25/04/2017

Oakland Park Grade Separation Feasibility Study

Feasibility Study

DPC
The Difference In thinking

Government of South Australia
Department of Planning, Transport and Infrastructure

Executive Summary

This Feasibility study aims to develop and analyse two main concepts for the upgrade of the intersection of the Diagonal and Morphett Road with Seaford Rail Line. This upgrade will be completed as a grade separation.

Initially 4 concepts were suggested as outlined in DPC's tender proposal, they are as follows; Rail Overpass, Rail Underpass, Road Overpass and a Road Underpass. The four concepts were initial reduced to two concepts; a Rail Overpass and a Road Overpass.

An in-depth analysis of the two options listed above was conducted to evaluate and determine the most suitable solution, the criteria of which are outlined within the report.

The final recommendation by DPC Engineering is that a Rail Overpass is the most feasible option for the grade separation of Diagonal and Morphett Road with Seaford Rail Line. This final recommendation come on the back of our expert design teams and the considerations found within the main report.

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Company Declaration

DPC Engineering is commitment to reaching the upmost level of integrity, accountability innovation and safety for all of our clients and stakeholders.

Our mission is to provide a product for our clients that meets or exceeds their expectations, while generating sustainable returns for our stakeholders. We aim to service the industry with regards to improvements in safety and design processes.

DPC Engineering understands that every project is different and every project must be approached in a suitable manner so as to meet the client's needs. DPC Engineering strives to achieve just this.

University Declaration

We declare the following to be our own work, unless otherwise referenced, as defined by the University's policy on plagiarism. This report is a part of a university project and is not an official document.

Sincerely,

Samuel Matthews

Project Manager

Jia Shi

Assistant Project Manager

1 Introduction

The intersection of Diagonal and Morphett Road with Seaford Rail Line has been highlighted by the Department of Planning, Transport and Infrastructure (DPTI) for upgrade. The aim of this upgrade is to improve both the safety of the intersection for motorists and other road users along with improving the traffic flow in this area. The solution must comply with all DPTI standards and be consistent with all relevant Australian Standards.

This feasibility study endeavours to analysis and evaluate a series of options for the upgrade of the intersection of Diagonal and Morphett Road with Seaford Rail Line to determine the most suitable solution. This will be done in conjunction with our rigorous quality standards as depicted in our Quality Management System of which is provided.

2 Deliverables

DPC will provide the following deliverables to the client as described in the tender proposal:

- Feasibility study with final design recommendation
- Environmental Impact statement
- Quality Management System and supporting documentation

3 Initial evaluations

During the tender stage four initial concepts were proposed based on the given information and known geometry, these four concepts are shown below.

- Overpass rail with at-grade Diagonal Road
- Overpass of Diagonal Road with rail at-grade
- Underpass rail with at-grade Diagonal Road
- Underpass of Diagonal Road with rail at-grade

An initial red-light, green-light evaluation was carried out to reduce the number of concepts to two. During this initial evaluation, each design team analysed the four options using a set discipline specific criteria to give each option a red or green light.

3.1 Red light, green light evaluation

3.1.1 Environmental

3.1.1.1 Evaluation criteria and aims

It is the aim of this document to provide clarity on the feasibility of the for-mentioned concepts from an environmental prospective. Furthermore, it is aimed to provide an environmental insight to help narrow down the plausible options in conjunction with other departments listed in this report. To do this the following criteria will be assessed against each design concept;

- Existing environmental conditions
- Site contamination
- Air quality
- Hydrology and water quality
- Noise and vibration
- Tree (vegetation) impact

3.1.1.2 Rail Overpass

Constants

- In terms of evaluation against contamination all design choices are adequate, as site is approved for industrial land use such as a transport interchange.
- Earthmoving and construction equipment for all design concepts are expected to create additional emissions in the short-term
- There is a low potential for groundwater contamination from the use of the site, and providing construction stage is managed correctly all design concepts are relevant in terms of Hydrology and water quality. Recommend consulting with water team to see if cost and ease of construction of the storm water design is a prevailing factor.
- Noise from construction will be a constant, despite the design concept chosen, recommend an analysis of noise and vibration in terms of use from the final product.

Advantages

- Design is suitable for topography and soil conditions
- Reduced land acquisition, thus, less impact on vegetation

Disadvantages

- High-rise, thus, sound is an issue. That being said the use of sound barriers, and dampening measures makes this option is viable.

3.1.1.3 Rail Underpass

Constants

- In terms of evaluation against contamination all design choices are adequate, as site is approved for industrial land use such as a transport interchange.
- Earthmoving and construction equipment for all design concepts are expected to create additional emissions in the short-term
- There is a low potential for groundwater contamination from the use of the site, and providing construction stage is managed correctly all design concepts are relevant in terms of Hydrology and water quality. Recommend consulting with water team to see if cost and ease of construction of the storm water design is a prevailing factor.
- Noise from construction will be a constant, despite the design concept chosen, recommend an analysis of noise and vibration in terms of use from the final product.

Advantages

- Design is suitable for topography and soil conditions
- Reduced noise and vibration when compared to first option.

Disadvantages

- Increased land acquisition, thus, greater impact on vegetation.
- Greater earthworks, more impact on vegetation, slight impact on ground water if sediments from runoff from construction.

3.1.1.4 Road Underpass

Constants

- In terms of evaluation against contamination all design choices are adequate, as site is approved for industrial land use such as a transport interchange.
- Earthmoving and construction equipment for all design concepts are expected to create additional emissions in the short-term
- There is a low potential for groundwater contamination from the use of the site, and providing construction stage is managed correctly all design concepts are relevant in terms of Hydrology and water quality. Recommend consulting with water team to see if cost and ease of construction of the storm water design is a prevailing factor.
- Noise from construction will be a constant, despite the design concept chosen, recommend an analysis of noise and vibration in terms of use from the final product.

Advantages

- Design is suitable for topography and soil conditions
- Almost no noise and vibration when compared to first option.

Disadvantages

- Far greater Increase in land acquisition for alternative road to access local business and residences, thus, greater impact on vegetation.
- Greatest earthworks, more impact on vegetation, slight impact on ground water if sediments from runoff from construction.
- Car fumes could pollute underpass, effecting air quality, compared to the first option.

3.1.1.5 Road Overpass

Constants

- In terms of evaluation against contamination all design choices are adequate, as site is approved for industrial land use such as a transport interchange.
- Earthmoving and construction equipment for all design concepts are expected to create additional emissions in the short-term

- There is a low potential for groundwater contamination from the use of the site, and providing construction stage is managed correctly all design concepts are relevant in terms of Hydrology and water quality. Recommend consulting with water team to see if cost and ease of construction of the storm water design is a prevailing factor.
- Noise from construction will be a constant, despite the design concept chosen, recommend an analysis of noise and vibration in terms of use from the final product.

Advantages

- Design is suitable for topography and soil conditions

Disadvantages

- Increased land acquisition for alternative road to access local business and residences, thus, greater impact on vegetation.
- Large earthworks, more impact on vegetation.
- Noise and vibration is greatest of all options and is more constant than rail overpass.

3.1.1.6 Summary of findings

Thus, from the summary above the two most feasible concept designs from an environmental design is a rail overpass and the Road Overpass, where all other designs come with a slightly greater environmental challenge to overcome. Thus, the environmental department recommends a greater in depth analysis into;

- Recommendation 1 - Rail Overpass
- Recommendation 2 - Road Overpass

3.1.2 Transportation

3.1.2.1 Selection Criteria

- Traffic management during construction and post construction
- Pedestrian/cyclist access
- Access to business
- Access to local street
- Land acquisition
- Future development
- Public transport access (bus to train coordination)

3.1.2.2 Rail Overpass

Advantages

- Better safety: reduce risk for all road users (pedestrian and bicycle way parallel to the over pass between Murray Terrace and Railway Terrace)
- Minimum land acquisition
- Improves local streets traffic system
- Better public transport and facilities
- Lifts and stairs for passengers to access the station
- Keep current grade for Morphett road (cheaper)

Disadvantages

- Dominant in the area (may affect close by properties)
- Noise pollution (due to high rise)
- Big impact for traffic users during construction

3.1.2.3 Rail Underpass

Advantages

- Clean and Aesthetically pleasing
- Minimal reworks to Diagonal Road's current Alignment
- Existing Routes unaffected for public transport
- Installation of more traffic signals will provide a safe crossing opportunities for pedestrians
- Cyclist Lane will be added on Diagonal road
- Rail infrastructure will not have an impact on the general area
- Allows for further development such as residential properties, business or additional roads on the existing surface as the railways line will be shifted underground
- Minimal Noise and Visual impacts from lowered rail and at-grade road

Disadvantages

- Possible services relocation
- Road widening may increase difficulty of pedestrians crossing roads
- Loss of business and residential properties for land acquisition
- Existing Vegetation could possibly be affected

3.1.2.4 Road Overpass

Advantages

- The rail will be operational during the construction period
- Possible but need considerable redesign to meet the demand
- Would be able to provide services to Aquatic centre and other business around it.
- cost effective
- Easier to construct

Disadvantages

- Some local houses will be effected
- Morphett Rd must be access diagonal Rd through prunes St at intersection
- Aesthetically doesn't suit the location
- Future development (restriction)
- Land acquisition
- Traffic management construction period (heavy traffic flow area)

- Noise barriers has to be implemented on the business and houses along over pass
- Not easy access to local streets

3.1.2.5 Road Underpass

Advantage

- No restriction for future development, as it will be below surface level and it will not cause any affect development of new building or any structure.
- It will not cause the shade on residential properties.
- Safer for pedestrian and cyclist.
- Better trains' services and easy traffic flow after construction as they will not share the junction.
- Easy access to train station (no need to climb upstairs or downstairs to catch train)

Disadvantage

- The both train service and road traffic need to be stop during construction and management of heavy traffic during peak hour will be tough
- Need to use alternative road to access local business and residence
- Required land acquisition as the width of road is wide and need to construct retaining walls
- Excavations are very expensive and can cause problem on footing of nearest infrastructures.
- The road might get flooding during heavy rainfall, if the drainage systems is inappropriate
- It's very expensive to construct and will also affect the services.
- The two roads can't underpass at the same junction so; traffic of Morphett road must access Prunes street to access Diagonal road to underpass.

3.1.2.6 Summary of findings

Based on the constraints set out previously, it can be suggested that Rail Overpass or Rail Underpass makes a better grade separator in Diagonal and Morphett Roads intersection which can solve current traffic issues and accommodate future traffic volume corresponding with increase in number of train services.

- Recommendation 1 - Rail Overpass

- Recommendation 2 – Rail Underpass

3.1.3 Structural

3.1.3.1 Design Objectives

The text evaluates structural features considered for Oaklands Park grade separation project. In order to propose two feasible options, the team has analyzed all structural aspect of the project. The aim of this text is to identify best option from the four proposed design concepts.

The following objectives will be used as benchmark for the purpose of finalizing the best options:

- Cost efficient
- Minimum project duration
- Feasible construction
- Simple design with effective structural features
- Innovative and sustainable

3.1.3.2 OPTION 1: Rail Overpass

Rail overpass structure is known as one of by far the most popular structure in Adelaide. Considering only the structural aspect of the project, the team has determined the following advantages and disadvantages:

Advantages

- One of the easiest way of grade separation
- No need to consider pedestrian bridge
- Minimum duration of project is expected

Disadvantages

- Cost issues could arise regarding the construction of the rail

3.1.3.3 OPTION 2: Rail Underpass

Structural Consideration

- This design considers initial horizontal alignment as well as land excavation for the underpass.
- Lateral loads such as wind load, seismic load will have a smaller impact to underpass structure when comparing to overpass options. And vertical loadings are transferred easily to the ground.
- Complicated design analysis is required for bored piles.

- Pedestrian bridge is considered for this option

Advantages

- Minimum reworks is expected on Diagonal Rd
- Simple design in terms of analyzing the design loads

Disadvantages

- Maximum clearance is required
- Is not considered to be an economic design

3.1.3.4 OPTION 3: Road Overpass

The design is based on the construction of bridge over the Morphett Rd and Diagonal Rd intersection. The following structural details have been analyzed:

Advantages

- Minimum duration of construction is expected
- Minimum use of material is expected
- Since railway is assumed to be levelled on ground that's why initial horizontal and vertical alignments can be used, which will result in minimum complexities in design procedure.

Disadvantages

- Complications in road alignment has been figured out, which is due to the road condition and the direction of four roads.
- Additional facilities such as pedestrian bridge should be considered
- It is a complex design, since several parameters based on loads should be considered, depending on what material is used for the deck of the bridge e.g. abrasion resistance of concrete

3.1.3.5 OPTION 4: Road Underpass

Structural considerations

- Morphett Road should be aligned with the excavated Diagonal Road to allow traffic flow from Morphett Road to Diagonal Road underpass

- Retaining wall will be constructed on both sides of the road
- Design loads are considered
- Underpass design should have an appropriate gradient
- Minimum vertical cover must be provided
- Pedestrian bridge should be provided across diagonal road beside railway tracks

Advantages

- Land usage will be minimized
- It can be visually appealing
- Railway station will not have to be relocated, which would help saving extra construction cost

Disadvantages

- Design will become complicated due to road alignment
- Building a road underpass will take much more time on comparison to rail under pass, as Morphett road will also need some excavation and construction
- Overall construction for road underpass will be costly because two roads will have to be considered for its complex design

Pedestrian bridge will add to the cost of underpass road design

3.1.4 Services

3.1.4.1 Evaluation Criteria

The services team has developed the flowing selection or valuation criteria to complete the red-light green-light analysis.

	Disturbance / Traffic & Rail	Resourcing / Time	Complexity	Services Relocation	Risk	Cost	Total
Option	10	10	10	10	10	10	60
Rail Overpass	8	6	7	3	6	7	37
Rail Underpass	8	9	8	9	7	9	50
Road Overpass	9	8	8	9	8	8	50
Road Underpass	7	8	8	4	7	7	41

3.1.4.2 Assumptions

All services are assumed to be at a depth between 500 and 1000mm unless otherwise specified. The dial before you digs are to be assumed correct at the time of the study undertaking and consideration has not been given to any service not identified on asset owner asset drawings. It is assumed all tie in and major road works are completed during night/weekend shifts due to traffic restrictions. The cost of service relocation has considered Rawlinson's construction cost guide and relative experts in the services field.

3.1.4.3 Option 1 Rail overpass with Diagonal Rd at grade

The main concerns with this option are the continual operation of the rail line during the period of construction. There are fairly strict rules set by the client (DPTI) which increase the complexity of the construction methodology, two examples are rail shutdowns may not exceed 60 hours and single operation is to be avoided. The primary services risk comes under the construction of the foundations of the proposed infrastructure, there may be clashes which require costly or complex relocations. The majority of the existing services will remain undisturbed as the critical works occur above ground, however consideration of the intersection works at Diagonal road will need to include the potential public services disturbance (Water, gas etc). Temporary feeds during these works will require detailed planning.

3.1.4.4 Option 2 Rail underpass with Diagonal Rd at grade

Services relocations are the main risk under this option as the amount of relocating, temporary feeds and shutdowns will affect the lives of the public and businesses. This brings an element of public perception risk through the increased chance of a major incident. Relocation costs and time will impact the duration and cost viability of this option. Water, nbn and electrical are the primary concerns under this option as they are major feeds to residents and businesses. As it is an underpass, necessary services such as electrical, comms, lighting, water etc will be required which adds a level of complexity through construction planning.

3.1.4.5 Option 3 Diagonal Road Overpass Rail at grade

Existing ground conditions can remain relatively the same; however some relocations and new feeds will be required for affected businesses and residents. Risk of service damage is minimised as less excavation is required. Most critical services are avoided under this option however structure foundation locations may dictate otherwise. Lighting/ITS impacts will be of high importance as electrical/data networks will have to be run throughout the overpass.

3.1.4.6 Option 4 Diagonal Road underpass Rail at grade

As with the rail underpass, all affected services networks will be relocated and in some areas redesigned. Criticality and complexity of service relocations will dictate costs, it is expected there will be major water and potentially electrical services as it is a major public locale. Underpass will require services inclusive of lighting, ITS, comms and water (fire suppression etc). Project duration may be extensive based on quantity of services to be relocated and existing ground conditions (non-documented older services, privately placed services etc).

3.1.4.7 Summary of Findings

The recommendation based on a general analysis of the existing ground conditions against the proposed solutions has yielded two preferable solutions. A road or rail overpass is the preferable option for the Oaklands park grade separation as the complexity, risk and time required to construct an underpass is far greater than that of an overpass. The majority of the ground services remain untouched with an overpass option, the exceptions being the foundations of the proposed structures and potential upgrades. An underpass will require detailed evaluation of current services followed by a redesign of all the affected services, this can become a costly exercise hence the recommendation of overpasses.

3.1.5 Urban Design and Community Consultation

3.1.5.1 Evaluation Criteria

- Evaluation of current urban design
- Comparison with 30 plan for greater Adelaide
- Heritage
- Land acquisition – minimization
- Determine impact on community
- Evaluate costs of land acquisition
- Security and Crime Prevention
- Local Access Impacts

3.1.5.2 Underpass of Diagonal Road with rail at-grade & Underpass Rail with Diagonal at grade

Underpass construction is under the ground, so planning, survey, design, construction methods, construction organization and maintenance and hydrogeological conditions about the entire project plays very important role for Underpass construction.

so we need to consider some of the conditions:

1. Less interference, closed construction is required.
2. Engineering geological and hydrogeological conditions at Underpass locations are required for Australian standards
3. The technical conditions and mechanical equipment of construction need to meet the

requirements.

4. the construction of power and raw material supply situation
5. The investment and social benefits and operating efficiency after the operation is profitable.
6. the safety situation of construction
7. Conditions about the pollution, ground subsidence and other environmental.

Advantages of underpass：

It can share the load of ground traffic and the flow of people, saving urban land.

Underpass can withstand better explosive loads and seismic loads.

The level of disruption may be lower against the residential area. For example, the cars or trains passing underground significantly minimize the noise generated.

Disadvantages of underpass:

Construction of Underpass is expensive, construct underpass need to consider adequate technical and economic benefits.

In addition, time of construct underpass is very long, the construction site is relatively narrow, and so the labor and mechanical space are very limited. However, the current situation is improving, because the constant improvement of industrial construction and mechanical properties.

Finally, underpass construction needs to cross the formation. However, the geological conditions are complex and varied, more unexpected circumstances happen in the construction process.

Therefore, the positioning of the project, design and construction methods must be adjustable at any time. Requirements of cooperation between planning, surveying, design, construction management are very high.

Diagonal Road build an underpass with two lanes on each side. According to the current situation the demolition will be very large. Because there are many residential areas and business areas around.

So this is very uneconomical, because it is very troublesome to remove a large building like a temple. In addition, there are many residential areas around, once dismantle, a lot of money will be needed to arrange their new residence.

Last but not the least, building underpass takes a lot of space to place some large machines. If the underpass construction is completed, it can share the load of ground traffic and flow of people, saving the city's land. However, compared to its contribution, it is very uneconomical.

3.1.5.3 Diagonal Road Overpass with Rail at Grade

Running Diagonal Road as an overpass would require a considerable redesign of the intersection with Morphett Road. This preference is one of the most cost efficient solutions to the grade separation, but the team will think more critically and analyses it in-depth. This choice may have several adverse impacts on the environment such as pollution, safety of the local community and noise.

Advantages

- Minimize the land acquisition of private property
- Significant minimize less disruption during construction
- More opportunity to develop community spaces below and enhancement in land use strategy plans.

Disadvantages

- Cause Traffic disruption (road line will be closed for construction which will impact on the local traffic, businesses, and commuters.
- Significant Complain may be occurs due to access difficulties.
- Significant redesign traffic flow and traffic design which will cost a lot.
- Land Acquisition is larger compare to other options due to number of traffic lanes need to be construct and design.

3.1.5.4 Overpass Rail with at grade diagonal road

This concept involves the construction of a railway bridge while maintaining the current grade of Diagonal road.

The requirements of this design are as follows:

- 2 broad gauge tracks which can be altered to standard gauge easily and cheaply (part of Norlunga railway line),
- Maximise design speed (able to maintain current speed limit through corridor or exceed it safely for faster travel),
- Provides enough vertical clearance for tall vehicles on road below
- Includes pedestrian crossings and,
- Footpaths for both pedestrians and bicycles,

- Low maintenance design solutions.

An initial evaluation shows that the nearby station will need to be elevated, so as to ensure there is enough track on the eastern side of Diagonal Road to slope downhill at the optimal angle. Likewise, the track on the Western Side of Diagonal Road will also be sloped downwards, and there is ample track length to allow this. In conjunction with the elevated platform and sloped track, the fill required to raise the platform and slope the hill will need to contain and secured within a small space, as there are residential streets on both sides of the current track, and it is assumed that these streets will remain present with the new ramp. It is desired the overall look of the station is updated and enhanced, to provide a safe, comfortable, attractive, welcoming, functional, and user friendly environment which encourages the use of rail transport.

Advantages

- Maintains alignment and grade of Diagonal road,
- Land acquisition of private property is minimizing
- Opportunity to enhance station and amenities,
- Opportunity to improve aesthetics of station and bridge creatively.
- Much can be built off-site and assembled over the existing railway which mean train line will be closed for a shorter time, reducing the impact on commuters, business and local traffic.
- Achieves the required noise objectives and eliminates any loss of privacy by the use of noise and privacy screens
- Significant minimize disruption during construction
- Existing flora and fauna can be retained due to the reduced impact on root systems
- More opportunity to improves rail line with strong pedestrian and cyclist connectivity across the rail corridor

Disadvantages

- Potential loss of visual amenity in the precinct
- Railway will need shutdown periods,
- Potential Overshadowing and loss of privacy certain properties

3.1.5.5 Conclusion

After reviewing all 4 options and recommendation, underpass shows significant negative impact compare to overpass design. However, for Diagonal Road Overpass with Rail at

Grade might be encounter with more private land acquisition and more traffic disruption during construction and after construction. Thus, road overpass will be excluded from our opinion. In conclusion, rail overpass is the best option among the 4 because more opportunity in strategies land use and significantly avoided traffic disruption during construction and the cost requires is significantly reduced due to avoided removal of more existing facility or environment systems. In conclusion, our team recommended either an Overpass Rail with at grade Diagonal Road or A Road overpass with the rail at grade.

3.1.5.6 4 Options Recommendations

Based on all review and team discussion the results of all 4 options are

First: Overpass Rail with at grade diagonal road.

Second**:** Overpass diagonal road with rail at-grade

3.1.6 Initial two recommended concepts

Based on the red-light green-light evaluations of each of our six design teams, a selection matrix was constructed as shown below in XXXXXX.

		Transport	Structures	Geotechnical	Services	Urban Planning	Environmental
Rail Over	**Option 1**	1	1	1	1	1	1
Road Over	**Option 2**	0	1	1	1	1	1
Rail Under	**Option 3**	1	0	0	0	0	0
Road Under	**Option 4**	0	0	0	0	0	0

Using the above-mentioned selection matrix the two final concepts to be explored further are a Rail Overpass and a Road Overpass, these will be known as Option 1 and Option 2 respectively.

4 Design team evaluations

For each of the respective design areas an in-depth analysis of the two concepts, option 1 and option 2, has been completed. This analysis looks at all aspects of the project, from design to construction and the continued use of the project into the future.

A map of the proposed upgrade area is shown below as .

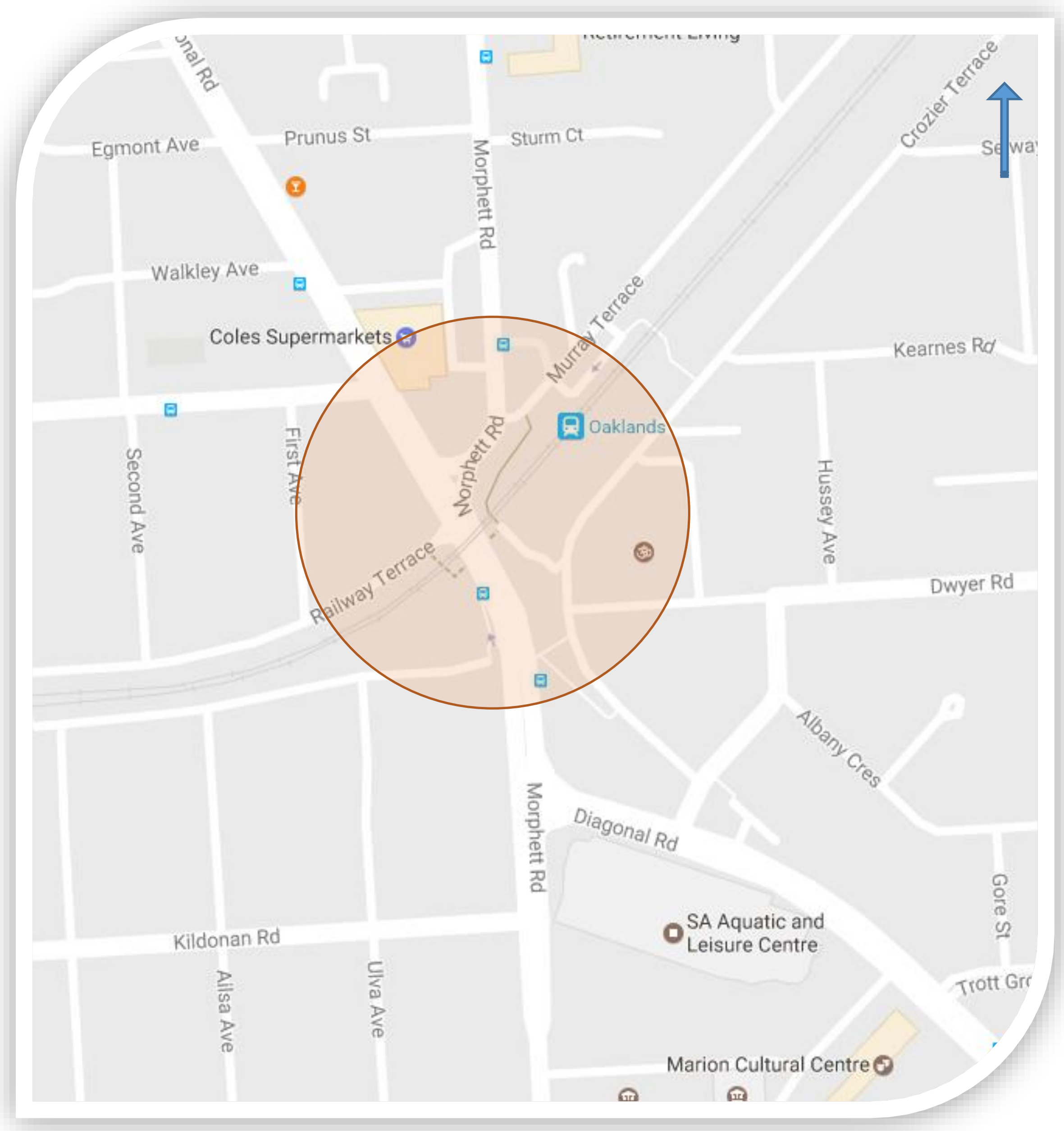


Figure 1 - Map of Proposes Upgrade Area

4.1 Transportation

4.1.1 Introduction

As the grade separation project in Oaklands Park plays the major part in the 30 year Great Adelaide plan, transportation and traffic management will be a significant portion. It has been estimated that future developments in the intersection would increase the traffic flow by 10 to 70 percentages in the year 2031. Furthermore there will be also a drastic increase in the number of train services from time to time. Hence, strategic management that comprises current traffic issues and future traffic volume has to be prepared in order to make this project successful. DPC Engineering's Transport team will strategize a plan by implementing suitable grade separation that accommodates future traffic volume and to reduce the possible traffic congestion that might occur over the construction period.

The transportation team will provide a recommendation that encompasses the following:

1. Provide a better transport link between north and western suburbs in Adelaide.
2. Solve current traffic issues and accommodate future traffic volume.
3. Improve the traffic flow.
4. Increase the number of rail frequencies along Seaford Train Line.
5. Integrate road and rail safety around Oaklands Park.
6. Improve accessibility for Adelaide to Marion Rocks Greenway.
7. Improve the Oaklands Park Interchange for safer community engagement.

4.1.2 Transport & Traffic Investigation

The morning peak for Diagonal Road, Morphett Road and Railway Terrace occurs between 7:00am to 9:30am (Traffic Analysis Report, 2011). Delays occur at this intersection due to the consistent train closures between the peak hours. Over the 2.5 hours of peak period, the rail closures amount to 25 minutes. These consistent rail closures impact the heavy south bound traffic in morning peak hours.

Table 1 - Table 2: Vehicle Movement Summary

Intersection of Diagonal Road/Morphett Road and Railway Terrace (Before the Rail Crossing)				
	Northbound		Southbound	
2015	Morphett Road	Diagonal Road	Morphett Road	Diagonal Road
AM (Peak – 8:15)	-	1544	444	1153
PM (Peak – 16:30)	-	1505	761	1342
2047	Predicting 30% Increase			
AM (Peak – 8:15)	-	2007	577	1500
PM (Peak – 16:30)	-	1957	990	1745

Evening peak occurs between 3:00pm and 7:00pm, which is a total of 4-hour peak period. Rail closure amounts to 45 minutes of the peak period; hence the evening peak experiences greater delay for southbound traffic where the traffic flow is 14% higher. Traffic Analysis Report, 2011, state, "travel time surveys show that the typical travel time to get across the level crossing in the peak are 4 minutes via Diagonal Road and 8 minutes via Morphett Road", therefore there are greater delays encountered on Morphett Road. This also suggests that commuters travelling on Morphett Road would use Prunus Street or Keynes Road to cut across Diagonal Road to avoid the extended delay from Morphett, resulting in a higher traffic movement and longer queues for Diagonal Road.

Overall, through the vehicle turning movement summary from 2015, it appears that traffic is three times heavier for southbound and northbound for Diagonal Road than Morphett Road.

Below is a table of the existing train services from 2011(Traffic Analysis Report, 2011), it is predicted that along with the traffic volume, the number of train services has also increased, which contribute to a longer rail closure time in both morning and evening peak hours.

Table 2 - Table 3: Rail Services 2011

Time	Adelaide Bound		Seaford Bound	
2011 (Provided)	**Stopping**	**Express**	**Stopping**	**Express**
7:00am to 9:00am	10	2	8	
4:30pm to 6:30pm	9		10	2
2016 (Provided)	**Predicted Increase**			
7:00am to 9:00am	8			
4:30pm to 6:30pm	11			
2047	**Predicted Increase**			
7:00am to 9:00am	24			
4:30pm to 6:30pm	14			

The northbound traffic on Morphett road and Diagonal road are increase and it's expected more traffic volume in future. The frequency of train service will rise by 30 %, which mean it will block 30 % of traffic flow. The two-major arterial road are insect at point of railway crossing which increase the traffic volume on northbound. The average stopping time of traffic flow required for train crossing is 60 seconds. The average time required for south bound train is about 45 second and for city bound express train is 60 second and stopping train is about 80 second. Every train flow will delay the traffic flow by 60 second in average.

The accident on major road in South Australia is increase due to traffic congestion and delay. The people do speeding or drive through red light to avoid the queuing so they can get on work, office or destinations on time and which might result road accident. The accident on Morphett road and Diagonal road will cause more delay as normal speed will down 25 km/hours and one lane need to shut down for emergency. On normal traffic, we lost 2 to 3 second on every circulation of traffic light and site has three traffic lights very close to each other, which means us losing significant amount of time.

The current issues acquire during site and traffic investigations are listed below:

- The traffic congestion is growing significantly during peak hour
- The average speed of northbound traffic during peak hour is slow
- Northbound traffic queuing and get delay by 60 second on every train pass
- The increment of railway frequency of Seaford line will increase traffic congestion
- The existing road has not enough capacity to hold future traffic volume

- The railway crossing cause significant delay to public busses, and cars during peak hour
- The time loss during traffic circulation also causing delay and congestion of traffic.

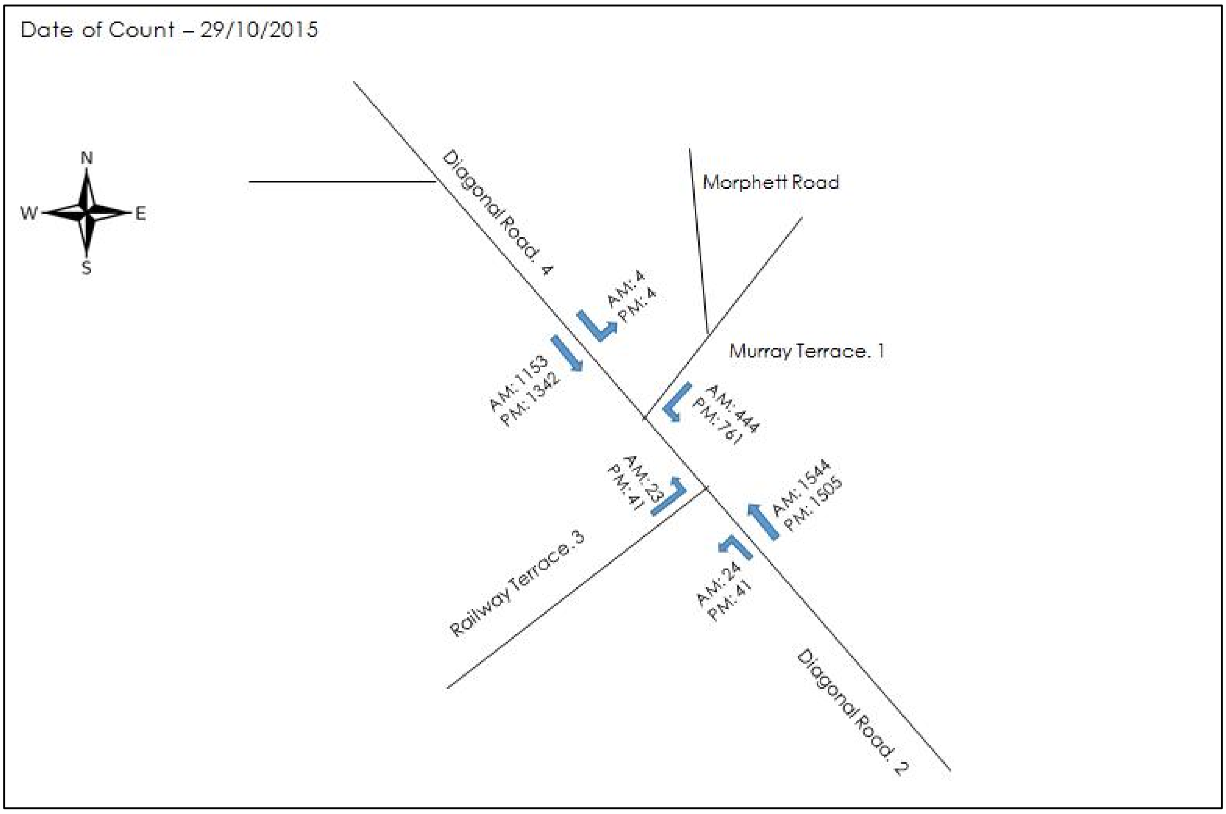


Figure 2 - Intersection of Morphett/Diagonal Rd Traffic Survey 1

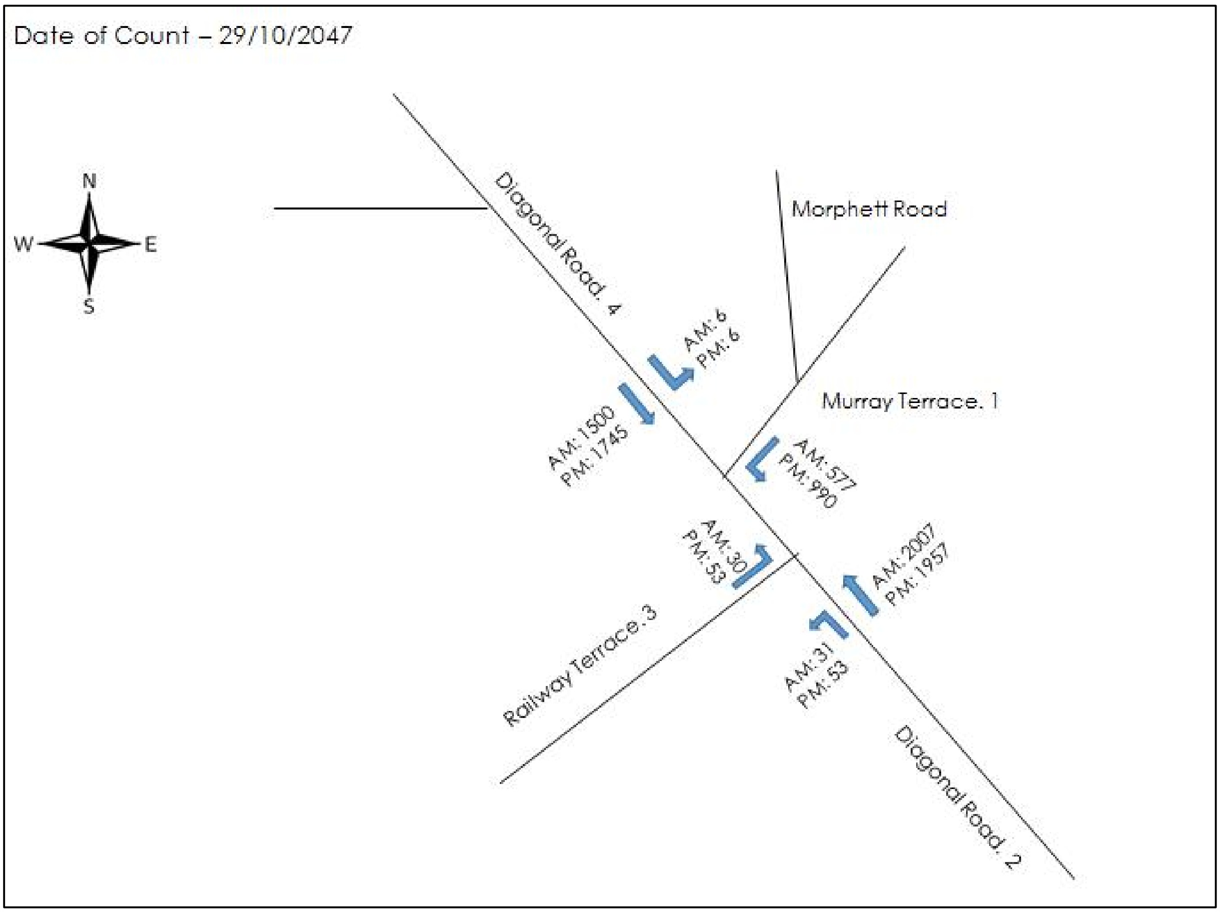


Figure 3- Intersection of Morphett/Diagonal Rd Traffic Survey 2

4.1.3 Technical Specifications

4.1.3.1 Road over pass

Table 3 - Transportation Road Overpass Specification

Specifications	Standard Requirements
Clearance	• According Australian Standards minimum clearance over light rail 5.3m AS5100.1 table 13.7 • being conservative total clearance of 6m is adopted
Lane width	• AUSROADS table 4.3 general standard Road width 3.5m
Maiden width	• AUSROADS table 4.15 minimum is 2.5m
Gradient	• According AUSROADS grade of 6% uphill will increase the risk of crass 2.6 times. • Grade 6% downhill increase the risk 5.6 times • In terms of safety and efficient lower gradient the better if possible • AUSROADS clause 8.5 and table 8.2, 8.3 • The maximum allowable grade 6% - 8% for 60Kmh table 8.3
Bike lane width	• AUSROADS table 4.18 for 60 km/h Roads

4.1.3.2 Rail over pass

Table 4 - Transportation Rail Overpass Specification

Specification	**Standard Requirements**
Plat form clearance	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
Platform width	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
Physical structure zone	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
Clear circulation zone	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
Clearance over the Road	AS 5100.1 table 13.7
Rail track gauge	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
TGIS zone	Public Transport Services Engineering Management System Technical Standard, AR-PW-PM-SPE-00129003, DPTI Cl 5.2
Footpath	AUSROADS road design part 3 table 8.1
Gradient	DPTI

4.1.4 Grade Separation Options

4.1.4.1 Railway Overpass

4.1.4.1.1 Background

In this intersection traffic jam in causing delay and affecting business, school, entertainments and sport centres. More than 4100 vehicles use the rail crossing every day and the boom gate closing the north-south road up to 130 times daily. City of Marion council confirmed that users can hold at this intersection for 20 minutes during peak times. Constructing the railway overpass will improve traffic jam and contribute a vital role for future investments.

4.1.4.1.2 Advantages

- Better safety: reduce risk for all road users (pedestrian and bicycle way parallel to the over pass between Murray Terrace and Railway Terrace)
- Minimum land acquisition
- Improves local streets traffic system
- Better public transport and facilities
- Lifts and stairs for passengers to access the station
- Keep current grade for Morphett road (cheaper)
- Clean and Aesthetically pleasing
- Existing Routes unaffected for public transport
- Cyclist Lane will be added on Diagonal road
- Rail infrastructure will not have an impact on the general area
- Minimal Noise and Visual impacts from lowered rail and at-grade road
- Installation of more traffic signals will provide a safe crossing opportunities for pedestrians

4.1.4.1.3 Disadvantages

- Dominant in the area (may affect close by properties)
- Noise pollution (due to high rise)
- Big impact for traffic users during construction
- Road widening may increase difficulty of pedestrians crossing roads
- Loss of business and residential properties for land acquisition
- Existing Vegetation could possibly be affected

4.1.4.1.4 Traffic Management

During the rail overpass construction, the roads will not be affected enormously; however, there will be large impact on the trains as the railway line will be closed for a maximum of 4 weeks. The rail way line will be closed between Warradale Station and Carlton Street, as the construction will be only taking place between this sections. Train will be substituted by various buses for four weeks until the construction is fully completed.

Train services will terminate at Warradale Station for Noarlunga rail line and commence there for Seaford rail line. Similarly, train services will terminate at the temporary station opposite of Carlton Street for Seaford rail line and commence there for Noarlunga rail line. Regular train commuters will experience delays in travel time due to the new bus routes. On average, it takes 10 minutes from Warradale station to Carlton Street but the new travel time will be 20 minutes during peak hours. The new routes will provide two temporary stops on either side at Kyenes Avenue and on Doreen Street. The additional bus stops and 50km/hr speed limit in multiple streets contribute towards the greater travel time for commuters between Warradale Station and Carlton Street.

There will be 11 new buses to accommodate for the construction during morning peak hours and 14 buses during evening peak hours. Movement for the roads will remain the same but there will be additional movement of buses on the road and a reduction in speed limit may also occur, from 60km/hr to 40km/hr, due to the construction. This may cause congestion on Diagonal and Morphett Road but as the rail line is closed, the congestion would not be as large as the existing conditions. The new proposed bus route is shown below in Figure 4.

Below is the New Bus Route

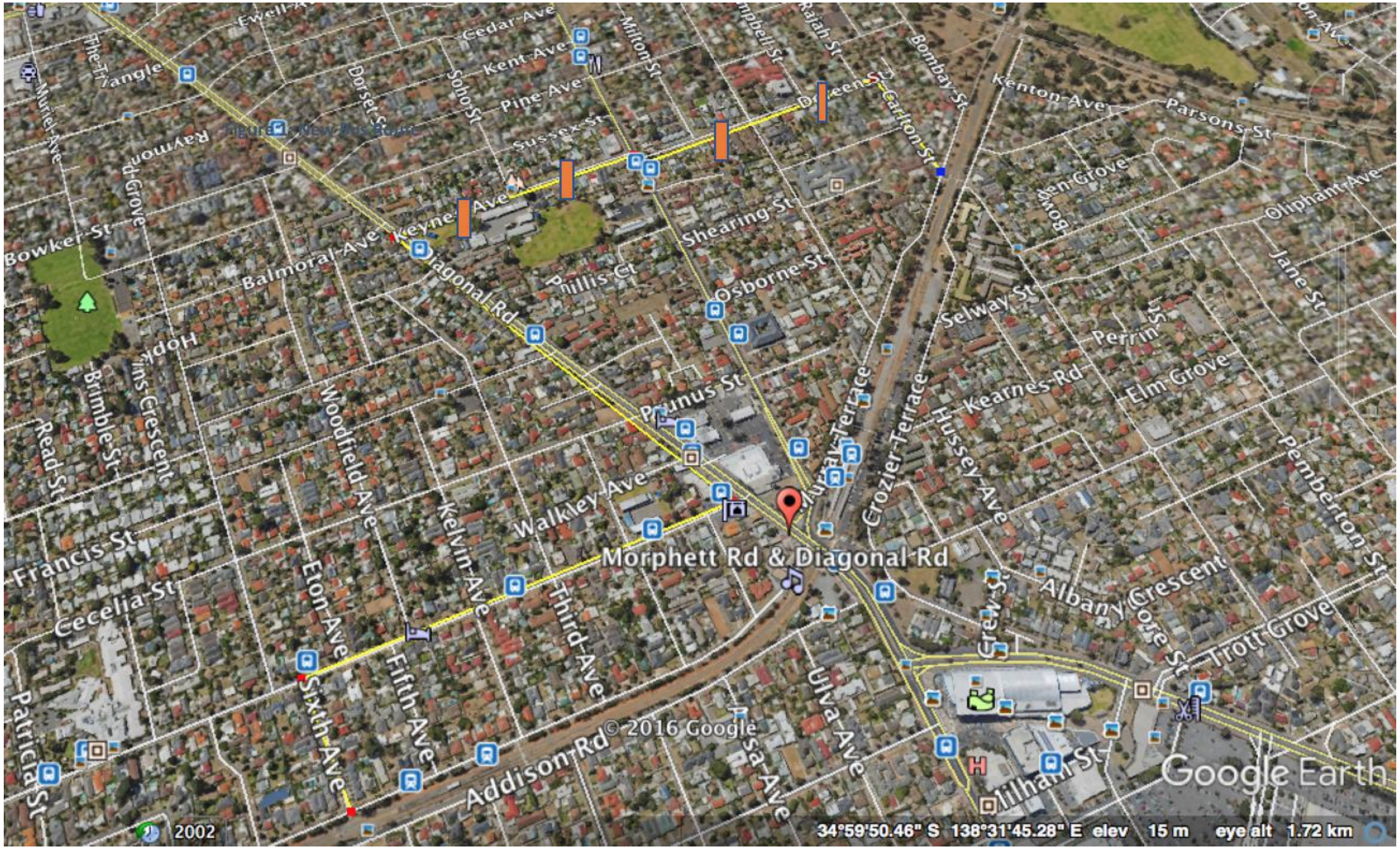


Figure 4 - Bus Route Relocation

4.1.4.1.5 Geometry

The picture below shows the overall rail overpass concept for the Oaklands Park Grade Separation Project. Detailed drawings for each section have been outlines in further stages in this report.

