South West Group
Australian Greens

Southwest LRT Corridor Study: Murdoch to Fremantle

Author:
Michael Crocker

Foreword

Scott Ludlam – Australian Greens Senator for Western Australia

Scott Ludlam is the Greens' spokesperson for Transport, Infrastructure and Sustainable Cities.

He developed a comprehensive plan for light rail for Perth in 2007 and has been working with a broad coalition campaigning for light rail to become part of Perth's transport mix (see www.scottludlam.org.au/perthlightrail).

This report, instigated as a research project for the Office of Senator Scott Ludlam, is intended to help inform and assist further planning for light rail in Perth's south-western suburbs in particular.

Senator Ludlam would like to thank Michael Crocker for his hard work and dedication to this project and Chris Fitzhardinge from the South-West Group for his assistance.

South West Group

The South West Group is a Voluntary Regional Organisation of Councils formed in 1983, representing the cities of Cockburn, Fremantle, Melville and Rockingham, as well as the towns of East Fremantle and Kwinana. Representing the councils in the study area, The South West Group has a keen interest in promoting sustainable and effective transit options for it's citizens, incorporating LRT into a holistic and comprehensive approach to the future of the region. for more information, please see: http://www.southwestgroup.com.au/

The South West Group provided background information and technical advice during the preparation of the study, as well as a peer review role, and as such are identified as a study partner to reflect this contribution.

Formation of this report

This report was created as a result of both the passion of all parties involved, and the need for investigation into LRT in the area. The author approached the office of Scott Ludlam regarding LRT projects, and the South West Group (represented by Chris Fitzhardinge) was asked to collaborate and assist where required with technical expertise and networking resources, as well as general advice on the structure of the project.

Executive Summary

The following report presents the findings of a Light Rail Transit (LRT) corridor study between the Murdoch and Fremantle Train stations. Potential corridors were identified and evaluated against criteria identified by preceding studies. This study does not make a comparison between LRT and other forms of transit, and as such alternatives should always be considered prior to further investigation. However, it is the author's opinion that LRT would be an appropriate method of transit within the area, as the areas surrounding both terminals prepare to grow in density and therefore require faster, higher capacity transport.

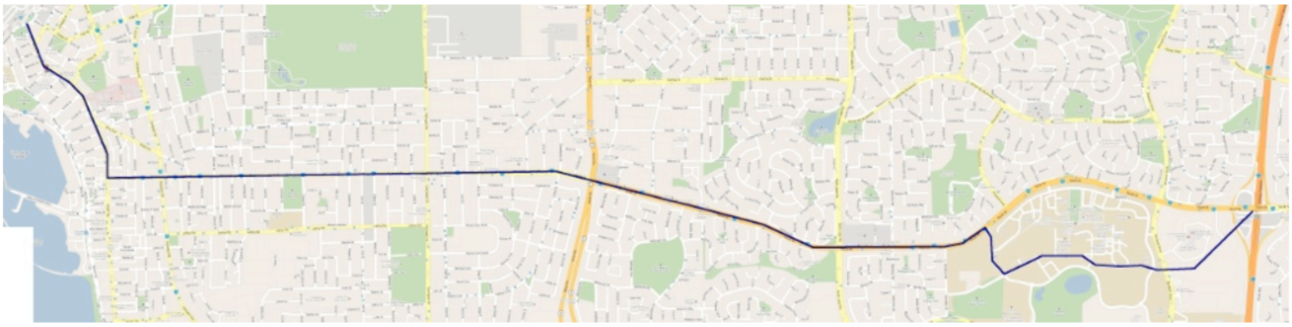
The reasons for implementing LRT can vary, and hence this report does not recommend a particular report. Instead, the evidence is presented in such a way as to make selection based on a particular set of criteria a simple process.

Table i. Route Recommendations

Rationale	1st Recommended Route	2nd Recommended Route
Cost	3	5
Environmental Impact	2	3
Feasibility	1	5/6
Legibility	3	5
Placemaking	2	6/7
Ridership	7	2
Speed	3	1
Trip Generators	5/6	2
Urban Renewal	3	7

If a particular route had to be recommended, then a combination of routes 2 and 3 would be most appropriate. This route would run from Fiona Stanley Hospital (down Barry Marshall avenue) to South street via Discovery drive. It would then follow South st, before connecting with the proposed Cockburn Coast LRT line, heading into Fremantle. Passing most trip generators, and several already high density areas, this route would capture a significant ridership.

Figure i. Recommended Route



Opportunities for Transit Oriented Development (TOD) exist surrounding Carrington street, as well as the Murdoch Activity Centre and Eastern Precinct near the Murdoch terminus, and such options can help raise capital to fund the line itself. By utilising an existing thoroughfare (South street), environmental damage is minimised and a rapid service is ensured.

It must also be noted that this is a very preliminary study, and further investigation may be needed to substantiate the data within and advance LRT Projects within the area. Wherever data is presented within, every attempt is made to give the source and rationale behind the interpretation.

Table of Contents

Background & Scope

Background

Recently, the Western Australian Department of Transport released the first medium-term plan for Perth's public transport sector, titled Public Transport for Perth in 2031: Mapping out the Future for Perth's Public Transport Network. According to this report, Perth's "public transport system is regarded as one of the best, newest and most efficient in the nation", but noted that "much more needs to be done to ensure the capacity and quality of service to meet the transport needs of a rapidly growing city" (Department of Transport 2011, p.3).

This acknowledgement of the growing importance of public transport reflects a worldwide shift shunning the private automobile and the associated planning principles of the post WWII period, such as the 1955 Stephenson-Hepburn plan for Perth (Committee for Perth 2011). Although considered appropriate in their time, these plans allowed for the rapid urban sprawl seen in cities such as Perth on the back of large highways. It must be noted that the Stephenson-Hepburn plan also called for a corresponding expansion of the heavy passenger rail system, but this did not receive the same level of political enthusiasm or investment (Committee for Perth 2011). The impact of this transport planning can be seen in the differences between older suburbs such as Mt Lawley and North Perth, and post-war suburbs such as Bedford and Morley. The higher density and 'Main st' style retail of the more established suburbs contrast with the sprawl and 'big box' retail style of the newer suburbs (Thomas 2002).

Although most cities in the world followed this oil dependent planning process, some cities experienced a transit renaissance of sorts. Following WWII, European planners were faced with the monumental task of rebuilding the continent's transport infrastructure. Cities such as Karlsrühe in Germany and Strasbourg in France kept or expanded their existing tram system, eventually switching to LRT (Thomas 2002). Several groups in Portland, Oregon noticed the relative successes in Europe and began to campaign for a similar shift in mentality. During the 1970's, increased awareness of the inherent troubles of urban sprawl led to a defined urban growth boundary (Thomson 2007). Combined with the Federal Aid Highway Act of 1973 which allowed regions to refuse federally funded road projects, and redistribute the funds to other transit projects with demonstrated viability, meant that the counties comprising the Portland Metropolitan Area were able to redistribute the funds allocated towards the future Mt Hood Freeway and I-5 towards 286 other transit projects. This is interesting to note as Perth and other Australian cities are similarly becoming aware of the dangers of urban growth and the importance of infill development (Curtis & Sheurer 2009, Adams 2009, WAPC 2010).

Perth's population is growing, standing to reach at least 2.2 million by 2031 (WAPC 2010). This represents a growth of almost 500,000 people, who must be housed and given options for transport. The Western Australian Planning Commission has called for 47% of new dwellings to be within the current Perth Metropolitan Area, resulting in an average increase in density from 10 to 15 dwellings per hectare in urban areas (WAPC 2010). Perth's public is also becoming increasingly aware that simply widening existing roads is not an effective solution (Estill 2006). These represent fundamental changes in the traditional thinking and point to a change in transit planning in the near future.

