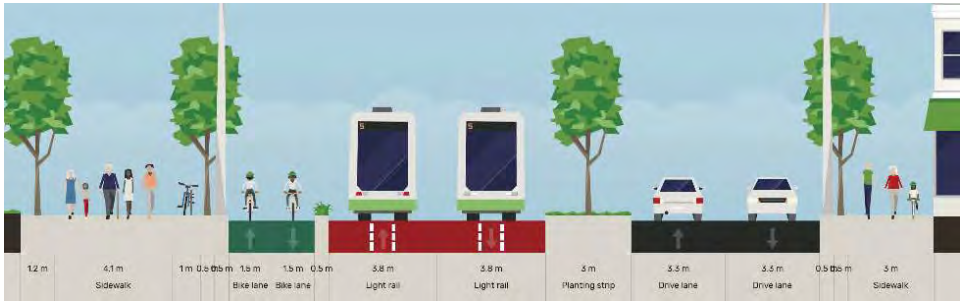
9.3 Cross sections

Typical cross sections achievable along the corridor will depend partly on the mode chosen but also the existing constraints and opportunities such as available road space, turning conflicts from side streets/ properties and desired place and amenity outcomes. The chosen cross section will also dictate the type of station/ stop type possible. It is also possible that any combination of these three cross-sections will be implemented along the corridor, dictated by the existing constraints and proposed station/ precinct outcome.



Median-running transit priority

- Uses existing road space and reduces mixed traffic by one lane in each direction
- Avoids conflict points with traffic turning to/ from side streets and properties
- Spatially efficient stations can be placed within the median serving both directions of travel.



Separated corridor transit priority

- Reconfiguration of road to run service down one side
- Enhances place and amenity outcomes along the corridor
- Opportunity to integrate with adjacent land use.

Kerbside-running transit priority

- Avoids pedestrian crossings between kerbside and median by direct boarding/ alighting onto sidewalk.

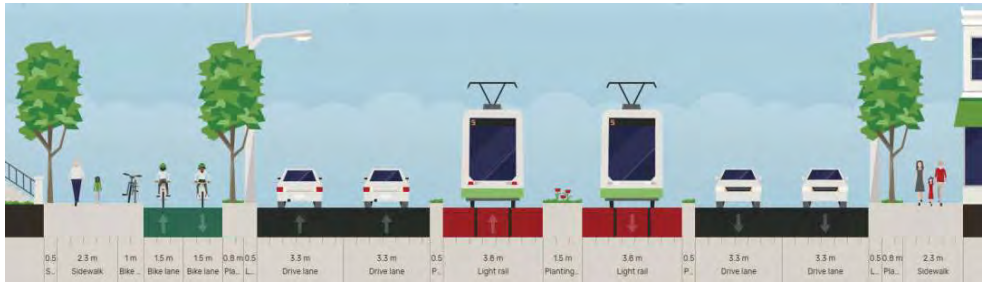
9.3.1 Option 5

Key assumptions:

- Median running TT/ LRT from Bull Creek Shopping Centre before entering the Murdoch Station precinct and existing bus interchange
- Separated corridor TT/ LRT within Murdoch Station precinct to avoid conflict with existing feeder bus operations
- Median running TT/ LRT upon exiting the Murdoch Station precinct and remains through Murdoch University, South Street and South Terrace to Norfolk Street
- On Market Street and South Terrace between Norfolk Street and High Street, the service operates in a dedicated corridor
- Corridor returns to a median running TT/ LRT corridor before entering the Fremantle Station precinct
- Service operates in a dedicated corridor upon entering the Fremantle Station precinct.

Cross Section 1: Dedicated corridor TT/ LRT cross-section (Market Street)

Cross Section 2: Median-running TT/ LRT cross-section (South Street)



Cross Section 3: Separated corridor TT/ LRT cross-section (Murdoch Station)

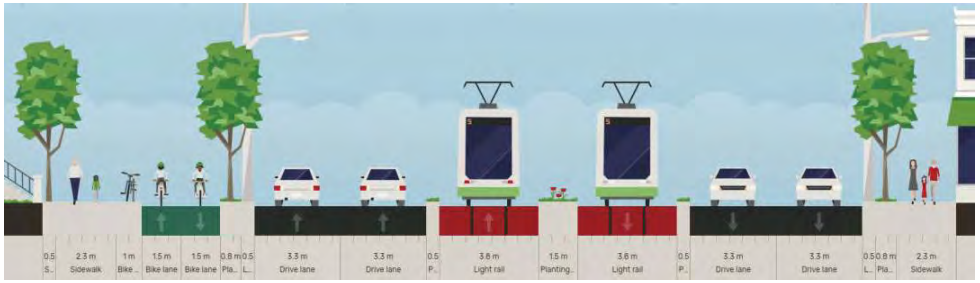
9.3.2 Option 6

Key assumptions:

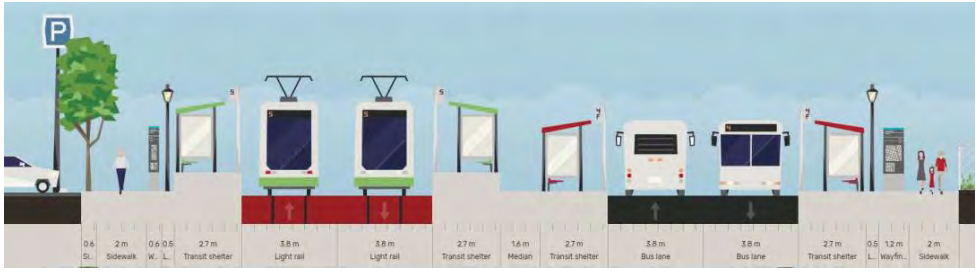
- Median running TT/ LRT from Bull Creek Shopping Centre before entering the Murdoch Station precinct and existing bus interchange
- Separated corridor TT/ LRT within Murdoch Station precinct to avoid conflict with existing feeder bus operations
- Median running TT/ LRT upon exiting the Murdoch Station precinct and remains through Murdoch University, South Street, Wray Avenue and South Terrace to Norfolk Street
- Between Norfolk Street and High Street, the service operates in a dedicated corridor
- Corridor returns to a median running TT/ LRT corridor before entering the Fremantle Station precinct
- Service operates in a dedicated corridor upon entering the Fremantle Station precinct.