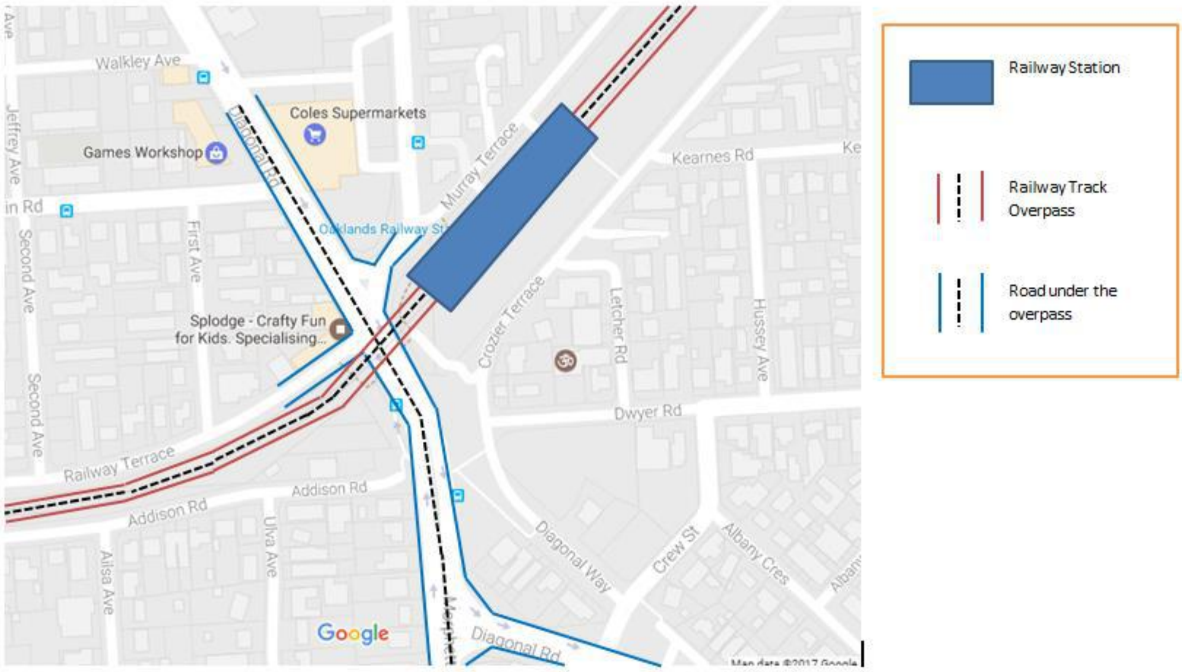


Figure 5 - Road and Rail Alignments

4.1.4.1.6 Costing

PACKAGE	UNIT	COSTING
Car parks	70 numbers	$ 204,050
Railway Track	1460 metres	$ 438,000
Road works	862 metres	$ 3,623,000
Footpaths	82 metres	$ 12,750
Traffic signals	2 sets	$ 210,000
TOTAL:		$ 4,487,800

4.1.4.2 Road Overpass

4.1.4.2.1 Background

The main purpose of upgrading Oakland's Park network is to increase the capacity to meet the future traffic demand of 35 years the Greater Adelaide Plan, as well as reduce traffic congestion and improve the safety of road users. The state government has allocated $42 million for the financial year budget of 2011-13 at-grade upgrades, which includes the widening of diagonals, widening of Prunes Street into 4 lanes as well installing new traffic lights at Prunes street and finally upgrading the Morphett and diagonal road intersection. This upgrade will support the 2020 traffic demand wouldn't able to support 2035 traffic demand. Furthermore, the study for grade separation of rail and road shows that there is two best possible options road overpass and rail over pass considered design could meet the future traffic demand. The advantages and disadvantages of both options are listed below.

4.1.4.2.2 Advantages

- The train service will continuously operate during the construction period.
- It's possible to design but need considerable redesign to meet the demand.
- The road expansion will provide easy services to Aquatic centre and Marion shopping centre.
- Its very cost effective than road underpass or railway underpass.
- The construction procedure is easier than other solution.
- The excavation is not required which will minimise cost expenses and won't affect footing of nearest infrastructures.
- The services will not be interrupted as we are not excavating but due to expansion of road some services will be interrupted.
- Improvement and expansion of Morphett road and diagonal road will reduce the traffic congestion.
- Improvement of road safety for road users with traffic signal modelling.
- The railway line will in same grade and not required the upgrade of train station.

4.1.4.2.3 Disadvantages

- Some local houses will be effected
- Morphett Rd must be access diagonal Rd through prunes St at intersection
- Aesthetically doesn't suit the location

- Future development (restriction)
- Land acquisition
- Traffic management construction period (heavy traffic flow area)
- Put shade on the business and houses along over pass

- Not easy access to local streets
- The both train service and road traffic need to be stop during construction and management of heavy traffic during peak hour will be tough
- Need to use alternative road or side road to access local business and residence
- Required land acquisition as the width of road is wide and need to construct retaining walls
- The road might get flooding during heavy rainfall, if the drainage systems is inappropriate
- It's very expensive to construct and will also affect the services.
- The two roads can't underpass at the same junction, so traffic of Morphett road must access Prunes street to access Diagonal road to underpass.

1.1.1.1.1 Traffic Management

There are few steps and procedures that will be carried out during the construction in order to manage the traffic and provide a better traveling experience for the road users. During the road overpass concept construction, the Seaford Train Line services will not be affected much as the Diagonal and Morphett roads. The train services will be operating as usual during the construction period. Even there is a need to close down the train traffic, the construction works will be carried out after the train operation hours. The construction package for the road overpass is suggested to start at the both end of the overpass.

One of the major issues in traffic management aspect for road overpass concept is the road closures or minimise the number lanes in use for both Diagonal and Morphett road. At current stage, two lines at each direction of both roads are in operation and during construction the lanes might be reduced to one or can be remained as two lanes once all the land along the overpass concept being acquired and demolished for construction purpose. Even though two lanes will be provided during the construction, the speed limit will have to reduce to 25km/h or 40km/h at certain stages.

This reduction will result in double the increase with the current traveling time. Moreover, the access to the local streets along the construction site and business premises will be affected during the construction. Public that needs to access the local streets and business premises will have to take an alternative route which creates congestion in detour routes and pollutions in the residential area. Diagonal and Morphett road closure is almost impossible because detour routes will increase the traveling time and distance massively. The traffic can be diverted through Sturt Road to Brighton or Marion Road and connects Oakland Road. The traveling time will increase averagely from 2.5 minutes to 6 minutes. .

There are currently three bus stops located along Diagonal Road from Sa Aquatic Centre and Prunus Street intersection. During the construction period these bus stops will no longer be operational and temporary bus stops will substituted in a different location after discussing further with DPTI and City of Marion Council.

4.1.4.2.4 Geometry

Affected Properties by the proposed plan

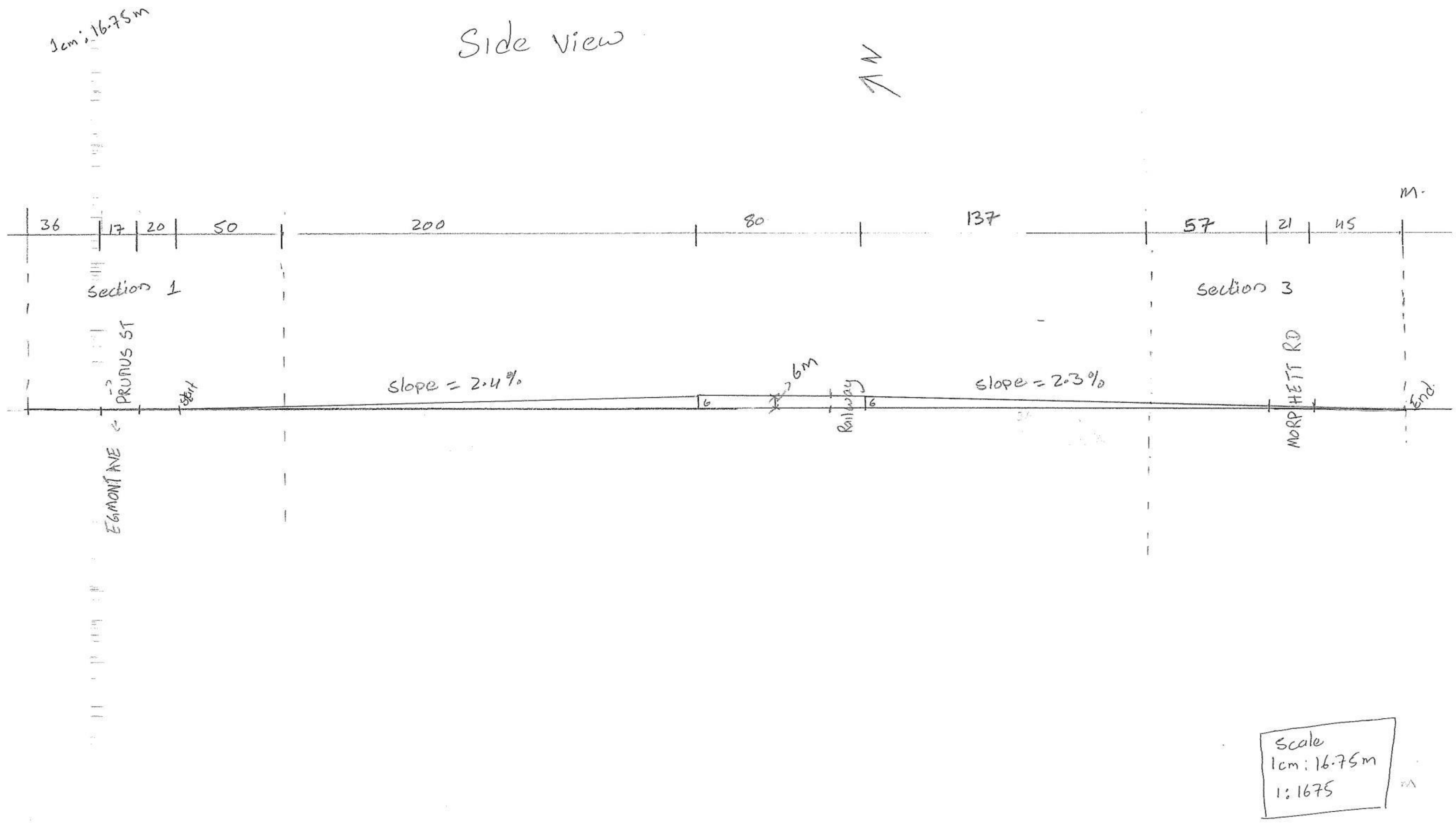
Over plan road lines

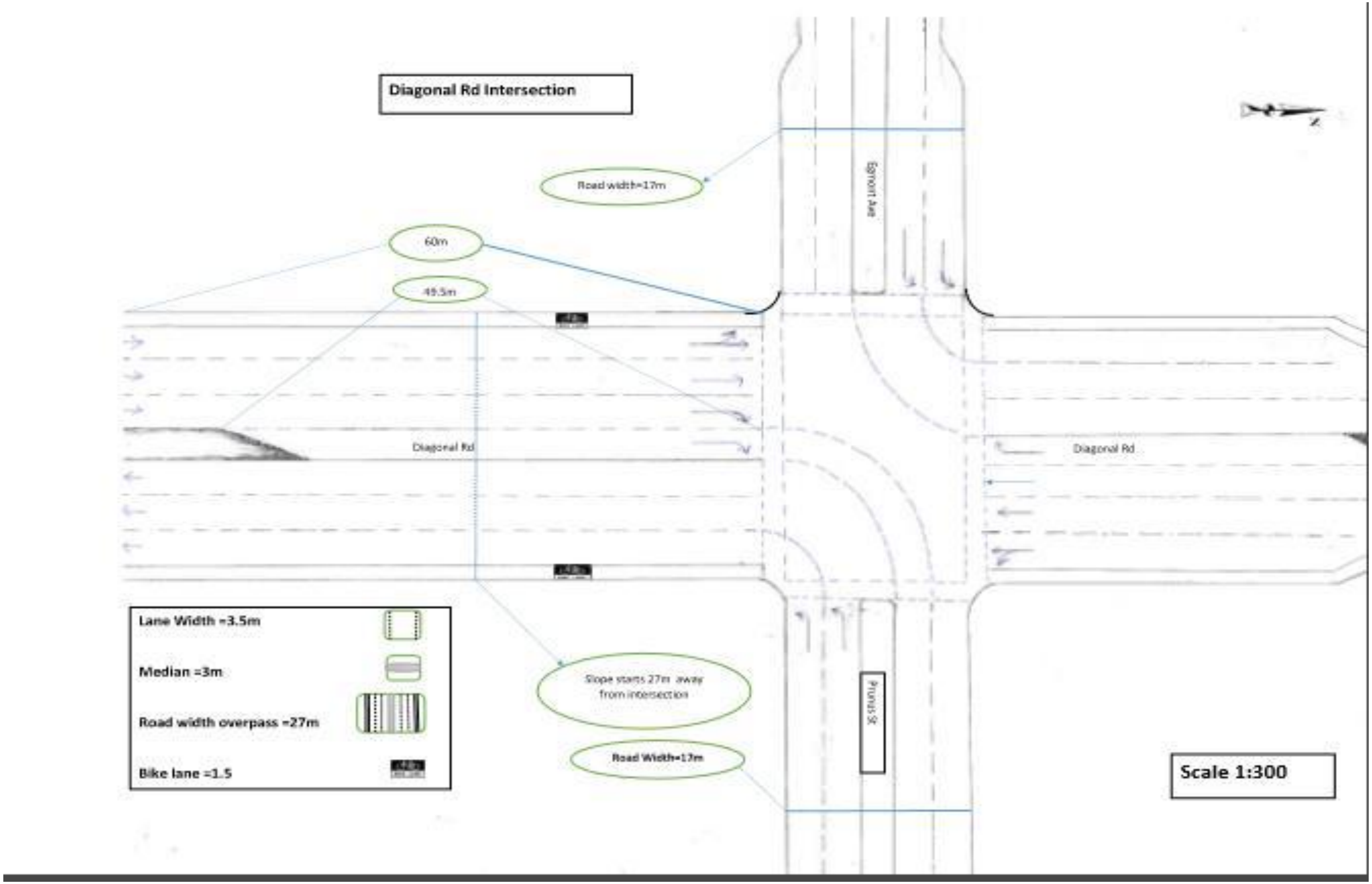
At grade road lines

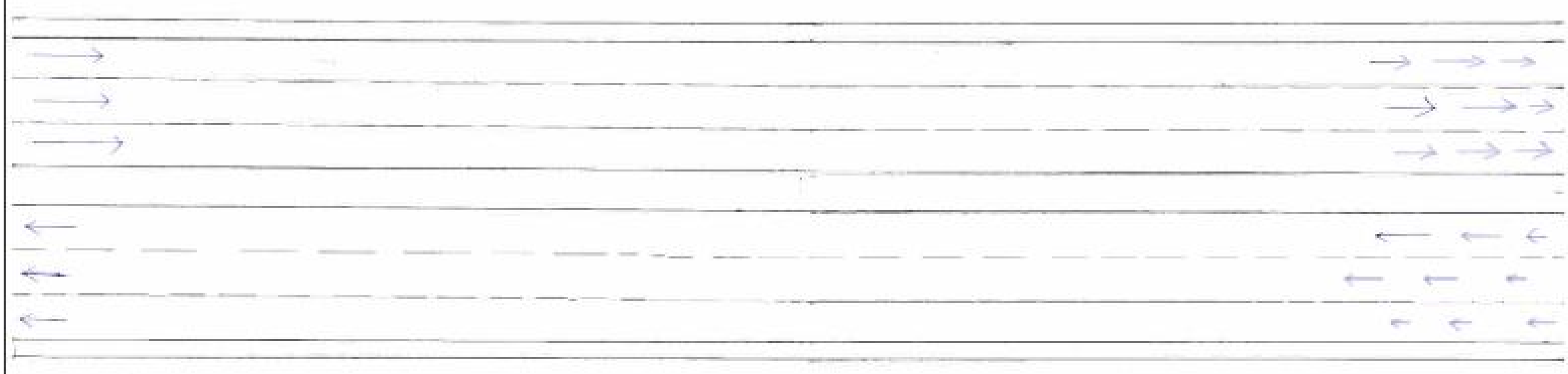
Proposed Intersections

The Road Overpass would be widened to 27meters at least to allow for a 1.5-meter shoulder either sides, a minimum 3-meter median. Diagonal road would also include slip lane to Morphett Road.

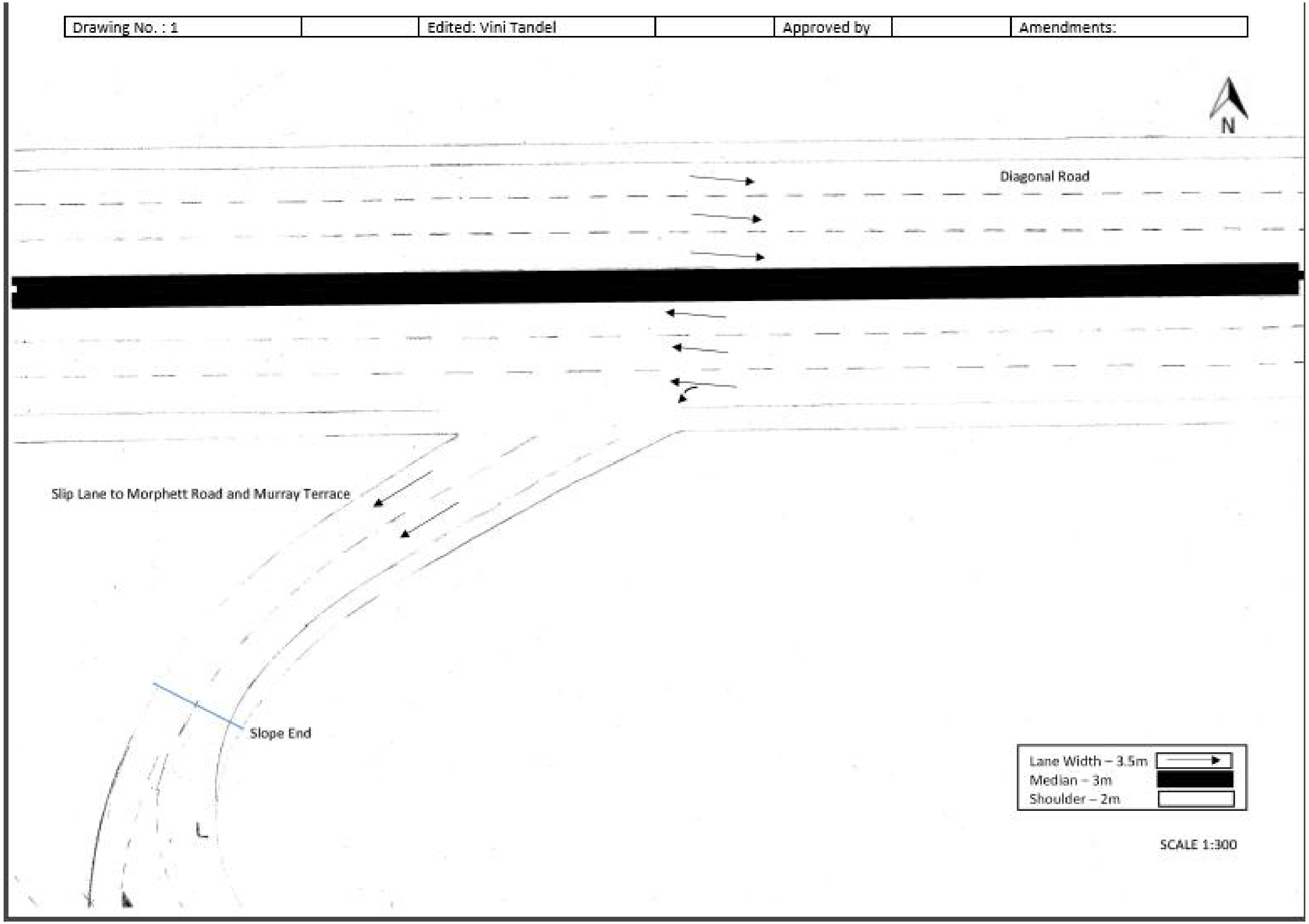
(Guide to Road Design Part 4A: Unsignalised and Signalised Intersections)


1cm: 16.75m
Side View
N
m.
36
17
20
50
200
80
137
57
21
45
Section 1
Section 3
PRUNUS ST
EGMONT AVE
Start
Slope = 2.4%
6m
6
6
Railway
Slope = 2.3%
MORPHETT RD
End
Scale
1cm: 16.75m
1: 1675

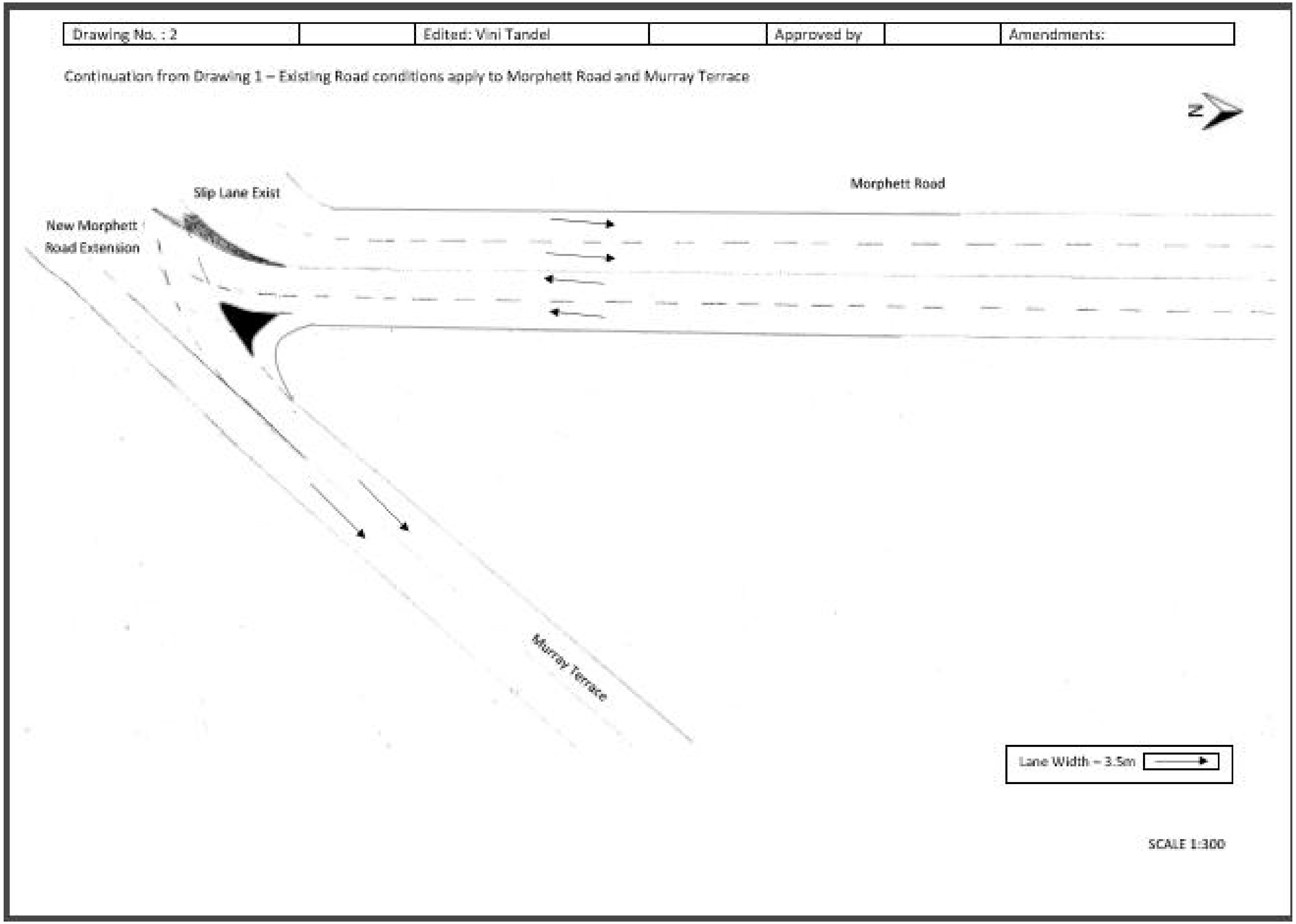

Diagonal Rd Intersection
Road width=17m
60m
49.5m
Egmont Ave
Diagonal Rd
Diagonal Rd
Lane Width =3.5m
Median =3m
Road width overpass =27m
Bike lane =1.5
Slope starts 27m away from intersection
Road Width=17m
Prunus St
Scale 1:300



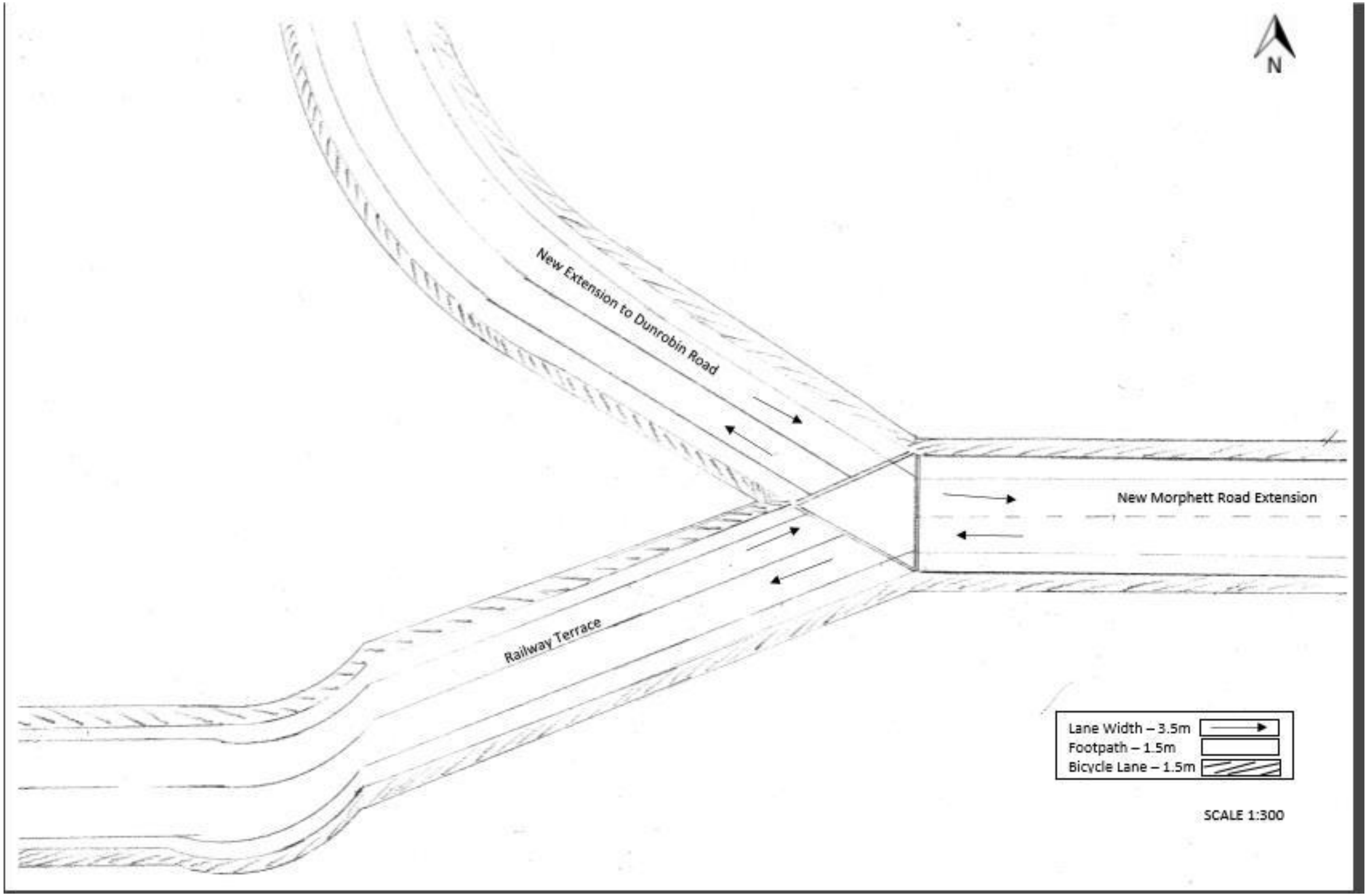
4.1.4.2.5 Section 1 Drawing – Diagonal Road and Morphett Road slip lane



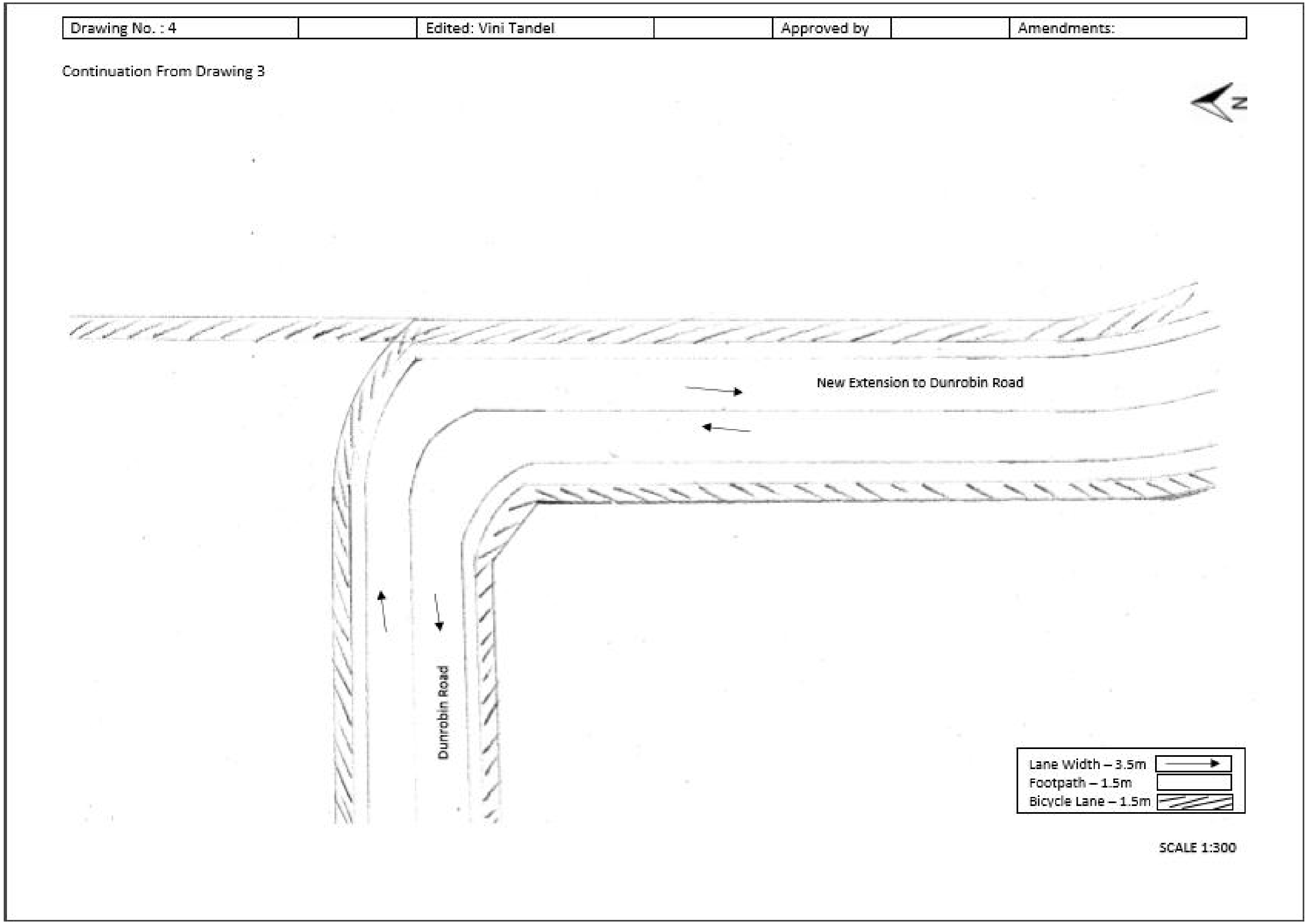
4.1.4.2.6 Section 2 Drawing –Morphett Road and Murray Road Intersection



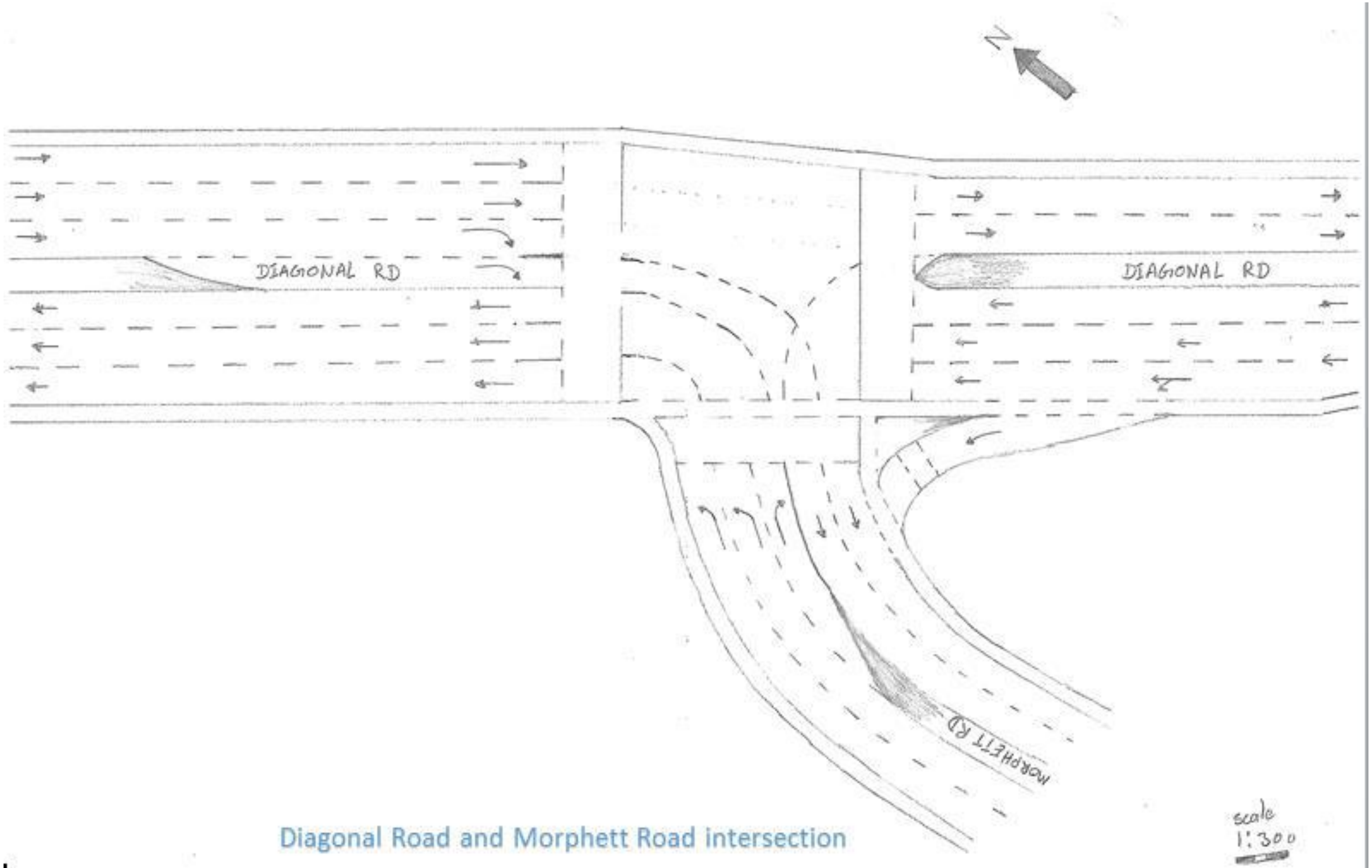
4.1.4.2.7 Section 3 Drawing - Morphett Road, Dunrobin Road, & Railway Terrace Intersection



4.1.4.2.8 Section 4 Drawing - Dunrobin Road



4.1.4.2.9 Section 4 - Diagonal & Morphett Road Intersection (Near SA Aquatic Centre)



Diagonal Road and Morphett Road intersection

Costing

4.1.5 Feasible Option

4.1.5.1 Railway Overpass

Detailed investigation of both rail and road overpass over Diagonal and Morphett Road shows that rail overpass is the most feasible option that can be implemented in Oaklands Park Grade Separation Project. Besides that, previous reports from DPTI have also suggested that rail overpass option is more recommended over the other options due to its efficiency. The rail overpass would be constructed over the Diagonal and Morphett Roads intersection. Both the roads will intersect towards approaching the rail overpass on north and south direction. It is predicted that the traffic flow would increase drastically over the years and strategic road plan would be proposed to enable community to access business premises and local streets that are located around the intersection.

One of the main reasons for eliminating road overpass concept in the feasible evaluation process is the traffic management conflicts during construction period. Traffic routes diversion and road closure most likely to be implemented for longer timeframe during construction of road overpass concept which will create severe traffic issues at the intersection. Previous survey shows that around 8000 vehicles pass by the intersection every day and current number of lanes is two in each direction. Reducing to one lane during construction for 800 metres which is the overall length of the overpass is nearly impossible as heavy amount of vehicles will cause traffic congestion on both northbound and southbound direction and also increases the traveling time massively. Another option that can manage the traffic during construction is the diverting traffic through Sturt Road to Brighton or Marion Road and connects Oakland Road. The traveling distance will increase to 6 kilometres which from Diagonal or Morphett Roads connects both Sturt and Oakland Roads within 2.5 kilometres. Averagely the road overpass construction will affect the traffic in the intersection by 100%. Whereas only 30% of rail overpass construction affects the traffic in the intersection and remaining 70% will be constructed over the existing railway line. Hence rail overpass has an advantage over the road overpass in traffic management issues during the construction period.

Furthermore accessing local businesses and streets would be an additional concern, if a road related concept is being constructed. As community engagement is one of the major policies of DPC engineering, the transport team will have to strategize an additional implementation including more signalised intersections or medians which ease the contentment of public access to the local businesses and streets located around the intersection. There are around 8 roads that intersect with Diagonal and Morphett road within Prunus Street and SA Aquatic Centre. The road overpass structure will be amended in a big scale in order to accommodate the intersection to the side streets which also results in massive changes in the economy perspective of the project. The suitable plan to access the side streets is having a side road at grade along the elevated road overpass which needs bigger road alignment in the overall width than the rail overpass concept. The total number of lanes that has to be constructed in elevated road would be three and additional one side lane at grade in each sides for the road overpass concept whereas within 3 lanes in total for each direction for rail overpass concept enables the public to access the side streets easily and more viable. Reducing the overall structure dimensions could minimize the project costing.

Economic consideration is one of the major elements that affect the outcome of the feasible options for the Oaklands Park Grade Separation Project. The total length of the road overpass or road alignment concept is 862 metres 730 metres for rail overpass. The fund needed to construct is $ 4,345,844 and $ 4,487,800 for road and rail overpass respectively. The rail overpass cost higher than road overpass concept about $ 150,000 but with that amount difference, both the road and rail can be upgraded within the project to solve current traffic issues and accommodates future traffic volume whereas only roads will be upgraded in road overpass concept. Moreover it has been estimated that rail overpass can be constructed earlier than road overpass concept which is more beneficial in economic terms and public use.

4.1.5.2 Advantages of Railway Overpass

These are the advantages or outcomes after implementation of rail overpass concept for Oaklands Park Grade Separation Project.

- Safety could be enhanced for all road users.
- Separate bicycle lanes along the roads comply with Marino Rocks Greenway project.

- Reduce the risk of traffic accidents.
- Safe pedestrian access to Oaklands Railway Station with signalised intersection.
- Improve traffic flow for current and future volumes.
- Improve access to local streets and business.
- Reduce traffic congestions.
- Increased frequencies of Seaford Railway Line.
- Better public transport coordination. (Bus stops under rail overpass which ease public's access to railway station).
- Safer and easy access for disabled users to the railway station. (Lift implementation on each side of the platform).
- Expanded Park 'n' Ride facility from 230 cars to 350 cars.
- Drop off zone or Kiss 'n' Ride zone for the public.

4.1.5.3 Design Layout & Geometry

4.1.5.3.1 Railway

The total length of railway track would be approximately 730 metres which about 540 metres will be on grade of 2 percentage and remaining 190 metres will be at grade. The railway station platforms and footpath to cross the Diagonal Road and Morphett Road intersection occupies about 190 metres.

4.1.5.3.2 Road

The total length of road would be approximately 862 metres which about 577 metres will be having 3 lanes on each direction and remaining 285 metres will be having mix of 2 and 3 lanes on each direction such as southbound of Diagonal Road.

4.1.5.3.3 Pedestrian & Cyclist

The pedestrian crossing is planned in order to comply with safety issues and the crossing will not affect the traffic flow because the access to the railway stations is planned on each side of roads. Besides that, a total of 860 metres length of cyclist path will be constructed along the Diagonal and Morphett roads in order to comply with Marino Rocks Greenway Project.

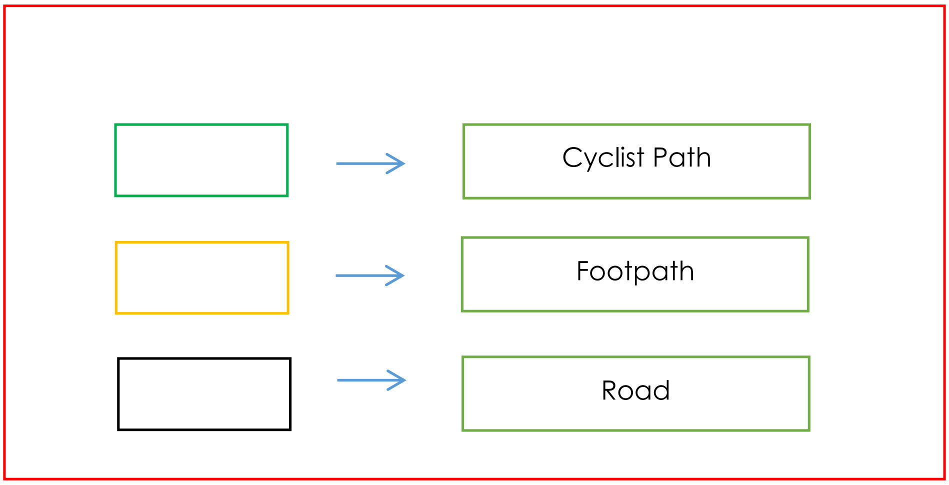
4.1.5.3.4 Car Park

The existing number of car parks in Oaklands Railway Station is 230 car parks and additional 70 car parks will be proposed in this project to enhance the public transport use within the local community and contribute to Park 'n' Ride project which also contributes in reducing the traffic volume in both Diagonal Morphett Road.

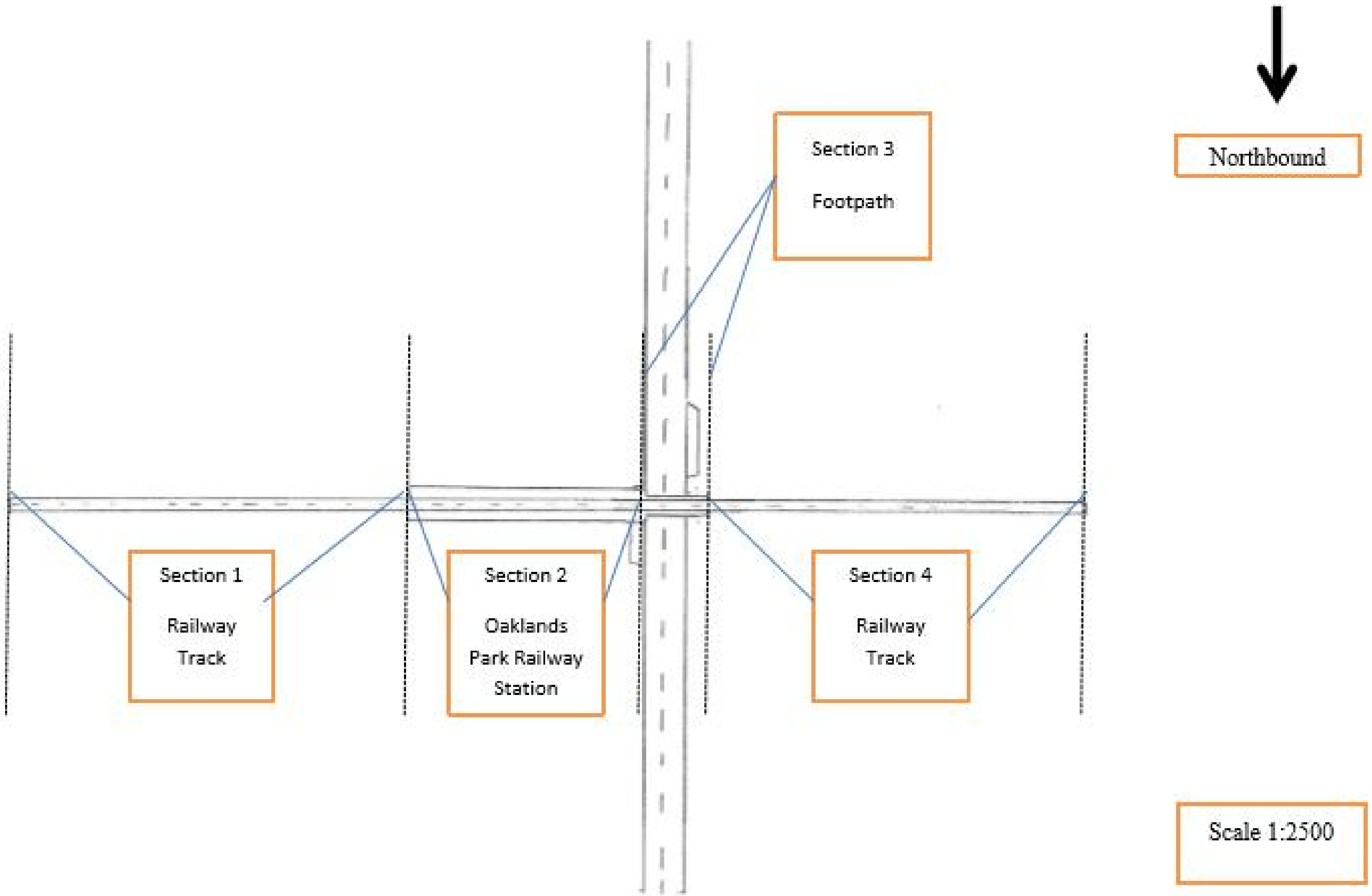
4.1.5.3.5 Bus Stops

There will be 2 bus stops located along the intersection which enables the public to access the Oaklands Park Railway Station. The bus stops can accommodate three buses at a time and will have lifts and staircase access for the community to reach the elevated railway station.