Light Rail Transit, or LRT, is often defined as "electric or diesel powered light rail vehicles running on a track, which can be an exclusive right of way (e.g. in a road median) or shared with general traffic" (SKM 2010). In terms of weight and passenger capacity, LRT occupies the space between the urban tram and a heavy rail passenger car. Commonly carrying 150-200 passengers per car (Maunsell & AECOM 2007), a Light Rail line can carry up to 20,000 people per hour per direction, and needs at least 10,000 passengers per day to be considered viable by the Department of Transport (2011). LRT is most effective as a mid tier transit solution, where the cost of a heavy passenger rail line cannot be justified but the predicted patronage exceeds reasonable bus capacity.

According to the US Department of Energy, Light Rail uses just 0.51 kWh per passenger km, compared to 0.64 kWh for a car or .77 kWh for a transit bus (assuming average passenger loads) (DART 2010). These figures do not take into account the added energy saved (and health benefits gained) by LRT passengers walking to their nearest station, or energy consumed by cars idling at traffic lights, or in traffic jams. This difference, combined with the 'sparks' effect, demonstrates the potential for LT to reduce the total energy consumed by a city. LRT can also be powered by renewable power more easily than cars, as energy storage is not an issue for most LRT carriages (there are alternatives to overhead wire powered cars that do require batteries, and these are described in detail later).

The social benefits of public transit has been well known and can be partially summarised as the cost to the community that is avoided when a commuter choses public transit over a car. The costs to society of car ownership and use can be seen in the expansive use of desirable areas wasted in the forms of carparks and freeways. To properly understand the impact of public transit, it may help to imagine the following scenario: If every commuter in Perth used an automobile to travel, what would Perth resemble? There would be a critical shortage of space required for carparks, productive time lost due to traffic jams would increase, as would the environmental impact (and price of fuel). The Department of Transport (2011) estimates that for an average peak time commuter using his or her car, the social cost to Perth is $30. By utilising public transport, the commuter 'saves' the community $20 (the remaining cost is predominately time lost in transit). These savings will only increase as the impact of traffic congestion sure increase, and the land value of dedicated automobile space increase.

The health benefits of LRT, and public transport usage in general, should also be considered when judging whether LRT is a sound economic investment. Studies have shown that the increased level of physical activity such as cycling or walking inherent in using public transport can have a small but noticeable effect on the health of users (Stokes et al. 2008).

Scope

The area to be studied stretches from the Kwinana Fwy in the east to the Indian ocean in the west, extending from the Beeliar wetlands in the south to the Swan river in the north (see Appendix). The area comprises 3 local governments - the cities of Fremantle, Melville and Cockburn, who are member Councils the South West Group.

A 'mid tier' transit system is sadly lacking in Perth, with heavy rail and local bus services comprising the bulk of public transport options. It is assumed that the current density and proximity to heavy rail lines means that a new heavy rail line is not justified, and the substantial cost of heavy rail invalidate it as an option. Local bus services are not an effective alternative for transit across such a large area, but can be utilised as a feeder option for an effective 'mid tier' option..

Currently, transport planners can use either Bus Rapid Transit or Light Rail Transit. This study investigates the feasibility and suitability of Light Rail Transit, with the Murdoch and Fremantle train stations as fixed terminals. Thus, the study doesn't investigate Bus Rapid Transport (BRT) or other forms of transport. However, it is expected that the information contained within may be used as a basis for advocating LRT within the area.

The study follows a simple process, similar to those observed in similar works around the world. Firstly, all probable routes were identified, regardless of identifiable boundaries or drawbacks. These options were then evaluated according to a range of criteria such as ridership, cost and environmental impact. While most of these criteria are scalable, some (such as feasibility and environmental impact) have cut-off points, beyond which a route is considered unsuitable, regardless of potential benefits in other areas.

LRT can serve several purposes such as accelerated transit or as an impetus for redevelopment , and has been employed both successfully and unsuccessfully around the world to serve these objectives. In deference to this, the study will not propose to recommend a particular route option over another. Rather, the collected information will be presented so that others may decide upon the intended purpose of LRT in the area, and select the appropriate route.

It must be made clear that this study is very preliminary, and much work remains before decisions can be made with confidence. As a result, it is expected that the study will serve mainly as a stimulant for discussion and as an indicator of potential impediments inherent with specific route sections. A chapter in this report examines the future work in greater detail.

This study was undertaken as part of the Perth Light Rail project, and it is envisaged the it will form part of this wider scope.

Route Descriptions

Introduction

Several primary routes were identified, and divided into sections where appropriate to allow for a more comprehensive and flexible approach. The primary corridors identified were:

- Roe Hwy Reserve / Forrest Rd
- Winterfold Rd / Lefroy
- South St
- Garling St
- Leach Hwy
- Marmion St
- Canning Hwy

Route 1 - Roe Hwy / Forrest Rd - Black Line Description

This route begins with section 1A at the Murdoch train station, heading down Barry Marshall Avenue toward Murdoch Drive and the Murdoch Activity Centre. Section 1B then turns towards the Beeliar wetlands, passing through via the Roe Hwy reserve towards Stock Road before connecting and running along Forrest Rd, turning right on Cockburn Rd, connecting with Route 3 at the intersection with South St. Section 1C deviates from this course, connecting Route 1 and 2 along North Lake Rd. This route would be relatively simple and cheap to build (per km), due to an existing reservation. The environmental impact inherent in traversing the Beeliar wetlands pose a serious hurdle however.

Figure 1. Route 1

Route 2 - Winterfold Rd / Lefroy Rd - Yellow Line Description

This Route begins at the Murdoch Activity Centre (it is assumed section 1A would be included). Section 2A crosses Murdoch University along Discovery Wy, while section 2B heads north along Murdoch Dr towards South St. Section 2C also connects routes 2 and 3 via St Ives. Section 2D continues from St Ives to Farrington Rd, connecting to Winterfold Rd. After crossing Stock Rd, Section 2E turns right at Carrington st, before heading west along Lefroy Rd, towards South Tce, where Several routes converge on the approach to Fremantle. This line would anchor a community and provide transport links to several schools, but lacks visibility on main arterial roads and will be slower than other routes.

Figure 2. Routes 2 &3

Route 3 - South St - Red Line Description

Arguably the most direct route at approximately 11 km between terminals, this route begins with section 3A, departing from the current bus station on the South st freeway overpass to the Murdoch Dr intersection. Section 3B runs along the northern edge of Murdoch University, connecting with section 2C. Section 3C continues along South St to the North Lake Rd intersection, where the Kardinya Park shopping centre is located. Continuing until Stock Rd, section 3D is followed by section 3E, which extends until Hampden Rd. Section 3F marks the final approach to Fremantle along South Tce, shared by several routes. This route is both direct and very visible, as it traverses a main arterial road. However, the length of the route dictates that there is less potential riders within the catchment area.