Cross Section 1: Dedicated corridor TT/ LRT cross-section (Market Street)

Cross Section 2: Typical median-running TT/ LRT cross-section (South Street)



Cross Section 3: Separated corridor TT/ LRT cross-section (Murdoch Station)



9.4 Stop/ station location and type

9.4.1 Location

Potential station/ stop locations have previously been undertaken by an SWG commissioned joint study between Macroplan, Dimasi, Jacobs and LUTI Consulting in 2018. The outcome of the study recommended a total of 16 stations/ stops between the Bull Creek Shopping Centre and Fremantle Station and determined the characteristics of the node and rezoning opportunities. These outcomes have been provided in Table 24 and shown in Figure 27.

Figure 27 – Macroplan recommended alignment and stop/ station locations

Table 24 – Macroplan recommended alignment and stop/ station characteristics

ID	Stop/ Station	Through Distance	Characteristics	ID	Stop/ Station	Through Distance	Characteristics
1	Stockland Bull Creek District Shopping Centre	0.00km	North East Quadrant of Murdoch Activity Centre with Bull Creek Shopping Centre having 16,622sqm of retail floor space. Major redevelopment opportunity.	**9**	O'Connor	6.45km	O'Connor industrial area and Samson residential area

2	Murdoch Rail Station	0.70km	Busiest heavy rail station outside of the Perth CBD. New Medi-Hotel development in catchment as part of the Murdoch Health and Knowledge precinct	**10**	Hilton	7.70km	Just east of Carrington Road. Limited redevelopment
3	Marshall	1.5km	Just east of intersection of Barry Marshall Parade and Murdoch Drive to serve St john of God Murdoch Hospital, Fiona Stanley Hospital and Challenger Institute of Technology	**11**	Beaconsfield	8.90km	Lewington Street. Major redevelopment of Department of Housing residential land to R80 and redevelopment of Challenger TAFE site
4	Discovery 1	1.95km	On Discovery Drive west of Campus Drive to serve Murdoch University Development area and east campus	**12**	Hampton Road	9.80km	Corner Hampton Road and South Street. Mixed use
5	Discovery 2	2.45km	On Discovery Drive near Amenities Building to serve the main campus	**13**	Fremantle Hospital	10.80km	Fremantle Hospital with redevelopment opportunities from site and adjoining oval
6	St Ives	3.15km	On Discovery Drive near existing bus station serving students accommodation and St Ives retirement village	**14**	Market Street	11.30km	Near Collie Street. Commercial
7	Kardinya	4.35km	Kardinya Park Shopping Centre having 13,709sqm of retail floor space with major redevelopment opportunity	**15**	Fremantle Rail Station	11.80km	Major heavy rail station on edge of business district
8	Plane Tree Grove/ Samson	5.65km	Start of O'Connor mixed commercial and residential. Services Kardinya and Samson	**16**	South Quay	12.50km	On Beach Street near Fremantle Passenger Terminal with major redevelopment opportunities

As shown, the alignment investigated in previous work is almost in direct comparison to Short List Option 5. Given their similarities, the stop/ station locations and general characteristics investigated in the previous work will progress for the agreed Short List options in the case that they are located on the respective Short List option's alignment, do not interfere with subsequent work undertaken and no alternative location can be recommended in order to improve the service. This section recommends stop/ station locations for each Short List option, while providing a comparison to previous work and justifications for changes.

9.4.2 Stop/ station type and precinct activation

The current provision of stops along the corridor consist of kerbside bus bays with limited amenity and prominence for precinct creation or value uplift. Given the limited on-road or kerbside infrastructure required for the operation of BP, it is considered that this service could quite easily utilise the existing bus stops without requiring changes. However, with the introduction of a higher occupancy vehicle with a greater potential for precinct activation, stations and stops should be provided that reflect the surrounding environment and vision of the precinct created. For the remaining modes, three different station/ stop typologies are recommended:

- Neighbourhood Station
- Prominent Median Station
- Prominent Side Platform Station.

Canberra Light Rail

© Formswell

Neighbourhood Station

Generally located within the centre median, using the entire width of existing median where possible.

Preferred width: 4.8m

Minimum width: 4.4m

Preferred length: 50m

Minimum length: Length of vehicle (~31m)

Recommended within residential areas and physically constrained corridors found commonly throughout Fremantle (Section 3).

Yibin, China

Prominent median station

Generally classed as an ‘interchange’ or landmark station likely to attract high patronage within the network and is used to stimulate value uplift.

Preferred width: 10m

Preferred length: 100m

Recommended within key activity centres (Kardinya, Murdoch University, St John of God Hospital) and end of the line stations (Murdoch, Fremantle).

Cypress Avenue Light Rail Station, Gold Coast

© Around Oz

Prominent Side Platform Station

Station located on side of the road, rather than within the median. One platform could be used within the existing median.

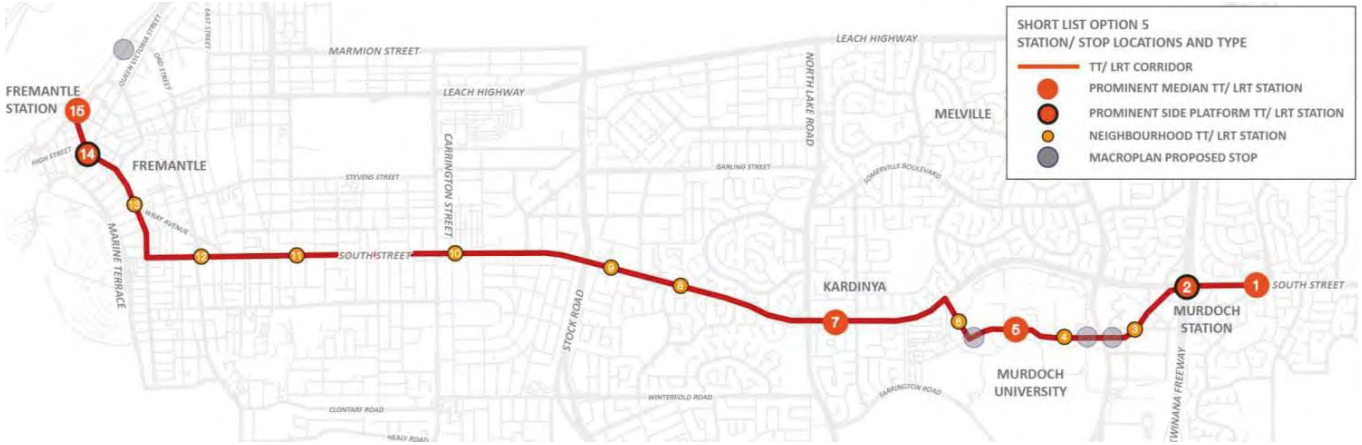
Minimum width of station and corridor: 18m

Minimum length: Length of vehicle (~31m)

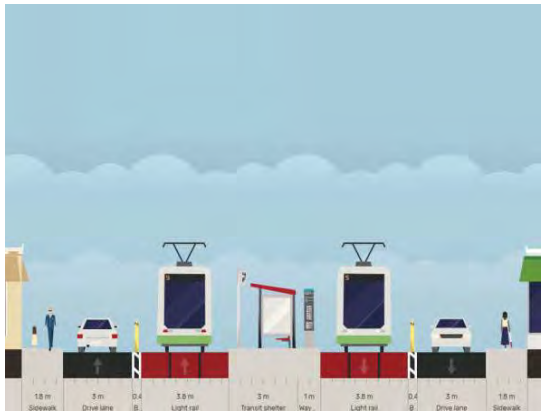
Preferred length: 50m

Recommended anywhere on the route where the service operates side by side and is not separated by a median.