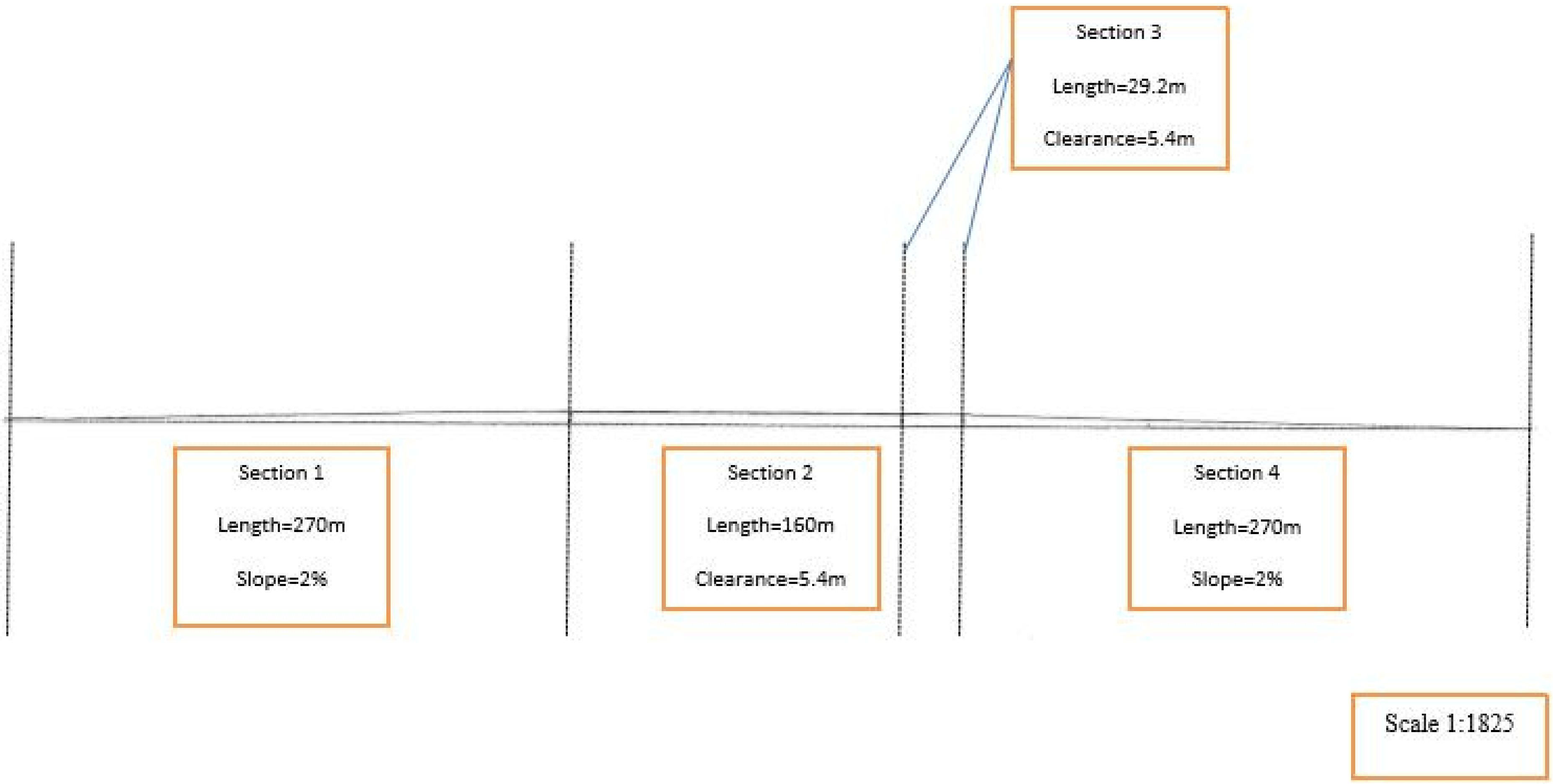
The following legend shows the coloured boxes and indication of the usage of that particular colour that outlined in further drawings.



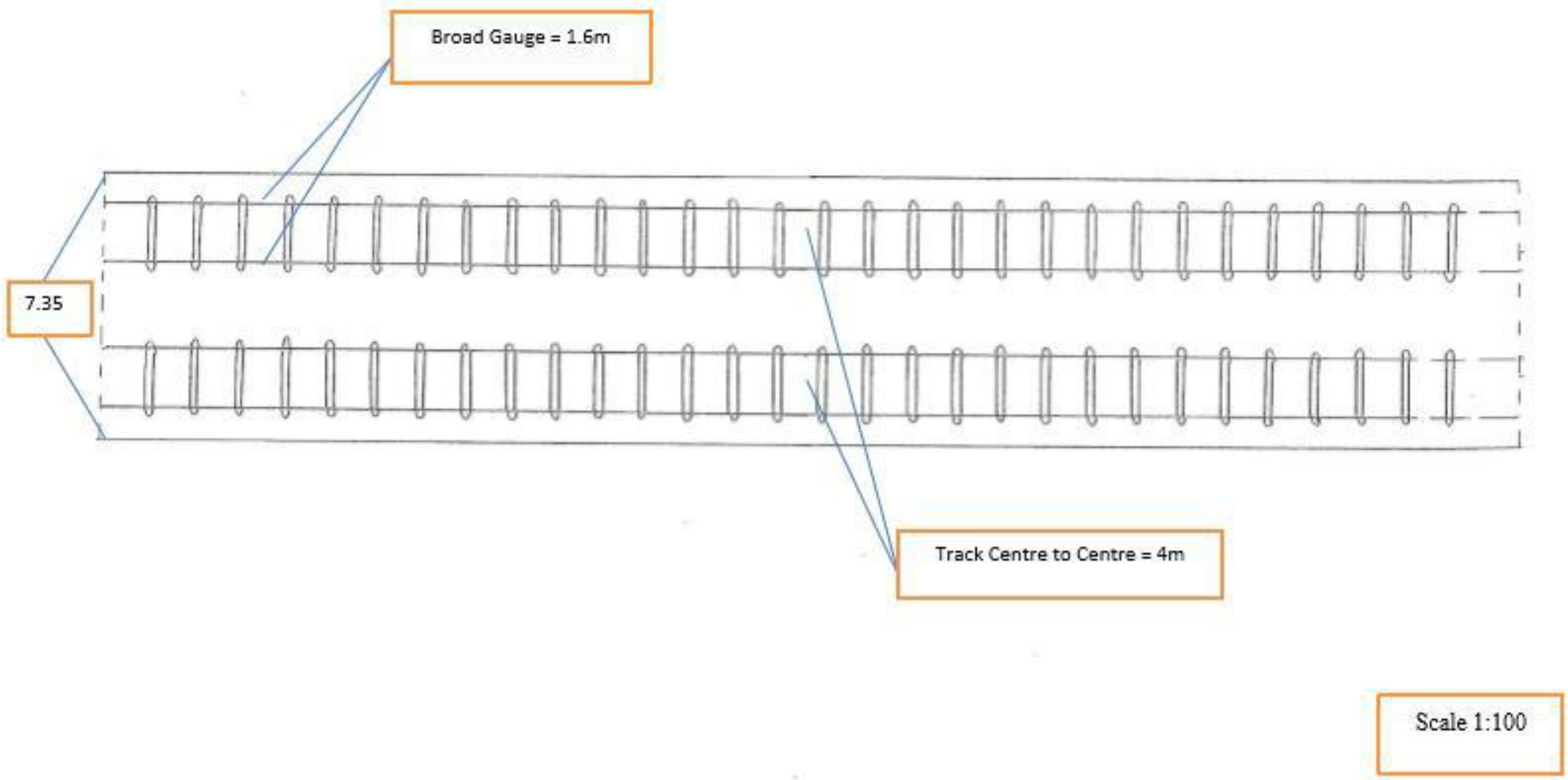
4.1.5.4 Rail Overpass Plan View



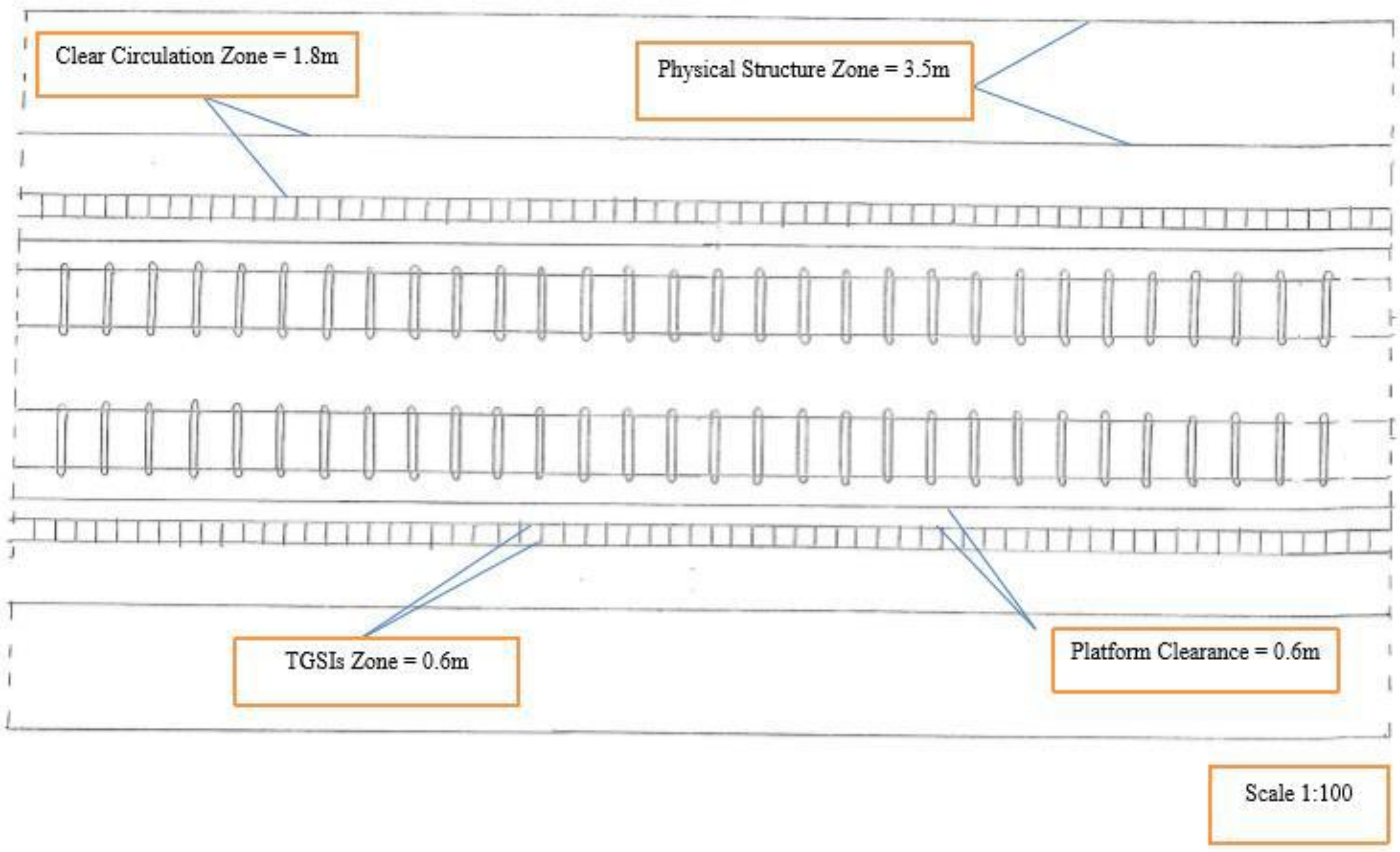
4.1.5.5 Rail Overpass Side View

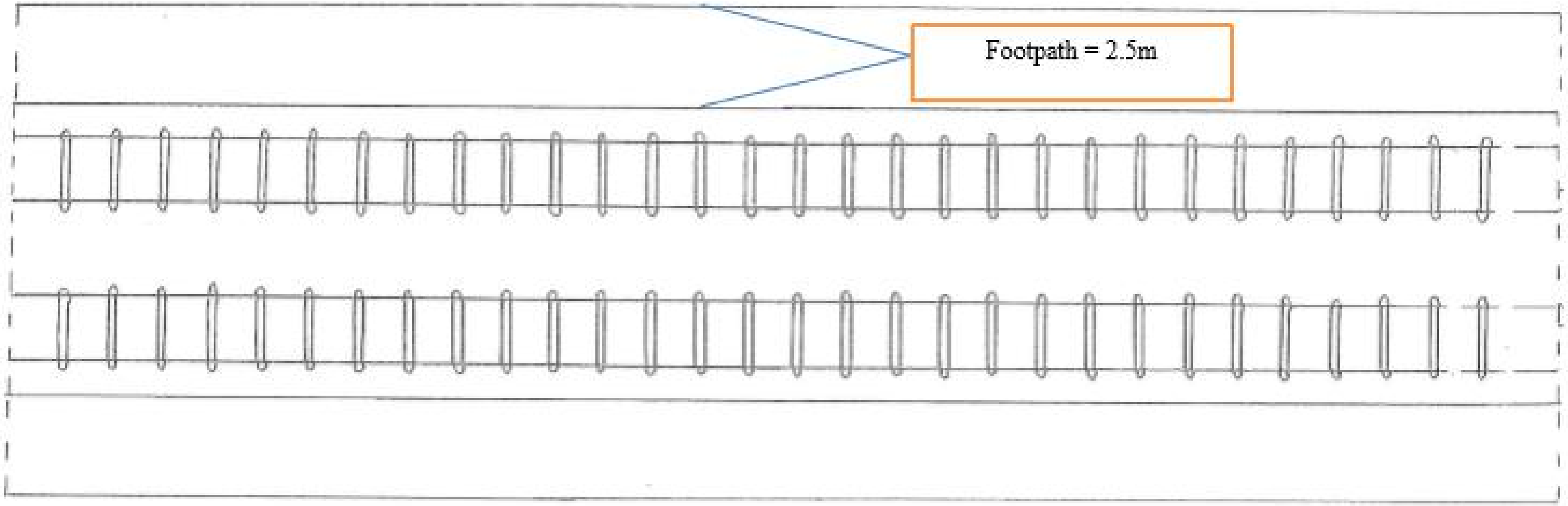


4.1.5.6 Section 2 Drawing

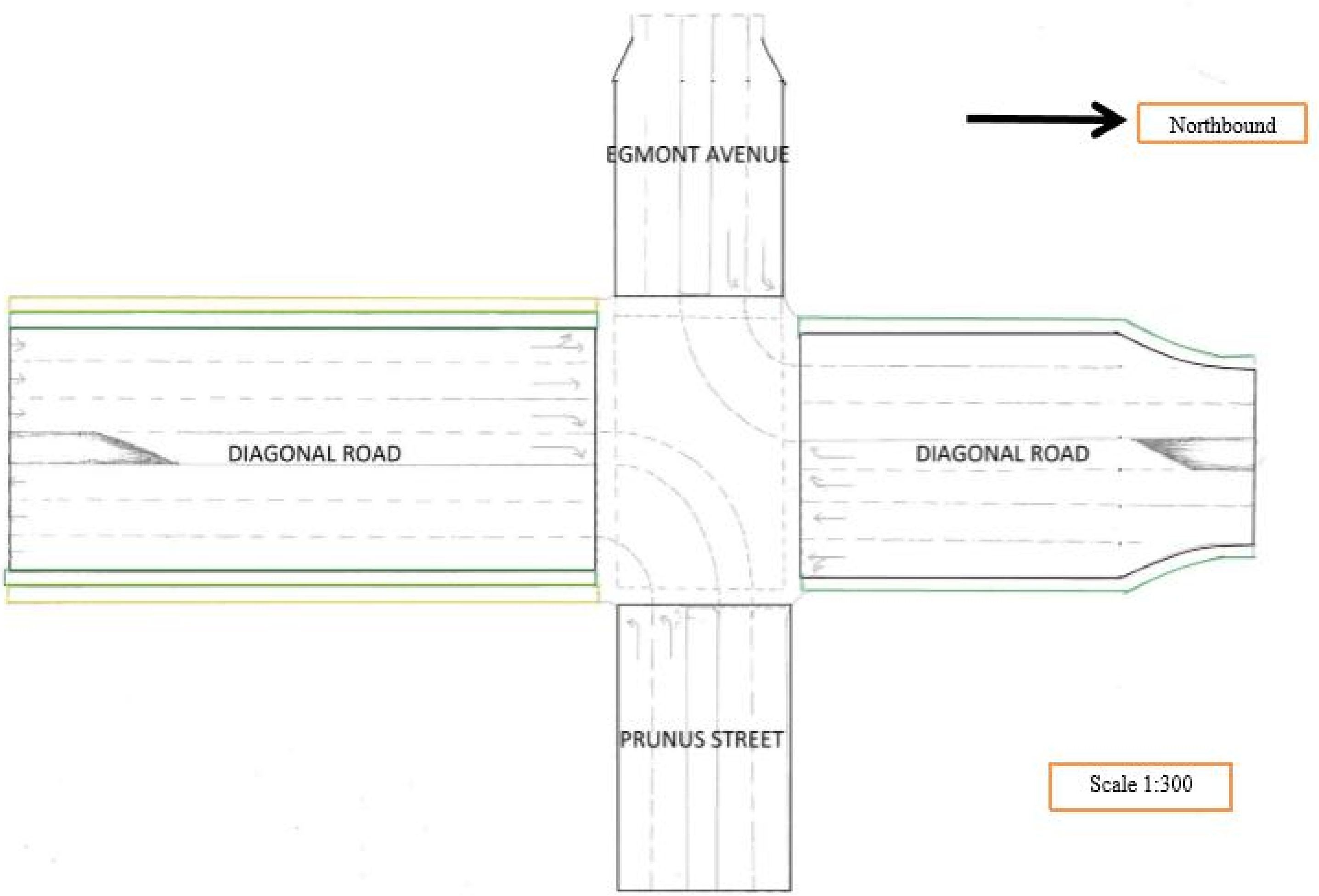


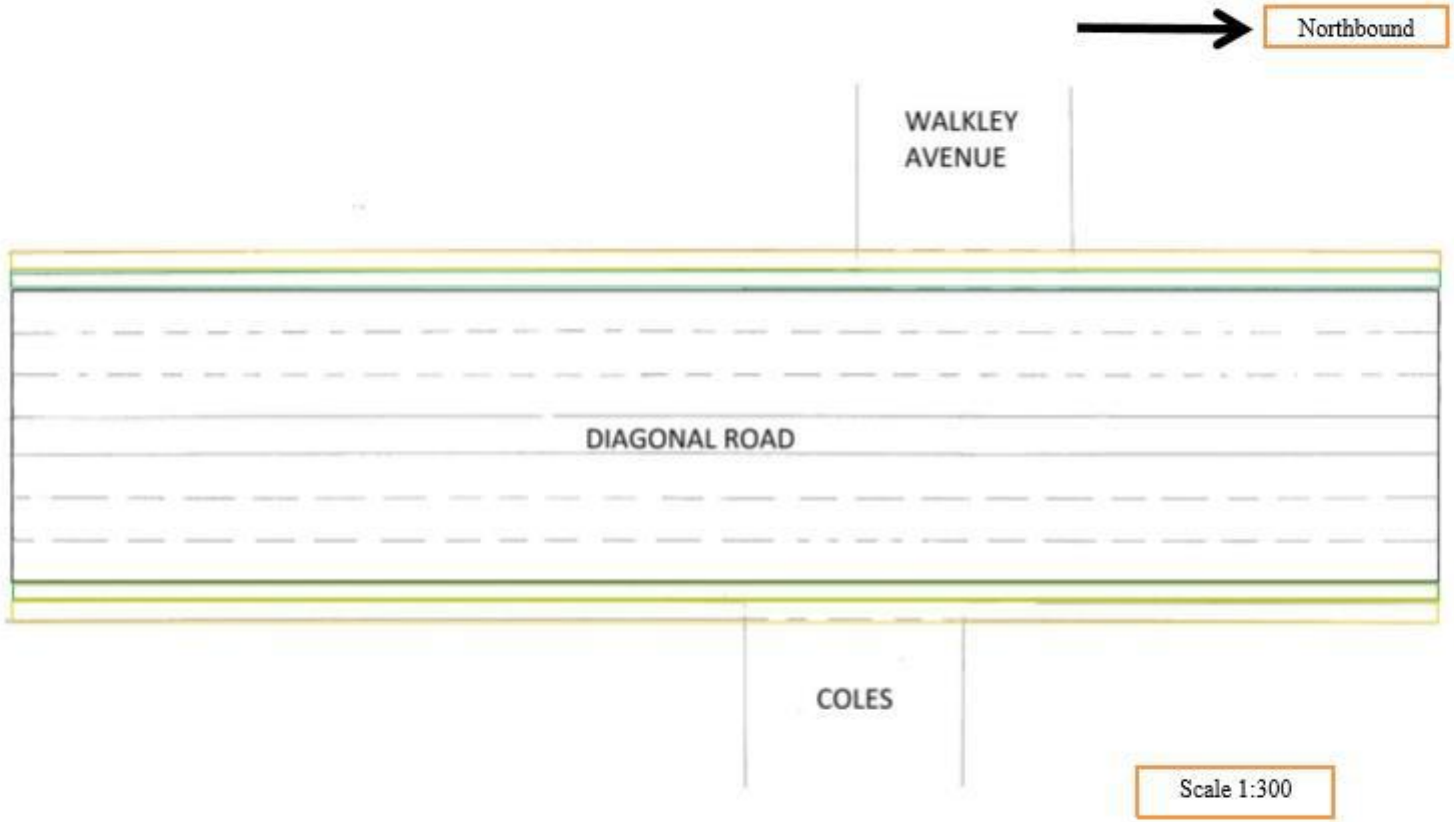
4.1.5.7 Section 3 Drawing

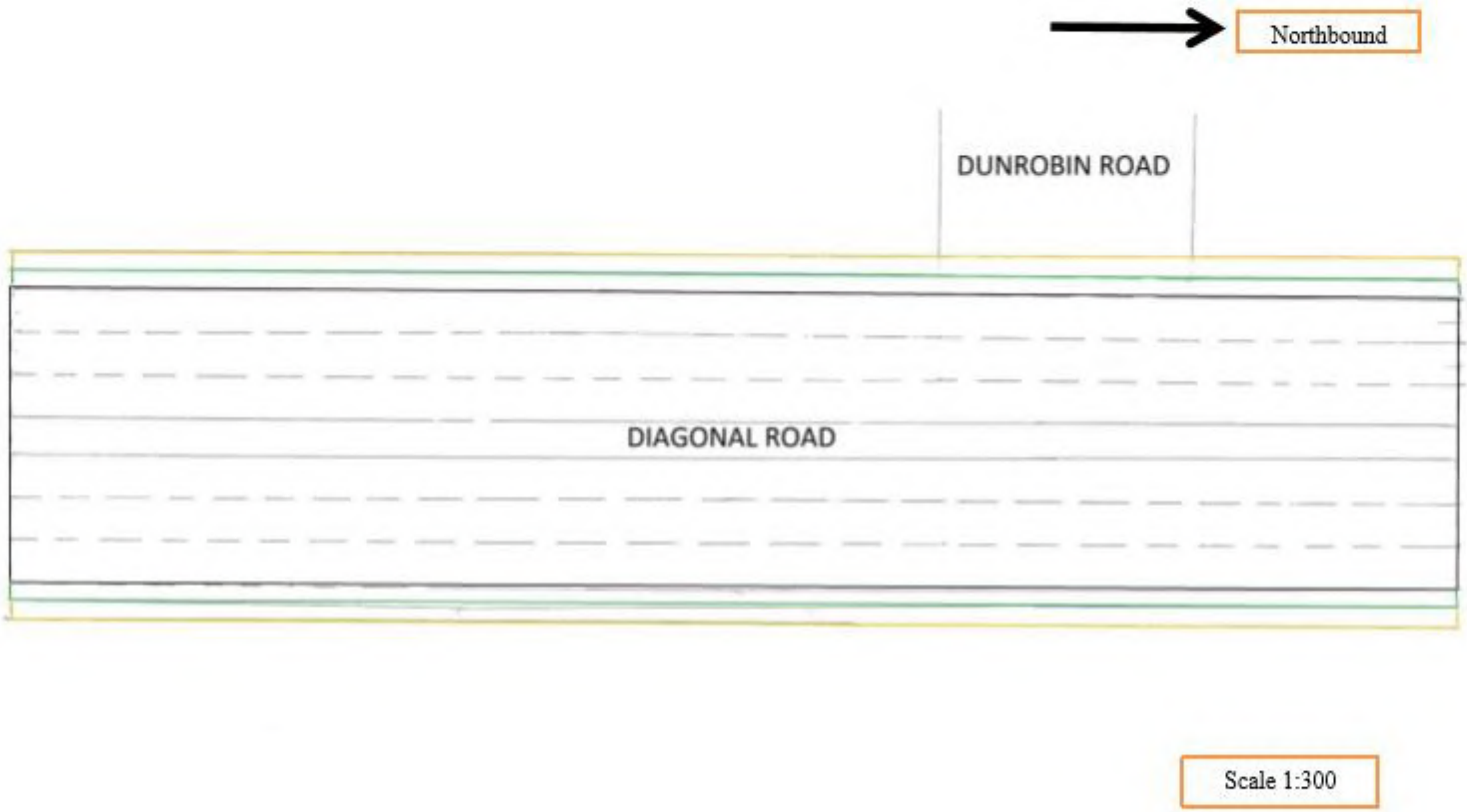


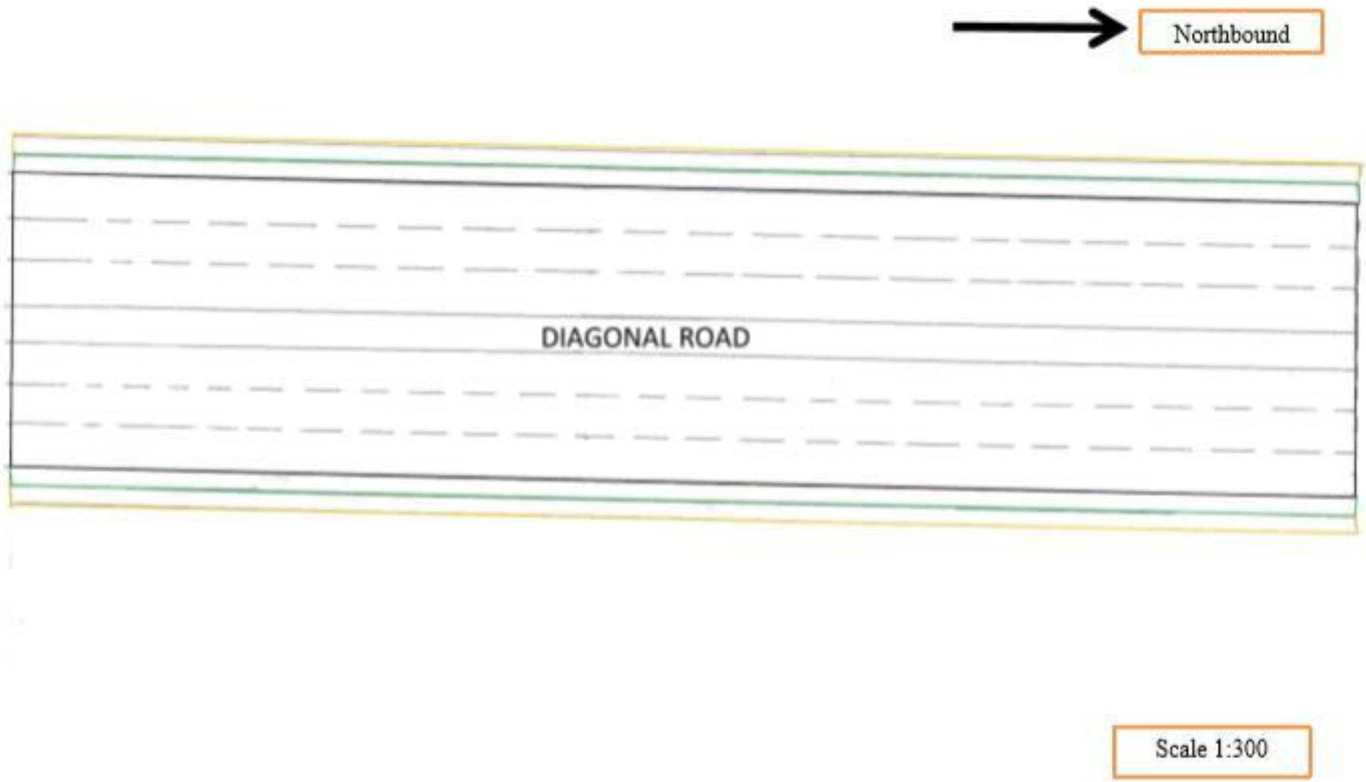


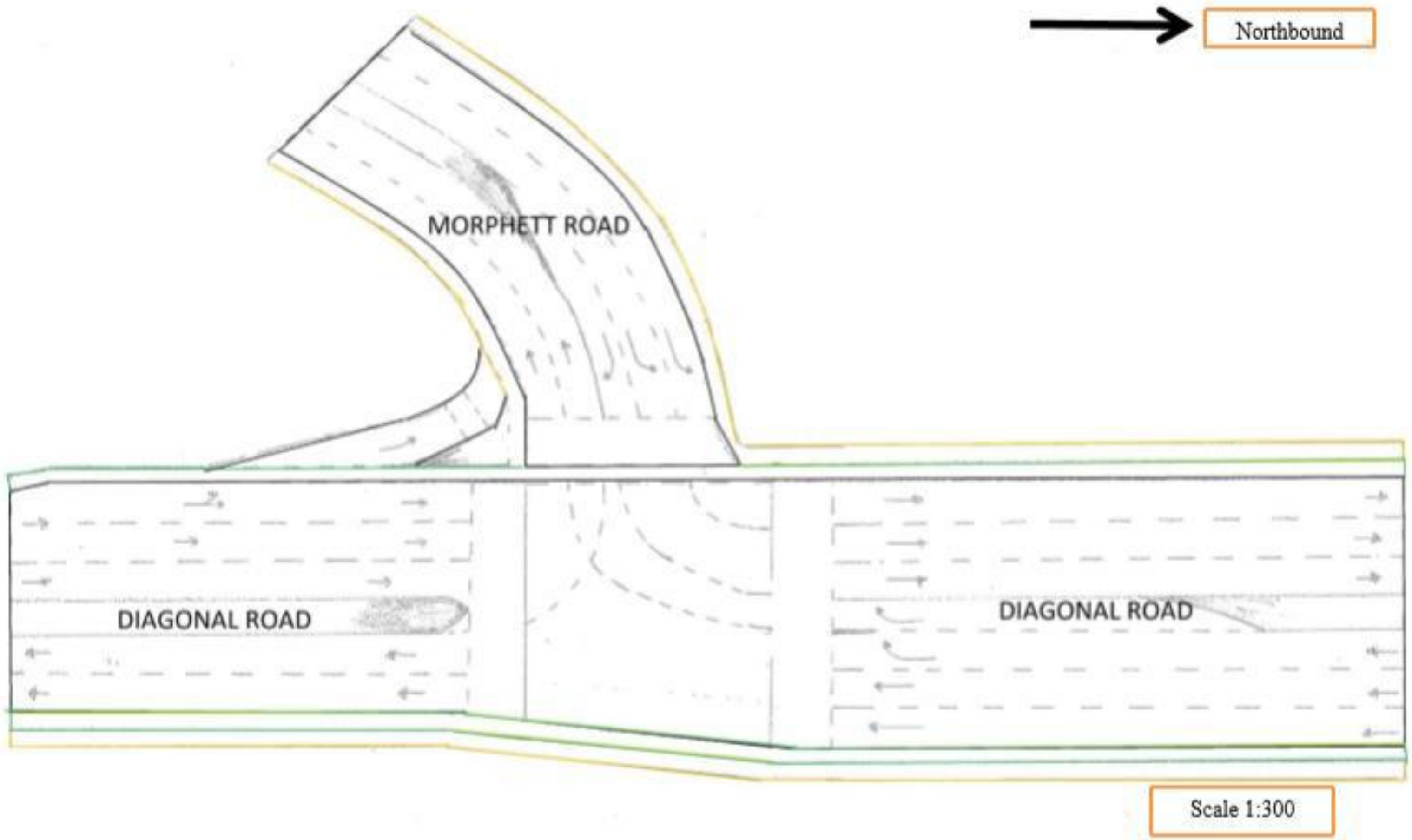
Scale 1:100


Northbound
EGMONT AVENUE
DIAGONAL ROAD
DIAGONAL ROAD
PRUNUS STREET
Scale 1:300


Northbound
WALKLEY AVENUE
DIAGONAL ROAD
COLES
Scale 1:300


Northbound
DUNROBIN ROAD
DIAGONAL ROAD
Scale 1:300


Northbound
DIAGONAL ROAD
Scale 1:300


Northbound
MORPHETT ROAD
DIAGONAL ROAD
DIAGONAL ROAD
Scale 1:300

Structural Analysis

Structural team will be analysing two options for grade separation of Oaklands Parks. Due to large scope of the project, DPC Engineers will perform in-depth investigation as well as technical analysis to ensure durability and serviceability of structures. Several factors have been considered, this section evaluates the structural aspect of the project, which provides conceptual design and its feasibility for the detailed design stage. The structure components considered for option 1 are columns, capping beams, head stocks, Super T girders and road deck. Since option 2 is also an overpass, same structural components have been considered in the design analysis. However, for option 1 a platform has been considered for easy access and has been assumed to be independent of the rail bridge design. In addition, the platform has been designed as a separate structure with different substructures to the rail overpass. The structural components analysed for the platform are I beams, columns and slab. The specifics of each structural components are discussed in the following sections.

The design procedure undertaken for this project includes analysis of all vertical loads on the substructure and finally a combination load has been provided. However, these loads may alter in detailed design stage due to the several other factors, which has been neglected at this stage. Even though the design for each substructure is conceptual, but still structural team has ensured that the design meets the safety criteria. So, it is essential to note that the given dimensions for each scheme are approximate values and should not be taken as the optimum result.

4.1.6 Overview of The Structures

As shown in, the location has a complex geometry due to the sharp intersection between Morphett Rd and Diagonal Rd. The structural team has set a goal to simplify the complexity of the problem by designing a rail and road overpass and finally recommending a feasible solution. The outcome of the design is expected to be safe, which meets the 30 Year plan for greater Adelaide.

The structural analysis begun initially by examining the geometry of the road provided by the Transport Team. The structural team has assured all design structure aligns well with the given dimensions and the current location. According to the dimensions provided, option 1 had span of 200m and rail width of 8m refer to Figure 6. In addition to this, 160m was allocated for the platform on both sides of the rail. The rail bridge will be supported by two embankments at 2% grade both sides and it should be noted that the whole structure is not supported only by the embankments but also supporting structures have been designed at 25m spacing through the span of the bridge. Furthermore, option 2 has a span of 80m and road width of 30m, which is supported by two embankments both sides at 2.4% grade. The road overpass is also supported by columns with spacing of 27.5m (refer to figure #).

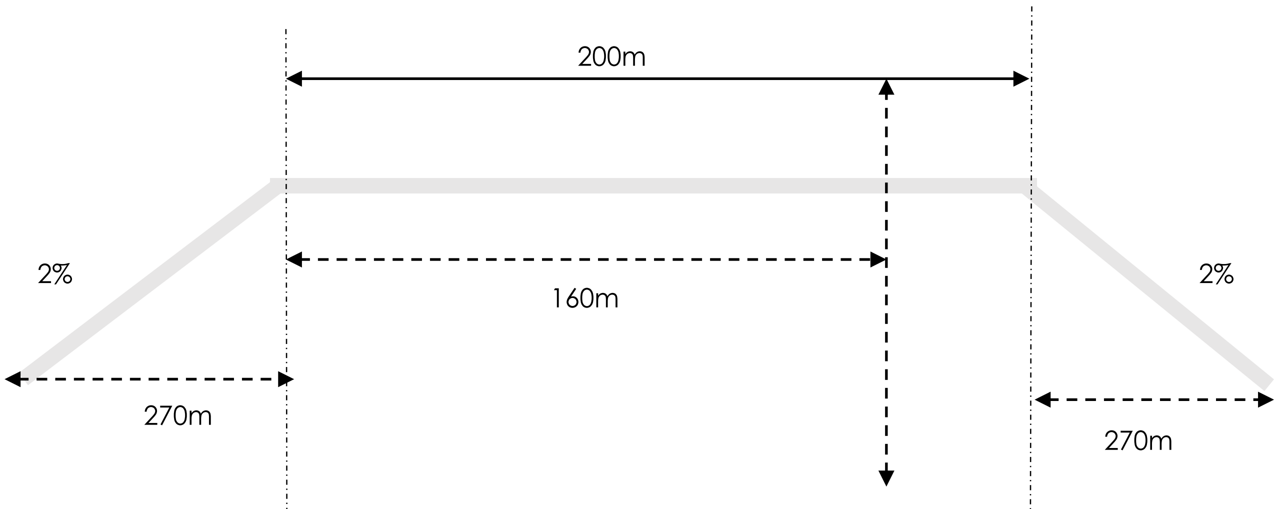


Figure 6 - Elevation View Rail Overpass

AAAre 7 - Precast I beam girder (source: CPCI, 2017)

These girders can be used on a small or a medium span bridge. A brief discussion on advantages and disadvantages pf plated girder can be found in the following section

Advantages

- Symmetrical shape provides a better stability to the structure
- With the help of bottom flange provides a high resistance against tension failure of the structure
- Easy to construct
- On comparison with box girders, they are easier to transport and assemble
- Because of its easy construction and transportation, plate girders are quite economic

Disadvantages

- Are heavy as compared to truss structures
- Will have a great wind resistance, which can affect the overall structural serviceability
- Are comparatively inefficient for a longer span of a bridge
- Due to its shape, more number of girders are required to support a wide bridge

4.1.6.1.1.1 Box Girder

Box girders are generally used to support overpasses for railway and highway having a long span. Because there is minimal flexural force acting at cross sectional body centre of the supporting element, these girders are kept hollow which makes their design more effective. Amongst different shapes available for the box girder, trapezoidal girders (tee girders) are more effective to support a wide bridge with a long span as they require a less number of girders in comparison to other shapes and they provide similar strength to the structure.

Figure 8 - Precast Super Tee Girders (Source: Sumit Engineering Group, 2010)

Advantages

- Can support deck with a long span
- Comparatively low wind resistance
- Less number of girders required
- Can accommodate services if required
- Because of its shape box girders have a very high torsional strength (The constructor- Civil engineering home 2015)
- Due to its high torsional strength, a lower prestressing is required

Disadvantages

- On comparison with I girders, it has a lower tensile strength
- Higher in cost and difficult to transport

4.1.6.1.1.2 Reinforced Girder

Reinforced concrete is widely used in preparation of girder bridges. These girders must be prestressed in order to increase their tensile strength. Girders are normally pre-casted, as to build them on site can be difficult and time consuming. In addition to that quality of each girder can be maintained with precast concrete. Length of these pre-casted girders are kept in accordance to their method of transportation.

Figure 9 - Precast Reinforced Girders

Advantages

- Easy construction of the girders
- Cost effective
- High compressive strength
- Does not require corrosion protection
- It has low deflection and hence can offer higher serviceability to the structure

Disadvantages

- On comparison to steel, reinforced concrete has low tensile strength
- High strength to weight ratio as compared to steel, hence transportation cost can increase

4.1.6.1.1.3 Steel Girder

Girders can also be casted entirely from steel. These girders are generally used to support decks of a bridges with a very long unsupported span.

Figure 10 - Steel Girders (Source: Haskins, M 2015)

Advantages

- Highly durable material
- Has a high tensile as well as compressive strength
- Comparatively easy to transport than reinforced concrete

Disadvantages

- Higher cost as compared to reinforced concrete
- Has greater deflection as compared to reinforced concrete
- Requires a high maintenance to prevent corrosion of steel

4.1.6.1.2 Recommendation

Final recommendation is provided after assessing a range of discussed options which are available for designing a bridge girder. Selection of the ideal type of girder is done after comparing the advantages and disadvantages of different girder types in accordance to the objective of the design.

The final design recommendations by structural department at DPC engineering was designed after considering the following key points

- Adequate strength and durability
- Cost effectiveness of the design
- Design efficiency
- Duration of construction
- Minimal post construction maintenance

Reinforced concrete is a suitable option for construction of girders on comparison to steel, because it is highly durable, cost effective and do not require much maintenance after its construction. Time duration for its construction can be decreased by using precast concrete. As reinforced concrete has a low tensile strength, prestressing is required. After prestressing, reinforced concrete will show a higher tensile strength. According to the location of the bridge, minimum concrete strength required for its construction is 32Mpa. Since girders are crucial support of the bridge, it is recommended that a high concrete strength should be used. Concrete strength of 50MPa should be used for precast girders. Tee girders are recommended for this design because tee girders can increase efficiency of the design due to its shape and are capable to withstand a higher load. By increasing depth of the girders, strength of the design increases and for this reason tee girder type T5 was selected. Its depth is 1800mm while its width is 2000mm. Total width of railway overpass would be 8m, hence 4 such girders are needed to support the bridge deck. A typical cross section of these girders which will be used for railway overpass is shown in the drawing below.

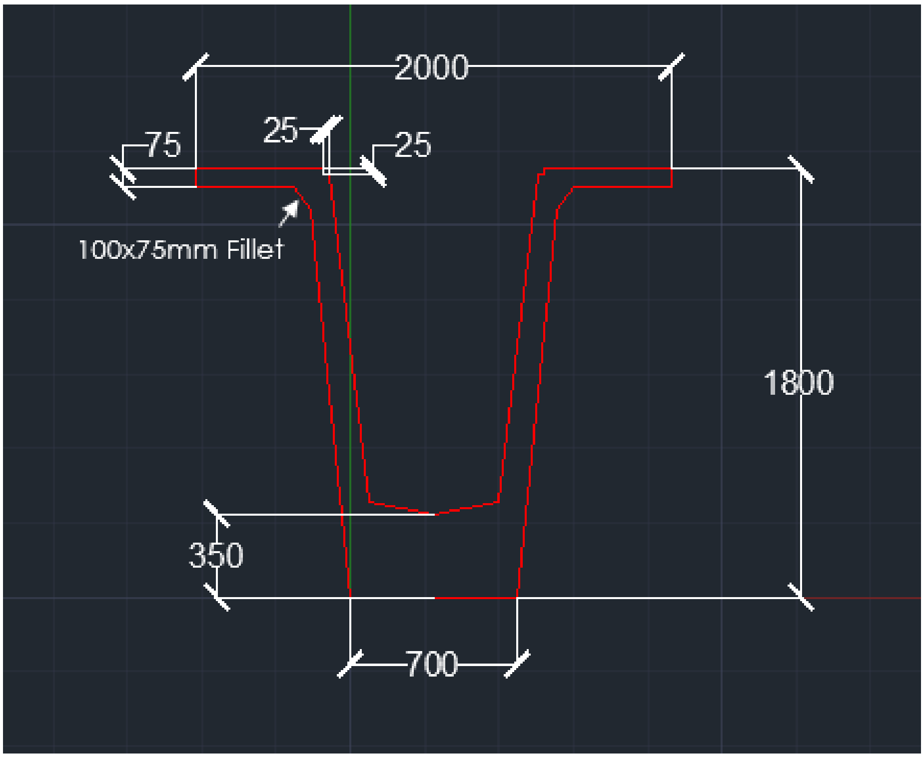


Figure 11 - Typical super-tee girder cross section

4.1.6.1.3 Costing

By following the recommended design, which is using super tee girders of type T5 precast and requires prestressing, final cost was estimated. The estimated cost discussed in this section is fairly accurate but it may change depending upon enhancement of the detailed design of the structure. For a span of 160 meters and width of 8m, total weight of the required precast concrete girders is 11,37,000 kg.

50MPa concrete strength was selected. Approxiamate cost for designing super tee girder includes labour cost. $327/m^3 was considered for the cost of the precast reinforced girders. Total volume of the girder is 76000m^3

Total Cost for super tee girder= $1,40,000

4.1.6.2 Columns

Regarding to option 1, which is rail overpass, the railway is designed to be elevated above the Morphett Road. The objective of building columns is to transfer the total combination load from the road deck to the foundation. It is very important to make sure that the columns are strong enough to withstand both dead and live. The differences between types of columns and the materials that are used to make it will be profoundly discussed in the following sections.

Regarding to the rail overpass, there are totally 14 columns required to support the slab with the area of 200m x 8m. Each two columns will be constructed at each side of the slab to be the same row. Therefore, there are totally 7 rows of columns combined with 2 retaining walls at each end of the slab that are used to support the whole slab. The dimensions in details as well as the corresponding locations of the supported columns with be indicated as follow:

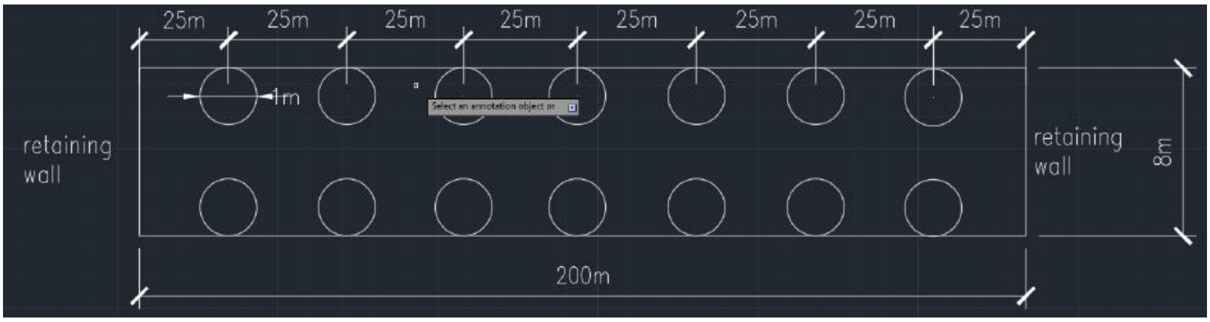


Figure 12: Top view for railway overpass with the locations of columns

4.1.6.2.1 Types of columns

4.1.6.2.1.1 Reinforced concrete columns

It is true that reinforced concrete is known as one of by far the most common materials that are used in the construction. Its properties include high compressive strength capacity that is compulsorily required in the building industry. So as to increase the capacity of bending moment created by eccentricity, reinforcement should be also added. A wide range of wheeled vehicles that travel in different lanes of the overpass road possibly result in the creation of the large eccentricity. Regarding to reinforced concrete columns, a variety of columns with different cross sections will be investigated in terms of advantages and disadvantages as follow.

4.1.6.2.1.1.1 Square reinforced concrete columns

Square reinforce concrete column have been one of the simplest forms aiming at designing and constructing since its comprised flat surfaces and perpendicular edges. As for road overpass option, the square columns could be applied to the structure as shown below:

Figure 13: An example of square reinforced concrete columns

Compared to one columns, the use of two or more columns contributes to making a reduction in the total loadings on each column. The required cross-section area of each column, as a result, will decrease. This not only makes the design more appealing but also adds additionally supports to withstand the eccentricity loads.

4.1.6.2.1.1.1.1 Advantages and Disadvantages

There are several advantages and disadvantages when using square reinforced concrete columns (SRCC) in the construction. With respects to the advantages, easy-to-cast is the highlighted properties of the SRCC. This makes the construction become time-saving and cost-effective. On the other hand, there is a limitation in the ability of transferring loadings to the foundation when using SRCC. Therefore, instead of using the smaller circular columns, larger square columns are generally required. Moreover, it is true that SRCCs must experience higher bending moment as well as larger deflective ratio compared to other symmetric columns such as circular ones. Finally, SRCC are said to be more vulnerable under the impacts of wind loads due to the perpendicular between two surfaces.

4.1.6.2.1.1.2 Circular reinforced concrete columns

Although both square reinforced concrete columns (SRCC) and circular reinforced concrete columns (CRCC) are said to be symmetric, the design of CRCC is much more complicated than SRCC. As discussed above, it is necessary to use more than 1 column to support the slab due to its benefits. The application of CRCCs can be shown as follow:

Figure 14: An example of circular reinforced concrete columns

4.1.6.2.1.1.2.1 Advantages and Disadvantages

It is a fact that the advantages of CRCC outweigh its disadvantages. Indeed, the CRCC makes structure stronger and more sustainable compared to other alternative options. As addressed above, CRCC experiences lessen bending moment and deflection in comparisons with either square or rectangular reinforced concrete columns under the same conditions. Finally, the total loadings will be effectively transferred from the decking to the foundation when using CRCC. Finally, CRCC owns outstanding abilities to withstand wind loads compared with other types of reinforced concrete columns. The only one disadvantage of circular reinforced concrete columns is either to pour or to precast them because of the irregularly shaped columns without any possessing edges.