Route 4 - Garling St Purple Line - Description

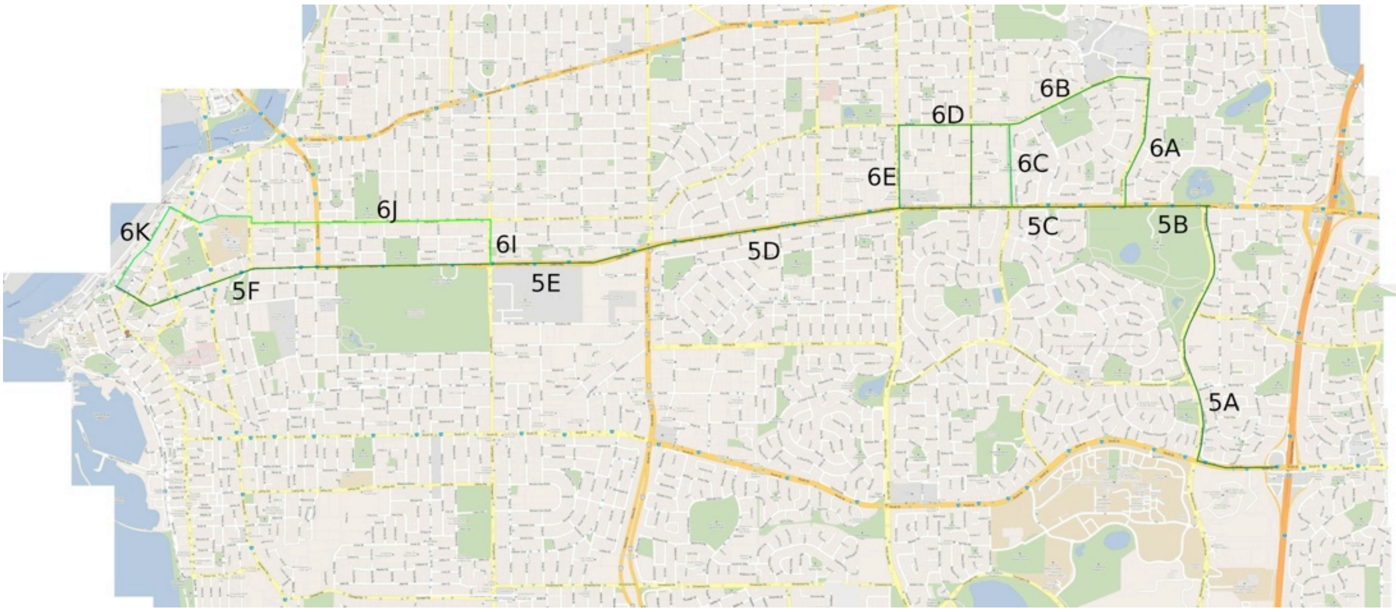
The main objective of this route is to supplement options provided by routes 3 and 5. Beginning at the South St/North Lake Rd intersection, Section 4A terminates at the intersection with Garling st. Section 4B continues along North Lake Rd to Leach Hwy and route 5. Section 4C leaves North Lake Rd along Garling St, turning north on Stock Rd past the Southern Coast Transit Bus depot to Leach Hwy and Route 5. This route provides a novel form of transport to an area relatively neglected by public transit, but significantly lengthens any route, and hence increases cost. The impact on locals also needs to be considered further.

Figure 3. Routes 4 & 6

Route 5 - Leach Hwy Dark Green Line - Description

This route also begins with section 5A at the Murdoch Dr/South St, heading north past corpus Christi College and Piney Lakes reserve to Leach Hwy. Section 5B traverses the northern boundary of Piney Lakes reserve to the intersection with Riseley St. Section 5C then continues west along Leach Hwy to the intersection with North Lake Rd and route 4. Section 5D connects North Lake Rd and Stock Rd via Leach Hwy, while section 5E terminates at Carrington St. Section 5F marks the final approach into Fremantle along High St. This route shares characteristics with route 3 but with a longer length, and correspondingly, a higher ridership and cost.

Figure 4. Routes 5 & 6



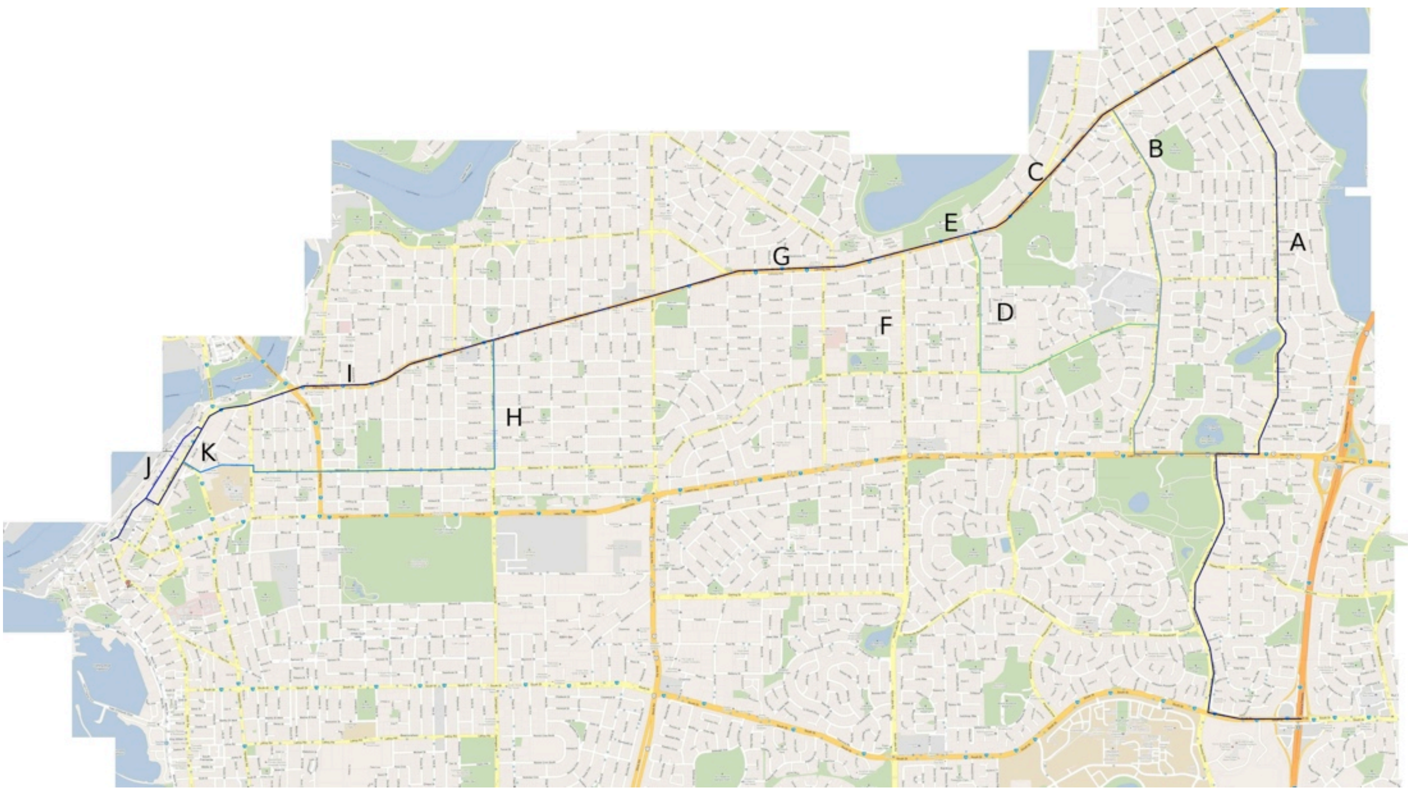
Route 6 - Marmion St - Light Green/Magenta Line - Description

This Route features several links between Marmion St and Leach Hwy, namely Riseley St, Robert Crawford Park, North Lake Rd, Stock Rd and Carrington St (designated sections 6A,C,E,G & I respectively). Section 6B runs from Riseley St along Marmion St to Robert Crawford park and the adjoining industrial area. Section 6D continues past through the industrial zone to North Lake Rd, where section 6F continues to Stock Rd. Section 6H then travels along Marmion st to Carrington st before section 6J heads towards Fremantle, past John Curtin college. Finally, section 6K runs parallel to the heavy rail line along Beach St towards Fremantle train station. This route links several major trip generators and would seem to be relatively simple to build, but will reduce the visibility of any route when compared to the nearby alternatives of Leach or Canning Hwy.