9.4.3 Option 5



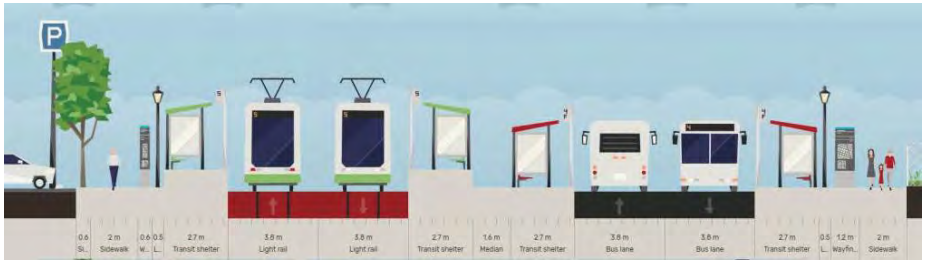
Neighbourhood TT/ LRT station cross-section (South Street, 10)



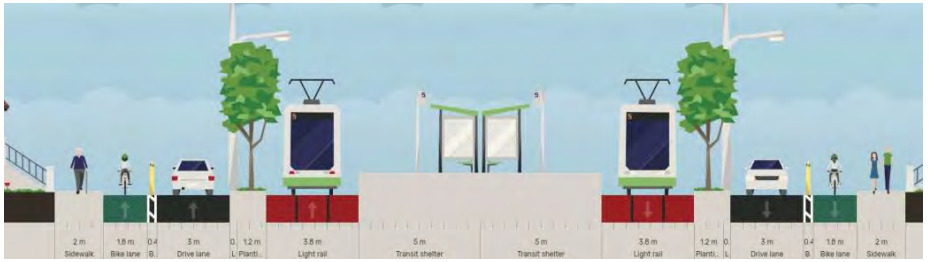
Recommended stop/ station locations and types for the Short List Option 5 have been shown above. Key changes to note from previous work include:

- Stop 3 has been relocated northeast on Barry Marshall Parade to achieve a more centrally located station within the St John of God and Fiona Stanley Hospital precinct
- Stop 4 and 6 have been relocated to reflect the Murdoch University Masterplan preferred LRT option
- Stop 16 has been removed to account for the termination of Option 5 at Fremantle Station
- Prominent median TT/ LRT stations have been proposed at both end-of-the-line stations (1 and 15) including central to Murdoch University (5) and adjacent to the Kardinya Park Shopping Centre (7)
- Prominent side platform TT/ LRT stations have been proposed at both the Murdoch Station precinct (2) and on Market Street/ South Terrace (14)
- Neighbourhood TT/ LRT stations have been proposed at other locations.

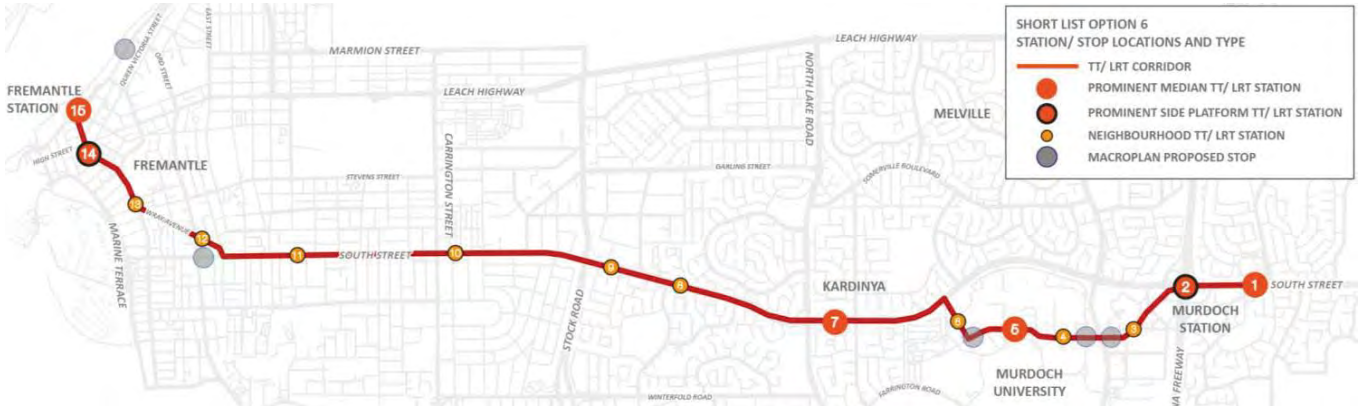
Prominent side platform TT/ LRT station cross-section (Murdoch Station, 2)



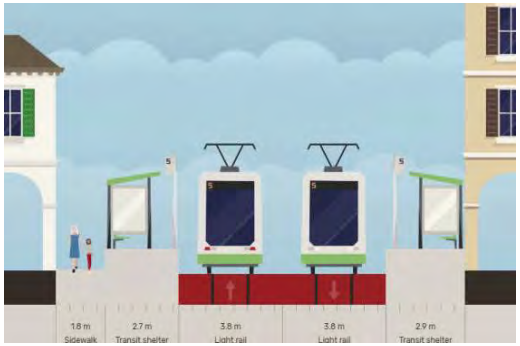
Prominent median TT/ LRT station cross-section (South Street, 7)