4.1.6.2.1.2 Steel columns

The use of steel columns for this project is not recommended by the DPC engineering group as there are a huge number of potential risks while using steel columns instead of reinforced concrete columns. It is a fact that the dimension of steel columns is smaller than the reinforced concrete columns. Consequently, under the high-compressive loadings, steel columns are subjected to occur buckling. This causes a threat to endurance of the whole structure. Moreover, some steel columns are subjected to the open atmosphere. Hence, several methods including coatings with use of anti-corrosion paint are compulsorily required. This will increase the maintaining costs which make the project become unprofitable. In case of incorrect maintenance, the thickness of steel columns will be corrosive day-by-day. This leads a serious consequence of reducing the compressive abilities of the columns.

4.1.6.2.2 Recommendation

To evaluate the suitability of each type of columns and materials used, a number of criteria are carefully taken into account as follow:

- Design Cost and Duration
- Ease of Design
- Material Cost
- Labour Cost
- Construction Duration
- Constructability
- Maintenance Required
- Design Life/Performance

After considering the Australian Standard combined with other similar projects in South Australia, the structural department from the DPC engineering group strongly recommends the use of 20 MPa circular reinforced concrete columns at the maximum spacing of 27.5m. Although there are some disadvantages as discussed above, the advantages of circular reinforced concrete columns outweigh their disadvantages. The proposed CAD drawing for this recommendation can be shown as follows:

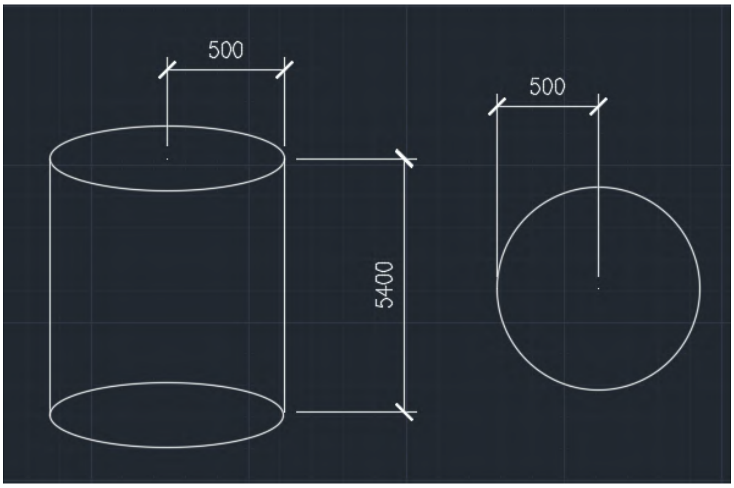


Figure 15: In-detail dimensions of the circular reinforced concrete columns in millimetres

4.1.6.2.3 Costing

From the proposed CAD drawing, the amount of reinforced concrete in volumes can be figured out as follow:

$$V_{require} = 14 \times \pi \times \left(\frac{1}{2}\right)^2 \times 5.4 = 59.4\, m^3 \approx 60\, m^3$$

According to "Rawlinsons Construction Cost Guide 2017", the costing for the required amount of reinforced concrete will be equal to:

$$Material\ costs = \$327\ (per\ cubic\ meter) \times\ 60\, m^3 = 19620\$ \approx 20000\$$$

Labour costs can be calculated as follow:

$$Labour\ costs = Number\ of\ labours \times Total\ hours\ for\ each\ labours \times Rate$$
$$= 20\ (labours) \times 52\ (= 2\ hours/m^3\ \times 26\, m^3) \times 120 = \$124800 \approx \$125000$$

Therefore,

$$Total\ costs = Material\ costs + Labour\ costs = 20000\$ + \$125000 = \$145000$$

Based on the calculations above, the total costs to build 14 columns completely in case of railway overpass is supposed to be equal to $145000. This amount is a preliminary cost estimation and is subjected to change in the next stages.

4.1.6.3 Capping Beams

The function of a Capping Beam is to prevent or inhibit lateral displacement of the installed retaining piles or columns during the excavation process. In addition, it transfers vertical structural loads from the building when constructed to the piles, columns or retaining structures. Figure 16 below shows a typical capping beam with reinforcements.

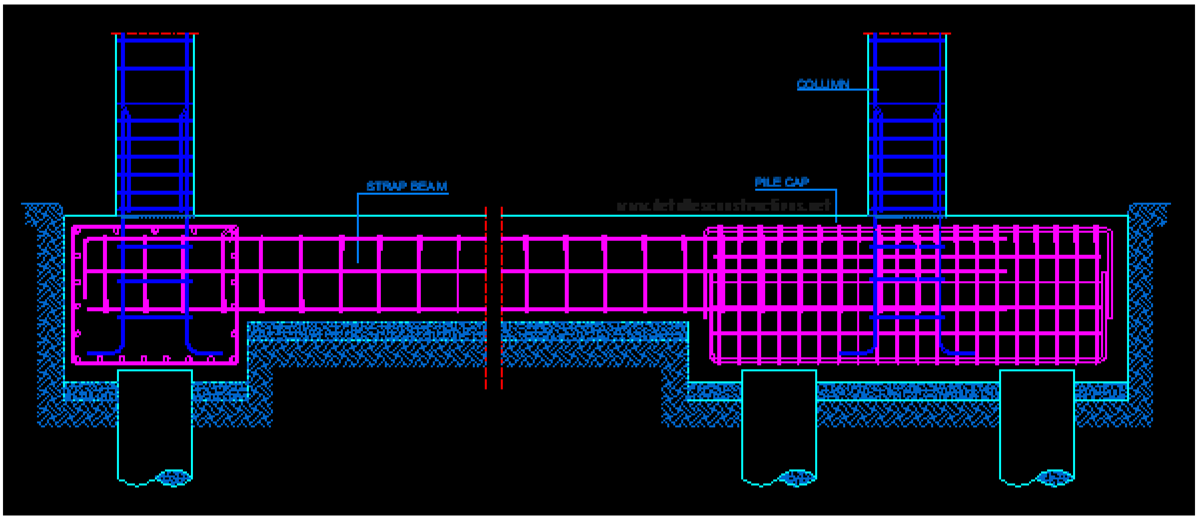


Figure 16: Capping beam with reinforcement

The size of a capping beam will ultimately be determined by the loading to which it is subjected as well as dimensional constraints. Figure 17below shows a capping beam sitting on a lining wall piles, and the width and depth of capping beam is related to the thickness of the piles underneath. Usually, there is reinforcement bars at top and bottom to resist bending moment and shear ligatures to resist shear force.

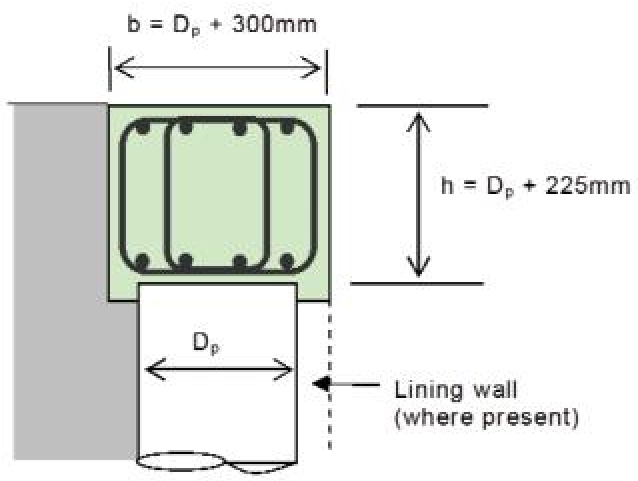


Figure 17: Typical section for capping beam

Capping beams are located at bottom of columns, it will be design as a rectangular cross section as in Figure 18 below.

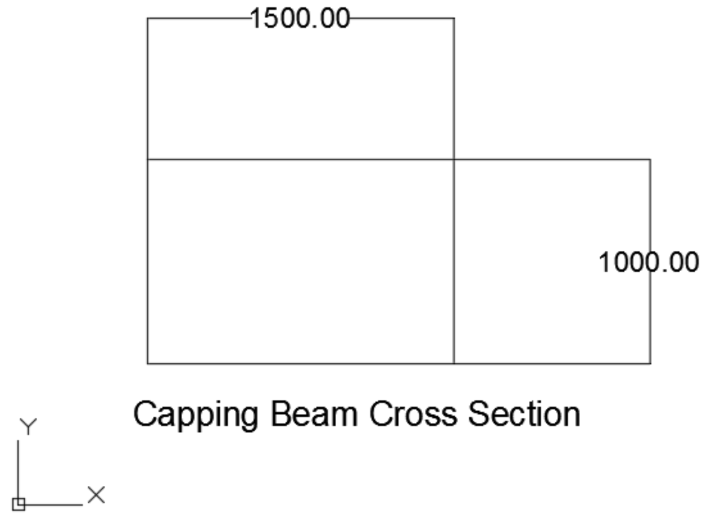


Figure 18 Capping beam cross section

The design team selected capping beam section of 1m by 1.5m, and it has the same length as bridge width 8m. Precast capping beam can be used in the project as construction time is limited, form the calculation part, a single capping beam is 288kN, so a crane is needed at construction site to lift and installation, as there are 8 spacing all along the bridge, 7 capping beams are needed at the bottom of intermediate columns which will transfer vertical loadings from columns to ground and two capping beams are needed at abutments both sides which will transfer horizontal loadings from abutments to ground as well.

Additionally, as precast beam installed on site, grouting process must be considered as well, as a precast beam, holes are left on precast beam in advance when fabricated, when installation, steel bars from piles should fit holes on precast beams, after they are fitting well, grouting process should be conduct, as capping beams are 1 meter height and grouting process is conduct at the time of installation which is done with aid of crane lift, under the condition, work safety issues should be considered. Figure 19 below shows the grouting process.

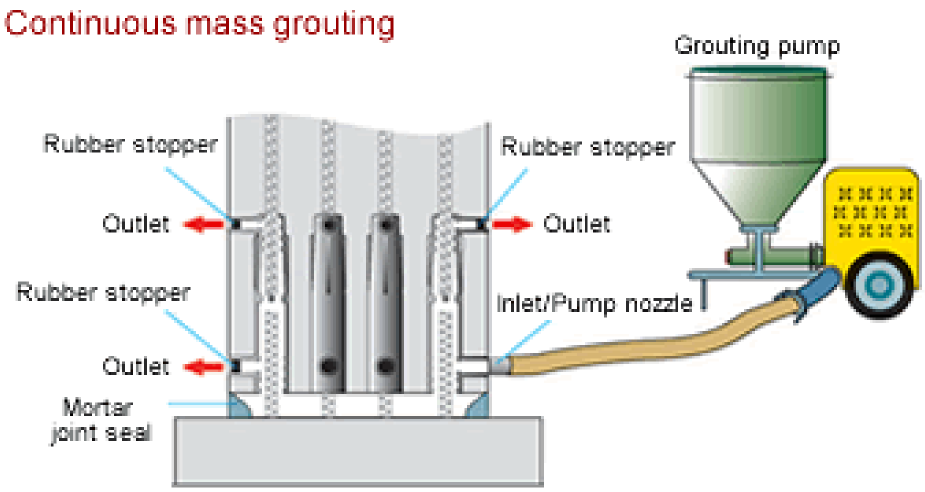


Figure 19Grouting process

The behaviour of a capping beam under vertical load from a column can be considered as a flexible continuous foundation on discrete flexible supports. A conservative approach that can be used in the situation is to model the capping beam as a continuous beam on spring supports, which means an elastic design. This requires input from a geotechnical engineer on suitable spring stiffness to be used for design. Use of transformed or cracked sections for analysis will more accurately reflect the stiffness of the beam relative to the piles. This approach will lead to a more economical design for the capping beam and avoid underestimation of pile loads. The appropriate reduction in stiffness varies with load and reinforcement percentage.

4.1.6.3.1 Material

As the capping beams are located at bottom of the columns, reinforced concrete structure can be the only option as concrete is known for its compressive strength. At the same time, reinforcement bars are used as well, by analysis forces and moment acting on a capping beam, reinforcement bars should be placed at top and bottom to resist bending moment action from columns and piles.

4.1.6.3.2 Costing

Based on Rawlinson's Australian construction handbook version of 2017. Cost of deck slab is estimated.

Based on the provided price, concrete price for each m3 at Adelaide is $327 AUD

Based on the dimension of capping beam, the volume =7* 8m*1.5m*1m=84m3

So, total costing of materials=56*327=$27,468

4.1.6.3.3 Recommendation

In railway overpass option, capping beams are precast concrete member with cross section area of 1.5 meters by 1 meters with same length as bridge width. Proper reinforcement and shear ligatures are required when fabricating, however, capping beam machinery installation must be organized carefully to ensure safety issues. The detail of reinforcement bars cross section area and spacing of ligatures will be further discussed in detail design.

4.1.6.4 Head stock

Head stock is located at top of columns and bottom of super tee girders, it is a part of structural member transferring loading from girders to column. The team designed the head stock beam as square section which is 1 meter by 1 meter, and length of it is 8 meters, which is same length as bridge width. Figure 20 shows a typical head stock

beam and Cross section.

Figure 20 A typical head stock beam

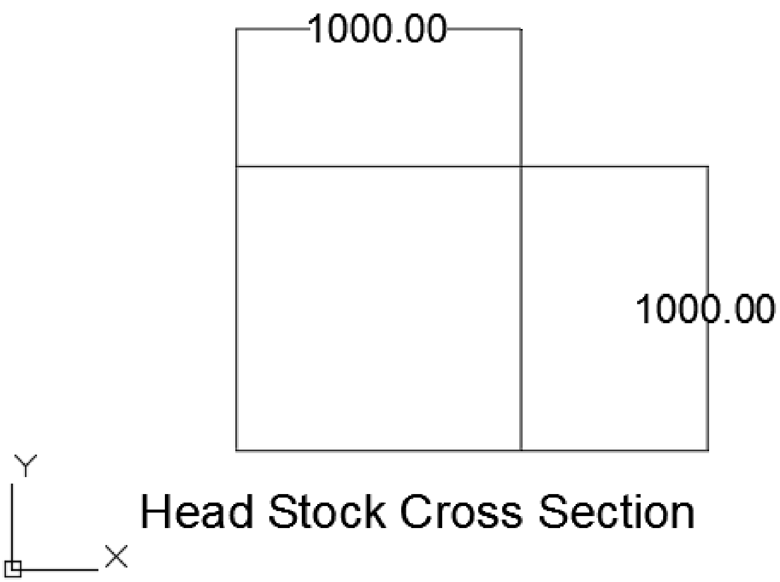


Figure 21 Cross section of head stock (dimension unit in mm)

Same as capping beam design, precast head stock beams are used, which will be fabricated at factory and then delivered to construction site for installation. As seven pairs of columns are designed along the bridge, so seven head stock beams will be used at each pair of column. Head stock beams will be installed when columns are being casted and reach a required strength, at this project, columns will be cast in situ.

For head stock beams installation, cranes are needed for lifting, capping beam installation are done before column casting, while head stock beams are installed after columns being casted and reach a required strength, so cranes should come into site for a section time, crane lifting, installing and grouting process will be conduct as normal, in the installation process, safety issues must be considered carefully as workers must work at height at head stock installation. On the other hand, super tee girders will be installed after head stock were ready, since there are eight 25m spacing along the bridge, and 200 meters of super tee girders be used, lifting frame could be an option in the case, as it would make the lifting work easier and safer.

Normally, bearings, the ancillary bridge components will be located on head stock to transmit the load from the superstructure to the substructure and to the foundations. It also must accommodate the resulting deformations, rotations and displacements. As bridges are subjected to numerous influences that cause different loadings and resulting movements. The movements can be temporary or permanent in the form of deformations, rotations or displacements.

Reason causes the movements may from:

- changes in temperature
- vehicular traffic including static and dynamic effects
- creep and shrinkage of concrete
- braking loads
- wind loads
- earth pressure loads transmitted from abutments
- Differential settlement of supports

In modern bridge construction, bearings are used since the loading from each span is more than 100 tonnes because of which pot bearings are selected to use due to its large bearing capacities.

Figure 22: Pot bearing between head stock and super tee girder

4.1.6.4.1 Material

Same as capping beam, reinforced concrete of head stock beam will be used as the structural member bearing vertical compressive loads mainly, and concrete is a good material to bear compressive load.

4.1.6.4.2 Costing

Based on Rawlinson's Australian construction handbook version of 2017. Cost of deck slab is estimated.

Based on the provided price, concrete price for each m3 at Adelaide is $327 AUD

Based on the dimension of head stock, the volume =7* 8m*1m*1m=56m3

So, total costing of materials=56*327=$18,312

4.1.6.4.3 Recommendation

The design cross section of 1 meter by 1 meter needs proper reinforcement and shear ligatures prior to fabricating. However, installation needs to be organized carefully to ensure safety issues. At the same time, bearing should be considered carefully at construction since it will prevent movements and ensure bridge stability.

4.1.6.5 Platform

The elevated railway bridge includes a 160m long and 6.4m wide platform. The platform will be supported by abutment and columns. Structural team has considered stairs and lifts to provide easy and safe access to the platform. However, the design for lifts and stairs will be examined in detailed design stage. At this stage, the team has analysed the required alignment and allocated area for the lifts and stairs both side of the rail bridge.

4.1.6.5.1 Slab

The structural team has decided on using Powerdek steel deck of 100mm depth, which is specifically designed for long spans. The slab (refer to Figure 23) is ideal for tensile reinforcement in the composite slab, which improves the stability of the structure. However, it should be noted that long spans are limited to deflection, which should be considered in detailed design stage.

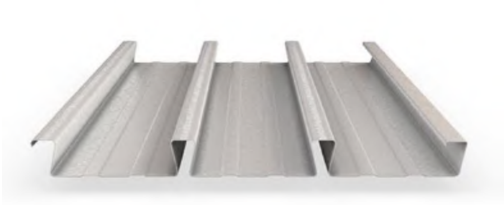


Figure 23: LYSAGHT Powerdek steel deck

4.1.6.5.2 Costing

Lysaght price list South Australia, which was effective from 13th, March 2017, price of Bondek is $99.17 AUD per square meter, in the design case, total area is 160*6.5=1040m2

Total cost of Bondek steel deck = $99.17*1040=$10,313.7

Based on Rawlinson's Australian construction handbook version of 2017, price of concrete price for each m3 at Adelaide is $327 AUD

Total volume of concrete used = 160*6.5*0.1=104m3

Thus, total cost of concrete = $327*104=$34,008

Thus, total cost of slab = $44,321.7

4.1.6.6 I Girders

Due to the large span of the platform, I girder is preferably the best choice for this structure, since it resists large bending moments. In addition, the section works well in conjunction with the composite slab, which makes the design achievable. For this purpose, the team has analysed two types of I girders; type 2 and type 4 (refer to Figure 24. The platform is designed by analysing 3 type 2 girders located at 6.5m spacing on top of the type 2 girder (refer to figure#). The analysis is focused on the stability of the structure as well as the cost.

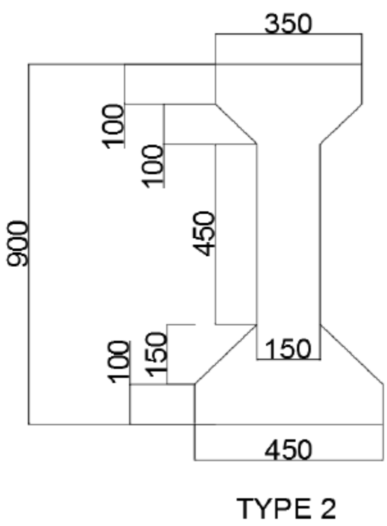


Figure 24 – Typical I beam Girder type 2

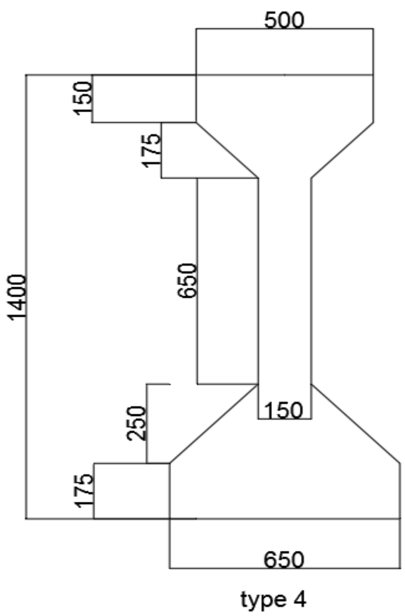


Figure 25 – Typical I beam Gireder type 4

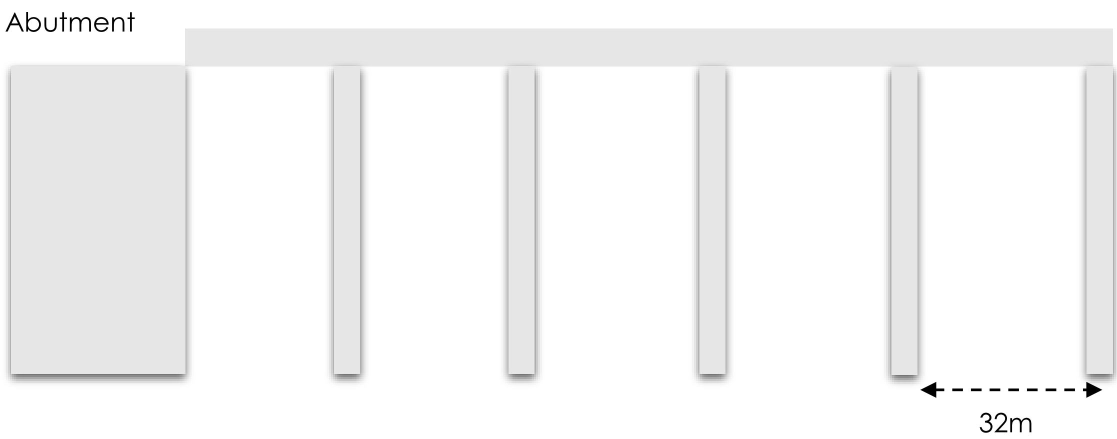


Figure 26 - Elevation view of platform

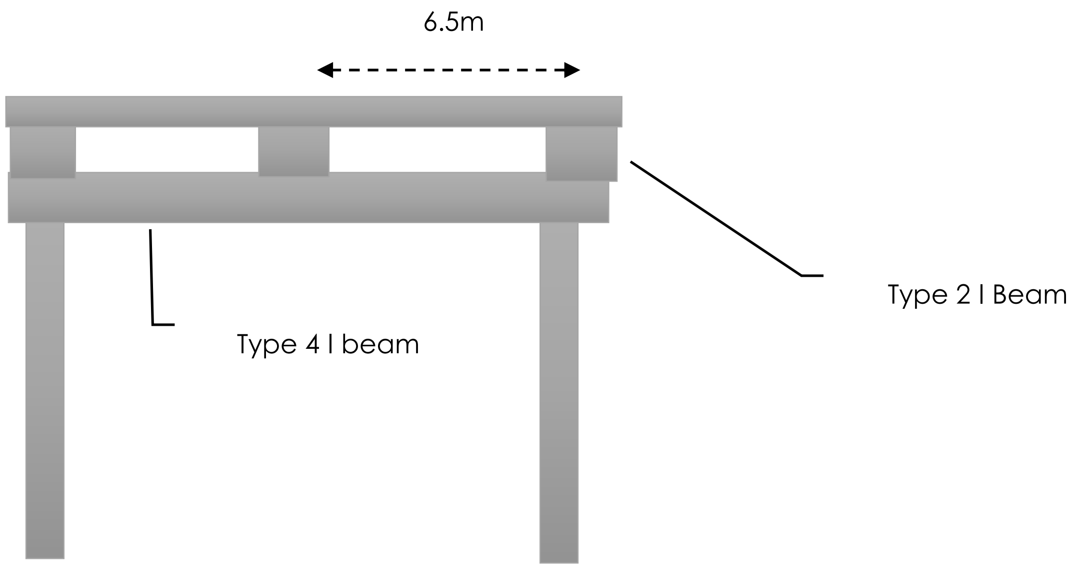


Figure 27:section view of platform

Figure 28below shows I beam girder in structural system, type 4 I beam supported by columns and type 2 I beam at top of type 4 I beam.

Figure 28 – Girder structural System

4.1.6.6.1 Costing

6 numbers of type 4 I section girder beams are recommended to use, (5 are placing at top of columns and 1 is placing at the abutment side). The cross-section area of a single section is 0.443 m2, each girder beam spans 6.5 meters.

The total volume = 0.443 *6.5 * 6 = 17.28m^3

Based on Rawlinson's Australian construction handbook version of 2017, price of concrete price for each m3 at Adelaide is $327 AUD

Thus, total cost of type 4 I girder beam = $327*17.28=$5,650.56

3 numbers of type 2 I section girder beam are used in each span, and there are 5 spans in total. So, 15 numbers of type 2 I section girder beams will be used. The cross-section area of a single section is 0.218m2, each girder beam spans 32 meters.

The total volume = 0.218*15*32=104.64m2

Based on Rawlinson's Australian construction handbook version of 2017, price of concrete price for each m3 at Adelaide is $327 AUD

Thus, total cost of type 4 I girder beam = $327*104.64=$34,217.3

Total cost of I section girder beam = $5,650.56+$34,217.3=$39,867.86

4.1.6.7 Columns

Refer to Section 1.4.2.3.

4.1.7 Option 2

Option 2 is road overpass, which will be constructed on the Diagonal Road. The overpass design was proposed in accordance to the dimensions provided by the Transportation Department of DPC Engineering. Total span of the overpass will be 590 m which includes a retaining wall and a bridge structure. Structural team at DPC engineering will focus on designing the bridge structure for the road overpass. Total span of the Bridge structure is 80m. Brief introduction to Bridge structure and bridge substructure is provided in the next section.

4.1.7.1 Bridge Structure

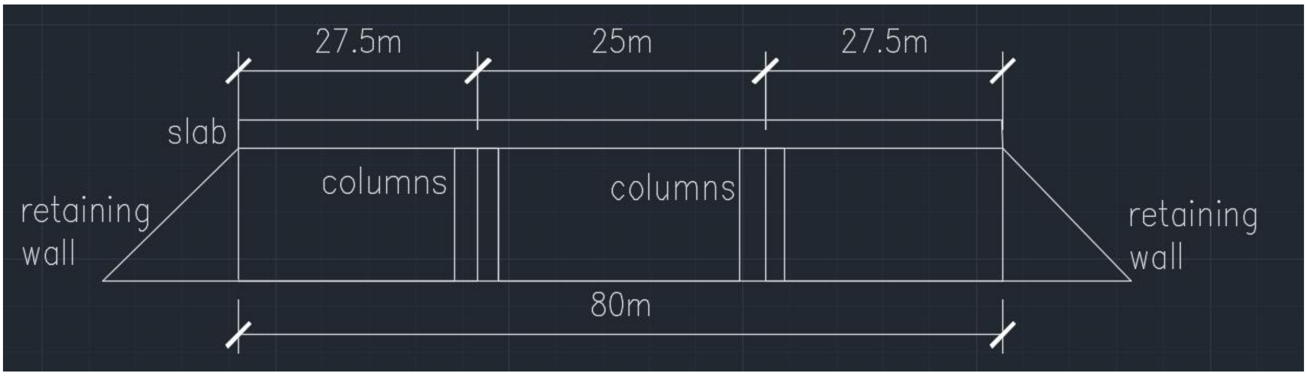


Figure 29: Side view of the bridge structure for road overpass option

As can be seen from the CAD drawing above, the slab, which has the dimension of 80mx30m, is supported by 2 retaining walls at each end combined with 2 rows of columns, totally 4 columns. From left to right, the distances between the retaining wall and the supported columns, between two supported columns, and between the supported columns and the retaining wall are 27.5m, 25m and 27.5m respectively. The slab thickness is said to be equal to 250mm, while the thicknesses of both head stock and the capping beam are equivalent to 1m and 1.5m respectively. The super tee girder is located under the slab.

4.1.7.2 Bridge Substructure

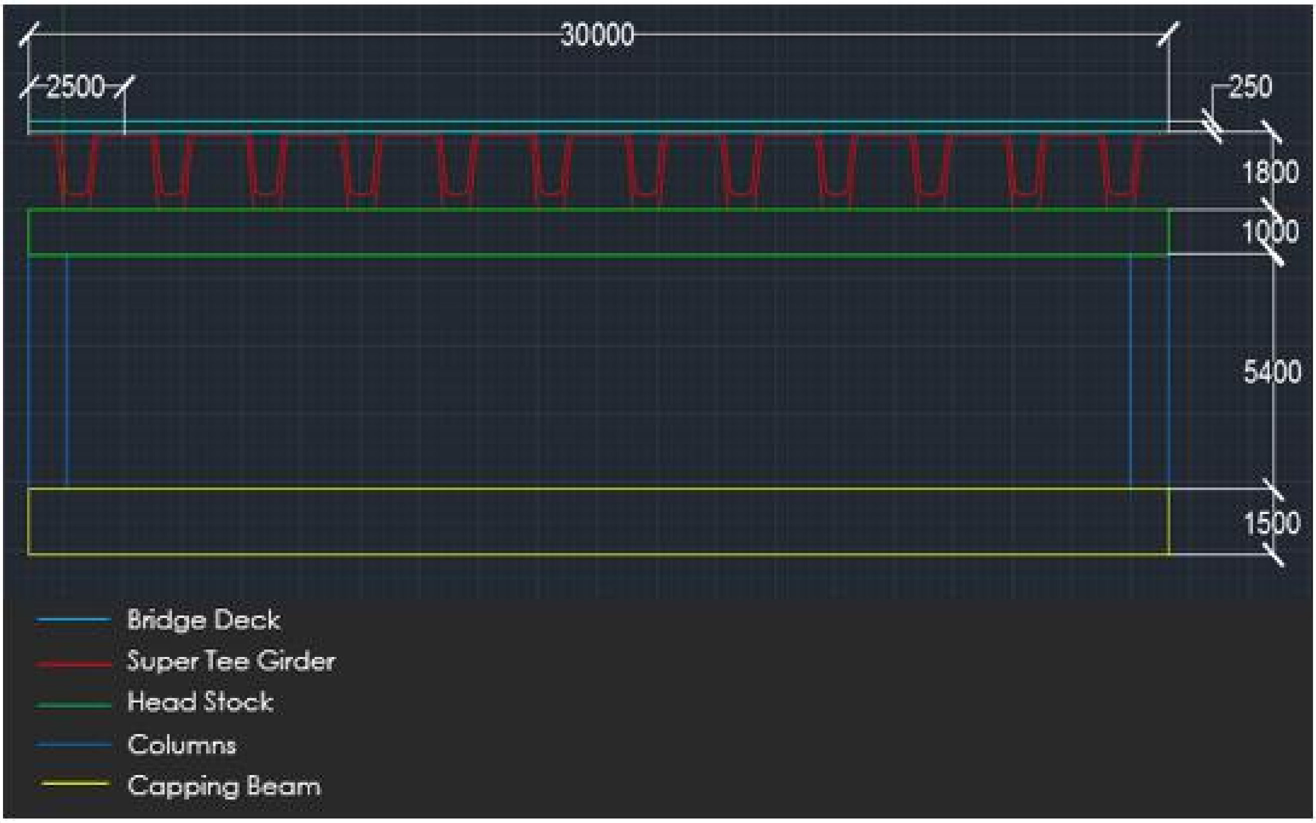


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Figure 30 - Road Overpass Bridge Cross Section

Substructure of road overpass is similar to that of railway over pass. As shown in the Figure 30, the cross sectional view of the bridge structure, there are five main components of bridge substructure, namely, Bridge Deck/slab, super tee girders, head stock, columns and capping beam. These structural components provide stability to the bridge. All the substructural components will be assessed and its construction recommendations as well as estimated cost will be provided in the following sections.

4.1.7.3 Road Deck

Same as railway overpass bridge design, the road slab deck is at top of super tee girders and is supported by super tee girders, based on design consideration, 250mm slab thickness is selected to use as well. But for road overpass design, there are some issues need to be considered differently.

- The total slab span is 80 meters
- Slab width is 30 meters

4.1.7.3.1 Material

In order to reduce construction time, the structural design team recommends precast concrete slab as a material for the slab. Precast concrete slabs are pre-fabricated and manufactured at factory, which has already reached to its 28-day strength.

4.1.7.3.2 Costing

Based on Rawlinson's Australian construction handbook version of 2017. Cost of deck slab is estimated.

Based on the provided price, concrete price for each m3 at Adelaide is $327 AUD

Based on the dimension of deck slab, the volume = 30m*0.25m*80m=600m3

So, total costing of materials=600*327=$196,200

4.1.7.3.3 Recommendation

As for road overpass design, the bridge deck designed be 250mm thick and 30m wide. As mentioned earlier precast concrete slab is recommended for this design, the team suggests post tensioning technology as it would reduce construction period and cut down budget. Meanwhile, it will provide a greater loading capacity and improve deflection control. At the same time deck slab joints must be fully considered to ensure the stability of the structure.

4.1.7.4 Super T Girder

Selection of super structure and its material is done by following similar process to option 1. After comparing the advantages and disadvantages of available options for super structure, a shape along with its material is recommended in the next section.

4.1.7.4.1 Recommendation

Total span of the bridge is 80m, while it is 30m wide. This road overpass can be considered as a wide bridge. The final design recommendations by structural department at DPC engineering was designed after considering the following key points

- Adequate strength and durability
- Cost effectiveness of the design
- Design efficiency
- Duration of construction
- Capacity to support a wide span

Because of its wide span, steel can be a good option for girders as it has high strength. However, due to its cost and high post construction maintenance, reinforced concrete is selected. If I shaped girders are selected then many girders must be installed because of its slender design. In addition, a higher prestressing is also required which will increase the design cost. Tee girders are quite suitable for a wide spanned bridge as comparatively lower prestressing is required and hence they are highly recommended for road overpass construction. T5 type of tee girder is selected by increasing its width to 2500mm. Total 12 girders are required for road over pass.

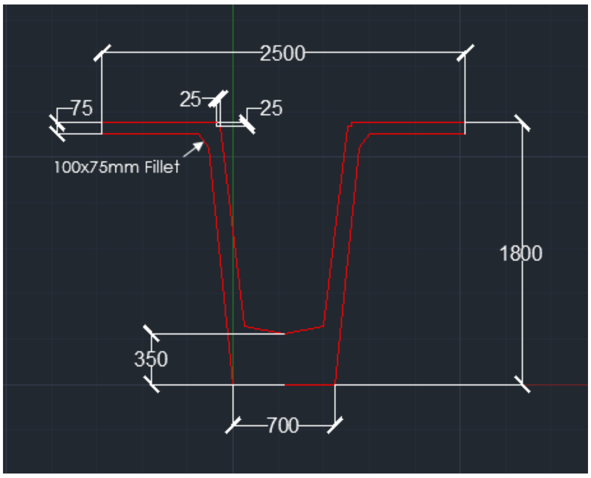


Figure 31 – Road Overpass Typical Super Tee Cross Section

4.1.7.4.2 Costing

By following the recommended design, which is using super tee girders of type T5 precast and requires prestressing, final cost was estimated. The estimated cost discussed in this section is fairly accurate but it may change depending upon enhancement of the detailed design of the structure. For a span of 80 meters and width of 30m, total weight of the required precast concrete girders will be 18,00,000 kg. Concrete strength selected for the tee girders is 50 MPa. Approxiamate cost for designing super tee girder includes a rough estimated labour cost. According to Rawlinson's handbook 2017, cost of precast girder is $327/m^3$, total volume of girders required for option 2 is $691.2m^3$.

Total Cost for super tee girder=$3,00,000

4.1.7.5 Columns

In regard to road overpass design, there are 4 columns required to support the slab with the area of 80m x 30m. Each two columns will be constructed at each side of the slab to be the same row. Therefore, the 2 rows of columns combined with 2 retaining walls at each end of the slab that are used to support the whole slab. The detailed dimensions as well as the locations of the supported columns with be shown as follow:

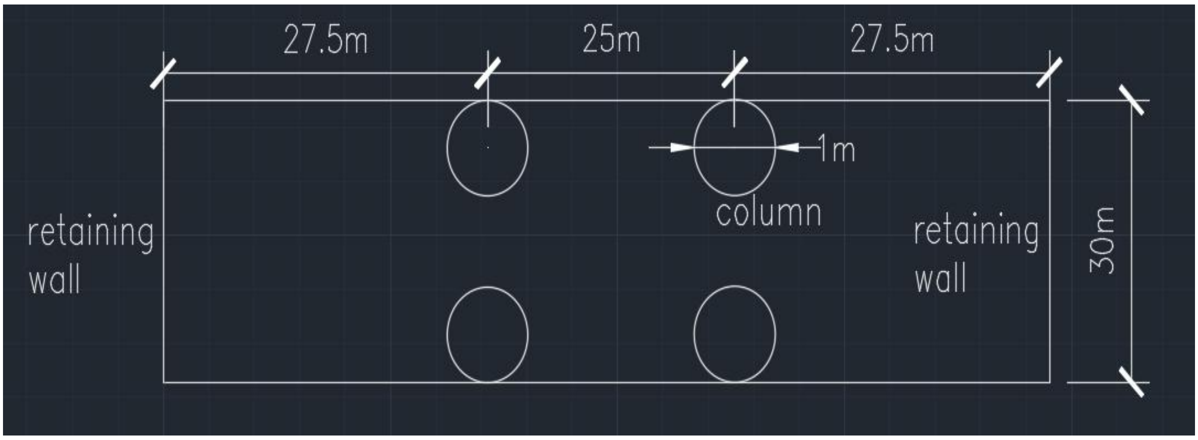


Figure 32: Top view for road overpass with the locations of columns

4.1.7.5.1 Types of columns

4.1.7.5.1.1 Reinforced concrete columns

Refer to option 1 – rail overpass.

4.1.7.5.1.2 Steel columns

Refer to option 1 – rail overpass.

4.1.7.5.2 Recommendation

Refer to option 1 – rail overpass.

4.1.7.5.3 Costing

From the proposed CAD drawing, the amount of reinforced concrete in volumes can be figured out as follow:

$$V_{require} = 4 \times \pi \times \left(\frac{1}{2}\right)^2 \times 5.4 = 16.96 \approx 17\ m^3$$

According to "Rawlinsons Construction Cost Guide 2017", the costing for the required amount of reinforced concrete will be equal to:

$$Material\ costs = \$327\ (per\ cubic\ meter) \times 17 = \$5559 \approx \$6000$$

Labour costs can be calculated as follow:

$$Labour\ costs = Number\ of\ labours \times Total\ hours\ for\ each\ labours \times Rate = 10 \times 52 \times 120 = \$62400 \approx \$63000$$

Therefore,

$$Total\ costs = Material\ costs + Labour\ costs = \$6000 + \$63000 = \$69000$$

Based on the calculations above, the total costs for road overpass is predicted to be equivalent to $69000. This amount is a preliminary cost estimation and is subjected to change in the next stages.

4.1.7.6 Capping Beams

Same as railway overpass design, capping beams are needed at bottom of columns, one capping beam spaning 30 meters will be used over the width direction of road bridge, but for using precast concrete capping, the total 30 meters will consist of several shorter precast beams, since the precast capping beams are fabricated at factory and transported to construction site, and the shorter beams are suitable for fabrication and transportation purpose.

4.1.7.6.1 Material

Refer to option 1, section 1.4.2.4.3

4.1.7.6.2 Costing

Based on Rawlinson's Australian construction handbook version of 2017. Cost of deck slab is estimated.

Based on the provided price, concrete price for each m3 at Adelaide is $327 AUD

Based on the dimension of deck slab, the volume =2*1.5m*1m*30m=90m3

Total costing of materials=90*327=$29,430

4.1.7.6.3 Recommendation

In road overpass option, capping beams are using precast concrete member and being installed on site, and the design cross section of 1.5 meters by 1 meters, and same length as bridge width, the total width is 30 meters and over the width direction, several beam segments should be considered to use. And proper reinforcement and shear ligatures are required when fabricating. However, capping beam machinery installation must be organized carefully to ensure safety issues.

4.1.7.7 Head stock

Same as railway overpass design, head stock locates at top of columns and bottom of super tee girders, it is a part of structural member transferring loading from girders to column, in the design, the design team designed the head stock beam as square section which is 1 meter by 1 meter, and length of it is 30 meters, same length as bridge width. In road overpass case, the 30 meters of head stock beam will consist of several segments.

4.1.7.7.1 Material

Same as capping beam, reinforced concrete of head stock beam will be used as the structural member bearing vertical compressive loads mainly, and concrete is a good material to bear compressive load.

4.1.7.7.2 Costing

Based on Rawlinson's Australian construction handbook version of 2017. Cost of deck slab is estimated.

Based on the provided price, concrete price for each m3 at Adelaide is $327 AUD

Based on the dimension of deck slab, the volume =2*1m*1m*30m=60m3

Total costing of materials=60*327=$19,620

4.1.7.7.3 Recommendation

Refer to option 1, section 1.4.2.5.3

4.1.8 Final Recommendation

The structural team has performed in-depth analysis on both options to be able to recommend a feasible option. The recommendation provided by the team is based on the criteria outlined below:

- Durability of structure
- Constructability
- Cost efficient
- Maintenance
- serviceability

After extensive investigation, the structural team recommends **option 1: Rail Overpass** to be the feasible solution to grade separation of Oaklands Park. The solution meets the criteria mentioned above. The structure will be designed to be durable, which would require minimum maintenance. In addition, the construction of rail bridge is more practical compared to road bridge due to minimum road reworks, easy geometry of the road, presence of no curve and bends and smaller width of rail. The ease of construction will ultimately result in minimum cost, which is also an important factor to be considered.

4.2 Geotechnical

4.2.1 Site overview

The project is located at the Oaklands Park in Morphett vale. There are two options that have been planned for this project for the grade separation. First option is the rail overpass and the second choice is road overpass. Base on the observation of the site, it can be concluded that the site rich with vegetation area especially around the railway station. This can be summarized that the site might be rich amount of underground water to support the green area there. Further observation can be seen from the photos below.

Figure 33 - Vegetation around Oaklands Railway Station

Figure 34 - Trees located at the side of the railway

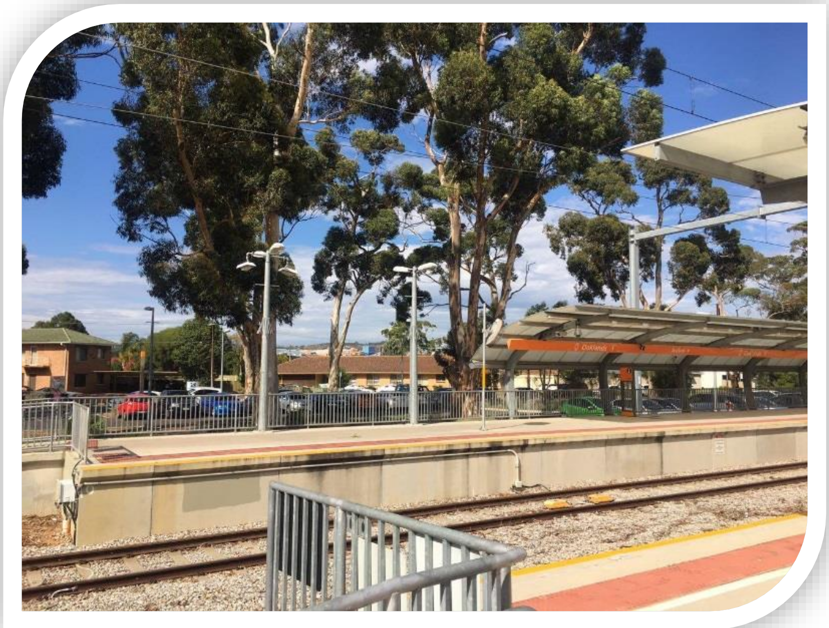


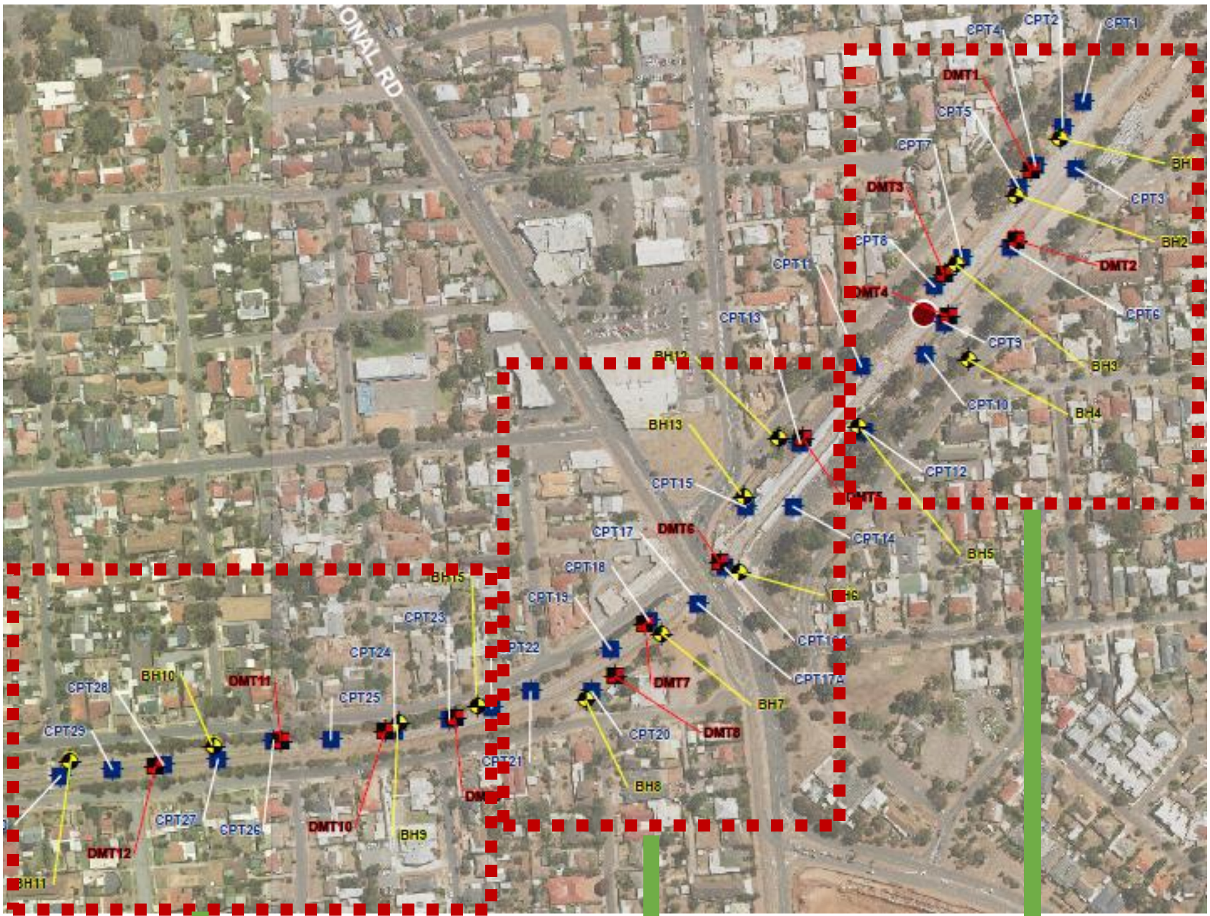
Figure 35 - Vegetation around the railway station

Figure 36 - Vegetation around behind the railway station

From geotechnical knowledge, the soil that rich with underground water can affect the strength and stability of the soil. Therefore proper footing design should be designed in order to ensure the structures are strong enough to support high capacity of traffic. The expansive soil will not be our main concern because we are planning to build the road overpass instead of underpass therefore the expansive soil will not give much effect to the structure. Apart from that, from the geotechnical investigation report by Parson Brinckerhoff, the investigation has shown that the soils at the site are mostly comprise silty clay which mean that the soils do not have good quality of soil. We also assume that the soils do not have enough bearing capacity to support the structure. Hence proper retaining wall and deep footing will be taken into consideration. Then, the existing of large trees around the site also will affect the construction. Deeper excavation will be required to remove the trees.