Route 7 - Canning Hwy - Dark Blue Line - Description

By far the longest route at almost 18 km (nearly 7 km longer than the South St option), this route features many options to connect to other routes. Starting at the Murdoch Dr/Leach Hwy intersection, section 7A runs the length of Reynolds Rd, turning Southwest along Canning Hwy until Riseley St. Section 7B connects canning Hwy to Marmion St along Riseley St. Section 7C continues along Canning Hwy from Riseley St to Norma Rd, where section 7D connects to route 6. Section 7E passes Tompkins park to North Lake Rd. Section 7F connects this intersection with route 6 (and by using section 6E, to route 5). Section 7G continues westward along Canning Hwy to Carrington St, where section 7H connects to routes 6 & 5. section 7I crosses Stirling Hwy, leaving 2 choices for the final corridor into Fremantle - either 7J, along Beach Rd to section 5K, or section 7K, which also joins 6K, but covers Queen Victoria St. This route would significantly add to the potential ridership and visibility of any route, but at a large cost. The reduced catchment on the northern side for parts of the route is also a concern.

Figure 5. Route 7



Feasibility

Introduction

As a rail-based form of mass transit (with correspondingly hefty loads), LRT favours relatively straight and flat corridors. Each of the potential routes were evaluated for Engineering Feasibility on a pass or fail basis. Design criteria were taken from the City of Fremantle (SKM) and Perth Light Rail Study (Maunsell/AECOM).

Table 1. Feasibility Criteria (SKM 2010)

Criteria	Preferred	Limit
Horizontal Turning Radius	150 metres	20 metres
Vertical Grade (< 250 metres)	6% or lower	8%
Vertical Grade (> 250 metres)	4% or lower	6%

Horizontal Turning Radius

The horizontal grades, or minimum turning circle represents the tightest corner the chosen LRT train could take. It must be noted that the train would need to slow down considerably to take this turn. Accordingly, routes with a minimal number of sharp turns should be favoured over meandering (and hence slower) routes.

Several intersections were shown to require land to be purchased, either publicly or privately owned, for LRT to travel (see Figure 1). While this can present challenges to any project, no heritage places were found to be affected, and so no route failed on this basis. Below is a list of intersections where parcels of land may need to be acquired.

Figure 6. Demonstration of tight corner. NE property would need to be resumed

Table 2. Intersections that will require further investigation or resumption of land

Corner of	And
Beach Rd	James St
Queen St	High St
Caning Hwy	Carrington St
Caning Hwy	Norma Rd
North Lake Rd	Marmion St
Robert Crawford	Marmion St
South Tce	South St
Stock Rd	Marmion St
Stock Rd	Garling St
Hampton Rd	South St
Lefroy Rd	Hampton Rd
Reynolds Rd	Canning Hwy

Vertical Grade

Light Rail capacity is heavily dependent on the corridor's vertical grade (and the length of that slope). Steeper slopes require smaller & more powerful trains, drastically reducing the capacity and financial potential of the line, as well as increasing the travel time. As a result, the maximum vertical grades in were assessed on a pass/fail basis. Sections 4C & 5F have been found to have a considerable grades, and will not be considered further

The eastern half of the study area is relatively flat, without any serious concerns. However, the approach towards Fremantle involves several large hills, particularly surrounding Stock Rd. The main arterial roads have already been graded for heavy haulage trucks and articulated buses, so should pose no great problems for Light Rail. Smaller roads have also been surveyed for any unsuitably steep gradients.

Table 3. Vertical Grade

Grade	Route Sections
Flat	1A, 1B, 2A, 2B, 2C, 3F, 5B, 6B, 6C, 6D, 6E, 6K, 7A, 7C, 7E, 7I, 7J, 7K
Minimal	1C, 2D, 3A, 3B, 4A, 4B, 5A, 5C, 6A, 6G, 6I, 7B, 7D, 7F
Moderate	2E, 3C, 3D, 3E, 5D, 6F, 6H, 6J, 7G, 7H
Considerable	4C, 5F

Table 4 is a list of road sections that have a vertical grade of at least 5%, and will need further assessment if they are to be considered.

Table 4. Road Sections for Further Investigation

Road	Between	And
Canning Hwy	Stock Rd	North Lake Rd
Canning Hwy	Stock Rd	Carrington St
Garling St	Stock Rd	North Lake Rd
High St	Parry St	East St
Leach Hwy	Stock Rd	Carrington St
Leach Hwy	Stock Rd	North Lake Rd
Lefroy St	Hampton Rd	Carrington St
Marmion St	Rome Rd	Carrington St
Reynolds Rd	Canning Ave	Queens Rd
South St	Stock Rd	North Lake Rd
South St	Caesar St	Carrington St
Winterfold Rd	Stock Rd	Carrington St
Winterfold Rd	Coolbellup Ave	North Lake Rd

Depot Locations

Light Rail Transit requires an area for maintenance and storage. Drawing from the Perth Light Rail Study (Maunsell & AECOM 2007), a line between Murdoch & Fremantle would need at least one depot, possibly a second, depending on future extensions of the line. An area of at approximately 110 metres by 120 metres is required, in the vicinity of one of the terminals. This represents a potential hurdle, as both terminals have scarce land suitable for such a terminal. As a well established area, Fremantle has minimal areas that could be considered suitable for a depot. However, the ability for a depot to act as a temporary 'cover' for environmentally hazardous areas unsuitable for other developments provides for several potential candidates. These areas contain residues (such as petroleum products) that make residential developments unsuitable. It must be noted that any potential route must pass a potential depot site. Some routes (3,5,7) lie on major thoroughfares, with little land available, and so may require a turnoff, with minor (<250m) rail extensions.   A list of identified potential sites is listed in table 5.

Table 5. Potential Depot Sites & Relevant Routes

Depot Location	Relevant Route Sections
Garden City - Marmion / Riseley	6A,6B,7B
Garling / Bowen	4C
Stock / Sainsbury	4C
Stockdale / Peel	3E, 4C
Rockingham / Cockburn	1B
Norma / McCoy	6C,6D,7D
Farrington / Murdoch Drive	1B
Lefroy Rd (next to South Fremantle High School)	2E
Winterfold / Stock	2E

Redevelopment

Potential For Redevelopment

LRT has been shown to provide the impetus needed to spark urban redevelopment through improvements in accessibility and liveability (ACT Light Rail 2009), and is often used as the transit basis for TOD projects (Joshi et al 2006). In fact, the ability of LRT to spark this urban redevelopment is often employed as a method of funding transit projects - capturing the expected increase in taxes as a result of increased density can partially cover the initial capital costs. Private consortiums have more confidence developing near rail lines, due to the inherent permanence of the capital infrastructure (a rail line is much harder to move than a bus stop).

The characteristics of areas ripe for development - large parcels of land owned by limited parties, with ageing infrastructure but in a desirable area, applies to several precincts within the study area. These have been highlighted as targets for LRT service. It is expected that redevelopment will occur throughout the length of the corridor selected, but that these areas provide an initial boost to the fiscal responsibility and potential ridership of any LRT line. The Murdoch Activity Centre and surrounding developments have been excluded from consideration, as well as developments within the Fremantle CBD, as all lines will pass within 400m of these areas.