9.4.4 Option 6



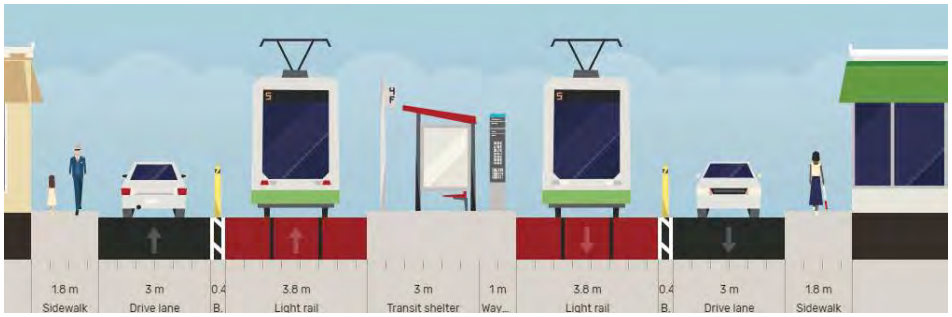
Prominent side platform TT/ LRT station cross-section (Market Street, 14)



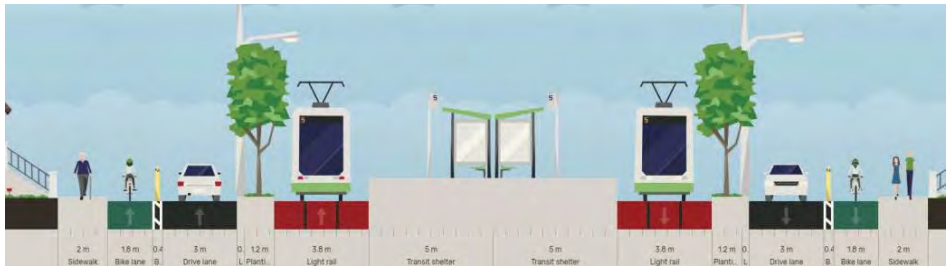
Recommended stop/ station locations and types for the Short List Option 6 have been shown above. Key changes to note from previous work include:

- Stop 3 has been relocated northeast on Barry Marshall Parade to achieve a more centrally located station within the St John of God and Fiona Stanley Hospital precinct
- Stop 4 and 6 have been relocated to reflect the Murdoch University Masterplan preferred LRT option
- Stop 12 has been relocated north to Wray Avenue adjacent to The Beaconsfield Hotel to account for the Wray Avenue section of the Option 6 alignment
- Stop 16 has been removed to account for the termination of Option 5 at Fremantle Station
- Prominent median TT/ LRT stations have been proposed at both end-of-the-line stations (1 and 15) including central to Murdoch University (5) and adjacent to the Kardinya Park Shopping Centre (7)
- Prominent side platform TT/ LRT stations have been proposed at both the Murdoch Station precinct (2) and on Market Street/ South Terrace (14)
- Neighbourhood TT/ LRT stations have been proposed at other locations.

Neighbourhood TT/ LRT station cross-section (South Street, 10)



Prominent median TT/ LRT station cross-section (South Street, 7)



9.5 Short List development

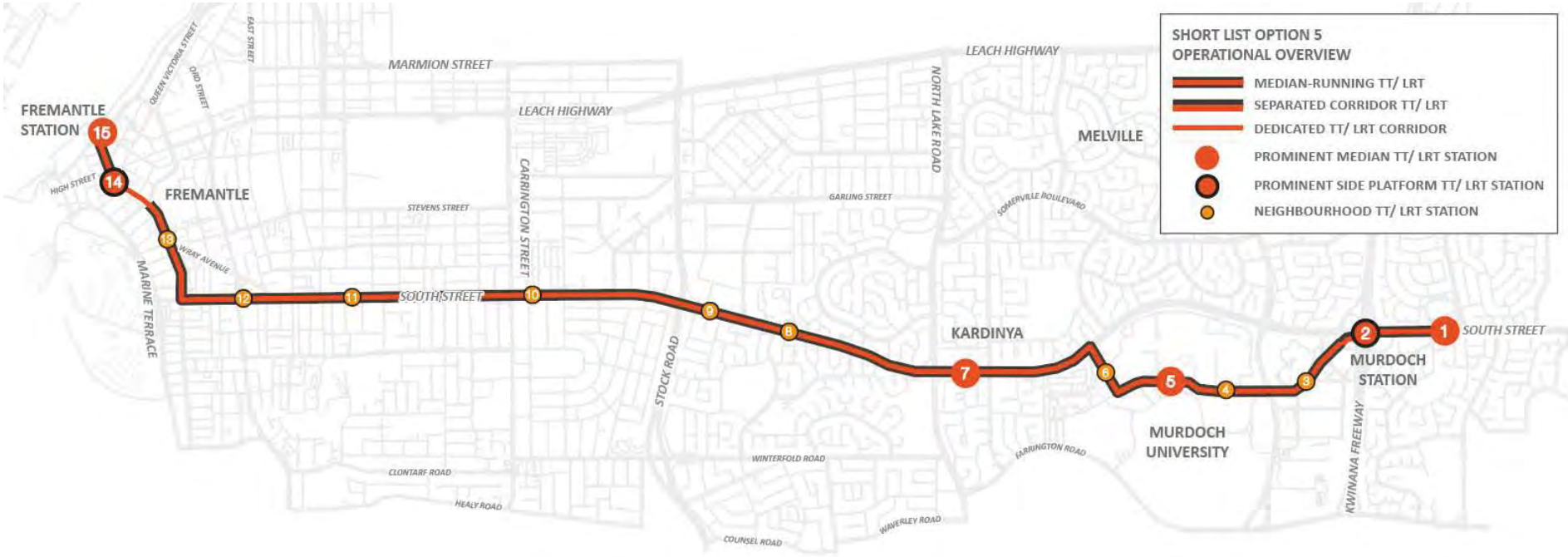
Following an evaluation of possible modes and mode combinations, typical cross sections along the alignment and stop/ station locations and types, an overall plan was developed for the agreed 2 Short List options by Arup in consultation with the PT. Summaries of the options are documented in this section and shown in Figure 28.

Figure 28 – Confirmed Short List options

Supplementary design information is contained in **Appendix D** including the following for each of the Short List options:

- Opportunities and constraints maps
- Long List MCA process
- Journey time assessment
- Long sections.

The preliminary designs were issued to the PT & TRG for comment and were subsequently finalised for this stage.



Key assumptions

- TT/ LRT from Bull Creek Shopping Centre to Fremantle Station – approx. 12km
- Median-running TT/ LRT between Bull Creek Shopping Centre and Murdoch Station – approx. 500m
- Separated corridor TT/ LRT between Murdoch Station and Barry Marshall Parade – approx. 400m
- Median-running TT/ LRT between Barry Marshall Parade and Norfolk Street – approx. 10.5km
- Dedicated TT/ LRT between Norfolk Street and High Street – approx. 400m
- Median-running TT/ LRT between High Street and Phillimore Street – approx. 300m
- Dedicated TT/ LRT on approach to Fremantle Station – approx. 50m.