4.2.2 Review of Geotechnical Investigation Report

From the Oaklands Overpass Geotechnical Investigation (2011) done by Parsons Brinckerhoff, there are 14 boreholes drilled along the rail line. The boreholes are divided and summarised into 3 section as shown in the figure below.



Section 3	Section 2	Section 1
OPBH 9	OPBH6	OPBH1
OPBH10	OPBH7	OPBH2
OPBH11	OPBH8	OPBH3
OPBH15	OPNH12	OPBH4
	OPBH13	OPBH5

4.2.2.1 Borehole Location

The boreholes were located along the up track and down track sides of the rail line near Oaklands Railway Station. A total of 14 boreholes were drilled and the location of the boreholes are as shown in the table below.

Table 5 - Borehole Location Data

Borehole Number	Easting	Northing	Depth (m)
OPBH01	275787	6213345	6.0
OPBH02	275755	6123353	8.0
OPBH03	275711	6123302	14.0
OPBH04	275720	6123232	11.0
OPBH05	275639	6123183	23.0
OPBH06	275551	6123076	29.64
OPBH07	275494	6123030	30.0
OPBH08	275439	6122982	25.0
OPBH09	275301	6122965	20.0
OPBH10	275165	6122981	15.0
OPBH11	275059	6122537	8.0
OPBH12	275580	6123174	29.81
OPBH13	275555	6123131	29.90
OPBH15	275359	6122977	29.60

4.2.2.2 Soil Properties

4.2.2.2.1 Section 1 - OPBH01 to OPBH05

According to the summary of general subsurface conditions for OPBH01 to OPBH05, SAND/CLAY is the predominant natural soil type. The soil profile for the boreholes are generally low to medium plasticity, dense to very dense/very stiff to hard. The maximum depth for the borehole is 23m (OPBH 05). Lenses of very dense SAND were present in all boreholes except OPBH 02 from depths varying from 5.0-10.0m with an average thickness of around 1.0 to 2.0m. Sandy CLAY with medium to high plasticity is encountered in Borehole OPBH03 at a depth of 2.0-4.0m as well as a layer of increased gravel content between 9.0 to 11.0m. For Borehole OPBH04, QUARTZITE is encountered at a depth of 10.7m. The soil profile of the boreholes is showing that the soil has a good supporting capacity. However, the boreholes are located at the side of the construction area especially OPBH4. The most important soil profile information is where we build the railway path or the road cross the railway. Therefore, we should get more boreholes data along the construction line for the final design.

	Colour Log	Soil/Rock Material Field Description
0		FILL: Sandy gravel; fine to coarse grained, blue grey, fine to coarse grained sand
2		Clayey SAND/Sandy CLAY; low to medium plasticity, brown, orange brown, red-brown, dense-very dense/very stiff-hard
6.8		SAND; brown, orange-brown, very dense
10.7 to end of borehole		Only encountered in borehole OPBH04: Quartzite

Figure 37 - Summary of general subsurface conditions for section 1

4.2.2.3 Section 2 - OPBH06-OPBH08 OPBH12 & OPBH13

Based on the summary subsurface conditions, SAND/CLAY was present to a maximum depth of 24.8m in these boreholes. The SAND/CLAY was dense to very dense/very stiff to hard. Approximately below 12.0m of the boreholes, a significant proportion of medium to high plasticity sandy/silty CLAY was found. The presence of sand lenses is reduced and the gravel content is increased below 6.5m depth. Between 14.5 and 29.7m, soft/low density material was exposed with the presence of firm to stiff/loose to medium sandy gravelly CLAYs and sandy clayey. The soil profiles of OPBH12 and OPBH13 were consisted predominately of low to high plasticity Sandy CLAY.

Depth (m)	Graphic Log	Soil/Rock Material Field Description
0		Clayey sand/clayey gravelly sand; brown
2		Clayey SAND/ Sandy Clay; low to medium plasticity, brown, orange-brown, red-brown mottled green, grey and white, dense-very dense/ very stiff-hard
7		Gravelly Clayey SAND/Clayey Gravelly SAND; orange brown, dense to very dense

Depth (m)	Graphic Log	Soil/Rock Material Field Description
12		Sandy CLAY/ Silty CLAY; medium to high plasticity; orange brown mottled green-grey and brown, dense to very dense/ very stiff-hard
23 to end of borehole		Clayey Gravelly SAND/ Clayey Sandy GRAVEL; brown mottled green-grey, dense to very dense.

4.2.2.4 Section 3 - OPBH09-OPBH11, 15

Based on the summary subsurface conditions, we can conclude that the predominant soil type is dense to very dense/very stiff to hard SAND/CLAY mixture to depth of 20.0m. The gravel content is increased in borehole OPBH11. In addition, lenses of higher plasticity clay and sand are existing in borehole OPBH09. As a result, the supporting force of this area is great for construction.

Summary of general subsurface conditions for OPBH 09-11, OPBH15

Depth (m)	Graphic Log	Soil/Rock Material Field Description
0		Clayey SAND/ Sandy CLAY; low to medium plasticity, brown, orange-brown, red-brown, dense-very dense/very stiff-hard
2		Clayey Gravelly SAND; brown
6		Clayey SAND/Gravelly SAND; orange-brown, very dense
9 to end of borehole		Sandy CLAY; medium to high plasticity, red-orange mottled grey

4.2.2.5 Groundwater Depth

The locations and depths are presented in the table. The groundwater was found between June to August 2011 and it might change due to changing natural forces or man-made influences. The water level is likely to vary with the seasonal changes. There is no ground water encountered in Borehole 1, 2, 4 and 11. The piles are more than 20m which means the foundation will encounter the groundwater. Therefore, effective stress have to be calculated in the detail design stage. The average groundwater depth for all the boreholes is 12m and this will be used for the calculation.

Table 6 - Boreholes and Groudwater Depths

Borehole Number	Groundwater Depth (m)
OPBH03	10.5
OPBH05	13.0
OPBH06	13.0
OPBH07	12.5
OPBH08	15.5
OPBH09	11.0
OPBH010	11.5
OPBH12	12.5
OPBH13	12.0
OPBH15	10.5

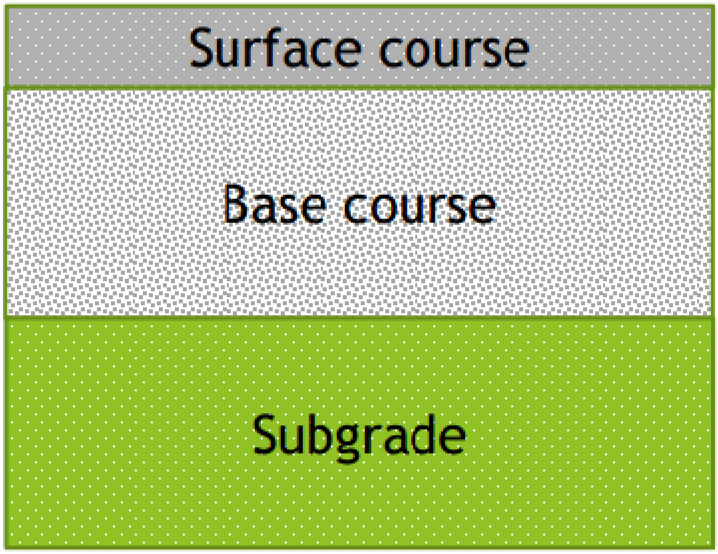
4.2.3 Expansive soil

Expansive soil is the swelling or expansion of wetted soil and shrinkage of the dried soil. Clays are usually prone to the expansive soil while sands are not reactive to the moisture change. The result of the expansive soil can cause the structure to crack and reduce the support of the building. Expansive soils normally occur in the hot and dry climate country. Therefore Australia is susceptible to expansive soil.

However, in the case of designing the footing for Oakland Park we have chosen two options which are rail and road overpass. The deep foundation and overpass method are not likely will be affected by the expansive soil because the structure will be supported by columns and the pile foundation.

4.2.4 Pavement design

To design the pavement that complies with the Australia Standard and able to sustain the high capacity of the traffic there will be three layers of pavement to be considered which are surface course, base course, and subgrade.



In Australia generally, there are few challenges that have to be encountered to produce a proper pavement design. The state needs to cope with the long distance, dry condition, low funding and little traffic on the rural road. Hence these will affect the implementation of pavement design in the certain area.

There are two general types of pavement that can be considered for the pavement in Oakland Park, they are flexible and rigid pavements. In the case of this project, flexible pavement will be chosen as the type of pavement. Then, in term of the pavement materials, there are five types of materials that are generally used which are unbound granular material, modified granular materials, cemented materials, asphalts, and concrete. Each of the materials has different behavior when the load applied to them.

To design the proper pavement for the Oakland Park overpass road, each of the course of materials and thickness will be determined based on the several variables and factors that they designed for. The design factors are as follow.

1. Traffic
2. Subgrade strength and stiffness
3. Pavement material performance
4. Water and Temperature

The quality of the pavement design can be assessed from the damaging effect of the loads and the frequency of the traffic over the life of pavement. This approach is defined as an equivalent standard axle or ESA. Using ESA approach it is equivalent to a number of applications of the "standard axle" to cause the same damage to a pavement as the actual traffic, over the life of the pavement. However, this method of approach is limited to granular pavements with thin bituminous layers.

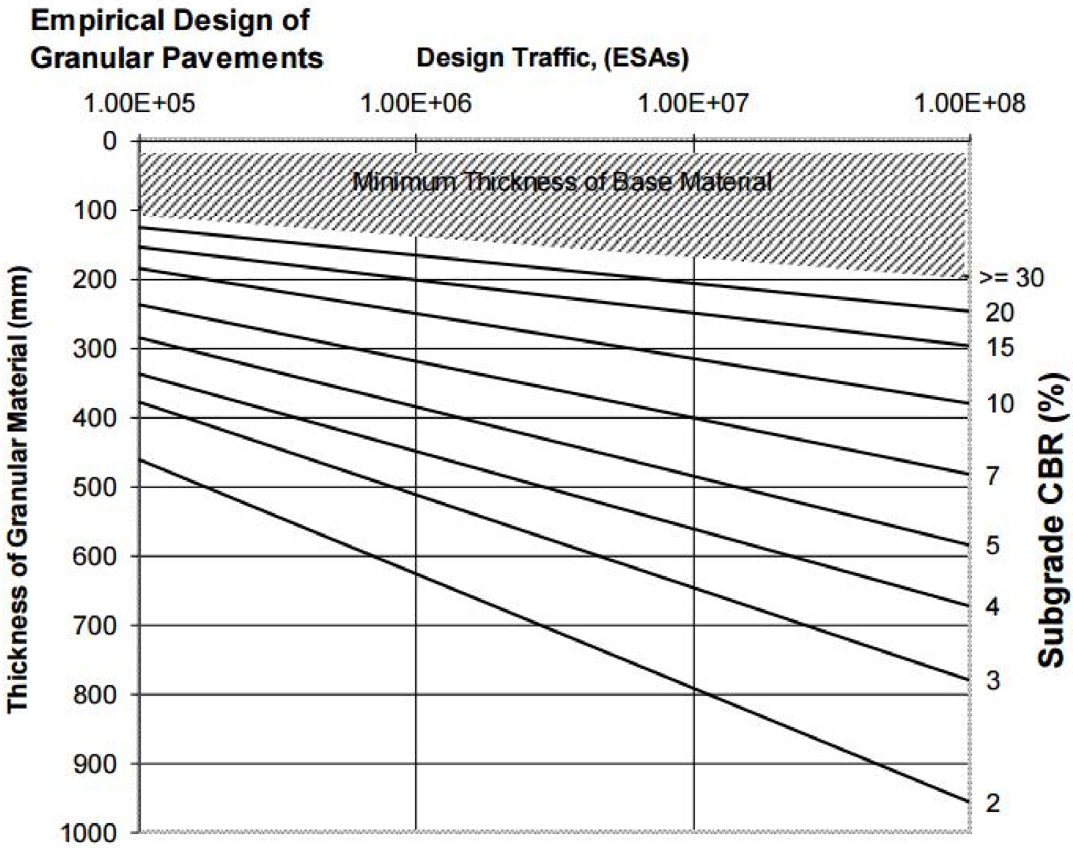
Every different heavy vehicle class will have different axle group and standard load. The values of total ESA from each axle of heavy vehicles are determined by using formula shown below.

$$ESA\ (non\ standard\ axel)\ = (\frac{NSA\ load}{SA\ load})\hat{}4$$

Then it is also crucial to estimate the cumulative growth factor or design life of pavement. This can help for the construction project based on historical data and also consider the effect of the future land development. Therefore using the formula below the design life of the pavement can be determined.

$$CGF = \frac{(1 + 0.01R)^P - 1}{0.01R}$$

The subgrades then can be assessed either by California Bearing Ratio (CBR) or resilient modulus. However, CBR method is widely used to determine the saturation of the soil at the site. The information of the soil at Oakland Park was retrieved from the Dynamic Cone Penetration test which related with CBR test. In SA, subgrades under many roads are likely to be unsaturated however due to local environmental factors may cause saturation in some cases. By using CBR method the information gathered are limited because of the assumption that stresses are highest in the upper zone and base and sub-base material layer performances are not taken into account. Then, by using the values of ESA and percentage of subgrade CBR the minimum thickness of the base materials and subgrade granular materials can be estimated.



In the case of selecting for bituminous road surfacing, there are four types of surfacing types which are sprayed treatment, asphalt, bituminous slurry surfacing, and concrete. However, for Oakland Park project, the suitable bitumen used is class 320 (Asphalt) because it has higher viscosity and suitable for high traffic and metropolitan roads and freeways.

Over time there will be defect occur on the pavement. The common design of lifetime for pavement is 30 years. However, sometimes it will need maintenance earlier than expected due to high traffic. Common major defects that occur are structural deterioration such as rutting or fatigue cracking and surface deterioration. However, these problems can be mitigated by using an additive such as polymer modified bitumen (PMB). This additive can improve the surface rigidity, and toughness to withstand deformation.

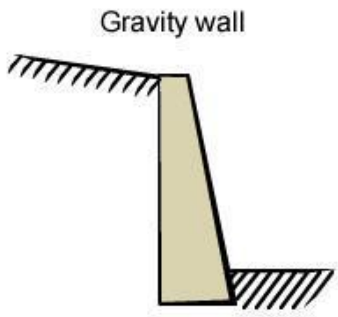
4.2.5 Embankment and Retaining Wall

4.2.5.1 Retaining Wall

Retaining wall is built in the slope, to reinforce the soil or rock slope. It is a relatively rigid wall is used to support the lateral soil quality, so that can keep both parties at different levels. Prevent landslides, prevent clod and rock fall, in order to protect the pedestrians and safety of nearby buildings, also can prevent water and soil erosion. For option 1 (rail overpass) and option 2 (road overpass), they both need retaining wall for embankment.

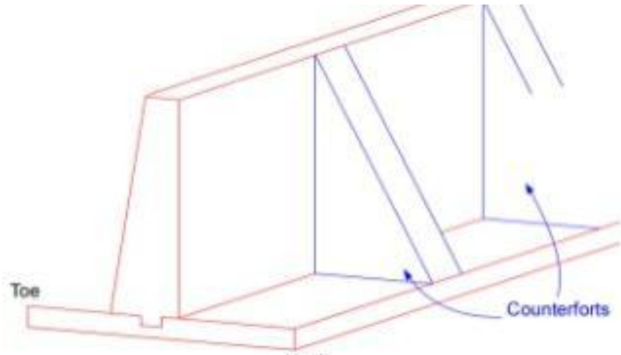
4.2.5.1.1 Type of retaining wall

4.2.5.1.1.1 Gravity retaining wall



Gravity retaining wall rely on upon their own weight and any soil resting on the concrete in resisting lateral earth forces. It depend on their mass which are includes stone, concrete or other materials to resist pressure from behind and may have a 'batter' setback to enhance dependability by reclining toward the held soil. For short walls, they are frequently made by mortar less stone or segmental solid units. Dry stacking gravity wall is somewhat soft and does not require a rigid foundation. The gravity retaining wall remains the earth structure entirely by no adding of reinforcement where it is better to use under 3.048 meters height. There are many types of material it will apply to construct such as stone, masonry or plain concrete which depending on the weight and soil that it will be holding on.

4.2.5.1.1.2 Cantilever retaining wall



Counterfort retaining wall

The cantilever retaining wall is made of internal bars of steel, cast-in-place concrete or mortar masonry (usually inverted T-shaped). The walls of the cantilever load to a large structural footing, the horizontal pressure from the back of the wall into the vertical pressure of the ground below. Sometimes the cantilever wall are supported on the back side which mean it is counterfort retaining wall or buttressed on the front side, to improve the strength against high loads. This type of wall is much less material than traditional gravity walls. With reinforced concrete structure, cantilever retaining wall is combining of footing of base slab to hold the vertical arm that this weight in position with the wall weight have been given a pressure on the top of heel also acting the crucial role on structure stability. Usually, backfill is position on the heel and toe is placed on the opposite side. The height of the vertical cantilever is commonly using in a range of 3.048 metres to 6.096 metres since the slope of the wall would be more rapidly with the increasing height.

4.2.5.1.1.3 Counterfort retaining wall

The structure of counterfort retaining wall consists of connecting the stem and base slab together by counterforts which this support increases the interior tension force and embrace the strength that mains reducing failure phenomenon. This thin vertical supports has regular interval in between along the heel side and brings refortify lateral load. The height for economical usage of counterfort wall is above 7.62m.

4.2.5.1.1.4 Gabion Gravity Wall Design

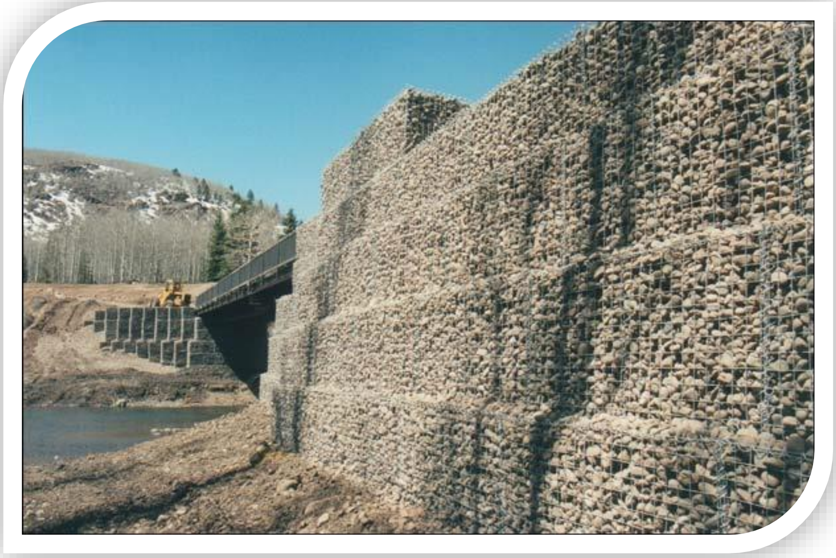


Figure 38 - Gabion Gravity retaining wall

4.2.5.1.1.5

Gabion Walls are generally analysed as gravity retaining walls, that is, walls which use their own weight to resist the lateral earth pressures. Gabion Walls are generally analysed as gravity retaining walls, that is, walls which use their own weight to resist the lateral earth pressures. Gabion blocks are simply stacked on top of each other. The water is easily discharged from the backfill through a large area of space. Ground fabrics usually need to be placed between the walls and the soil to prevent fines from being removed from the soil. Recommended for riverbank because it has anti-flowing water and consumes energy.

4.2.5.1.1.6 Concrete crib wall

Figure 39 - Concrete Crib Wall

Concrete crib wall is belong to gravity retaining wall which usually constructed from component of concrete, interlocking and precast. Concrete crib wall can be inexpensive erected, since it is ease to construction, there is no require for skilled labour and easily to be set up the component using handled by two people. By using the draining material for open web structure will reduce the cause of failure, one is failing by hydrostatic pressure of water coming from the soil to affect the sliding and another is failing by destructive pressure of tree root system growing to damage the structure of retaining wall. With high quality precast concrete structure, retaining wall will stay for a long-term as well as advoiding from rot or warp.

Mainly, crib wall is designed for minimizing the budget and no future maintenance cost since it requires ease to build with fast speed. Also, with the standard concrete, high quality and stable material allow for various wall height under considering in economical solution. Nowadays, with environmental-friendly aspect, plant, flowers, shrubs or creepers can be planted on the face side of the wall which allow the plant to tighten up the soil and enhance the wall steadier. Moreover, concrete crib is extremely flexible to construct in different geographic location such as gentle curves, slopes, laid around corner and area of undulating terrain. Furthermore, the capacity of re-erect component is easily to be form temporary or permanent structure as it required, however, it might be affect due to weather conditions or other factors. This our project, the section of the wall is selected to be a certain height which means the permanent connection between component is applied for it. As the concrete crib wall is using the strategy of using system of four header sizes, a large scale of wall height up can be catered up to 20 metres. The operation and performance for the gravity retaining wall component have been tested by Queensland University of Technology where a full report stated the available for requirement.

4.2.5.1.1.7 Mechanically stabilised Earth (MSE) wall

Figure 40 - Mechanically stabilised Earth Wall (MSE)

The geometric pattern of mechanically stabilized earth wall always appear in a large interlocking block, also it can hold a large quantities of earth from sliding. The common MSE wall is made up by compacted granular backfill with 30 to 45 degrees of sild angle. What's more, the common material using for mechanical reinforcement can be metal (ribbed steel bars, bar mats, welded wire mesh, woven wire mesh) or geosynthetic fabric in shape of linear, grids, mats or continuous sheets.

Table 7 - Comparing four types of retaining wall

Category of retaining wall	Material
Mechanically reinforced earth	Called 'gravity' wall
Gravity	Reinforced earth, concrete, masonry
Cantilever	Concrete, sheet-pile

Anchored	Sheet-pile, certain configuration for reinforced earth.

4.2.5.1.2 Summary Table

The table below shows a summary of all three types of retaining walls.

Table 8 - Retaining Wall Summary

	Pros	cons	Adopt
Concrete crib wall	➢ Ease of construction ➢ Safety, stability, strength. ➢ Low cost ➢ Aesthetics-plant ➢ Adaptability ➢ Height up to 20m	➢ Unless concrete is roughened, base friction performance is not better than gabions. ➢ Need more space for both side. ➢ Not allow to use in passive soil.	➢ Driveways ➢ Building site ➢ Garden areas
Mechanically stabilized Earth (MSE) wall	➢ Flexible, economical, durable ➢ Withstand different settlement without any structure distress ➢ Ease of construction	➢ Limited for connecting to all type of soil	➢ Highway embankment ➢ Bridge abutment ➢ Seawall ➢ dike
Gabion gravity wall	➢ Easy to transport to sites ➢ Easy to unload and place ➢ Easy to drainage	➢ More expensive to install ➢ Need time to maintenance ➢ Unsightly	➢ Pond ➢ Beach

4.2.5.1.3 Retaining wall costing

Rail Overpass diagram

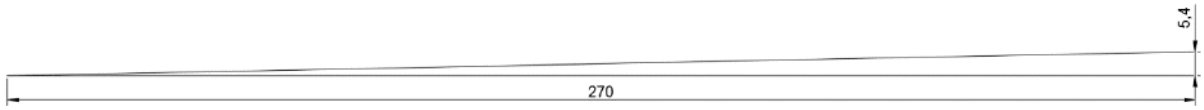


Figure 41 - right side of the rail overpass bridge

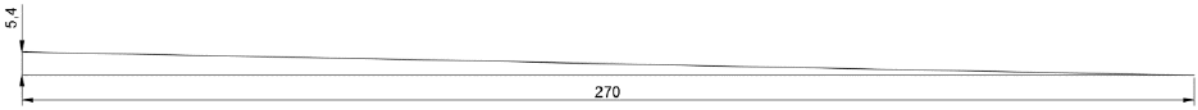


Figure 42 - left side of the rail overpass bridge

Road Overpass diagram

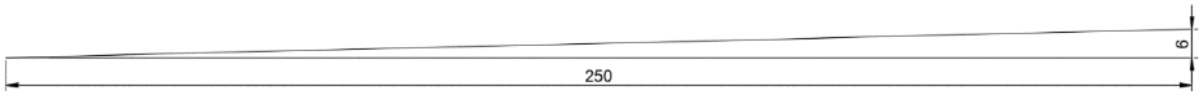


Figure 43 - right side of the road overpass bridge

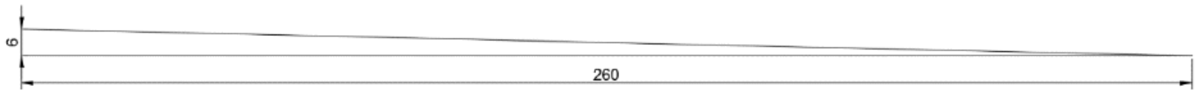


Figure 44 - left side of the road overpass bridge

Table 9 - Embankment Costing Entirety

Rail Overpass (Both side)			
Length distance(m)	Height(m)	Area (m^2)	Total Cost including Labour (per m^2)
270	5.4	1458	$400.00
Sub Total Cost (Both side)			**$1,166,400.00**

Table 10 - Embankment Costing Breakdown

Road Overpass (Left side)			
Length distance(m)	Height(m)	Area (m^2)	Total Cost including Labour (per m^2)
250	6.00	1500	$400.00
Cost (Left side)			$600,000
Road Overpass (Right side)			
Length distance(m)	Height(m)	Area (m^2)	Total Cost including Labour (per m^2)
260	6.00	1560	$400.00

Cost (Right side)	$624,000.00
Sub Total Cost	**$1,224,000.00**

The costing is done based on Rawlinson Australian Construction Handbook (2007). From the handbook, we know that the cost of the reinforced concrete block is around 400$ per m^2.

4.2.5.1.4 Recommendation

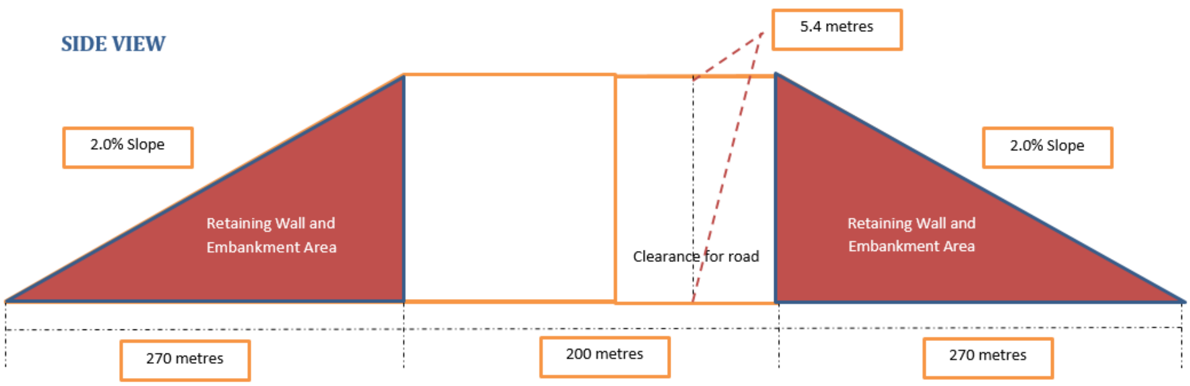
As mentioned above, the following recommendation have been compared all the advantages for selecting the most convenience choice to adopt in term of considering the cost, ease of construction, pre-knowledge of labour and difficulty of operation. Since the height of rail overpass and road overpass are quite close (separately 5.4m and 6m), we recommend that using the type of gravity retaining wall with reinforce concrete blocks wall is chosen. In term of transportation, carrying capacity of the bridge, suitability of soil with concrete wall, the 90 degrees vertical of retaining wall brings more space for both side to plant or other usage.

Therefore, gravity retaining wall will be feasible for both option 1 and option 2 which are rail overpass and road overpass. By comparing the material cost of retaining wall, we can say that rail overpass is cheaper than road overpass.

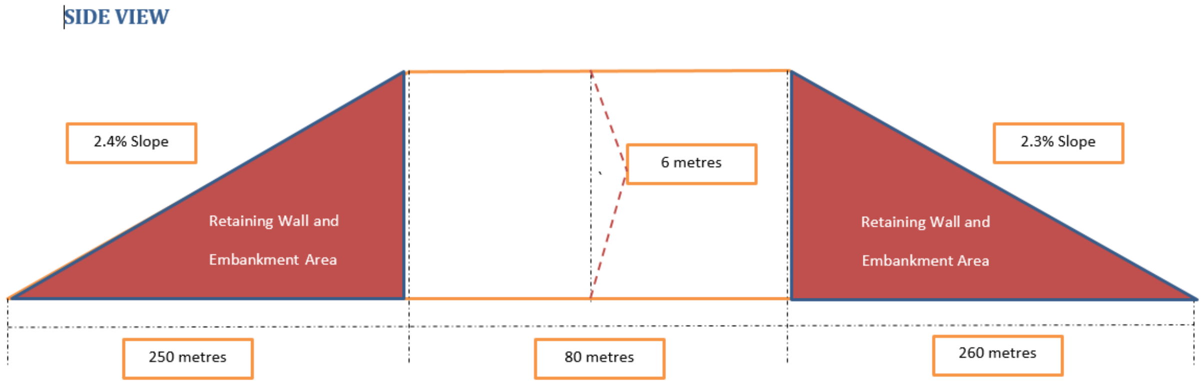
4.2.5.2 Embankment

After several meetings with Transport department, they come out with rail overpass design and road overpass which are as shown in the figures below. Due to the limited space at the site location, retaining walls are be constructed to retain an earth embankment of up to 6m. We will assume all the areas under the slope need retaining wall and embankment. The middle part will be supported by columns.

Gravel and would be the main material used for the embankment. The top few layers of the embankment will be filled up by grained sand to fill in all voids on top and sides of the embankment. Once embankment is done, compaction process will be carried out with heavy compaction equipment such as steel roller, sheepsfoot roller or pneumatic roller.



Rail overpass design



Road overpass design

4.2.6 Foundation

Foundation design is the most crucial design of every structure. It is used to transfer the load of the building to the ground. The stable and strong foundation should be able to withstand the load for long period of time. Foundations are generally considered into two types which are the shallow and deep foundation. Before choosing the suitable foundation for the structure there are few factors that should be considered, for example, types of soils, load from the building and types of structure in the neighborhood. The different between these two types of foundation are their width and footing depth. For deep foundation, the depth is normally bigger than the width of the footing and shallow foundation the width of the footing is bigger than the depth.

4.2.6.1 Shallow Foundation

The shallow foundation has many types of footing some of them are spread, combined, strap and mat footing. The foundations are generally embedded about a meter into the soil. Shallow foundation normally will be used when the soil has sufficient bearing capacity to sustain the load from the structures. The depth of the foundations are normally can be determined by the amount of the load from the building. Before deciding the foundation the soil assessment needs to be done to know the nature of the soil, depth of water table and types of the soil. In term of the ranking of suitable soil for the foundation, sand and gravel soil are the best and silt and soft clay is the poor soils. Soil that has higher plasticity index and cohesiveness has greater potential for shrinkage and swelling.

In this project, we also need to consider for the expansive soil. The expansion and shrinkage of the soil can cause the structure to crack and reduce the support of the structure. Therefore the construction of any structure on the expansive soil should be avoided and clay soils are usually susceptible to the expansive soil.

4.2.6.2 Deep Foundation

In this project, we have decided to choose a deep foundation to build the flyover for the rail and road overpass. This is because we consider the high load from the vehicles that will pass through this road especially during the peak hours. A deep foundation is usually used when bearing capacity of the soil does not able to withstand the load from the building. Some of the examples of the deep foundation are pile, caissons a, cylinders and shaft foundation. After comparing all these foundations, pile foundation system will be used for the overpass option of this project. It will be able to support high compression load of the structure by transfer the load to a deeper depth.

4.2.6.2.1 Type of Piles Design

4.2.6.3 Continuous Flight Auger (CFA) Piling

This piling is a non-displacement piling system which produce less noise and it is very fast and economical (2017). CFA piling is a cast in-situ process which is suited for soft ground where deep casing or use of drilling support fluids might otherwise be needed. CFA piles can be installed faster than conventional bored piles and produce less noise and vibration if compared to driven piles.

To construct flight auger piling, a full length auger with a hollow stem is drilled into the soil using a constant penetration rate. The pile locations are decided by the structural department. After the auger reach the toe level, concrete is pumped through the hollow stem of the auger while the auger is extracted. During the process, the auger must always remain embedded into the concrete. To facilitate reinforcement installation and avoid pile necking, CFA have to be poured to platform level. The reinforcement cage is then plunged into the fluid concrete after the concrete placement process.

The advantages of CFA piling including:

- The auger can be drilled into the soil up to 32m
- Able to carry high load, shear and moment capacity
- Produce less noise and vibration
- Can be installed very fast if compared to other method
- Can overcome interbedded clays and sands
- Able to deal with water bearing sands and gravels and penetrate weak rocks

Figure 45 - CFA Piling Procedure - Augering

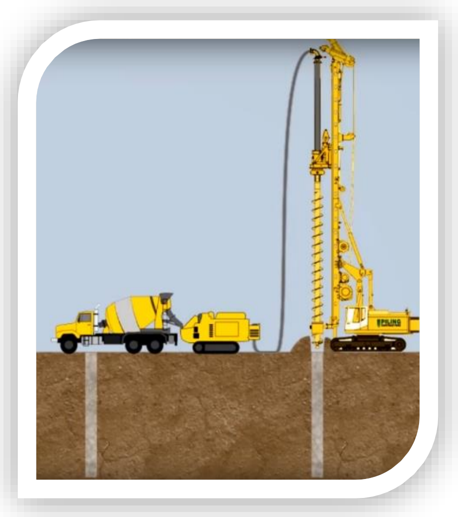


Figure 46 - CFA Piling Procedure Concrete Pumping/extraction

4.2.6.4 Driven Piles

Driven Piles are relatively long and slender column. They can be installed by impact hammering, vibrating or pushing into the earth to a design depth or resistance. Pre-drilling process might be necessary for the pile to reach the design depth if the soil is very dense.

There are a variety of driven pile types available. They usually come in 350mm or 450mm wide square pre-cast concrete piles or steel tube piles. To carry the anticipated loads, more than one pre-cast concrete piles are tied together at the surface with a pile cap. The ultimate axial capacity of individual pre-cast concrete piles is governed by their structural capacity. For pile size 350mm or 450mm, the structural capacity is about 1,400 to 1,700 kN. To accommodate both vertical and lateral loads, a detail analysis is required to design the pile layout. On the other hand, steel tube pile with 1m diameter could also be driven to rock. Steel tube piles are able to carry bigger axial loads if compared to individual pre-cast piles. As a result, less piles would be needed.

Driving piles can be advantageous if compared to other piles because a greater friction against the sides of the piles is produced during the pushing process and this will increase their load-bearing capacity. Other than that, there is no cost of spoil disposal incurred as driving pile method displaces the soil rather than removes it. However, driven piles will produce very loud noise to the surrounding areas which might affect the residents around the site location.

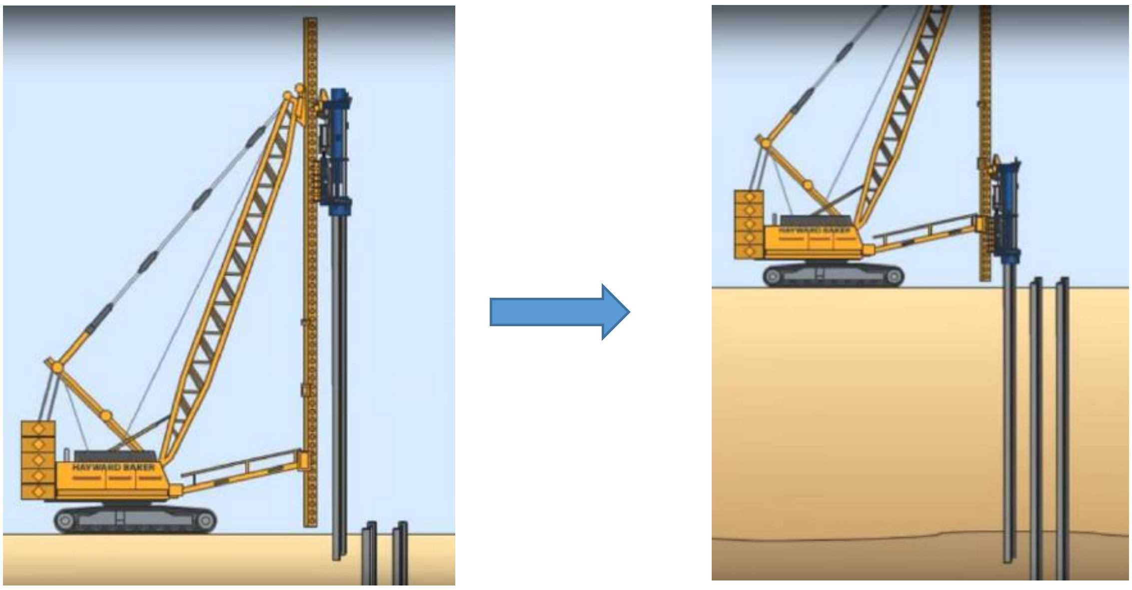


Figure 47 - Pile Driving - H-Piles

The figures above show the drilling process of a steel H-piles into the soil.

4.2.6.5 Bored Pile

Bored pile is basically another type of reinforced concrete pile. It can be used to support high building or bridge which produce heavy vertical loads. Bored Pile is a cast-in-place concrete pile. It has to be cast on the construction side unlike spun pile or reinforced concrete square pile which are precast concrete piles.

Drilled shafts are cast by using bored piling machine to remove the soil and rock. It can usually be used to drill into 50 meters depth of soil. The main advantage of using bored pile is bored piling produce less vibration and noise if compared to traditional piling systems.

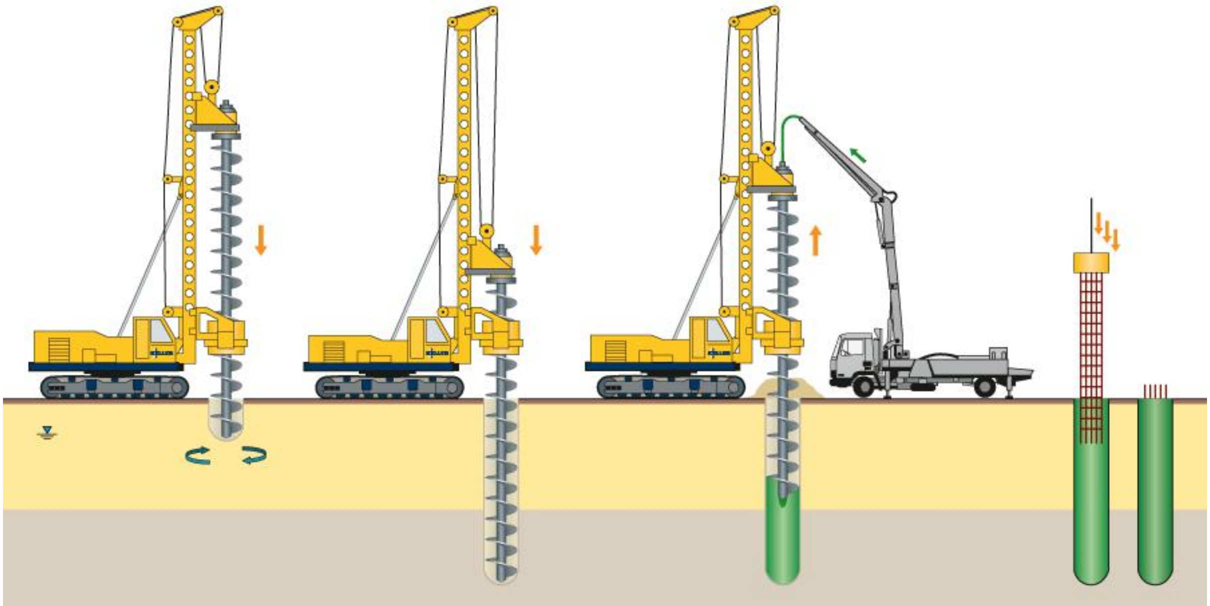


Figure 48 - Process of bored piling

4.2.6.5.1 Summary of Piles

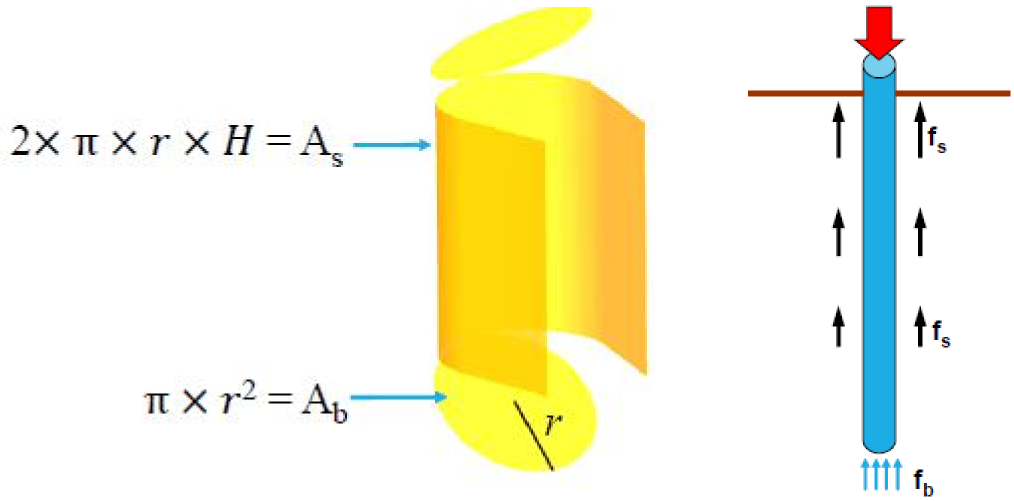
Pile Type	Comment
Driven Piles	➢ Driven piles could reduce the generation of cuttings. It could be installed in a short period of time. Due to the limited space on site, driven pile is feasible because it can be fabricated off-site which could reduce the construction plant and working areas required. ➢ We have to consider the environmental impact of using driven piles. The high level of noise and vibrations might affect the residents nearby. ➢ Dense/very stiff-hard layers with high gravel contents might prevent the piles being driven to target depths. According to the soil profile of section 2, the soil between 12 to 23m is very stiff-hard. Pre-boring of piles could be used as a solution but it would increase the time and cost of construction
Continuous Flight Auger (CFA) Piling	➢ CFA piles may be favoured and feasible in this project. This is because the installation speed is relative fast. Other than that, CFA piles produce less noise and vibration effects which is very important because the site is surrounded by residential area. ➢ CFA piles are usually suited to the ground conditions encountered on site. However, further site investigation should be carried out so that we could assess the likelihood of granular layers present which might cause 'draw-in'. ➢ Might cost higher as CFA piles are not commonly used in South Australia.
Bored Piles	➢ Minimise large excavations and subsequent backfill ➢ Bored piling required disposal of soil cutting from boring. ➢ Bored piling need temporary or permanent casing, or bentonite slurry so that the bore against collapse and 'necking' can be supported.

4.2.6.5.2 Size and Number of Piles

4.2.6.6 Road overpass

The design calculation for piles is obtained from the lecture slide given by Dr. Rajibul. From Structural department, we know the combination road of the road overpass is 14132.4 kN. To support the structure, the ultimate axial capacity must greater than the combination load. The ultimate geotechnical capacity formula is as shown below:

$$R_u = f_s A_s + f_b A_b$$



650mm diameter of piles with depth of 20m is assumed to be used as the deep foundation.

Diameter of pile = 0.65m
Height of the pile = 20m

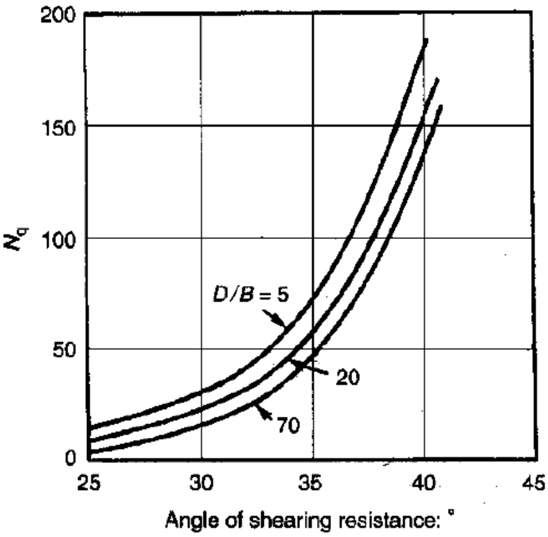
$$A_s = 2 * \pi * \frac{0.65}{2} * 20 = 40.8\ m^2$$

$$A_b = \pi * \left(\frac{0.65}{2}\right)^2 = 0.3m^2$$

$f_b = N_q * \sigma_{v0}$

N_q can be found based on the relationship between N_q and $\emptyset'$, after Berezantsev (1961)

The angle of shearing resistance of the soil is around 35 degrees. Therefore, the Nq is found to be 30.



The effective stress is found by the following equation

$\sigma_{v'} = \sigma_v - \sigma_w$

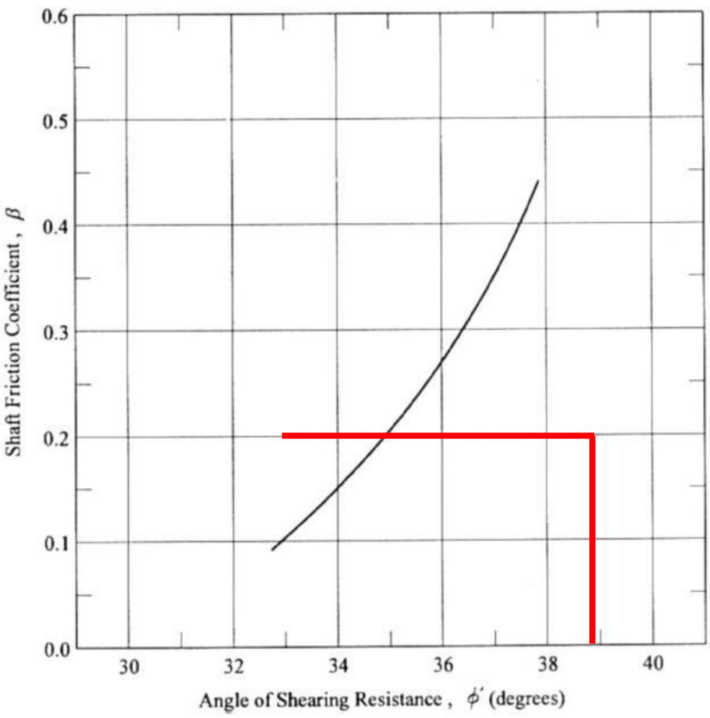
The water table is about 12m under the ground level. The unit weight of soil is assumed to be 20 kN/m^3 . Therefore,

$$\sigma_{v'} = 20kN/m^3 * 20m - 9.81kN/m^3 * 8m = 321.6\ kN/m^2$$

$$f_b = 60 * 321.6 = 19296\ kN/m^2$$

$$f_s = \beta * \sigma_{v0}$$

β can be determine from the figure below:



$$f_s = 0.2 * \left(\frac{20kN}{m^3} * 10m\right) = 40kN/m^2$$

$$R_u = 40kN/m^2 * 40.8m^2 + 19296kN/m^2 * 0.3m^2 = 7421\ kN$$

$$3\ piles = 3 * 7421 = 22263kN > 14132.4kN$$

When a group of piles are connected with pile cap, the ultimate geotechnical capacity might be reduced. This will be discussed further in the detail design. Therefore, at least 3 piles with diameter 650mm and 20m depth must be used to support the structure with combination load up to 14132.4 kN. Based on the design from the structural team, 4 columns will be used. Therefore, there will be at least 12 piles used for the construction of road overpass.