Transit Oriented Development

Transit Oriented Development (TOD) is the urban planning concept whereby districts are built around, and built to serve, mass public transport, generally by increasing density around transit and pedestrian thoroughfares (Adams 2009). This sort of development leads to an increase in mass transit use, and is a major focus in urban planning for Perth's future (WAPC 2010). The focus is on developing hubs, so as to reduce the need for traveling by car, by promoting pedestrian and transit modes of transport. Developments such as East Perth and Subiaco are the best examples of TOD in Perth so far (Renne 2007), but it is expected that these kind of sustainable developments will only increase in number and effectiveness in reducing the number of private automobile trips taken.

Consultation with Local Government

To ensure a truly comprehensive and collaborative approach, each of the three main local councils involved were consulted to identify potential areas for development, as well as ensure that TOD is a priority for all municipalities concerned

City of Melville

The City of Melville have released the Melville 2050 plan, providing a strong planning framework and direction for the area. In it, and after meeting with strategic urban planner Gavin Ponton several priorities and opportunities were identified.

The city (and it's residents share the view that simply widening lanes is not an effective transport option, and TOD has in principle support along main thoroughfares, such as Leach Highway and South Street. This is consistent with a planning study conducted in 2006 by Estill on behalf of the council, where residents themselves suggested a LRT route along Riseley st past Garden City Shopping Centre.

The intersection of Canning Highway and Riseley Street has recently been redeveloped, and could become a TOD anchor point. The Murdoch Activity Centre and Garden City were also identified as having significant potential to become TOD style areas.

Myaree has been identified as an expensive area for development, and not recommended as a potential depot site. Within the City of Melville, two areas have been determined as good potential candidates for depots: an area south of the MAC, on the intersection of Murdoch Drive and Farrington Road (subject to the Roe Stage 8 development) and south of Garden City, near the intersection of Riseley Street and Marmion Street

City of Fremantle

As an established area, Fremantle is relatively difficult to develop, and sites suitable for potential depots are a rarity. However, the local council is showing considerable foresight in recognising the need for infill development.

Recently, bureaucratic controls and regulations concerning the building of 'granny flat' style housing has been relaxed, allowing residents to construct multiple dwellings on single plots without the burden of council oversight. It is hoped that this will allow for an increase in density without the voter backlash typical of large scale developments.

Some sites outside the CBD have been distinguished as undeveloped. Recently the immediate area surrounding the intersection of Carrington Street and South Street have had the density limits increased, meaning the area is currently ripe for development. However, the overwhelming potential for TOD lies on the Cockburn Coast, and this should be considered when selecting an approach into the CBD, as track sharing may reap significant financial savings.

As mentioned previously, there are areas of the city that are considered environmentally hazardous, and hence economically unfeasible to develop for residential and commercial areas. It is these areas (such as adjacent to South Fremantle High School) that should be considered for temporary depots.

City of Cockburn

Although only a small portion of the study area, the City of Cockburn has the potential to lead the state in TOD planning and LRT implementation. Currently, the main LRT priority in Cockburn is the Cockburn Coast project, and opportunities for TOD reflect this. However, some areas along Clontarf Road are ripe for development.

As previously mentioned, the proposed Cockburn Coast LRT route should be considered in the routing of the final approach into the Fremantle CBD.

Table 6. Potential for development

Areas With Immediate Potential For Development	Nearby Route Sections
Carrington / South St	3D,3E,2E
Clontarf / Cockburn	1B
Wood / Knutsford	5F
Canning / Riseley	7A,7B,7C

Accessibility

Transport for the masses

Light rail provides transport options to members of society for whom conventional forms of transport such as automobiles remain out of reach. Groups such as students and the differently-abled rely on public transit for access to services (such as shopping and entertainment) across the city. By linking education institutions (such as Murdoch University and local high schools) and other trip generators with low floor vehicles, LRT can improve public access to services for all members of society.

LRT needs to be judged not only on the impact on society in general, but specifically the impact on disadvantaged sectors of Perth's population. In this way, LRT can be judged as a social good, and possibly open up new avenues for funding.

In Portland, Oregon, TriMet have actively worked to encourage bicycle use on their LRT network through the use of bicycle hooks and end of trip facilities. By encouraging the use of multiple modes of transit, authorities can greatly increase the catchment areas of any one mode. Coordinating services to encourage use of multiple modes of transit including bicycles should be considered a top priority.

The design and location of stations is critical to the success of Light Rail. Stations must be accessible for those with disabilities. Low floor vehicles enable stations to be built at a level close to kerb height, with small ramps to allow for wheelchair access. The need to integrate a station with its surrounds needs to be balanced with ensuring that stations are conspicuous enough to serve as a visual reminder of LRT. Pedestrian access to stations located within the median of arterial roads must be balanced with avoiding a traffic bottleneck on these important roads. While parking should not be considered as high a priority as heavy rail, pick up and drop off areas and a small number of parking bays should be considered. Stations should be located near trip generators, according to the principles of transit oriented development.

Speed vs. Placemaking

Speed

In order to attract rides, the speed of any LRT system needs to be comparable to other forms of transit. Current evidence suggests that many residents living south of Fremantle travel east to Murdoch train station rather than Fremantle, due to the difference in speeds of the two heavy rail lines. LRT offers an opportunity for commuters to use public transport for this eastward journey, rather than park their cars at the already straining Murdoch Park and Ride. To reduce both energy use and travel time, LRT will be given priority at intersections. Paul Zebell from TriMet in Portland, OR, explained in an interview how their system works: essentially a communication system is established between intersections and LRVs, allowing intersections to anticipate incoming LRVs and alter signals appropriately. This ensures that intersections are clear, and LRVs can pass through unobstructed, without needing to slow down (and hence wasting energy). If LRVs are given an exclusive right of way, speeds of up to 130 km/hr are achievable, only stopping for stations. Table 7 lists the expected time taken to travel the entire length of each respective route. For more information, please refer to Appendix.

Table 7. Speed of Sections

Route	Travel Time	Rating
1	28.59	2nd
2	39.08	4th
3	26.01	1st
4	5.21	-
5	33.48	3rd
6	22.71	-
7	42.29	5th

Placemaking

It has been well documented that LRT has the ability to 'anchor' a community, and become a catalyst for renewal. In order to optimise this effect, potential corridors should emphasise legibility and overall visibility within a community.

However, this need for 'placemaking' must be reasoned with a need to provide a fast, efficient service. Light rail (and public transport in general) must be comparable in time cost compared to private automobile use (REFERENCE). The future speed of lines can be estimated using the length of track, predicted placement of stations and mode of travel (with traffic or exclusive right of way). It is expected that future LRT lines will utilise predictive technology to avoid time delays at traffic intersections, similar to that currently in use in cities such as Portland, Oregon. Indeed, transport planners in Zurich, Switzerland found that giving priority to LRT increased the ridership, as a passing LRV served as a visual reminder of the potential of transit (Thomas 2002).

Table 8. Areas of high potential for placemaking

Area	Applicable Route
Canning Hwy / Riseley St	7A,7B
Discovery Dr	2A
Winterfold Rd / Carrington St	2E
Barry Marshall Ave	All
Marmion St / Carrington St	6H,6I,7H
Beach St / James St	6K,7J

Legibility

The legibility, or visibility of a route is also an important factor to be accounted for in routing decisions. Essentially this boils down to the ratio of main arterial versus residential road traversed. Therefore, there will be a high correlation with the speed of the routes, and the relative evaluation is considered identical.