Station typologies

- 4 prominent median TT/ LRT stations (Bull Creek Shopping Centre, Murdoch University (central), Kardinya Park, Fremantle Station)
- 2 prominent side platform TT/ LRT stations (Murdoch Station, Market Street)
- 9 neighbourhood TT/ LRT stations (Hospital, Murdoch University (east), Murdoch University (west), Plane Tree Grove, O'Connor, Hilton, Lewington Street, Hampton Road (South Street), South Terrace (Alma Street)).

Total one-way journey time – 26-minutes*

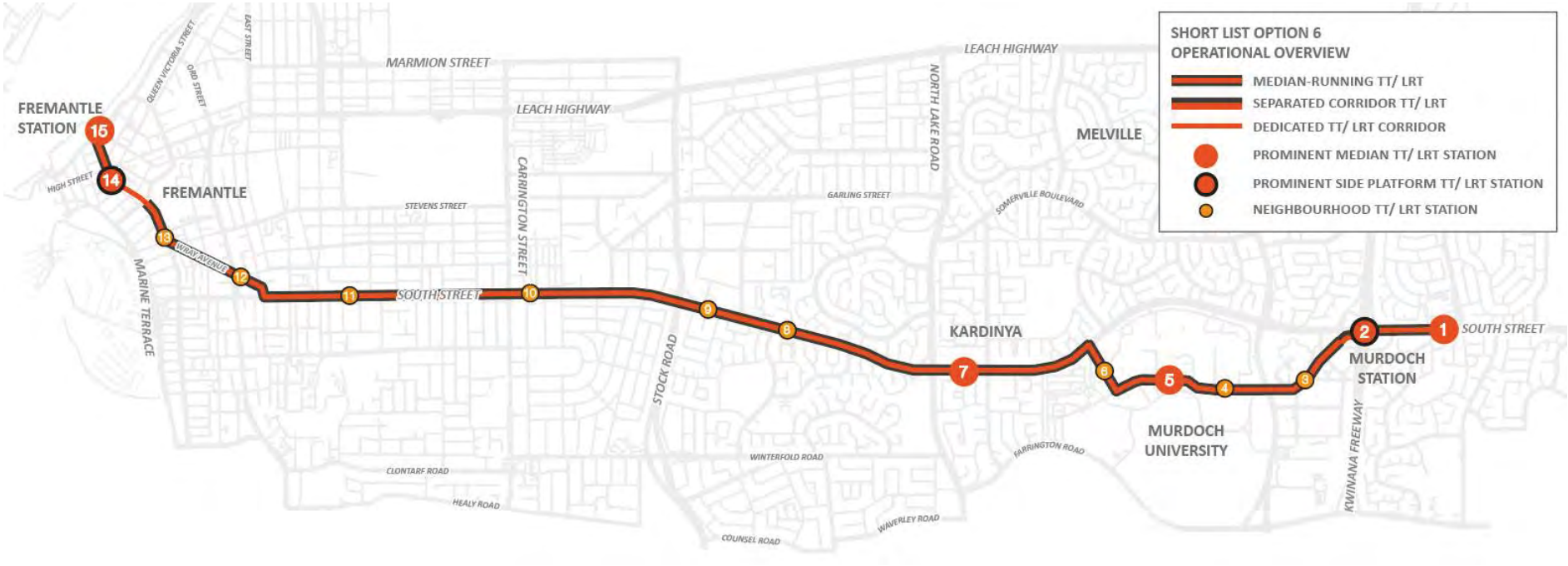
Average entire journey speed – 27kph

(Assumes station dwell times and acceleration/ deceleration time. Does not assume red-light delays).

*Despite the one-way journey time appearing long, this will only exist of passengers with a destination of Fremantle or Murdoch Station when travelling from the other end of the line. It should be considered that passengers using the service to transfer at either Murdoch or Fremantle to continue their journey, will travel from their origin to their closest respective terminus. In theory then, the longest passengers are likely to travel when factoring in a transfer at either Murdoch or Fremantle Station, is half this total travel time, i.e. 13-minutes.

All journey time assumptions have been included in **Appendix D.**

Figure 29 – Short List Option 5 overview



Key assumptions

- TT/ LRT from Bull Creek Shopping Centre to Fremantle Station – approx. 12km
- Median-running TT/ LRT between Bull Creek Shopping Centre and Murdoch Station – approx. 500m
- Separated corridor TT/ LRT between Murdoch Station and Barry Marshall Parade – approx. 400m
- Median-running TT/ LRT between Barry Marshall Parade and Norfolk Street – approx. 10.5km
- Dedicated TT/ LRT between Norfolk Street and High Street – approx. 400m
- Median-running TT/ LRT between High Street and Phillimore Street – approx. 300m
- Dedicated TT/ LRT on approach to Fremantle Station – approx. 50m.

Station typologies

- 4 prominent median TT/ LRT stations (Bull Creek Shopping Centre, Murdoch University (central), Kardinya Park, Fremantle Station)
- 2 prominent side platform TT/ LRT stations (Murdoch Station, Market Street)
- 9 neighbourhood TT/ LRT stations (Hospital, Murdoch University (east), Murdoch University (west), Plane Tree Grove, O'Connor, Hilton, Lewington Street, Hampton Road (Wray Avenue), South Terrace (Alma Street)).

Total one-way journey time – 26-minutes*

Average entire journey speed – 26.5kph

(Assumes station dwell times and acceleration/ deceleration time. Does not assume red-light delays).

*Despite the one-way journey time appearing long, this will only exist of passengers with a destination of Fremantle or Murdoch Station when travelling from the other end of the line. It should be considered that passengers using the service to transfer at either Murdoch or Fremantle to continue their journey, will travel from their origin to their closest respective terminus. In theory then, the longest passengers are likely to travel when factoring in a transfer at either Murdoch or Fremantle Station, is half this total travel time, i.e. 13-minutes.

All journey time assumptions have been included in **Appendix D.**

Figure 30 – Short List Option 6 overview

10 Preferred options

Options 5 and 6 have been determined as the preferred options in facilitating the largest increase in land use intensification and generating an uplift in patronage between the two activity centres of Murdoch and Fremantle, while linking new mixed-use developments, educational and recreational facilities. These options have subsequently been endorsed for the purpose of this project by SWG, CoF and CoM and are recommended to be progressed to a full investigation and an ensuing Business Case.

10.1 Route descriptions

Both the preferred options involve a TT or LRT service running approximately 12km between Bull Creek Shopping Centre in the east to Fremantle Station in the west. From Bull Creek Shopping Centre, each service is proposed to travel in the median of South Street before entering the Murdoch Station precinct via the bridge over the Kwinana Freeway. From here, the services run in a separated corridor to enter the hospital precinct on Barry Marshall Parade before returning to a median-running service, crossing Murdoch Drive and entering the Murdoch University campus on Discovery Way. The median-running services then traverse South Street in length towards Fremantle.

The distinguishing factor between both options is their separation in proposed routes at Wray Avenue, with Option 5 continuing along South Street before heading north on South Terrace, while Option 6 exits South Street and continues north along Wray Avenue before meeting South Terrace. From here, both options continue along South Terrace, operating in the median until reaching Norfolk Street. Between Norfolk Street and High Street, each service is proposed to operate on a dedicated service, before returning to a median-running service on its approach to Fremantle Station after crossing High Street.

10.2 Alignment

As discussed, both progressed Short List Options are proposed to consist of either an LRT or TT service along the corridor. An overall cross section assessment of the options has been provided previously in Section 9.5.

At this stage, a preliminary assessment has been undertaken that identifies the major utilities that are likely to be impacted at key intersections based on the characteristics of the modes and alignment proposed. Utility impacts have been assessed based on the utilities deemed critical as described in Section 5.1.1. In addition, the assessment included a high-level concept design at key intersections, showing the likely level of reconfiguration required to achieve the service. As per the brief, initial high-level concepts have been developed at four key intersections along the route, at:

- Barry Marshall Parade/ Discovery Way/ Murdoch Drive
- South Street/ North Lake Road
- South Street/ Stock Road
- South Street/ Carrington Street.

Given the key characteristics of each mode as discussed in Table 19, a corridor width of 13m has been assumed through each intersection to represent the width of a TT service. It should be noted that while a benchmarked corridor width of 10m has been attributed to LRT, the 13m corridor width of TT has been used as it provides a higher extent of utilities analysed, acknowledging that an LRT corridor is likely to impact less utilities from a corridor width perspective. It has also been assumed that Discovery Way is realigned to accommodate the service, as built on by previous work undertaken by Arup in collaboration with Murdoch University involving the associated works involved in the realignment.

10.2.1 Barry Marshall Parade/ Discovery Way/ Murdoch Drive

Figure 31 and Table 25 illustrates the key utilities impacts associated with the Barry Marshall Parade/ Discovery Way/ Murdoch Drive intersection.

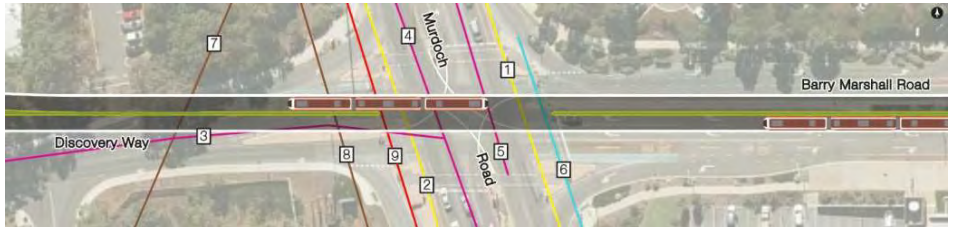


Figure 31 – Barry Marshall Parade/ Discovery Way/ Murdoch Drive concept design and utilities impacts

Table 25 – Major utilities constraints

Utility ID	Description
1	ATCO Gas High Pressure Main
2	ATCO Gas High Pressure Main
3	AARNet Fibre Optic Communications
4	AARNet Fibre Optic Communications
5	NBN Fibre Optic Communications
6	Water Corporation Water Main (460mm diam.)
7	Water Corporation Sewer Gravity Main (1220mm diam.)
8	Water Corporation Sewer Gravity Main (1650mm diam.)
9	Western Power Transmission Overhead Powerlines (132 kV)

10.2.2 South Street/ North Lake Road

Figure 32 and Table 26 illustrates the key utilities impacts associated with the South Street/ North Lake Road intersection.

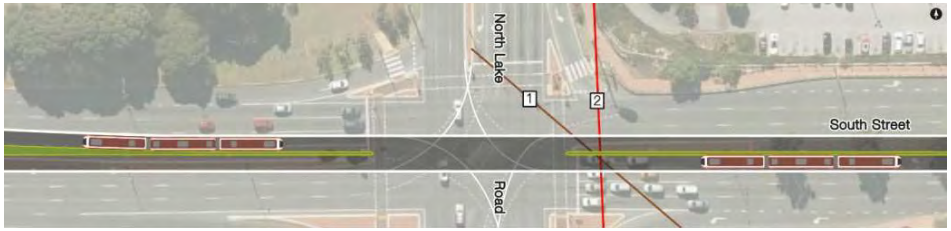


Figure 32 – South Street/ North Lake Road concept design and utilities impacts

Table 26 – Major utilities constraints

Utility ID	Description
1	Water Corporation Sewer Gravity Main (600mm diam.)
2	Western Power Transmission Overhead Powerlines (66kV)

10.2.3 South Street/ Stock Road

Figure 33 illustrates a high-level concept design of the service through the South Street/ North Lake Road intersection. No major utilities have been identified crossing the intersection.

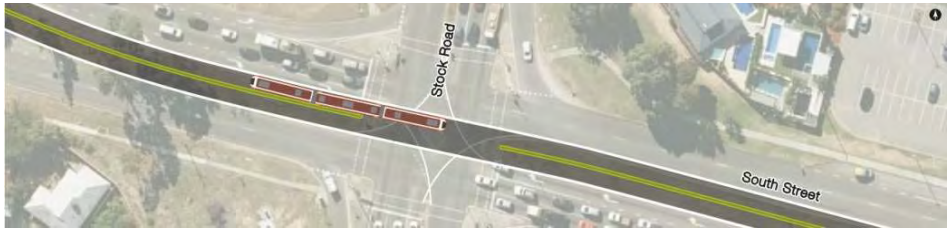


Figure 33 – South Street/ Stock Road concept design

10.2.4 South Street/ Carrington Street

Figure 34 and Table 27 illustrates the key utilities impacts associated with the South Street/ Carrington Street intersection.

Figure 34 – South Street/ Carrington Street concept design and utilities impacts

Table 27 – Major utilities constraints

Utility ID	Description
1	NBN Fibre Optics Communications
2	Water Corporation Water Main (610mm diam.)

10.2.5 Recommendations

For all intersections, a detailed review is recommended to be undertaken as part of the detailed Business Case submission/ concept design phase in consultation with services authorities to verify the actual constraints imposed by each potential service impact.

It is to note that major assets have been identified as crossing the above intersections. Discussions with respective asset owners and government authorities will be required to determine the appropriate course of action including any accommodation or protection requirements, diversions or easement constraints.

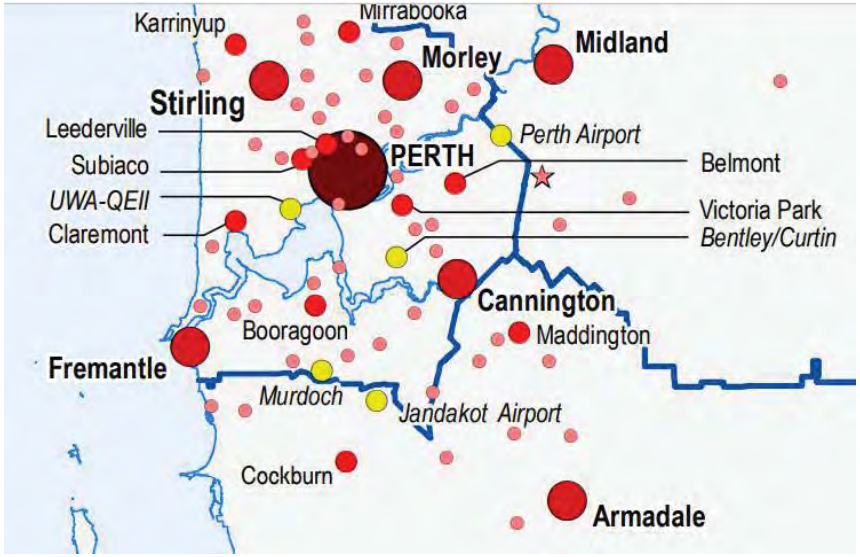
10.3 Strategic and policy alignment

Plan Policy or Strategy	Date	Body	Comment
Perth and Peel @ 3.5 Million	2018	State Government	Fremantle is a secondary centre and Murdoch is a specialised centre Link between Fremantle and Murdoch is identified as an Urban Corridor
Perth and Peel @ 3.5 Million Central Sub Region Planning Framework	2018	State Government	47% of new dwellings as an infill target 215,000 new dwellings in the Central Sub Region by 2050
Perth and Peel @ 3.5 Million – The Transport Network	2018	State Government	Fremantle to Murdoch has been identified as a High Priority Transit Route
State Planning Policy 4.2 Activity Centres for Perth	2010	State Government	Fremantle is a secondary centre and Murdoch is a specialised centre
Murdoch Specialised Activity Centre Structure Plan	2014	State Government	Is based on a major public transport trunk infrastructure in an east west direction
Murdoch Health and Knowledge Precinct		State Government through Development WA	A well designed connected centre providing 35,000 jobs for education facilities for 44,000 students and homes for 22,000 residents
Inner City Light Rail Problem Definition	2019	State Government through Metronet	Stage 1 Submission to Infrastructure Australia
City of Fremantle Integrated Transport Strategy	2015	City of Fremantle	The City of Fremantle believes that Light Rail is capable of providing sufficient capacity to serve Fremantle and the surrounding growing regional centres
Murdoch University Masterplan	2016	Murdoch University	Makes provision for light rail or bus rapid transit through the site
Perth Rail Growth Plan		State Government through PTA	PTA Plan for rail capacity growth to 2051 and beyond
Public Transport Major Road Corridor Review	2018	State Government through PTA	The corridor between Fremantle and Murdoch is identified as part of Corridor 19 in the review. Bus priority lanes proposed for the full length of South Street
Australia Infrastructure Audit	2019	Infrastructure Australia	Seeks to align transport infrastructure with universities and hospitals
Planning Liveable Cities	2018	Infrastructure Australia	Our cities need more high quality, high density development supported by adequate infrastructure
Future Cities – Planning for our growing population	2018	Infrastructure Australia	Australian governments should increase investment in public transport infrastructure

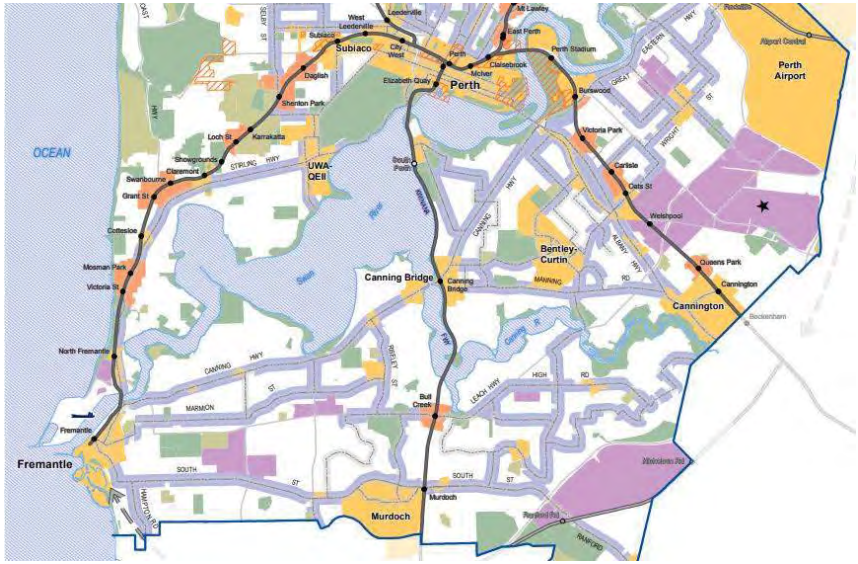
10.3.1 State

10.3.1.1 Perth and Peel @3.5 Million 2018 (State Government)

Fremantle is a secondary centre and Murdoch is a specialised centre under the activity centre under Perth and Peel @ 3.5 Million.



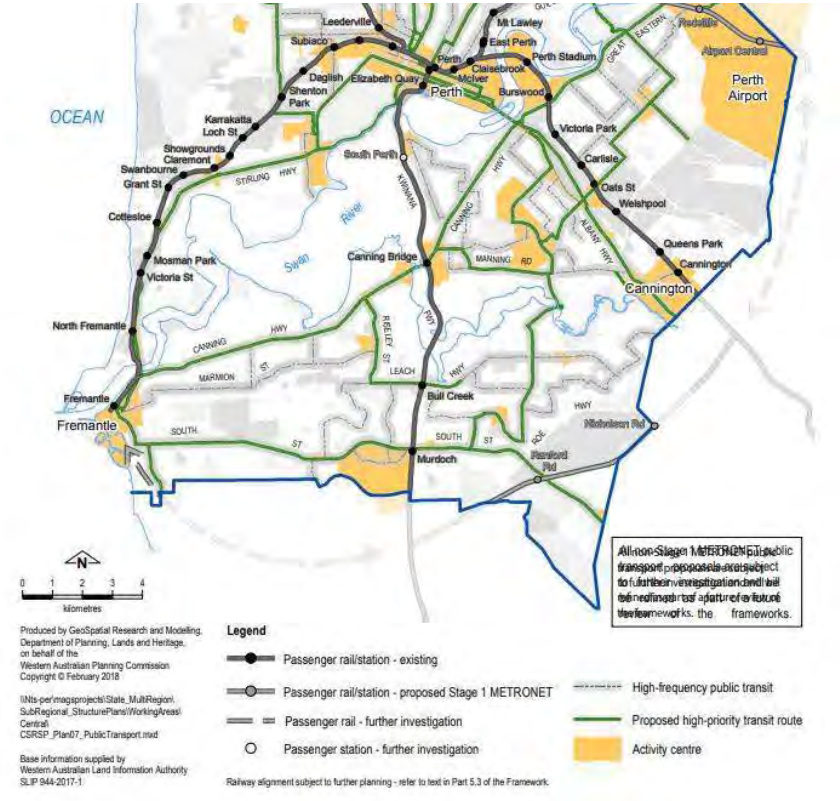
The link between Fremantle and Murdoch is identified as an urban corridor under Perth and Peel @ 3.5 Million.



“Ensure existing and planned high-quality, high-frequency public transit corridors connecting quality residential land uses with station precincts, activity and industrial centres. Focus higher-density residential development along high frequency public transit corridors and around station precincts.”

10.3.1.2 Perth and Peel @3.5 Million - The Transport Network 2018 (State Government)

South Street and the link between Fremantle and Murdoch are identified as proposed high priority transit routes in Perth and Peel @ 3.5 Million.



10.3.1.3 Murdoch Specialised Activity Centre Structure Plan 2014 (State Government)

"There will be a dynamic shift in the approach to transport planning and the introduction of major public transport trunk infrastructure in an east-west direction will transform Murdoch from being an origin of public transport trips and a redirector of traffic, to a centre which is both an origin and destination."

10.3.1.4 Murdoch Health and Knowledge Precinct (State Government through Development WA)

"The Murdoch Activity Centre will become the Southern Corridor's home to health research, medical care, higher education and innovative business development, delivering economic benefits for all Western Australia.

Just 12km south of Perth's CBD, the Murdoch Activity Centre will offer a new city centre, providing jobs for 35,000 Western Australians, education facilities for 44,000 students and homes for 22,000 residents.

The ambitious project is part of the State Government's planning strategy to manage population growth in Perth, and meet demand for well-designed, connected centres where people can work close to home."

Murdoch Health and knowledge Precinct (Source Hassell)

10.3.1.5 Murdoch University Masterplan (Murdoch University)

"The key initiatives of the Strategic Masterplan include:

- Develop cutting-edge learning, teaching and research facilities in the Academic Core
- Create a physical chain linking with our Murdoch Specialised Activity Centre neighbours, integrating the State's Health Campus with the university's broader life sciences
- Extend the Broadwalk as an iconic pedestrian and cycle boulevard connecting all precincts to Murdoch Station
- Protect and restore the campus ecological networks with their wealth of biodiversity
- Uphold the campus farm and surrounding living lab as an asset of our university
- Prioritise Discovery Way as the primary gateway for public and private transport, including provisions for future rapid bus and light rail along with a clear university arrival point at a Southern Plaza."

10.3.1.6 Public Transport Major Road Corridor Review 2018 (State Government through Public Transport Authority)

The corridor between Murdoch and Fremantle is part of Corridor 19 identified in this review.

"The corridor supports the movement of daily commuters travelling to Fremantle, Murdoch University, Fiona Stanley Hospital, and Canning Vale industrial areas. With both residential and commercial density increasing in these areas, pressure on the corridor to connect key destinations will continue to grow…. The PTA will review and implement identified future opportunities in partnership Main Roads WA, as well as relevant Local Government Authorities - the City of Canning, City of Melville, and City of Fremantle."

10.3.2 Federal

10.3.2.1 Australia Infrastructure Audit 2019 (Infrastructure Australia)

"Aligning the delivery of transport infrastructure with housing, employment growth and other key infrastructure that influences the demand for transport, such as schools, universities and hospitals, is a particularly complicated task that requires whole of government coordination."

10.3.2.2 Planning Liveable Cities 2018 (Infrastructure Australia)

"Our cities will need more high-quality, higher-density development supported by adequate infrastructure."

"We need to better assess the full range of infrastructure required to make places liveable before they grow. 'Place-based' approaches to infrastructure planning and delivery provide governments with a cross-sectorial view of the needs of a community and identify options to address them."

10.3.2.3 Future Cities – Planning for our growing population 2018 (Infrastructure Australia)

"Australian governments should take an active role in developing employment centres in our largest cities. A well-planned network of employment centres can help to improve a city's economic performance but directing the location of jobs in large cities can be difficult. Governments have an opportunity to make better use of tools and levers to achieve their strategic economic plans and enable labour and capital to access one another efficiently. Key levers include:

- Providing strategic transport infrastructure to ensure employment centres are easily accessible
- Providing fiscal incentives for employers to move to strategic urban centres, subject to appropriate assessment to ensure this use of taxpayer money benefits the city
- Strategically re-purposing underutilised government land to support the growth of new employment centres."

"Australian governments should increase investment in public transport infrastructure in cities experiencing significant population growth. Investment in mass transit is crucial to reducing congestion, increasing accessibility and reducing the rate of emissions growth. This is particularly relevant for higher density areas where space is limited. Governments should prioritise:

- High-capacity public transport trunk routes linking key centres and transport nodes
- Regular and reliable feeder public transport routes, designed to connect to trunk routes and maximise the reach of the network
- Prioritisation of road space for high occupancy vehicles including trams and buses
- Walking and cycling as principal means of transport within centres and to transport nodes."

11 Next steps

This Proof of Concept is not intended to be an exhaustive examination of all options and scenarios, nor is it a full business case – it is a proof of concept that is prepared with professional rigour from a transport engineering perspective and a land intensification perspective. From here, based on the analysis and supporting material, the South West Group ask that the State Government make a public commitment that:

1. the proposed transport link has strong merit
2. it will be meaningfully included in future stages of METRONET (or its equivalent), and
3. it will budget appropriately in 2021/22 financial year for development of a full business case.