4.2.6.7 Rail Overpass

For the rail overpass, the combination load will be 5538.4 kN.

The same pile with 0.65 diameter and 20m depth can also be used for rail overpass. In this case, only single pile is required under each column as the ultimate geotechnical capacity of one pile is 7421 kN which is greater than the combination load. According to the design of the structural team, there will be 14 columns. Therefore, at least 14 piles will be used in the rail overpass design.

Table 11 - Summary table of size and number of piles

Option	Dimension of Piles	Number of Piles
Road Overpass	Diameter: 0.65m Depth: 20m	12
Rail Overpass	Diameter: 0.65m Depth: 20m	14

4.2.6.7.1 Costing

Table 12 - Piling Costing

Option	Item	Unit Cost	Unit	Amount	Cost ($)
Road Over Pass	Mobilization Cost of Drill Rig	145000	Per CFA machine	1	145000
	Mechanics and Labour Cost	6580	Per Pile	12	78960
	Total:				223960
Rail Over Pass	Mobilization Cost of Drill Rig	145000	Per CFA machine	1	145000
	Mechanics and Labour Cost	6580	Per Pile	14	92120
	Total:				237120

According to Rawlinson Australian Construction Handbook (2017), the price for the pile will be 329$ per m. The total depth for each pile is 20m. Therefore, the unit cost per pile will be 6580$.

4.2.6.7.2 Recommendation

According to the geotechnical aspect, the best deep foundation in this feasibility study is continuous flight auger piles. CFA piles are used commonly as foundation piles for bridges. Based on the soil profile of section 2, very stiff-hard sandy clay is found between 12-23m which might stop the drilling process. To mitigate this issue, CFA piles are suitable for penetration and removal of underground obstruction. In addition, water table is found about 12m below the ground level. CFA piles are also suitable for installation below the ground water table. They also works well in the non-homogenous soil.

By comparing rail overpass and road overpass, the cost of piles construction for road overpass is cheaper than rail overpass.

4.2.7 Final Costings

Final costing is shown in table below is based on various geotechnical work for two different options which is road overpass and road overpass. Costing of each and every aspect includes the labour cost in total.

Options	Type of work	Number and area of work	Unit	Cost per unit ($)	Total cost($)
Railway overpass	Piles	12	Per pile	6580	237,120
	Mobilisation cost for drill rig	1	Per CFA machine	145,000	145,000
	Retaining wall	1458	Square meter	400	1,166,400
	Railway track laying	740	Per meter	300	222,000
	Total Cost				1,770,520
Road overpass	Piles	14	Per pile	6580	223,960
	Mobilisation cost for drill rig	1	Per CFA machine	145,000	145,000
	Retaining wall	3060	Square meter	400	1,224,000
	Road pavement	1266	Per ton	175	243,734
	Total Cost				1,836,694

4.2.8 Final Recommendation

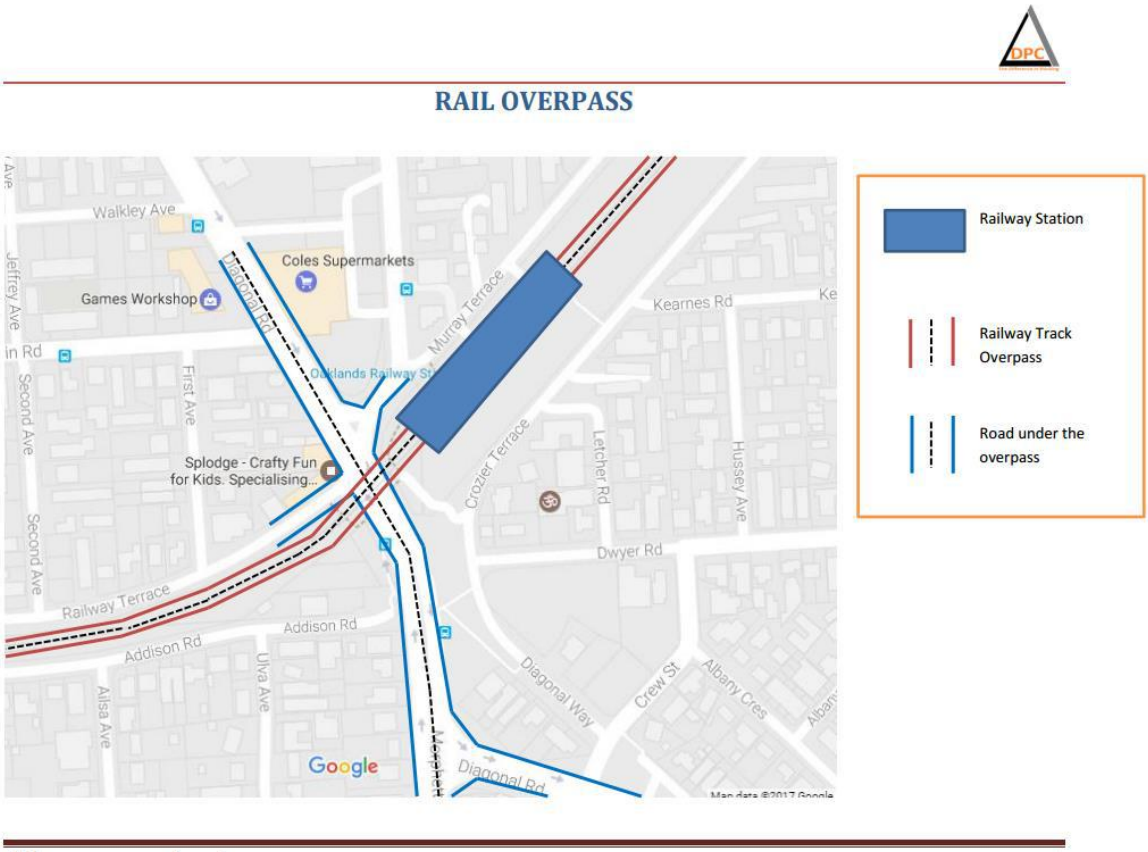
As per the geotechnical study the team would like to recommend the option 1 which is railway overpass over the option 2. In comparison to the total cost of geotechnical engineering work of option 1 is less than that of option 2 as calculated in the costing table. Option 1 is $66,174 cheaper than option 2. On the other hand ease of construction is more in railway overpass project than the road overpass according to the different geotechnical aspects. Moreover the bore log data provided by the course homepage is along the railway line, so according to the geotechnical team it is easier to work along the railway track because of better knowledge to soil properties. Construction processes in Road overpass is more complicated and time consuming in road overpass than that of rail overpass.

Therefore, railway overpass (Option 1) is more feasible than road overpass (Option 2).

4.3 Services

4.3.1.1 Option 1 Rail Overpass

After the initial stages the two of the options has been identified from the original 4 options as deliverable and potential options to surmount congestion problems in the project area. One of the options the Rail overpass with Diagonal Road at grade, as shown in the sketch below.



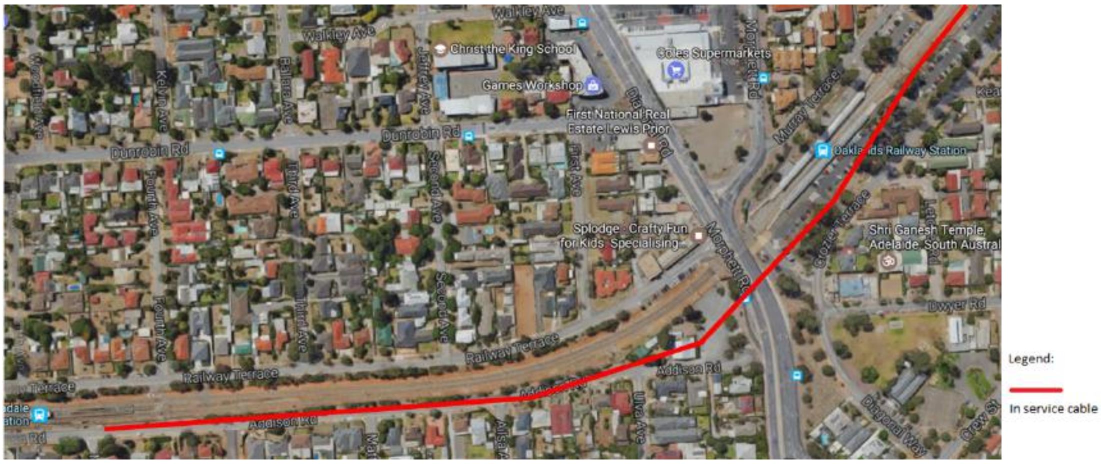
From the point of service department, a wide range of services has been identified and will be marked in the map below to give the idea for our clients that how much the disturbances will be caused under this option.

The affected services include:

- NBN: The telecommunication fibre runs along the railway line. The depths are not indicated in the DBYD files and will require survey or Autocad calculations. Cooperation with NBN is needed to work out the service depths & any approvals required to make sure that NBN services are kept running or cutovers minimised during the period of construction.

Relocation:

Since the pile location will be located at the corner of Railway Terrace and Morphett Road, it may require a possible relocation such as the one outlined below (Assuming approved land acquisition). The cost estimate (minus land acquisition): (lay approx. 450m cable @ 150$/m)+(tie over shift) = 67500 + 4000 = $71500 and will take approx. 6 weeks including cutover to lay due to traffic/rail restrictions and additional department construction sequencing.



- APA

  Gas assets are scattered throughout the construction area, one of the most critical, a transmission line, runs straight up Diagonal Road and veers north east at Railway Tce and continues straight up North. These services have various depths, and these are provided. The maximum depth of any APA service is 1 metre, indicated on the drawing as 1D, found in Murray Terrace. While the minimum depth is denoted by 0.5D (500mm below). Meanwhile the 'Work In The Vicinity Of Critical Gas Assets' request form is needed to be filled and forwarded to APA as soon as possible to notify them of potential works occurring around their assets.

Legend:
APA High pressure transimision 1500kPa

Relocation:

Since the transmission will align between the foundation piles, there will not be any relocation for this service. However, if there are strong vibrational forces employed during foundation construction, necessary protection measures will be implemented to safeguard the asset. An alternate solution (red) details the proposed solution if verification techniques such as survey indicate a clash with foundations. If this is the case, construction is predicted to take 3-4 weeks including cutover and cost: (dig crew @ 3000/day for 3 days)+(2000 materials)+(tie over shift) = 9000 + 2000 + 4000 = $15,000. This can be reduced if planned to coincide with rail track removal and acquired land.

- Nextgen

After checking with the DBYD maps, there are two cables identified in the project area. The first cable will be located in near the Morphett rd. and Milham Street, which located from 450 meters from the cross section of railway Terrace and Morphett road. The next cable lies along Johnstone road from north to south direction. Compared with the first cable the second cable may hold significance if the rail overpass down ramps extend that far to it.

After comparison and evaluation with the sketches of the proposed alignment from the transportation team and structural team, the impact for this area will be limited as the two service cables are outside the project works. However continuous consultation is required if any works are to be performed near this area and further overpass design will indicate if cable 2 (red) interferes with any works.

- Optus

  The cable for Optus to provide service is located near Milham Street, as indicated in the map below. The distance from this cable to the area of works is roughly 450 meters.

Relocation:

There are no cables running though the structure area which mean there is no relocation issue needed to consider.

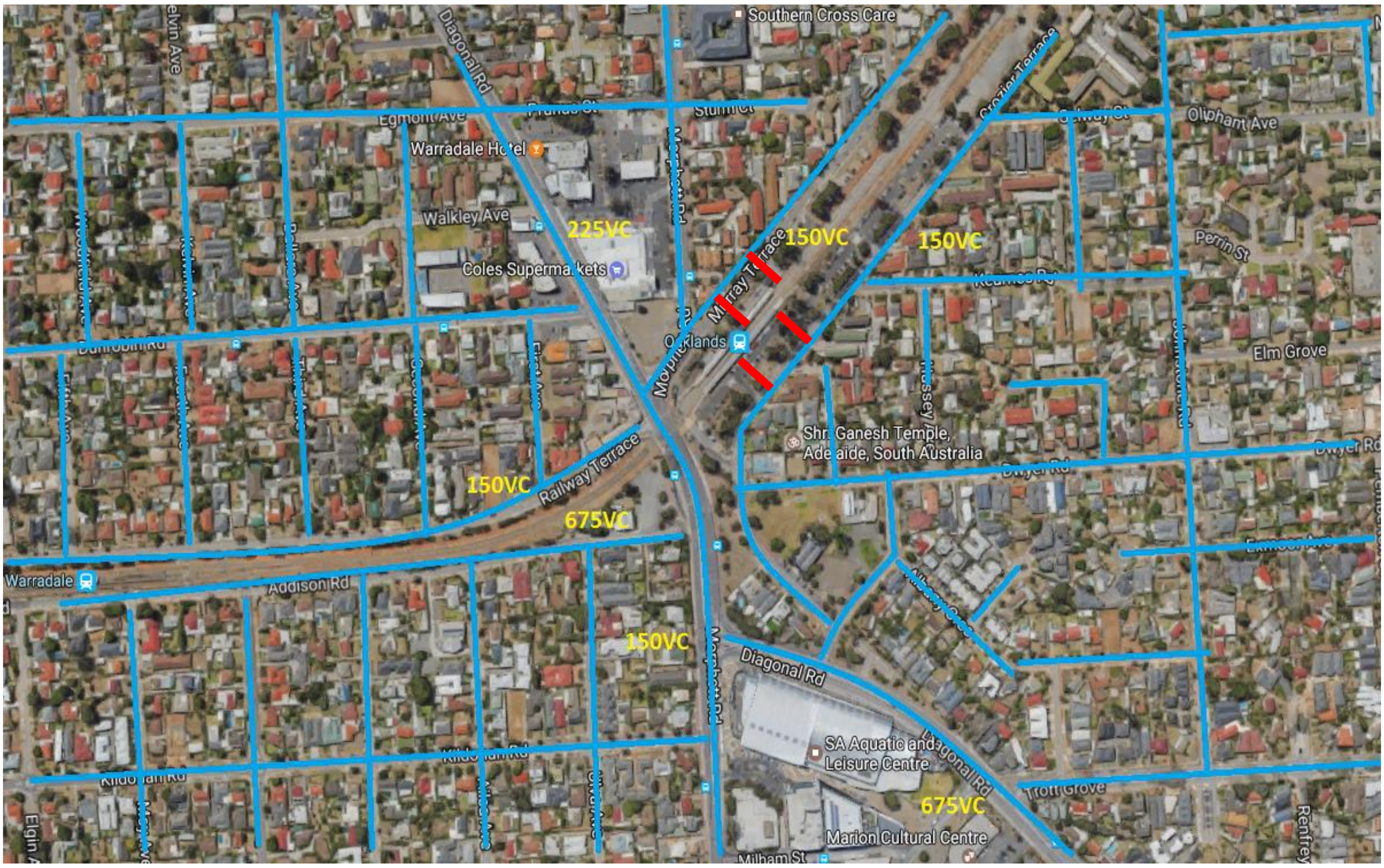
- SA water

  The wastewater network and dimensions of pipes has been sketched as below map with the assumed depth 0.5m.

Under this option, the construction work will mainly impact the residential and business areas near Murray Terrace. Consideration to final product and future design is necessary to design new property and business connections with minimal impact to public supply during construction.

Relocation:

According to the drawings from location of piles, which is taken as the area in the white square in the figure below, the foundation area will not affect the major SA water services. The 675VC pipe is outside the area of the structure, if in future design changes or survey verification it does clash, it will be moved to between the overpass foundations. The 225VC service running up diagonal road under the rail will also remain unaffected due to the overpass span. As seen in red, and in reference to the railway station service plan generated by Urban, water supply will have to be tapped off the existing 150VC pipes parallel to the rail line. These can be laid as the foundations for the platform are created and should only take 1 – 2 weeks and cost: (lay new pipe @ 100$/m for 45m)+(1000 materials) = 4500 + 1000 = $5500. However any upgrades or network redesigns based on future appearance, amenities supply and topography should be considered to add to the network.



- SAbreNet :

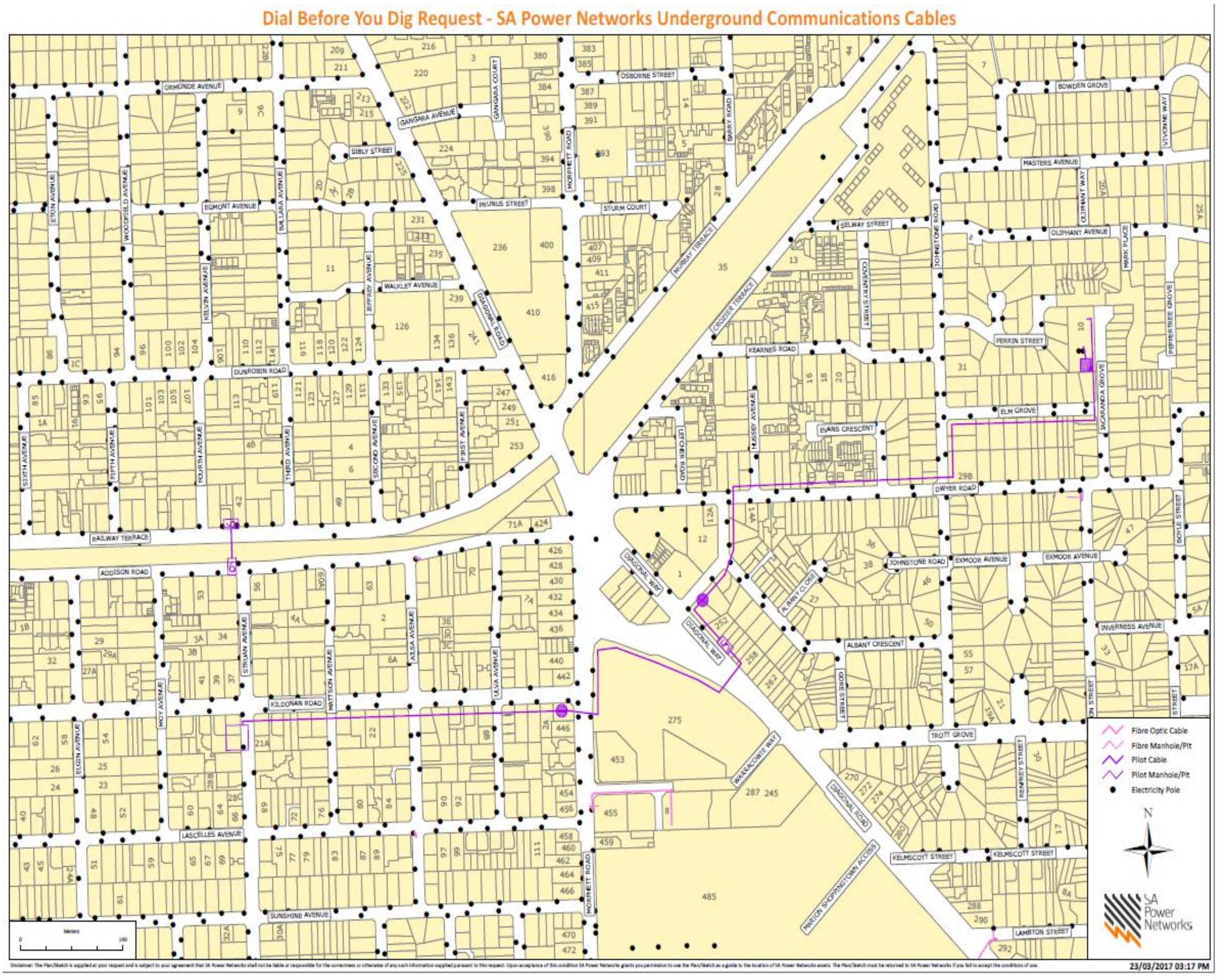
Sabre Net:

Two SabreNet pits are located near the cross section between railway Terrace and Morphett road as indicated in the map below. There are some minimum clearance and cover requirements as outlined by the asset owners, which will be illustrated in the figure below.

Relocation:

There are no cables running though the structure area which mean there is no relocation issue needed to consider.

- SAPN service

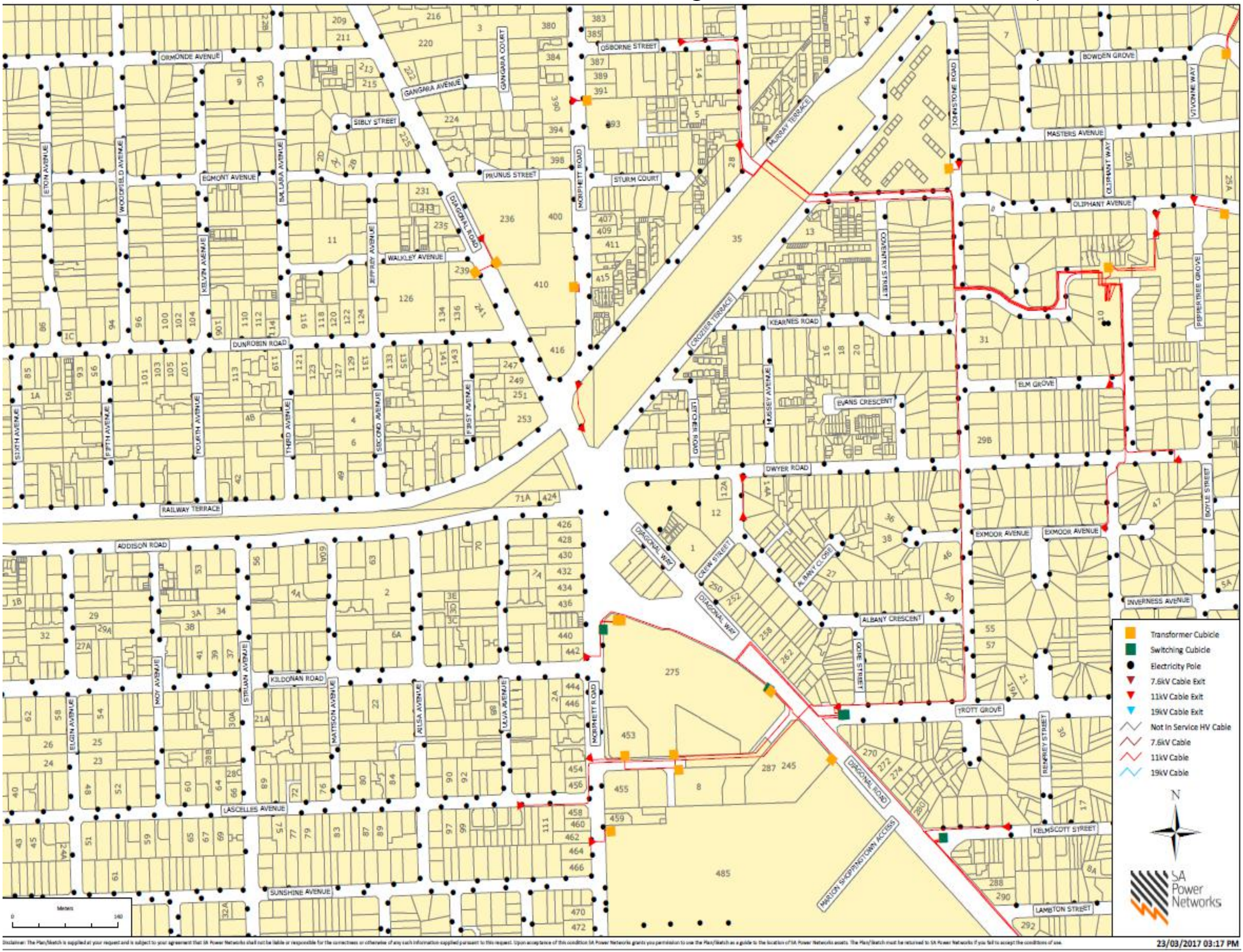


Pilot Cable: The pilot cable for SAPN is for the majority outside the scope of works. However there may be a need for relocation at Kildonan Road, where the service comes from the east heading north-west and cuts down south of Kildonan before crossing the road onwards. Greater intersection detail is required before any allocation can be made, for this purpose it has been assumed as non affected.

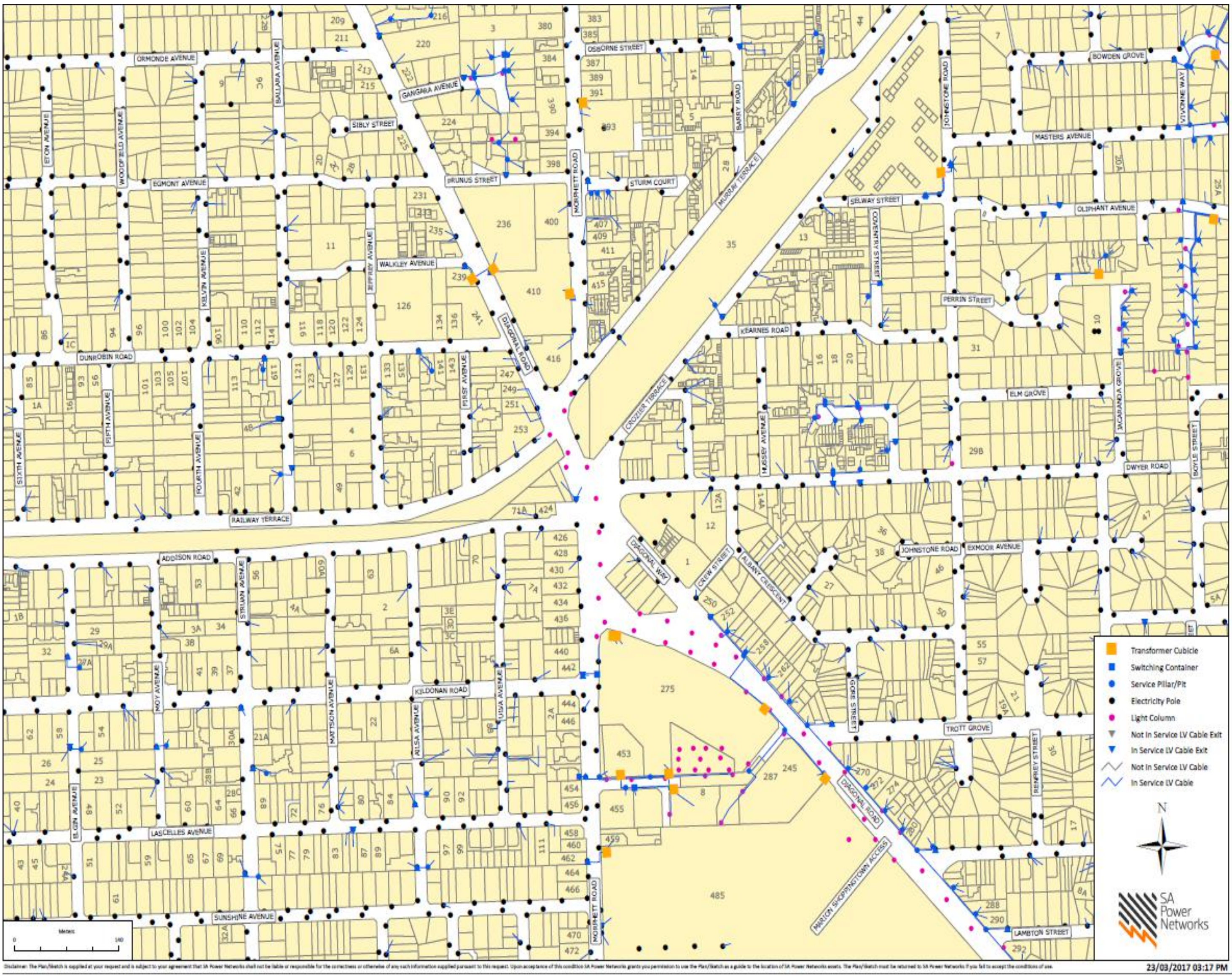
Electricity pole: numerous electricity poles run alongside of Murray Terrace and Railway Terrace from west to east direction. Two options are a) to remove all of the electricity poles and install underground conduits where all the power cables would run (i.e. street lights, new train station platform lighting + amenities as seen in Urban drawing), and b) leave the poles and remove redundant/ old poles for an improved network and reduced pole count. The removal of all the poles is more costly than a

select amount, however aesthetics are more pleasing and future works becomes easier. The average cost to remove a light pole is between 500-100 dollars, installing a new can very between 2000-4000 dollars depending on pole height/mast type etc. Costing for removal of all poles and install of conduit capable of electrical requirements for the new train platform and amenities has been estimated (7.5% contingency) at (approx. 50+ electricity poles @ 700 per pole) + (install approx. 500m conduiting @ 150$/lm)= 35000 + 75000 * 1.07.5 = $118250
To leave the network and remove a select amount of poles and replacing them with upgraded locations and pole capabilities: (approx. 10-15 poles total removed @ 700 per pole)+(connections to platform & affected residents & businesses approx. 100m @ 100$/m) = 10500 + 10000 = $20500

SA power high voltage: 11kV voltages cable lines on Morphett Rd crossing the rail line in north-south direction and 2 more conduits again further north-east. Cooperation



with SAPN is needed to generate a construction plan allowing constant power to be supplied to residents and businesses and if not possible, a temporary feed or notice of shutdown is required. Pending the function and significance of these cables, an initial budget and time allowance of 5 weeks and conduiting + labour hire =(150$/m * 150m)+(3000$/day crew * 25 days) = 22,500 + 74000 = $96,500


Transformer Cubicle
Switching Container
Service Pillar/Pit
Electricity Pole
Light Column
Not In Service LV Cable Exit
In Service LV Cable Exit
Not In Service LV Cable
In Service LV Cable
N
SA Power Networks
Meters
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Services Summary:

	Expense						
Service	***Relocations***	***Land Required***	***Planned Duration***	***Access***	***Risk***	***Allocated Budget ($)***	
NBN	1 Major	yes	7 weeks	okay	Works at road & Rail	71500	
APA	1 Major	no	4 weeks	good	Rail & cutover	15000	
Nextgen	Potential minor	no	2 weeks	okay	Rail	10000	
Optus	nil	no	-	-	-	0	
SA Water	Properties + potential 225VC	no	8 weeks	okay	Water supply loss, damage	5500	
SabreNet	No	no	2 weeks	okay	Unsure of function	0	
SAPN	Major + Minor	no	10 weeks	okay	Power loss, Asset/building damage	214750	
Total							**$316750**

4.3.1.2 Option 2 Road Overpass

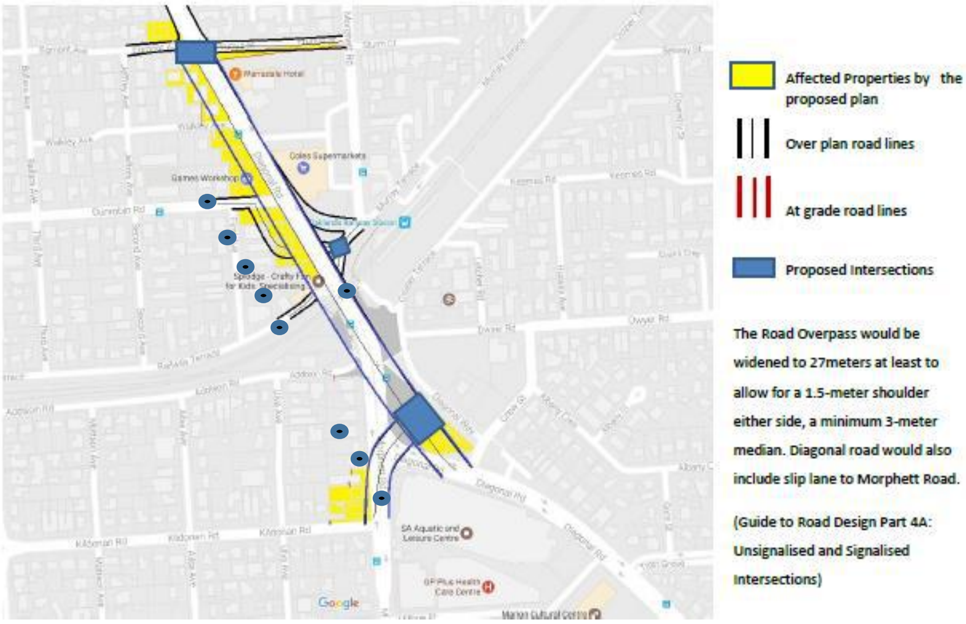


Figure 49 Project Area – Road Over Pass

Figure 1 above shows the map of Oakland parks, the area shown in the map will undergo construction for road overpass. Services in this area are to be aligned and relocated. Properties that will be affected by work are marked in yellow. Dots shown on the figure are the location of piles. All the services present along this strip will be relocated.

Services that would be affected during construction are:

- APA: APA is a network of gas lines present in South Australia.
- Optus: Telecommunication
- SabreNet: Telecommunication

4.3.1.2.1 APA

Whole map of APA services in this area, critical parts from the map has been selected and

Figure 50 APA Overview map

<u>Legend:</u>

ITEM	SYMBOL	TERMS
LOW PRESSURE 1.2 - 1.7kPa		B - BOUNDARY
MEDIUM PRESSURE 35 - 100kPa		
HIGH PRESSURE 70 - 350kPa		D - DEPTH
TRANSMISSION PRESSURE 900 - 15000kPa		Bok - Back of Kerb
PROPOSED MAIN 1.2 - 15000kPa		
ABANDONED MAIN		Fok - Front of Kerb

Scale 1:1000

Figure 51 legend

Area 1 Diagonal road

The thicker red lines marked on the diagonal road are high pressure gas lines, these lines are 0.6m deep inside the road. Each property has its own gas line and a gas meter, but these aren't shown on this map. These gas lines are located at the starting point for overpass construction works and fall in the alignment of the foundations for the overpass structure.

Relocation

Figure 52 Relocation (Red lines marked are services present and marked white line show the proposed solution for relocation)

In the figure above, the existing high pressure lines present on Prunus street (red) will have to be relocated to a proposed new curb location (white) to avoid clashes with structural design. Similarly, the high pressure line on diagonal road needs to be relocated, the pedestrian's walkway is around 2 meters wide so there is potential to relocate them as close to the property boundary within reason. These relocations are predicted to take 3-4 weeks to complete due to existing traffic restrictions.

Cost is estimated as follows: (lay approx. 140m Diagonal RD of 100diaCI @ 90$/m)+(220m of 150diaCI @ 110$/m)+(tie in shift) = 12600 + 24200 + 4000 = $40,800

Area 5 Interchange, Morphet t road, Diagonal road and Rail line

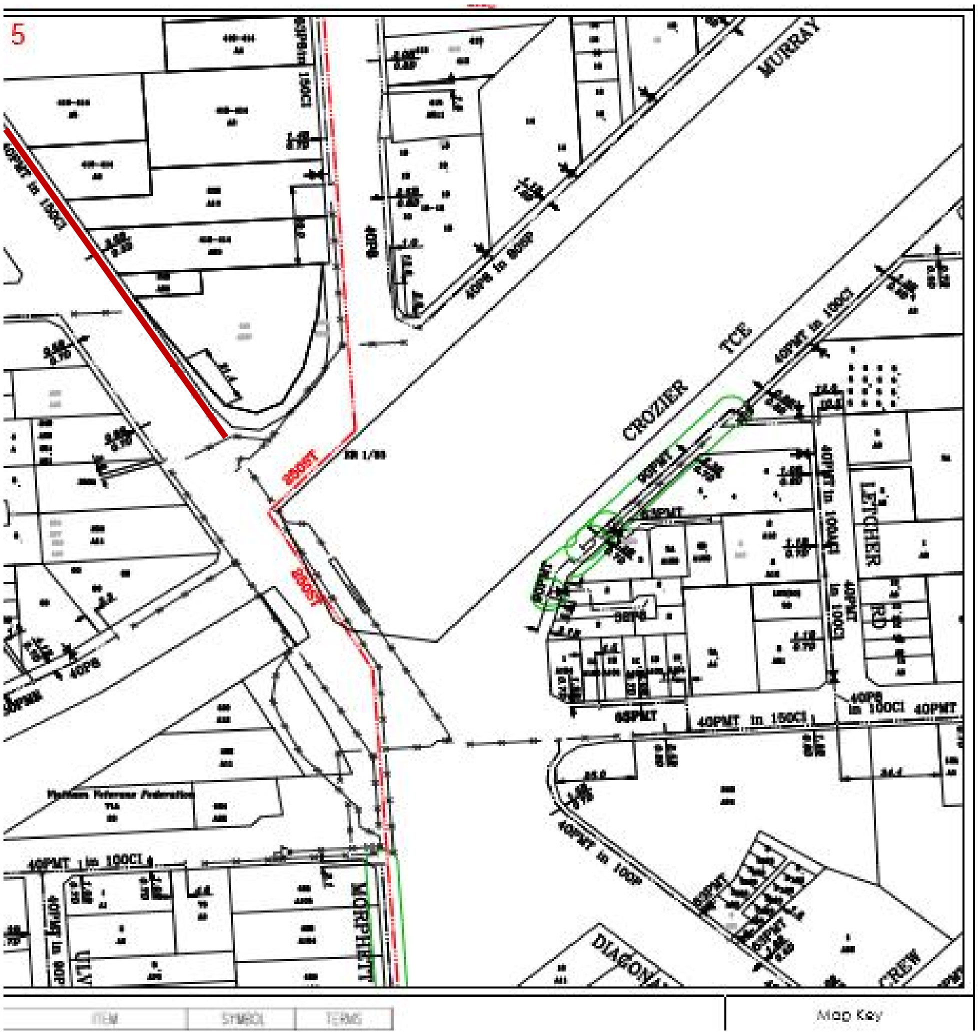


Figure 53 Intersection

The solid red line marked on the diagonal road show where the high pressure gas line is located whereas the cut red line on the intersection indicates where the transmission pressure gas lines. High pressure lines are 0.6 meter deep.

Relocation

All gas lines will be relocated on the walkway or back of curb if possible, if the condition of the high pressure line is not good then will be needed to replace. The tie in for the proposed transmission main will occur approx. 50 metres into Morphett road, cross 3-5m before the rail line and tie in to the existing network on the other side also before the rail. The two white lines indicate two options pending the future use of land left of the proposed solution. The existing high pressure main up diagonal road will have to be shifted approx. 5m right to back of curb to avoid foundation locations. This will take 4-5 weeks given rail and traffic environment. The cost of the relocation works has been estimated as (150m of Transmission 250diaST @ 140$/m)+(55m of 150CI @ 110$/m)+(tie in shift) = 21000 + 6050 + 4000 = $31,050

Area 6 Southern part of Morphett Road

Figure 54 Lower part Diagonal Road

On the lower part of Morphett Road, both pressure lines are placed, both lines are essential to be relocated. Lines in the start are 0.6m deep and moving on lines change their depth according to the elevation of the road, lines change their depth till 0.4m.

Relocation

Figure 55 Lower part of Morphet Road

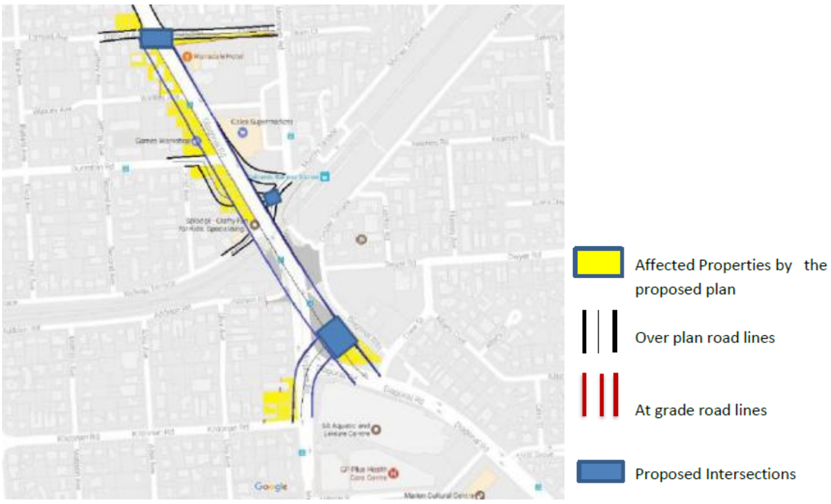
As there are planned intersection upgrades, both lines will have to be relocated on the pedestrian's walkway as indicated in figure 7. They will have to be placed as far away from roadline as possible to avoid foundations. Due to the location of the works the relocation will be progressive and most likely over nights and weekends, 4-6 weeks. Costing is as follows: (lay approx. 110m of 250diaST @ 140$/m)+(tie in and cut over shift) = 15400 + 4000 = $19,400

4.3.2 Considerations

The services team will use the same evaluation criteria as that developed during the initial red-light green-light analysis. This can be found in section 3.1.4.

4.3.3 Option 2 Diagonal Road overpass and Rail Line at Grade

From four options stipulated in the initial stage, two options are identified for final feasibility, (1) Rail overpass with Diagonal road at grade and (2) Road overpass with rail at grade. The figure below shows the alignment of Diagonal road overpass option.



The construction of a road overpass will require the planning and evaluation of existing ground conditions to see what services are most affected. These services will be identified below and detail any relocation or possible temporary feed as necessary. This will provide clear information to the client and highlight the significance and justification of this option. The pile locations are to be taken as per the structures teams evaulations and direction.

4.3.4 Affected services

4.3.4.1 NBN Services:

The National Broadband Network is a telecommunication fibre service which is running along the rail line, shown in the figure below. The yellow circle indicates the extent of the disturbance to the service. It is encased in an in-service cable conduit in the information as provided by the Dial Before You Dig (DBYD), but there is no any additional information provided, such as width and depth of the service. Consultation is required to obtain this information and discuss potential relocation concerns or requirements with the asset owner. In regards to the level of complexity, the NBN relocation is not that complex however the surrounding conditions make it difficult to access freely with machinery and still maintain traffic flow. To construct a proposed solution as denoted in white in the figure below, detailed consultation is required with structures to confirm the locations of the overpass foundations and align the NBN cable at a safe distance away. It is approximated the proposed solution would cost: (lay 55m of fibre cable @ 150$/m)+(tie in shift) = 8250 + 3000 = $11,250 and take 2 weeks pending traffic requirements.

Description	Length	Cost per meter	Total cost
NBN line	55.5 m	$400	$22,200

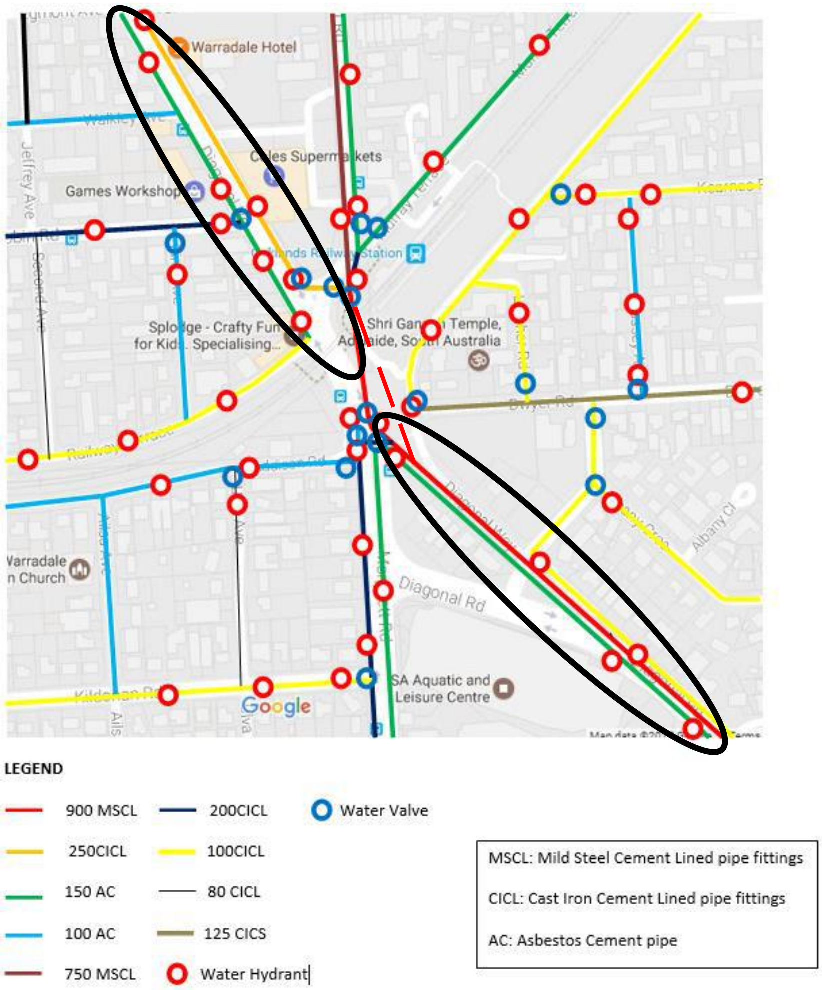
4.3.4.2 SA Water:

4.3.4.3 Water Reticulations:

It is the major services provided by the SA Water. Water reticulation system is the complex part, which requires more attention. The services need to relocate and potential disturbance and relocations are tabulated as follows:

Sl. No.	Services	Qty.	Potential Disturbance	Relocation
1	900 MSCL	-	Yes	Maybe
2	750 MSCL	-	Yes	No
3	250 CICL	-	Yes	Maybe
4	200 CICL	-	Yes	Maybe
5	150 AC	-	Yes	Maybe
6	125 CICS	-	Maybe	No
7	100 CICL	-	Yes	Maybe

Sl. No.	Services	Qty.	Potential Disturbance	Relocation
8	100 AC	-	Yes	Maybe
9	80 CICL	-	No	No
10	Water Hydrant	20+	Yes	Yes
11	Water valve	11+	Yes	Yes



The figure above and information circled in black highlights the most critical parts of the SA Water network (i.e. 900 MSCL pipe). For every pipe system, the minimum depth will be diameter of pipe plus 500mm cover. This depends on the site topography as it may go beyond the minimum depth requirement. For this purpose, in the next stage it is necessary to carry out a survey study and find out the level and accurate depth of the services. Discussion with structures and transport can reduce the impact relocating the affected water services has on the project. The water services north of the rail line can potentially be moved to the outsides of the footpath allowing room for the overpass foundations. South of the rail line, the 900MSCL cross over can be shifted approx. 20 metres back and rejoin at the junction on the other side as denoted in dashed red line. These works will approximately take 6-8 weeks in total.

4.3.4.3.1 Costing:

There are two 150mm diameter pipes, one 250mm and one 900mm. two of the pipes (150 & 250) north of the rail line can be moved to the outside of the footpath. The 900 can be shifted to join earlier as per the red dashed line, finally laying new 150 for southern side replacement. Costing is as follows (lay 225m of 900dia PMSCL @ 180$/m)+(tie in shift) + (lay 250m of 150dia PVC @ 110$/m)+(tie in shift)+(120m of 250dia PVC @ 125$/m)+(tie in shift)= 40500 + 4000 + 27500 + 4000 + 15000 + 4000 = $95,000

As per the 2016-2017 Major land Development Fees and Charges, there are various charges such as Land Developer Agreement Charges, water and recycled water Connections, Manifold Connections, Provide and Install Metal Underground Box to Cover Water Meter, Altering an Existing Water Meter and/or Connection, Water Relocations and Fire Connection Requirements.