Table 9. Legibility

Legibility	Route Sections
Main Road	1B,1C,3A,3B,3C,3D,3E,4A,4B,5B,5C, 5D,5E,7B,7C,7E,7G,7I
Busy Residential/Commercial	1A,2B,2D,3F,4C,5A,5F,6A,6B,6D,6E,6F, 6G,6H,6I,6K,7D,7F,7H,7J,7K
Quiet Residential/Commercial	2A,2C,2E,6C,6J,7A

Trip Generators

Definition

Trip generators are destinations that draw large populations to their centres and hence represent an opportunity for significant ridership on any potential LRT corridor. Therefore, any transit corridor must attempt to capture as many trip generators as possible from a variety of sources to ensure a consistently high patronage.

Description

The Murdoch train station on the Southern Suburbs rail line is currently the 2nd busiest station in Perth, with 9,500 boardings per day. Combined with the expanding St John of God Murdoch / Fiona Stanley Hospital complex, the Murdoch Activity Centre and Murdoch University, the imperative to adequately service this area with a mid tier public transport option is obvious. The Directions 2031 report has appropriately named Murdoch as a major Activity Centre, meaning surrounding areas will be encouraged to increase both commercial and residential densities, according to the principles of TOD.

The City of Fremantle contains a multitude of trip generators, ranging from Notre Dame University and John Curtin College to the cappuccino strip and shopping malls. The current parking problems (that will no doubt worsen with time) mean that a public transport alternative will be required to improve accessibility for the growing number of visitors looking to explore the historic port city.

Shopping centres have a distinct advantage as trip generators, as shoppers typically travel outside of peak periods. While Australians are not as enthusiastic as Europeans about using public transport for shopping trips, these attitudes are beginning to change. Accordingly, a LRT line should pass a shopping centre, preferably closer to the Murdoch terminus as the Fremantle CBD has ample shopping opportunities.

Located in Booragoon on Riseley St, Garden City shopping centre is a 'big box' style retail destination, offering shoppers a multitude of stores to choose from. Comprising of several supermarkets, a cinema complex and an array of speciality shops, Garden City is the largest and most popular single shopping destination in the Southwest area. The Hamilton Hill IGA is the largest store in a small group of shops located at the intersection of Carrington St and Winterfold Rd. Although not a significant destination compared to Garden City or others, by it's own estimates, it attracts several thousand shoppers a day on weekends. Several shopping centres are located along North Lake Road, on both South Street and Leach Highway, and these should also be considered. Essentially, the only route not to pass any shopping centres is Route 1. All sizeable shopping centres outside the Fremantle CBD were asked to participate in the study and submit estimated patronage, although many did not (or could not) respond.

Schools can also be considered limited trip generators. For the purposes of this study, all schools in the study area were assessed, although only large high schools were considered on the basis of the relative independence of the students.

The concentration of reasonably sized high schools around Murdoch University needs to be considered, and routing LRT along Discovery Way should sufficiently 'capture' these students. Other important schools to consider include Applecross adjacent to Garden City Shopping Centre, and Melville, along Leach Highway.

Table 10. Trip Generators and Applicable Routes

Trip Generator	Size (if known)	Applicable Routes
Murdoch Train Station / Fiona Stanley Hospital Complex	9500	All
Murdoch Activity Centre		All
Eastern Precinct		All
Murdoch University	19000 (total)	All
Fremantle Train Station		All
City of Fremantle		All
Notre Dame University	5500	All
Applecross Senior High School	1300	7B
Garden City		6A,6B,7B
CBC	800	5F,6J,7K
John Curtin College of the Arts	1050	5F,6J,7K
Melville Senior High School	1000	5D,6F
Corpus Christi	1360	5A
North Lake Shopping Centre		4B,5C
Fremantle Hospital	~1000	3F
Kardinya Park		3C,4A
Hamilton Hill IGA	1000-2000	2E
Challenger TAFE (Lefroy Rd Campus)		2E
St Ives / Murdoch Village	1100	2A,2B
Winthrop Baptist College	680	2A

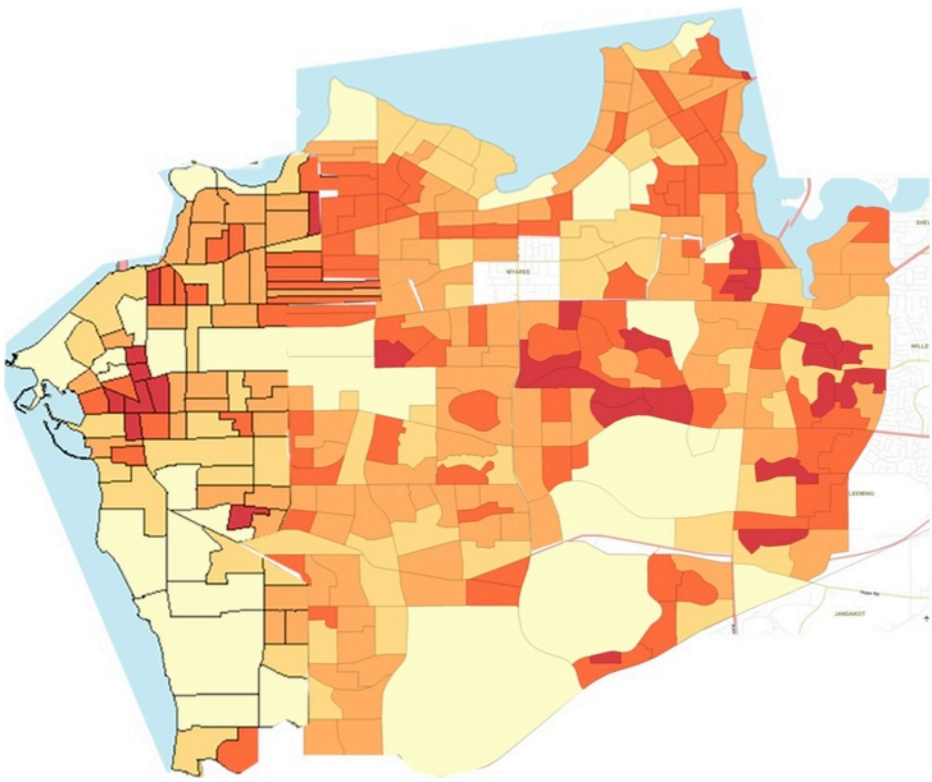
Ridership

Introduction

The most critical component in determining the viability of any LRT line is the ridership, or the predicted popularity and usage (Joshi et al 2006). A LRT line is considered justified when expected ridership exceeds 10,000 passengers per day, within the accepted 8-21,000 that would be needed to significantly contribute to the operating costs of the line (Ginn 1998). While this level of patronage will not mean the line is financially self-sufficient, it will be cost competitive with road transport, insofar as Western Australia has no toll roads, and therefore no financially self-supported roads.

Prediction Rationale & Method

Expected ridership was calculated using population data from the 2006 census conducted by the Australian Bureau of Statistics. From population densities taken at a collection district level, and accounting for local population increases (also provided by ABS) an approximate number of residents within 400m of each line could be calculated. Adding expected riders traveling to trip generators, and using the expected % share of transit in Perth (Department of Transport 2011), the number of potential riders along a line can be calculated. The 'sparks' effect (the unexplained higher level of patronage for rail based transit over other forms) is also accounted for.



NB: trip generators where the size could not be determined have been excluded. Therefore, these results represent the ***minimum*** expected ridership. In reality, it is expected that the connection to the Fremantle CBD will ensure that most lines 'capture' sufficient riders. Employment numbers, where available, were included. However, these details are not often recorded or published, and so often have not been accounted for. It is stressed that more investigation is required in this area.

For more detail, a spreadsheet is available online from the South West Group website with embedded formulae. Routes 4 and 6 do not include Murdoch trip generators as they are intended as 'option extenders' for other routes.

Table 11. Predicted Ridership

Route	Predicted Ridership
1	6374
2	7076
3	6883
4	240
5	7081
6	2612
7	9461

Cost

The total cost (capital and operating) were estimated using data and research from several studies, both in Perth and around the world (Department of Transport 2011; Maunsell & AECOM 2007; Parsons Brinckerhoff 2009; Gunduz 2011 amongst others). It must be stressed that the data used in the study is expressed to be used as a rough indicator only, and hence is not used to pass/fail any potential routes.

The critical component in determining the cost of LRT is the level of the guideway - either below ground (subway), at grade (either shared running with traffic or exclusive ROW), or elevated (as seen in Vancouver). Running LRT at grade produces significant cost savings (Parsons Brinckerhoff 2009), and is feasible across most routes. Hence, running LRT above or below grade will not be considered further.

Therefore, the most significant cost factor in this study is simply the length of the respective routes (Gunduz 2011). The costs of trackway (per km) are assumed to be similar for all sections. According to the US Federal Transit Administration (2005), prices have not experienced any great fluctuations in price over the last few decades, and so comparisons can be made from lines constructed some time ago with some confidence (assuming CPI changes have been accounted for). In order to guarantee service frequency, longer routes would require more vehicles, incurring a greater rolling stock and operating cost. The assumptions are: an average speed of 50 km/hr for street running and 100 km/hr in exclusive right-of-ways with 2 minute delays at stations, and 5 minute turnaround at terminals. This is a conservative estimate based on data from similar systems around the world, but will be used to calculate the maximum necessary number of vehicles required to ensure a peak service frequency of 10 minutes.

A study by Professor Alan Hoback (2007) (available at: http://eng-sci.udmercy.edu/programs/eng/civil-environmental/research/transit-research/index.htm) resulted in an accurate methodology and spreadsheet calculator that has been proven to estimate costs on average within +/-6%. This research is continuing and utilising more data is expected to further improve this accuracy. As around 85% of costs involved are local costs, and the study uses cost of living comparisons between US cities, an appropriate scaling factor was applied for Perth, taking the base year as 2011. The results: $ 49.9 million/km for in-road construction, $24.95 million/km for median/exclusive ROW construction, and $4 million per LRV.

This is in stark contrast to predicted figures of up to $20 million/km released by Bombardier (Maunsell & AECOM 2007) based on experience in Melbourne and Adelaide. It is believed that the difference in these results may be attributed to the high cost of living index for Perth, and that in-street construction in the Hoback study usually was located within the CBD of the selected city. The Bombardier estimates would also need to take into account depot costs, etc.

Table 12. Estimated Costs

Route	Length (km)	# Vehicles	Estimated Cost (Hoback)	Estimated Cost (Bombardier)
1	13.56	7	$578,641,227.00	$299,200,000.00
2	11.95	9	$618,776,102.00	$275,000,000.00
3	11.11	7	$387,953,506.00	$250,200,000.00
4	1.01	3	$68,453,433.00	$32,200,000.00
5	12.44	8	$462,018,197.00	$280,800,000.00
6	7.25	6	$406,983,362.00	$169,000,000.00
7	17.74	10	$676,230,173.00	$394,800,000.00

This cost cannot be assessed on it's own, but as a comparative cost. The expected restructuring of bus services could produce significant savings, and savings generated by averting additional road construction costs should also be considered.

The expected costs of route sections are available online from the South West Group. For a more detailed investigation in the trend of LRT capital and operating costs, see the Federal Transit Administration (2005) report.

Environmental Impact & Heritage

Environmental Impact

Although LRT may be a more environmentally beneficial form of transport than the automobile, the construction of the transit corridor can have a considerable effect on the environment. Accordingly, a windshield study was completed, and each route option was assessed according to the potential for impact on the environment.

Most routes involve simply altering existing road reserved, with a minimal or almost non existent effect on the environment. The distinction between the two categories lies in the removal of some mature trees on the edges of the road reserve, or on the island on dual carriageway sections. Aboriginal burial remains have been discovered in the bushland located in the Southwest corner of the Murdoch drive/South street intersection. While resumption of this land is not expected, it must remain foremost in consideration of any potential LRT corridor, particularly section 2B.

Moderate effects on the environment include an expected resumption of small parcels of bushland, or large numbers of trees on road reserves.

2 route sections are considered to have potentially considerable environmental consequences. Section 1B not only passes bushland in the Southeast corner of Murdoch University, but also passes through the Beeliar wetlands. The Beeliar wetlands are a rich and diverse chain of natural preserves, and contain several protected species such as the Quenda (Isodon obesulus fusciventer) and Carnaby's Black Cockatoo (Calyptorhynchus latirostris) (DPI 2007).

While the Roe hwy extension is expected to continue, the expansion of the road reserve required to accommodate LRT has probably not been considered. This option is strongly recommended against without a thorough Environmental Impact Assessment.

Section 6C passes through Robert Crawford park, and would involve the resumption of the park, and potentially some private land. The noise and environmental impact is outweighed by the potential benefits of the route option. As a result, section 6C will not be considered further in the study.

Table 13. Environmental Impact of Routes

Impact Level	Routes
Negligible Impact	1A, 2A, 2C, 3A, 3B, 3F, 4A, 4B, 5F, 6A, 6B, 6D, 6E, 6G, GI, GK, 7D, 7F, 7H, 7J, 7K
Minimal Impact	2B, 2D, 2E, 3C, 4C, 5A, 5B, 5E, 6F, 6H, 6J, 7A, 7B, 7I
Moderate Impact	1C, 3D, 3E, 5C, 5D, 7C, 7E, 7G
Considerable Impact	1B, 6C

Heritage

The south west metro area is home to a significant proportion of culturally and historically significant buildings, landmarks and places. While LRT is important for the future of Perth, it doesn't have to be at the expense of the past (In fact, LRT can be a visual reminder of Perth's enviable tram history).

A comparison between potential routes and heritage lists of place, buildings and landmarks in the study area shows no significant heritage impact. This was to be expected, as LRT is not expected to require an expansion of road reserves in sensitive areas. The majority of track to be laid will be within the road reserve on major roads with little heritage value. It must be noted that this comparison did not include the southern approach to Fremantle station, as the heritage issues associated with this area have already been partially addressed in the SKM corridor study, and further assessment will be completed during the course of the Cockburn Coast LRT study.

No heritage places were found to be on tight corners where land may have to be resumed (such as South tce / Lefroy).

Within the Fremantle CBD, significant heritage value combined with tight clearances would require further investigation. LRT carriages could be propelled using induction/third rail power or batteries, as this would avoid the need for overhead catenary poles and similar infrastructure.

Future Work

This report only begins to scratch the surface of the work required, and the following gives an indicator of the required direction of future work:

- Most of the work in this study has been at a high, or conceptual level. Therefore, most sections require further and more focused work to confirm and clarify the rationales and decisions made. The Downtown Dallas or Perth Light Rail Study both provide good examples of more advanced studies.
- The study area represents only a part of metropolitan Perth, and as such, the findings within this report need to be integrated into a city-wide vision for transit such as 'Light Rail for Perth' or the Department of Transport's 2031 plan
- Further investigation is needed to establish
- Strategic relationships are critical to the success of multidimensional projects like these. Accordingly, effort needs to be made to include all stakeholders in future discussions and planning processes
- LRT operates most efficiently within a legislative and community framework that restricts car use while promoting transit use. Effort needs to be made in the political arena to alter transport priorities, and encourage density increases with the existing metropolitan area.
- Considerable further investigation is needed in costing a LRT line in Perth. It is expected that more advanced proposed lines will yield hard data that will improve the reliability of such estimates.
- Additional effort needs to be made to raise the public awareness of the potential of LRT and shift public perceptions towards transit.