For this particular proposed project, some of the water meters and water valves need to relocate and the cost are tabulated below:

Sl. No	**Description of work**	**Quantity**	**Cost (AUD $)**	**Total Amount ($)**
1	Drinking Water and Recycled Water Administration, Design Examination and Documentation ***For Level 2 Consultation***		2445 + $2.7 per meter Appro. 500m	2445+(2.7*500)= $3795.00
2	Temporary water meter removals	Appro. 100	$ 113	$11,300.00
3	Relocation of water pipes with metered (Need to do quotation greater than 50mm)	Any distance(about 3 types)	$ 6,000	$6,000 *3= $18,000

			Total:	$33,095.00

In some cases need to do quotation and estimate the costing by the company and for this more detail will be discussed in the later stage of the project.

Government of South Australia

SA Water

2016–17 Major Land Development Fees and Charges

Land Developer Agreement Charges

Drinking Water and Recycled Water Administration, Design Examination and Documentation	
Level 1 Consultant*	**$1,678 + $2.70 per metre**
Level 2 Consultant*	**$2,445 + $2.70 per metre**
Contract Examination and Inspection Fee*	**$538 + $3.65 per metre**
Administration Fee for Link-up (Service Fee* applies)	**$175**
Recycled Water Lock Off Service Fee	**$TBA**
Wastewater Administration, Design Examination and Documentation	
Level 1 Consultant*	**$2,756 + $2.70 per metre**
Level 2 Consultant*	**$4,057 + $2.70 per metre**
Contract Examination and Inspection Fee*	**$483 + $5.40 per metre**
Administration Fee for Link-up (Service Fee* applies)	**$70**

* **GST inclusive**

Provide and Install Metal Underground Box to Cover Water Meter

Metal underground box to cover 20mm or 25mm water meter	**$692**
Metal underground box to cover 40mm or 50mm water meter	**$2,028**
Shortening metered water connection – 20mm or 25mm into an underground box	**$1,645**
Shortening metered water connection – 32mm to 50mm into an underground box	**$3,203**

Altering an Existing Water Meter and/or Connection

Disconnection of water connections 50mm or less	**$613**
Disconnection of water connections over 50mm	**Quotation required.**
Temporary water meter removal (Connection remains)	**$113**
Shortening water connection – 20mm or 25mm	**$953**
Shortening water connection – 32mm to 50mm	**$1,175**
Raise or lower water connection – 15mm to 20mm	**$706**
Raise or lower water connection – 25mm to 50mm	**$1,146**
Rotation – 20mm and 25mm water meter up to 180 degrees	**$184**
Rotation – 40mm water meter up to 180 degrees	**$701**

Water Relocations

Relocate a 20mm or 25mm metered water connection 4 metres or less	
0.1m – 2.0m	**$570**
> 2.0m – 4.0m	**$980**
Relocate a 20mm or 25mm unmetered water connection 4 metres or less and installation of a water meter	
0.1m – 2.0m	**$848**
> 2.0m – 4.0m	**$955**
Relocate a 20mm or 25mm metered water connection more than 4 metres (Connection Fee + Disconnection Fee)	
20mm meter	**$2,595**
25mm meter	**$3,591**
Relocate a 40mm or 50mm metered water connection any distance (Connection Fee + Disconnection Fee)	
40mm meter	**$4,567**
50mm meter	**$5,525**
>50mm meter	**Quotation**

** Charge is for standard connections only, refer to connections policy for non-standard connections

4.3.4.4 Wastewater Reticulation:

The wastewater reticulation system is another complex system need to take more attention when aligning pile foundation locations. The services need to relocate and potential disturbance and relocations are tabulated as follows as per the pile foundation location:

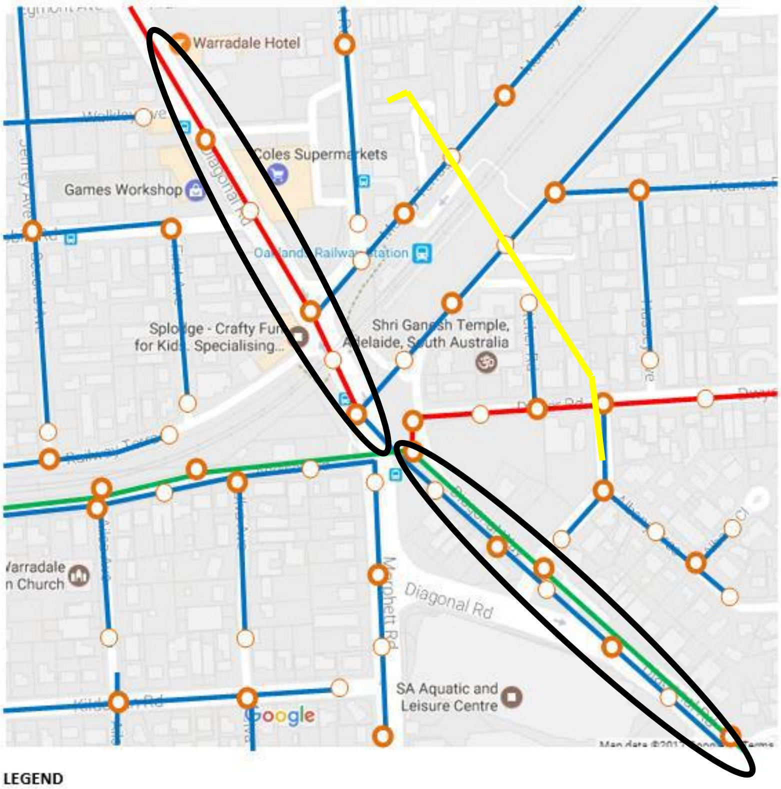
Sl. No.	Services	Qty.	Potential Disturbance	Relocation
1	225 VC	-	Yes	Yes
2	150 VC	-	Yes	Yes
3	675 RC	-	Yes	Yes
4	Maintenance hole	10	Yes	Yes
5	Inspection Opening	8	Yes	Yes

Th figure below shows that the critical waste water system by the development. The black ring area are the critical area which need more attention, which might need to temporarily relocate and some parts need to relocated parmenently (i.e. network upgrade). The yellow line below indicates the proposed service solution for the red line (225VC). Then the circled green and blue (675RC and 150VC) will be shifted right to the curb out of the structures way.

4.3.4.4.1 Costing:

Costing for the wastewater system are calculated by the following table:

Pipe	Length (m)	Diameter (mm)	Cost per meter ($/m)	Total cost $
150 VC	1585	150	200	317000
225 VC	365	225	260	94900
675 RC	280	675	750	210000
Total				621900



LEGEND

225 VC	Maintenance hole
150 VC	Inspection Opening
675 RC	

WASTEWATER

Wastewater Connection	
100mm **	**$4,200**
150mm **	**$7,398**
Disconnection – 100mm and 150mm **	**$994**

****Charge is for standard connections only, refer to connections policy for non-standard connections**

Wastewater Application Fee*	
100mm *	**$141**
150mm *	**$141**

Note:
*GST applies to the **Wastewater Application Fee** only.

Miscellaneous

Service Rent Applicable where there is more than one meter under one account.	**$71.60 per quarter**

Service Fee*

Please note a service fee may be applicable for investigations and/or assessments of supply requests and/or other miscellaneous charges.	**$70 per hour**

Augmentation Charges

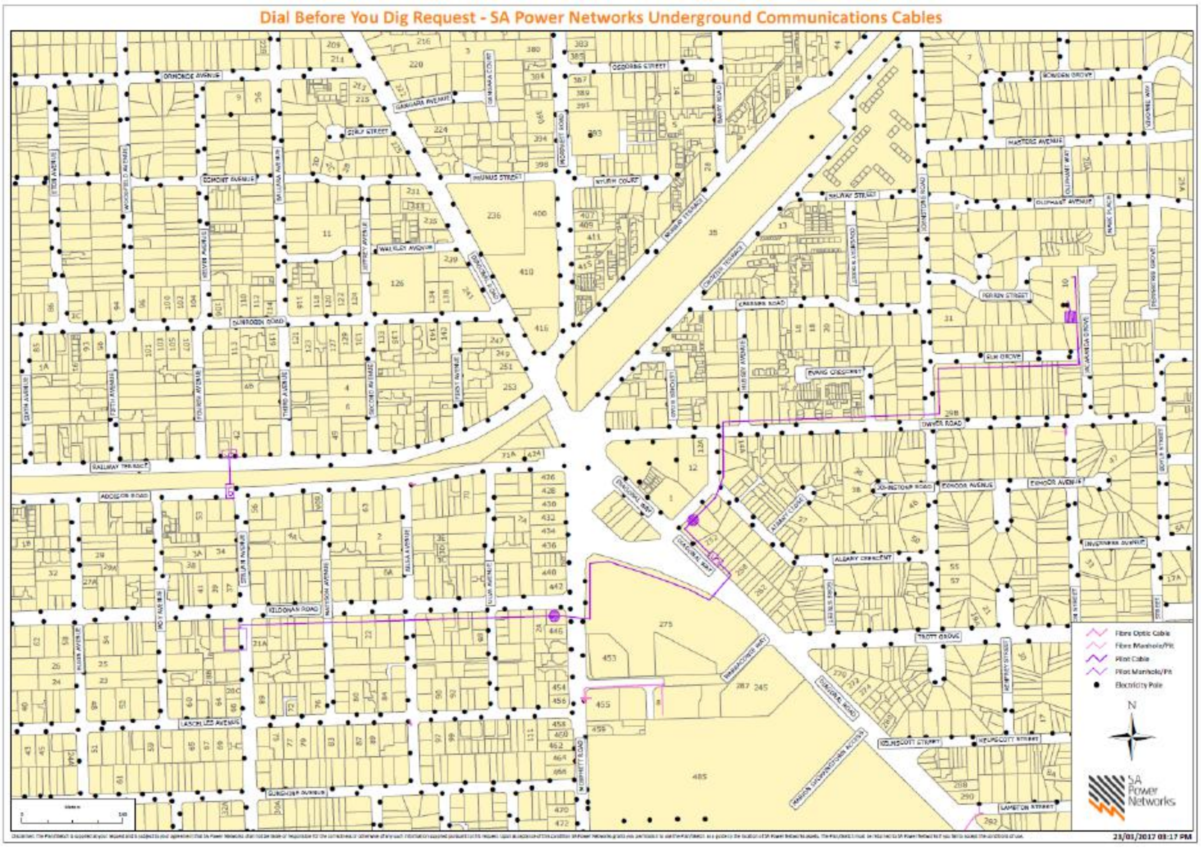
Augmentation Charges also apply in designated areas throughout the state. For further information refer to this link augmentation charges or contact SA Water on 7424 1135.

* **GST inclusive**

4.3.4.5 SAPN Services

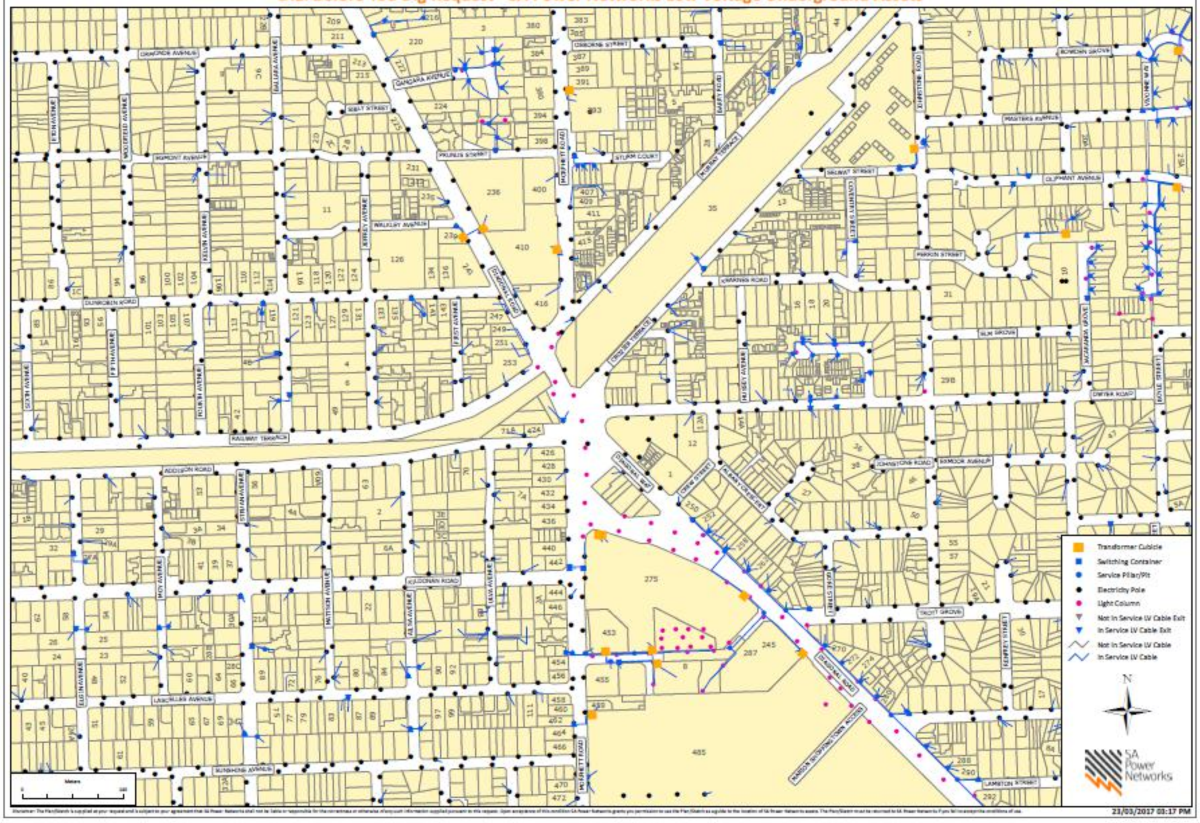
4.3.4.6 Electricity pole:

Electricity poles are running alongside of Diagonal road and Morphett road. For the future development with Diagonal road overpass, need significant amount of electricity poles need to relocate and upgrade to underground system. Figure below shows that there exist pilot cable which are used for control, protection, signalling, telecommunications and data transmission purposes associated with power distribution and transmission systems. It is located towards the southern end of Diagonal and Morphett road which need to take more attention on it.

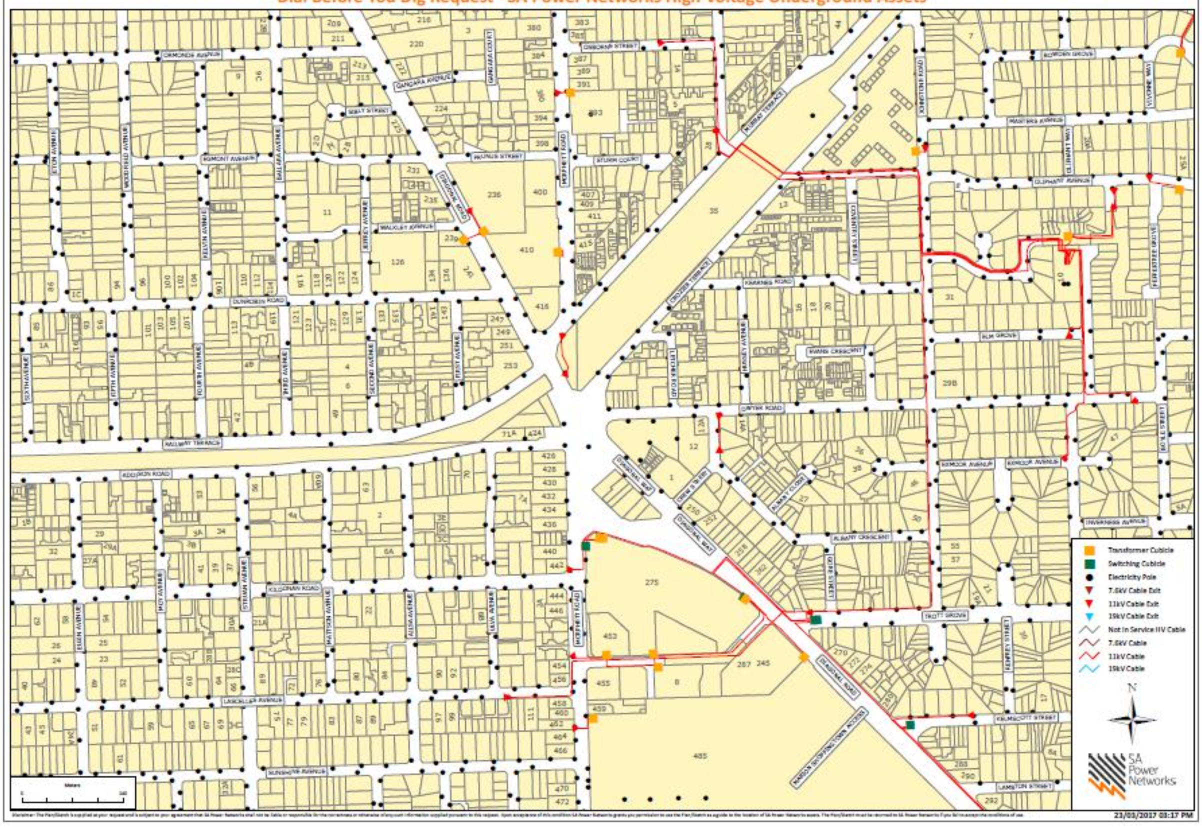


The figure below shows about the SA Power Networks for low voltage underground Assets where it includes Transformer cubicle, switching container, Service piller/pit, Electricity pole, Light columns etc. From all these services, transformer cubical, switching containers and electricity pole are in crtical location along the diagonal road. Those critical services need to relocate and shift temporarily for the upcoming development. They must also cater for the requirements of the road overpass.

Dial Before You Dig Request - SA Power Networks Low Voltage Underground Assets



Dial Before You Dig Request - SA Power Networks High Voltage Underground Assets



4.3.4.7 SA Power High Voltage:

The figure above shows about the high voltage for SA Power. 11 kV voltage line runs through the Morphett road which crosses the rail line and diagonal road. Therefore, this need to be incorporate with SA power to relocate and plan necessary alternative power supply to the users while the new network is being constructed.

Costing:

Electricity pole removal for road overpass alignment (remove approx. 45 poles @ 650 per pole)+(underbridge + platform amenity conduiting @ 90$/m)+(light column removal approx. 45+ poles @ 600 per pole)+(install approx. 30+ new light poles @ 2000 per pole)

Services summary:

Service/Pole	Count/Length (m)	Conduit/Pipe Diameter (mm)	Cost per pole/metre ($/m)	Total cost $
Electricity poles	45+	-	650	29250
Light Poles	30+	-	2400	72000
LV	1300	100	300	390000
HV	-	-	-	-
Total				491250

1. **Optus**

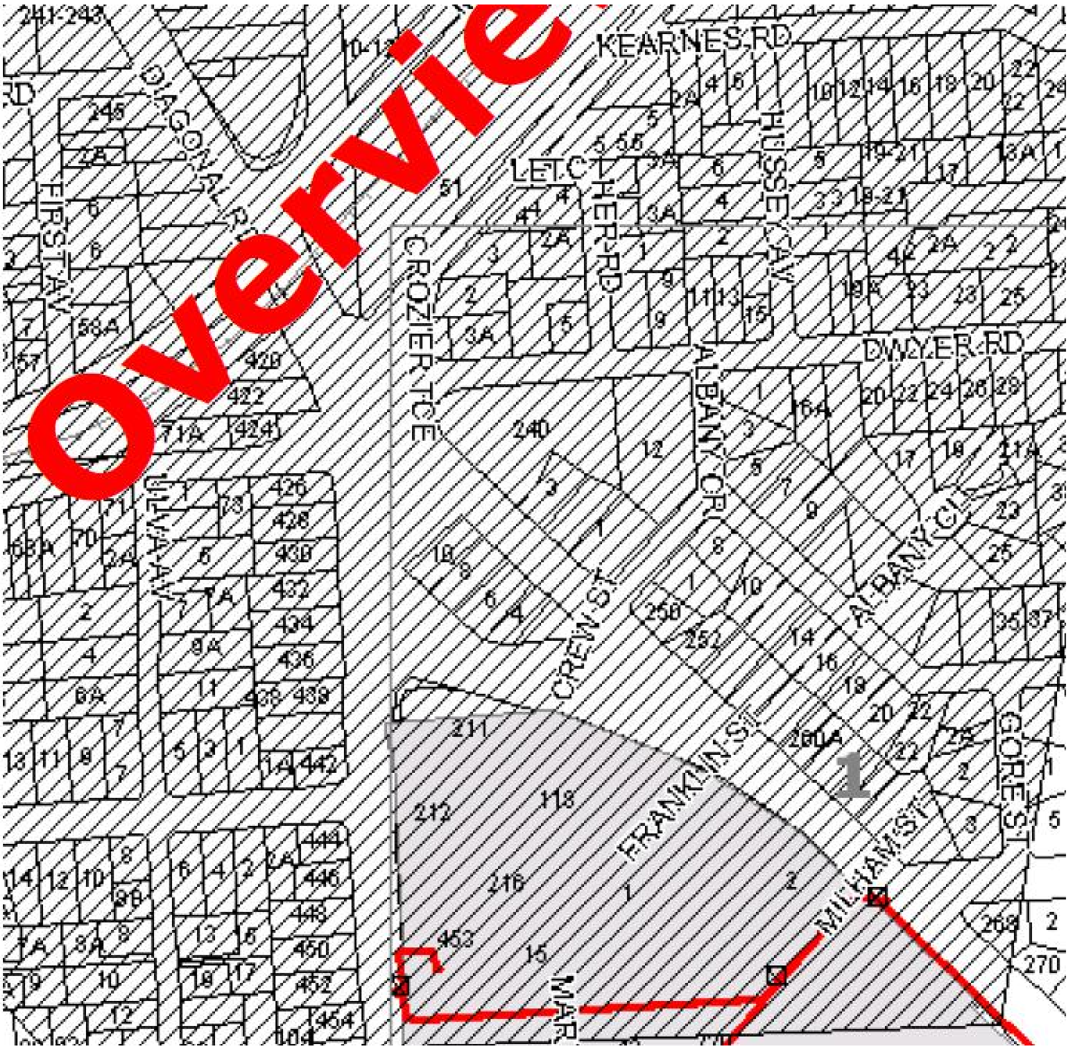


Figure 56 Optus lines overview

Optus lines appear to be on the outskirts of the project area and while at present do not seem to interact with structural designs. Greater intersection detail will yield more accurate results however at present, it is not predicted to interfere with road alignment.

2. SabreNet

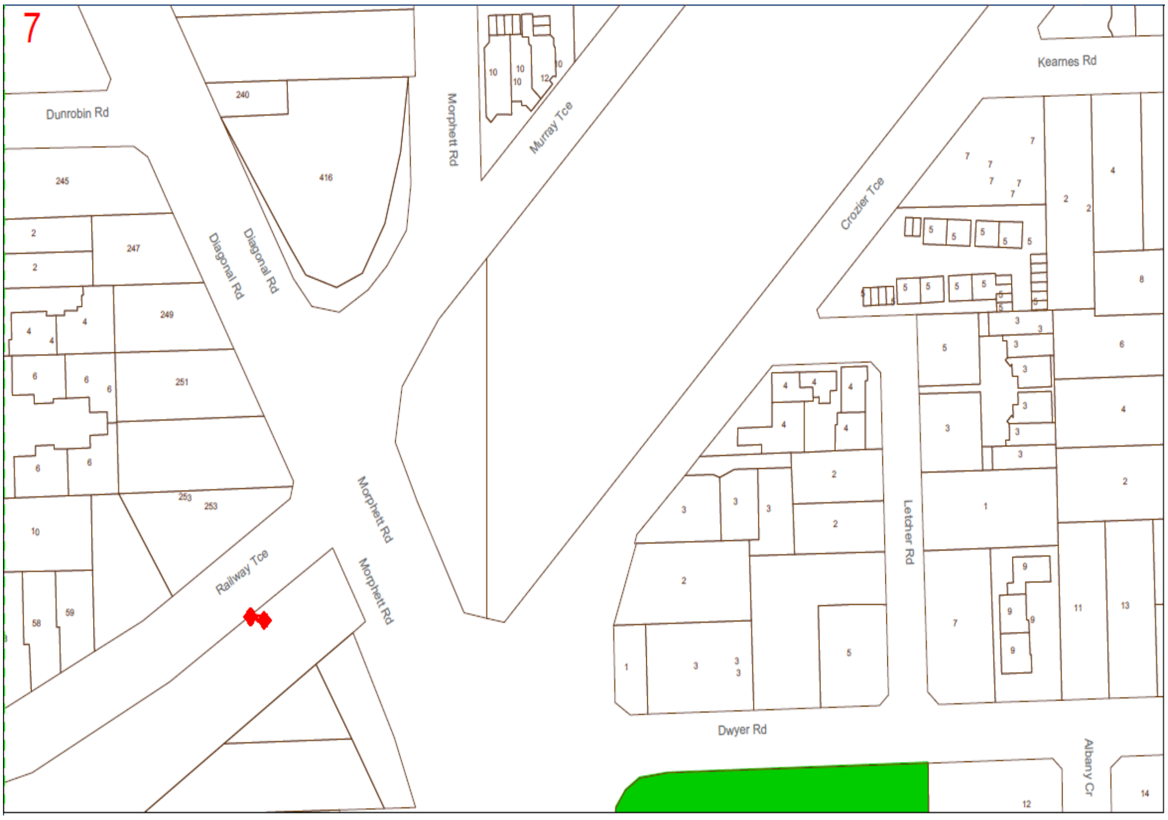


Figure 57 SabreNet pits location

Only two pits of SabreNet are present in the project area which fall close to the rail line. These do not appear to clash with any works on the alignment. Information is limited on these pits and little information is known as to services running in or out thus further investigation is required.

Services Summary:

	Expense						
Service	***Relocations***	***Land Required***	***Planned Duration***	***Access***	***Risk***	***Allocated Budget ($)***	
APA	4 Major	yes	15 weeks	okay	Rail & some trees, Traffic	91,250	

					impedance		
Optus	0	No	-	-	Future design	-	
SabreNet	0	no	-	-	-	-	
Total							**$ 91,250**

4.3.5 Summaries

4.3.5.1 Option 1 Rail Overpass:

	Expense						
Service	***Relocations***	***Land Required***	***Planned Duration***	***Access***	***Risk***	***Estimated Cost ($)***	
NBN	1 Major	yes	7 weeks	okay	Works at road & Rail	71500	
APA	1 Major	no	4 weeks	good	Rail & cutover	15000	
Nextgen	Potential minor	no	2 weeks	okay	Rail	10000	
Optus	nil	no	-	-	-	0	
SA Water	Properties + potential 225VC	no	8 weeks	okay	Water supply loss, damage	5500	
SabreNet	No	no	2 weeks	okay	Unsure of function	0	

SAPN	Major + Minor	no	10 weeks	okay	Power loss, Asset/building damage	214750	
Total			**33 weeks**				**$519,634**

4.3.5.2 Option 2 Road Overpass:

	Expense						
Service	***Relocations***	***Land Required***	***Planned Duration***	***Access***	***Risk***	***Estimated Cost ($)***	
NBN	1 Major	no	2 weeks	open		11,250	
SA Water	4 Major	no	8 weeks	restricted	Traffic exposure/Rail	95,000	
SAPN	Poles	yes	14 weeks	okay	Bridge & traffic	165,000	
APA	4 Major	yes	15 weeks	okay	Rail & some trees, Traffic impedance	91,250	
Optus	0	No	-	-	Future design	-	
SabreNet	0	no	-	-	-	-	
Total			**39 weeks**				**$ 362,500**

The detailed analysis of the options chosen by the project manager and given the road alignment, structure locations and urban considerations from Transport, Structures and Urban respectively has yielded close results in terms of cost. It can be seen from the table of summaries that the first option, a rail overpass will cost approximately $316,750. This, compared to option 2 which is the sum of both tables, gives $362,500. There is a small cost difference of $45,750 and this is most likely made up by lineal metres laid. The average crew cost of $3000/day is broken down in the table below (table 4), with a day being considered 8 working hours. This method does not take into account money lost through related events such as not completing essential prior works causing a fall behind schedule, damaging a service, noncompliant products & reworks.

Type	Charge out ($)
Operator	115
Supervisor	100
Labourer	80
Labourer	80
Total	**375**

Option 1 is cheaper and is of less overall duration in weeks. However, there are more service relocations following this option. The savings in option 1 may be able to be used as contingency for the services (as contingency is not calculated in the price above). This may enhance client perspective through reduced contingency and confidence in work ethic and quality. Two major costs in both options are SAPN assets and the surrounding lighting of the areas. A mostly new network will have to be designed underground to cater for the removal of stobie poles and also run through either overpass to provide power to lights, maintenance, public spaces and amenities. Both designs, Rail or Road overpass have negligible effect on Optus and SabreNet assets, however further detail is required to determine the impact of the southern intersection at Diagonal Rd-Morphett Rd.

The rail overpass presents less work in terms of APA and their assets (4 major relocations in comparison to 1), which are transmission and high pressure gas mains. These have been deemed of high importance and so avoiding disturbing these services would be prioritised. SA Water presents challenges in both solutions, although as the road overpass encompasses more road space than the rail overpass, there are considerably more SA Water assets that are affected. This is reflected through the cost allocations in each option. Option 1 the rail overpass only has an estimated $5,500 worth of works in comparison to $95,000 under option 2 road overpass.

The NBN works in the rail option is far greater than that of the road overpass as the NBN cable follows the rail line, similarly how the water assets follow the road line. Although this is the case, the moving of one cable along a rail alignment is less complex than relocating 4 mains on the road. This is due to service and shutdown requirements, however involvement from the rail authority is required to determine safe working measures in the rail corridor.

After the evaluation of both options against both alignments as received from traffic, taking into account the services requirements from Urban, **option 1 a rail overpass** is the final recommendation from the services department. This is based on the complexity and quantity of the relocations required for the project completion. Not only is the workload in this option reduced as reflected in weeks to completion, it is also a cheaper option.

4.4 Urban Design and Community Consultation

4.4.1 Introduction

The land use strategies for transport infrastructure and structural element are important components of the Oaklands Park Traffic Redevelopment. With better coordination of land use strategies, communities can plan more comprehensively for housing, commercial and retails uses. Besides that, will also benefit the environment by reducing several pollutions. In order to achieve high-performance infrastructure and buildings, our urban planning team will achieve all the requirements according to the best land-use strategies designs. Overall, our team will ensure any approaches will be applied after the approval of the local council or any private parties. In term or community, local community are informed about their rights, responsibilities, and options. This approach is executed through channels that are accessible to all members of the community. Such as one-on-one meetings, project intranet site and so on. Best options will be selected based on site strategies and behavior of local communities to avoid disruption to the community. Key information to be distributed are purpose of the project, timeline of the development, and more to come after evaluation.

4.4.2 Generals

4.4.2.1 Noise

In expectation, there will be more traffic flow and probably trains scheduled. Therefore, more noise and vibration from braking and acceleration by traffic can cause disruption to residents. Noise impact will be discussed in the (Environmental Section – To be Confirmed). Thus, full enclosure station or appropriate noise wall is applied for the rail overpass and road overpass. However, design cost for each option will be different based on the level of noise and vibration impacts and overpass dimension. These parts of design should be consolidated further at detailed design stage.

4.4.2.2 Aboriginal and European Heritage

According to site investigation and google map identification, urban team concluded that there is no any aboriginal or European heritage identified within the project area. Accordingly, both options would be reasonable from a heritage perspective.

4.4.2.3 Local Properties Privacy

The location of rail overpass and road overpass is located at the major commercial and residential properties. Consequently, the privacy of local residential properties and commercial areas got impacted. The best way to mitigate the impact are through strategies landscaping or tree planting around the overpass areas. Besides that, fully enclosure of the station across the overpass also one of the options to avoid local properties privacy impacts. Appropriate visual privacy prevention and tree planting is conducted in detailed design stage

4.4.2.4 Station Facilities

Station facilities is designed based on Department of Planning Transport and Infrastructure (DPTI) technical standard.

In station facilities, pedestrians, passengers, or any users must be provided with the following basic requirements. Several DPTI standards to be included are:

- Toilet Facilities
- Fencing
- Signage

- Pavement Marking
- Lighting
- Security Systems

These facilities are designed respectively based on **DPTI Technical Standard.**

Appropriate shelters shall be provided to protect pedestrians, cyclists, or any public transport user to avoid rains, wind, or any environmental issues. Furniture such as seats, lean rails and litter bins must be included. Self- ventilating is designed as a requirement of the standard for the elevated stations to comfort

4.4.2.5 Station Maintenance and Vandalism

Maintenance of structure is one of the component of urban design. However, station maintenance will have conducted depends on the used materials in the structure. Besides that, all structure maintenance is conducted according to DPTI Station Guidelines. This part will be correlated to sustainability and further discussed in detailed design stage.

Vandalism prevention will depend on the design and materials modification. One of the approach will be using materials which are vandal resistant which can minimize the vandalism impact. For example, seats provided are covered appropriate paint to prevent writing. Most durability surfaces such as rock- cement will be take into consideration.

4.4.2.6 Security and Crime Prevention

Increased security must be included for the new design of the stations. There are several approaches are introduced such as more depot lighting and installed CCTV. Besides that, 24 hours' patrol of train station security or police must be included with assistant of CCTV which will achieve better performance. Movable barriers and gate for the entrance can be implemented to reduces the risk of robbery or physical assaults. Station will be installed with emergency call tools at appropriate location also one of the solution to reduces the potential of crime.

4.4.2.7 Development Effect against Community

The benefit of overpass for Oaklands area is very significant such as the accessibility for several directions and the accessibility of railway station also enhance.

This project will enhance the accessibility of pedestrians at Morphett Road in north-south direction due to eliminating the current intersection of railway and Morphett road. Besides that, the opportunities of increasing access point for Morphett road in all direction will be consider because of the opening space created under the overpass. Due to that, connectivity between the north direction communities and south are improved.

Accessibility for east and west pedestrian will also be improved because the existing pedestrian path will be eliminated and redesigned to the overpass. Overpass will provide pedestrians path with lift access and stairs. Besides that, existing ground level pedestrian path will be improved by adding signal phases for crossing Morphett Road and Diagonal Road intersection.

There are opportunities to improve the accessibility for cyclist as well. Bicycles lanes is added on the roads for north-south directions. With the lane strategy created by applied overpass, cyclists for east-west direction also got enhance by added bicycle lanes for the overpass.

Overall, the communities for north south and east west direction is improved by overpass strategy. The proposed project created lots of opportunities to improve the connectivity at Oaklands areas.

4.4.2.8 Land Acquisition

This project requires several land acquisitions to perform the construction project. Investigation has been made and assumed several private property and business might encounter major impact which will need to be remove or purchase to construct the station overpass or road overpass. Any private land acquisitions made are according to standard South Australian Legislation – Land Acquisition Act 1969.

4.4.2.8.1 Rail Overpass

Figure 58 Land Acquisition - Rail Overpass

From the figure above, showing that the land required to construct rail overpass. The red indicator representing there are several commercial buildings which can have significant impact during the construction process. Most of the land required for rail overpass are open space area or parking space which indicated with yellow lines. As site investigated, the open space around Oaklands Station can achieve the requirements of the developments of rail overpass. Overall, there will be insignificant privacy land required for the rail development. Any further or additional land requirements will depend on the final design during the design stage.

4.4.2.8.2 Road Overpass – North Direction

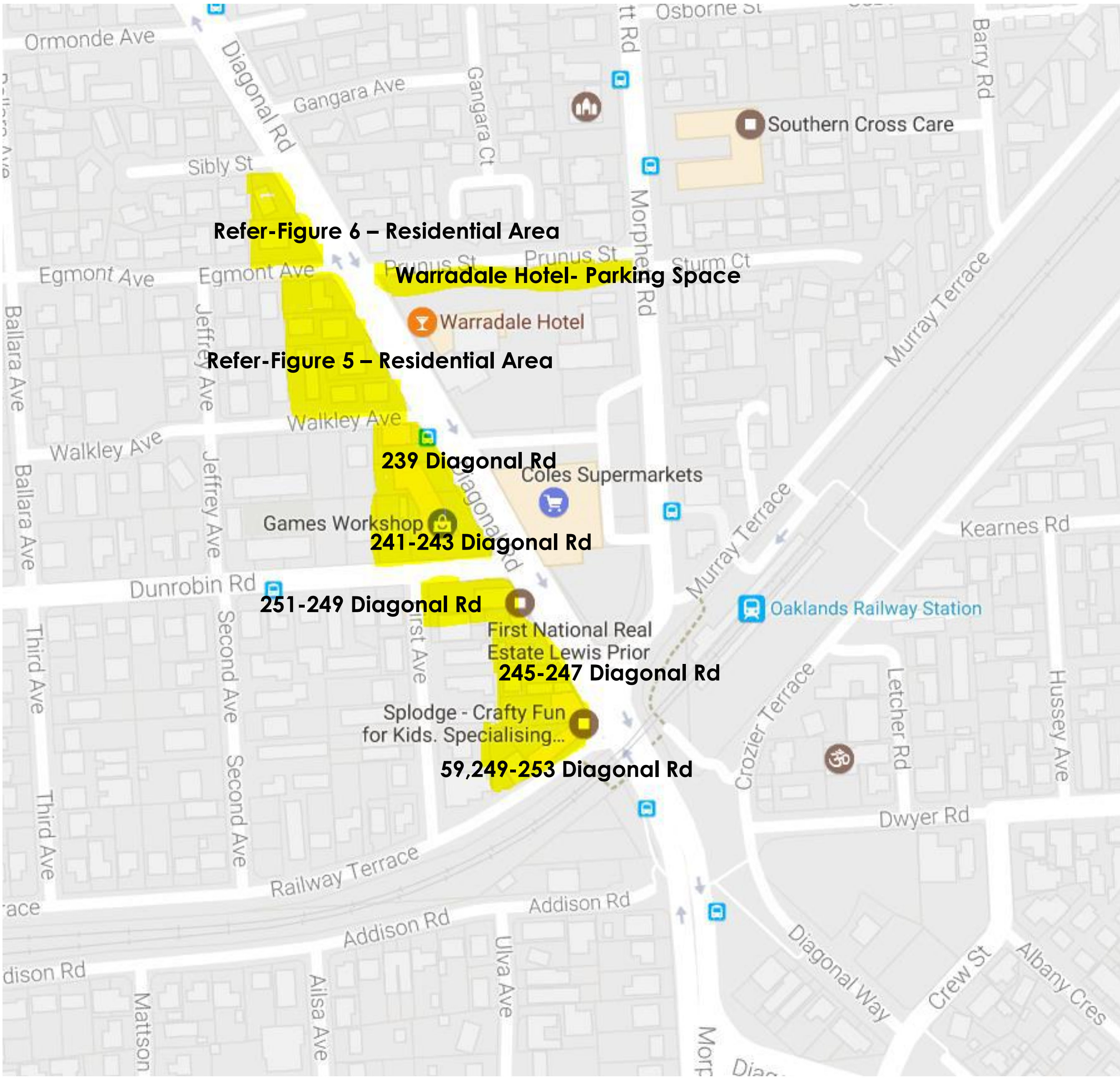


Figure 59 Land Acquisition Road Overpass North Direction

No	Address	Purpose
1	59 Railway Terrace Warradale SA 5046	Business
2	249 – 253 Diagonal Rd Warradale SA 5046	Business
3	245 – 247 Diagonal Rd Warradale SA 5046	Business
4	241 – 243 Diagonal Rd Warradale SA 5046	Business
5	239 Diagonal Rd Warradale SA 5046	Business
6	231,233,235 Diagonal Rd Warradale SA 5046	Residential
7	225,227,229 Diagonal Rd Warradale SA 5046	Residential
8	1 Walkley Avenue Warradale SA 5046	Residential
9	Unit 2/1 Walkley Ave Warradale SA 5046	Residential
10	Unit 3/3 Walkley Ave Warradale SA 5046	Residential
11	402 Morphett Rd Warradale Hotel SA 5046	Parking Space

Table 13 List of Residential and Business Property North Direction

The figure above showing the land requires for road overpass development in north direction and table has been made to allocate affected private property. According to site investigation, the impact of privacy lands is significantly for road overpass. Several business and private property might need remove and purchased for development purposes. Major impact will be the business and residential nearby the Diagonal Road. Due to safety and construction purpose, these lands are required with performing appropriate land acquisition process. Parking space of Warradale hotel also included for the intersection of the road overpass. To reduce the impact of loss for these residential and business, appropriate compensation will be provided and discussed detailed in the detailed design stage

Figure 60 Residential Area

Figure 61 Residential Area

4.4.2.8.3 Road Overpass – South Direction

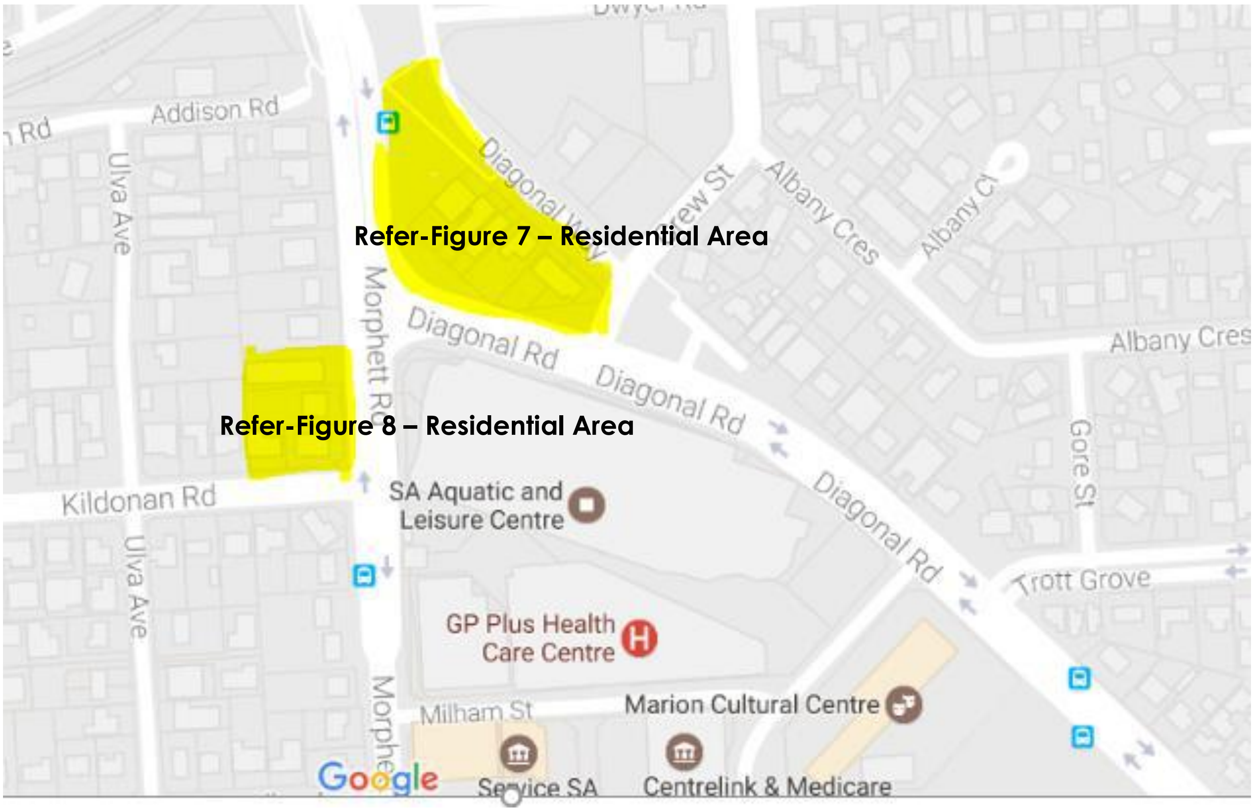


Figure above shows the property required in south direction. The impact of differences of north direction and south direction is significantly but in overall the impact that investigated from development of road overpass is huge. The impact that happen in south direction mainly on residential private property. These private properties will be listed and shown in the figure and table below.

No	Address	Purpose
1	10 Diagonal Way Oaklands Park SA 5046	Residential
2	8A Diagonal Way Oaklands Park SA 5046	Residential
3	8 Diagonal Way Oaklands Park SA 5046	Residential
4	6 Diagonal Way Oaklands Park SA 5046	Residential
5	4 Diagonal Way Oaklands Park SA 5046	Residential
6	2 Diagonal Way Oaklands Park SA 5046	Residential
7	Unit 3/438 Morphett Rd Warradale SA 5046	Residential
8	440 Morphett Rd Warradale SA 5046	Residential
9	442 Morphett Rd Warradale SA 5046	Residential
10	1A Kildonan Rd Morphett Rd Warradale SA 5046	Residential

Table 14 Residential Area

Figure 62-Residential Area

Figure 63 Residential Area

4.4.3 Summary

In term of land acquisition, rail overpass shows significant less impact to the residential and business property within Oaklands Park Area compare to road overpass. From the figure and table above, road overpass shows numbered of property required to be purchased and numbers of businesses and private property need to be removed for safety and development purposes. Impact mitigation plans will be discussed in engagement plan section. Overall, rail overpass is the most recommended options for this aspect.

4.4.4 Construction Phase

4.4.4.1 The similar impact on residential properties between road overpass and rail overpass

DPC Engineering aims to meet the expectations of state government and local residents. So that, we list out the impact on mainly residential properties and give the way to minimize impacts as below.

First of all, local residents will inevitably be affected by the trip during the construction phase. In order to reduce the impact, methods are listed below:

- Building the road as different stages. Detail information can be seen in the transport department area.

- Building temporary road during the construction to reduce the impact of the nearby residents.
- The construction time as far as possible to avoid traffic rush hour during the weekdays. Such as 7:15-9:00 am and 4:30-6:00 pm.
- Ahead of time to tell people the road construction date to let vehicles bypass (on the side of road set up billboard; through Radio Data System- Traffic Message Channel), thereby reducing the traffic pressure.

The noise and vibration during construction will affect the rest of nearby residents. It is cannot be ignored part in the process of the construction. The construction noise and vibration is mainly caused by the cargo trucks that transportation of land and stone and other building materials, it will be impact on both sides of the road within a certain range of residents. Secondly, the construction machinery in the construction site will also produce noise, it also have an impact on residents. DPC Engineering through the following measures to reduce the impact of noise and vibration on the residents:

- Scientific arrangement of construction, reasonable selection and adjustment of construction time. In the process of road construction, the construction should be scientifically arranged, as far as possible the construction operation time in the daytime. In residential areas, suspended some large noise project at night, such as the drilling construction projects, and avoid the large-scale construction activities in the evening.
- Reasonable selection and adjustment of mechanical configuration. In some environmentally sensitive areas during construction, such as timely adjustments to the construction equipment, increase to use the light vibration equipment, thinning of subgrade filling each layer thickness, increase paving layer, increase the number of roller compaction, reduce construction equipment vibration and noise impact on residents.
- Set up sound absorbing baffles around the construction site.

Dust in the construction process will affect the health of nearby residents. The construction process of the dust, a part is due to the transport process of material because the road uneven or full shipment; another part is the construction site of loading and unloading, stacking materials and construction process, the ground is dry loose by blowing dust. The following measures will be taken to reduce the impact of dust on the health of residents:

- Take the necessary materials piled up measures to reduce wind dust; organize the material and earthwork transportation, especially in sediment transport vehicles out of the site, to rinse of sediment in the tyre to prevent dust, sand and scattered materials caused by environmental pollution.
- The transport of materials should be used well sealed dump truck transport or take measures to cover the transport materials.
- On the construction site, material transport and access to the site of the road should be sprinkler.
- Using 'n mist cannon truck' to reduce the dust during the construction.