Conclusions

Cities across the globe are embracing Light Rail Transit, or LRT, as a solution for rapid transit over small distances. By occupying a space between local bus and heavy rail services, LRT can significantly contribute to the future transportation mix in Perth. Taking into consideration the future direction of planning in Western Australia as outlined in the Directions 2031 report, an increase in density in the study area is expected. With proper planning and investment, this increase can be accommodated in attractive and functional Transit Oriented Developments, encouraging higher public transport use. By anchoring these communities with LRT, Perth can slow the rapid widening and expansion of roads built to carry more users further each day.

This report has identified and investigated several potential LRT corridors between the Murdoch and Fremantle train stations. Each route have been evaluated according to different criteria (listed in Table 14), and ranked accordingly. In deference to LRT's ability to serve different interests according to the desires of planners, corridors are rated according to each criteria, not overall.

Table 14. Recommended Routes

Rationale	1st Recommended Route	2nd Recommended Route
Cost	3	5
Environmental Impact	2	3
Feasibility	1	5/6
Legibility	3	5
Placemaking	2	6/7
Ridership	7	2
Speed	3	1
Trip Generators	5/6	2
Urban Renewal	3	7

While it is not the intention of this report to recommend a particular route, it would appear that a combination of both routes 2 and 3 would be an optimal solution. This route would run from Fiona Stanley Hospital (down Barry Marshall avenue) to South street via Discovery drive. It would then follow South st, before connecting with the proposed Cockburn Coast LRT line, heading into Fremantle. Passing most trip generators, and several already high density areas, this route would capture a significant ridership. Opportunities for Transit Oriented Development (TOD) exist surrounding Carrington street, as well as the Murdoch Activity Centre and Eastern Precinct near the Murdoch terminus, and such options can help raise capital to fund the line itself. By utilising an existing thoroughfare (South street), environmental damage is minimised and a rapid service is ensured.

Bibliography

ACT Light Rail 2009, 'Solution assessment', Proposal submitted to Infrastructure Australia. pp 46-68.

Adams, R 2009, Transforming Australian Cities for a More Financially Viable and Sustainable Future, City of Melbourne & Department of Transport, Melbourne.

Australian Conservation Foundation 2009, Investing in Sustainable Transport: Our clean, Green Transport Future.

Cohen-Blankshtain, G & Feitelson, E 2011, 'Light rail routing: do goals matter?' Transportation, vol. 38, pp 343-361. Available from: Springer Science+Business [7 April 2011].

Committee for Perth 2011, What we thought would kill us: The Evolution of Perth's Passenger Rail, Available from: [13 June 2011].

Curtis, C & Sheurer, J 2009, Network City Activity Centres: Developing an analysis, conception and communication tool for integrated land use and transport planning in the Perth metropolitan area, Curtin University Sustainability Policy Institute, Fremantle.

DART 2010, Downtown Dallas Transit Study Dallas CBD AA/DEIS, Federal Transit Administration, Dallas.

De Bruijn, H & Veenman, W 2009, 'Decision making for light rail' Transport Research Part A, vol. 43, pp 349-359. Available from: Elsevier [7 April 2011].

Department of Transport 2011, Public Transport for Perth in 2031: Mapping out the Future for Perth's Public Transport Network, Available from www.transport.wa.gov.au .

DPI 2007, Murdoch Activity Centre Structure Plan: Part A- Fiona Stanley Hospital and Health Precinct, Department for Planning and Infrastructure & the Department of Health, Perth.

Dueker, KJ & Bianco, MJ 1999, 'Light Rail Transit Impacts in Portland: The First Ten Years', Presented at the seventy-eighth annual meeting of the Transportation Research Board, Washington D.C.

Estill 2006, Dialogue with the City of Melville (Melville Visions): Community Consultation Report, Available from the City of Melville, Perth.

Federal Transit Administration 2005, *Analysis of Cost Elements and Their Effect on Operating Elements.* Available from: www.utrc2.org/research/assets/107/utrc-2005-fta1.pdf [22 September 2011].

Ginn, S 1998, An overview of light rail technology and its potential within an australian environment, Western Australian Planning Commission, Perth.

Gunduz, M, Ugur, LO & Ozturk, E 2011, 'Parametric cost estimation system for light rail transit and metro trackworks' Expert Systems with Applications, vol 38, pp 2873-2877.

Hoback, A 2007, *Sensitivity Analysis of Light Rail Transit Unit Capital Costs.* Available from: eng-sci.udmercy.edu/programs/eng/civil.../research/.../08-0024.pdf [22 September 2011].

Joshi, H, Guhathakurta, Konjevod, G, Crittenden, J & Li, K 2006, 'Simulating the effect of light rail on urban growth in Phoenix: An application of the UrbanSim modeling environment', Journal of Urban Technology, vol. 13, no. 2 pp 91-111.

Manning, I 1984, Beyond Walking Distance - The gains from speed in Australian urban travel, Australian National University, Canberra.

Maunsell & AECOM 2007, Perth Light Rail Study: Feasibility Study for a Light Rail Alignment between Subiaco and East Perth, Available from the Western Australian Department for Planning and Infrastructure, [5 May 2011].

Parsons Brinckerhoff 2006, Ipswich to Springfield Transport Corridor Study, Queensland Transport & Ipswich City Council.

Parsons Brinckerhoff 2009, Alternatives Development and Alignment Screening Report, Dallas Area Rapid Transit

Parsons Brinckerhoff 2010, Stirling tram feasibility study - Preliminary patronage estimates, City of Stirling, Available from: [29 March 2011].

Parsons Brinckerhoff, KPMG, APD & Steer Davies Gleave 2004, Gold Coast Light Rail: Feasibility Study [DRAFT], Gold Coast City Council, Australian and Queensland Governments.

Renne, JL 2007, Measuring the Performance of Transit-Oriented Developments in Western Australia, Planning and Transport Research Centre & Institute for Sustainability and Technology Policy (Murdoch University), Available from the Western Australian Department for Planning and Infrastructure.

SKM 2010, Transit Corridor Alignment Study, City of Fremantle, [29 March 2011].

Stokes, RJ, MacDonald, J & Ridgeway, G 2008, 'Estimating the effects of light rail on health care costs' *Health & Place,* vol. 14, pp. 45-58.

Thomas, L 2002, Light Rail for Perth. Honours Thesis, Murdoch University.

Thompson, GL 2007, 'Taming the Neighborhood Revolution: Planners, Power Brokers and the Birth of Neotraditionalism in Portland, Oregon', Journal of Planning History, vol. 6, no. 3, pp214-247. Available from: http://jph.sagepub.com/content/6/3/214 [1 July 2011].

Trubka R, Newman P & Blisborough, D 2008, Assessing the Costs of Alternative Development Paths in Australian Cities, Curtin University Sustainability Policy Institute and Parsons Brinckerhoff, Fremantle.

WAPC 2006, Development Control Policy 1.6: Planning to Support Transit Use and Transit Oriented Development, Available from the Western Australian Planning Commission, Perth.

WAPC 2010, Directions 2031 and beyond: metropolitan planning beyond the horizon. Available from Department of Planning & Infrastructure [31st March 2011]

Appendix A: Map