The construction process will also affect the soil and environment. Although these effects are not obvious in the short term, but in the long run, its impact on the local population is enormous. The road itself occupied land vegetation destruction, large temporary facilities, temporary housing also occupy a lot of land during road construction; mechanized operation and the tread on of construction workers will also bring the loss of vegetation. In addition, in the process of road construction, the vegetation around the earth embankment is broken, if the recovery is not timely, it is easy to cause erosion and soil erosion. Furthermore, in the process of the road construction, a large number of solid materials, such as sand stone, lime block, cement block, etc., will be discarded, there is a considerable portion of the loss of solid waste around the construction site, resulting in soil contamination. The other part due to surface water erosion into the local river, causing pollution to the local water system. Also, there are large number of construction workers working in the road construction site every day, these workers produce a certain amount of waste water and garbage, although the amount is very few. However, if not treated in time, it will cause soil and environmental pollution.

DPC Engineering through the following measures to ensure the minimize impacts of soil and environment:

- According to the actual excavation soil set slope reasonable so as to reduce soil erosion.
- Setting up reasonable temporary drainage system, timely drain rain water, to reduce rain erosion on slope.
- Slope embankment should be timely reinforce and green.
- Rational application of soil, the extra earth is used to arrange the slop as far as possible.

- Strengthen the construction team of domestic sewage treatment, it is strictly prohibited to directly into the river flow.
- Bridge construction machinery should avoid the oil pollution.
- Strictly control the size of the temporary land, and also avoid the land outside the scope of mechanical rolling land.

The construction process affect the safety of residents. In the process of road construction, the proportion of accidents caused by machinery is very large. The main causes of the accident include: the driver is lack of safety consciousness, violate the rules and regulations; the mechanical safety protection device fails, and the construction machinery has its own fault; due to the limited visual field at night, traffic and safety accidents may occur. The inspection wells also have large potential safety problems. As a result of a variety of reasons leading to the road surface and part of the drainage inspection well is not the same level, which will bring some harm to road safety and road surface structure.

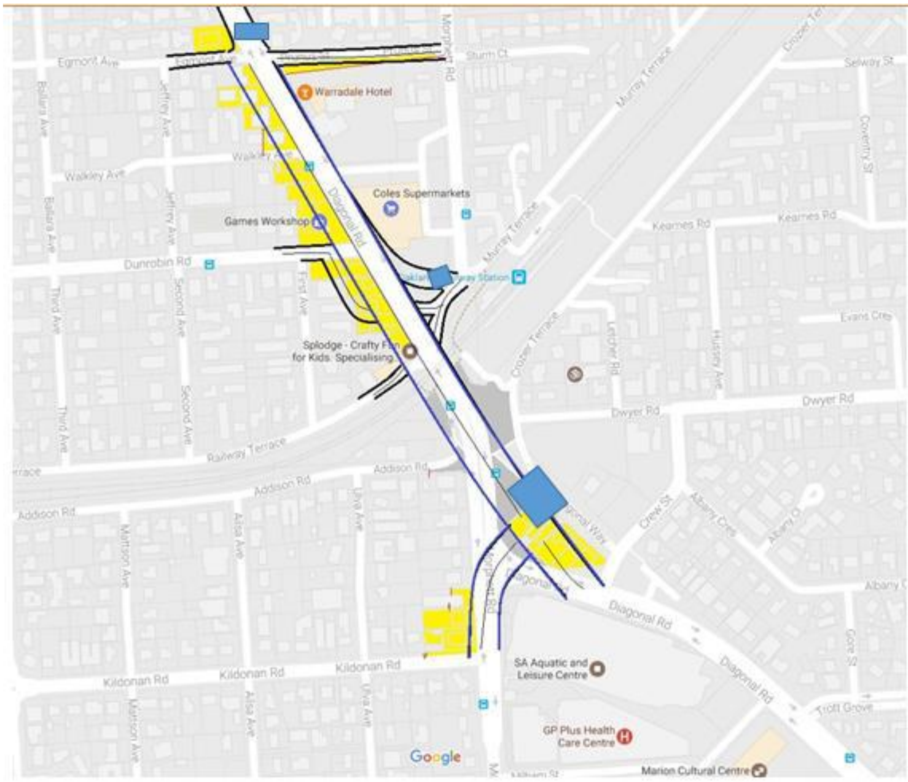
The following measures to ensure the safety of the pedestrians and constructors:

- In the construction area perimeter fence, to protect the safety of pedestrians.
- Regular inspection and maintenance of construction machinery to prevent accidents caused by construction machinery failure.
- Organize staff regular education and training to improve the construction skills, professional ethics and sense of responsibility
- High power lighting device and warning lamp at night.
- Reserving pre-sedimentation cycle, in order for the inspection wells settlement occurs. If the inspection wells surrounding soil can not be used in large-scale machinery, then use small machinery to ensure the compactness of the soil meets the design requirements.

4.4.4.2 The different impact between road overpass and rail overpass

4.4.4.3 Direct affected area

The direct affected areas are different between road overpass and rail overpass. The affected area of road overpass can be seen in fig 1, and the direct affected area of rail overpass can be seen in fig 2. It is very clearly that, the direct affected area of road overpass is broader than the affected properties of rail overpass. For road overpass option, the most of direct affected areas are business area. However, for rail overpass most of the direct affected areas are residential areas.



Affected Properties by the proposed plan

Over plan road lines

At grade road lines

Proposed Intersections

The Road Overpass would be widened to 27meters at least to allow for a 1.5-meter shoulder either sides, a minimum 3-meter median. Diagonal road would also include slip lane to Morphett Road.

(Guide to Road Design Part 4A : Unsignalised and Signalised Intersections)

Figure1. Direct affected area of Road overpass

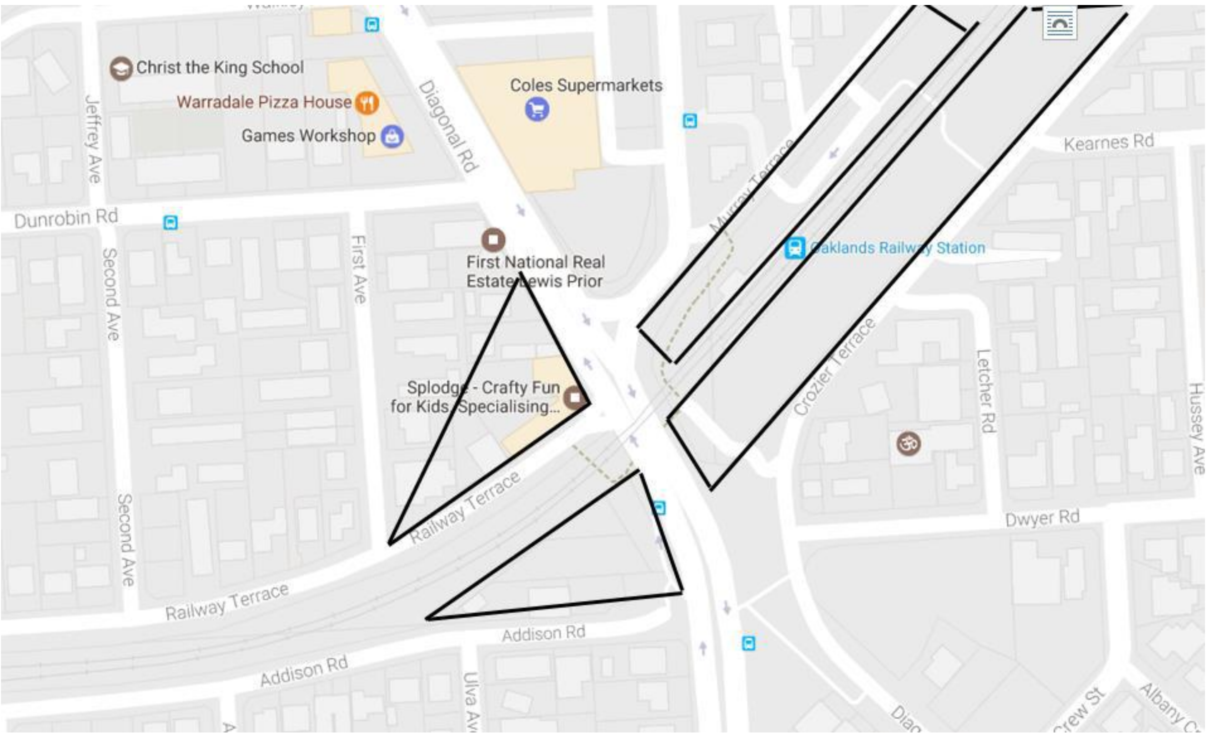


Figure2. Direct affected area of Rail overpass

4.4.4.4 Construction time

The construction time is different between road overpass and rail overpass. According to the previous report, DPTI has mentioned that the construction time of road overpass is longer than rail overpass, because the greater amount of construction (more intersections, more road work). So that the road overpass causes the road closure to be implemented for longer timeframe which will create severe traffic issues in the study area.

4.4.4.5 Land use

The land use is different between road overpass option and rail overpass option. From the department of transport, the road overpass option require more construction materials, as a result, more temporary land will be required to pile up the materials. This will cause more soil and environment problems.

4.4.4.6 Summary

To sum up, the rail overpass option is a better choice to minimize the impact of the construction process on the surrounding residents. It has a significant advantage in the direct impact of the region, the impact of time and land use.

4.4.5 Economy

4.4.5.1 Development Effect Against Business

This project will bring several impacts toward the business, employment, and industry. Most major impact will be the disruption generated during construction. During construction, some businesses might encounter certain physical impact such as closure and disruption of accessibility. Besides that, visually impact might happen too due construction site safety wall which might block the visual of passenger and vehicle toward the business area.

Figure 64 North Side Important building

The figure above showing the commercial building around the construction area. The most nearby and may encounter with major construction phase impact commercial building are Coles Super Markets and Splodge – Crafty Fun for Kids Games Workshop and First National Real Estate Lewis Prior. Impact that might happen are traffic closure which affected the passenger flow and accessibility for these commercial building. Splodge-Crafty Fun for Kids. Specialising in Parties, Corporate Events & Workshops can no longer run their business during the construction phase and after construction due to safety issues and land acquisition. However, any compensation method will be discussed in our engagement plan. On the other hand, the accessibility and traffic congestion will be improved with the development of overpass. Thus, businesses within these areas might benefit from decent customer flow. Besides that, with the improvement of economy for Oaklands areas, the employment opportunities will have high possibility to be increase as well.

The local business will be impact in the study area show as below.

1. Warradale Hotel

   Address: 234 Diagonal Rd, Warradale SA 5046

   The Warradale Hotel offers simple rooms free Wi-Fi & parking, plus a bistro, 2 bars and live music. It can be accessed by Prunus Street and Diagonal Road.

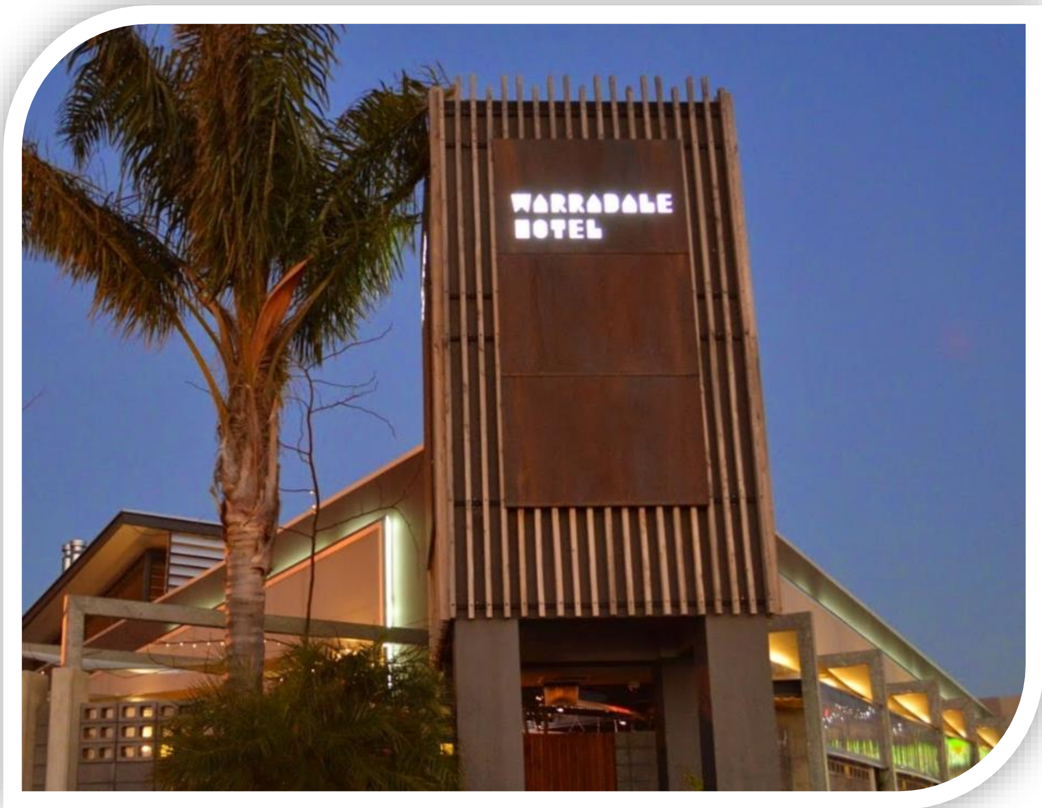


Figure 65. Warradale Hotel

2. Bernie Jones Cycles

   Address: 239 Diagonal Rd, Warradale SA 5046

   Bernie Jones Cycles (BJC) is *the Family Bike Shop*. BJC is a family-owned & operated bike shop committed to servicing all types of bike riders in all categories of cycling. The main a**cces**s is from Walkley Ave and Diagonal Road.

Figure 66. Bernie Jones Cycles

3. Christ the King School

   Address: 126 Dunrobin Rd, Warradale SA 5046

   The Christ the King School is a catholic school. It can be accessed by Walkley Ave, Jeffery Ave and Dunrobin Road.

Figure 67. Christ the King School

4. Warradale Pizza House

   Address: 6/241 Diagonal Rd, Warradale SA 5046

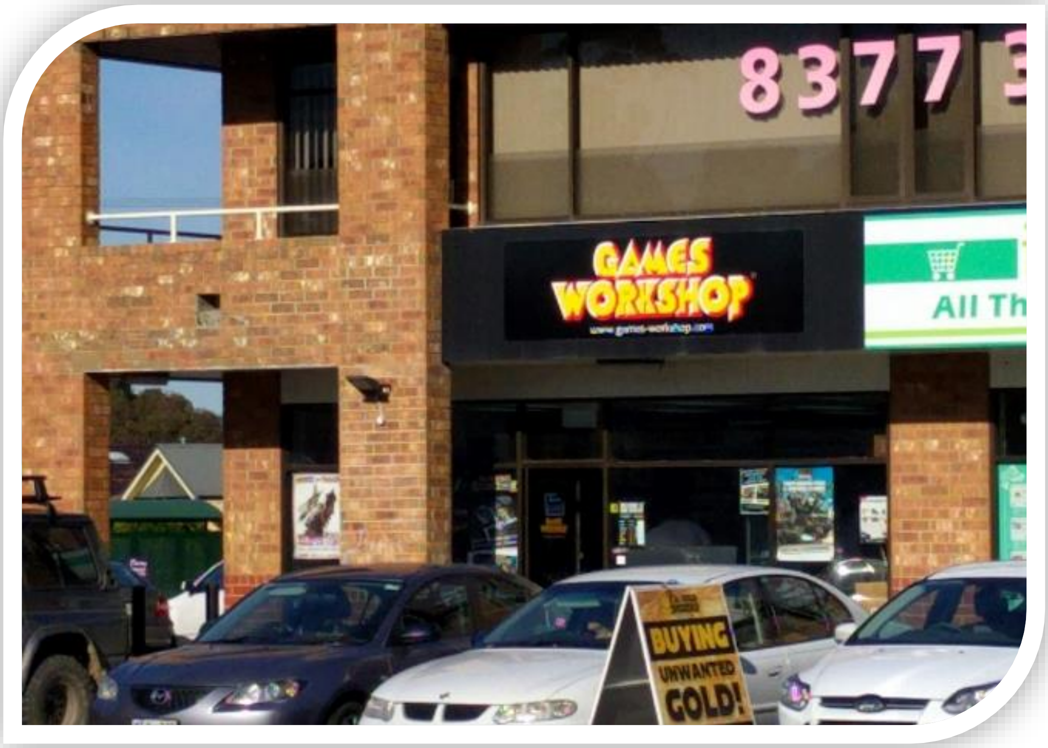
   Warradale Pizza House is a restaurant that offer familiar fast food. It can be accessed by Diagonal Road.

Figure 68. Warradale Pizza House

5. Games Workshop

Address: 241 Diagonal Rd, Warradale SA 5046

Games Workshop is a retailer of fantasy board games also selling miniatures for painting. It can be accessed by Diagonal Road, Dunrobin Road and



Walkey Ave.

Figure 69. Games Workshop

6. Coles Supermarkets

   Address: 238 Diagonal Rd, Warradale SA 5046

   Coles Supermarkets is a comprehensive supermarket, closely related to the lives of nearby residents. It can be accessed by Diagonal Road, Prunus Street and Morphett Road.

Figure 70. Coles supmartets

7. Alsham Supermarket

   Address: 60 Railway Terrace, Warradale SA 5046

   Alsham Supermarket is offering fresh zabiha halal Fresh, baked bread and pastries everyday groceries. It can be accessed by Diagonal Road.

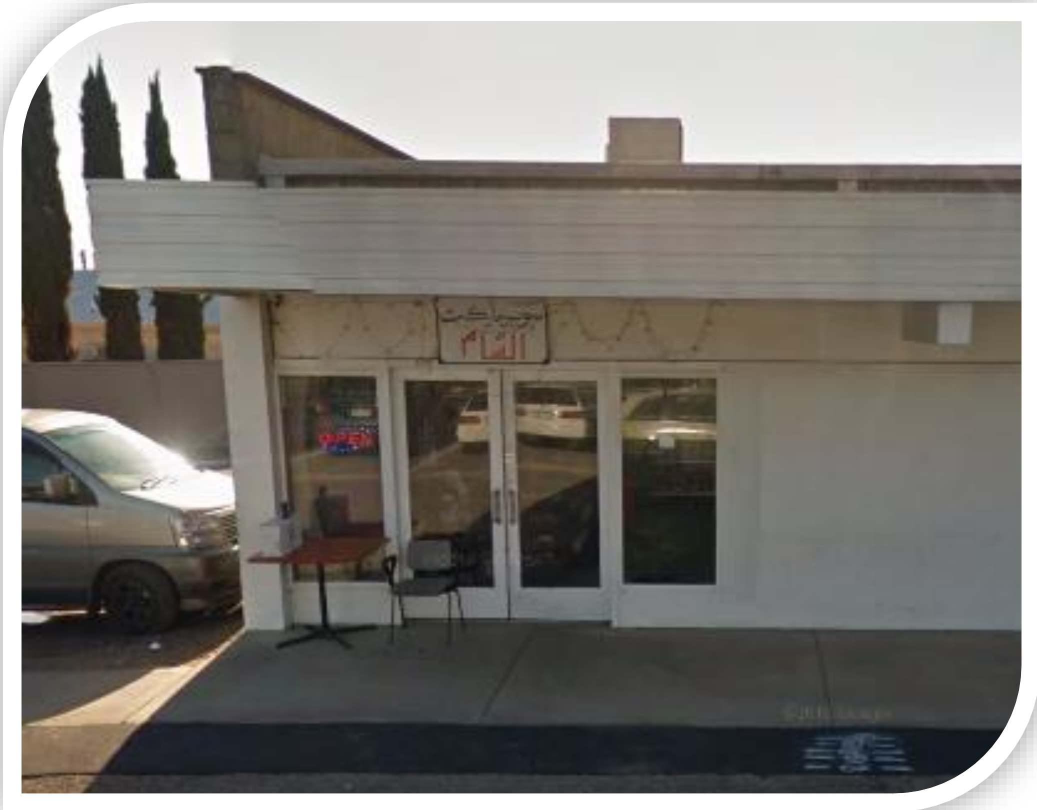


Figure 71. Alsham Supermarket

8. Coin-op Laundromat/Laundry

   Address: 251 Diagonal Rd, Warradale SA 5046

   Coin-op Laundromat/Laundry offers Laundromats services in Warradale, SA

   area. The main accesses is by Morphett Road and Diagonal Road.

Figure 72. Coin-op Laundromat/Laundry

9. Splodge Corner

Address: 253 Diagonal Rd, Adelaide SA 5046

Crafty Fun for Kids. Specialising in Parties, Corporate Events & Workshops. The main accesses is from Railway Terrace, Morphett Road and Diagonal Road.

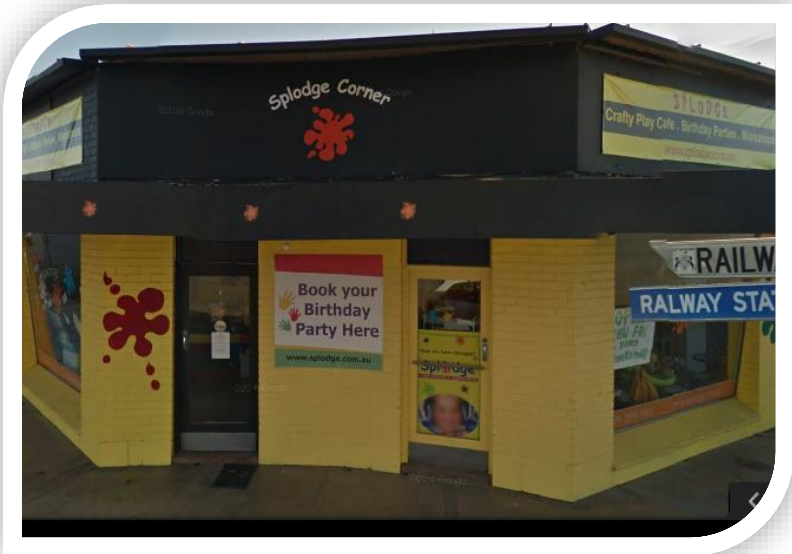


Figure 73. Splodge Corner

10. SA Aquatic and Leisure Centre

    Address: 443 Morphett Rd, Oaklands Park SA 5046

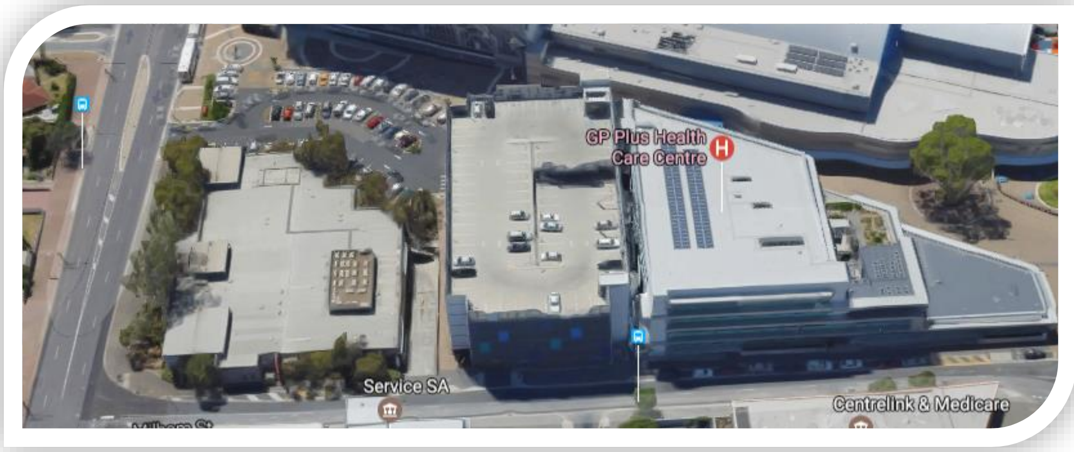
    SA Aquatic & Leisure Centre is South Australia's premier state of the art health and recreational facility. It can be accessed by Morphett Road, Diagonal Road and Milham Street.

Figure 74. SA Aquatic and Leisure Centre

11. GP Plus Health Care Centre

    Address: 10 Milham St, Oaklands Park SA 5046

    The GP Plus Health Care Centre offers a broad range of health care services. The main access is from Diagonal Road, Morphett Road and



Milham Street.

Figure 75. GP Plus Health Care Centre

12. Westfield Marion

    Address: 297 Diagonal Rd, Oaklands Park SA 5046

    There are lots of business in Westfield Marion shopping centre, such as Bunnings, Dan Murphy's, BIG W, Coles, Kmart, Jay Jays, Target and so on. It can be accessed from Strut Road, Morphett Road and Diagonal Road.

4.4.5.2 Rail overpass impact on local business

During the construction, all of the local business listed above will have a reduction in traffic congestion due to railway construction, thereby reducing traffic flow and human flow. For the local business No.1 to No.9, customers are mostly from the north of railway terrace. If the customer who comes from the south of railway terrace he/she need make a detour by Brighton Road or Marion Road. This is very inconvenient, some customers maybe choose other alternative option. So in the process of railway construction, the local business will be depressed. For the local business No. 10 and No. 12, customers are mostly from Diagonal Road (south) and Morphett Road. For the same reason, the local business will be depressed. After the construction of rail overpass, the frequencies of railway line will be increased, and also the traffic flow with Diagonal Road and Morphett Road will be increased. There for, the local business will have a significant improvement.

4.4.5.3 Road overpass impact on local business

The impact on local business of road overpass is similar with rail overpass, in the course of construction will have a negative impact on the surrounding business, and have a promotion of the commercial after the completion of the construction. Because most of the local business was located along Diagonal Road, so the Road overpass option will have a significant impact on the business. Furthermore, some local shops (like Warradale Pizza House) just can be accessed by Diagonal Road, so that, these shops need to be closure during the construction of Diagonal Road. Also because of the complexity of road overpass construction environment, the construction time of road overpass is greatly prolonged. This will increase the impact on local business.

4.4.5.4 Impact on Main Recreation and Tourism Building

Figure Recreation and Tourism

There are few recreation and tourism component around such as SA Aquatic and Leisure Centre, Greenway, Oaklands Estate Reserve, and Sturt Oval. From the figure above, the recreation and tourism avoided major disruption impact from the construction site.

Currently the greenway is sharing the crossing of the rail line at Morphett Road. During construction phase, the greenway will been shut down due concerning the safety of the pedestrian and cyclist. However, any possible and appropriate detour will be considered to provide alternative accessibility which avoid disruption of the community. In contrast, the development of overpass provides a better opportunity to redesign the greenway with a safer and smoother ride.

By the space created below, the cycle movement can be enhanced across Morphett road with traffic signal or other appropriate traffic systems. However, the opportunities of improvement will depend on the final design in detail design stages.

Through the investigation, most of business which along the Diagonal Road have been identified. And also the large passenger flow volume business community have been identified, these businesses will be seriously affected during the construction, so is required to be made a high priority.

4.4.6 Community Consultation Plan

Community management plays a very important role in urban planning. Having a good community consultation capability can reduce a lot of trouble in the construction of the project. Community Consultation Plan will make a great contribution to the construction process.

Our goal is to maximize the information with less interference. Therefore, the entire project will need a wide range of community and stakeholders to cooperate with each other.

The proposed project will be very rewarding for stakeholders and communities. Because they will become customers in the future.

We will have Community assistance, Community consultation and Community engagement. These are all in order to better run the entire project, reduce unnecessary trouble.

4.4.6.1 Community Engagement Strategy

Main issues from community:

- Traffic effects: pedestrians, cycling, freight,
- Property impacts
- Affect the local connectivity and access

- Environmental influence

We will establish a variety of information platform to provide the project team contact and information release. They will be provided with a lot of information about the project. Better communication can provide communities and stakeholders with an opportunity to focus on relevant feedback.

The company will build on site community rooms nearby of construction area to solve residents, businesses, and other stakeholder problems. Once the Small office receive complaints, we will make the appropriate strategy based on the content of the complaint. Collaboration is the most challenging goal to be achieve and the most efficient way to comfort the community. Public aspect will be the highest priority when identifying community complaints.

4.4.6.2 Business Consulting:

The impact caused during the construction period.

Whether to maintain the current visit

How to deal with occupied land and acquisitions

This business management plan will focus on ways to mitigate their impacts during the construction phase.

For example: open a forum every 2 hours to update, so that businesses can get some information. This forum will continue to update, and it can receive business feedback. The forum will set a fixed time to meet, for example: there will be a big meeting every 2 months, the meeting will report the current construct situation and solve some problems.

4.4.6.3 School Counseling

School participation programs are very effective programs. Because the surrounding students are living in the vicinity. So, communication with the school is very important. Because it is possible to inform the parents of some important information on the school website. This allows parents to understand the project information. So active cooperation with the school is necessary.

4.4.6.4 Complaints management

The dissatisfaction expressed by tenants, businesses and stakeholders will be dealt with seriously. Classify all complaints according to different circumstances, types and times. Will communicate with community team members, project community consultants, community managers and community team members.

All complaints and inquiries must be promptly recorded, confirmed, and resolved.

When we get complained, we should express our understanding. Then, inform the other side that we will give the complainant the corresponding answer after 1 working days. All complaints will be resolved via email or phone. We will do related consultation to manage and determine the ongoing problems. We need to understand the importance of stakeholder relationships with the community, and make the success of the project ultimately. The company will provide relevant training to understand the community's expectations and needs and be able to handle any complaints and enquiries. Throughout the project, the team has the ability to make meaningful contributions through investing in community life. We are actively improving community and business outcomes, seeking opportunities, honest communication, and maximizing community engagement.
During the construction period, if the residents or businesses have an impact, the company will give them corresponding economic compensation according to the situation.

4.4.6.5 Information database collected

We need to record detailed feedback from residents, businesses, and stakeholders.

Because people's feedback is very important. Knowing the feedback information is to understand the idea of households and businesses which is more conducive to solving the problem.

The details of the time, content and type of all feedback are recorded. Will get some common feedback. Managers need to be aware of whether these feedback is beneficial to community projects.

In addition, Community feedback also shows whether they support the operation of the project. To a large extent, the opinions and comments provided are very useful for the project and indicate the expectations of the community for the future.

4.4.6.6 Community Engagement Channel

Several technology and methodology we might include to provide the community with information at high efficiency. Besides that, maintaining and improvement of our connectivity between the community also relatively important.

Communication Techniques that applied:

- Web based engagement or Website information
- Public Meeting
- Street Stalls
- Facebook
- Newsletters
- Photography and Video

Web based engagement or Website information

The advantages of using web-based engagement are very cost effective and is convenient for communities that cannot attend any construction information event. DPC suggests that during both the design and construction phases that a web basesed engagement system be setup up and maintained.

Public Meeting

Figure 2 Public Meeting

Benefits from public meetings is the opportunities to provide information and gather feedback is very efficient. Besides that, community consultation can be conducted directly during the meetings. More opportunities to attract publicity and enhance their participations to any future events

Street Stalls

Figure 3 Street Stall

By using this method, our team can easily collect communities' suggestion and views in a huge amount of people. Maps and plans for construction project will be displayed which provide information efficiently. At the same time, local communities can comment and share their thoughts for our project. Such events are very helpful in getting communities attraction and generates their interest.

Newsletters

Newsletters is a very informative message, and the content is extremely simple. Compared to Facebook, its cost is expensive. However, it spreads more widely. News letters are a proven way to engage the community within your target area, they are especially effective with people of the older generation of which may not have access to social media.

Social Media

Use Facebook to constantly update the new progress and activities.

Now, a lot of young people use this APP. So, Facebook is very convenient to update the project information for young people. In addition, Facebook's promotional costs are more economical. Last but not the least, social media sites can also collect some feedback about residents, businesses, and stakeholders.

Nowadays, everyone likes to watch and share videos. Video promotion information is a very good way to advertise.

It spreads better than words and pictures. We all know that the video views is very large, the transmission speed is very fast. Features of video is intuitive, simple to share, accurate and cost-effective.

In conclusion, these are the engagement plan that currently our team try to focus on. However, further efficient engagement plan will be considered depends on the reaction from the communities.

4.4.7 Recommendation

The table shown below summarised all of the issues involved with the application of both Option 1 and 2.

Table 15 - Urban Planning and Community evaluations

Criteria	Sub-Criteria	Rail Overpass	Road Overpass
Land Acquisition	**Residential**	Estimated negligible Land Acquisition	Significant Land Acquisition North and South direction
	Business	Estimated negligible Land Acquisition	Significant Land Acquisition North and South direction
Important Building	**School**	None within construction area	Existing building within construction area
	Temple, Church	None within construction area	Existing building Nearby construction area
	Residential Care	None within construction area	Existing building nearby construction area
Accessibility	**Local Road**	Less Impact on Local Accessibility	Huge modification on local road accessibility
	Pedestrians	More opportunities to improve pedestrian's accessibility	More opportunities to improve pedestrian's accessibility
	Cyclists	More opportunities to improve cyclist's accessibility	More opportunities to improve cyclist's accessibility
	Public transport	Less modification for existing bus accessibility	Huge modification for existing bus accessibility
Economy	**Local Business**	Insignificant Impact during construction phase	Multiple business demolishes for the development
	Construction cost	Low costing due to none specific land requirements	High cost for private land and business requirements and mitigation impact

Criteria	Sub-Criteria	Rail Overpass	Road Overpass
Impacts after developments	**Connectivity**	More opportunities to perform improvements	More opportunities to perform improvements
	Business	Human flow, traffic flow increased	Human flow, traffic flow increased
	Opportunities	Employment improvement	Employment improvement
Construction	**Timing**	Less Construction Process	High Construction Process

Table 16 - Final Recommendation based on community impact

Criteria	**Sub-Criteria**	**Options 1: Rail Overpass**	**Options 2: Road Overpass**
Land Acquisition	**Residential**		
	Business		
Important Building	**School**		
	Temple, Church		
	Residential Care		
Accessibility	**Local Road**		
	Pedestrians		
	Cyclists		
	Public transport		
Economic Impact	**Local business**		
	Construction cost		
Impact After Developments	**Connectivity**		
	Business		
	Opportunities		
Construction	**Timing**		
Feasibility Result		√	

Table 16 above showing the summary of all urban and community aspect and criteria summary clearly summarize all the impact that might happen for both options. As the table shown that, most of the impact are coming from road overpass options. Among all these aspects, the most significant impacts are land acquisition for options 2: road overpass. In conclusion, rail overpass is the most recommended options from urban planning design aspect.

5 Feasibility Summary

5.1 Summary

Each of DPC's expert engineering teams have completed their in-depth and extensive evaluations of the final two concepts for the upgrade of the Diagonal and Morphett Road Rail Intersection. During these evaluations DPC has critiqued all factors that may influence the final design outcomes for the project.

5.2 Recommendation

Following the evaluations by each of our expert engineering teams DPC has combined all the information gathered to produce a final recommendation. This final recommendation encompasses all of the design criteria set out by the client along with all relevant standards and specifications.

Based on the analysis completed by DPC it is our recommendation that the grade separation of the Diagonal and Morphett Road Rail Intersection is completed as a Rail Overpass or Option 1. A Rail Overpass at the intersection will allow traffic to flow freely and safely, while ensuring that all client demands are met.

5.2.1 Assumptions and Omissions

This feasibility study assumes that all assumptions laid out within the initial tender proposal are acceptable. The design of the pavements, structures and geotechnical structures have all been simplified to allow them to be designed during the detailed design stage, this is due to the level of experience and education of those doing the design.

5.3 Cost

5.3.1 Expected project cost

The Expected project cost is based on the design teams evaluation of the works required. The part of cost in the final recommendation should be taken as indicative and not as a comprehensive representation of the final project cost, this is due to the costing process being simplified to enable it to be completed in the allotted time. If this feasibility study was to be completed again with more allotted time the costing mechanisms could be improved to give a better representation of the actual project cost. The costing will be revaluated during the detailed design stage, of which will give a better but not perfect cost estimate.

Table 17 - Expected Project Cost

Area	Expected Cost
Transportation	$ 4,487,800.00
Structures	$ 3,371,321.70
Geotechnical	$ 1,836,694.00
Urban Planning and Community	$ 200,000.00
Services	$ 1,152,650.00
Environmental	$ 6,415,000.00
Total	**$ 17,463,465.70**

DPC expected the final cost of the project to be in the neighbourhood of $17,500,000. This total cost for the project is based on the evaluations and costing from the 6 design teams.

5.3.2 DPC Design Cost Forecast

The Design costs for DPC to complete the final design stage of the project are listed below. All rates are to be taken as inclusive unless otherwise specifies.

Over heads			
Administration			**$ 10,000.00**
insurances			**$ 8,000.00**

Position	**Rate**	**Hours**	**Total**
Management			
PM	240	105	$ 25,200.00
APM	200	105	$ 21,000.00
Total:			**$ 46,200.00**

Structures			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
PE	150	105	$ 15,750.00
Grad	120	105	$ 12,600.00
Grad	120	105	$ 12,600.00
		Total:	**$ 75,600.00**

Services			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
PE	150	105	$ 15,750.00
Grad	120	105	$ 12,600.00
Grad	120	105	$ 12,600.00
		Total:	**$ 75,600.00**

Enviromental			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
PE	150	105	$ 15,750.00
Grad	120	105	$ 12,600.00
		Total:	**$ 63,000.00**

Urban Planning and Community			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
Draftsperson	130	105	$ 13,650.00
Senior Architect/Urban Planner	180	105	$ 18,900.00
Architect/Urban Planner	130	105	$ 13,650.00
		Total:	**$ 80,850.00**

Geotechnical			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
PE	150	105	$ 15,750.00
Grad	120	105	$ 12,600.00
Grad	120	105	$ 12,600.00
		Total:	**$ 75,600.00**

Transport			
Position	**Rate**	**Hours**	**Total**
Manager	180	105	$ 18,900.00
PE	150	105	$ 15,750.00
PE	150	105	$ 15,750.00
Grad	120	105	$ 12,600.00
grad	120	105	$ 12,600.00
		Total:	**$ 75,600.00**

Total Contract Value:	**$**	**510,450.00**

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7 Appendix

7.1 Design Loads for Road overpass

Dimensions:

Slab:

Slab thickness= 250mm

Slab total span= 80m

Slab Width= 30m

Tee beam:

Width = 2.5m

Height =1.8m

Head stock:

Depth= 1m

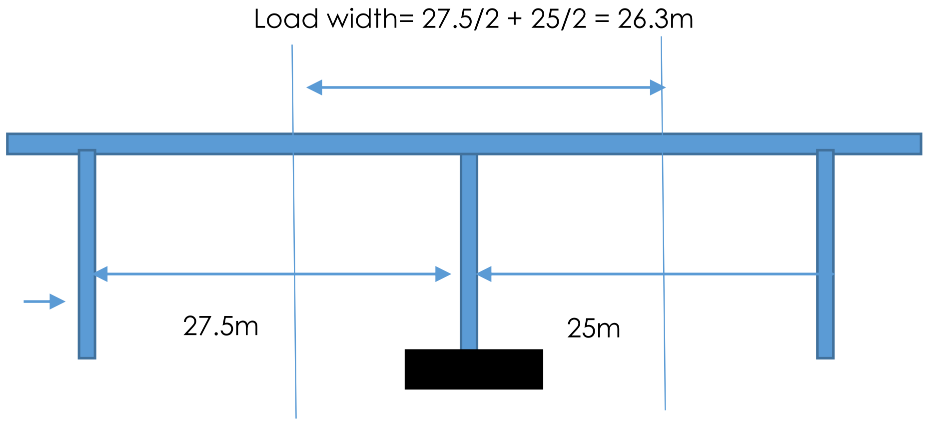
Column:

1mx1m square column

Column height = 5.4m

Capping beams:

Depth = 1.5 m



(Note: this is a long section view of the bridge, total span =80m)

Dead loads:

Slab Self weight:

$$d * b * h * \rho = 0.25 * 26.3 * 30 * 24 = 4734KN$$

Head stock:

$$d * b * h * \rho = 1 * 1 * 30 * 24 = 720KN$$

Capping Beam:

$$d * b * h * \rho = 1.5 * 1 * 30 * 24 = 1080KN$$

Column Self-weight:

$$\pi * (\frac{d}{2})^2 * h * \rho = 3.14 * \left(\frac{1}{2}\right)^2 * 5.4 * 24 = 101.7\ KN$$

Super tee girder:

$$12 * 1.777\frac{t}{m} * 25m = 533T = 5330KN$$

Total Load:

$$4734 + 720 + 1080 + 101.7 + 5330 = 10988kN$$

Live Loads:

According to AS5100.2 cl. 7.2.5, the live load for stationary traffic is considered to be as follows:

Live load = 24 kN/m

Hence,

Live Load= 24 kN/m X 26.3m = 631.2 kN

Combination Load

Fd= 1.2G+1.5Q

= 14132.4 kN

7.2 Design Loads for Rail Overpass

Dead load of railway:

For steel railway sizes, 50 kg/m and 60 kg/m are the current standard in Australia. (Australia government website)

Total dead load of steel track is 60*25 = 15 KN (use 60kg/m)

For bulk density = 1200 kg/m^3 (from AS2758.7)

Thickness of ballast is 350mm (from AS2758.7)

The total dead load of ballast is:

1200 kg/m^3 * 8m * 0.35m * 25m = 840 KN

Column:

$$\pi * (\frac{d}{2})^2 * h * \rho = 3.14 * \left(\frac{1}{2}\right)^2 * 5.4 * 24 = 101.7\ KN$$

Head Stock:

$$d * b * h * \rho = 1 * 1 * 8 * 24 = 192KN$$

Slab:

$$d * b * h * \rho = 0.25 * 25 * 8 * 24 = 1200KN$$

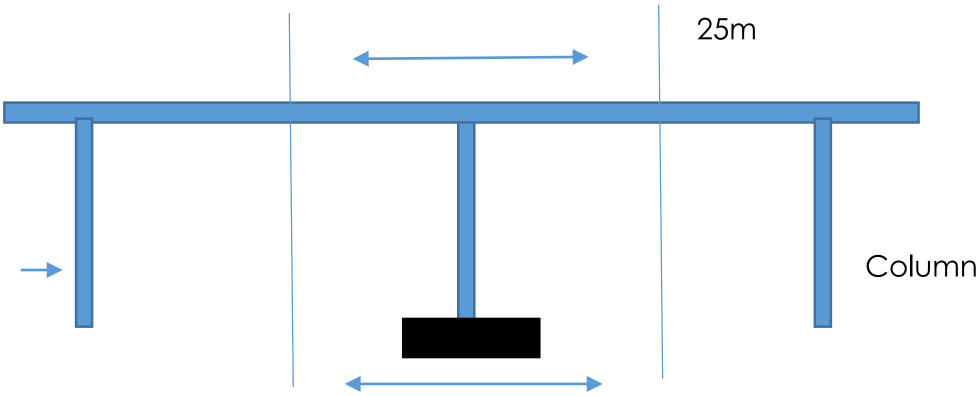
Capping Beams:

$$d * b * h * \rho = 1.5 * 1 * 8 * 24 = 288KN$$

Super tee girder:

$$4 * 1.777\frac{t}{m} * 25m = 177.7t = 1777KN$$

Total dead load of bridge = 101.7 X 2 + 288 +1777 + 1200 + 192= 3660.4 KN



Total Dead Load of 25m of bridge is 2070.7KN

Therefore, the total dead load of the structure for railway overpass is:

840+101.7*2+192+1200+288+1777 = 4500kN

Live Loads:

Calculation is based on AS5100.2, Clause 8.5

Unfactored design live load = (1+a) * static live load

Where a is dynamic load allowance

- Calculation of a

For bridge abutments

Characteristic length $L_\alpha = 25m$

$$\alpha = \frac{2.16}{{L_\alpha}^2 - 0.2} - 0.27 = 0.18$$

For bridge, intermediate piers

Characteristic length $L_\alpha = 50m$

$$\alpha = \frac{2.16}{{L_\alpha}^2 - 0.2} - 0.27 = 0.044$$

- Calculation of static live load

Based on research

Weight of a train carriage is 48 tons, which is 480kN

106 passengers in a train carriage averagely, and an average weight of 74kg each passenger

Weight of passengers = 74kg*106=7844kg, which is 78.44kN

Usually, a train has 6 carriages on the railway, total weight of a train full with passenger = (480+78.44)*6 = 3351kN

- Calculation of unfactored live load

For bridge abutments

unfactored live load = (1+0.18)* 3351=3954kN

For bridge intermediate piers

unfactored live load = (1+0.044)* 3351=3499kN

A separate platform structure designed

Design concept

- Supported by 1m diameter circular column at each 32m span, one end side supported by retaining wall
- I beam and Lysaght slab used
- From AS5100.5, Type 4 I beam supported by columns
- For the span of columns at long direction, Type 2 I beams used and are supported by Type 4 I beam girder, and each span of Type 2 I beam is 500mm, 14 Type 2 I beams used along the direction of Type 4 I beam
- Lysaght slabs are at the top of Type 2 I beams, refer to Lysaght structural deck documents, Powerdek is selected, 100mm slab thickness

Calculation of dead loads, 32m of load width

Refer to AS5100.5 appendix H

Self-weight of column = 3.14*(1m/2)^2*5.4m*24kN/m3=101.7kN

Self-weight of Type 4 I girder = 0.443m2*6.5m*24kN/m3=69kN

Self-weight of type 2 girder = 0.218m2*32m*4*24kN/m3=670kN

Self-weight of slab = 6.5m*32m*0.1m*24kN/m3=499kN

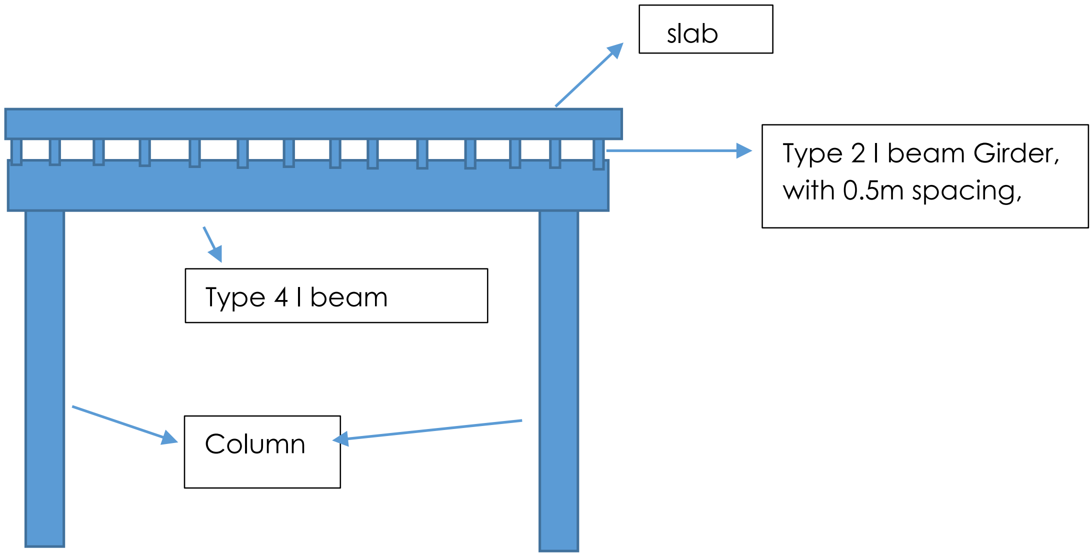
In conclusion, total dead load = 101.7*2+69+2344+699=3315.4kN

Live load

Refer to AS 1170.1, a platform is categorized to C3, ground level subject to wheeled vehicles, 5kPa selected. Load acting area is 32m*6.5m=208m2

Live load = 5kPa*208m2=1040kN

Platform design Section view:



Platform design Front view: