Project:

Oakland's Park Grade Separation

Document:

Detailed Design Report

For:

Department of Planning, Transport and Infrastructure (DPTI)

By:

DPC Engineering

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DOCUMENT DECLARATION STATEMENT

This document has been developed by students from the University of South Australia as part of a Civil Engineering Design Project. This document and any associated works relating to it is for the purposes of academic study only and does not represent the views or opinions of the end client (Department of Planning Transport and Infrastructure).

DECLARATION

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.

DPC 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.

Sincerely,

Jia Shi

Project Manager

Kavvithiran S Rajendhiran

Assistant Project Manager

EXECUTIVE SUMMARY

DPC Engineering presents this detailed design document for Oaklands Park Grade Separation Project in South Australia. The purpose of this document is to propose a detailed design for this project that will overcome current traffic issues and accommodate future traffic volume. Diagonal and Morphett Roads are the major roads that involved in this project. These roads connect between most of the western and southern suburbs with Adelaide city centre. Both major roads intersect with Seaford Rail Line which creates significant traffic issues due to the increase in the traffic volume. Besides that, rapid development in Marion area also contributes significantly to the traffic issues.

Several stages were completed beforehand to produce a detailed design for a concept that will be most feasible for the project. The first step undertaken in this process was creating an initial evaluation of four different concepts to choose a suitable structure to solve the identified issues. Two options namely railway and road overpass were narrowed done in this stage and a depth evaluation and research of both concepts were done in the feasibility stage. Thereafter, railway overpass concept was chosen as the most feasible option for this project based on depth research from various department of DPC Engineering and detailed design were carried out and presented in this document.

DPC Engineering assigned each department in the company to undergo detailed design for railway overpass concept to implement in the Oaklands Park Grade Separation Project. Department of Planning, Transport and Infrastructure (DPTI) as the main client of this project, the railway overpass concept was designed according to their requirement and expectation. Supplementary stakeholder's requirements were also taken into consideration during the detailed design stage to meet their expectation. Various upgrade including environmental consideration and community preferences were also outlined in this document. The total costing to build this structure in Oaklands Park would be approximately 58 million dollars.

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1 INTRODUCTION

Oaklands Park Grade Separation Project contributes a significant role in the 30 years Great Adelaide Plan. This project upgrades the intersection of Diagonal and Morphett Road with Seaford Rail Line. The particular intersection was mainly highlighted by Department of Planning, Transport, and Infrastructure (DPTI) because there was a significant rise in the traffic issues. Besides that, the project was initiated in 2008 by the state government and the costing was estimated between $100 to &110 million. The intersection causing major delays to the users and affects the businesses around the area. Previous surveys show that 4000 vehicles cross the intersection and railway boom gate closes up to 130 times daily which causes significant traffic issues. Hence DPC Engineering was assigned by the client to design a most feasible concept that will be able to solve current traffic issues and also future traffic volume.

DPC Engineering has adopted the railway overpass concept after the completion of the initial evaluation and feasible stage. In the detailed design stage, DPC Engineering will produce a detailed report, architectural and engineering drawings of all physical components that involved in the project. This project involves multi-disciplinary of engineering sectors including structural, water, and transport departments. Hence, the sectors involved in this project have designed all the physical components via report and drawings. Besides that, a pre-construction plan final costing for this project will also be exhibited.

DPTI as the owner of the project required several expectations that have to be meeting by the project implementation as listed below.

- Reduce current traffic issues.
- Accommodate future traffic volume.
- Design to increase the number of Seaford Rail Line services.
- Enhance public transport coordination.
- Enhance safety for cyclists and pedestrians.

Besides that, supplementary clients that involve in this project are Marion City Council and residents around the project's site. DPC Engineering will consider all the expectation and will provide the best solution to implement the expectations. Each department of DPC

Engineering will follow the legislations and procedures set by the company and design the concept in accordance with the Australian industry's standards.

TRANSPORTATION

2 TRANSPORTATION

ABBREVIATION LIST

Abbreviation	Description
DPTI	Department of Planning Transport and Infrastructure
SIDRA	Signals Intersection Design and Research Aid
DPC	Design Planning and Construction

2.1 Scope of work

The Oakland Park Grade separation is one of the major projects which includes Rail overpass and the diagonal road upgrade. The scope of the work that transport team will be responsible for this project is listed below.

- The AutoCAD drawing which includes alignments for new upgraded roads and overpass
- The AutoCAD drawing for car-park at the train stations
- Overpass detailed drawing with alignments
- Detailed drawing Upgraded Road including bus stops.
- Make Sure all designs are according to Australian Standard and AUSROADS Guide
- Analysis the performance of the new Upgraded roads using SIDRA software
- SIDRA analysis report outcome include Level of service based on delay for the Network
- SIDRA analysis report outcome include level of service all three upgraded intersection
- Discussion on SIDRA analyses outcome recommendation and Limitation
- Traffic management during construction and post-construction the
- Traffic control plan
- Provide an alternate route for public services such as train and busses.
- Alternate route for public commuters
- Maintain the safety protocol at 100% for road user
- Proper signage along the route
- The Standard specification used are listed in Table 1 and 2.

2.2 Approach to Final Drawing

The railway and road grade separation was required to avoid the delay of traffic due to the railway crossing. The four possible options were proposed during the tender stage, railway overpass, railway underpass, road overpass and road underpass. Furthermore, during early feasibility stage, the DPC company analysed the all four possible options to overcome with 2 feasible options, railway overpass and road overpass. In addition, each department did further investigation on those two options and finalise our one possible solution for Oakland Park Grade Separation, which is railway overpass. Thereafter, transport team designed final railway and road alignment based on the client's requirement during the final design stage.

2.2.1 Railway Alignment

From the feasibility study of this project, transport team has determined few recommendations that can be applied to the final design of this project. The total length of railway track would be approximately 730 metres, which about 540 metres will be in the grade of 2.2 percentage. The railway station platforms and footpath to cross the Diagonal Road and Morphett Road intersection occupy about 190 metres.

The dimensions of footpath, broad gauge, clear circulation zone and platform clearance will be complied with the Australia standard to make sure that the design meet the requirement of DPTI. During detailed design stage, there have been changes made along with another department such as structure to make sure this design is much more realistic and reasonable. The total width of the physical structure zone was reduced to 2 m from 4 m which were proposed in the feasibility stage based on the recommendation of other departments.

Since the structure team has designed the T-beam depth of 1.8 m in the railway overpass, the initial length of the railway line will be extended from 730 m to 850 to maintain the grade of maximum 2.2 percentage. Besides that, free area on west side of the diagonal road will not be used for public car-park, hence the initially designed footpath on the platform will not be removed.

The final Railway alignment and platform drawing are shown clearly in AutoCAD drawing under transportation.

Table 1: Elements of railway line considered from Austroad and DPTI Standard

Railway elements	Specification
Vertical clearance (over the road)	5.4 meters
Grade	2.2 %
Broad gauge	1.6 meter
Railway track width	7.35 meter (track Centre to Centre = 4m)
Platform width (marginal platform)	5 meter including loading zone, TGSIs zone, primary access path and physical structure zone
Car–park clearance	3 meter
Physical structure zone	2.0 meter
Primary access path	1.5 meter
TGSIs zone	0.6 meter
Loading zone	0.6 meter
Footpath and bicycle lane (Greenway)	1.5 meter (2.5 meters)

2.2.2 Road Alignment

The transport department during feasibility study decided that the current road alignment has inadequate capacity to hold the future traffic volume and further development required. The railway and road separation will also help to improve the traffic flow effectively with no obstruction and delay. The study during final design stage also provided the evidence of delay occurrence during peak hour in future as per future traffic volume. During the final design stage, transport team did further upgrade on the road alignment with three lanes.

The current road alignment has three main intersections very close and having those intersections reduce the frequency of free flow. Furthermore, SIDRA analysis for the overall network including the Coles intersections has resulted in poor performance. The transport team discussed and come up with the idea of removing the middle intersection which is Morphett Road and Diagonal Road (Coles intersection). The Morphett Road was also connected with car-park, and entry and exit of the car could obstruct the traffic flow. So, instead of Morphett Road, transport team decide to upgrade the Prunus Street having two left turning lane and one right turning lane to the diagonal road and having two right turn lane from Diagonal Road.

The client expectation was to have one main intersection of Diagonal Road and Morphett Road with multiple lanes turning rights. The study shows that, if we connect and make it as one main intersection, it will be under Railway Bridge and platform which is very complex and unsafe design. As we cannot make it as one main intersection and it was also impossible to make right turning lane from Diagonal Road to Morphett Road as an area of median under the bridge on road will be used for a column by structure team. Transport team came with the idea of shifting of Morphett Road close to Coles, which will allow one right turning lane to Morphett Road from Diagonal Road and three left turning lanes From Morphett Road to Diagonal Road because traffic volume of turn left to the Diagonal road is huge.

All side streets are open to Diagonal Road and Morphett Road except Walkley Ave as it is short street and not much traffic flow on that junction. The Dunrobin Road will be upgraded to 2 lanes in each direction at the junction because it has enough space available without any land acquisition and transport team assume that Walkley Ave traffic will use this route to access Diagonal Road.

The final Road alignment and detail drawing of each intersection shown in AutoCAD drawing under transportation.

Table 2: Elements of road alignment considered from Austroads and DPTI Standard

Road Element	Specification
Overall Road upgrade	1157 meter
Lane width	3.5 meter
Median	3 meter
Footpath and cycle lane	1.5 meter

2.2.3 Benefits

The multiple lanes upgrade on roads and the grade separation between railway and road was required due to the traffic congestion. The advantages of this project are listed below:

- The upgraded road will allow traffic flow without any delay during peak hours.
- There will be better transport link between Northern and Western suburb without any interruption with the railway line.
- There won't be any time loss due to queue on railway crossing and they will save their queuing time.
- Safe cyclist, pedestrian and greenway to Marino Rock
- Safer for road user and Improve local traffic systems
- The frequency of railway service can be improved without considering traffic flow on Diagonal Road.
- Maximum number of car-park include access carpark, for train passenger
- Safer Oakland Park interchanges
- The installation of traffic light will minimise the road incidents and safer pedestrian crossing.

2.3 SIDRA analysis

2.3.1 Layout of Upgraded Intersection

The layout of each intersection with the right, left turning lanes and straight going lanes were defined in SIDRA as shown in the figure below.

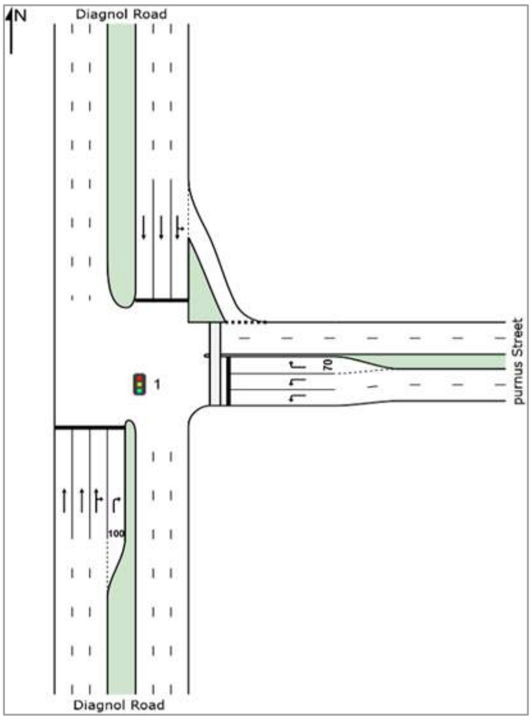


Figure 1: Prunus Street and Diagonal Road Intersection layout

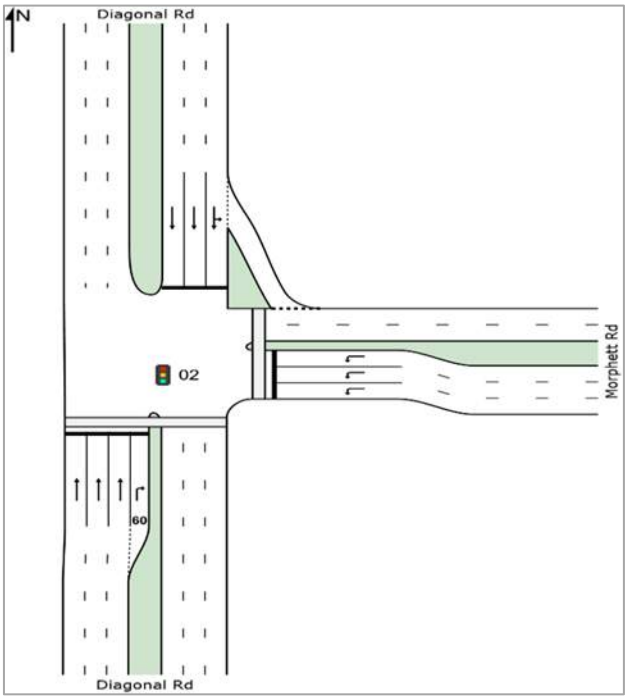


Figure 2: Cole's Intersection layout (Diagonal road and Morphett Road)

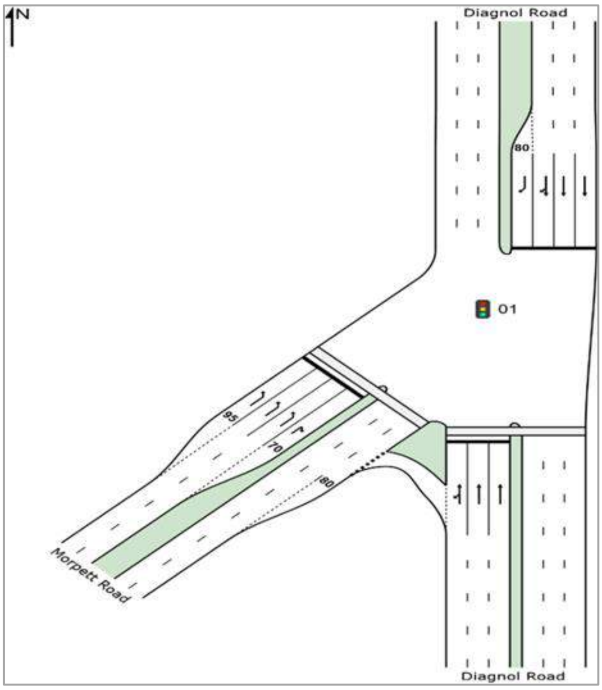


Figure 3: Swimming centre intersection layout (Diagonal Road and Morphett Road)

2.3.2 Overall Network layout

The overall network layout of the upgraded road with three main intersections connected to Diagonal Road. The below network is formed from upgraded model intersections.

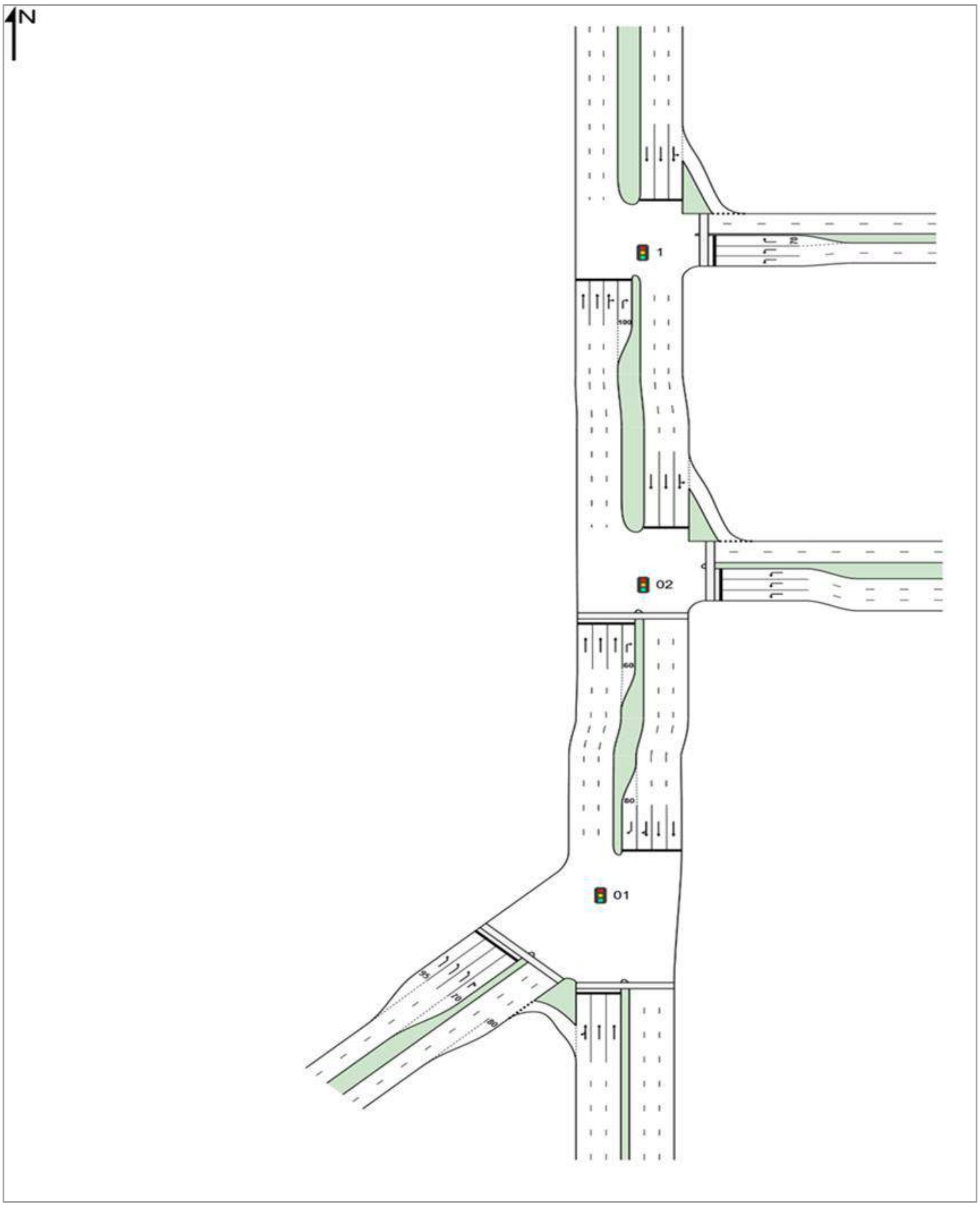


Figure 4: The overall Network of upgrade road

2.3.3 Input data from SIDRA

2.3.3.1 Traffic volume

The below traffic volume was Adopted from Survey Data provided by DPTI, the data that were used based on 2031 traffic volume during the peak hour in the afternoon. This data was used to check whether these new updated roads will able to meet the future traffic demand. As in figure 5, the traffic volume on Diagonal Road heavier than Morphett Road. The below figure also represents the expectation of distribution of traffic flow after construction.

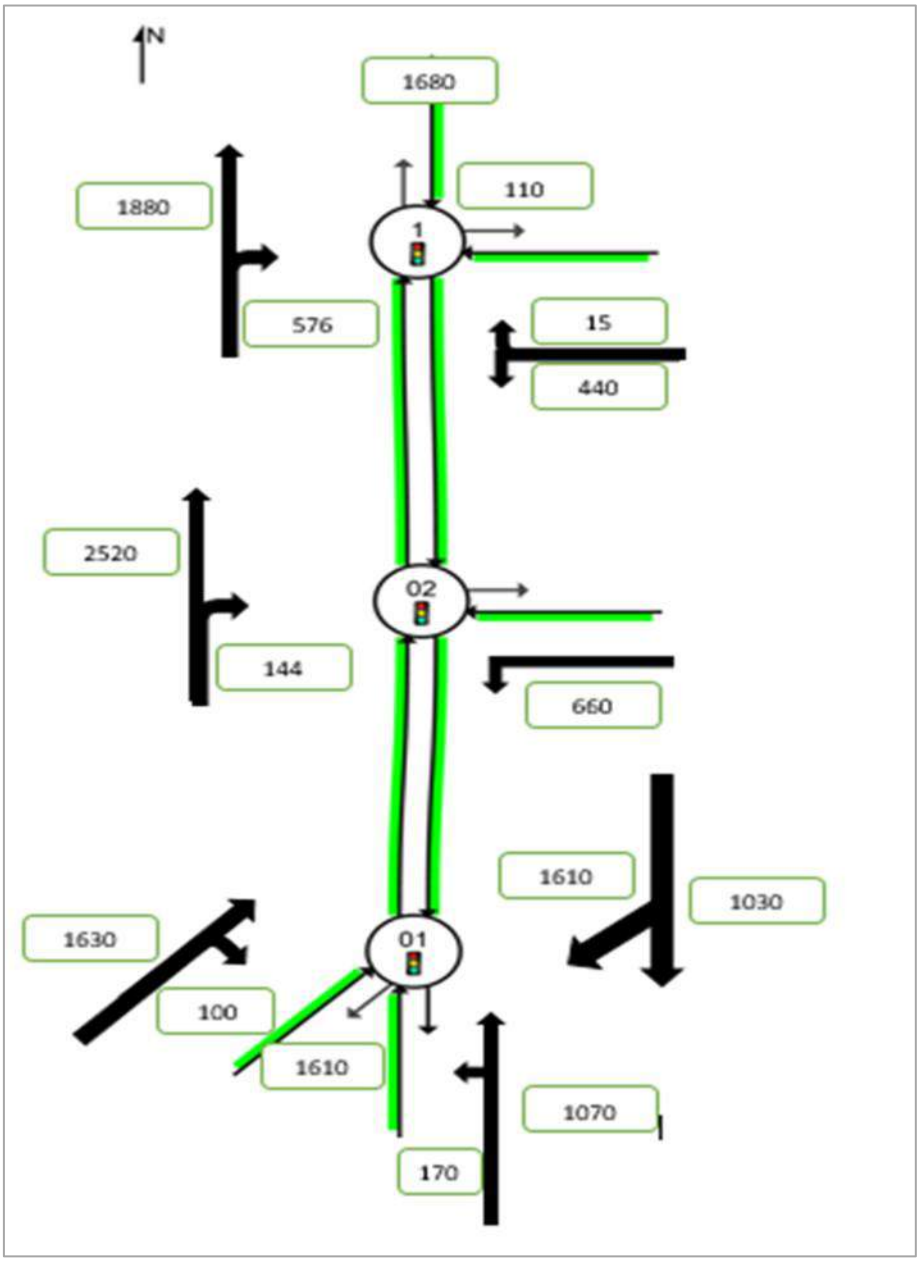


Figure 5: Traffic volume Data input in SIDRA

2.3.4 SIDRA analysis result

The analysis results are shown in tables and figure below for all intersection and overall networks. The analysis result on figures below are coded with colour and definition of colour code is on table 6.

2.3.4.1 Intersection layout and results

1. Diagonal Road and Prunus Street Intersection

The result was analysis for all movement classes include heavy and light vehicles.

Table 3: Results Summary Prunus Intersection

	South	East	North	Intersection
Level of Service (LOS)	B	B	B	B
Degree of Saturation	0.54	0.21	0.58	0.58
Queue Distance (Aver)	41m	11m	36m	41m

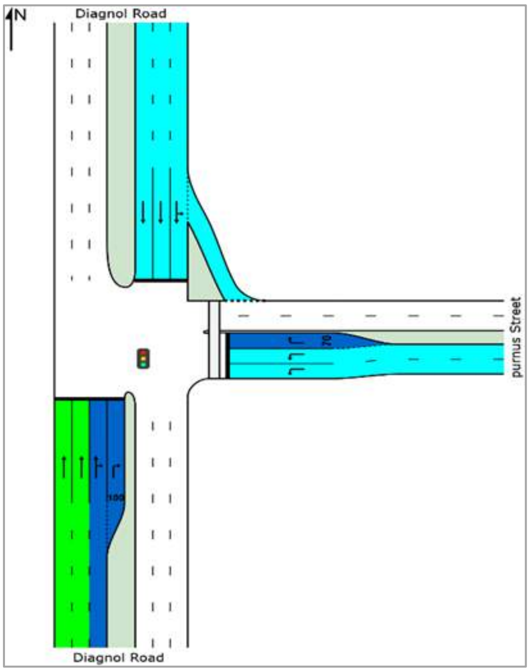


Figure 6: Level of Service with colour code

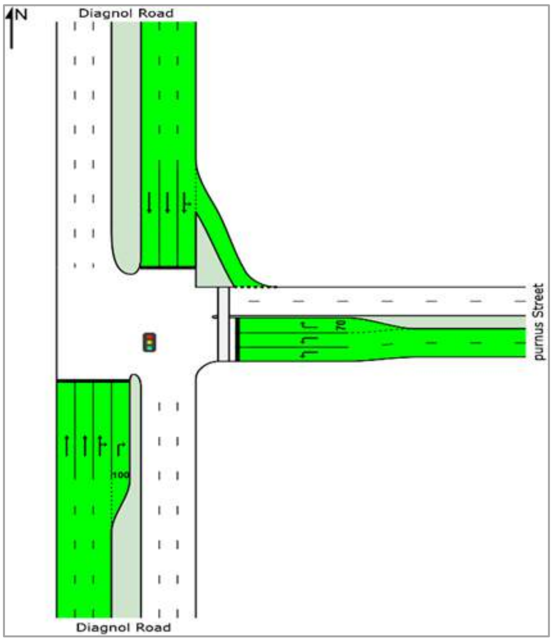


Figure 7: The Degree of Saturation with colour code

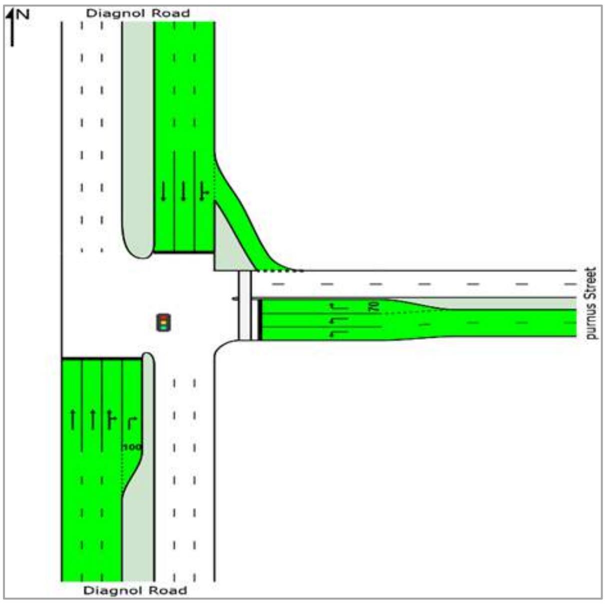


Figure 8: The figure of Queuing Distance Average with colour code

Discussion –

The intersection accommodates approximately 5000 number of vehicles in the morning peak and 6000 number of vehicles in the afternoon peak. There will be a total of four lanes approaching towards the intersection from the southbound of Diagonal Road. Most right lane will be only applicable for a right turn towards Prunus Street.

There are no significant conflicts in this direction as the level of service from the SIDRA analysis is A and B which is among the best category for a road network. Besides that, the analysis shows that southbound of Diagonal Road approaching away from the intersection and eastbound of Prunus Street approaching the intersection also has a satisfactory level of service which doesn't raise any major concern on the traffic issues. The significant conflict from this intersection would be northbound Diagonal Road approaching towards the intersection where the level of service is C and D which is a reasonable outcome from the analysis. These outcomes are affected by traffic volumes and phasing time for each cycle.

The above layout results also give an average traffic queue in the intersection by which means during the peak hour by knowing the queue distance number of the vehicle can be estimated. For example, South approach queue distance Average is 41m while normal standing car cover 6-meter length, therefore dividing 41 by 6 and multiply the number of lanes will provide estimated number of the car waiting at signalised intersection. Furthermore, Level of services and degree of Saturation colour code has been further summarising in detail under heading (level of services and Saturation).

2. Diagonal Road and Morphett Road (Coles intersection)

The result was analysis for all movement classes include heavy and light vehicles.

Table 4: Result Summary of Coles intersection

	South	East	North	Intersection
Level of Service (LOS)	A	B	B	A
Degree of Saturation	0.34	0.18	0.54	0.54
Queue Distance (Aver)	17m	7m	26m	26m

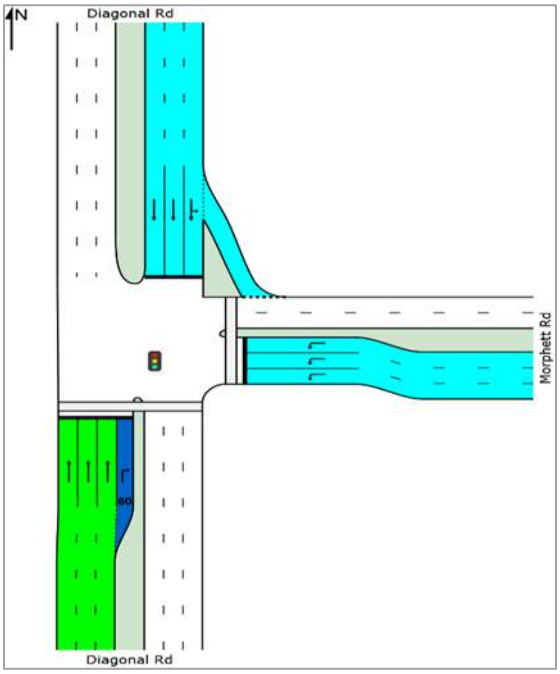


Figure 9: Level of Service with colour code

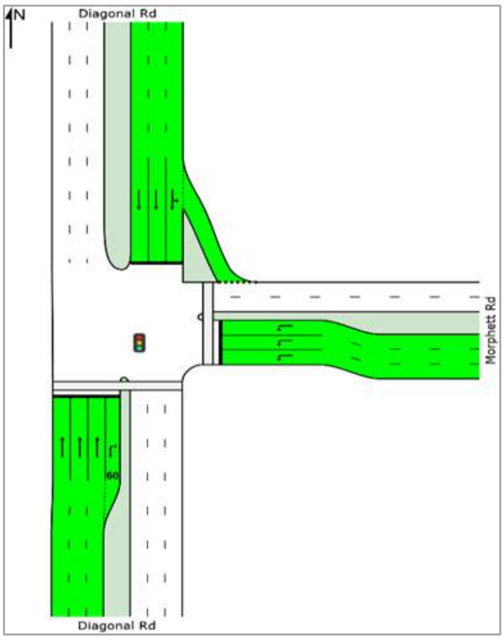


Figure 10: The Degree of Saturation with colour code

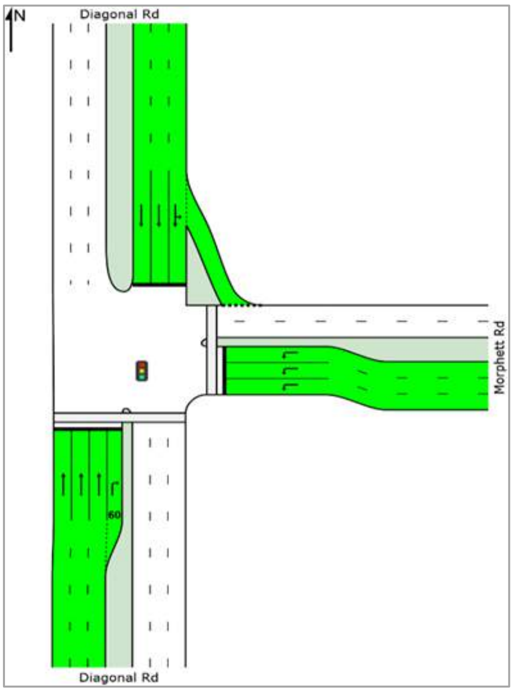


Figure 11: The figure of Queuing Distance Average with colour code

Discussion –

The intersection accommodates approximately 5500 number of vehicles in the morning peak and 6000 number of vehicles in the afternoon peak. There will total of four lanes approaching towards the intersection from the southbound of Diagonal Road. Most right lane will be only applicable for a right turn towards Morphett Road. There is a significant smooth movement in this direction as the level of service from the SIDRA analysis is C for the right turn towards Morphett Road and this is because the total allowable number of vehicles to turn right. As the grade separation project limits the length of the rightest lane in the direction, it also limits the number of vehicles to turn right due to shorter length of shoulder right turn lane.

The overall intersection level of service is A, similarly, the Right turn lane movement could have been better if the number of lanes turning right is increased. Otherwise, the length of the lane is increased but both the option will have impact heavily on the current alignment and affects the structural and services department scope of works. Besides that, the analysis shows that southbound of Diagonal Road approaching away from the intersection and eastbound of Morphett Road approaching the intersection also has a satisfactory level of service which doesn't raise any major concern on the traffic issues.

Furthermore, queue distance along the intersection is exceptionally good and there are no signs of major queue Distance. The level of services and Degree of Saturation with the colour code has been further summarised that can be seen under the heading (Level of Services and Degree of Saturation).

3. Diagonal Road and Morphett Road (Swimming centre intersection)

The result was analysis for all movement classes include heavy and light vehicles.

Table 5: Result summary of swimming centre intersection

	South	North	Southwest	Intersection
Level of Service (LOS)	C	A	B	B
Degree of Saturation	0.61	0.66	0.32	0.66
Queue Distance (Aver)	25m	27m	15m	27m

Figure 12: Level of Service with colour code

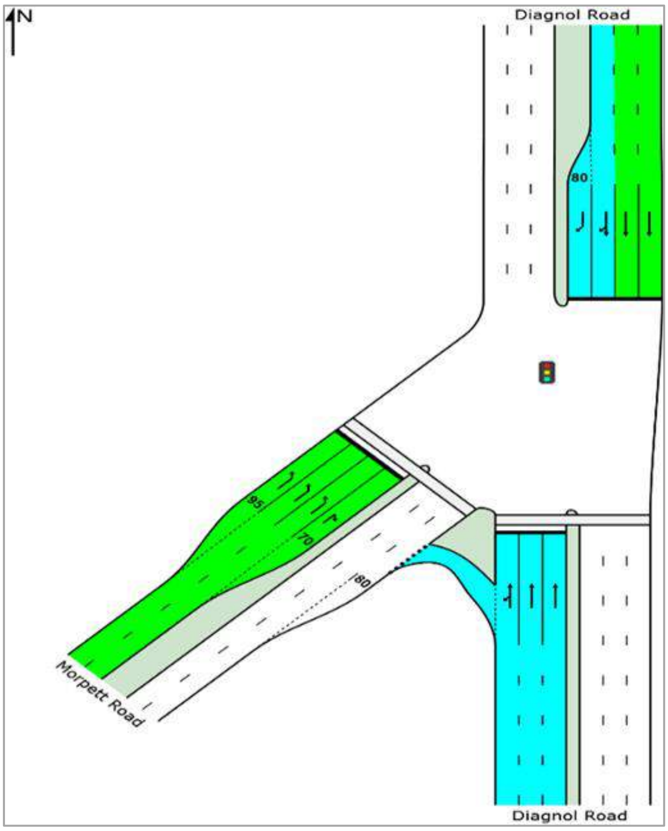


Figure 13: The Degree of Saturation with colour code

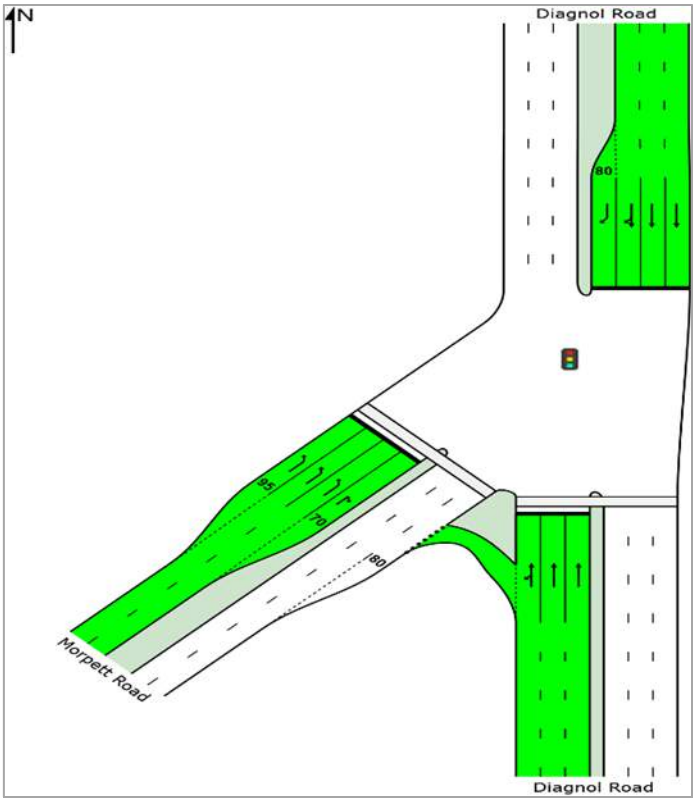


Figure 14: The figure of Queuing Distance Average with colour code

Discussion –

The intersection accommodates approximately 4000number of vehicles in the morning peak and 7500 number of vehicles in the afternoon peak. There will be a total of three lanes approaching towards the intersection from the southbound of Diagonal Road which one most left additional lane will be only applicable for a left turn towards Morphett Road. Besides that, there will be a total of four lanes approaching towards the intersection from the westbound of Morphett Road which most right lane will be only applicable for a right turn towards Diagonal Road.

There are no significant conflicts in the Morphett Road as the level of service from the SIDRA analysis is A and B which is among the best category for a road network. However, southbound Diagonal Road approaching towards the intersection has the level of service is C and D which is a reasonable outcome from the analysis.

Finally, the above results show that there will be no heavy queue during the peak hours. The level of services and degree of saturation Colour code has been further detailed summarised that can be accessed under heading (level of Services and Degree of Saturation)

2.3.5 Level of services

The level of services (LOS) is a qualitative measure used to relate the quality of traffic service to a given flow rate. Transport team has come up with the satisfactory traffic design which will be able to achieve the best level of services. In the following table 6 LOS letters are mentioned from A-F, where A represents the best quality of service and F represents the worst level of service.

Table 6: Summary Table of colour code

LOS	Signalised Intersection (delay in seconds)	Colour code based on Level of Service
A	≤10 sec	
B	10-20 sec	
C	20-25 sec	
D	35-55 sec	
E	55-80 sec	
F	>80 sec	

The explanation of above code on table 6.

Level A: - This level is defined as the best LOS for all road traffic. Level A has highest freedom of operation with smooth traffic flow at the desired speed.

Level B: - This level can be taken as the second-best LOS, with reasonable freedom of operation.

Level c: - This Level has a restricted level of freedom operation and it provides less comfort to road users relative to the above levels.

Level D: - This level has a more restricted degree of freedom compare to level C and provide very less comfort for road users.

Level F: - This level is the worst LOS for road users.

2.3.5.1 Network

The below Drawing Highlights the Overall Network Level of Service with colour codes.

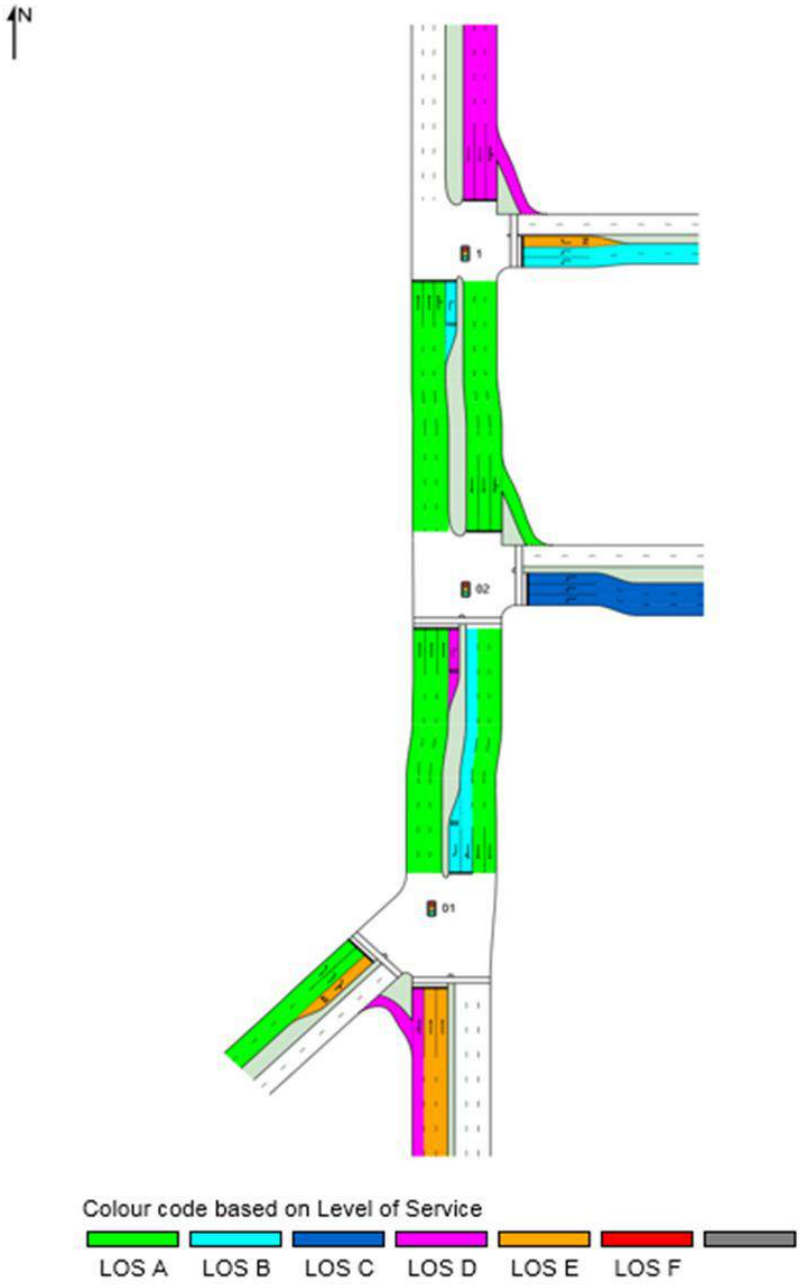


Figure 15: The Level of Service for the overall Network

2.3.6 Degree of saturations

The Degree of saturation flow measures the congestion level in the intersections on how much demands it is experiencing compare to its total capacity. Normally drivers preferred the lanes with minimum congestion level. The degree of saturation is equivalent to the ratio of traffic flow (veh/h) and total capacity (veh/h). In SIDRA degree of saturation over 85% or 0.85 values considered as suffering from traffic congestion, with queues of vehicles starting to form.

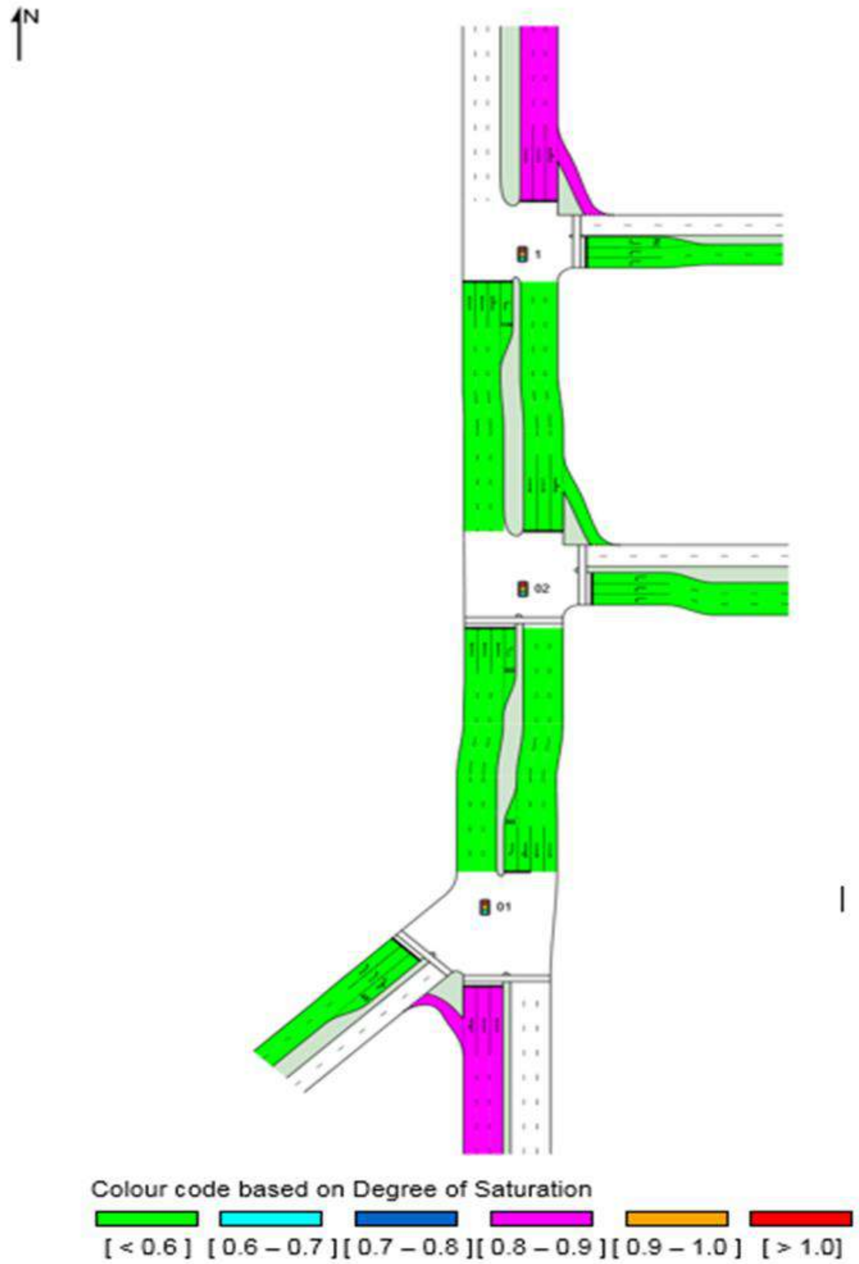


Figure 16: The degree of saturation of overall Network

2.3.7 Queue Distance Average

The Queue distance gives us a rough estimation of possible traffic vehicle queue at the intersection, where using the queue distance possible number of the car waiting could be estimated. For example, South approach queue distance Average is 41m while normal standing car cover 6-meter length, therefore dividing 41 by 6 highlights approximately 7 cars are queuing. Then multiply queuing cars with a number of lanes will provide estimated number of the car waiting at signalised intersection.

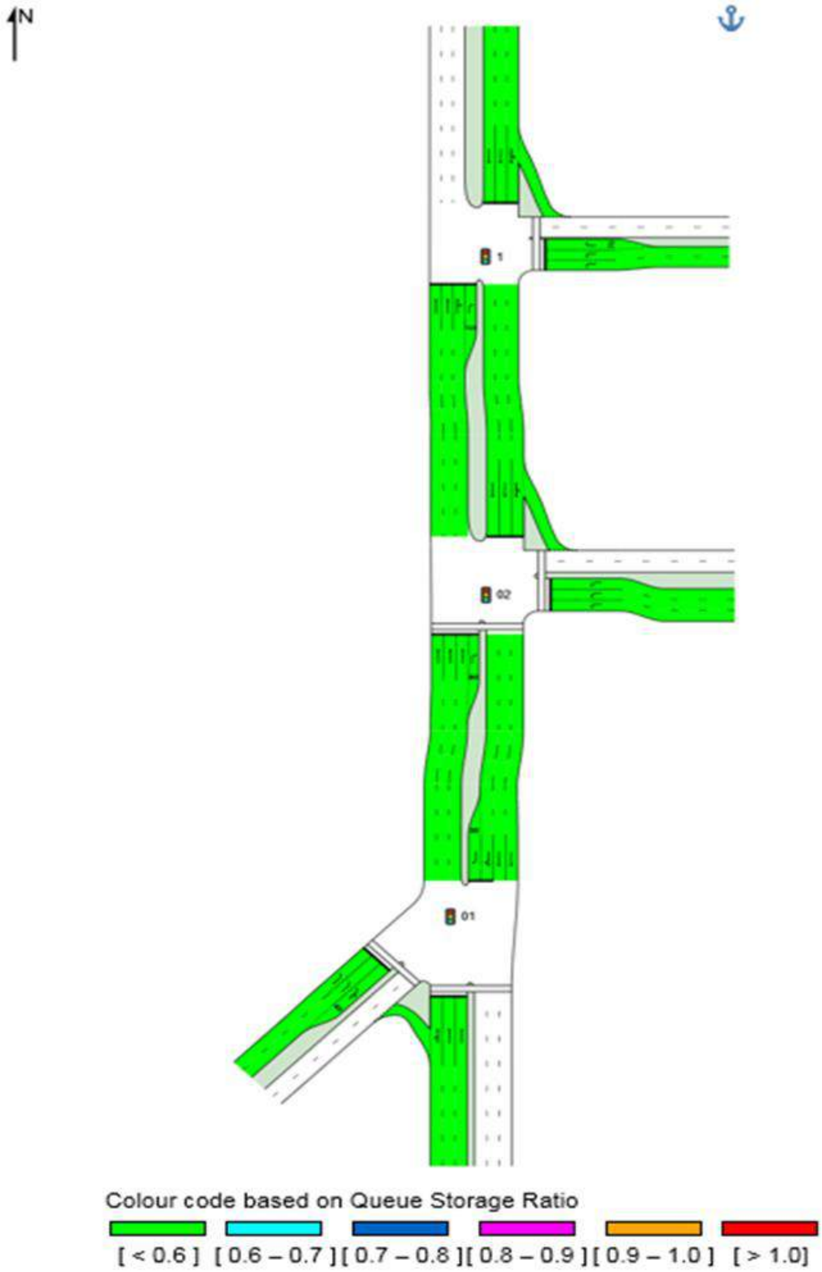


Figure 17: Queue Distance Average of Overall Network

2.3.8 Discussion and recommendation

SIDRA Software is used to create Intersection model with respect given traffic volume provided by DPTI. SIDRA software is one of the best tools to estimate the modelled Intersection capacity. Firstly, the Individual intersection was modelled to check the level of services where the results show that level service is A and B which mean smooth traffic movement at the intersections based on the code definition provided by SIDRA.

Secondly, the intersections were formed into a network where the whole network was analysed. The output of the results shows that mixed range of colour code mostly A, B, C and D while summarises the overall network level of service it highly C level which means there will be some delay but it will not make road uncomfortable to take the risk. Furthermore, the performance level could be improved by implying proper phases modelling and coordination with the individual intersection.

2.3.8.1 Recommendation

The newly upgraded intersections were formed into a network which is approximately 575m. Where three sets of signalised traffic systems have been designed, we recommend Coles intersection shall not be designed as signalised intersection due to close distance of approximately 210 meter another traffic signal close to swimming centre designed. As this design, will not be cost effective it will also require precise coordination close by signalised intersection.

2.3.8.2 Limitation

SIDRA software is a good tool to estimate the possible level of performance of the intersection and Roads but their limitation includes in the results. There are many factors that slow down traffic on the roads was SIDRA is not capable of counter those factors. For example, type of drivers on the road as we aware everyone will not be driving 60Km/h consistently as there will be drivers will be driving quite slow range of 45 to 55km/h especially senior aged driver and new drivers which have an impact on slowing down traffic.

2.4 Traffic management

Within DPC engineering the TCP (Traffic control plan) has been generated to make sure that the impacts of traffic on the road from commencing stages of this projects will be minimised. Under this traffic control plan, alternative plans for the public bus and railway services and detour plans for the normal vehicle on the road has been defined. An electronic signs board will be employed to provide early notices and information future road closure and it will be also used to guide all the road users to comply with the detour plan. The traffic controllers will be employed to provide the guidance using radio communications to road users and additional road signs will be placed to make sure that traffic flow efficiently.

The successful outcomes which would be expected from this plan have been laid as below:

- Provide the safe access for all the road users
- Maintain the free flow of the traffic
- Make sure that successful access to the alternative bus and railway service for a local resident.

2.4.1 Traffic control plan

The traffic control plan for different stages has been generated to counter the negative effects which have been imposed on the traffic by taking into different factors into account.

The expected outcome of this Traffic control plan:

- Free flow of the traffic on or near the projection area by executing traffic control plan for different stages
- Safe access for the local resident for the local business

2.4.1.1 Commencing stages

In the commencing stages, DPC Engineering will work with Adelaide Metro to notify the local passengers about the alternative bus and railway services.

As per the information, that has provided in the previous study, there is a larger of the amount of the vehicles will be transported by the diagonal road and Morphett Road. Therefore, this is a great necessity to control the traffic volume, namely the diversion plan, during the period of the construction to avoid the congestion problem during the construction.

To control the traffic volume on the diagonal road and Morphett Road there will be no access to the vehicle whose destination is not in the project area. The traffic from both directions will be diverted to the nearby south - north connecting road which are Marion Road on the east and Brighton Rd on the west. By implementing this diversion plan the negative impacts such as the congestion problems will be minimised during the construction phase. To achieve this, the message boards will be placed in the diagonal road and Morphett Road in the northbound and southbound to give out information about these restrictions and guide the traffic to designed path.

Moreover, there is another two-diversion path, one in the Bowker Street in the northbound and two lanes on the Stopford Road and Trot Grove in the southbound, to further decrease the traffic volume in the project area during the construction stages and the message signs will be placed to inform drivers to comply with the changes.

2.4.1.2 Demolishing stages

During the demolishing stages, one signal lane on the Westside of diagonal road and south side of Prunus Street will be closed for the demolishing purpose and upgrading purpose in the later stages as well. By closing one single lane on the diagonal road and Prunus Street the impacts on the road will be minimised and the impacts to access the local business will be minimised.

2.4.1.3 During the constructing stages

- During the constructing stage, the rest of lanes on the diagonal road and Prunus Street will be kept as open for all the vehicle to access.
- Avoiding working in the peak hours in the morning and afternoon, which are from 7:00 am to 9:30 am and 3:00 pm and 7:00 pm from previous feasibility studies.
- A detailed detour plan indicated in figure 19 below on the intersection has also been generated for during the construction work on the railway line. This optional detour will be arranged via Kildonan Rd, Ulva Ave, first ave and Dunrobin Rd. moreover, this traffic detour will be performed incorporate with local government, residents, business owners and DPTI.
- During the construction, we also recommended that electronic message will be deployed to guide all the road users to comply with the detour plan and diversion plan mentioned before.
- A group of traffic controllers holding the signs, on the construction site will also be employed to make sure that traffic flow will be smooth.
- When the project is completed, all the requirements set during the demolishing stages and construction stage to manage the traffic will be removed.

2.4.2 Traffic diversion

The traffic diversion is one of the main solutions for management of traffic during construction periods. This will help to keep work environment safer from a road accident or any kind of incident on construction area. The traffic diversion to the non-arterial road could cause traffic congestion and delay so proper management planning and right routes required to have no impact on another road while diverting traffic.

The Diagonal Road and Morphett Road are arterial roads, it will have the maximum amount of traffic volume and to divert those traffic, we need arterial having multi-lane. The main arterial roads close to the site are Brighton Road and Marion Road with multi-lanes and they are the best route to cross railway track. These roads have the capacity to carry the maximum volume of traffic but during peak hour the road will be congested with diverted traffic. The Diagonal Road and Morphett Road will slightly open for residence and at least one lane in each direction during peak hour to reduce traffic congestions on other roads.

A detour plans, as shown in figure 18, the southbound traffic on Diagonal Road will be diverted towards the Brighton Road via Oakland Road and Bowker Street. The southbound traffic on Morphett Road will be diverted toward Marion Road via Oakland Road. The northbound traffic on both Diagonal Road and Morphett Road can be diverted toward Marion Road (east side) or Brighton Road (west side) via Sturts Road. The south side of railway overpass has a big shopping centre and swimming pool, which generate lots of traffic volume and those traffic volumes can be diverted toward road Sturts Road which is closed multi-lanes road. The below figure represents the possible route that can be used to divert traffic to minimise the delay and congestion.

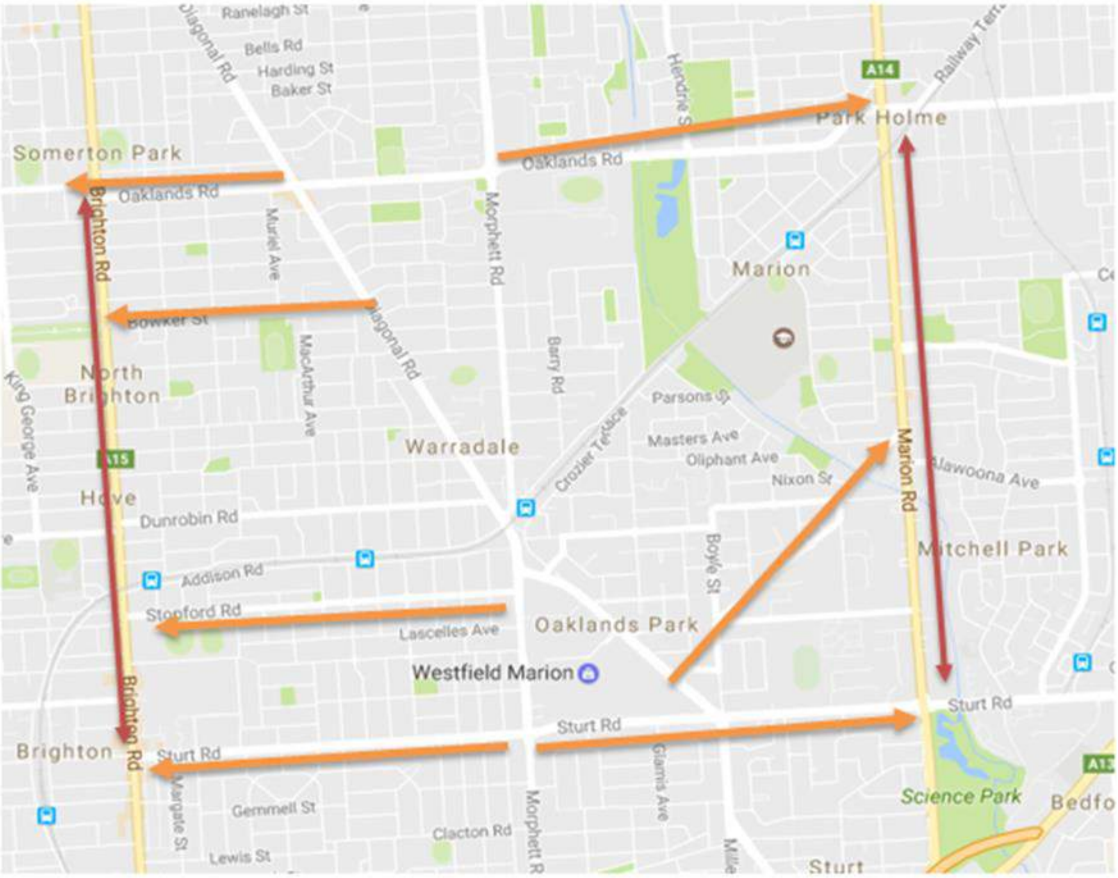


Figure 18: The Traffic diversion plan drawing (source: google map)

2.4.2.1 Alternative Options

Additionally, the next possible detour option will work more effectively as it will be diverted just avoiding the construction area. This option required construction new temporary road over railway track so, the cost will be little expensive and required the development of railway line on that section to be after completion road construction, which might cause a delay in railway construction. This optional detour will be arranged via Kildonan Rd, Ulva Ave, first ave and Dunrobin Rd. this detour is more effective for local resident, business and Diagonal Road users. Furthermore, this traffic detour will be performed incorporate with local government, residents, business owners and DPTI. The detailed plan about the route is shown in below figure 19.

Figure 19: Alternative Detour plan during construction period (Source: Google map)

2.4.3 Public transport

Before 28 days of commencing of this project, DPC engineering along with Adelaide Metro will notify all passengers about the information about the alternative bus stop, location, time and schedules for the railway services. During construction, the alternative plan for bus and railway services has been generated along with Adelaide Metro to make sure that impacts on all passengers will be kept as small as it can.

2.4.3.1 Bus services

Based on all the data collected from Adelaide metro there are total 15 buses(detailed in Table 7 below) will pass through the intersection of the diagonal road and Morphett Road with the 15 mins interval. Since the railway construction and upgrading road on the diagonal road and Morphett, the affected bus stops will be either relocated or merged with other bus stops.

Due to the closing of a signal lane on diagonal road bus stop 28C on the west side and east side will affect and will be relocated to places near the sibyls St on the diagonal road. The residents will be informed about such changes to allow them to plan their trips more properly. Stop 29 on the west side and east side on the Morphett Road will be relocated to a nearby location to control the traffic flow near the intersection during in the construction phase. Stop on West side will be relocated to Kildonan road and the stop on the east side will be relocated near the Torte grove.

Table 7: List of affect bus services and bus stop

BUS			Affected Bus Stop
241	248	248F	Stop 28C Diagonal Rd - West side
263	300	300H	Stop 28C Diagonal Rd - East side
300J	300M	300U	Stop 29 Morphett Rd - West side
980	981	982	Stop 29 Morphett Rd - East side
991	J7	J8	

2.4.3.2 Railway service

Due to the construction of the railways, Seaford line railway service between the Warradale Station and Oakland station will be temporally closed while the rest of the railway line for is kept running as old times. In order to counteract the negative effect has been caused to the local resident the express bus service running between Warradale Station and Oakland station and Marion station will be implemented with a 15-minute interval.

2.4.4 Detour plan

In the Northbound the substituted bus has been running from Warradale Station from Marion Station through Woodfield Ave, Doreen St, Barry Road and Oakland Road then to the marine railway station. There is a temporary bus stop along the Murray terrace and Barry Road for a local resident who wants to access railway to the marine station or to the city. The detailed plan for the south substituted bus route is shown in figure 20 below and the location for the temporary station is indicated in figure 21 as well.

Figure 20: The route of detour for substitute bus service, Northside (source: google map)

In the South bound the substituted bus has been running from Warradale Station to Marion station through Moy Ave, Kildonan RD, Trot Grove, Kearns RD, Selway St then to the marine railway station. There is a temporary bus stop along the Murray terrace and Barry Road for a local resident who wants to access railway to the marine station or to the city. The detailed plan for the South substituted bus route is shown in figure 8 below and the location for the temporary station is indicated in figure 21 as well.

Figure 21: The route of detour for substitute bus service, Southside (source: google map)

The detailed route planned for temporary bus service is in the tables 8 and 9 below. The table explains the detail about the fast and safe route for temporary public bus service. There is two optional route that can be used and the northbound route is best options for express bus service from Marion and Warradale Station.

Table 8: The Detail route for substitute bus services

North Bound (express and all stop)		
Direction	From street	Onto Street
	Warradale Station	Fifth Ave
Right turn	Fifth Ave	Woodfield Ave
Straight	Woodfield Ave	Vigo Ave
Right turn	Vigo Ave	Balmoral Ave
Straight	Balmoral Ave	Keynes Ave
Straight	Keynes Ave	Doreen St
Right turn	Doreen St	Barry Rd
Right turn	Barry Rd	Temporary station
Straight	Temporary station	Murray Terrace
Left turn	Murray Terrace	Carlton St
Left turn	Carlton St	Morphett Rd
Right turn	Morphett Rd	Oakland RD
Right turn	Oakland RD	Pethick Terrace
Right turn	Pethick Terrace	Bassi St
Left Turn	Bassi St	Marion Station

Table 9: The Detail route for substitute bus services

South Bound		
Direction	From street	Onto Street
	Warradale Station	Moy Ave
Left turn	Moy Ave	Kildonan RD
Right turn	Kildonan RD	Morphett RD
Left turn	Morphett RD	Milham St
Left turn	Milham St	Trot Grove
Left turn	Trot Grove	Johnstone RD
Left turn	Johnstone RD	Dwyer RD
Right turn	Dwyer RD	Hussey RD
Left turn	Hussey RD	Kearnes RD
Right turn	Kearnes RD	Crozier Terrace
Right turn	Crozier Terrace	Selway St
Straight	Selway St	Oliphant Ave
Left turn	Oliphant Ave	Nixon St
Left turn	Nixon St	Finiss st
Left turn	Finiss st	Marion RD
Left turn	Marion RD	Avalon RD
Left turn	Avalon RD	Farne Terrace
	Farne Terrace	Marion station

2.4.5 Pedestrians and cyclists

In this project, pedestrians are located on both sides of Morphett Rd and Diagonal Rd. Construction team should keep footpaths available for local residents, access to public transportations and commercial access with enough safety considerations during the construction period. In order to meet client's requirements, new footpaths should be located on both sides of two roads after construction is completed. Footpaths will be paved with same materials and slightly changed in geometry because it will follow the new on-grade Morphett Road and Diagonal Road.

In this project, exclusive bicycle lanes would be applied on both sides of the roads. An exclusive bicycle lane is a lane constructed with typical lane markings and signs. In general, it is located on the left side of a road. In this project, space is not available to protect the bicycle lane, whereas exclusive bicycle lanes are utilised. Moreover, this type of cyclist is implemented due to three safety considerations listed below.

- Edge drop-off between the pavement and ground surfaces, especially in the case of open graded friction course will be applied.
- Hazards in and adjacent to the kerb and channel such as the channel surface condition and entrances of drainage pits.
- The potential safety risks of the bicycle pedals striking the kerb.

According to Austroads guide, a table 10 showing lane width for exclusive bicycle lanes is listed below.

Table 10: Exclusive bicycle lane dimensions in urban areas

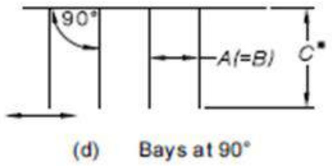
Speed limit (km/h)	Lane width (m)		
	60	80	100
Desirable minimum	1.5	2.0	2.5
Acceptable range	1.2-2.5	1.8-2.7	2.0-3.0

Throughout the table 10, three different speed limits are specified. Three lane widths can be defined according to the speed limits. Where in this project, speed limits set up for Morphett Road and Diagonal Road are 60-70 km/h. Therefore a desirable minimum lane width for the exclusive bicycle lanes is 1.5m with an acceptable range of 1.2-2.5m.

2.4.6 Carpark

As discussed in the previous section, an upgraded car park will be constructed under the elevated rail line allowing a larger capacity of cars. This car park connecting with the elevated rail station so that passengers can get the access to rail service straight after parking. In order to manage the traffic flow entering and exiting the car park, transport team connecting the car park with Murray Terrace and Crozier Terrace where traffic volumes can get access from both Morphett Rd and Diagonal Rd avoiding traffic congestion at the intersection of these two roads. Two access points are designed on each terrace allowing cars entering and exiting the park with a lower chance of traffic congestion and accidents. The two-lane aisles are set up on each side of the park and one in the middle of the park connecting with both terraces.

Due to safety concerns, transport team assumed the value of 75 m for the width and 400m of length for the park. In most cases, 90-degree angle parking would be considered as most efficient use of space in a large area so transport team implemented the 90-degree angle parking in the car park design. According to As 2890.1, user class can be defined as user class 1 where the standard parking space length is 5.4m, parking space width is 2.4m and aisle width is 6.2m.



User class (Note 1)	A (Note 3)	B	C_1	C_2	C_3	Aisle width (Note 4)
1	2.4	2.4	5.4	4.8	5.4	6.2
1A	2.4	2.4	5.4	4.8	5.4	5.8
2	2.5	2.5	5.4	4.8	5.4	5.8
3	2.6	2.6	5.4	4.8	5.4	5.8
3A	2.6	2.6	5.4	4.8	5.4	6.6
3A	2.7	2.7	5.4	4.8	5.4	6.2
4	(See Note 5)					

*Dimension C is selected as follows (see Note 6):

C1—where parking is to a wall or high kerb not allowing any overhang.

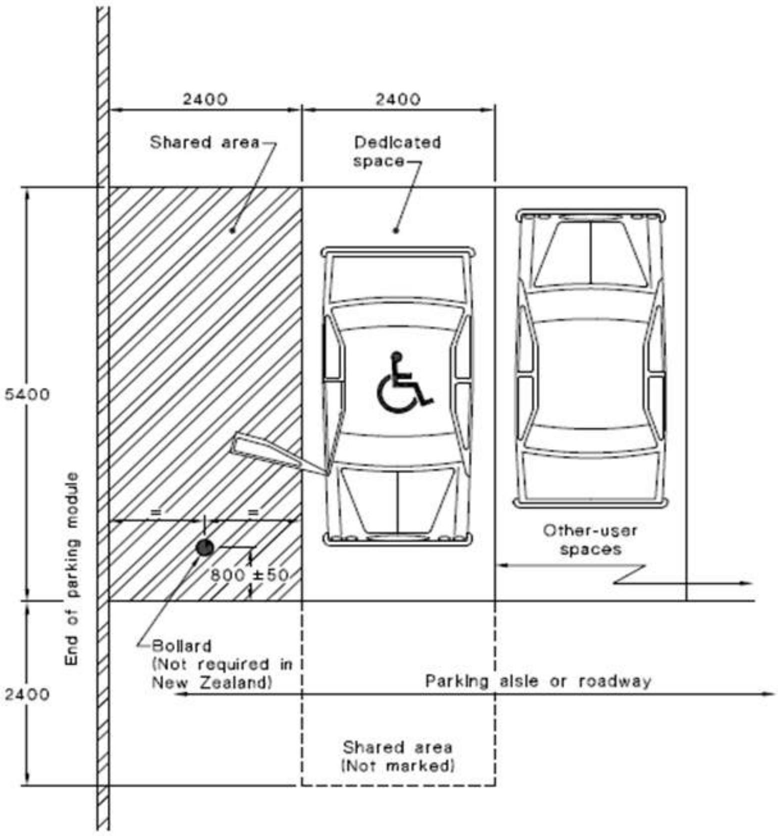
C2—where parking is to a low kerb which allows 600 mm overhang in accordance with Clause 2.4.1(a)(i).

C3—where parking is controlled by wheelstops installed at right angles to the direction of parking, or where the ends of parking spaces form a sawtooth pattern, e.g. as shown in the upper half of Figure 2.4(b).

For Notes—see over.

DIMENSIONS IN METRES

Figure 22: Layouts for angle parking spaces (AS 2890.1, Cl 2.4.1)



DIMENSIONS IN MILLIMETRES

Figure 23: Example of an angle parking space with shared area on one side only (AS2890.6, Cl 2.2.1)

Moreover, considering parking space for people with disabilities, a shared zone and parking space would be set up on both sides of the car park. According to the AS 2890.6, the length of the shared zone and space is 5.4m and width of these two are 2.4m.

As a result, two aisles are designed on both sides of the car park and one in the middle of the park where this car park can be divided into two parts with 2 share zones, special parking spaces and 8 normal parking spaces on the side near Murray Terrace, and similarly, 2 special spaces with shared zones plus 7 normal parking spaces on the side near Crozier Terrace.

Moreover, two aisles are set up on both hands of the park so it is more flexible for cars to access. Two columns of parking space are designed on both hands and 11 groups of parking lots and 10 access aisles in between.

During the rail line construction period, car park would be closed for safety concerns and would be reopened after completion of the east-end rail line construction. As discussed in the previous section, road upgrading would start from north to south. Due to this reason, car park allows cars entering from Crozier Terrace when the intersection nearby the Coles supermarket is under construction. Due to safety considerations, cars cannot access the park by entering from Morphett Rd.

However, Barry Rd would not be closed during the construction which allows cars entering and exiting to the park. On the other hand, cars can access to the car park by entering the Murray Terrace from Morphett Rd while roads around the Aquatic centre were under construction. During this period, two main roads and Diagonal Way will close for safety concerns. However, traffic flows still can use the car park through other roads like Kearnes Rd and Selway St will not be closed.

2.4.7 Signage

As mentioned in the previous section, the rail overpass contains greenway and bicycle on each side with a width of 1.5m. Moreover, passengers can exit the station through stairs connecting to the car park which leads to several bus stops around. Due to safety considerations, several signage should be set up in different places especially near the intersection. Safety operation of a pedestrian crossing is dependent upon the driver being able to see both a pedestrian on and about to use the crossing and the markings associated with the crossing in time for the vehicle to be able to be stopped if necessary to give way to the pedestrian. Several signage should be highlighted in required locations which will be introduced in following sections. Moreover, during construction periods, construction departments should allocate several safety signs alarming passengers and guide them to the temperate footpaths.

SPEED LIMIT (R4-10)

The Speed limit sign should be placed at each entry to a local area on road boundary informing drivers the travel speed in this area. There will approximately 10-speed limit signs including all intersections.

Pedestrian Crossing (R3-1)

The pedestrian crossing sign should be placed at both sides of a vicinity to a pedestrian crossing. These signs should be manufactured using fluorescent yellow sheeting. This sign will mainly use in car-park as pedestrian will use traffic to close the road.

Children's Crossing (R5-35)

The children's crossing is a facility catering primarily for school children. The existence of pedestrians on or entering the crossing imposes a legal obligation on vehicular traffic to stop and not enter the crossing until all pedestrians have cleared the crossing. There is one school close to workplace, so this might use especially during constructions period.

Keep Left (R2-3)

The keep left sign can be placed where a physical obstruction exists and in the case this situation, all vehicles approaching the obstruction are required to pass it on the left side only. This sign should be located not closer than 2m to the approach end of the obstruction.

Safety Zone (R3-2)

The safety zone sign should be used to design the pedestrian refuge and loading islands as safety zones.

Buses Excepted (R9-2)

This sign should be used in conjunction with the keep left sign when used at a loading island, to allow buses to pass to the right of the island. It will be used in the bus stop next to stations so, other traffic won't distract bus service and it is also for safety reason.

Keep Clear

This sign will be used to avoid queuing about the intersection of Local Street or car park and Main Street to make easy right or left turn from the local street or car park.

No U-turn sign R2-5

This sign is used to prevent illegal U-turns at intersections or in private driveways. This sign will be used in each right-tuning space to avoid dangerous right turn.

One-way sign R2-2

The one-way sign is used to indicate the street is either facilitating only one-way traffic or designed to direct vehicles to move in one direction. This sign will be used for local street intersections, where it only permitted to turn left.

GIVE WAY R1-2

Give way sign indicates that each driver must prepare to stop if necessary to let a driver on another approach proceed. This sign will be used mainly in car-park to avoid any kind of accident on car-park and easy traffic management.

NO RIGHT TURN SIGN R2-6

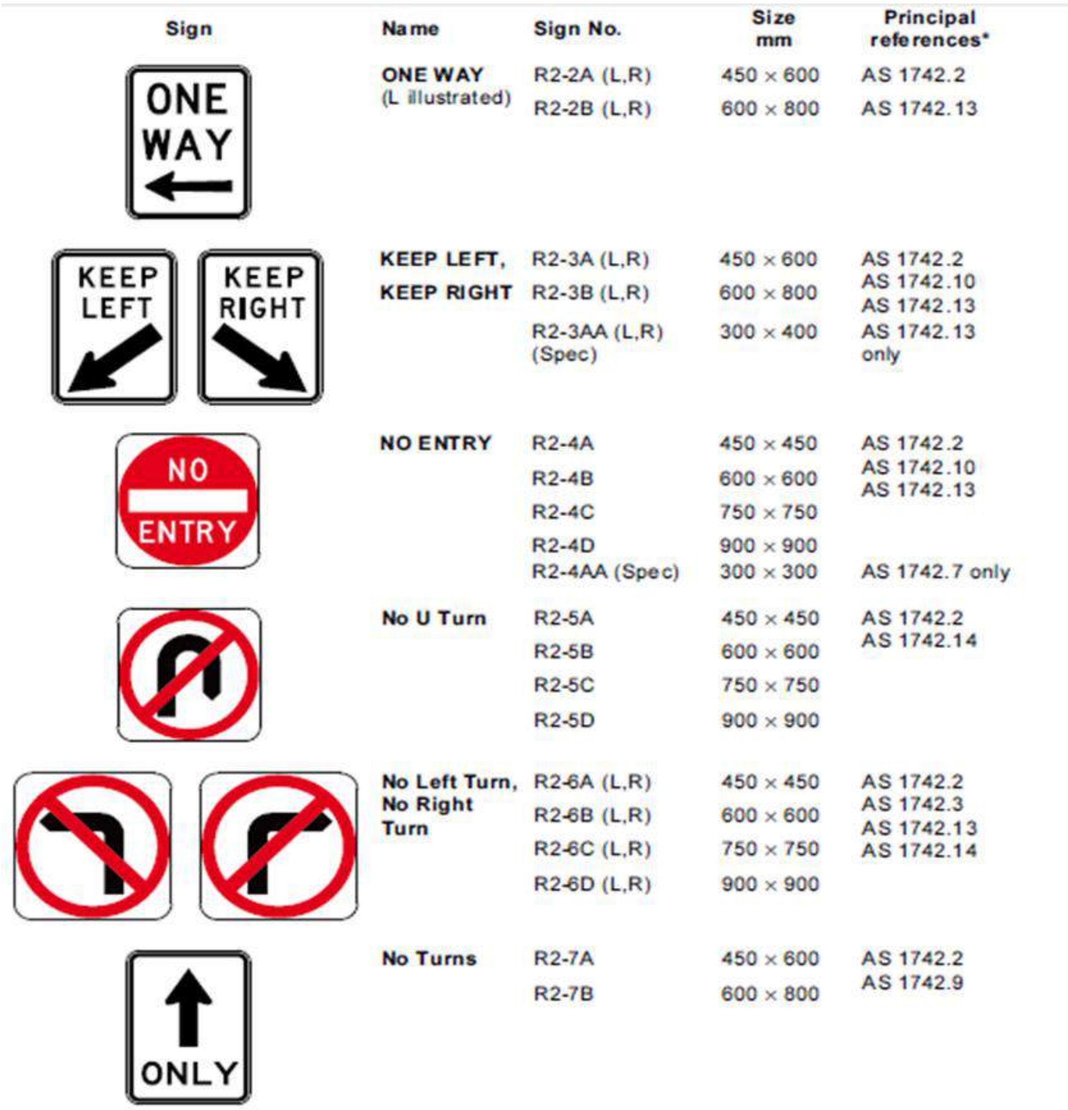
This sign is used to prohibition a right-turn movement to deny wrong-way entry to a one-way street.

STOP SIGN R1-1

A stop sign is a traffic sign to notify drivers that they must make sure no cars are coming and slow down before proceeding.

Sign	Name	Sign No.	Size mm	Principal references*
	STOP	R1-1A R1-1B	600 × 600 750 × 750	AS 1742.2 AS 1742.7 AS 1742.13 AS 2890.1
	GIVE WAY	R1-2A R1-2B	750 height 900 height	AS 1742.2 AS 1742.3 AS 1742.7 AS 1742.13 AS 2890.1
		R1-2AA (Spec)	375 height	AS 1742.9 only

Figure 24: The standard size signage for post constructions period. (Source AS1742.1, Cl 2.4.1)



Sign	Name	Sign No.	Size mm	Principal references*
ONE WAY	ONE WAY (L illustrated)	R2-2A (L,R)	450 × 600	AS 1742.2
		R2-2B (L,R)	600 × 800	AS 1742.13
KEEP LEFT / KEEP RIGHT	KEEP LEFT,	R2-3A (L,R)	450 × 600	AS 1742.2
	KEEP RIGHT	R2-3B (L,R)	600 × 800	AS 1742.10 AS 1742.13
		R2-3AA (L,R) (Spec)	300 × 400	AS 1742.13 only
NO ENTRY	NO ENTRY	R2-4A	450 × 450	AS 1742.2
		R2-4B	600 × 600	AS 1742.10 AS 1742.13
		R2-4C	750 × 750	
		R2-4D	900 × 900	
		R2-4AA (Spec)	300 × 300	AS 1742.7 only
	No U Turn	R2-5A	450 × 450	AS 1742.2 AS 1742.14
		R2-5B	600 × 600	
		R2-5C	750 × 750	
		R2-5D	900 × 900	
	No Left Turn, No Right Turn	R2-6A (L,R)	450 × 450	AS 1742.2 AS 1742.3 AS 1742.13 AS 1742.14
		R2-6B (L,R)	600 × 600	
		R2-6C (L,R)	750 × 750	
		R2-6D (L,R)	900 × 900	
ONLY	No Turns	R2-7A	450 × 600	AS 1742.2 AS 1742.9
		R2-7B	600 × 800	

Figure 25: Some standard size post construction signage. (Source AS1743.1, Cl 2.4.2)

ONLY

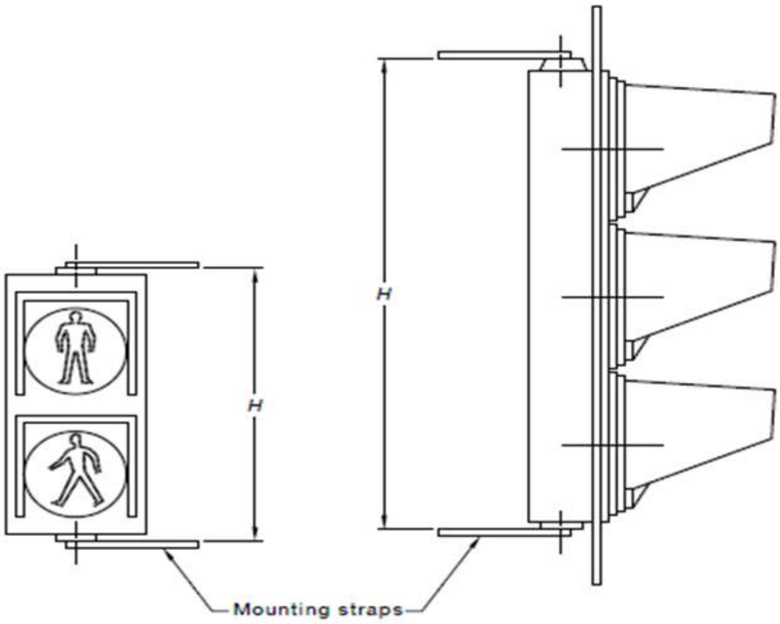
The only sign as shown in above figure will use under the bridge to avoid the queuing of right turning traffic on straight going lanes. There will be also information about more right turning lane in next intersection.

The additional signage or notice board will be utilised during post-construction to guide the road user. Some examples of signage are, maximum clearance, public bus only, Oakland railway crossing, more right turn in next intersection, no parking zone, bus stop, cycle lane, upcoming street name and intersection and penalty apply.

2.4.8 Traffic light

After upgrading the Morphett Road and Diagonal Road intersection, redesign and relocation of traffic lights are required. According to AS 2144, the nominal diameter of the exposed faces of the lens or apparent light source shall be either 200mm or 300mm. Lanterns shall be provided with facilities to enable them to be effectively secured between two parallel lantern mounting straps. The spacing between two straps can be specified in the following figure. Unless otherwise specified, each lantern shall be supplied with two mounting straps having dimension L as follows:

- For 200mm diameter vehicular lanterns, L=150mm.
- For 300mm diameter vehicular lanterns, and for pedestrian and two-aspect bicycle lanterns, L=260mm



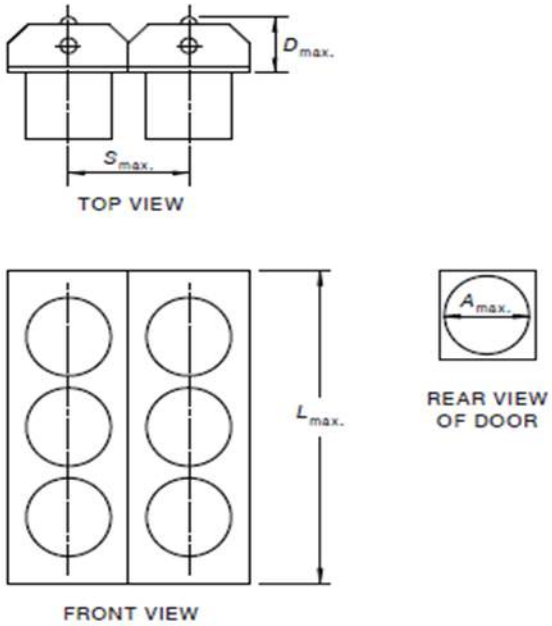
Lantern type		Height
Nominal signal diameter mm	Number of aspects	H mm
200	1	317 ±2
	2	577 ±2
	3	857 ±2
	4	1097 ±2
300	1	397 ±2
	2	747 ±2
	3	1097 ±2

Figure 26: Standard dimensions of traffic light (Source AS2144, Cl 4.1.4)

According to AS 2144, the size and shape of a vehicular lantern shall be such that:

- Two lanterns can be mounted side-by-side in accordance with the arrangement illustrated in figure 27;

- There is no discernible gap between the two lantern bodies when viewed from a distance of 10m within the range of viewing angles;
- The horizontal distance between the plane of the lantern face and the rearmost projection of the body, excluding the mounting straps, is not greater than Dmax in figure 27.



Dimensions	Nominal signal diameter, mm	
	200	300
$S_{max.}$	260	350
$D_{max.}$	200	300
$L_{max.}$	763	1019
$A_{max.}$	215	310

Figure 27: Dimensions controlling overall size of vehicular lanterns (Source AS2144, Cl 4.1.5)

Moreover, according to AS 2144, the mass of a lantern with any target boards, louvres and visors removed shall not exceed the sum of the following:

- 3.5kg for 200mm diameter;
- 5kg for 300mm diameter.

2.4.9 Lighting

The design for at-grade lighting will keep remaining on where it is on the north part of the Morphett Road and Diagonal Road. However, lighting on the other part of two roads requires redesigning of the lighting. According to AS 1158.0, there are two types of lightings can be applied.

- Category V lighting is applicable to roads on which the visual requirements of motorists are dominant and its subcategories range from V1 to V5.

- Category P lighting is applicable to roads on which the visual requirements of pedestrians are dominant. Subcategories range from P1 to P12.

According to AS 1158.1, road lighting should be located on both sides of the road with a spacing of 50m preventing from non-illuminated areas. The height of the pole with single sided outreach is 10.5m from ground level and the dimensions for the outreach is 3.0m.

The lighting in the car park is spaced assuming 1 light tube can light up to 10 – 15 m radius. The lighting poles are spaced between 20 to 30 m spaces, depend on locations. The under the bridge are closed and off are little far apart.

2.4.10 Lane marking

When the construction finished all the pavement markings will be painted as the pavement marking is an essential component of successful transportation systems. In our project, all the pavement markings will be strictly followed the requirement set by the Australia standard.

There are various kinds of pavement markings has been included in our design. The size of the longitudinal line which includes the broken lane and discounting lane with preferred width 100 mm. The lane lines are used to the separate the traffic while continues line forbid the vehicle crossing the line. The below figure clearly shows that standard-broken lanes, special purpose-broken lane and standard continues lanes has different gaps and thickness. These standardise lanes marking will be used to provide guidance and understanding about lane distribution to the road user.

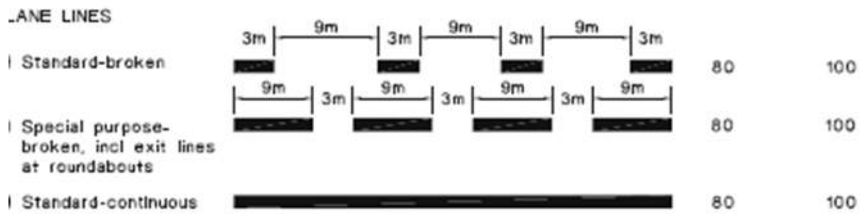


Figure 28: Dimension detail of lane lines

Turning line is used in the intersection to guide the road users the correct line to follow. As shown in the figure below, the gap between strips need to be 600 mm and thickness 80 mm * 600 mm.

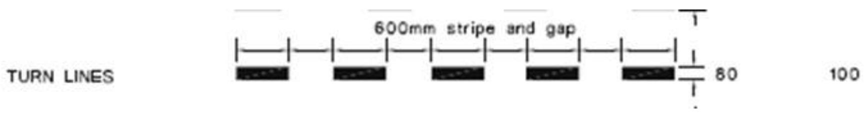


Figure 29: Dimension detail of turning line

According to The Australian Standard 1742.1(2014), the Give way lines is used to indicate the safe position for a vehicle to be held at a GIVE WAY sign at an Intersection. And the given line will comprise a broken line a minimum of 300 mm wide with line.

Segments 600 mm long separated by 600 mm gaps. It shall be placed in a similar position to that specified for a stop line.

The outline marking of splays, medians, islands, safety bars and shoulders shall be a single

Continuous line. The detailed dimension is shown below.

Figure 30: Dimension detail of outline marking

According to Australian Standard 1742.1(2014),Stop lines is a continuous line that shall be marked across the traffic lanes approaching a Traffic control device at which traffic is required to stop. It shall be a minimum of 300 mm wide at a STOP sign and shall be parallel to the line of the intersecting road.

2.4.11 Risk assessment

Risk assessment is a significant method in any sectors to identify situations that may cause damage to, particularly people. There are few steps that can be undertaken to assess a risk in any workplace.

1. Identify the hazards

   Any situation can be identified as a hazard if anything that could hurt a human being.

2. Assess the risk

   Assessing the risks that have identified enables a judgement of how likely the hazard would take place and how extent can it harm a human being.

3. Control the risks

   There are few ways can be used to control the risks

   - Elimination
   - Substitution
   - Isolation
   - Safeguards
   - PPE Usage

4. Reviewing risk controls

   The risk controlling principles has to be monitored throughout the process to ensure the control management to be effective.

The risk assessment methods that have been listed above will enable transport department to manage the construction and traffic to take place with minimal or eliminating risks occurrence throughout the project.

2.5 Cost estimation

The Cost is estimated using Rawlinson's Australian Construction Handbook. The Handbook provide costing as per square meter, meter length and quantity. The costing of traffic management during construction will add up with contractor costing.

Transport	Quantity	(AUD) price/Quantity	Cost (AUD)
Road			
Traffic Light	4 set	130,000/set	520,000
Three Lane Road	2130 meter	2830/meter	6,027,900
Two lane road	184 meter	2330/meter	428,720
Signage	17	415/sign	7,055
Arrow, STOP, disable parking, and Give Way Marking	125 Marking	25.6/mark	3,200
Car-Park	350 Car-park	1168/car-park	408,800
Signage	31 signs	400/signs	12,400
Railway			
Greenway Lane marking	690 meter	155/meter	106,950
Addition signs writing (Approximately)	750 letter or number	5.45/number or letter	4,090
		Total	7,519,115

Note: The Costing of quantity depends on the quality and size of products.

2.6 Recommendation for Construction

The traffics during constructions period must be diverted to another road. The massive amount of traffic diversion on another road for long period can cause daily delays as per the capacity of the road. The impact of construction on traffic management can be minimised and maintain. There are some recommendations to minimise those impacts:

The construction start from each end of railway line; this will have minimum impact on road and traffic can flow easily. At the same time, demolishing process should start which will consequence the road closure on one side but another side will be free so one lane traffic flow can be operated.

The road construction also needs to start from each end and side of the road. While upgrading one side of the road, another side will be free, where we can allow traffic flow. The next possible options are to start construction from Prunus Street till railway intersections and after its completion, the Morphett Road constructions can begin, by doing so, one road will be free to carry the maximum amount of traffic volume and minimise the traffic diversion period.

The construction at railway crossing (Railway Bridge and road) should be held at the same period as it is the main point and during these constructions period, most traffic needs to be diverted to another road. The construction on this point should be either at the beginning or last of construction period for easy traffic management as it discussed above.

2.7 Reference

1. Australian Standard 1742.1-2014. 2014; Manual of uniform traffic control device – General introduction and index of signs, Committee MS-012, Road Signs and Traffic
2. Australian Standard 1744-2015. 2015; Standard alphabets for road signs, Committee MS-012, Road Signs and Traffic.
3. Australian Standard 2144-2014. 2014; Traffic signal lanterns (p. 154), Committee MS-012, Road Signs and Traffic.
4. Australian Standard 2890.1-2009. 2009; Parking facilities – Off-street car parking. Committee MS-012, Road Signs and Traffic.
5. Australian Standard 2890.6-2009. 2009; Parking facilities – Off-street car parking for people with disabilities. Committee MS-012, Road Signs and Traffic.
6. Austroads, Sydney 2016, Guide to Road Design Part 3: Geometric Design.
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8. Department of Transport, Energy and Infrastructure (DTEI) 2011, Traffic Analysis Report, South Australia.
9. DPTI, 2011, Oakland's Park Road Capacity Improvements Planning Investigations in 2010 & 2011.
10. DPTI, 2015, Oaklands Park Ultimate and Interim Options Review.
11. DPTI, 2012, Oaklands Park Grade Separation Planning Study.
12. DPTI, 2013, Public Transport Services Technical Standard Part 129003.
13. Kuldeep, Z, & Rob. T, 2013, Public Transport Services Engineering Management System Technical Standard part 129003, AR-PW-PM-SPE-00129003 (D062).
14. *Rawlinsons Australian Construction Handbook* 2016, 34th edn, Rawlinsons Publishing, Perth, Western Australia, pp. 679-683.

STRUCTURES

3 STRUCTURAL DESIGN

ABBREVIATION LIST

Abbreviation	Description
BMD	Bending Moment Diagram
SFD	Shear Force Diagram
SUP	Shared User Path

3.1 Introduction

The Structures department has designed a Rail Overpass for Oakland Parks Grade Separation. The overall structure was divided into five packages to assist with the completion of the design. The packages designed below are designed In accordance with the Australian Standards and require guidelines. To ensure the durability and serviceability of the structure, future considerations of up to 100years have been taken. Various assumptions have also been taken due to the complexity and the time constraints of the overall project. Majority of the loads and calculations for the Rail Bridge was using SpaceGass whereas the Rail Platform was designed using hand calculations.

Package 1 – Rail Bridge, consists of overall dead and live loads of the bridge. The package was further divided into dead and live load elements which include; Rail Bridge Deck, Ballast, Super-Tee, Parapets, Head stock and columns. Pile caps are used for the foundation for this structure.

Package 2 – Rail Platform, designed as independent structure from the bridge itself. The Platform is a self-supported structure and the foundation of the structure is designed a footing. Two symmetrical platform are created on either sides of the Bridge. This package includes slabs, beams, column and services.

Package 3 – Rail Platform Access Structures, for this package a lift shaft is designed. This structure supports the hydraulic elevator which is installed for pedestrian access.

Package 4 – Centre Median Barriers, these are located under the bridge to protect the columns which are placed directly in the centre of the road. This particular structure was not manually designed, but an appropriate barrier was selected using the Australian Standards and given criteria.

Package 5 – Electrification Structures, includes the electrical components for the structure such as Insulators, overhead wiring, pantograph, cantilever arms and masts.

3.2 Package 01: Rail Bridge

3.2.1 Structure Overview

The Rail Bridge will consist of a 510m long elevated railway alignment, the structure will be designed with respect to AS5100. All loads will be consistent with AS1170, and other relevant specifications. Figure 31 shows a concept sketch of the proposed structure as laid out in the feasibility report.

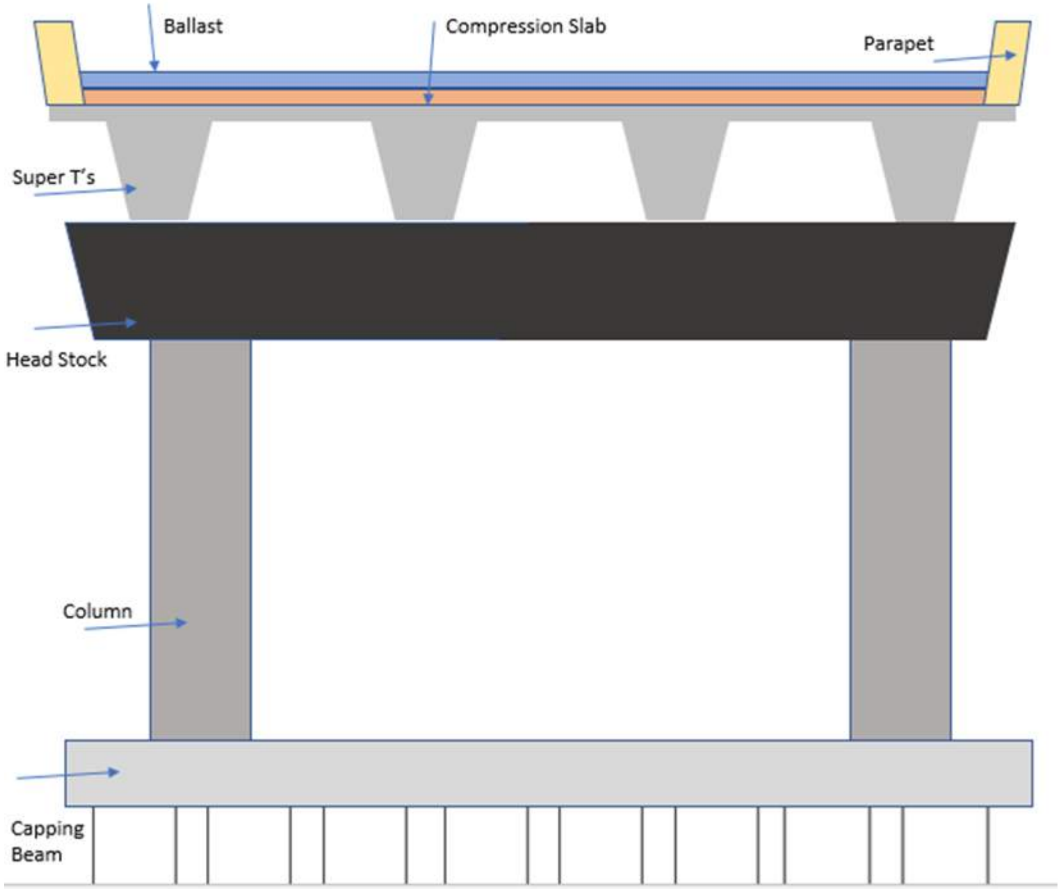


Figure 31: Proposed bridge structure cross section

The structure will be elevated to a clearance height of 5.1m with and deck height of 7.1m, the rail deck will be approximately 8m wide with the a 2.5m Shared user path on the northern side (not shown in Figure 31).

The elevated rail bridge will be divided into 22 spans, of which 8 will be 20m and the remaining will be 25. This will give a total length of elevated rail as 510m.

3.2.2 Load Calculations

An initial set of loads were produced to be distributed to the relevant design teams, these loads are initial only and may not represent the final designs. This was done to ensure that all teams had a reasonably accurate set of loads to work with. Below are the initial loads

3.2.2.1 Dead Loads

Concrete Density assumed to be 26kN/m^3 as per AS5100 CL.

3.2.2.1.1 Rail Bridge Deck:

Depth: 250mm

Width: 10,000mm

Load width/Length: 25,000mm

Load: 1625kN

3.2.2.1.2 Ballast:

Ballast thickness assumed to be 200mm

Width: 10,000mm

Ballast density assumed be to 19KN/m^3 as per AS5100.2 CL

Load: 950kN

3.2.2.1.3 Super-Tee:

Mass/m assumed to be 18kN

Number of Super-tee's: 5

Load: 2250kN

3.2.2.1.4 Parapets/Balustrades:

Assumed cross section: 75,000mm^2

Load: 975kN

3.2.2.1.5 Head stock:

Depth: 1,300mm

Length: 10,000mm

Width: 1,000mm

Load: 338kN

3.2.2.1.6 Columns:

Height: 5,100mm

Cross section: 1000,000mm^2, assumed to be square for this calculation

Load: 265kN

3.2.2.2 Live Loads

The live loadings shown here are not for use during the design of the bridge but for the supporting structure, the loadings use for the design of the bridge structure will be found using spacegass, where a moving load analysis will be completed. The moving load analysis can be found in

3.2.2.2.1 Train:

It is assumed that the trains running on this bridge will be classified as light rail as described in AS5100. AS5100 states that light rail should be taken as 150LA, this equates to an axel load of 150kN. All load spacing's were taken from AS5100 and a simulated locomotive was used.

The maximum span for the rail bridge will be 25m, combining this with the load spacing from AS5100.2 CL9.2 a live load of 2160kN is suggest for this design. The suggested load spacing are shown below in Figure 32 and Figure 33.

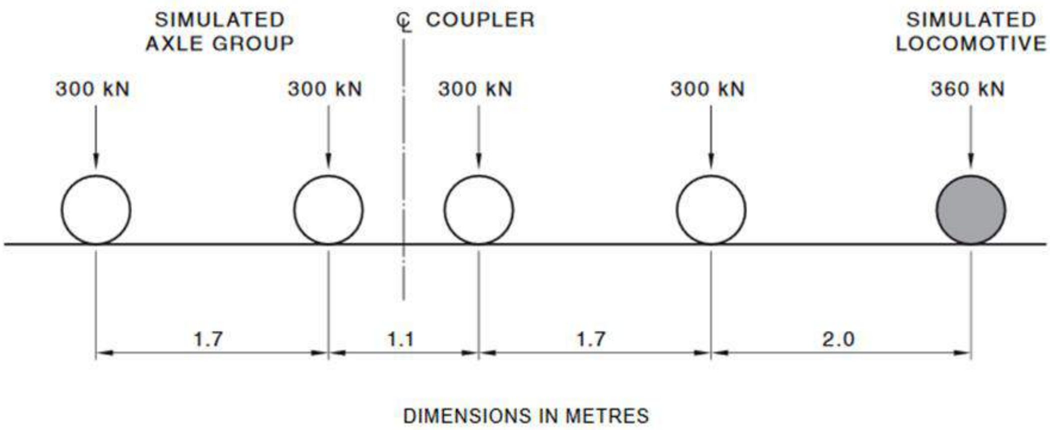


Figure 32: Axel Loads

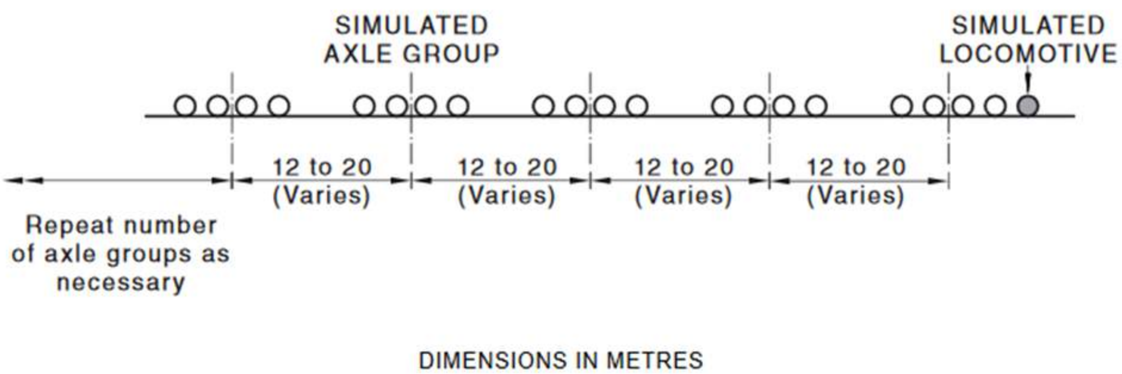


Figure 33: Axel Load Spacings

3.2.2.2.2 1Braking/Traction Loads:

AS5100 Mentions, breaking/Traction loads, it is assumed that these are non-critical and have not been taken into account in any of the design calculations. They are shown below for completeness but not used in the final designs.

3.2.2.2.3 Collision Loads:

Collision loads have been taken from AS5100.2 CL 10.2. It will be assumed that the entirety of these loads are taken by the crash barriers installed around the columns.

3.2.2.2.4 Wind Loads:

Wind loads have been calculated on the following parameters:

- Adelaide Region A1
- Ultimate Wind speed v2000: 48m/s
- SLS With permanent effects v20: 37m/s
- Height: assumed 10m (conservative)
- Terrain Cat: 3
- Mz,cat: 0.83
- Md: 1
- Ms: 1
- Mt: 1
- Vdes, ultimate: 40m/s equating to 0.96kPa

Loaded area: 62.5m^2

Cfig: 0.4 assumed façade to be hemispherical table F1 AS1170.2

Load 25m span: 24kN per 25m span

Total Load: 460kN

3.2.3 Considerations

3.2.3.1 Fatigue:

The fatigue of the bridge should be considered due to the cyclic live loading from trains, however due to the nature of the project these calculation will be assumed to be non-critical and that the bridge will not experience fatigue.

3.2.3.2 Thermal Expansion

AS5100.2 TABLE 18.2(A) gives the max and min air temperatures for shade shown below in Figure 34.

TABLE 18.2(A)

EXTREMES OF SHADE AIR TEMPERATURES

Location	Height above sea level m	Shade air temperature °C — Region I North of 22.5°S		Region II South of 22.5°S		Region III Tasmania	
		Max.	Min.	Max.	Min.	Max.	Min.
Inland	≤1000	46	0	45	−5	37	−5
	>1000	36	−5	36	−10	32	−10
Coastal	≤1000	44	4	44	−1	35	−1
	>1000	34	−1	34	−6	30	−6

NOTE: Coastal locations are locations that are less than 20 km from the coast.

Figure 34: Air Temperatures

Minimum Temperature (assumed): 1°C

Maximum Temperature (assumed): 44°C

These maximum and minimum temperatures are taken in the shade, our structure will be in full sun for the majority of its life, because of this it is assumed that the maximum temperature reached by the structure will be higher. The maximum temperature reached is assumed to be 60 °C.

The coefficient of thermal expansion is taken to be 11x10^-6 m/m/k. This has been assumed for the entirety of the structure

An assumption has been made that the average temperature of the bridge during construction and during its design life will be 25 °C.

Maximum thermal expansion for the 25m spans in either direction will be: 10/2mm, based on a maximum temperature change of 35 °C from the average.

This movement will be accommodated with the use of elastomeric bearings, and the use of an expansion joint of 20mm.

3.2.3.3 Differential Settlement:

Differential settlement in the foundations could cause the structure to experience some adverse stresses. Due to the nature of this project and the timeframe, it has been assumed that the elastomeric bearings are able to accommodate this differential settlement.

3.2.3.4 Earth Quake Loadings:

The structure is located in relative proximity to a fault line, however due to the nature of the project it has been assumed that any loadings resulting from an earthquake are non-critical.

3.2.3.5 Vibration and Noise

As noted by the environmental team, the noise and vibration of the track during operation may have adverse effects on the surrounding businesses and residents due to the elevated nature of the rail line. An architectural screen will be attached to the bridge structure along its length, it is assumed that this will damp any noise made by the trains to an acceptable level. Vibrations will be damped through the previously mentions elastomeric bearings. An acoustic resonance evaluation of the structure will not be completed, as it is assumed that these measures will have the desired effects.

3.2.3.6 Approach Slabs

It has been assumed that any lateral loads transferred to the superstructure during the approach of any rail traffic will be non-critical and shall thus be ignored for this design.

3.2.3.7 Durability and serviceability

3.2.3.7.1 Superstructure

The superstructure has been designed in accordance of the durability requirements of AS5100, requirements as follows:

- Design Life: 100 years
- Exposure classification: B1 (as5100)
- Concrete Strength
  - 40mPa (in suite elements),
  - 65mPa (super-tee)
- Concrete Cover
  - In suite Elements – 40mm
  - Precast Elements – 40mm

The replacement of elements such as elastomeric bearings should be considered and designed, however it is assumed that there will be enough space for jacking points to be installed and that the structure is able to withstand these loads.

3.2.3.7.2 *Headstock*

The headstock has been designed in accordance with AS5100.

- Design Life: 100 years

3.2.3.7.3 *Columns*

The columns have been designed in accordance with AS5100.

- Design Life: 100 years

3.2.3.7.4 *Waterproofing*

The deck of the rail bridge superstructure is to be waterproofed using a post fix membrane such as Duram InstaProof HA80, spec sheet found in appendix B. All joints between slab sections are to be sealed with Granors XJS system, spec sheet found in appendix B.

3.2.4 Elements

3.2.4.1 Superstructure (Deck + Super-tee)

Super Tees are used in conjunction with a deck slab for the Rail Bridge structure, this will allow for considerable resistance in lateral bending. The Designs comply with AS 5100.1 Bridge design - Scope and general principles and AS 5100.2-2004 Bridge design - Design loads.

3.2.4.1.1 *Loads:*

Super Imposed Dead Loads

Element	**Unit Weight**		**kPa**
Rail	500N/m	4 rails (2 tracks)	0.33
Sleeper	26Kn/m^3	Rail spacing assumed to be 600mm	0.45
Ballast	19kn/m^3		7.8
Ballast mat/water proofing		Assumed	1
Total:			9.02
Allowed:			10

3.2.4.1.2 *Design Process:*

The deck and super-tee system have been modelled in SpaceGass and a moving load applied to generate the final bending and shear force diagrams. The spacegass wire frames and input data can be found in appendix B.

1. Input Parameters

Dead Loads:

- Ballast: as shown in section 3.2.2.1.2
- Deck: Self weight used in Spacegass (concrete density of 26kN/m^3)
- Super-Tee: Self weight used in Spacegass (concrete density of 26kN/m^3)

Live Loads:

- Train loads (moving): the live loads were taken from AS5100.2 CL9.2 as shown in Figure 32 and Figure 33 and assumed speed of 50km/hr (13.89m/s).
- Pedestrians: The pedestrian loads are taken from AS5100.2 Cl8.2, 5kPa was used and it had been assumed there will be no access for a vehicle of any nature.

SpaceGass parameters:

- 1 train moving in each direction, 2 carriage
- 150 load cases evaluated, 0.1 second intervals
- A train speed of 15m/s
- 150LA rail traffic as per as5100.2 light rail

2. Results:

The loads were input into spacegass and load cases applied, the finial critical load cases were taken using the envelope function and thus used in the final designs. Appendix B shows the calculations, these were completed in an excel spreadsheet of which can be supplied.

3.2.4.1.3 Final Design:

The final design for the rail bridge superstructure is 5 t5 super-s's, 4 with a flange width of 2000mm (type 1) and 1 (supporting the SUP) with a 2500mm flange width (type 2). The super-t's were designed for a 25m span, however the same design will be carried forward for the 20m spans, drawing DPC-Structures-Package 01-Rail Bridge-Super-Tee-008-rev shows the super-t's and drawing DPC-Structures-Package 01-Rail Bridge-Deck Reinforcement-009-rev shows the deck reinforcement. The deck will be reinforced with N16 bars at 100 cts on the top and bottom.

3.2.4.2 Headstock

The Headstock is designed to transfer all loads from the rail bridge deck through to the columns and thus to the footings. The headstock will experience a sustained dead load from the rail bridge and all of it ancillaries, it will also experience the live loadings from the Rail traffic.

3.2.4.2.1 Loads:

Due the eccentric nature of the loadings on the headstock it was modelled in SpaceGass to produce the final bending and shear force diagrams. The loads from the super-t's were considered as point loads, with the loads being 1160kN Dead Load, 540kN Live Loads for the super-t's carrying rail traffic and 1160kN Dead Load and 314kN for Live for those carrying pedestrian traffic. The input loads are shown in appendix B.

Shown in Figure 35 is the BMD and Figure 36 shows the final SFD. The maximum positive bending experience by the headstock is 2803kNm and the maximum negative bending is 3073kNm, while the maximum shear is 3492kN.

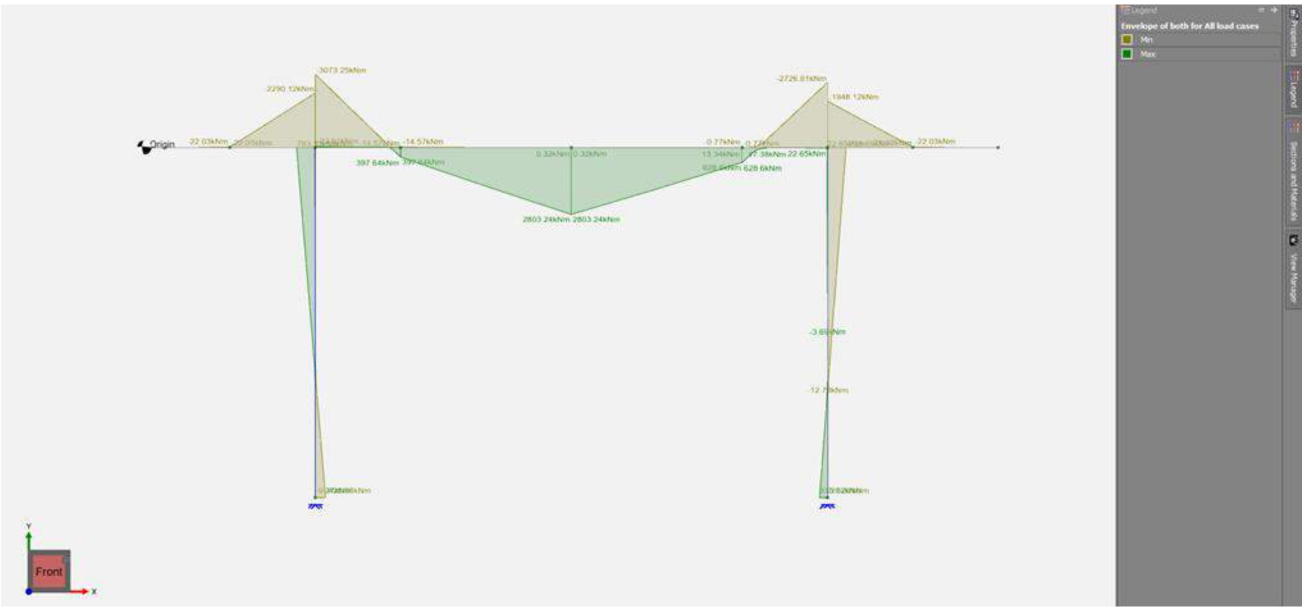


Figure 35: BMD, Headstock/Columns

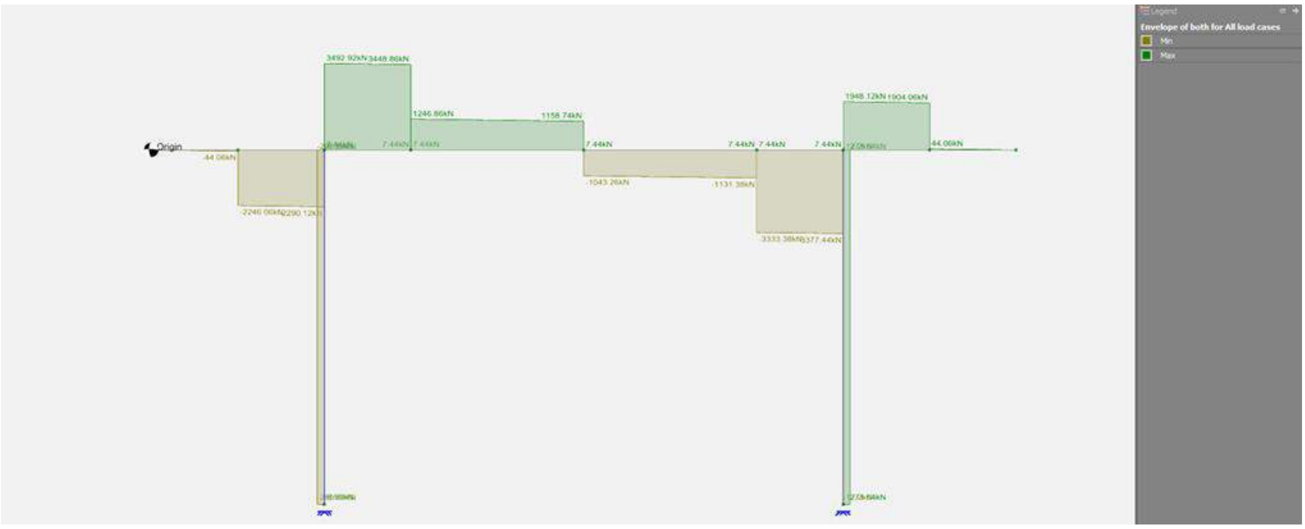


Figure 36: SFD, Headstock/Column

3.2.4.2.2 Design Process:

After completing a SpaceGass analysis, the beam was then designed using the inbuilt concrete beam design module in SpaceGass. The output of which can be found in Appendix B. All applicable design parameters were selected and tailored to the situation. The reinforcement designed by SpaceGass is Shown below in Figure 37. SpaceGass Suggests 9 N28 bars for the top and 10 N32 bars on the bottom with an additional 2 N32's in a second bottom layer. N10's at 50 centres were specified for shear. All of the above data was then verified using the relevant sections of AS 3600, this can be found in Appendix B along with any changes.

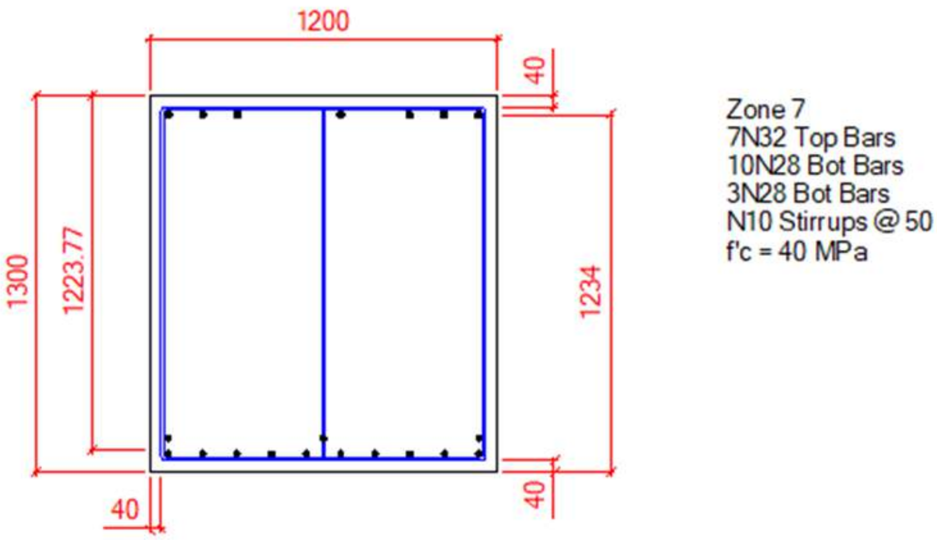


Figure 37: Critical headstock Section Design

3.2.4.2.3 Final design:

The final Design for the headstock is shown below and can be seen in full, on Drawing: DPC-Structures-Package 01-Rail Bridge-Capping Beam-005-rev1.

3.2.4.3 Columns:

1000mm x 1000mm square columns will support the rail bridge structure, there are 2 columns that carry the load through the centre on the road for the rail bridge. There are also 44 columns, in total, which are located under the Rail Bridge and Rail Platform which vary in height, the width for Rail bridge columns are consistent but differs for Rail Platform. It is assumed that the columns are fully braced for reinforcement calculations. Concrete strength for the columns is taken as 40 MPa, while its suitable cover is 25mm. Australian standard AS 3600 are used to ensure that the columns comply. Spacegass model was created and checked with hand calculations to ensure that the obtained loads were correct. The Spacegass output is attached in the appendix B.

3.2.4.3.1 *Loads:*

It is assumed that the columns transfer the entirety of the loads taken by the headstock to the footing. The columns were modelled in SpaceGass in conjunction with the headstock, this allowed the loads to be automatically generated, the maximum axial load on the columns was used as the design load. The design load is 5898kN and is shown in Figure 38 below.

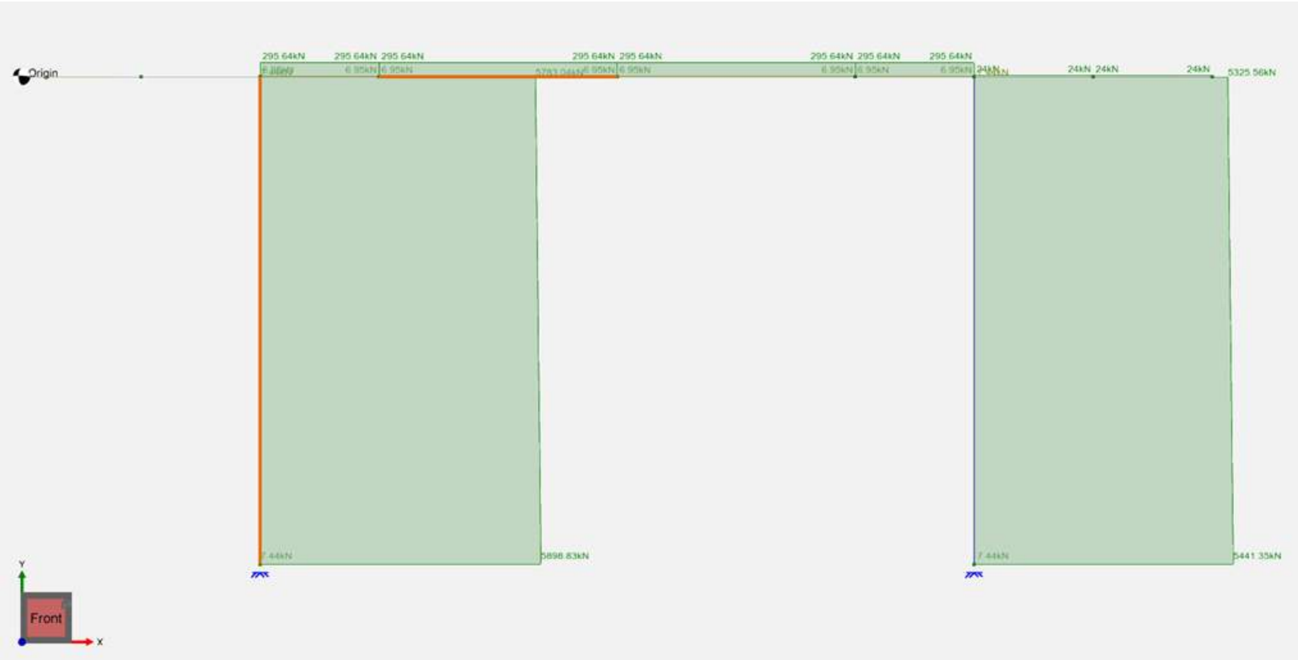


Figure 38: Axial Load Columns

3.2.4.3.2 *Design Process:*

After completing a SpaceGass analysis, the column was then designed using the inbuilt concrete column design module in SpaceGass. The output of which can be found in Appendix B. All applicable design parameters were selected and tailored to the situation. The reinforcement designed by SpaceGass is Shown above in Figure 38.

3.2.4.3.3 *Final design:*

The final design for the columns of the rail bridge can be seen in full, on Drawing: DPC-Structures-Package 01-Rail Bridge-Columns-006-rev.

3.2.5 Costing

Table 11: Rail bridge costing

Element	Rate	Unit	Total
Super-t	$ 60,000.00	110	$ 6,600,000.00
Elastomeric Bearing	$ 800.00	220	$ 176,000.00

CrossHead	$ 25,000.00	23	$ 575,000.00
Columns	$ 10,000.00	46	$ 460,000.00
Footing	$ 12,000.00	46	$ 552,000.00
Deck	$ 50,000.00	22	$ 1,100,000.00
Parapets	$ 12,000.00	66	$ 792,000.00
Water Proofing	$ 7,000.00	22	$ 154,000.00
Anti Grafiti Coating	$ 80,000.00	1	$ 80,000.00
Electrification Structure	$ 7,000.00	44	$ 308,000.00
Ballast	$ 250.00	1680	$ 420,000.00
Sleepers	$ 600.00	1000	$ 600,000.00
Rail	$ 200.00	2800	$ 560,000.00
Tamping + Install	$ 500,000.00	1	$ 500,000.00

Total estimated cost according to the Rawlinson's Construction Handbook (2017)

3.3 Package 02: Rail Platform

Railway platform will be an elevated structure with length, width and height as 160 m, 5m and 8.5 meters respectively. According to the transport team at DPC engineering, a railway platform will be provided for each direction of the bridge. Both the platforms will have same design as it is assumed that the loads acting on these platforms will be similar. Railway Platform will be constructed entirely from reinforced concrete. Platform will be supported by square columns with span of 10 meters at long side. Band beams with depth of 0.8 meters and width of 1 meter will support slab for its long span. All the design elements are designed with a capacity to accommodate future upgrade in the structure like double storied platform for two storied train. Railway Platform will be a self-supported structure, independent from Railway Bridge. It is assumed that the structure will have sufficient lateral bracing provided by lift shaft.

3.3.1 Load Calculations

3.3.1.1 Dead Loads

3.3.1.1.1 Slab:

Slab Depth-225 mm

Slab Width-5000 mm

Load Width- 10,000 mm

Load- 67.5 KN

3.3.1.1.2 Beam:

Beam Depth- 800 mm

Beam Width- 1000 mm

Load Width- 2500 mm

Load- 69 KN

3.3.1.1.3 Columns:

Column Height- 7,700 mm

Column Cross section- 500mm x 500mm

Load- 46.2 KN

3.3.1.1.4 Services

It is assumed that the structure will experience dead load from services equal to 1 KPa

3.3.1.2 Live Loads

The Platform will mainly be subjected to live loads due to passengers. According to AS 1170.1, suitable live load for this classification is 5 KPa.

3.3.2 Considerations

3.3.2.1 Thermal Expansion

The coefficient of thermal expansion is taken to be 11x10^-6 m/m/k. This has been assumed for the entirety of the structure

An assumption has been made that the average temperature of the bridge during construction and during its design life will be 25 °C.

This movement will be accommodated with the use of an expansion joint of 20mm at every 40 m of the platform.

3.3.2.2 Differential Settlement

It is assumed that the possible differential settlement will be accommodated by the footings.

3.3.2.3 Earth Quake Loadings

The structure is located in relative proximity to a fault line, however due to the nature of the project it has been assumed that any loadings resulting from an earthquake are non-critical.

3.3.2.4 Fatigue:

The fatigue of Railway Platform is considered due to cyclic loads from pedestrians. It is assumed that these loads are not critical enough for platform to experience fatigue.

3.3.2.5 Vibration:

Railway platform will be an independent structure. Since there is no connection between main railway bridge and platform, it is assumed that the railway platform will not have vibration due to movement of train.

3.3.2.6 Durability and Serviceability:

3.3.2.6.1 Slab

The platform slab has been designed in accordance of the durability requirements of AS3600, requirements as follows:

- Design Life: 100 years
- Concrete Strength: 40 MPa
- Cover: 25mm

3.3.2.6.2 Beam

Platform beams has been designed in accordance with A3600.

- Design Life: 100 years
- Concrete Strength: 40 MPa
- Cover: 25mm

Long term and short term deflection are taken into consideration.

3.3.2.6.3 Columns

The columns have been designed in accordance with AS3600.

- Design Life: 100 years
- Concrete Strength: 40 MPa
- Cover: 25mm

3.3.2.6.4 Footing

The Footings has been designed in accordance with AS3600.

- Design Life: 100 years
- Concrete Strength: 25 MPa
- Cover: 50mm

3.3.3 Elements

3.3.3.1 Slab

Slab thickness estimated by structural team at DPC engineering will be 225mm. According to AS3600 'exposure classification table 4.3' and the figure 4.3 climate zones, Oaklands Park is located in Non-industrial and temperate climatic zone as exposure classification A2. By looking at AS3600 Table4.4, the minimum concrete strength($f'c$) is 25Mpa. For this project, assuming concrete strength as below.

$$Concrete\ Strength:\ f'c = 40MPa$$

Minimum cover required for the reinforcement is 25mm according to AS3600 Table 4.10.3.2 where exposure classification is A2.

Slab for the platform design is a one-way slab and reinforcement calculations for the slab is done in accordance to this consideration.

3.3.3.1.1 Loads:

1. Dead Load

Dead load for slab will be equal to its self-weight.

Slab Thickness = 0.225 m

Load width = 10 m

Dead load = 5.4 KPa

Live Load = 5KPa

3.3.3.1.2 Design Process:

The slab design for slab of the platform should be capable of withstanding applied bending moment and shear force. A spacegass model was generated for slab for 1m width to obtain critical positive and negative bending moment. It was observed that combination load case of 1.2G +1.5Q was critical for bending moment and shear force. Results for bending moment for slab from spacegass are as follows:

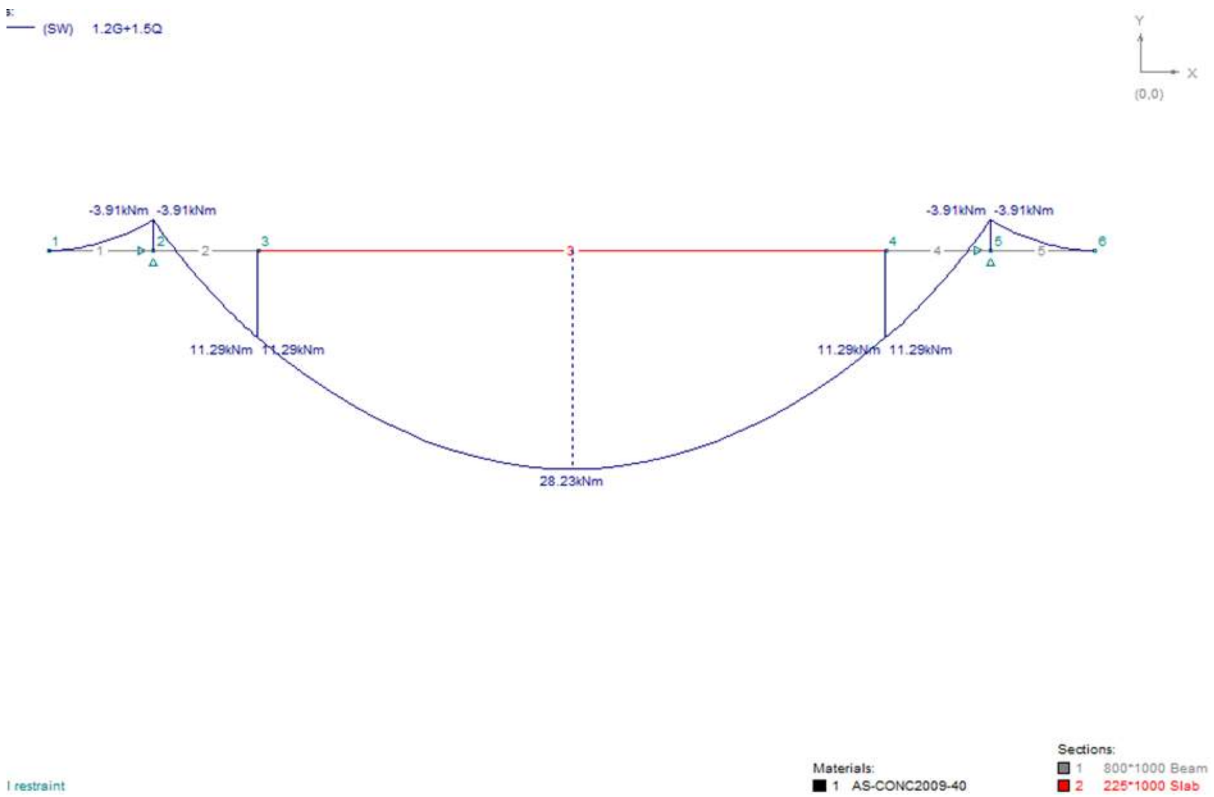


Figure 39: Bending moment for slab from spacegass

Maximum negative bending moment is at the middle of the support is -3.91 kNm, and the maximum positive bending moment is 28.23 kNm at the middle of the slab.

Top Reinforcing Design:

Critical Negative bending moment is considered to design top reinforcement, M*=3.9 KN.m. On calculating area of steel in accordance to beam dimensions (1000mm wide x 800mm Deep) minimum required area was found to be 1219 mm^2.

N12 bars @75cts were selected since it was closest upsize area. Moment capacity of beam was calculated to be 438 KN.m which is considerable greater than maximum Negative bending moment applied on beam and hence it is OK to select this bar size.

Hence we will adopt N12bars @ 75cts

It was found that the slab reinforcement was sufficient to withstand shear force and hence no ligatures are required for slab.

Bottom Reinforcing Design:

To design bottom reinforcement, the critical positive bending moment will be considered, M* = 28.2KN.m. Calculations were similar to that of top reinforcement. Since critical positive bending moment is at the middle of the slab span, slab thickness of 225mm will be considered. N12 bars @ 275cts were suitable for the bottom reinforcement of the slab, since bending moment capacity of N12 bars was more than the critical positive bending Moment.

3.3.3.1.3 Final design:

On considering the bending moment and shear force design, it was found that

Top reinforcement of the slab will be N12 bars S 75 T

Bottom reinforcement for slab will be N12 bars S 275 B

It is recommended that ligatures shouldn't be added to the slab since slab has sufficient capacity to withstand shear. It is impractical to install ligatures in slab because of less available space.

Figure 40 shows reinforcement details on the slab from the section view for 1 m width

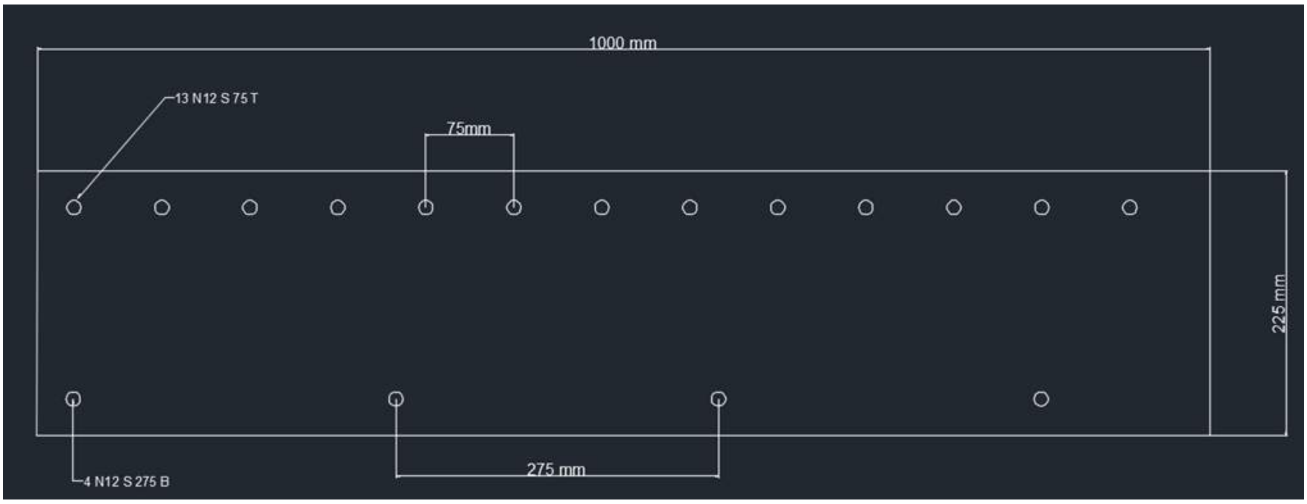


Figure 40: Cross sectional view of the slab over its 1m span

3.3.3.2 Beams:

Band beams with depth of 0.8 meters and width 1 meter will be designed in this section following Australian concrete standard AS 3600. Concrete strength of 40 MPa will be required for the construction of the beams. Beam will support slab for its long span, maximum span for which beam will provide support is 10 meters. On referring AS 3600, cover was taken as 25 mm. Spacegass model was generated to get critical bending and shear acting on the beam. Effective beam width (b_{eff}) was considered for modelling the frame in spacegass.

3.3.3.2.1 Loads:

Load Width =2.5m

Dead load for the beams will be:

G= self-weight of beam + G_{slab}

G_{slab} = 13.5 KN/m

Self-weight = 13.8 KN/m

Dead load for beam = 27.3 KN/m

Since live load according to 1170.1 is 5KPa

Live load = 12.5 KN/m

3.3.3.2.2 Design Process:

1. Bending Moment

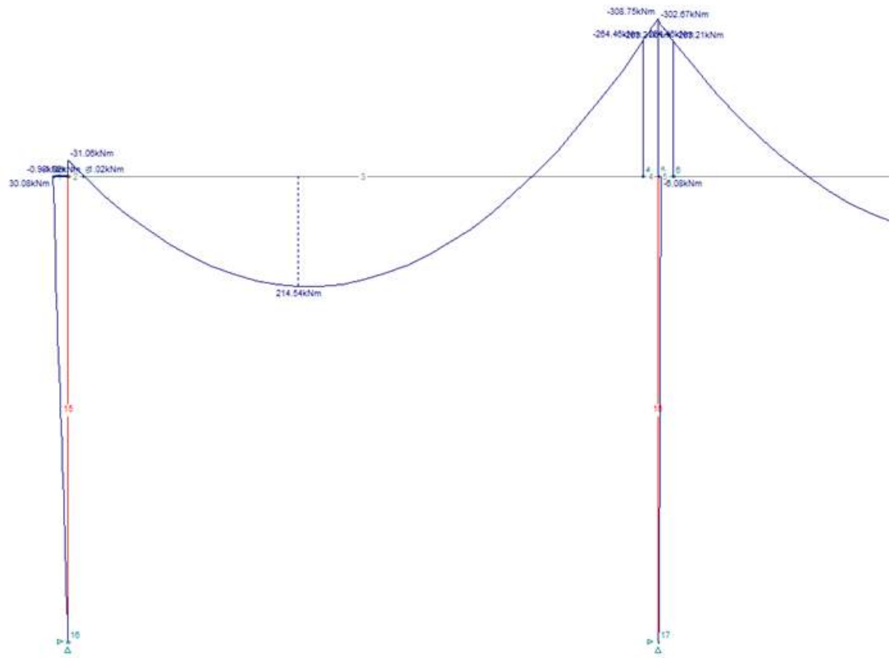


Figure 41: Bending Moment for beams from spacegass

Top and bottom reinforcement for the beams were designed by following similar design process to slab reinforcement. Critical positive bending moment is considered for top reinforcement and critical negative bending moment is considered for the bottom reinforcement. Maximum positive bending moment is 214.54 KNm while maximum negative moment of the beam is 308.75 KNm. 4 N20 bars will have sufficient moment capacity for resisting the critical positive as well as negative bending moment and hence 4 N12 bars are selected for top and bottom reinforcement of the beams.

2. Shear Design

Maximum shear on the beam at first span is critical and hence our design focuses on this span. From the spacegass model of Platform, it was found that maximum shear force acting on the beam was 181 KN.

$V^* = 181$ KN

To check if beam is adequate for shear, its ultimate shear strength must be calculated. Ultimate shear strength for the beam will indicate if there is a requirement of ligature design. Ligatures will provide reinforcing bars extra capacity to withstand shear force.

Ultimate shear strength was calculated by referring AS 3600-2009, cl. 8.2.7. Ultimate shear strength is then multiplied by capacity reduction factor (ϕ). It was found that the beam did not had sufficient shear strength with 4 N20 bars. To increase its shear capacity, ligatures are designed. 6 N12 ligatures at 800 mm spacing are sufficient to provide extra shear capacity to withstand critical shear force acting on the beam. Refer Appendix D for detailed calculations.

3. Deflection

Calculated failure deflection for the structure was 40mm which was calculated by referring Australian standards AS 3600, however structural team considers limit of the maximum deflection for the beam should be 25mm since structure can visibly appear displacing if deflection is more than 25 mm. Critical deflection of the beam was at its mid-span, short term deflection of the beam was calculated by using equation, $\Delta_{\text{short term}} = \frac{5}{384} \times \frac{(G+\psi_s Q)L^4}{E_c \times I_{eff}}$

Short term deflection of the beam will be 2.5 mm. Similarly, long term deflection was calculated to be 1.8 mm.

Total deflection of the beam would be 4.3 mm < 25mm, hence the beam is OK for deflection.

3.3.3.2.3 Final design:

After considering Bending moment, shear force and deflection for the beam, structural team recommends beam should have the following reinforcing:

Top Reinforcement: 4N20 bars

Bottom Reinforcement: 4N20 bars

Ligatures: 6N12 HH 800 centre spacing

Cross section of beam reinforcement can be seen in Figure 42.

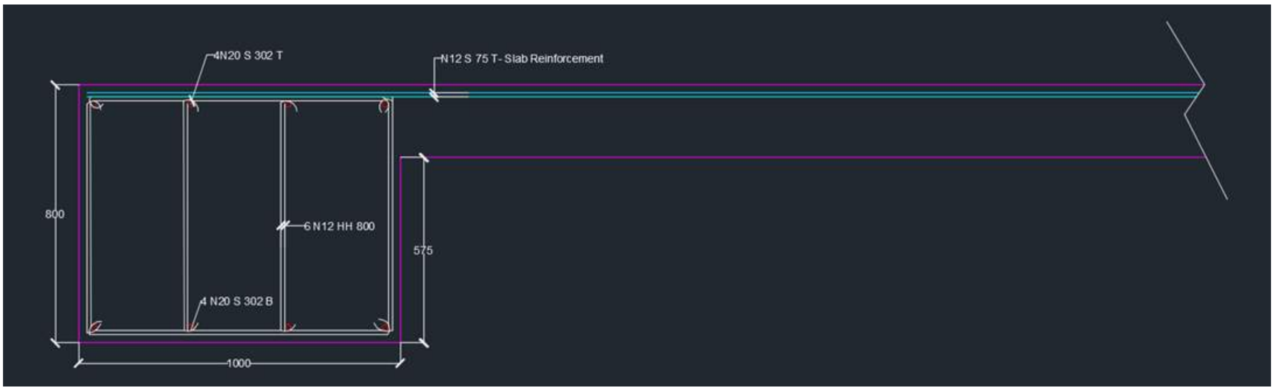


Figure 42: Beam Reinforcement, cross sectional view

3.3.3.3 Columns:

500mm x 500mm square columns will support the platform structure, since the span is 10 meters for the long side there will be 17 columns on each side of the platform. It is assumed that the columns are fully braced for reinforcement calculations. Concrete strength for the columns is taken as 40 MPa, while its suitable cover is 25mm. Australian standard AS 3600 is referred to design column. Spacegass model was created to obtain loads acting on the column.

3.3.3.3.1 Loads:

Loads acting on column will be similar to loads acting on beam.

Load Area = 25 m^2

Dead Load = 273 KN

Live Load = 125 KN

3.3.3.3.2 Design Process:

Initially it was determined that the column was slender since Le/r > 25. Axial loads from spacegass were obtained, critical squash load was 397.2 KN. Minimum bending moment was found by referring clause 10.1.2 of AS3600, 30.1 KNm was the critical bending moment. Minimum reinforcement area was found to initialize column calculations and 4 N32 bars are adopted to reinforce columns.

An interaction curve is generated by considering four cases which will be critical conditions for the column. These four cases are as follows

- Squash Load Point
- Pure Bending Point
- Balanced Point
- Decompression Point

Values obtained from these cases are factored accordingly by following clause 2.2.2 of AS 3600, then plotted on a graph to examine the behaviour of the column. The following table shows the obtained values from the critical cases.

Table 12: Critical Points for Interaction Diagram

	Moment (KN.m)	Axial Load (KN)
Pure Bending Point	290.616	0
Balanced Point	695.454	2073.582
Decompression Point	358.422	4210.65
Squash Load Point	0	6060

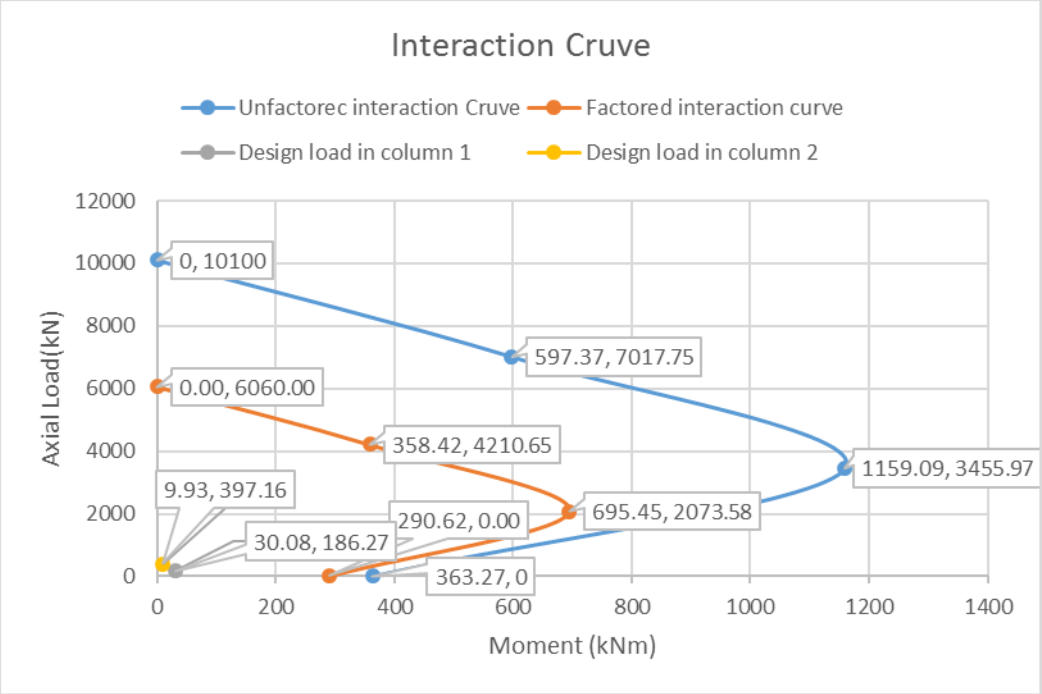


Figure 43: Interaction Diagram

It is observed that the design loads are within the interaction curve which states that the reinforcement if adequate for the column.

Stirrup size of N12 is adequate for N32 bars according to Table 10.7.4.3 from AS 3600. Spacing between stirrup is 480 mm. Footing will be connected to the column with the help of lapping bars, Lapping length for these bars would be 1280 mm.

Columns were lastly checked by using column chart g=0.7 from AS 3600. It was observed that the forces are in tension and hence design is satisfactory. Detailed calculations can be referred from appendix E.

3.3.3.3.3 Final design:

After considering all the critical failure cases for the column, structural team recommends beam should have reinforcement of 4 N32 bar.

Stirrup size will be N12 at 480mm spacing

Cross section of column reinforcement can be seen in Figure 44.

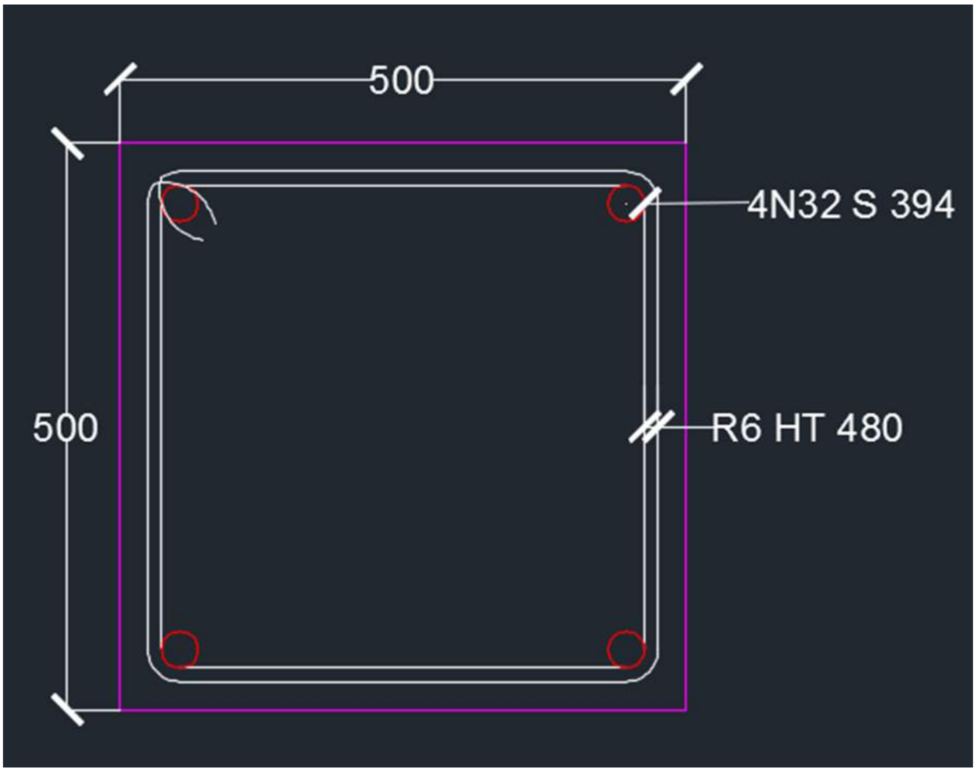


Figure 44: Column Reinforcement, Cross sectional view

3.3.3.4 Footing:

Simple square footings will support the entire structure of Railway Platform. These footings will be under each column. Geotechnical Team of DPC engineering calculated the value of allowable bearing pressure (qa) = 250 KPa. Concrete strength for footings will be 25 MPa and by referring Table 4.10.3.2 and clause 4.10.3.5, suitable cover for footing according to its classification was selected to be 50 mm.

3.3.3.4.1 Loads:

Dead Load:

Dead load from column G= G_{slab} + G_{beam} + G_{column}+ $G_{service}$

G_{slab} = 67.5 kN

G_{beam}=69 kN

G_{column}=46.2 kN

$G_{service}$=12.5 kN

Dead load from column G= 195.2 kN

Live Load:

Q = 5KPa

Live load from column Q = 62.5 kN

3.3.3.4.2 Design Process:

Footing dimensions were estimated according to the bearing pressure of the soil, it was found that footing will be 1.5 m x 1.5m and 0.375m deep. Footing was then checked against Bending failure, critical shear failure and bearing failure. Maximum Shear failure was, V*=287.9 KN. The proposed footing has punching shear capacity of 430.2 KN which is more than the critical shear. For Beam shear calculations its critical shear was calculated to be 84.31KN and its shear capacity was 84.1 KN which is within 1% of critical shear. On checking Bending Moment for the footing it was found by using 8 N12 bars each way for bottom reinforcement will provide the footing enough capacity to withstand applied bending moment. Bending moment capacity for the footing will be 47.2 KN/m

3.3.3.4.3 Final design:

After Bending failure, critical shear failure and bearing failure, structural team at DPC engineering recommends to use 8 N12 bottom reinforcement in each direction.

Designed footing will be 1.5m x 1.5m x 0.375m

Figure 45 shows reinforcement details for footing from a cross sectional view.

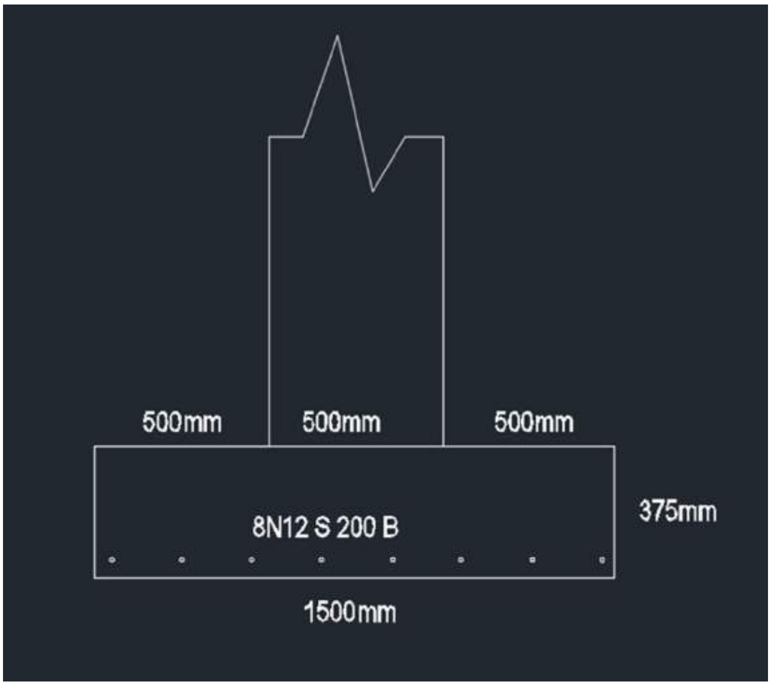


Figure 45: Footing reinforcement, Cross sectional view

3.3.4 Costing

Rawlinson's handbook was referred for estimating the final cost for the Railway platform. Both the platforms are considered to determine final costings. The following tables will show details of the costings for major structural elements:

Table 13: Reinforcement Costing for Platforms

Reinforcement	Slab Bottom	Slab Top	Beam Top	Beam Bottom	Columns	Footing
Area of steel (mm²)	400	1467	1240	1240	3200	880
Length (m)	160	160	160	160	7.7	1.5
Volume of steel (m³)	0.064	0.235	0.198	0.198	0.025	0.001
Density of steel (kg/m³)	7750	7750	7750	7750	7750	7750
Weight of steel (T)	0.4960	1.8191	1.5376	1.5376	0.1910	0.0102
Cost for each element ($)			33,337	33,337	4414	222
Each Platform Cost ($)	11,076	18,947	6673	6673	75,038	3774
Total cost ($)	22,152	37,894	133,346	133,346	150,076	7548
Total Reinforcement Cost for both platform($)	**489,362**					

Table 14: Concrete costing for Platforms

Concrete	Slab	Beam	Columns	Footing
Volume (m³)	360	432	130.9	57.375
Price/cum	299.000	299.000	299.000	261.000
Cost for one platform ($)	107640	129168	39139	14975
Total cost for both platform ($)	**581,844**			

Table 15: Labour costing for platforms

Labor Cost	Slab	Beam	Columns	Footing
Volume (m³)	360	432	130.9	57.375
Hours/cum	1.250	1.250	1.800	0.900
Cost hours	450	540	236	52
Labor required	65	65	65	65
Cost ($)	29250	35100	15315.3	3356.4375
Total ($)	**83,022**			

Table 16: Engineer's Cost for platform

Engineers' cost	Rate/hour	Hours	Cost
Project Manager	180	105	$18,900.00
Team Manager	150	105	$15,750.00
Department Manager	150	105	$15,750.00
Grad Engineer	120	105	$12,600.00
Grad Engineer	120	105	$12,600.00
Grad Engineer	120	105	$12,600.00
Total ($)	**88,200.00**		

Total estimated cost according to the Rawlinson's Construction Handbook (2017) for the structural elements will be equivalent to $1,242,500 for both the platforms.

3.4 Package 03: Rail Platform access structures

3.4.1 Load Calculations:

Load Calculations for the Lift Shaft were completed in Accordance to Australian Standards 1735 – Lift Code and as per the Design provided Urban Department.

3.4.2 Lift Shaft:

Below in Figure 46 is the Lift shaft model created in SpaceGass for calculations.

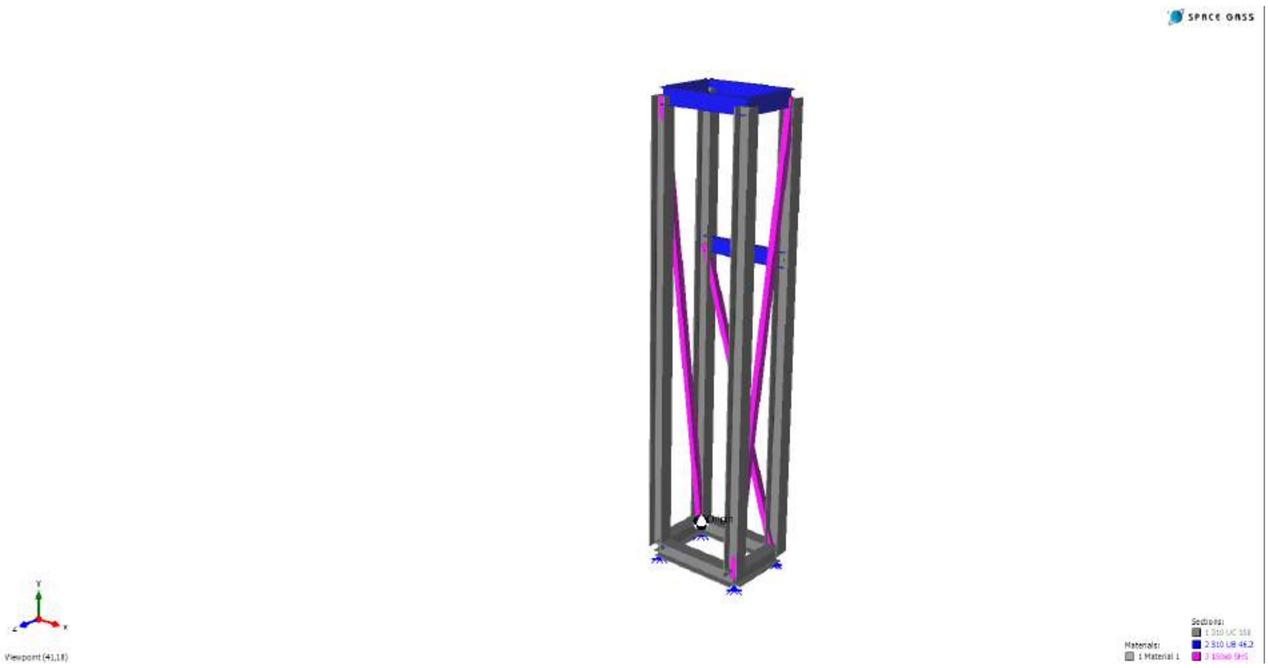


Figure 46: Lift Shaft Model

3.4.2.1 Elements:

3.4.2.1.1 Columns

310 UC 158 Columns were used for the lift shaft design according to AS 1735

3.4.2.1.2 Beams

310 UB 46.2 Beams were used, four beams at the top of the shaft and one 6 meters above the ground for the second opening, according to AS 1735

3.4.2.1.3 Bracings

150 x 8 SHS bracings were used for the back for the lift shaft and the sides.

3.5 Package 04: Centre Median Barriers

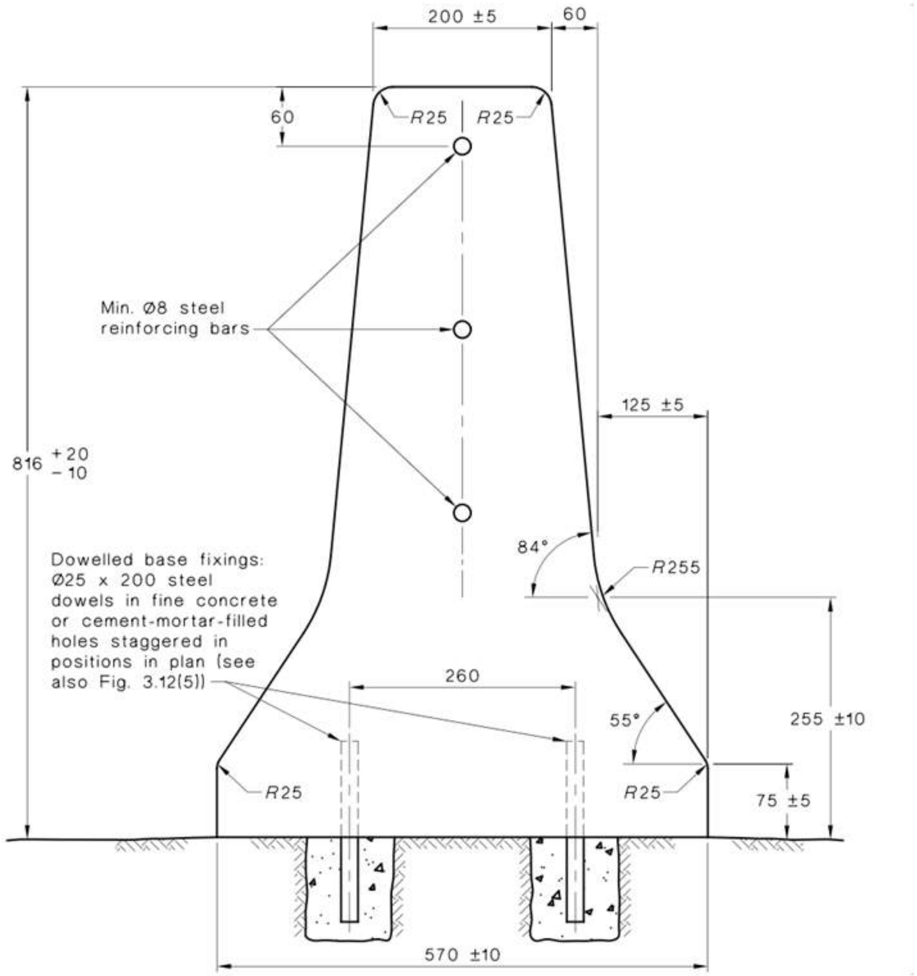
Centre Median barriers are typically used to separate opposing traffic flow and prevent heavy vehicles from travelling into the opposing traffic lanes. Centre median barriers are also used to prevent vehicles from colliding with dangerous obstacles such as columns, signs, trees, bridges and other obstacles. They are also used to discourage pedestrian crossing. Barriers are normally designed to minimize injury to vehicle occupants however, injuries do occur in collisions with them. They are designed to take partial load from the crash before the vehicle collides with an object to minimize the effect of the overall of the collision. Type of barrier is based on the traffic volume, speed, and median width, the number of lanes, road alignment, road width, crash history, installation and maintenance costs (STRUCTURES Standards & Guidelines, 2015).

For the new proposed alignment of Diagonal Road, the centre median barriers are designed across the width of the bridge overpass. The total length of the Centre median barriers is 15 meters in either direction. The red lines below, Figure 477, show the location of centre median barriers below the rail track.

Figure 47: Centre Median Barrier location on the map

According the AS 5100.2 – 2004, the protection barriers are designed to resist a minimum equivalent static load of 2000 kN applied at an angle of 10 degrees from the direction of the road centre-line passing under the bridge.

For Diagonal Road, crash barriers are designed in accordance with Austroads standards, Figure 48, relevant Standards and DPTI technical guidelines. There are nominally three types of barriers: rigid, semi- or non-rigid and flexible barriers. In this case, Rigid Barriers have been used due to the assumption and considerations specified below.



NOTES:

1 Details of the installation of the foundation are indicative only.

2 Units are to be connected at the top of the barrier to obtain the 150 kN force specified in Clause 2.3.6.

DIMENSIONS IN MILLIMETRES

Figure 48: Centre Median Barrier, Rigid Barrier, Type F, AS/NZ 3845:1999

3.5.1 Considerations:

Road Safety barriers systems are designed assuming there will be no movement of the device, other than the elastic strain, during a crash involving the design vehicle. These barriers are only installed below the rail overpass as the hazard and risk associated with impact the device are significantly less than the hazard and the risk of impacting the columns that are protected.

According to the AS/NZS 3845:1999, Rigid Barriers are to be installed in medians and road edges where there is:

- limited space
- a high heavy vehicle content (which need to be constrained)
- few transitions to flexible systems are necessary

As these criteria meet the requirement of Diagonal Road, Rigid Barriers are used.

3.5.2 Costing

Table 17: Costing for Centre Median Barriers

Element	Rate	Length	Total
Barriers	$ 3,000.00	30m	$ 90,000.00
Install	$ 10,000.00		$ 100,000.00

Total estimated cost according to the Road Piers and Barriers (2015)

3.6 Package 05: Electrification Structure

3.6.1 Structure type

The selection of the structure for the overhead wiring support structures will be depend on several factors for example configuration of the track, ground and environmental condition, adjacent vegetation and sighting of signal for the trains drives. There are few types of the structures that are considered to be used for the electrification structure for the Oakland Railway Overpass which are single mast, portal structures, twin track cantilever structure, structure with anchors and balance weight anchors. However for this project we will be using single mast. The structure will be built from a universal column with a fix base. The fixity is provided by holding down bolts in a reinforce concrete footing

3.6.2 Electrical Components

- Insulators
- Overhead wiring (catenary and contact wire)
- Pantograph
- Cantilever arms
- Masts

3.6.3 Design Criteria

3.6.3.1 Australian Standards

- AS 1158 Lighting for Roads and Public Spaces Set
- AS 1680 Interior and Workspace Lighting
- AS 1735.2 Lifts, escalators and moving walks – Passenger and goods lifts - Electric
- As 1742.3 Manual of uniform traffic control devices - Traffic control for works on roads
- AS 2239 Galvanic (Sacrificial) Anodes for Cathodic Protection
- AS 2293.1 Emergency Escape Lighting and Exit Signs for Buildings – System Design, Installation and Operation
- AS 2648.1 Underground marking tape - Non-detectable tape
- AS 3000 Electrical Installations (Wiring Rules)
- AS 3008.1.1 Electrical Installations - Selection of Cables - Cables for Alternating Voltages up to and Including 0.6/1 kV - Typical Australian Installation Conditions
- AS 3013 Electrical Installations – Classification of the fire and mechanical performance of wiring system elements.

3.6.3.2 Design standard

The design of the overhead wiring structure will be accordance to the relevant Australian standard. For concrete footing will be designed base on Australian standard AS3600- Concrete Structures and the design of the overhead wiring structure shall be done accordance with the requirement of RailCorp Engineering Manual TMC 331 -Overhead wiring design.

3.6.3.3 Design Life

The overhead wiring structure will be designed for serviceable of 100 years

3.6.3.4 Design Load

The permanent load that used in designing the overhead wiring structures are to be accordance to with AS 1170 - Structural design actions. The following of the overheard wiring structure will be considered as permanent action.

- Static weight load
- Radial load
- Regulated tension
- Maximum fixed anchor tension
- Weight stack load.

Meanwhile the wind load will be determined in accordance with AS11700 -Structural design action. The ultimate regional wind speed shall determine using appropriate average recurrence interval using important level and design working life from AS1170.2-Wind action

3.6.3.5 Works program

In this electrification structure it will include the installation of the mast and a 25kV of alternate current for the overhead system. However, to support this alternate current a substation that is connected to the SA Power Networks 66kV need to be constructed. Apart from that, the relocation of existing services electricity cables mostly 11kV also need to take into consideration.

3.6.3.6 Spacing

The height of the single mast will be 8 metres tall and will support 4 wires. The return conductor and earth wire will be attached directly to the mast. The contact wire and catenary wire will be held above the track using cantilevered attached to the mast. The spacing of the overheard wiring will depend on environment factor for example wind and curvature of the track. However in this project the spacing of the wiring support will be 50 metres.

3.6.4 Consideration

3.6.4.1 Overlaps

The typical length of overhead wire is 1600metres.Overlaps occurs when one length of the overhead wire comes to end and a new length of overhead wire start. To ensure the continuity of the wiring the first overhead wiring does not come to end where the new overhead wire start but it runs parallel over distance 50metres.So to support two set of overhead wire overlap twin mast are installed two metres apart at both ends of the overlap.

3.6.4.2 Safety

The safety of the rail network of an electrified system are the most important thing during construction and operation. Safety infrastructures need to be installed and safety measures should be enforced to avoid any unexpected incidents. Some of the safety precautions that can be considered are.

- Signage across the network to reinforce safety messages to the passengers and pedestrians.
- Screening at road bridges and pedestrian to restrict people from being able to come into contact with the overhead wires.
- Access to the station will be dedicated pedestrians paths only.

3.6.4.3 Footing

The main loads that carried by the overhead wiring system will be mainly lateral forces and moments rather than vertical forces. There are a few types of footing that can be considered for this project as shown below.

- Regular (box shaped excavated footing)
- Piled
- Footing in Rock

The choice of the footing is determined by construction requirement and site condition. Pile footing is the most economical option in generally however due to site factor such as in ground services or machine access issue often lead to the use of regular footing. In this Oakland Railway Park rock footing will be more feasible because of limited spaces.

3.6.4.4 Cost Estimation components for electrification structures

3.6.4.4.1 Overhead Wiring including Poles

- Overhead traction power wiring, including all associated support structures, catenary wiring and power supply
- Trackside posts, gantries and fittings associated with the support of over track wiring
- Catenary and power wiring and associated tensioning systems within or outside of tunnels
- Transformers, switchgear, insulators, earthing, bonding, registration equipment
- Under track crossings for overhead wiring installation

3.6.4.4.2 Power Supply and Distribution

- Incoming raw power supply to sub-stations
- Substations
- High and low voltage power distribution along corridor
- Transformers for supply to overhead wiring
- Trackside installations associated with Power Distribution

3.7 Reference

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10. Australian Standards AS 1735.2 – 1997, Lifts, escalators and moving walks – Passenger and goods lifts – Electric, Committee ME/4, Lift Installations.
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12. Australian Standards 2239, Galvanic (Sacrificial) Anodes for Cathodic Protection, COMMITTEE MT-014, STEEL IN CONCRETE STRUCTURES.

13. Australian Standards 2293.1 – 2005, Emergency Escape Lighting and Exit Signs for Buildings, Committee LG-007, Installation and Operation

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18. AUSTRALIAN STANDARDS 5100.2 – 2004, BRIDGE DESIGN – DESIGN LOADS, COMMITTEE BD-090, Bridge Design.

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GEOTECHNICAL

4 Geotechnical Design

Abbreviation List

Abbreviation	Definition
Piles Section	
CFA	*Continuous Flight Auger*
FOS	*Factor of Safety*
BH	*Bore Hole*
Retaining Wall	
γ	*density*
$\emptyset'$	*friction angle*
c'	*cohesion*
cts	*centers*
Pavement	
AADT	Average Annual Daily Traffic
HV	Percentages Heavy Vehicles
N_{dt}	total number of heavy vehicle axel groups over pavement design period
TLD	average ESA per each Heavy Vehicle Axel Group
N_HVAG	Average number of axle groups per heavy vehicle
LDF	lane distribution factor
CGF	Cumulative growth factor or effective design life in years
ESA	Equivalent Standard Axles
DESA	Design Equivalent Standard Axles
CDF	Cumulative Damage Factor
AC	Asphalt Concrete
E	Modulus
CBR	California Bearing Ratio

4.1 Scope of work

Geotechnical team is a professional team from DPC engineering company conducting geotechnical aspects designs, in the Oaklands Park Grade Separation Project, geotechnical team is responsible for the geotechnical related design, such as CFA pile footing design, retaining wall design, pavement design, and ballast design.

The whole superstructure were supporting by columns above ground, the loads are transferring through columns then to ground, the geotechnical design team is responsible for dealing with the loads from columns and design proper structure to transfer loads into ground so that providing a footing that will safety support the superstructure all through its design life and perform its intended function, the design team selected CFA pile footing system to transfer load into ground, the footing system consists of pile caps and piles deep into ground, and the pile caps were designed under Australia Standard AS3600:2009, concrete structure, and plies were designed under Australia Standard AS2159:2009, piling design and installation,

The bridge approaching part is 330 meters long, refer to transportation department and urban planning department management strategies, 150 meters of the approaching part is designed to be supporting some soil based structures at both ends of the structure, which is from ground level until 3 meters clearance under the approaching part. Geotechnical team evaluated the planning strategy and selected backfill and retaining wall system to support the structure, as indicated in feasibility study report, cantilever retaining wall will be used in the project, at the design part, detailed design suggestion about backfill and retaining wall design will be given, in the design part, Australia Standard AS4678:2002, earth retaining structures was used, at the same time, Australia Standard AS3600:2009, concrete structure was used to design reinforcement for retaining wall.

As a new traffic management scheme was develop by transportation department, the main roads will be widened from two lanes to threes and new intersection alignment plan at Morphett Rd and Diagonal Rd, so that the new constructed road area needs a pavement design solution to providing traffic a safe road condition, basing on traffic volume and latest pavement design technology, the design team selected flexible pavement solution for the project.

At the same time, as new railway bridge built, the geotechnical design team is responsible for ballast design under rail to providing a comfortable base for rail traffic, the outcome of ballast design will present ballast materials as long as dimension of the ballast.

Costing remains fundamental to a part of design work, after all the design solution are confirmed, the design team will present the total costing of the geotechnical design basing on DPC Engineering Company management regulations.

Accordingly, the design team will work with cad drawing manger delivering design drawings and all the drawings can be found in the drawing document separately.

4.2 Investigations and geotechnical conditions

The aim of site investigation is to obtain adequate information on the physical conditions in the vicinity of the structure including the topography, site layout, nature of soil, foundation bearing capacity and the ground water conditions, together with information on any adjacent structures and services that may be affected, also, investigation includes an assessment of the regional geotechnical conditions where may impact on proposed development.

Based on the structures being designed, attention will be paid to the properties of the soil in the immediate vicinity of the structure as well as underneath the structure, also, the structure type and size are relating to the depth of investigation, also, careful attention will be paid to the geology condition, including geological defects and discontinuities, bedding planes, joints and faults. At the same time, soil conditions like expansive soil should be accounted, as expansive soil is prone to large volume changes including swelling at wet condition and shrinking at dry condition, the suction change of expansive soil is the direct reason lead to ground movement that could affect structure stability.

The geotechnical investigation was organized by client and done by Parsons Brinckerhoff at year 2011 which providing the ground conditions and the factual information on the subsurface soil profile will be used to obtain the adequate information for related geotechnical design. At the other hand, the site investigation results into idealized models that is the basis for all the following geotechnical design, a geotechnical model will describe sub-surface profile as a series of layers, determine the key geotechnical parameter for design, assign values for these key geotechnical parameters for each layer and groundwater be included in the model.

4.3 CFA Pile Foundation Design

4.3.1 Design concept

CFA pile is a reinforced concrete pile which is used to support high building and bridge producing heavy vertical loads. Bored pile is a cast-in-site concrete. Drilled shafts are cast by using bored piling machine which has specially designed drilling tools, buckets and grabs, used to remove the soil and rock. Normally, it can be used by drilling into 50 meters depth of soil. One of the key advantages of a CFA pile system is that it won't produce a lot of vibration and the noise level is also reduced when compared to traditional piling systems.

The main advantages of bored piles or drilled shafts over conventional footing or other types of poles are:

- Piles of variable lengths can be extended through soft compressible or swelling soils, into suitable bearing material.
- Piles can be extended to depths below frost penetration, and seasonal moisture variation

- Large excavations and subsequent backfill are minimized
- Less disruption to adjacent soil
- Absence of vibration will not disturb adjacent piles or structures
- Extremely high capacity can be obtained by expanding the base of the shaft up to three times the shaft diameter, thus eliminating construction of caps over multiple pile groups
- For many design situations, bored piles offer higher capacities with potentially better economic than driven piles

Bored piling is populate to be used in construction as a foundation, especially for Bridge work and tall buildings as well. Bored piling work has to be done by specialist bored piling contractor, normal piling contractor cannot execute there type of work without experience and knowledge about bored piles (Rodriguez 2017).

Continuous Flight Auger (CFA) Piling is a type of bored pile, the design team will use CFA piling system in the design. This piling is a non-displacement piling system which produce less noise and it is very fast and economical. 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.

4.3.2 Design method

The design process are based on Australian Standard AS2159-2009: piling design and installation, and design objective is to provide a footing that will safely support the superstructure over its design life.

The footing must be durable, of adequate strength and its performance be compatible with the superstructure so that it remains serviceable and can perform its intended function.

Basing on geotechnical consideration, the design team will design the pile footing for strength, meanwhile, the design will take into account pile and soil interaction and values of soil parameters are related to the design, so that, in the design part, a simplified soil profile and soil parameters are developed.

Refer to the geotechnical design principles recommended by AS2159-2009, the design team will check:

- Ultimate geotechnical capacity R_u, and be satisfied to $R_u \geq E_d$, where E_d is the design action effect. And the design team will use factor of safety to evaluate design performance.

  $$Factor\ of\ Safety: FS = \frac{Ultimate\ \text{Design Capacity}}{Design\ Action}$$

  $The\ FS\ normally\ between\ 2\ and\ 3.5\ for\ pile\ foundations$
- Geotechnical strength design, the design geotechnical strength $R_{d,g}$ should not less than E_d,

the design action effect, and geotechnical strength is calculated from geotechnical strength reduction factor multiplied by the ultimate geotechnical strength. The geotechnical strength reduction factor was calculated using a risk assessment procedure.

- Group piles efficiency check, as pile groups are used under each column, a group piles efficiency check will be conducted by the design team to ensure a safe design, in the process, the each pile group was treated a singular mega pile.

All the design process and calculations will be in Appendix G.

4.3.3 Design actions and loads

The design of pile for ultimate strength and geotechnical strength limit states shall take account of appropriate action effects arising from the:

- All actions specified in AS 5100.2 and other relevant actions (Done by Structure Team)
- Permanent actions of pile and pile cap
- Ground movement, include NEGATIVE FRICTION, EXPANSIVE SOIL AND VERTTICAL AND LATERAL EARTH MOVEMENTS that may arise from various sources
- Handling
- Installation (for CFA pile)
- Any other addition loads and actions that may be applied (impact, dynamic loading, water pressure and scour)

Load combination for strength design are factored loads that produces the most adverse effect on the pile in accordance with AS 1170.0 which are done by Structure team. And the design actions for serviceability design of piles shall be taken from the appropriate combinations of actions for short-term situations and long-term situations in accordance with AS 1170.0

4.3.4 Soil profile for pile footing design

Basing on geotechnical investigation report and borehole data provided by client, the complete engineering borehole logs with descriptions of the encountered materials are studied by design team.

OPHB06 - OPHB08, OPHB12 and OPHB13 are locates at pile footing design area, 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.

Refer to appendix G for summarized soil profile and a typical borehole data of OPBH06.

Basing on the typical borehole data OPBH06 and other borehole data in the design area, a simplified soil profile was developed as show in table below.

Table 18: Simplified soil profile for pile footing design

Layer	Depth (m)	Layers Depth (m)	Relative Density/Consistency	$\gamma\ (kN/m^3)$	$C_u(kPa)$	Angle of Shearing Resistance ∅
1	0 - 2.5	2.5	SAND; D	20.5		30
2	2.5 - 6	3.5	CLAY; VST-H	20	30	
3	6 - 9.4	3.4	SAND; VD	21		35
4	9.4 - 11.3	1.9	CLAY; H	20	200	
5	11.3 – 14.75	3.45	CLAY; ST-VST	19.5	150	
6	14.75 – 20	5.25	CLAY; H	20	200	
7	20-25.8		CLAY; H	20		
8	25.8 - 29.64	3.84	SAND; VD	19.5		
9	29.64 --	--	SAND; VD	19.5		

Explanation for Table 18

- Soil layer depth and relative soil density, consistency are based on borehole log data
- Soil unit weight, cohesion and angle of shearing resistance are determined by Part 3 of AUSTROADS Bridge Design Code, refer to appendix G for details.

- C_u for clayed soil layers were calculated by using $C_u = 6 * N$ accordance with AUSTROADS BRIDGE Design Code

$layer\ 2: N = 8,\ C_u = 6 * 8 = 48$

$layer\ 4: N = 38, C_u = 6 * 38 = 228$

$layer\ 5: N = 38, C_u = 6 * 38 = 228$

$layer\ 6: N = 38, C_u = 6 * 38 = 228$

- The final C_u values were determined in the table above for the safe consideration.

4.3.5 Detailed Design

4.3.5.1 Design scope of work

Accordance to the design purpose and design loads, the design team selected continuous flight auger CFA piling system for the project, and continuous flight auger CFA piling is a quiet, fast and economical piling technique. It is a cast in situ process and very suitable for soft ground condition and deep piling design.

In the design, there are 4 Continuous flight auger piles in a pile cap system, therefore, there are 46 pile caps refer to 46 columns total of 184 CFA piles were designed.

4.3.5.2 Ground water level consideration

In the geotechnical investigation report, the water level was indicated at 12.5 meters depth from ground level, however, considering the potential flood effect for long term design, the water level was considered as at the ground level for the design as the safety consideration.

4.3.5.3 Final design recommendation

The dimension for each pile will be 20-metre-deep and 1200mm diameter.

The pile cap under each column is 5 meters by 5 meters.

Refer to appendix G for all design process and figure below for the plan view for the CAF pile footing foundation.

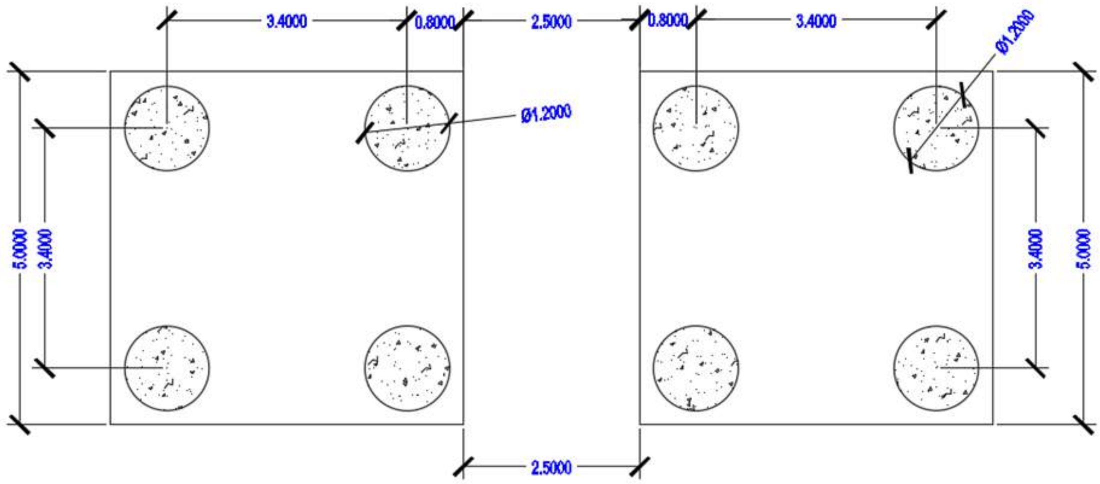

Figure 49: CAF pile foundation plan view

4.3.5.4 Pile reinforcement

Piles are designed fully embedded in the ground, the total loads apply on each pile cap is 5145kN, and four piles under each pile cap, which is 1200mm at diameter and 20 meter depth, based on AS2159, CL5.3.3, the minimum reinforcement is required for the project, which is $0.005A_g$, A_g is the gross section area of pile.

$$0.005A_g = 0.005\pi r^2 = 0.005 * \pi * 600^2 = 5652mm^2$$

Then 13N24 bar are required, which provides a $5850mm^2$ reinforcement area.

75mm concrete cover used.

Accordance to with AS 3600- 2009, Clause 10.7.4.3

N12 bar used.

And spacing was determined by:

Smaller values of D_c and $15d_b$

Where,

$$D_c = pile\ diameter = 1200mm$$

$$d_b = bar\ diameter\ in\ pile = 24mm$$

Then,

$$15d_b = 15 * 24 = 360mm$$

Thus,

$$\text{Spacing} = 360\text{mm}$$

Hence, reinforcement schedule for pile is 13N24 with N12 fitments at 360mm centres.

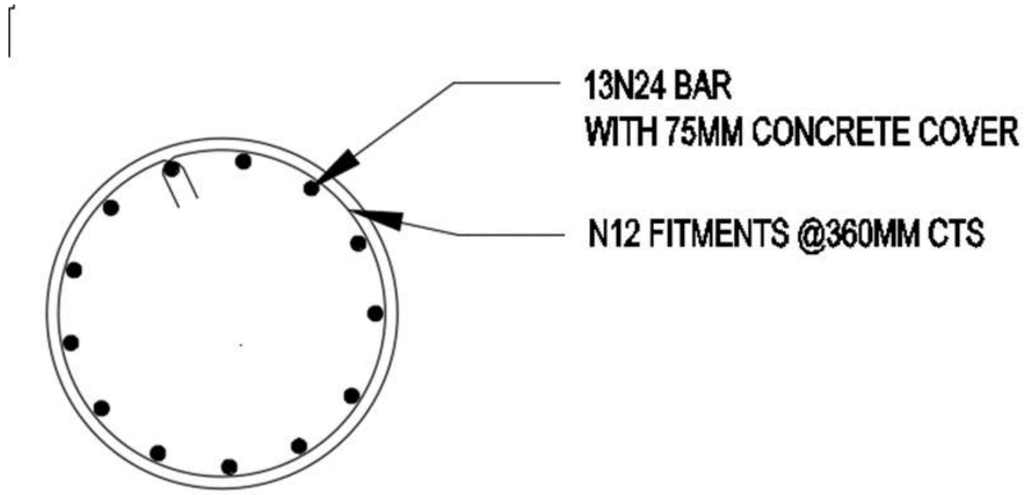

Figure 50: Pile reinforcement

4.3.5.5 Pile cap design and reinforcement

Design parameters:

Cover=75mm

Concrete strength=40Mpa

Based on AS3600, Concrete structure design, the pile caps will be designed as deep beam, and strut and tie model will be used to design.

Refer to appendix for break down design steps.

The pile cap was designed as 5000mm by 5000mm square section with a depth of 2550mm.

Bottom reinforcements were provided as 5N24, at four sides of the square section, bar center to center length is 300mm.

Refer to Figure 51 for detailed bottom reinforcement.

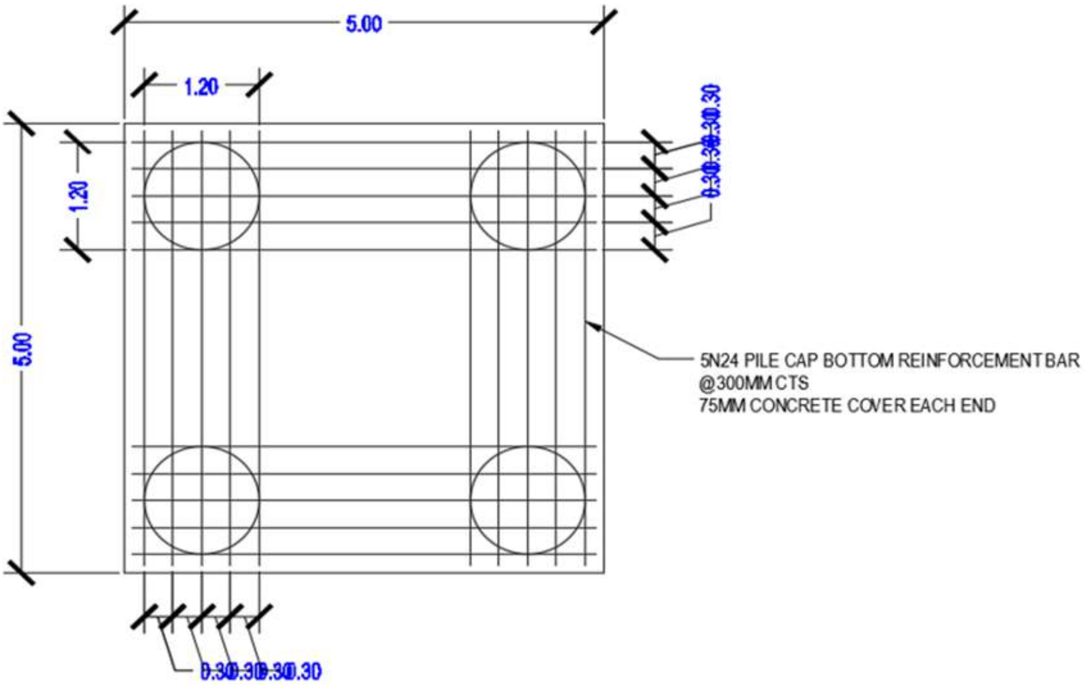

Figure 51: Pile cap bottom reinforcement (unit in meters)

For concrete crake and shrinkage control purpose, top reinforcement mesh was provided as N12 bar at 970mm centres for both directions.

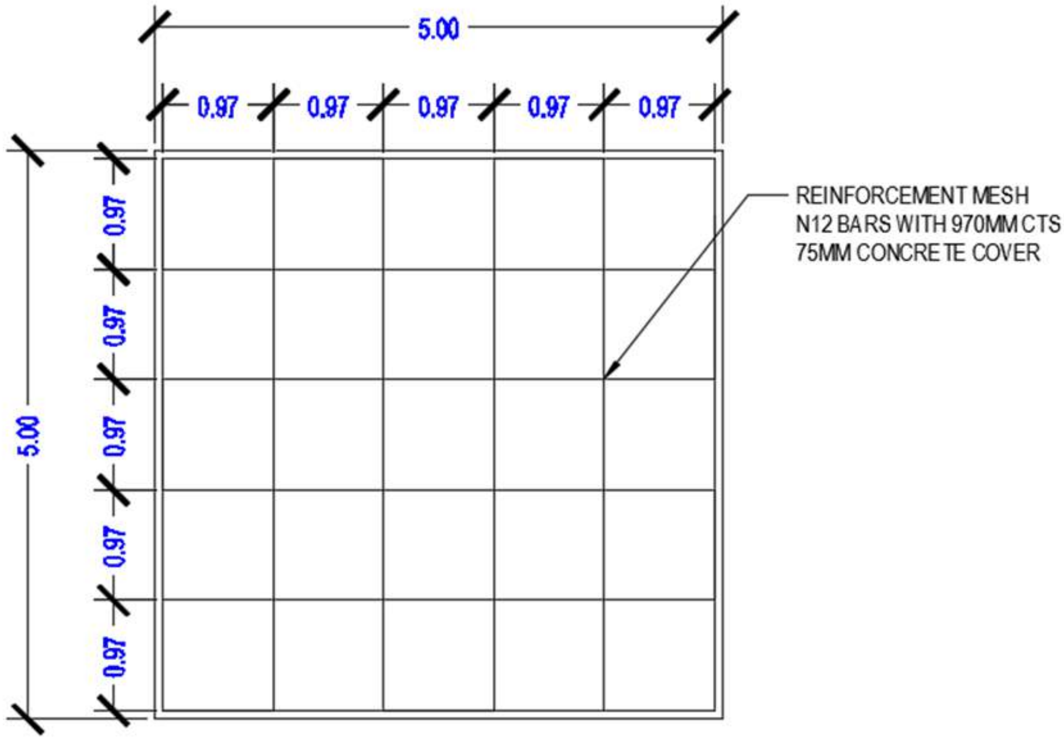

Figure 52: Pile cap top reinforcement mesh (unit in meters)

And figure below shows the pile footing system reinforcement schedule.

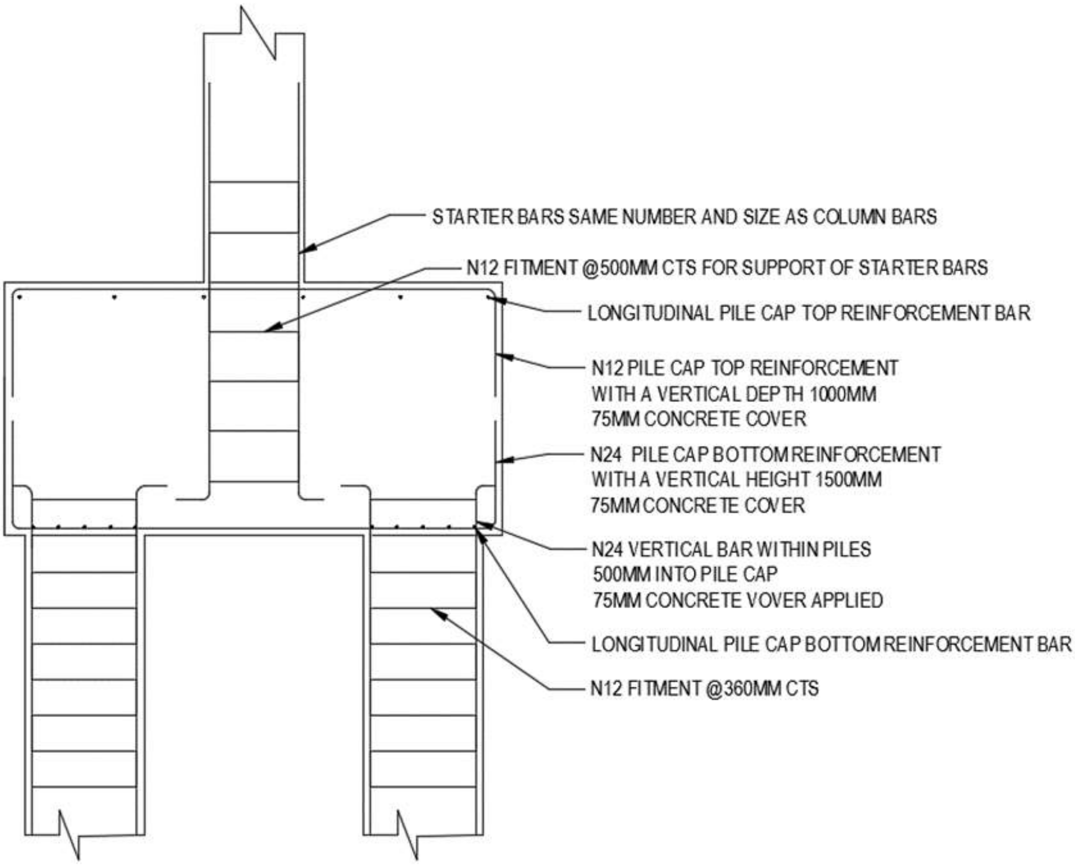

Figure 53: Pile footing system reinforcement schedule

4.3.5.6 Pile installation

CFA method is a system used in construction of bored piles. Pile drilling is made with a long solenoid drill. The drill is continuous and it is inserted in the ground by rotating in the same direction until the bottom end of the pile. While a part of the drilled foundation is extracted to the surface, the other part is displaced and pushed to the pile walls in the ground.

After drilling to the desired level, compressed concrete is pumped inside the well from the hole at the centre of the special CFA drill while pulling out. After the drilled are is filled with concrete up to the platform surface, the prearranged reinforcing cage is placed inside the fresh concrete. All installation procedure will be designed accordance with the Australian Standard AS 2159: 2009.

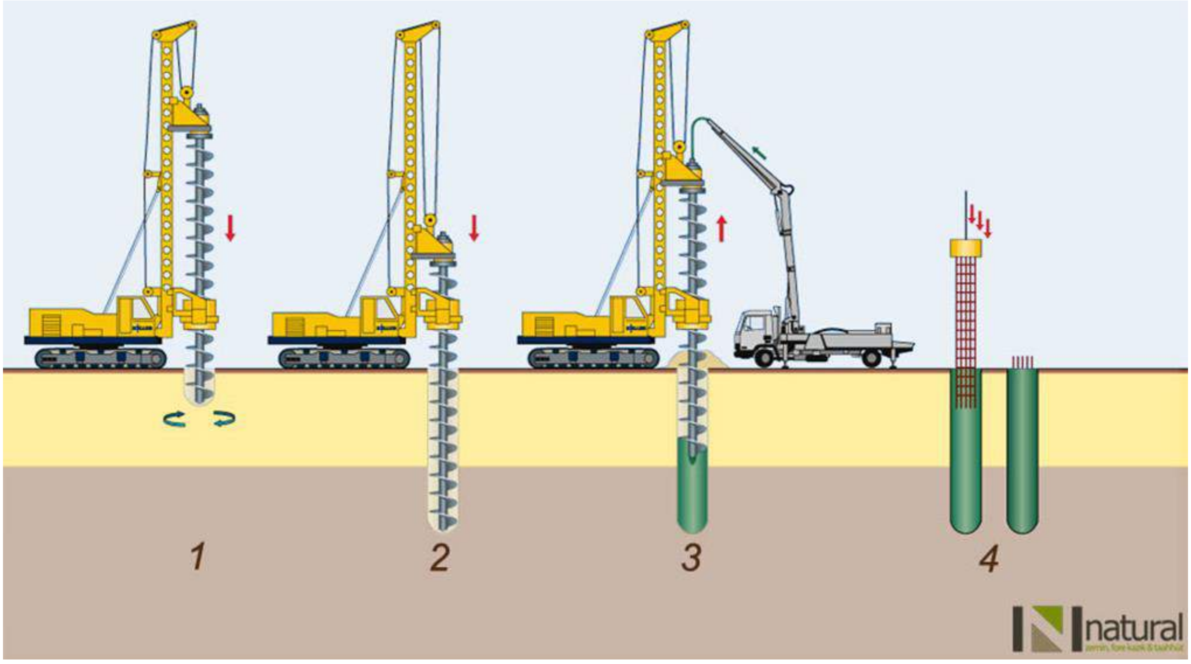

Figure 54: Pile footing installation process

(Source: CFA Pile, 2017, natural Zemin, fore kazik & tahhut)

4.4 Retaining wall and backfill supporting system design

4.4.1 Design concept

Basing on project specific condition and design requirement, the 150 meters long bridge approaching part will be supported by retaining wall and backfill supporting system, which is from ground level till 3 meters clearance under approaching part and its 3D illustration shows below.

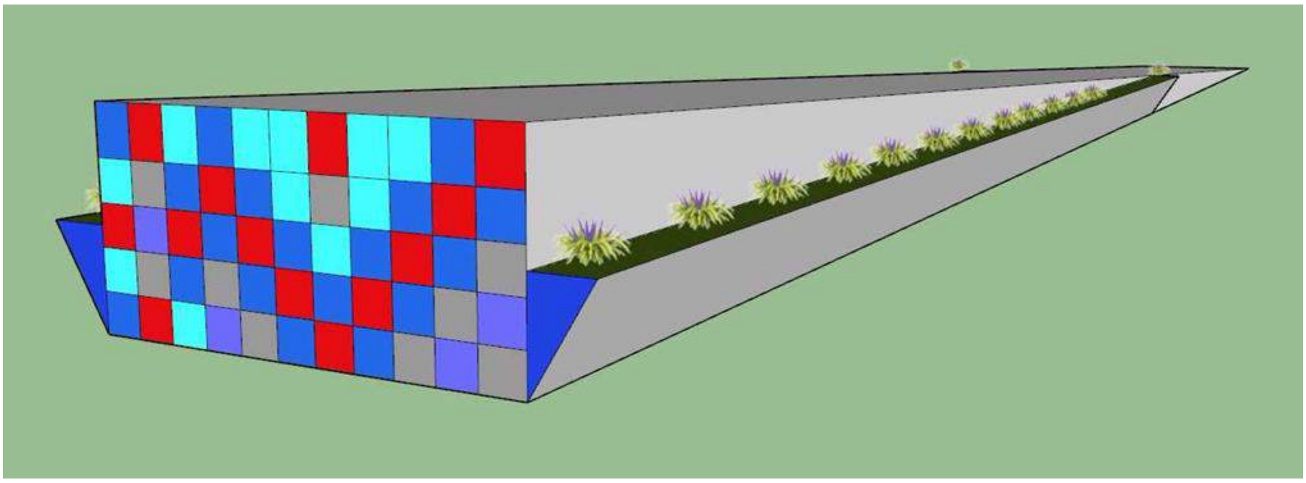

Figure 55: 3D illustration of retaining wall

According to the recommendation of feasibility study report, cantilever retaining wall is selected for the project, cantilever retaining wall is made of internal bars of steel, cast-in-place concrete. 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. This type of wall is using 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.

4.4.2 Design method

4.4.2.1 Back filling materials selecting criteria

And the backfill refer to the dirt behind retaining wall, the most important feature of backfill materials is a proper drainage as retaining wall are built with impervious materials such concrete and steel and water cannot pass through them, then well graded compatible granular aggregate backfill materials are required.

The reason to select granular materials can be expressed as: clay soils are comprised of small flat particles and the micro soil structure will drain away water very slow while soil with high percentage of sand and gravel are comprised of larger more angular particles, and the type of soil has a lower cohesive properties but it can drain water away rapidly, the features of these soil provides a more stable soil mass and reduce hydrostatic pressure in saturated.

4.4.2.2 Cantilever retaining wall design method

In the cantilever retaining wall design proves, three failure types will be checked, such as overturning check, base sliding check and ultimate bearing capacity.

Overturning refers to the tipping over of the retaining wall rotating about the toe of the retaining structure, the overturning force is from backfill soil passive pressure acting on the wall stem while the stabilizing force is the sum of structure total weight and vertical soil pressure acting on wall, overturning failure happens when stabilizing force is smaller than overturning force.

Base sliding refers to the outward movement of the bottom of the retaining wall as the resultant lateral force generated by earth pressure and water pressure, the force resisting base sliding is the friction between wall footing and soil layer underneath, increasing the front to back dimension of the wall can increase resisting force and keep the structure safe.

Bearing capacity is referring to the ability of the foundation soil support the weight of the retaining wall, the footing base of retaining wall is regarded and analyzed as shallow foundations method, increasing the structure base area would help to increase soil bearing capacity and to increase the depth of retaining wall would increasing the ability of soil bearing capacity underneath.

The factor of safety will be used to evaluate the three design components for the project to ensure the final design is safe and performing the structure contented function.

For overturning component design:

$$Factor\ of\ Safety: FoS = \frac{resisting\ moment}{overturning\ moment}$$

And FoS should greater than 2.5 to satisfy design criteria.

For base sliding component design:

$$Factor\ of\ Safety: FoS = \frac{sliding\ resisting\ force}{sliding\ force}$$

And FoS should greater than 1.5 to satisfy design criteria.

For bearing capacity component design:

$$Factor\ of\ Safety: FoS = \frac{allowable\ bearing\ pressure}{force\ per\ area}$$

And FoS should greater than 1.5 to satisfy design criteria.

4.4.3 Backfilling design

4.4.3.1 Filling materials

In order to minimized soil and moisture pressure applying on retaining wall structure as well as settlement of the filling, the design team used granular, free-drainage material filled behind the retaining structure, also, the filling materials should be high level of compaction so as to avoid any subsequent railway settle.

The design team uses two types of granular materials blending together to form a finer filling materials for the project. According Australia Standard AS4675-2002 earth retaining structures, two groups of soil materials meet the backfilling design criteria, Class I soil group and it is a good soil group for filling, which is referring to gravelly sands, compacted sands, controlled crushed sandstone and gravel fills and dense well graded sands, to an average material level, Class II soil group is an option as well, and it is referring to stiff sandy clays, gravelly clays, compact clayed sands and sandy silts, compacted fill, usually, Class I soil group has lower cohesion parameter and greater friction angle.

The backfill is designed to have two types of fill, the structural zone, which is 500mm or 1000mm under formation capping level, the design team select 800mm of structural zone filling thickness and general fill under structural zone. In the project, the design team selected Class I materials for general fill and Class II materials for structural zone filling.

Refer to ballast design section for the information of formation capping level.

Basing on the soil classification table and soil unit weight table below, the back-filling soil parameter determined as:

$\gamma = 21.5\text{kN/m3}$

$\emptyset' = 32\text{deg}$

$c' = 0$

Table 19: Soil classification (AS4675-2002)

SOIL CLASSIFICATION

Soil group	Typical soils in group	Soil parameters	
		c' (kPa)	ϕ' (degrees)
Poor	Soft and firm clay of medium to high plasticity, silty clays, loose variable clayey fill, loose sandy silts	0 to 5	17 to 25
Average	Stiff sandy clays, gravelly clays, compact clayey sands and sandy silts, compacted clay fill (Class II)	0 to 10	26 to 32
Good	Gravelly sands, compacted sands, controlled crushed sandstone and gravel fills (Class I), dense well-graded sands	0 to 5	32 to 37
Very good	Weak weathered rock, controlled fills (Class I) of roadbase, gravel and recycled concrete	0 to 25	36 to 43

Table 20: Unit weight of soil (AS4678-2002)

UNIT WEIGHTS OF SOILS (AND SIMILAR MATERIALS)

Material	γ_m: moist bulk weight (kN/m³)		γ_s: saturated bulk weight (kN/m³)	
	Loose	Dense	Loose	Dense
A—Granular				
Gravel	16.0	18.0	20.0	21.0
Well-graded sand and gravel	19.0	21.0	21.5	23.0
Coarse or medium sand	16.5	18.5	20.0	21.5
Well-graded sand	18.0	21.0	20.5	22.5
Fine or silty sand	17.0	19.0	20.0	21.5
Rock fill	15.0	17.5	19.5	21.0
Brick hardcore	13.0	17.5	16.5	19.0
Slag fill	12.0	15.0	18.0	20.0
Ash fill	6.5	10.0	13.0	15.0
B—Cohesive				
Peat (very variable)	12.0		12.0	
Organic clay	15.0		15.0	
Soft clay	17.0		17.0	
Firm clay	18.0		18.0	
Stiff clay	19.0		19.0	
Hard clay	20.0		20.0	
Stiff or hard glacial clay	21.0		21.0	

4.4.3.2 Compaction

Compaction is expulsion of air from filling materials and rearrange soil to consolidation, the process of compaction is to applying a force or vibration on the soil, the backfill materials under proper compacted would increase strength as internal soil internal strength has been increased due to soil particles be realigned staying together tighter, at the same time, compaction process increase soil coefficient of friction when under loading condition, as air void be decreased so that the undesirable settlement would be reduced to minimum during design life. In the other words, compaction would increase strength, stiffness and durability of filling materials and decrease permeability at the same time and low permeability of backfill materials can reduce water press by reducing water level to ensure structural stability.

Usually, in order to achieve specific compaction requirement, compaction process is conducted at a specific moisture content, within 2% of moisture content is optimum for compaction purpose. There are two types of standard compaction methods used in civil construction, such as Compaction A and Compaction B.

As for cohesive soils Compaction A requires a not less than 100% relative compaction as determined by AS1289, while for rock fill or cohesion less soil, it requires a no visible deflection of surface under 10 tones vibratory rollers after 6-8 passes. Compaction B requires not less than 95% relative compaction as determined by AS1289.

In the project, Compaction B is recommended for general fill and Compaction A for structural zone.

For compaction purpose, heavy compaction equipment such as smooth steel rollers, sheepsfoot roller can be used

Figure 56: Smooth steel rollers (Source: Compare factory)

Figure 57: Sheepsfoot Roller (Source: the county of Lincoln – Road)

4.4.4 Retaining wall detailed design

4.4.4.1 Railway traffic surcharge

Railway sleepers supporting rail traffic load and transferring to backfill, the design team regarded the load applying on backfill as a uniformly distributed load over the area defined by the length of sleepers and the length of loaded track, according to bridge design code, AS5200.2, surcharge load from rail traffic was estimated as 90kpa applying on backfill, which will be used in retaining wall design process.

4.4.4.2 Retaining wall design process

As the design concept and 3D illustrate shown Figure 58, there are three pieces of retaining walls need to be designed, a underneath wall under the bridge approaching part which is perpendicular to railway track direction, two side wall at each side of railway which are parallel to railway track direction. These retaining walls are indicated in the figure below. And Figure 59 shows the cross section of retaining wall.

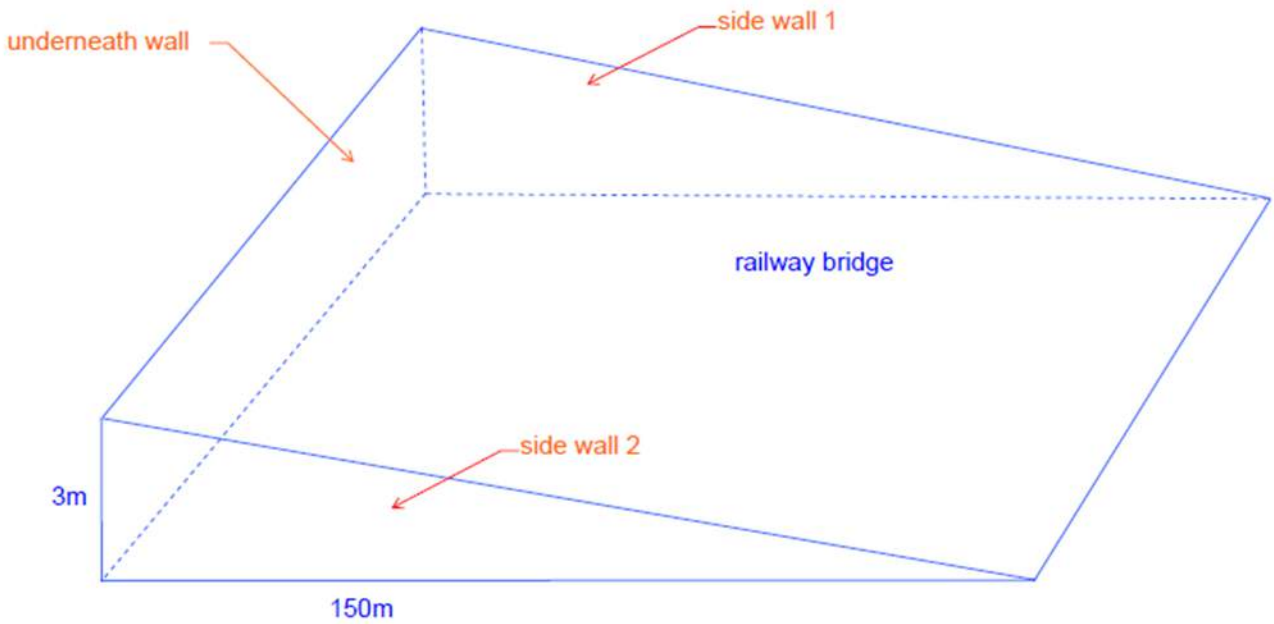

Figure 58: Retaining walls need to be designed

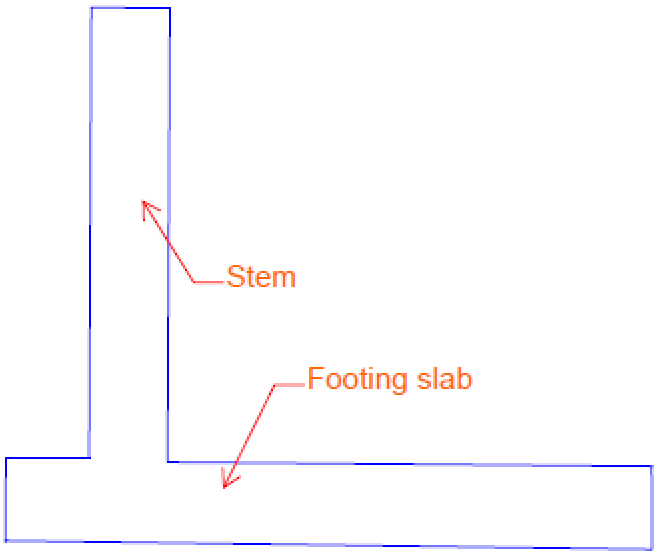

Figure 59: Cross section of retaining wall in the project

In the design process, the underneath retaining wall was design 3 meters height and same width as the bridge span, and the surcharge applying on the backfill was inclined, however, the ration of vertical to horizontal is small enough and the horizontal length of backfill is 150 meters, the design team regarded the surcharge was vertically applying on backfill.

For the side retaining wall design process, each of the side retaining wall is a triangle with a maximum height of 3 meters and 150 meters long, for an economic design purpose, the design team will provide a design solution for each 0.5 meter at height.

Refer to the calculation process provided in appendix G.

4.4.4.3 Final design solutions

The final design solution is below:

Final Design for Underneath Wall

The conditions for underneath wall is same as the side wall which mean the final design of underneath wall will be the same as the side wall for 3 meters height which show at Figure 60.

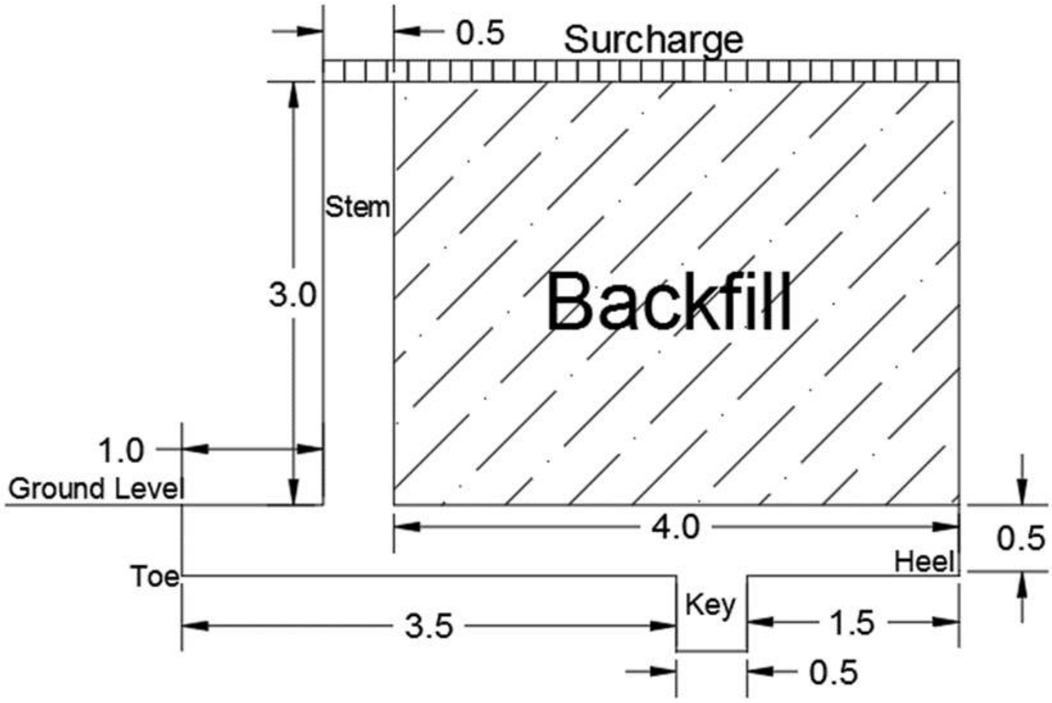

Figure 60: Final design for Underneath Cantilever Retaining wall (meter)

Final Design for Side Wall

Since it is not economic for use dimensions with maximum height for the rest of the design. Figure 61 and Table 21 show the dimensions needed for different height

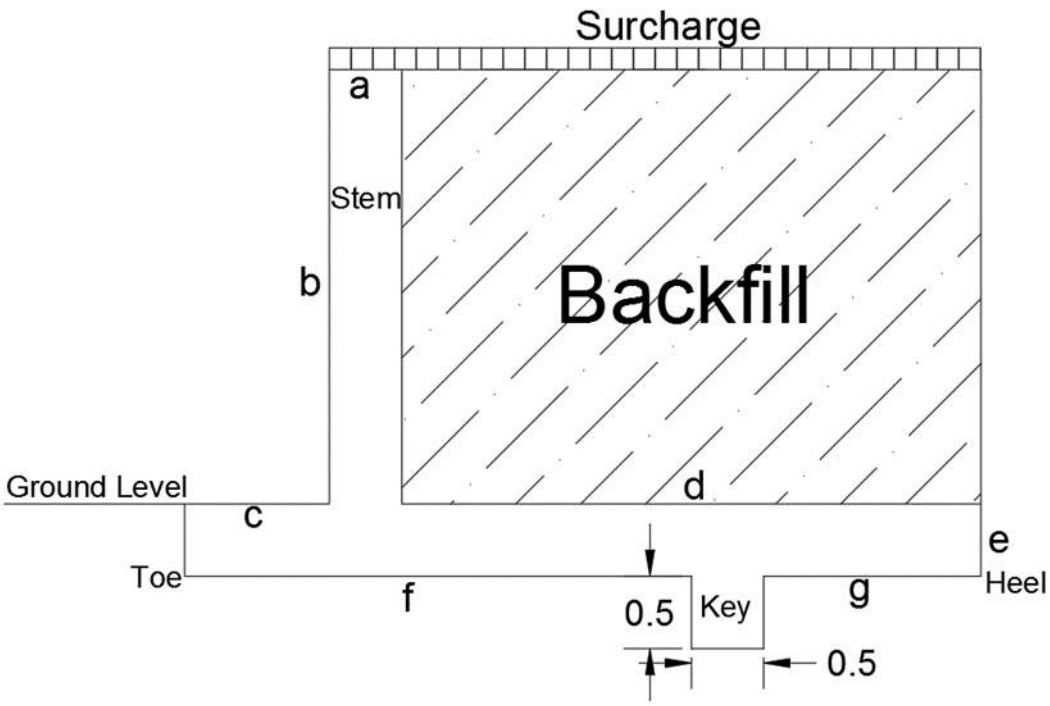

Figure 61: Diagram of cantilever wall with key (meter)

Table 21: Dimensions for side wall design for different height level

Height (m)	a (m)	b (m)	c (m)	d (m)	e (m)	f (m)	g(m)
3	0.5	3	1	4	0.5	3.5	1.5
2.5	0.5	2.5	1	3.5	0.5	3	1.5
2	0.4	2	0.8	3.2	0.4	3	1
1.5	0.3	1.5	0.7	3	0.3	2.5	1
1	0.3	1	0.7	3	0.3	2.5	1
0.5	0.3	0.5	0.7	3	0.3	2.5	1
0.1	0.3	0.1	0.7	3	0.3	2.5	1

4.4.4.4 Detailed reinforcement schedule

Retaining wall is constructed by using cast-in-suit concrete, for a strength limit state, 40Mpa concrete will be used, and 500Mpa strength reinforcement bars are used.

For reinforcement bar will be designed as four proportioning, wall proportioning, heel proportioning, toe proportioning and key proportioning, each proportioning will be provided vertical reinforcement bars and longitudinal reinforcement bars.

All proportioning is using 50mm cover except toe proportioning using 75mm cover.

Refer to appendix G for reinforcement bar design process and summarized design information are below:

Wall proportioning

- Vertical reinforcement: N20 bars at 200mm centers.
- Longitudinal direction:
- N20 bars at 175mm centers @ back face (facing to backfill materials)
- N16 bars at 225mm centers @ front face

Heel proportioning

- Vertical reinforcement: N20 bars at 200mm centers
- Longitudinal direction:
- Two layers of N16 bars at 200mm centers

Toe proportioning

- Vertical reinforcement: N16 bars at 200mm centers

- Longitudinal direction:
- Two layers of N16 bars at 200mm centers

Key proportioning

- Vertical reinforcement: N20 bars at 200mm centers
- Longitudinal direction:
- Two layers of N20 bars at 225mm centers

Refer to Figure 62 For detailed reinforcement schedule.

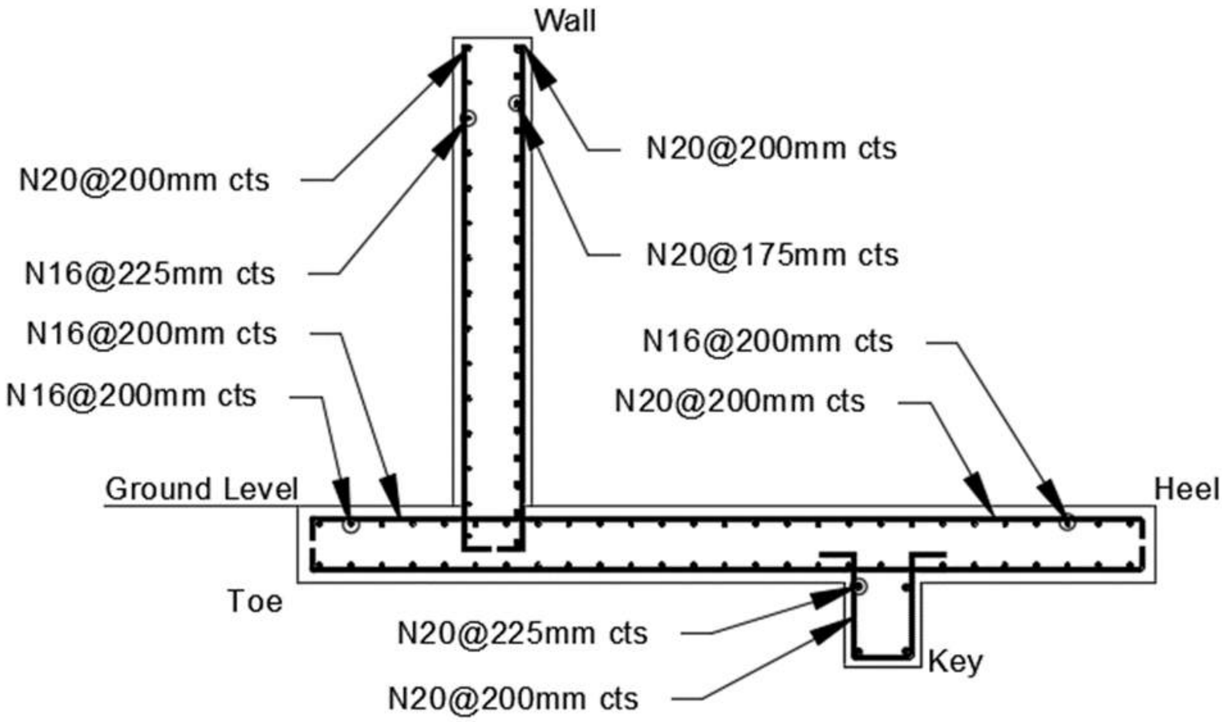

Figure 62: Retaining wall detailed reinforcement schedule

4.5 Pavement design

4.5.1 Design concept for pavement

Pavement is one of the important component in Geotechnical design. Pavement is a structure comprising of superimposed layers of prepared materials over the natural soil whose essential capacity to distribute the vehicles load to the soil sub-grade. Our goal is to design the pavement ought to have the capacity to provide surface of satisfactory vehicles users quality, sufficient skid resistance, light reflecting attributes and low noise pollution. Ultimately is to achieve the transmitted stresses causes by vehicle wheel load are achieving the requirements reduction to prevent the surpass of bearing capacity of the sub-grade.

Pavement Design Consideration for Specific Project Area:

- Satisfactory thickness to distribute stress load caused by wheel vehicles according to requirements of the sub-grade soil
- Fundamentally strong to withstand a wide range of stresses forced upon it
- Satisfactory coefficient of erosion to anticipate skidding of vehicles
- Satisfactory smooth surface to provide comfort pavement condition
- Achieve minimum noise pollution from moving vehicles
- Well-protected sub-grade soil with impenetrable surface pavement.
- Reducing visibility impact with dust proof surface
- Long life design with economy maintenance cost

4.5.2 Design method

4.5.2.1 Traffic data analysis method

Based on Oaklands Park Road Traffic Analysis Report provided by Planning & Design, Transport Services Division, DTEI, several important roads within the construction area is being targeted. In order to perform the pavement design, traffic data analysis is relatively important such as average annual design traffic, percentage of heavy vehicles and so on. Pavement design is enormously impacted by the measure of vehicles and in this way the examination of traffic volume is the need in the plan. The traffic volumes is generated and can be found in appendix G.

The average of AADT for particular road is calculated and designation of pavement are selected based on estimated critical %HV and critical average AADT with the motivation to achieve cost efficiency in pavement design. From the summarized traffic volume data, the highest Average Annual Daily Traffic, AADT is 60100 vehicles per day with 2020 trucks which are heavy vehicles. Therefore, the pavement design will priority on the most critical road which are Diagonal road with the highest AADT. Besides that, as a lower traffic volume at Prunus Street, another separate design for Prunus will be conducted, refer to traffic volume analysis report, the AADT for Prunus Street is 21500 and 3.6% HV.

Ultimately, two sets of pavement design layers will be provided, such as pavement design layers for Morphett Road & Diagonal Road and pavement design layers for Prunus Street.

Design traffic on a pavement is estimated based on AUSTROADS Guidelines.

4.5.2.2 Pavement design method

As main roads be widened and new road alignment at intersection area, new design pavement will be applying in these areas.

As discussed in feasibility study report, flexible pavement will be selected as the type of pavement, a flexible pavement yields elastically to traffic loading, it is constructed with a bituminous treated surface over some unbound base courses resting on a subgrade. The advantage of a flexible pavement is to distribute loadings to these layer systems that designed to ultimately protect each underlying layers including subgrade from shear compressive shear failure.

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.

4.5.3 Traffic data analysis

4.5.3.1 Selection of design period

Table 22: Typical design periods

Annual Average Daily Traffic (AADT)	Typical Design Period
$\geq \mathbf{30000}$	30
$< \mathbf{30000}$	20

$ADT = Average\ Annual\ Daily\ Traffic = 60100$

$Based\ on\ the\ table\ above\ and\ average\ annual\ daily\ traffic\ for\ Diagonal\ Road\ are\ 60100\ which$

$more\ than\ 30000. Therefore, the\ standard\ design\ period\ is\ selected\ 30\ years.$

4.5.3.2 Design traffic equivalent standard axles

In pavement design, the first step is to calculate the design traffic. The simplest approach is the Equivalent Standard Axel (ESA) method. Different type of axle configurations carry different standard loads are converted to one ESA. The design traffic can then be represented as a single number which is the number of applications of the ESA to cause the same damage to a pavement road as for the actual traffic, over its entire design life. For an axel configuration with non-standard load, the ESA can be calculated as below:

$$ESA = (\text{non} - \text{standard axel load} \ \div \ \text{standard axel load})^4 \qquad (1)$$

As for a small vehicle which has axel load much less than the standard axel load, the ESA will be very small due to the power of 4 from above equation. Thus the small vehicles are unlikely to cause significant damage in comparison with heavy vehicles which likely to have larger than standard axel load. As a general approach, the design ESA is calculated as:

$$DESA = N_{dt} \times TLD \qquad (2)$$

Where:

N_{dt} is the total number of heavy vehicle axel groups over pavement design period

TLD is the average ESA per each Heavy Vehicle Axel Group (HVAG)

And the total number of heavy vehicle axel groups over pavement design period is calculated by

$$N_{dt} = 365 \times AADT \times DF \times (\%HV) \times N_{HVAG} \times LDF \times CGF$$

Where

AADT = Average annual daily traffic count

DF = Direction factor

%HV = Percentage of heavy vehicles

N_{HVAG} = Average number of axle groups per heavy vehicle

LDF = lane distribution factor

CGF = Cumulative growth factor or effective design life in years

Basing on traffic data, the design equivalent standard axle is 3.3×10^7

4.5.4 Pavement Layers Design

4.5.4.1 Wearing Surface

The main function of the wearing surface is to endure the common loading and environmental effect such as moisture, dust and minor vehicles oil leakage during pavement usage. Main motivation is to provide a protected and functional riding surface with diminished moisture and noise while in the meantime shielding the basic asphalt courses from moisture infiltration. Among all the common utilized surface courses such sprayed seals, asphalt and concrete, sprayed bituminous seal is selected because it gives an efficient solution to the surfacing issues. Sprayed bituminous seal comprises of a thin film of bitumen showered on top of a compacted base and consolidates a layer of single-sized stone. Overall, they are a minimal cost option to different types of sealed pavement such as asphalts.

4.5.4.2 Base Course Layer

Base surface as known as the load carrying layer which commonly utilized a treated or mechanically settled unbound granular to enhance the properties to achieve better performance in term of loading. Improvement such as stabilization can be applied to improve the quality of the base. Most commonly utilized stabilizer is cement. In considering the project design, life span and strength of the pavement is the most critical among other aspect.

4.5.4.3 Subbase Layer

Subbase is a layer that also having the similar function as base course layer. However, this layer is most related to economics and lower stress levels than other layers closer to the pavement surface. The fundamental part of the subbase is to provide sufficient support to the base and decrease the stress and strains applied to the subgrade.

The design parameters for type A fill is used in the pavement design for standard fill materials. The table below showing the typical material fill for pavement design. The maximum allowable design modulus for fill materials is 100 MPa.

Material	Design Parameter
Type A Fill	$E \leq 70MPa$, $\nu = 0.45$
Type B Fill	$E \leq 50MPa$, $\nu = 0.45$
Type C Fill	$E \leq 50MPa$, $\nu = 0.45$

4.5.4.4 Subgrade layer

Subgrade as knowns as the preparation layer of the formation on which the pavement is constructed. The purpose of subgrade layer is to provide sufficient support to the upper layers and able to withstand the stresses applied from the upper layer. Based on the provided soil provided, the layer below the subgrade level is Clayed Gravelly SAND which having CBR values > 12%. Therefore, the subgrade layer design is designed based on the provided CBR values.

The design ESA in the design road was calculated as 3.3×10^7. According to heavy duty pavement definition of DPTI pavement design supplement, such design traffic loading exceeding 10^7 ESA and are referred to as easy duty pavement.

Asphalt is a prefer method for road surface treatment in urban area for heavily trafficked arterial roads, then asphalt is used for the project.

Two typical heavy duty flexible pavement design method shows in the figure below.

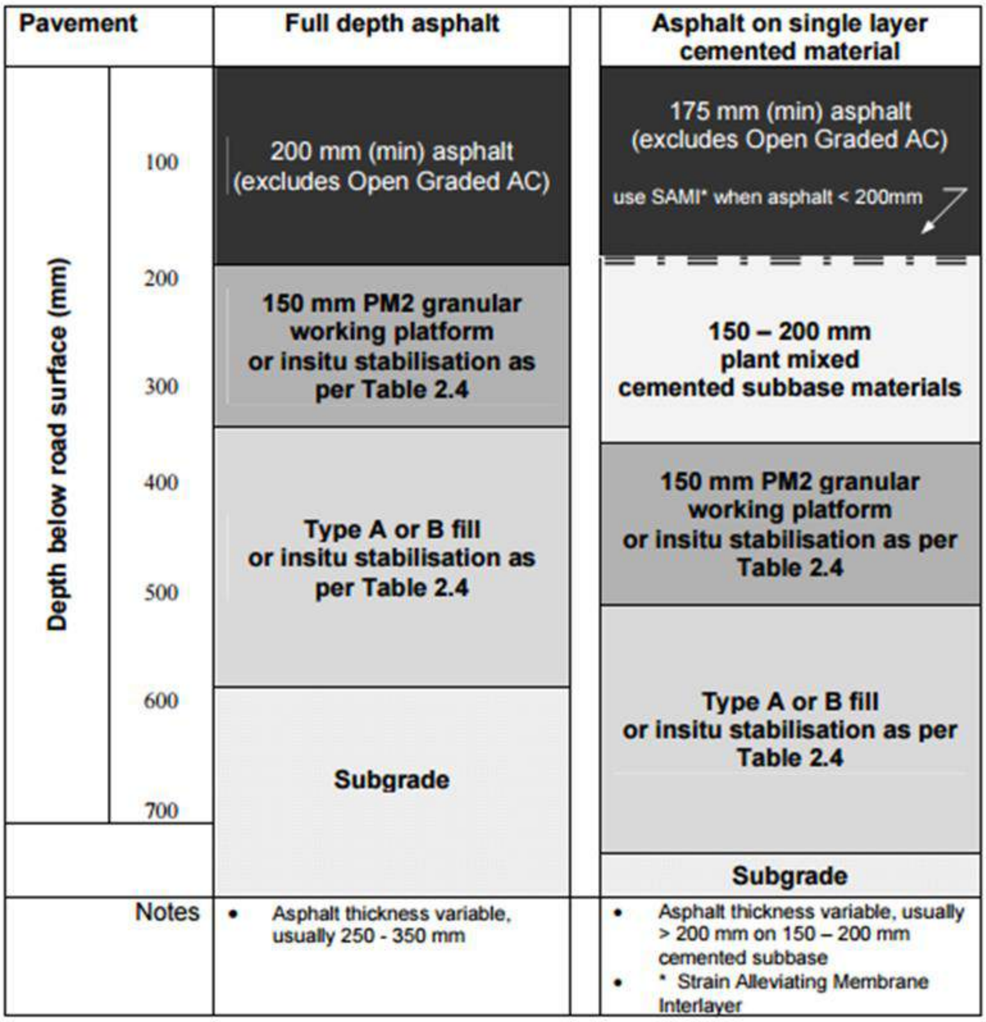

Figure 63: Typical heavy duty flexible pavement

(Source: Part 2: Pavement Structural Design of the Austroads Guide to Pavement Technology, DPTI)

4.5.5 CIRCLY design approach

CIRCLY is a powerful and window-based software analysis package for mechanistic pavement design and analysis, and the software package uses a rigorous flexible pavement design approach, materials properties can be added to the software and performing model by calculating the cumulative damage included by the traffic spectrum. The cumulative damage factor will be generated to evaluate design model.

4.5.5.1 Morphett and Diagonal Road

Table 23: CIRCLY design layers and cumulative damage factor

Layer	Title	Thickness	CIRCLY CDF	$\frac{1}{CDF}$ =Design DESA	Target DESA
1	AC20 Mix Size 80km/h	150			
2	Cemented E=3500MPa	200			
3	Subgrade CBR 3 = Aniso	175			
4	Type A Fill E<70	400			
5	Subgrade CBR 15 Aniso	150	2.62×10^{-8}	3.82×10^{7}	3.3×10^{7}

Table above showing the final design for critical DESA condition. From the analysis proven that Morphett Road consider to be heavy duty traffic flow with target DESA is 3.3×10^{7}. Therefore, the material use and thickness requirement is slightly higher. 150mm layer of asphalt layer is consider to be stronger material and applied on the upper layer to withstand most of the vehicles loading. Due to heavy duty pavement design, cemented material is selected and with thickness 200 to withstand and achieve the target DESA. Other layer such as subgrade and type A fill is applied to support the upper layer in an economic efficient design. From the CIRCLY software analysis and calculation, the design DESA of Morphett pavement structure had achieved the target DESA requirement as $3.82 \times 10^{7} > 3.30 \times 10^{7}$. Figure below showing the final design pavement for critical DESA condition.

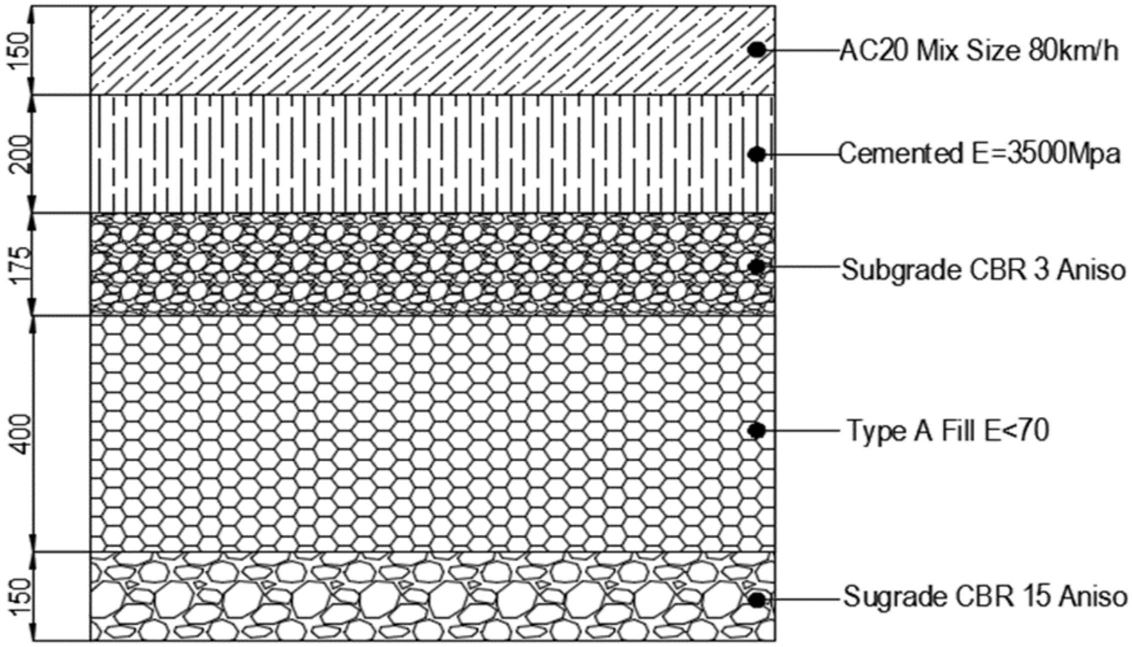

Figure 64: Final pavement design layers for Morphett Road

4.5.5.2 Prunus Street

Table 24: CIRCLY design layers and cumulative damage factor

Layer	Title	Thickness	CIRCLY CDF	$\frac{1}{CDF}$ =Design DESA	Target DESA
1	AC20 Mix Size 80km/h	150	3.15×10^{-1}		
2	Gran_350	250			
3	Cemented E=3500MPa	175	5.17×10^{-3}		
4	Type A Fill E<70	300			
5	Subgrade CBR 12 Aniso	0	6.75×10^{-8}	1.48×10^{7}	1.3×10^{7}

Table above presenting the final design for critical DESA condition. In consideration of cost efficiency and 30 years Adelaide plan, Prunus street is targeted to be design based on its traffic flow characteristic. According to DPTI traffic flow analysis, AADT for Prunus street are 21500 and 3.6% HV which is significantly lower traffic volume compare to other lanes. Therefore, traffic analysis for Prunus street is conducted and target DESA is calculated. Therefore, circly design for Prunus street is required and shows in the table and data analysis is displayed in the appendix G. Prunus street target DESA is 1.3×10^{7}. Due to the lower traffic data, the thickness of the pavement is reduce significantly compare to Morphett Road. Cemented material is applied to support the upper layer pavement. Type A fill is applied as well due to economic efficient design. Ultimately, design DESA achieved $1.48\times10^7 > 1.3\times10^7$ which is sufficient for the Prunus street pavement. Figure below showing the final design pavement of Prunus street for critical DESA condition.

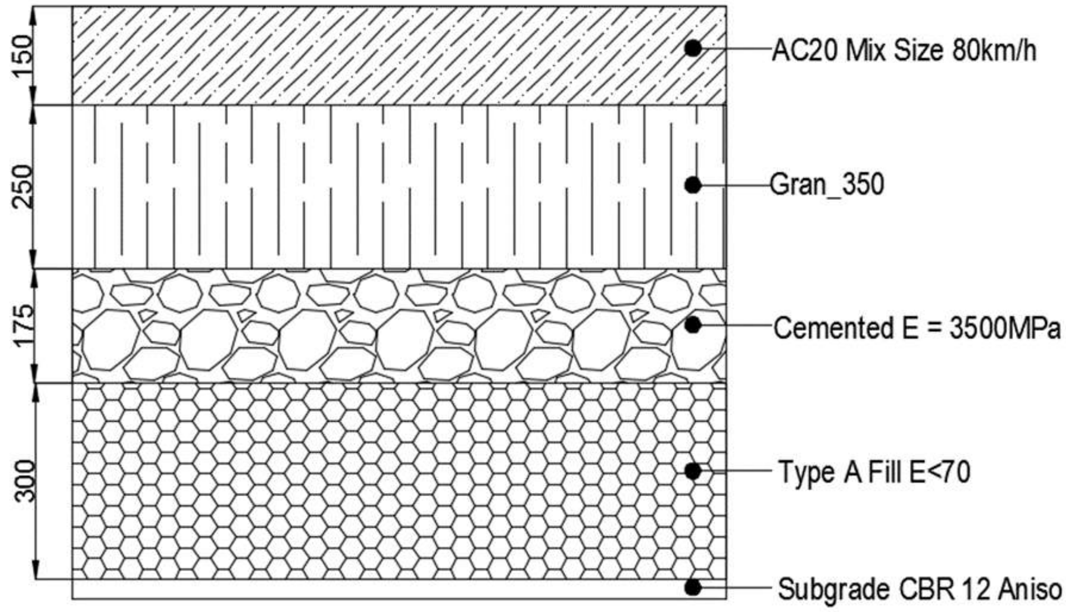

Figure 65: Pavement Design Layers for Prunus Street

4.6 Ballasted track design

4.6.1 Design concept and method

Responding to design requirement, two broad gauge railway tracks are requirement and are capable of being easily and cost effectively converted to standard gauge. According to DPTI design standards, the width of broad gauge is 1600mm, and centre to center distance between two tracks is 4 meters. As the vertical grade in the project is less than 2.222% (1 in 45), the ballasted track was selected for the project, and the ballasted track design be developed in consideration of some design criteria:

- The track support system can bear service loads including track alignment and traffic moving loads.
- Required ballasted be designed under AS 2758.7 and well consolidated.
- Select a suitable sleeper material and ensure the interfaces between sleeper and ballast.
- The track support system is durable enough and interlock is sufficient, providing a good resistance against excessive vertical or lateral or longitudinal movement of sleepers and fastens.
- Can provide adequate drainage of the track system.
- Rail fastening system to reduce noise and vibration.

DPTI Code of Practice (COP) Documents, CRN Engineering Standard as well as Australian Rail Track Corporation design codes are used for the ballasted track design.

4.6.2 Formation capping level

4.6.2.1 Formation level materials

Formation level is the finished level at the top of backfilling, it was prepared to laying ballast.

The materials used in the layer is required to be well graded blended soil or gravel, and can be compacted to high density, soil such as natural ridge gravel free from vegetable staff, ripped sandstones with low clay content or crushed and blend tough, durable rock can be used for formation capping level as they soil properties meets design requirement.

The material is being well-graded and its typical particle size distribution as shown in table below, the test is done with AS1289, test 3.6.1)

AS Sieve	% Passing Nominal Size (20mm)	Minimum Frequency of Testing
53mm	100	One per 500 cu metres
37.5mm	100	
26.5mm	100	
19.0mm	95-100	
9.5mm	-	
4.75mm	-	
2.36mm	30-80	
0.075mm	6-10	

Figure 66: Formation capping materials particle size distribution

(Source: Australia rail track corporation LTD, EMT-08-01, earthworks, formation and capping material)

4.6.2.2 Formation level preparation

The formation capping materials be placed and compacted to a level of 30mm above the base of formation capping level. The materials be filled and trimmed to final profile before compacted by smooth steel rollers.

Compaction A is required and a not less than 100% relative compaction as determined by AS1289 applied.

According to road geometry to 2009 Austroads Guide to Road Design, nominal cross fall of formation level is 3%.

4.6.3 Track supporting system

4.6.3.1 Track class

Based on design requirement and 30 year greater Adelaide plan, the track class is defined as Main Line 1, which will provides a maximum axle loads 25 tones, and maximum operation speed 115km/h for passenger train, 80 km/h for freight train.

4.6.3.2 Rail type

According to rail length used and the rail type is determined using Continuously Welded Rail (CWR), 60kk rail is used.

4.6.3.3 Sleeper type and size

As rail type is CWR, the sleepers are decided using concrete sleeper, and resilient fastenings system used. Sleepers are determined to be designed for heavy duty purpose. The length of sleepers using 2500mmm, width at base as 250mm and 230mm for depth, and the spacing of sleeper is determined as 600mm.

4.6.4 Ballast design and profile

4.6.4.1 Ballast material and grading

Ballast is a free draining coarse aggregate used to support railway track, the proposed ballast materials must be angular rock which will provide a good interlock and a less deformation, one of the best option for ballast is crushed aggregate, the materials can provide track stability, drainage, and distribution of the loads carried into the ground underneath.

Rail ballast is using single size aggregate, generally has a nominal size of 63mm, the grading requirement is expressed as particle size distribution, as shown in table below.

Sieve Size (mm)	Nominal Size (mm)
	60
	% passing by mass
63.0	100
53.0	85-100
37.5	20-65
26.5	0-20
19.0	0-5
13.2	0-2
9.50	-
4.75	0-1
1.18	-
0.075	0-1

Figure 67: Ballast aggregate particle size distribution

(Source: Australia rail track corporation LTD, ETA-04-01, Ballast specification)

4.6.4.2 Ballast profile

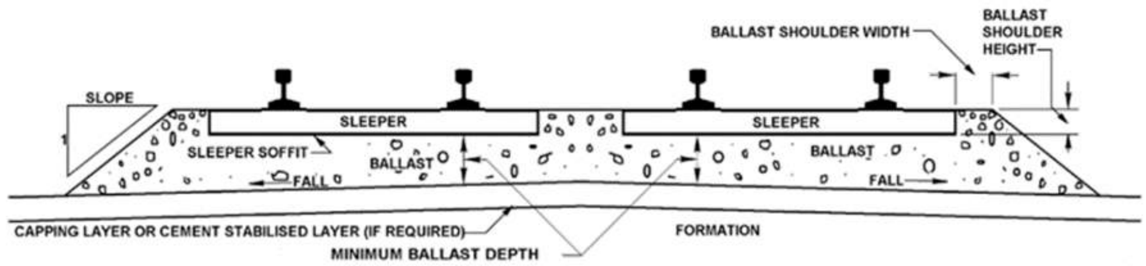

Figure 68: Typical track cross section and ballast profile

(Source: CP – TS – 960, Track support system, DPTI)

Shoulder height

The shoulder height is distance from the bottom of sleeper to the underside of the rail, which is be determined by sleeper design.

Shoulder slope

As the ballast is a freestanding ballast, the slope is assumed to be 1:1.5 (height: width)

Shoulder width

The ballast shoulder width is the width measured from the extreme end of sleeper, and the designation of shoulder width is related to overall track lateral stability, usually, the ballast shoulder width was designed above minimum width to ensure the track lateral stability, otherwise ballast windrow used to ensure track lateral stability.

The shoulder width is determined by rail length, basing on CRN Engineering Standard- track ballast, the design team using ballast shoulder width 700mm for critical design purpose, which can be 400mm for minimum and 700mm for maximum.

Ballast depth

The ballast depth is the distance from the finished formation level to the underside of sleeper. It was decided by track class and rail type and sleeper type. Basing on the critical design and economic purpose, the design team select ballast depth as 350mm, as the track type is classified into Main Line 1 and concrete sleeper used with 60kg rail type.

The final ballast design profile shown below

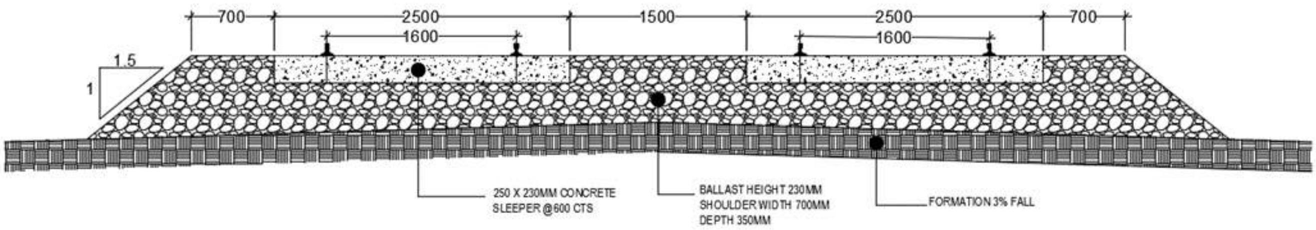

Figure 69: Final ballast design profile (unit in mm)

4.7 Costing estimation

Table 25: Cost estimation for geotechnical

	Unit	Qty	Rate	Total cost
Plie footing				
CFA piers dirll price	m	3860	$210.00	$810,600.00
pour in concrete, delivery to site	cum	4364	$172.00	$750,608.00
pile cap concrete, deliver to site	cum	2932.5	$172.00	$504,390.00
reinforcement, all cost included	t	152.45	$2,410.00	$367,404.50
			subtotal=	$2,433,002.50
Retaining wall				
filling	cum	9540	$91.00	$868,140.00
base concrete, delivery to site	cum	1438.6	$172.00	$247,439.20
reinforcement, all cost included	t	104.72	$2,410.00	$252,375.20
wall concrete, all cost included	cum	695.7	$324.20	$225,545.94
concrete formwork	sqm	963.6	$130.00	$125,268.00
			subtotal=	$1,718,768.34
Pavement				
AC 20 Mix size 80km/h	sqm	11360	$35.00	$397,600.00
Cemented E=3500Mpa	sqm	11360	$27.50	$312,400.00
Subgrade CBR= Aniso	sqm	11360	$17.05	$193,688.00
Type A fill E<70mpa	sqm	11360	$33.10	$376,016.00
Subgrade CBR= 15	sqm	11360	$14.55	$165,288.00
Gran_350	sqm	11360	$25.00	$284,000.00
			subtotal=	$1,728,992.00
Ballast				
formation capping materials	cum	210	$35.00	$7,350.00
ballast	m	1700	$300.00	$510,000.00
sleepers	m	1700	$385.00	$654,500.00
rails and fasteners	m	1700	$420.00	$714,000.00
			subtotal=	$1,885,850.00
			Total=	$7,766,612.84

All the items and cost unit price was estimated based on Rawlinsons Australian Construction Handbook, Edition 35, year of 2017.

According to the spreadsheet provided, the total costs for Geotechnical detailed design is 7.77 million in Australian dollars.

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SERVICES

5 SERVICES

ABBREVIATION LIST

Abbreviation	Description
MSCL	Mild Steel Cement Lined
VC	Vitrified Clay
CICL	Cast Iron Concrete Lined
SAW	SA Water
SAPN	South Australia Power Networks
PE	Polyethylene
DICL	Ductile Iron Concrete lined
LV	Low Voltage
PVC	Polyvinyl Chloride

5.1 Package 01: Early Services Interface & Relocations

5.1.1 SA Power Networks

5.1.1.1 Design Assumptions & Considerations

Electrical network is owned by South Australian Power Network. In our project site, all the electricity light poles, cables, low voltage in service cables and exits will be relocated. There are no works involving high voltage assets within this project scope. As it is an overpass underground relocations have been proposed for in service cables, this allows only light poles to be installed, which is more aesthetically pleasing. All the new installation and relocations will be carried out in reference to the Australian standards. All the component and materials used will be chosen with help of standards and SAPN specifications.

Within the electrical scope of works, we will be removing light poles and low voltage poles. All electrical services will be upgraded to the most recent DPTI material spec; Pits will be installed as required and all electrical poles within the project scope are to be moved underground.

Light pole locations under the bridge in the car park and intersection has been designed by transport department, power to these have been provided through the electrical network from the transformer room.

SAPN network in relocation and upgrading has been designed with help of Australian standards and SAPN network rules. Used standards are following:

i) SAPN Technical Standard TS085: Trenching and Conduit standards for underground
ii) AS/NZS 2053 Conduits and fittings for electrical installations
iii) AS/NZS 1477 PVC pipes and fittings for pressure
iv) AS/NZS 2032 Installation of PVC pipe systems

5.1.1.2 Low Voltage (LV)

Trenching

All trenches used in the lay and backfill of all electrical services, including but not limited to all ground relocations and the railway platform will be installed in accordance to SAPN Technical Standard TS085: Trenching and Conduit Standard for Underground Distribution Cable Networks clause 10.1. Refer relevant drawing for a typical trench layout. The design requirements are as shown below:

- The trench is designed to be as straight as possible with firm and smooth base
- A minimum separation of 25mm is required for the installation of multiple conduits in all directions between SAPN conduits. The purpose of this is to ensure the bedding sand is fully encompasses the conduit during back filling and reduce compaction issues in the future. (Refer to Figure *70*).

- Also, a minimum separation of 50mm is required in all directions between direct laid SAPN cable circuits. The greater the cable circuit separation, the greater the carrying capacity of the electrical cable. It is also shown in Figure *70*
- There will normally be a minimum separation of 50mm from a trench wall to any SAPN infrastructure to reduce the likelihood of any damage by sharp edges, stones etc.
- The maximum depth of the open trench is designed not greater than 1.2m without SAPN approval.
- Street Code "A code for the Placement of Infrastructure Services in New and Existing Streets' is used to locate the trench where practicable.
- The installer will submit all variations to the constructions drawing for inclusion on the "As Constructed" SA Power Networks drawing.
- Civil and Electrical Contractors are responsible to forward hand written mark-ups of hard copy drawings detailing all changes and necessary installations information to designer within 30 days of completion to ensure the final "As Constructed" drawings are correct.
- For the specific requirements relating to the submission of "As Constructed" drawings, refer to TS-100 – clauses 6.3 and 6.5 which is applicable to all civil installations.

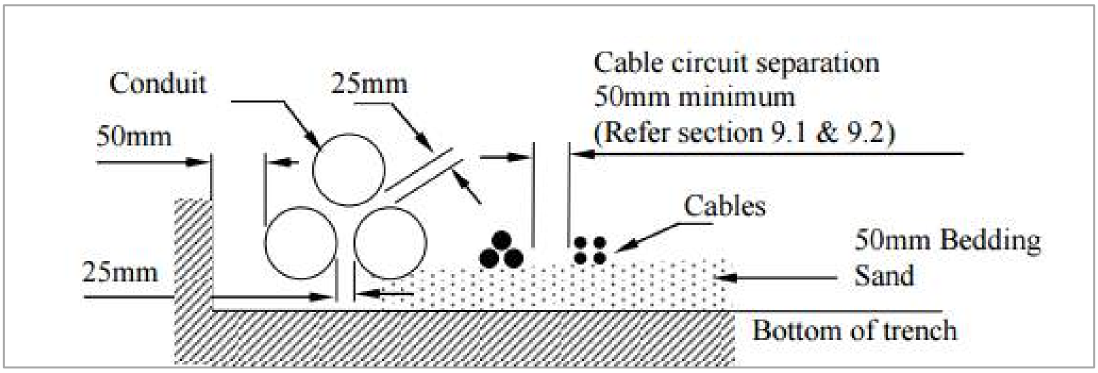


Figure 70: Trenching (it shows a typical SAPN conduit and cable arrangement)

Service Clearance

At the proposed trench relocation, there are other services nearby such as telecomm cable and SA water pipe. These other assets bring certain construction restraints and require protection before, during and after the conduits have been laid. Therefore, there must be a minimum clearance from the Power Network to the other services. Table 27 and Table 27 specify the minimum clearance from SA Power Network assets to other service utility assets for normal trenching and trenchless technology installation. Written agreement on reduced clearances must be obtained from the relevant SA Power Networks Manager and relevant Service Owner.

Table 26: Vertical Separation between Services (Adopted from TS 085 Clause 10.6)

Types	SA Power Networks LV Mains	SA Power Networks HV < 66kV Mains	SA Power Networks 66kV Cables
Non-SA Power Networks Telecomm. Pipe	100	300	Approval Required from SA Power Networks' MNP **(Refer to Notes 3 & 4, in clause 10.6 and Section 17.4)**
Non-SA Power Networks Telecomm. Pits	100	100	
Low Pressure Gas Non-Metallic Pipes **(Refer to notes 9 & 10, in clause 10.6)**	250	250	
SA Water - Sewer	225 (for sewer main pipe diam. ≤ 300)	225 (for sewer main pipe diam. ≤ 300)	
	300 (for other sewer mains)	300 (for other sewer mains)	
Private Sewer	600 **(Refer to note 1, in clause 10.6)**	600 **(Refer to note 1, in clause 10.6)**	
SA Water - Water	225	225	
Private Water	600	600	
Storm Water	100 **(Refer to note 6a, in clause 10.6)**	100 **(Refer to note 6a, in clause 10.6)**	
	600 **(Refer to note 6b, in clause 10.6)**	600 **(Refer to note 6b, in clause 10.6)**	
	100 **(Refer to note 8, in clause 10.6)**	100 **(Refer to note 8, in clause 10.6)**	

Table 26 shows the vertical separation between services: These minimum dimension are relevant where external parties' infrastructure is vertically parallel, cross over or under SA Power Networks equipment. The notes in the table can refer to the SA Power Networks Technical Standard TS 085 Clause 10.6.

Table 27: Horizontal Separation between Services (Adopted from TS 085 Clause 10.6)

Types	SA Power Networks LV Mains	SA Power Networks HV < 66kV Mains	SA Power Networks 66kV Cables
Non-SA Power Networks Telecomm. Pipe	100	300	Approval Required from SA Power Networks' MNP **(Refer to Notes 3 & 4, in clause 10.6 and Section 17.4)**
Non-SA Power Networks Telecomm. Pits	100	100	
Low Pressure Gas Non-Metallic Pipes **(Refer to notes 9 & 10, in clause 10.6)**	250	250	
SA Water - Sewer	500 (for sewer main pipe diam. ≤ 300)	500 (for sewer main pipe diam. ≤ 300)	
	1000 (for other sewer mains)	1000 (for other sewer mains)	
Private Sewer	600 **(Refer to note 1, in clause 10.6)**	600 **(Refer to note 1, in clause 10.6)**	
SA Water - Water	500 (for water main pipe diam. ≤ 200)	500 (for water main pipe diam. ≤ 200)	
	1000 (for other water mains)	1000 (for other water mains)	
Private Water	600	600	
Storm Water	100 **(Refer to note 6a, in clause 10.6)**	100 **(Refer to note 6a, in clause 10.6)**	
	600 **(Refer to note 6b, in clause 10.6)**	600 **(Refer to note 6b, in clause 10.6)**	
	100 **(Refer to note 8, in clause 10.6)**	100 **(Refer to note 8, in clause 10.6)**	

Table 27 shows the horizontal separation between services: Horizontal separation will be dependent on the extent that the external plant is parallel with the SA Power Networks infrastructure. In accordance with the NICC-404, only hand digging is permissible for any excavation within 0.1m of any SA Power Networks assets. The notes in the table can refer to the SA Power Networks Technical Standard TS 085 Clause 10.6.

Conduit Sizing

The type of conduits are selected based on consideration of all factors which may affect the operation of the conduit such as temperature of operation as well as future provisions, extension requirements and external loading. In addition to construction, extra care will be taken while joining conduits. This is because different grades have different internal diameters and resultant raised internal edge has the potential to damage the outer layer of cable during cable pulling.

The conduits are designed in compliance to AS/NZS Standards as shown below:

- Conduits and couplings used will be UPVC material and meet the requirements of AS/NZS 2053 Parts 1 and 2 for Rigid Plain designation
- The conduit will be marked with the type, conduit size and class such as “Electrical Ducting 100mm 6.0 Class”
- Without the approval of MNSP, no lower grade form of rigid conduit is allowed.
- All the conduits must meet the requirements of AS/NZS 1477 for the Test for Impact at 20 degrees Celsius
- The conduits colour must be orange except for Telecoms, which shall be ‘White’.
- The installation and handling rigid LD PVC conduit must be in accordance with PIPA website which provides information on “Solvent Cement Jointing of PVC Pipe”. Other than that, it must be in accordance with AS/NZS 2032: Section 3.3.11-Bending of PVC pipes which recommends a minimum radius of 150 x outside diameter for non-pressure (electrical) pipes.

The following tables specify the minimum conduit sizes for various cable sizes and rated voltage.

Table 28: Conduit Sizes – Straight Lengths (Adopted from TS 085 Clause 11.5)

CONDUIT Nominal Size (mm) /Applications	**CONDUIT Class/ Type**	**CONDUIT Required**	**APPLIES To**	**CONDUIT TECHNICAL DATA**					**SA Power Networks CONDUIT Stock Item (Iplex Part Nos. as GUIDE only)**
				Inside Diam. (mm)	**Avg. Wall Thick. (mm)**	**Mean Belled Mouth Diam. (mm)**	**Effective Straight Length (m)**	**Belled Socket Length (mm)**	
*32 (OD), HD	HD PVC	1	Public Lighting Circuits	*26.4	2.8	32	4	25	EA8045
40 (OD), HD **(Customers Service)**	HD PVC	1	Customers Mains to Service Pillars	33.6	3.2	40	4	32	EA8046
100 (Nom.), LD **(Most Projects + CBD + Earthing)**	LD PVC	1	LV mains (1x150mm² cable size)	108	3.2	114.3	6	100	NC2505
		1	(Greater or Equal to 95mm² upto Less than 300mm² cable sizes)						
		3	300mm² or 630mm² HV cable sizes **<u>Note:</u>** 1Cable/per Conduit/ per Phase						
100 (ID), HD **(Special Projects)**	HD	1	LV mains (1x150mm² cable size)	102	6.2	114.3	4	100	(Non-Stock) P6001004, HD or Equivalent **(See Note 2)**
		1	(Greater or Equal to 95mm² upto Less than 300mm² cable sizes)						
		3	300mm² or 630mm² HV cable sizes **<u>Note:</u>** 1Cable/per Conduit/ per Phase						
100 (Nom.), MD **(Telecoms)**	MD PVC (White)	1	Optic Fibre	104	5	114.3	6	100	NC4527
100 (Nom.), MD **(NBN)**	MD PVC (White)	1	Optic Fibre	104	5	114.3	4.5	100	CNBN100445 or Equivalent **(See Note 2)**

Note:

- Written approval is required from SA Power Networks Network Standards and Performance (NS&P) group before using these items. These items are SA Power Networks non-stock/non-catalogue and they are manufactured by special order with sufficient lead-time.
- LD= Light Duty, HD= Heavy Duty, MD= Medium Duty
- OD= Outside diameter (conduit sizes between 16mm to 63mm)

ID= Internal Diameter (conduit sizes greater than 63mm).

Table 29: Conduit Sizes – Straight Lengths (Adopted from TS 085 Clause 11.5)

CONDUIT Nominal Size (mm) /(Applications)	CONDUIT Class/ Type	CONDUIT Required	APPLIES To	CONDUIT TECHNICAL DATA					SA Power Networks CONDUIT Stock Item (Iplex Part Nos. as GUIDE only)
				Inside Diam. (ID) (mm)	Avg. Wall Thick. (mm)	Mean Belled/ Mouth Diam. (mm)	Effective Straight Length (m)	Belled Socket Length (mm)	
125 (Nom.), LD **(CBD + Earthing)**	LD PVC	1	LV mains (1x150mm² cable size)	132	4.0	140	6	115	NC2509
		1	(Greater or Equal to 95mm² upto Less than 300mm² cable sizes)						
		3	300mm² or 630mm² HV cable sizes **Note:** 1Cable/per Conduit/ per Phase						
150 (Nom.), LD **(Option)**	LD PVC	1	LV mains (1x150mm² cable size)	151	4.5	160	6	124	NC2518
		1	(Greater or Equal to 95mm² upto Less than 300mm² cable sizes)						
		3	300mm² or 630mm² HV cable sizes **Note:** 1Cable/per Conduit/ per Phase						
200 (Nom.) /225 (OD), LD (Orange) **(66kV Projects)**	LD PVC	3	300mm² or 630mm² HV cable sizes **Note:** 1Cable/per Conduit/ per Phase	214	5.7	225	6	N/A	(Non-Stock) P4002006 or Equivalent **(See Note 1)**

5.1.1.3 Action Plan

1. Acquire all necessary shutdown approvals
2. Plan temporary feeds where required
3. Set out & prove dead/removal of redundant cable
4. Lay temporary feeds
5. Excavate, lay, backfill
6. Complete connections
7. Testing & commissioning

5.1.1.4 Costings

Table 30: Costing of SA Power Networks Relocation

Component	Unit	Cost per unit	Units	Cost $
Light Poles	Each	1000	126	126000
In service LV cable	m	250	2150	537500
Conduit	m	55	2150	118250
Trenches	m^3	27	192.6	5200.2
Transformer	Each	90000	1	90000
Pits	Each	1000	126	126000
			Total Cost $	**1002950**

5.1.2 APA Gas

APA is an Australian Gas Pipelines company; APA provides gas pipelines and gas connections to all houses present in this area and to the commercial area of this suburb. There are 2 major gas lines that are passing from the project area and these both need to be relocated. Transmission pressure line runs south down from Morphett intersection; this pressure line holds 1700kPa pressure and so has been deemed pressure critical. An APA high pressure line is situated 180 meters on the left from this intersection, this line is a high pressure line, operating between 300-700kPa. For the locations of these existing design gas networks, see drawing *SER-REL01*.

5.1.2.1 Design Assumptions & Considerations

Several aspects are to be kept in mind while designing the pipe line and those are:

- Selecting Pipe using Australian standards.
- Selecting the pipe material and its diameter according to the pressure flowing in the line.
- 50 – 80 years of design life
- Transporting the pipe to the location
- Clearing the area and taking out old pipelines and setting up new pipelines. Old pipeline for Transmission pressure lines were made of steel, in relocation same material will be selected because steel is better with temperature and pressure. Old pipelines for high pressure line were made of cast iron and new pipeline will be made of PE. Reason to choose PE pipelines is that these pipelines are flexible and highly resistant to corrosion.
- Trenching
- Installing the pipes
- Testing the pipes
- Backfill and restoration
- Corrosion prevention
- Pipeline inspection and maintenance

- Management and surveillance

5.1.2.2 250Dia Transmission Main

To select the pipeline for Transmission pressure line we have used AS 2885.1-2012.These standards are for the pipes that have pressure more than 1050 kPa. Transmission line present here has pressure of 1700 kPa, refer drawing *Design & Existing Gas*. Requirements to select the pipe are the following:

- To select material and components, API 5L and ISO 3183 should be referred.
- Appropriate way of inspections and quality assurance should be done before installing pipes
- Pipes Chosen with help of this standard will not have Specified Minimum Yield Stress (SMYS) greater than 555 MPa (X80).
- Wall thickness tolerance should be founded with help of API Spec 5L, whether it is chosen from different standard or same.
- API Spec 5LC and 5LD should be used for corrosion resistant. For anti-corrosion coatings refer to AS 2312
- For trenches refer to AS 2566.1:1998

Trenches

- To specify minimum cover as below:

Table 31: Minimum Cover

MINIMUM COVER

Location	Minimum *H** m
Not subject to vehicular loading	0.30
Subject to vehicular loading—	
not in roadways	0.45
in sealed roadways	0.60
under unsealed roadways	0.75
Pipes in embankment conditions or subject to construction equipment loading	0.75

* Subject to variation by the regulatory authority.

Min cover = 600mm for services under sealed roadways

- To specify width as below:

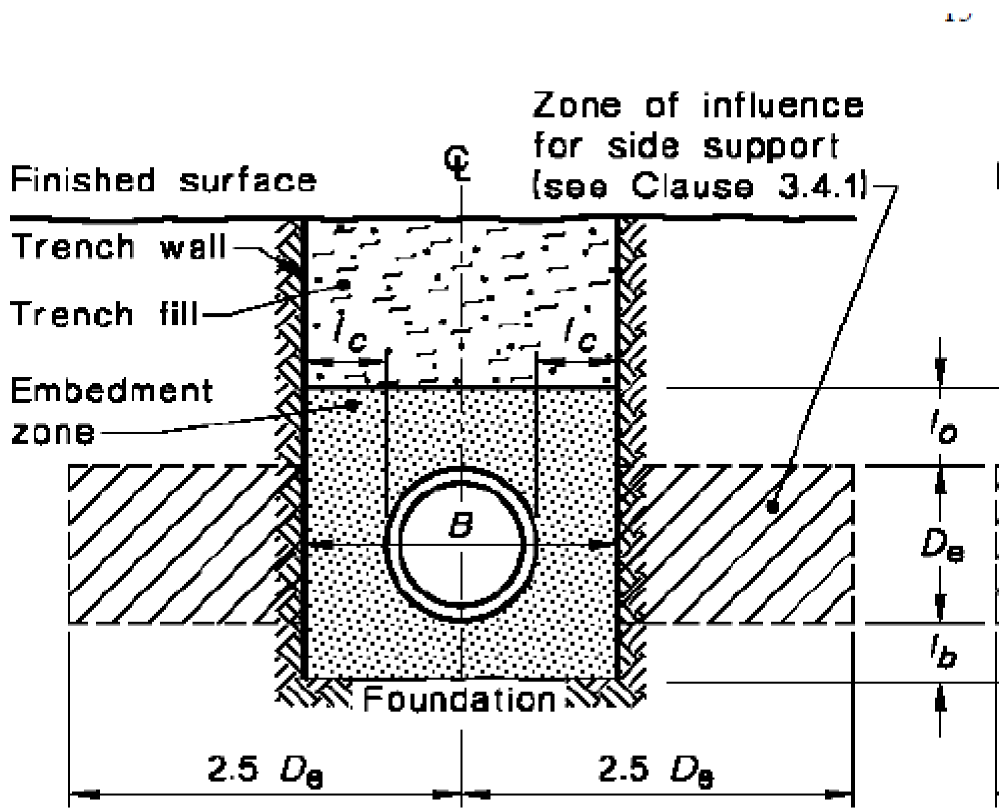


Figure 71: Trench Elements

Table 32: Trench Element Values

millimetres

D_e	Minimum values*		
	l_b	l_c†	l_o‡
≥75 ≤150	75	100	100
>150 ≤300	100	150	150
>300 ≤450	100	200	150
>450 ≤900	150	300	150
>900 ≤1 500	150	350	200
>1 500 ≤4 000	150	0.25 D_e	300

Pipe Diameter is 250 mm

l_b = 100 mm bedding

l_o = 150 mm Upper Embedment zone

l_c = 150 mm Side support

B = (2 x l_c) + De

B = (2 x 150) + 250

B = 550 mm

Side support zone = 2(2.5 x De) = 1250 mm

Table 33: Selected Pipe and Trench

New Pipe material and diameter (mm)	Trench Width (mm)	Trench Cover (mm)	Bedding (mm)	Trench Depth (mm)
250 ST	550 mm	600	100	1000

Backfilling

- For adequate compaction around the service TS4 Sand will be used in the whole trench.
- After trench fill Asphalt surfacing, will be done, Asphalt surfacing will be 200 mm.

5.1.2.3 High Pressure Mains

High pressure lines will be relocated and these lines will be relocated according to Australian standards, refer drawing *Design & Existing Gas*. Standards used are AS 4645.3:2008. Pressure in these lines is between 70 – 350 kPa. As discussed earlier Polyethylene pipes are selected for relocation. Polyethylene pipes have capability to hold pressure till 700 kPa and gas temperature of -20 – 40 °C.

Table 34: Materials for Plastic Pipes

MATERIALS FOR PLASTICS PIPES

Material	Standard	Additional limitations and specific requirements
PE 80B	AS/NZS 4130	Suitable for a MAOP (PE 80B) of 700 kPa and a gas temperature of >–20°C and <40°C
PE100	AS/NZS 4130	Suitable for a MAOP (PE 100) of 700 kPa and a gas temperature of >–20°C and <40°C
PA	AS 2943, ISO 15439	Suitable for a MAOP of 400 kPa
PVC	AS ISO 6993	Suitable for a MAOP of 100 kPa

Selected Pipe is PE80B. Both PE pipes have capability to hold pressure but PE80B has smaller radius and that shows it will be cheaper than PE100.

Trench

- To specify minimum cover

Table 35: Trench Depth Identification

MINIMUM DEPTH OF COVER—MAINS

Location	Type of main		
	MAOP above 210 kPa		MAOP below 210 kPa
	>DN100	≤DN100	
	Cover (mm)		
High density community use areas			
Sandy/clay areas	750	750	600
Rock	600	450	450
Low activity/risk areas: e.g. country, rural or uniform fully serviced residential/urban areas.			
Sandy/clay areas	750	600	500
Rock	500	450	450

NOTES:

1 For 210 kPa (MAOP) upwards, rail and major highway crossings—minimum 1200 mm cover or as required by relevant authority.

2 Where mains are common trenched with other utilities the low activity/risk depth may be applied.

3 In some locations, ground temperatures may be such that they will determine the depth of burial through the design aspects of temperature (see f_2 in Appendix B).

MAOP for our selected pipe is above 210 kPa and radius is below 100 mm. The minimum cover for the buried high pressure line is 800 mm.

- To specify min width
- Width should be designed as much that safe working environment could be created and in that width padding should also be included and space for thermal expansion and contraction should also be made.
  - Min space for paddings should be 150mm.
  - Material used for padding should be cohesion less and approved.
  - Padding material should not contain any organic material that will affect its performance.
  - Should not contain materials that are harmful physically or chemically to main or service component.

  Min selected width is 400mm.

Backfilling

- For adequate compaction around the service Sand TS4 will be used for the trench fill.

5.1.2.4 Action Plan

Gas pipelines present in the project area are transmission pressure line and high pressure line. Both gas lines will be relocated before start of the work and both gas lines has been relocated in such way that the gas should not be stopped while the overpass structure work goes on. Gas lines have been relocated away from overpass columns and away from the interruption of foundation of column. Transmission pressure pipeline material is not being changed, this aids connection works. Whereas high pressure lines material has been changed from Cast Iron to Polyethylene. At first of relocations, it is important to perform relocation of water lines before the gas lines as they are not only the deeper service but also carry more overall demand in terms of commercial and residential use.

1. Acquire all relevant approvals and permits, develop drawings package for site
2. Site inspection, cleaning & mobilisation
3. Lay temporary feed for any affected areas surrounding works
4. Install traffic management
5. Excavate, lay backfill
6. Tie ins & Cutovers
7. Permanent reinstatement

Transmission Pressure main

Method applied for installation: Trenching

Duration to relocate: 18 Days, majority of works to occur at night in linear metre instalments due to nature of location and traffic requirements

Total Length of Relocated pipe: 366 meters

High pressure main

Method applied for installation: Trenching

Duration to relocate: 11 Day, only day works involved.

Total Length of Relocated pipe: 414 meters

5.1.2.5 Costings

Table 36: Cost of APA

Transmission Pressure line				
Material & Works	Unit	Cost per unit	Units	Cost $
Site Preparation - remove bitumen paving	sqm	3.85	50.325	193.7513
Trench	m^3	201	171.105	34392.11
Backfilling - stabilised sand	m^3	135	171.105	23099.18
250 Steel	m	100	366	36600
Labour (4 men crew plus plant)	m	8000	18	144000
High Pressure line				
Material & Works	Unit	Cost per unit	Units	Cost
Site Preparation	sqm	0.69	41.4	28.566
Trench	m^3	201	228.528	45934.13
Backfilling - stabilised sand	m^3	135	228.528	30851.28
PE80B	m	120	414	49680
Labour (4 men crew plus plant)	m	8000	11	88000
			Total Cost $	**452779**

5.1.3 SA Water

Water is one of the major service that needs to be relocated in this project. Project area has main water lines passing through it, these water lines are connected to commercial and residential area around the project site. Relocation of these water lines are to be undertaken at the start of the project so that supply water services to the surrounding areas are not stopped. As the whole intersection is being redesigned and the rail area under the rail overpass is redesigned, there are some changes done at the connection of Murray terrace and Morphett Road. The relocation of the water lines are designed in such way that it can support the current development in this area during construction, and once the new alignment has been constructed it holds enough capacity for future requirements in the greater Adelaide 30 year plan. Refer drawings *SA Water Design & Existing alignment* which outline the existing water mains and shows the proposed new alignment. The pipes under consideration are constructed of CICL and MSCL.

Current CICL pipelines are of three different diameters. Diameters are 150mm, 200mm and 250mm. The largest water main on the project is a 750 diameter MSCL which will require a small relocation out of the alignment of the foundations of the overpass structure.

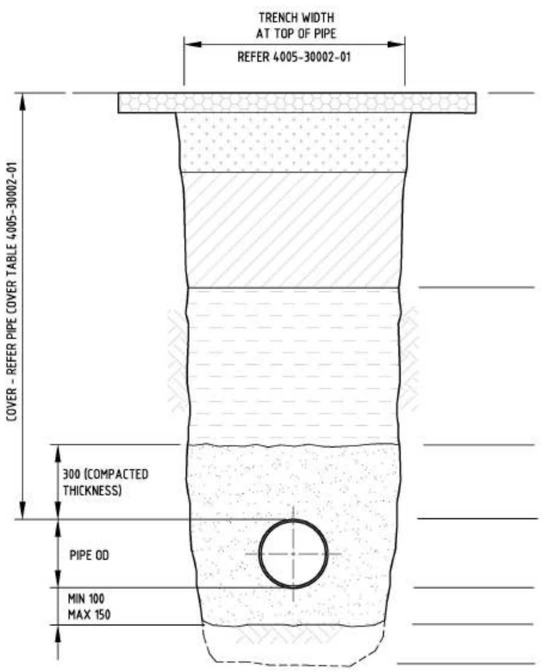
5.1.3.1 Design assumptions & Considerations

- Moving the main water line on diagonal road so that it's out of way of columns.
- Upgrading Murray Terrace therefore relocation of waterlines present on Murray terrace.
- Water system present in this area belongs to SAW, all the changes, redesigning and maintaining will be done according to their standards and codes. Standard provided by SAW is WSA 03-2011.
- Design life min 100 years
- Gas interface with 750 MSCL main requires detailed traffic management and has been assumed to be possible
- Current installed pipelines are made of CICL, these will be changed to DICL. 750 MSCL pipeline material is kept same and is just relocated.
- 250 mm CICL pipeline has been removed from Murray terrace it is now directly connected with 750 MSCL pipeline at diagonal road, no further relocation required for 250 CICL pipeline present on diagonal road.
- Diameters of the pipes will be kept same and these can support future requirements
- Trenches will be made according to the way provided in the SA water standards and codes.

5.1.3.2 Trenches and Trench Fill

- Minimum Cover

Figure 72: Min Identification of Cover of Trench



MATERIAL / COMPACTION			
ZONE		TRAFFICABLE AREAS (ROAD PAVEMENTS & SHOULDERS)	NON-TRAFFICABLE AREAS (EASEMENTS, ETC.)
SURFACE ZONE		REFER TO 4005-30003-03 FOR ROAD PAVEMENT REQUIREMENTS. REINSTATE BRICK PAVING, BITUMEN FOOTPATH, ETC. TO MATCH EXISTING.	REINSTATE TOPSOIL WITH GOOD QUALITY TOPSOIL LIGHTLY COMPACTED AND SEEDED, TURFED, ETC. TO MATCH EXISTING MINIMUM 150 mm THICK.
TRENCH FILL		PM2/20 OR SA-C SAND COMPACTED TO 95% MMDD OR TS4 SAND COMPACTED TO 100% SMDD.	INORGANIC FILL WITH MAXIMUM STONE SIZE OF 75 mm COMPACTED TO 95% SMDD. PLACE ALL MATERIALS IN MAXIMUM 200 mm (LOOSE) LAYERS. EACH LAYER TO BE COMPACTED SEPARATELY.
PIPE EMBEDMENT FILL	OVERLAY	TS4 SAND REFER TO 4005-30003-02	TS4 SAND REFER TO 4005-30003-02
	SIDE SUPPORT		
	BEDDING		
OVER-EXCAVATION BACKFILL			

- Surface Zone

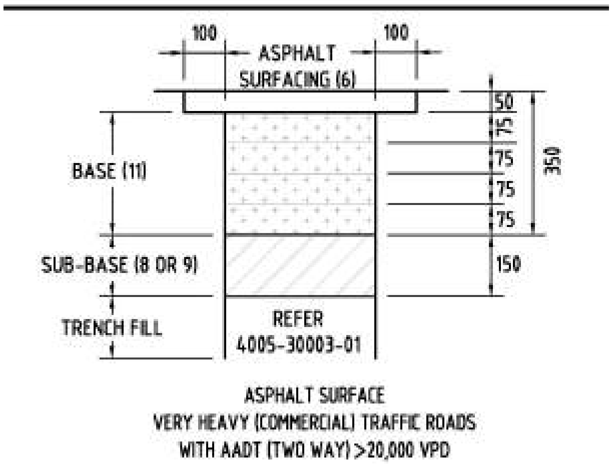


Figure 73: Asphalt Surface Layer above Trench

MINIMUM PIPE COVER

PIPE DN	PIPE COVER	
	MINIMUM	MAXIMUM
63 - 200	750	1200
250	800	1200
300	875	1200
375	950	1200

Table 37: Selection of Min Cover of Trench

- Trench fill, Pipe Embedment Fill
  As the area is trafficable therefore TS4 Sand will be used.

Table 38: Selected Pipe and Trench

New Pipe material and diameter (mm)	Trench Width (mm)	Trench Cover (mm)	Bedding (mm)
150 DICL	750	1200	150
200 DICL	800	1200	150
750 MSCL	1350	1200	150

5.1.3.3 Action Plan

There are 4 SA water pipelines present in the project area each have different diameter but same material. Except 250 CICL all 3 of them will be relocated before start of the work so that residential and commercial area don't face any water problems while the overpass work goes on. Relocation have been designed with careful consideration of structure, development of interchange and other services present in area. SA water relocations are to be done before any other service relocation. CICL pipelines has been changed to DICL because these are better than old one and are approved by SA water whereas main 750 MSCL will remain same.

1. Plan & lay temporary feeds for any affected areas surrounding works
2. Acquire all relevant approvals and permits, develop drawings package for site
3. Site inspection, cleaning & mobilisation
4. Install traffic management
5. Excavate, lay backfill
6. Permanent reinstatement
7. Tie ins & Cutovers

150 DICL

Method applied for installation: Trenching

Duration to relocate: 7 Days of night works. Night works will be carried out on Morphett Road. 3 Days of day on Murray terrace. Total Days 10.

Length of Relocated pipe: 215 meters

200 DICL

Method applied for installation: Trenching

Duration to relocate: 1 Day of day work.

Length of Relocated pipe: 25 meters

750 MSL

Method applied for installation: Trenching

Duration to relocate: 16 Days, only night works because of main road.

Length of Relocated pipe: 315 meters

5.1.3.4 Costings

Table 39: Costing of SA Water

150 DICL				
Material & Works	Unit	Cost per unit	Units	Cost $
Trench	m^3	65	329.4	21411
150 DICL	m	144	215	30960
Labour (4 men crew plus plant)	m	8000	10	80000
200 DICL				
Material & Works	Unit	Cost per unit	Units	Cost
Trench	m^3	65	24	1560
200 DICL	m	192	25	4800
Labour (4 men crew plus plant)	m	8000	1	8000
750 MSCL				
Material & Works	Unit	Cost per unit	Units	Cost
Trench	m^3	65	510.3	33169.5
750 MSCL (including labour and connection)	m	700	315	220500
			Total Cost $	**400400.5**

5.1.4 Wastewater Reticulation

Waste water come under the management of SA water. There are two waste water lines that are placed in the project area therefore these require relocation. The main line passing on diagonal road has to be relocated, this is 225 VC line. The second line is coming from Murray terrace and is connected with the main on diagonal road. This 150 VC line, requires relocation due to the redesign of the traffic intersection.

5.1.4.1 Design Assumptions & Considerations

- 225VC pipeline present on diagonal road will be relocated because it will interrupt will the columns of structure.
- 150VC pipeline coming from Murray terrace will be relocated because of upgradation Murray terrace and the main interchange.
- It is assumed possible and easy to connect new water mains into existing VC lines
- Main pipeline has obstacle in its way and that is gas line crossing it on diagonal road.
- Water system present in this area belongs to SAW, all the changes, redesigning and maintaining will be done according to their standards and codes. Standard provided by SAWC is WSA 02-2014.
- Current installed pipelines are made of VC, these will be changed to PVC as per SA water codes and standards.

- Diameters of the pipes will be kept same and these can handle future requirements.
- Trenches will be made according to the way provided in the SA water standards and codes.
- Trench Width and Depth

Table 40: Selected Pipe and Trench

New Pipe material and diameter (mm)	Trench Width (mm)	Trench Cover (mm)	Bedding (mm)
150 PVC	750	1000	150
225 PVC	850	1000	150

5.1.4.2 Action Plan

There are 2 wastewater pipelines present in the project area each have different diameter but same material. Both of them will be relocated before start of the work so that residential and commercial area don't face any water problems while the overpass work goes on. Relocation have been designed with careful consideration of structure, development of interchange and other services present in area. Wastewater relocations will be done after the relocation of SA water. VC pipelines has been changed to PVC because these are better than old one and are approved by SA sewerage.

1. Lay temporary feed for any affected areas surrounding works
2. Acquire all relevant approvals and permits, develop drawings package for site
3. Site inspection, cleaning & mobilisation
4. Install traffic management
5. Excavate, lay backfill
6. Permanent reinstatement
7. Tie ins & Cutovers

150 PVC

Method applied for installation: Trenching

Duration to relocate: 4 Days of day works.

Length of Relocated pipe: 140 meters

225 PVC

Method applied for installation: Trenching

Duration to relocate: 12 Days of night works because of main road.

Length of Relocated pipe: 225 meters

5.1.4.3 Costings

Table 41: Costing of Wastewater

150 PVC				
Material & Works	Unit	Cost per unit	Units	Cost $
Trench	m^3	65	105	6825
150 DICL	m	49	140	6860
Labour (4 men crew plus plant)	m	8000	4	32000
225 PVC				
Material & Works	Unit	Cost per unit	Units	Cost
Trench	m^3	65	191.25	12431.25
200 DICL	m	96	225	21600
Labour (4 men crew plus plant)	m	8000	12	96000
			Total Cost $	**175716.3**

5.1.5 NBN & Communications

NBN cable present in the area belong to Telstra. This is the only cable that will be interrupting in the projects area. Cable is crossing through the railway track at railway terrace that is why it is important to relocate it at this location only. The NBN is also assumed to carry provisions to be tapped into for the communications feed to the rail platform and there is a fibre access point at the pit just north of the rail line.

5.1.5.1 Design Assumptions & Considerations

- Cable used in NBN are optic fibres and new ones will also be of optic fibre and co-axial.
- Underground relocation, include pits, conduits and minimum clearance from other services.
- Installation should be done as per advised in standards, following rules and regulations. Standards used are C524-2013 and AS S009 - 2013
- There should be enough working space around the NBN service, min clearance space between all other cables so that any other underground work is carried out without any hindrance.

5.1.5.2 Conduits

- Conduits for cables should be designed according to manufacturer's design specifications. Considered factors in designing a conduit will be operational life, mechanical loads experienced during installation and under anticipated environmental loads.
- Material of pipes should be defined with help standards. Selected material is PVC and diameter of pipe is 100 mm.
- Colour of pipes in the conduits should be as per advised by standards.
- Conduits bends should allow easy installation of anticipated cables.

5.1.5.3 Cable Location

- Observing the alignment of conduit and depth and cover of pits.
- Marker or metallic element should be on the pit that should indicate that it is an NBN pit.
- Ownership of the service should be identified with help of any marking method.

5.1.5.4 Depth of Cover and Width

- Underground NBN service on roads and footpaths should have minimum depth of 450 mm.
- Minimum width is 400 mm.
- Clearance from other services is defined in the table

Table 42: Clearance from other underground utility and carrier services

Clearance from other Underground Utility and Carrier Services

Underground Plant Item	Minimum Radial Clearance from Underground Telecommunications Cable in mm (Notes 1, 4)
Gas Pipe	
Large Main (Over 110 mm diameter)	300
Small Main (75 mm diameter or less)	100
Power Line and Service Lines	
HV	300 (Note 2)
LV	100 (Note 3)
Water Main	
High Capacity Main	300
Local Reticulation	150
Sewer	
Mains	300
Connections to Mains	150 (Note 3)
Other Carriers' Telecommunication Cables	100

5.1.5.5 Action Plan

Telstra NBN is the only NBN service present in the area. Relocation of Telstra NBN starts from railway terrace and the rail crossing of the service has been pushed west. This allows it to be removed from the footprint of structure foundations. NBN will be the last service to be relocated as it is the shallowest, however it will be relocated before start of overpass bridge works.

1. Lay temporary feed for any affected areas surrounding works
2. Acquire all relevant approvals and permits, develop drawings package for site
3. Site inspection, cleaning & mobilisation
4. Install traffic management
5. Excavate, lay backfill
6. Permanent reinstatement
7. Tie ins & Cutovers

5.1.5.6 Telstra NBN

Method applied for installation: Trenching and conduits

Duration to relocate: 25 Days of day work and 6 Days of night works because of main road.

Length of Relocated pipe: 1612 meters.

5.1.5.7 Costings

Table 43: Costing of NBN

Component	Unit	Quantity	Cost ($)	Total ($)
Data cable	Metre of cable	1612	80	128,960
Pits	each	28	1000	28,000

5.2 Package 02: Rail Platform

5.2.1 Design Assumptions & Considerations

It is a design assumption that the solar panels (arrays) incorporated into the platform are integrated into the design electrical network and it is connected to the network via twin core cable at the locations still under consideration. It is also assumed there is enough space requirements in the control room to house the hardware needed for the solar system (inverter, combiner box, main breaker box, cabling etc).

5.2.2 Electrical Infrastructure

Existing DPTI Standard pits and conduits will be utilised on site wherever practicable and must comply with the following:

- Utility services required to transverse the railway corridor must be via the overpass structure
- A minimum distance of 300mm must be maintained between the footing of structure and conduit trenches
- All electrical cables and conduits should be concealed within the shelter structural framework.
- If the conduits cannot be concealed within the structure, cabling must be fixed to the exterior of structure within a galvanised duct in a continuous run to a minimum height of 3m.

5.2.2.1 Power Distribution Network

According to the Engineering Standard Part 129014, the power supply used at a railway station will be a 400V, 3-phase, 50Hz power system. The designed electrical network must be capable of supporting this system. AS 3000: Electrical Installations (Wiring Rules) is used to calculate the maximum electrical power demand at the Oakland's Park Railway Station. To cater for future or unknown loads/demands, there must be a minimum of 30% additional capacity in the power system. The power distribution network will include the components as shown below:

- Isolation Transformer

The purpose of isolation transformer is to isolate the railway traction supply earthing from the local Electricity Supply Authority earthing Multiple-Earthed-Neutral system. Other than that, isolation transformer must be separated at least 3m away from ETSA Distribution Substation. The isolation transformer used for the train station must comply with the requirements of:

- AS 61558.1: Safety of Power Transformers, Power Supplies, Reactors and Similar Products – General requirements and test

- AS 61558.2.4: Safety of power transformers, power supplies, reactors and similar products for supply voltages up to 1 100V – Particular requirements and tests for isolating transformers and power supply units incorporating transformers
- AS 60076.11: Power Transformers – Dry-type Power Transformers
- Part 129002: Earth and Bonding

According to Engineering Standard Part 129014 Appendix 1, the electrical characteristics of the isolation transformer electrical characteristics are as shown in the table below:

Table 44: Electrical characteristics of an isolation transformer (Technical Standard Part 129014)

Characteristic	***Requirement***
Rated Power	Standard sizes (kVA): 400
Power System	3-phase, 50Hz
Nominal Primary Voltage	400 V phase-to-phase
Primary-to-Secondary Ratio	1:1
Tapping	Transformers must be provided with tappings 5% above and below the nominal input voltage in 2.5% steps. Tappings must be arranged so as to be suitable to be altered by off circuit bolted links
Vector Group	Dyn11

➢ Main Distribution Board

Main distribution board consists of an electricity supply authority's metering. The function of MDB is to incorporate sub circuits for lighting and power for the supply of the train platform. Other than that, main distribution board must be able to cater for the maximum power demand and a minimum of 30% spare capacity. The main distribution board as well as lighting control system will be both placed in the equipment room.

➢ Cabling

All the cables used (including the cables entering the isolation transformer and light poles) will be double insulated. Cross-linked Poly Ethylene (XLPE) X-90 insulation is used for consumer main cables whereas PVC sheath will be used for sub main cables and sub circuits.

The type of cables used at the train station are selected based on AS 3008.1.1: Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and including 0.6/1kV – Typical Australian Installation Conditions and also AS 3000: Electrical Installations.

- Sub Circuits

Each sub circuit must be specified clearly on the switchboard single line diagram. Sub circuits required in the railway station are listed as shown below:

  - Lighting
  - Power outlets for shelter
  - Heated Mirrors
  - Control Room
  - Toilet Facility
  - Passenger Information System
  - Security System
  - Lift

- Power monitoring system

The Power Monitoring System (PMS) used at the railway station will be connected to a system called central monitoring system. All the metering devices within the switchboards will be connected to power monitoring system and the cables will be reticulated through communications conduits.

5.2.2.2 Lighting System

The lighting system at Oakland's Park Rail Overpass will be designed to minimise glare to both users and train drivers. Also, it is designed to reduce the impact of light spill to neighbouring properties by not exceeding the light level requirement. Other than that, the light fitting locations must be coordinated with CCTV cameras to optimise CCTC images. According to Technical Standard Part 129014 Clause 6.2, different areas at the train station will have different levels and they must meet the requirements indicated in the table as shown below.

Table 45: Required lighting levels for an open station (Technical Standard Part 129014)

Station Element	Average Horizontal Illuminance	Minimum Horizontal Illuminance	Minimum Vertical Illuminance	Vertical Uniformity	Horizontal Uniformity
	$E_{ave}(lux)$	$E_{ph}(lux)$	$E_{pv}(lux)$	$U_1 = \frac{E_{min}}{E_{ave}}$	$U_2 = \frac{E_{max}}{E_{ave}}$
Open Station	42	21	14	-	7
Under shelter and covered areas (on open platforms)	160	-	-	0.5	-
Yellow line at platform edge – open platform	-	30	-	-	-
Emergency Help Phones	200	-	-	-	-
Enclosed Areas including but not limited to Toilet Facilities and equipment rooms	200	-	-	0.5	-
Access paths, ramps, stairs and overpasses	42	21	14	-	7
Subways	200	-	-	0.5	-
Other paths, ramps, stairs, and overpasses	14	4	4	-	10
Any other area	As per AS 1158 and AS1680				

Lighting system will be provided to the areas such as primary access and other paths, platform, ramp, equipment room, toilet facilities, lifts, stairs and so on. The lighting system at rail will include luminaire complete with accessories and wiring, lighting control system and emergency lighting. According to the drawing Railway Services Drawing ECRP01, there will be 62 light poles on the railway platforms.

Luminaires

Long service life and energy efficient luminaires which have low wattage and high output will be used at the railway platform. Luminaire must not be too heavy and safe for installation and maintenance purposes on a ladder or mobile platform. Luminaires on platform shelter will be integrated into the structure ensuring the following:

- Have a uniform light and good quality
- Must be concealed, protected or mounted to prevent vandalism
- Maintenance work can be done easily
- Minimise the light spill to the surrounding residential area

According to the Standard Part 129014 Clause 6.3, different types of luminary will be used and they are indicated as shown in the table below:

Table 46: Luminaires for railway station (Technical Standard Part 129014)

Station Element	Specification	Selection
-Open Car Parks **-Open Areas other than Platforms**	➢ Compliant with Australian road lighting standards ➢ LED luminaire ➢ Fitted with DALI dimmable ballast ➢ Robust die cast aluminium body ➢ LEDs and reflectors shielded from angles above 90 degrees elevation ➢ Simple access	➢ Unilumen LED ➢ Versalux StarLED ➢ Aldridge LED ➢ GE LED
Open Platforms	➢ LED luminaire ➢ Fitted with DALI dimmable ballast ➢ Robust die cast aluminium body ➢ LEDs and reflectors shielded from angles above 90 degrees elevation ➢ Simple access	➢ Versalux Star LED ➢ WE-EF LED ➢ LRL LED
Covered Areas, Enclosed Areas, Indoor Areas	➢ LED 'linear' luminaire with integral DALI dimmable ballast ➢ High performance total system 99.5 Lm/W minimum ➢ Projected life 50,000 hours (L70) ➢ Vandal resistant ➢ 5mm, UV stabilised, polycarbonate lens ➢ Industrial grade stainless steel security fasteners ➢ Option for integral maintained emergency function	➢ Thorn Gladiator LED ➢ Versalux Enduralux LED ➢ Cellite Excelsior LED

Lighting Control System

To save electricity, dimming is incorporated in the lighting design for the railway station. The lightning requirement during various hours of the day is indicated in the table as shown below:

Table 47: Lighting Situation (Technical Standard Part 129014)

Season	Time	Lighting Requirement
Spring and Summer	0700 to 1900	Must be off
	1900 to half an hour after last scheduled service	Must be on
	Half an hour after the last scheduled service to half an	Dimmed

	hour before the first scheduled service	
Autumn and Winter	0800 to 1700	Must be off
	1700 to half an hour after last scheduled service	Must be on
	Half an hour after the last scheduled service to half an hour before first scheduled service	Dimmed

Emergency Lighting

Emergency lighting are installed based on AS 2293.1: Emergency Escape Lighting and Exit Signs for Buildings – System Design, Installation and Operation. Emergency luminaires will be part of the normal light fittings. When the main power fail, emergency light will be supported by Uninterruptible Power Supply (UPS) via a fire rated cabling system throughout the station. The battery autonomy in the UPS is anticipated to provide the emergency and escape lighting for 3 hours. An average lighting level of 1 lux will be provided under emergency conditions.

5.2.2.3 Lift

Lift will be designed, supplied and installed in accordance to PTS Standard Part 129004. The lift car will be a standard size of carrying 21 people, minimum size of 1600mm wide and 2100 deep to carry a stretcher and provide a 180 degree wheelchair turning space.

Interior Lighting

A minimum of 200 lux illumination will be provided in the lift car at all times. All the light fittings will be accessible within the lift car and protected by vandal proof diffusers.

Uninterruptible Power Supply (UPS)

A battery powered UPS will be installed at the railway station to provide 240V AC power during failure of mains power supply. UPS will have sufficient capacity to operate for another 30 minutes of the lift car air conditioning system and an additional 90 minutes of the lift car lights, car alarm bell and lift shaft smoke detection. It require at least 8 eight hours for recovery after restoration of mains power.

Lift Fire Detection/Protection

Smoke detectors or heat sensors will be installed at the top of the lift shaft in proximity to the hoist machine and lift control equipment. They are powered from the lift mains electricity supply and APS will be used in case of loss of mains power. Smoke detection system installed will be able to maintain the service for a minimum period of two hours during the failure of main power supply.

5.2.2.4 Security System – CCTV and Emergency Phone

CCTV facilities will be provided to ensure the safety of the passengers at the railway platform. The CCTV system at the railway platform will monitor the passenger flows, emergency situations, station security as well as day to day station operations.

Placement of CCTV cameras will be the priority on a platform over any other facility. The camera layouts will require coordination with lighting, sources of glare, auxiliary power supply and also CCTV rack within the control room. The coverage of the CCTV will include the station entry/exit, lifts, passenger information system, emergency help points as well as staircase. CCTV is an essential station service. Therefore, it must continue to remain operational during a power outage.

The fixtures and mounting requirements are as shown below in accordance to ESB 004: RailCorp Engineering Standard- Stations and Buildings.

- Must be placed in clearly vulnerable vandal locations
- Mounted at a minimum height of 2600mm off the finished floor level
- CCTV conduit must be vandal resistant or concealed
- CCTV concealed conduit runs will be coordinated with other services conduits during design and construction phase.
- The way CCTV cameras mounted must avoid birds nesting.
- CCTV must be placed where access for maintenance is considered easy and safe for technicians.
- Avoid the use of expanded metal mesh security cages for CCTV protection.

24-hour emergency help phones will also be provided at platform 1 and platform 2. CCTV will be activated immediately when using an emergency phone to record the area around the phone.

5.2.3 SA Water

5.2.3.1 Water and Amenities Supply

The water supply is designed according to Engineering Standard ESB004: Station Services and Systems, AS3500: National Plumbing and Drainage Code and Building Code of Australia (BCA). As there are no toilets to present on the actual rail platform, only a supply pipe to the water fountains on the platform is required. Whereas the toilets located at grade below the structure require connection to an existing SA Water main.

Water Supply

The minimum requirements for cold water supply in accordance to Engineering Standard ESB004 are listed as shown below:

- Cold water services are extended to the toilet of the train station from the nearest, existing SA Water main service.
- All potable water supplies have to be fed to all plumbing fixtures, equipment items and firefighting points.
- A water meter will be constructed at the entry point of the station.
- Water supplies must be designed in such a way to meet the minimum flow and pressure and requirements.
- Metallic water pipes with diameter greater than 50mm will be layered with a proprietary system for corrosion protection of in ground services.
- Services with 50mm diameter or less laid in ground will be installed within heavy-duty UPVC conduits.

The design criteria and flow rates requirements are tabulated as shown below:

Table 48: Design Criteria and Flow Rate Requirements of Water Supply

Design Criteria	**Maximum velocity: 1.6m/s** **Maximum pressure at outlet: 500 kPa** **Minimum pressure at outlet: 100kPa**
Flow Rates	Sinks: 9 litres/minute Hand basing: 6 litres/minute Showers: 9 litres/minute

Drinking Fountain

Drinking fountains will be installed at both platforms and the design is accessible for most people including those using wheelchairs. The drinking fountain will be fabricated from grade 316 stainless steel and polished to a satin finish. The drinking fountains will also be equipped with automatic off taps to reduce water wastage.

5.2.3.2 Stormwater

Roof drainage

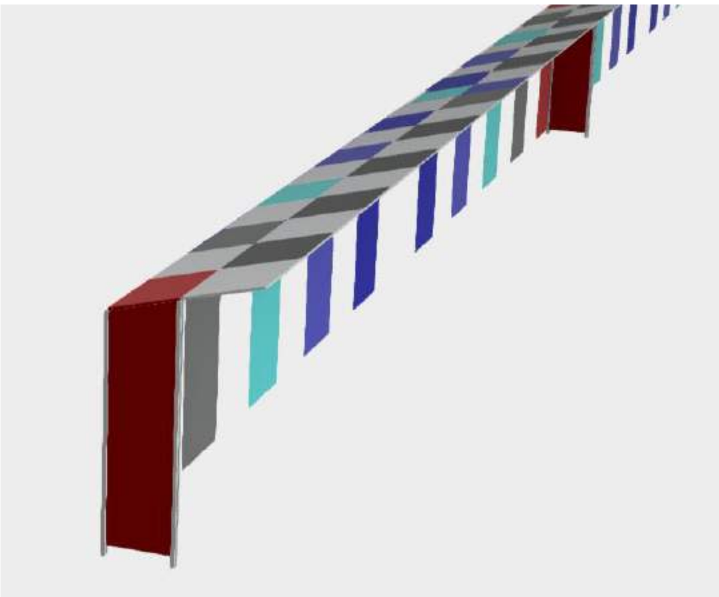


Figure 74: Shelter Design on the Platform

The figure above shows the design of the shelter by urban department. Stormwater is not allowed to drain onto the track. Where there is an incline shelter on the platform, a gutter system will collect and direct rainwater through downpipes into a drainage system (Refer drawing *Platform Stormwater*. The figure above shows the design of the shelter by urban department. The drainage systems designed must be able to prevent leakage into or onto the structure, an additional benefit of the rearward slab cross fall is the rollaway protection for prams, wheelchairs, baggage etc.

- Gutters

Custom designed fabricated steel plate section will be used for roof gutters. The gutters is designed and installed to drain to downpipes, support point loads from ladder support of 100kg and support a minimum hanging point load of 100kg.

- Downpipes

Hot rolled CHS steel section with 3mm minimum wall thickness will be used for downpipes which will be alight with structure columns and not climbable. The diameter for the downpipes will be 100mm. Flying downpipes must be designed to support point loads from ladder support of 100kg and a minimum hanging point load of 100kg. The rainwater will be drained to the new stormwater system for the overpass through the downpipes.

Platform Drainage

It is important to ensure the walking surface on the platform is flat enough to allow for safe travel but it must be designed with a slight crossfall to allow for efficient drainage. The platform is designed to slope away from the rail track, this has two advantages in it allows for a single line grate system as shown below, but also incorporates safety features such as rollaway protection for prams and wheelchairs. We have faced the challenge of keeping the slab level of railway station safe whilst ensuring adequate provision for drainage. Water can pool easily and create puddles during storms when the slab is flat. This will be slip hazards for the people. To harmonise with the requirements of a flat slab, linear trench drainage for platforms is designed to adequately intercept all the surface water along the length of the platform. The figure below shows an example of a linear trench drainage at railway platform.

Figure 75: Linear Trench Drainage

The dimension of the linear trench drain used will be 200mm x 200mm. Anti-slip grate will be used to help prevent public falls and injuries as we believe that small slotted grates should also be slip resistant. Each grate complies with the legislative requirements including AS 4586 for slip resistance. The following figure shows the example of the linear trench design.

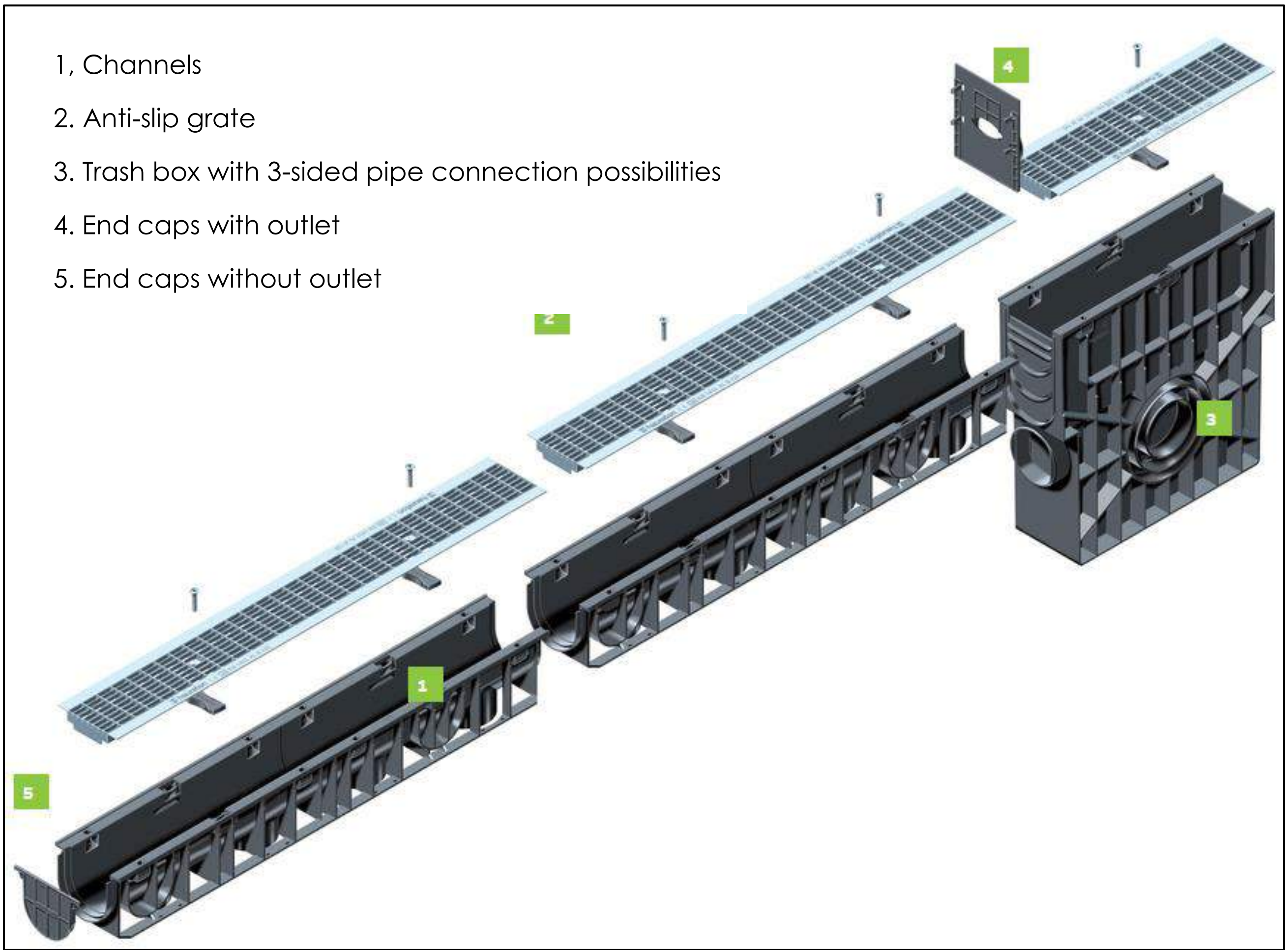


Figure 76: Linear Trench Drain (RECYFIX Standard)

As a result, the linear trench drain will collect run off and deliver into pipes down the overpass into Modular Pollutant Trap pit. This is tied into the existing stormwater system.

5.2.4 Fire Service System Design

The fire service system at the train station is designed based on the following Australian Standards:

- AS 2118 Fire Sprinklers
- AS 2444 Fire Extinguishers
- AS1670 Fire Detection, Warning, Control and Intercom systems

The fire service system will include the components as shown below:

- Fire Sprinklers

Figure 77: Fire Sprinkler (Firequip 2016)

Fire sprinklers as shown in figure 1 will be used to comply with the requirements of Building Code of Australia, AS2118 and also subject to the adopted recommendations of any Fire Engineering and Life Safety Report. All the main sprinkler valves affecting supply and operation of the system must be monitored and interfaced to signal the Fire Indicator Panel (FIP) in the event of valve closure or tampering.

- Fire Extinguishers

The fire extinguishers is provided to comply with the requirements of AS 2444 and will be CO2 type. The fire extinguisher as shown in figure 2 will be placed at the equipment room. Based on the RailCorp guidelines, fire extinguisher will not be provided at the platform or public areas.

Figure 78: 5kg CO2 Fire Extinguishers (Australia Fire Safety, 2012)

- Fire Detection

Smoke detectors will be installed at all the areas of the railway platform including ventilation ducts, lift shafts, stairs, equipment room and electrical room. Audible and visual alarms will be placed as required by Australian Standards.

As required by Australian Standards, audible and visual alarms will be placed. Non-habitable spaces for instance control room must be fitted with alarm sounders.

There are some requirements for smoke detectors. For example, smoke detectors must be zoned according to their respective station sectors. Apart from that, to detect potential fire hazards early, detectors within the same zone will be linked by a common closed loop wiring system and interfaced to the station Fire Indicator Panel.

5.2.5 Passenger Information System

Technical Standard Part 129016 is used while designing the passenger information system of the overpass railway platform.

5.2.5.1 Passenger Information Audio System

PA system at train platform is very important in delivering announcements such as emergency evacuation, general information and also delay announcements. According to AS60849, coverage of the full platform length must be provided including the stairs, ramps and the lifts for overpass. Passenger information audio system consists of the components such as speakers, voice annunciator and hearing impaired loop.

Speakers

The speakers will be fixed at the underside of the shelter structure in a vertically down-facing orientation which is as shown in the figure below. They will be mounted using sturdy brackets and locking washers and secured using two fixings.

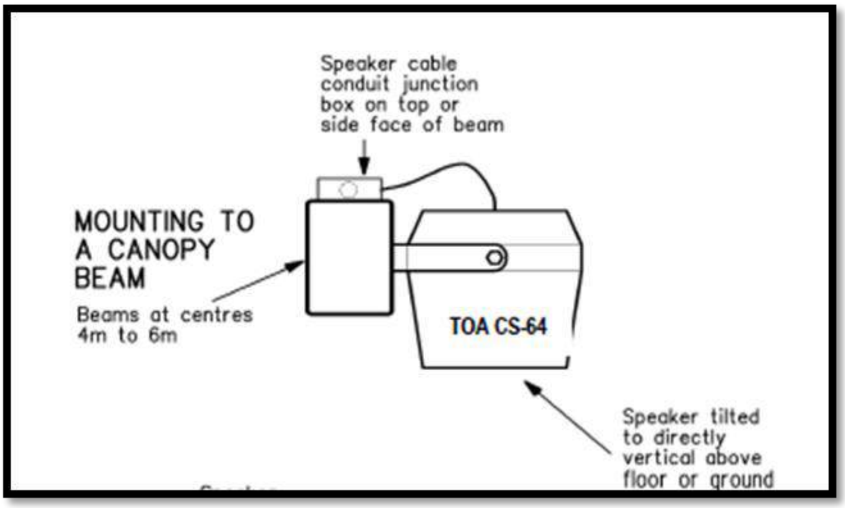


Figure 79: Mounting to a canopy beam (Technical Standard Part 129016)

Other than that, a pair of speakers will also be installed on the light pole with spacing between 20 to 24m. The speaker will be angled at 22 degrees from a vertical height of 4m. An anti-climb guard shell with spikes at 30 degrees out to the pole's vertical alignment must be installed to the pole fitted with speakers. The speakers mounted to a lighting pole is shown in the following figure. There will be a total number of 32 speakers be installed on the platforms according to the Railway Platform Services Drawing ECRP01.

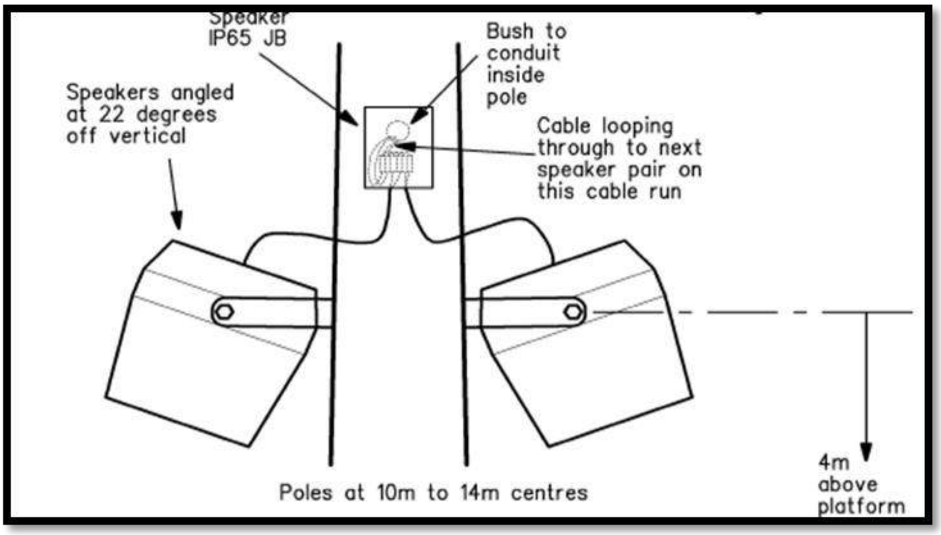


Figure 80: Mounting to a lighting pole (Technical Standard Part 129016)

Voice Annunciator

One voice annunciator will be installed at platform 1 and platform 2. They will be located near the centre of each platform and announces next train information automatically. Other than that, there is a push button on the voice annunciator. When the button is pressed, it will signal the Network Amplifier Controller to replay recorded timetable information on demand.

The voice annunciator will be fixed securely on the platform to prevent human injury and resist vandalism. They will be secured with M6 security-head bolts but still allow access for maintenance.

Hearing Impaired Induction Loop (HIIL)

The voice annunciator will have an associated hearing impaired induction loop which comprises a turn cable embedded into the platform and driven by an amplifier in the network amplifier controller. The hearing impaired induction loop will create a magnetic field which can be received by hearing aids.

The hearing impaired induction loop will be installed in concrete. It will run in a 32 mm conduit. The conduit will be installed with sweep bends and both ends will be fed into the voice annunciator column. The conduit will be installed before pouring of concrete and there will be a joint inspection prior to concrete pour.

According to the Technical Standard Part 129016 Clause 5.8, the designed hearing impaired induction loop will have the following specification:

- The cable type will be a 2.5 mm^2 PVC-coated flexible copper wire with tinned strands
- The loop-end connector type used will be a 2-pin female, Delphi Weather-pack, part number 12015792

- The cable-end connector type used will be a 2-pin male, Delphi Weather-pack, part number 12015793
- The loop length will be between 12 m to a maximum of 14m

Other than that, it is important to test the area of each proposed voice annunciator/loop position with a Loop Field Strength Meter during the design phase to determine the amount of electrical interference at the location.

5.2.5.2 Passenger Information Display

According to PTS Technical Standard Part 129016, for platform over 120m long, two passenger information displays will be installed on each platform as per drawing *CCTV Platform*. Passenger Information Display will be mounted to a support bracket suspended from the canopy structure above, with a down tilt angle of 10 degrees. The position of the passenger information display must be co-ordinated with CCTV to ensure it can viewed by a CCTC camera if its tamper alarm is activated. They will be located around the main platform waiting area which is toward the centre of the platform. Other than that, the bottom surface of the passenger information display must not be lower than 2700mm above platform level or higher than 3000mm above platform level. According to the Railway Services Drawing ECRP01, there will be a total number of 4 passenger information display installed on the platform.

According to the Technical Standard Part 129016 Clause 6.2, the passenger information display will comprise the following components:

- Timetable information stored in the network amplifier controller and updated over the PIS WAN IP network
- 100 base T Ethernet and 100base-FX network switch
- DVI splitter
- DVI cord per monitor with
- Passenger information display power and tamper alarm cabling

5.2.6 Control Room

A suitable control must be provided to securely house the infrastructure required for train station such as electrical infrastructure, security system and passenger information system. Refer drawing *Control Room layout* for the layout of the proposed control room to be located under the platform as part of the embankment structure.

5.2.6.1 Security

To ensure the safety of the control room, the walls and doors of the control room will be constructed capable of withstanding malicious vandal attack. There will be no access to the control room by removing panels or in-wall air conditioners. The walls will be constructed with masonry or concrete whereas the door will be made with solid timber and steel clad.

The entrance door to the security system enclosure within the control room will also be fitted with a lock. The external door of the control room will be fitted with weather and dust seals in order to prevent ingress of water or contaminants into the room. A lock keyed will also be fitted to the external door to suit a Principal supplied “K11/K12” Security Key. There will be a self-closing mechanism installed to the door so that it will be lock automatically from the outside but it can still be opened without the use of a key from inside.

5.2.6.2 Power Supply

The power will be supplied to the control room. The following circuits will be provided in the control room in accordance to Technical Standard Part 129017 Clause 3.11.

- 15 A rack pendant outlet #1 (CCTV Rack main – Non-RCD)
- 15 A rack pendant outlet #2 (CCTV Rack backup-Non-RCD)
- 15 A rack pendant outlet #3 (PA/ICT Rack main-Non-RCD)
- 15 A rack pendant outlet #4 (PA/ICT Rack backup-Non-RCD)
- Wall convenience general power outlets (RCD protected)
- Security alarm panel general power outlet (Non-RCd)
- Lighting

The average equipment demand under normal steady state power supply condition is estimated at 1500 VA excluding lighting. A 6mm^2 G/Y cable will be provided from a Communications Earth Terminal at the main distribution board to each of the CCTV rack, PI rack and also the main distribution frame.

5.2.6.3 Main Distribution Frame

A public carrier network boundary facility (Main Distribution Frame) will be located in the control room. There will be a cable tray support pathway to the ER perimeter wall cable tray, to the public carrier entrance cable penetrations and also to the site distribution pathways.

5.2.6.4 Telstra Service

A 10 pair Telstra point of entry cable will be provided from the nearest point of Telstra service connection. According to the Technical Standard Part 129017 Clause 3.13, the services as shown below will be wired to the Main Distribution Frame and carried on this cable as Public Switched Telephone Network (PSTN) services.

- Emergency Help Phone – one line per telephone

- Lift car Emergency Help Phone
- Security alarm panel dialler
- Police Security Services Branch (PSSB) link Digital Subscriber Line (DSL) service

5.2.7 Costing

Table 49: Platform services costing

Task/Material/Element		Unit	Cost ($)	Quantity	Cost ($)
Electrical Infrastructure	Lighting Poles	Each	1500	62	93,000.00
	Lift	Each	150000	2	300,000.00
	CCTV cameras (including hardware and wiring)	Each	1000	16	16,000.00
	Cables Combined (Electrical, Comms etc)	m	80	640	51,200.00
	Emergency Help Phone	Each	1000	2	2,000.00
SA Water	Water Supply Pipe	m	25	100	2500.00
	Drinking Fountain	Each	3000	2	6,000.00
	Gutter	m	75	320	24,000.00
	Water Drainage Pipe	m	100	350	35,000.00
Fire Service System	Fire Sprinklers System	Each	25000	1	25000.00
	Fire Extinguisher	Each	200	1	200.00
	Smoke Detector System	Each	25000	1	25000.00
Passenger Information System	Speakers	Each	800	32	25,600.00
	Voice Annunciators	Each	500	2	1,000.00
	Hearing Impaired Induction Loop System	Each	2000	1	2,000.00
	TV	Each	2000	4	8,000.00
	Passenger Display System Components	Each	5000	1	5,000.00
	Combined Cables (Electrical, data etc)	m	80	200	16,000.00
Control Room	Control Room System	Each	250000	1	250,000.00
Total					**794,500.00**

5.3 Package 03: Miscellaneous

5.3.1 Traffic Signalling

5.3.1.1 Design Assumptions & Considerations

It is assumed that there are three resultant intersections to be signalised based on the recommendations from the Traffic Signal Operation Performance Report (TSOPR) carried out as per section 4 and 6.2 of DPTI TS100 Traffic signal design standards. Refer drawing *Traffic Signals* for the alignment of the new signal network including Comms and power supply at the newly signalised intersections.

Traffic signal performance analysis must be undertaken, including:

- capacity analysis to guide the design and operational requirements of traffic signals;
- modelling using current and specified future design flows, and
- Detailed assessment of the traffic impacts of alternative traffic management arrangements to be used during construction of the project.
- The following design and operational requirements must be achieved:
- lane, phasing and coordination requirements at traffic signals that ensures the safe and efficient operation of road network for the current and future design flows, as specified;
- traffic signals integration within DPTI's current systems used to monitor and control traffic signal operation; and
- The needs of all road users (e.g. buses, heavy vehicles, freight, cycles, and pedestrians) are taken into account.

5.3.1.2 Conduiting

The proposed signal network construction, including trench work, conduit layout and associated pit design will comply with the following DPTI specifications:

(a) Part 206 "Under-road Boring"

(b) Part 207 "Trench Excavation and Backfill"

(c) Part 208 "Reinstatement of Existing Pavements"

(d) Part 253 "Supply and Installation of Conduits and Pits".

5.3.1.3 Intersections

The new intersections are designed to incorporate Extra Low Voltage network (ELV) equipment approved by DPTI with allowance for spare conduits as outlined in 7.1, 7.3 and 7.4 of TS100. The new traffic signal controllers used in the intersection are designed to conform to specification TSC/4 of Transport for New South Wales in addition to DPTI approval. S7.7 of TS100 details location determining of traffic signal controllers. Similarly, the location of traffic signal poles must take into account various constraints such as site layout and function of intersection, refer section 7.11.5 Traffic Signal Poles.

5.3.2 Traffic Signal Controller

All new traffic signal controllers must conform to Transport for New South Wales Road and Marine Services, NSW specification TSC/4 and be approved by DPTI.

The location of the traffic signal controller must be determined using the following criteria:

- minimisation of obstruction to pedestrians;
- minimisation of visual obstruction to drivers;
- minimisation of the risk of accidental damage by traffic;
- provision of a safe and easy access for maintenance personnel and associated vehicles;
- permits maintenance staff to have a clear view of the whole of the intersection from the controller as far as is practicable;
- orientation so that the cabinet door(s) open away from the centre of the intersection; and
- Close location to the power supply and telecommunications service.

The programming of the traffic controllers is part of DPTIs scope, however DPC nor DPTI will provide the hardware required, Programmable Controller Personality Module (PCPM). CCTV cameras are to be installed where S7.8 of TS100 dictates and are to be installed in an external housing on top of the traffic signal cabinet. All level and pedestrian/bicycle detection crossings are to be designed to sections 7.11.3 and 7.11.4 of TS100 relating to requirements, location, geometry and restraints of these crossings. All records of construction required by DPTI as stated in section 8, TS100 will be provided.

5.3.3 Stormwater

5.3.3.1 Design Assumptions & Considerations

In this detailed design brief report, since it is the railway overpass, it is necessary to consider the design of the stormwater system on the bridge with the road to ensure the possibility of resisting any floods and to maintain adequate rainfall capacity in the area. The main aim is to ferry the stormwater runoff from the overpass as quickly as possible to minimise flood danger and damage. The secondary aim is to limit the entering of pollutants into the receiving waters. These designs will be connected to the existing stormwater system along Murray Terrace, and then become part of the existing network. The new stormwater system will be described in further detail below and the alignment can be found under drawing *Stormwater*. It is a design assumption that the existing stormwater system in effect during a 1 in 100 ARI storm event has the capacity to withstand the new inflow from the proposed rail overpass. The delivery of new stormwater inflow from the rail overpass to the existing network is carried down stormwater pipes or grades

In order to keep the existing stormwater system in that area, a drainage pipe will be designed on the bridge to connect the rainwater to the ground stormwater drainage system. Assume a 300mm dimeter as a drain pipe.

The stormwater drainage system needs to be controlled from the following sources to collect, process and store runoff: Rainfall, flood control and accidental leak. In order to design a new rainwater system on the bridge, two sub-catchments are divided so as to produce a preliminary pipe size and use the DRAINS software, develop appropriate rainwater systems. The stormwater system will be designed to flow along the slope to the bridge and then into the original rainwater drainage system as the rain flows north and south.

5.3.3.2 Distances between other services

According from AS/NZS 3725:2007, the minimum distance between stormwater systems designs of pipes with other services designed is 50 mm, the required compaction is able to get the pipe around the filling material. Due to the size of the pipe and the required work design, it is necessary to design around the layout of the stormwater pipe.

5.3.3.3 Minimum depths/cover

The minimum depth of stormwater system design is 600mm as a reinforced concrete pipes. And for PVC and steel pipes of the stormwater system design as a cover are requires for 750 mm and 400 mm. During the construction period according to the provisions of DPTI, to carry out construction.

5.3.3.4 Pipes, Pits, Junction Boxes and Access covers

All pipes, concrete rainwater inlet pits, junction boxes, access covers and grates and culverts are designed and constructed according from the Australian/ New Zealand standard and DPTI specifications for design and construction:

AS/NZS 3725:2007 - Design for Installation of Buried Concrete Pipes;

AS 3996:2006 - Access covers and grates;

AS 3735 - Concrete structures retaining liquids;

DPTI Road Design Standards and Guidelines – Stormwater Design - DD 300;

Storm Drainage Design in small urban catchments – John Argue, 1986.

The pipeline and pits for this project design of the specific requirements are:

Minimum pipe grade of 0.5%

Minimum pipe diameter of 375mm

Minimum cover of 600mm

Maximum spacing between pits is 100m

Assume 100 years ARI event.

5.3.3.5 Catchment travel time

The critical travel time for each sub-catchment is determined using the flow distance shown in Figure 81.

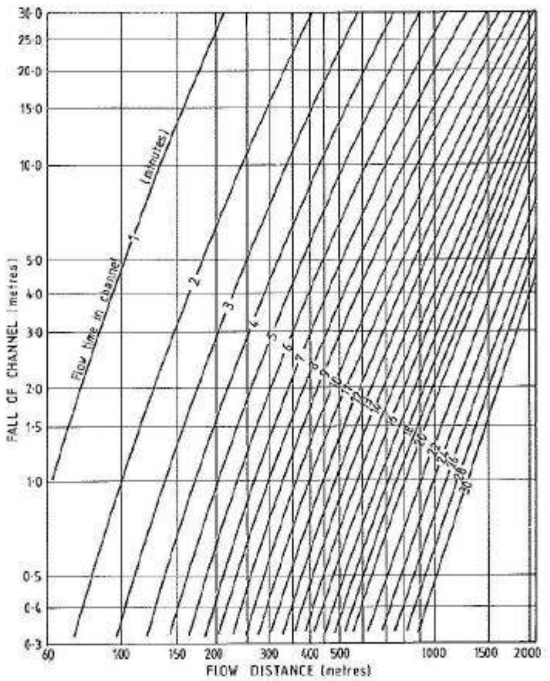


Figure 81: Travel time for paved surfaces.

Table 50: Stormwater initial catchments area

Catchment	Road area (m^2)	Property area (m^2)	Total area (m^2)	% paved area	% pervious area
1	7807.5	5855.25	13662.75	87.14	12.86

From table above, shows the properties of the sub catchments that were found. From CAD file can find the total area, and which area can is road area and property area. The following equation was used to find the % of paved area.

$$\%\, paved\ area = \frac{(0.7 \times Property\ Area) + Road\ Area}{Total\ Area} \times 100$$

Therefore, to find out the intensity of rainfall in each sub catchment areas, it is necessary to find the time for concentration travel time for each sub catchment. The longest travel distance and height difference are required to determine the slope of the sub catchment. Using John Argue's book to find the travel time.

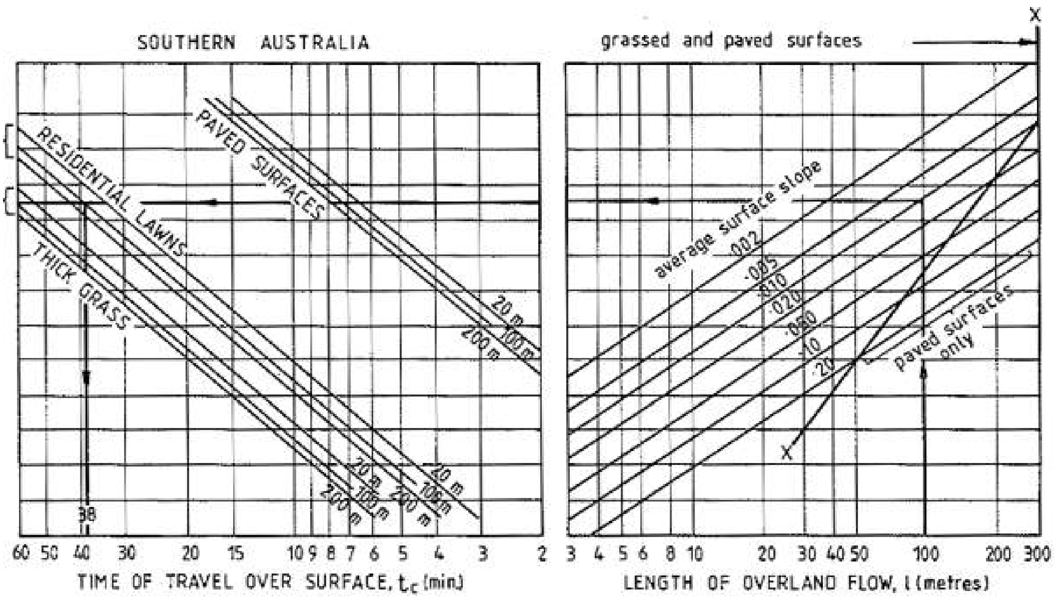
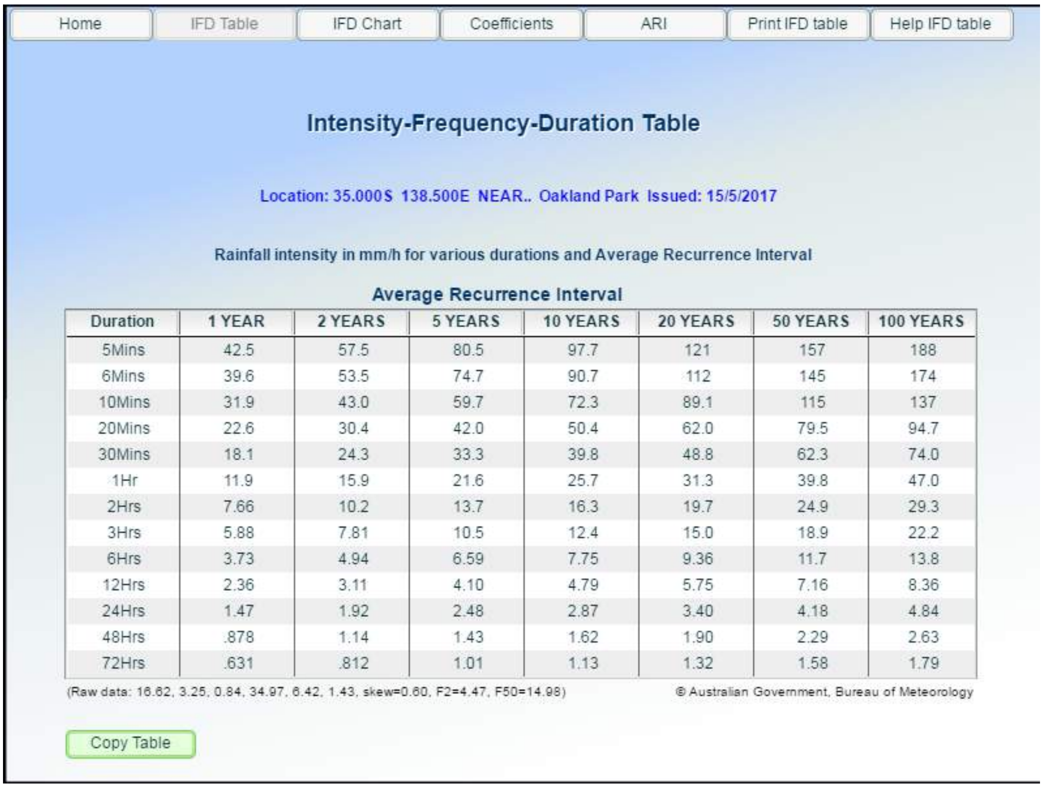


Figure 82: Travel time of stormwater - John Argue 1986

From Figure 82 shows, the travel time for pervious area was found for catchment. The travel time for pervious area was found for catchment. The minimum travel time for paved area is assumed to 5 minutes for the impervious area and up to 30 minutes for pervious area, in order to be conservative in case of flooding events.



Home | IFD Table | IFD Chart | Coefficients | ARI | Print IFD table | Help IFD table

Intensity-Frequency-Duration Table

Location: 35.000S 138.500E NEAR.. Oakland Park Issued: 15/5/2017

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval

Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	42.5	57.5	80.5	97.7	121	157	188
6Mins	39.6	53.5	74.7	90.7	112	145	174
10Mins	31.9	43.0	59.7	72.3	89.1	115	137
20Mins	22.6	30.4	42.0	50.4	62.0	79.5	94.7
30Mins	18.1	24.3	33.3	39.8	48.8	62.3	74.0
1Hr	11.9	15.9	21.6	25.7	31.3	39.8	47.0
2Hrs	7.66	10.2	13.7	16.3	19.7	24.9	29.3
3Hrs	5.88	7.81	10.5	12.4	15.0	18.9	22.2
6Hrs	3.73	4.94	6.59	7.75	9.36	11.7	13.8
12Hrs	2.36	3.11	4.10	4.79	5.75	7.16	8.36
24Hrs	1.47	1.92	2.48	2.87	3.40	4.18	4.84
48Hrs	.878	1.14	1.43	1.62	1.90	2.29	2.63
72Hrs	.631	.812	1.01	1.13	1.32	1.58	1.79

(Raw data: 16.62, 3.25, 0.84, 34.97, 6.42, 1.43, skew=0.60, F2=4.47, F50=14.98) © Australian Government, Bureau of Meteorology

Copy Table

Figure 83: IFD table of Oakland's Park

Figure 84: Duration in hours or minutes for Oakland Park area

Figure 83 and Figure 84 shows the rainfall intensity for different ARI and storm durations. As the stormwater system is being designed for a major storm and minor storm events. The rainfall intensities to be utilised, involve a 100 year ARI for major storms and a 10 year ARI for minor storms.

Blow is shows the details calculation about each sub catchment rainfall intensity.

Table 51: Catchment rainfall intensity

Catchment	Change of elevation (ΔEL)	Length	Slope	Travel time pervious area (min)	Travel time paved area (min	Total Travel time (min)	Total rainfall intensity (mm/hr)
1	3	200	0.0015	39	5	44	61.4

$$Slope = \frac{\Delta EL}{Distance}$$

For 10 years ARI situation:

$$C_{10} = \frac{C_1A_1 + C_2A_2}{Total\ Area} = \frac{0.9 \times 87.68 + 0.1 \times 12.32}{100} = 0.8$$

Therefor for 100 years ARI situation,

$$C_{100} = C_{10} \times F_y$$

Table 52: Frequency conversion factor - Argue, et al 1986, table 5.5

ARI (years)	1	2	5	10	20	40	60	80	100
F_y	0.80	0.85	0.95	1.00	1.05	1.13	1.17	1.19	1.20

Rail: $C_1 = 0.9 \times 1.2 = 1.08 \approx 1.0$

Platform: $C_2 = 0.1 \times 1.2 = 0.12$

$$C_{100} = \frac{C_1A_1 + C_2A_2}{Total\ Area} = \frac{1 \times 87.14 + 0.12 \times 12.86}{100} = 0.89$$

Table 53: Effective runoff coefficient for 100 years ARI

Catchment	C1	C2	Effective runoff coefficient for 100 years ARI
1	1.0	0.12	0.89

Design catchments flow rate, Q

$$Q = \frac{CIA}{360}$$

Table 54: Catchments flow rate, Q

catchment	C100	Q (m^3/s)
1	0.89	0.18

5.3.3.6 Pipes

Due to the nature of the pipe position and the safety hazards of the surface water along the bridge, the piping design needs to be conserved in several respects. According from the DPTI guideline, the minimum size of reinforce concrete pipes is 375 mm. The lowest grade of the stormwater piping is 0.5%.

5.3.3.7 Pipe diameter calculation

Therefore, to find out the diameter of pipe,

$$Q = AV = \frac{A}{n}(R)^{\frac{2}{3}}(S_0)^{\frac{1}{2}}$$

$R = \frac{D}{4}$, $A = \frac{\pi D^2}{4}$ For the circular pipe.

Team is going to use PVC pipe in this project for stormwater system design. Therefore, the manning's roughness (n) is 0.013. Also, the minimum slope is 0.5%, but our team choosing 1% as conservatives and ensure that the stormwater system will have adequate flow.

$$D_{catchment} = \left(\frac{Q \times 4n \times 4^{\frac{2}{3}}}{\pi (S_0)^{\frac{1}{2}}}\right)^{\frac{3}{8}} = 0.28m$$

Table 55: Pipe Diameter

Catchment	C100	Q	n	Pipe Diameter
1	0.89	0.18	0.0013	0.28

Therefore, is choosing 300 mm as pipe diameter.

Then, check the velocity,

$$V = \frac{1}{n}(R)^{\frac{2}{3}}(S_0)^{\frac{1}{2}} = 2 < 3\frac{m}{s}\ ok!$$

5.3.3.8 Stormwater Entry Pits

Using two different types of pit for collecting the stormwater, which is side entry pits (SEPs) and grated entry pits (GEPs). The GEPs have been designed for middle of the bridge and platform and side entry pits are for two side of the ground. SEPs are used for the ground of the two side of the bridge, it can be easily realized to prevent flooding to the pedestrian road. The grates are according from AS 3996:2006 to be design. Grated entry pits can reduce the possible pump damage caused by large pollutants and debris.

Table 56: Stormwater Entry Pits

Pit type	Number of pits
Side entry pit	4
Grated entry pit	14

5.3.3.9 Stormwater management during construction

The implementation of interim measures during temporary construction is essential to accommodate surface runoff in areas where existing infrastructure has been implemented or dismantled. The temporary pipe will reposition the runoff through the working area and return to the existing pipeline. During the project, should pay attention to the situation of nearby residents, to prevent the impact of the surrounding residents. The degree of implementation of the measures will be regularly determined in accordance with the progress of the project.

5.3.3.10 Stormwater Costing

Table 57: Stormwater costing

Item	Price	Quantity	Total
Pipe Stormwater PVC 300 mm 6 metre	$ 219.98	145	$ 31,897.10
Pre-cast Concrete Pit 1500mm deep by 900x900	$ 1,368.00	14	$ 19,152.00
Pre-cast Concrete Pit 1900mm deep by 900x900	$ 1,640.00	4	$ 6,560.00
Total			$ 57,609.10

5.3.3.11 DRAINS

It is a design assumption that the existing stormwater system in effect during a 1 in 100 ARI storm event has the capacity to withstand the new inflow from the proposed rail overpass. The delivery of new stormwater inflow from the rail overpass to the existing network is carried down stormwater pipes within the void space between super-T's of the structure and these are fed via pervious ballast.

5.4 Drawings Reference List:

5.4.1.1 Relocations

1. Plan view of existing and design services – project extent
2. Plan view of existing and design services – detailed
3. Cross section of typical trench – each service
4. Cross section of typical road crossing – wherever crossing

5.4.2 Rail Platform

1. Plan view of rail platform showing skeleton structure + services – all services
2. Plan view of rail platform showing services – detailed
3. Cross section of stormwater drainage into overpass drainage + Mod Grease Trap
4. Control Room drawing

5.4.3 Misc.

1. Stormwater design network tie in to existing
2. Traffic signalling plan view project extent + detailed
3. Greenway drawing

5.5 Reference

1. Public Transport Services 2013, Design-Stations-Passenger Information Systems, Technical Standard Part 129016, Department of Planning, Transport and Infrastructure, South Australia.
2. Public Transport Services 2013, Stations – Platforms, Technical Standard Part 129003, Department of Planning, Transport and Infrastructure, South Australia.
3. Public Transport Services 2014, Design-Stations-Electrical Infrastructure, Technical Standard Part 129014, Department of Planning, Transport and Infrastructure, South Australia.
4. Public Transport Services 2013, Stations – Earthing and Bonding, Technical Standard Part 129002, Department of Planning, Transport and Infrastructure, South Australia
5. Public Transport Services 2013, Stations – Equipment Room, Technical Standard Part 129017, Department of Planning, Transport and Infrastructure, South Australia.
6. Public Transport Services 2013, Design – Stations- Overpasses, Technical Standard Part 129004, Department of Planning, Transport and Infrastructure, South Australia
7. Track and Civil Infrastructure 2013, Code of Practice Volume 2: Drainage, CP-TS-958, Government of South Australia, South Australia.

6 URBAN DESIGN AND COMMUNITY

6.1 Introduction

Upon completion of the feasibility study, DPC Engineering, has narrowed the four initial design options down to a singular focus, which is the rail overpass for the detailed design. The Urban Planning department has begun detailing the specific requirements needed to ensure the success of the rail overpass, starting with the initial scoping document. This document has provided a map, for the expected course of action the department will take during the final design stage, and supplements this report. The following section of this report aims to cater for the communities and stakeholders within the area of the project.

The Urban Planning department at DPC engineering, will achieve this by developing plans for the use of land around the project, while considering the political, zoning and legal issues related to the project. Additionally, the urban team will provide a strong input into the final design of the project, by providing a conceptual model, that will provide direction for the various departments in their design, whilst ensuring synergy with the existing design of current area. Lastly the urban team will implement a strong and positive interface with the public, providing community engagement measures to determine their needs and limitations, whilst gathering data, environmental studies and economic reports to review the design.

6.2 Demographics

The final design, construction and operation of the rail overpass will have a strong impact on the residents, businesses and commuters of the surrounding area. That being, the people of Warradale and Oaklands Park, and to a greater extent the Marion council, will need to be consulted with to minimize any negative impacts that the project could potentially raise during the construction and operation of the rail overpass. To do this information from the City of Marion's social atlas, which gives the total population of Marion as 81479, will be utilized to assess the impact on the general population of the area. Where the specific population of Warradale and Oaklands Park, (4578 and 3251 respectively), will be used to assess the immediate area of the project. It is a target of the department to achieve a 50% participation rate in the feedback surveys as the project goes on.

Other data such as the average age (42 years old), house ownership details (Warradale area is 39.4%, and Oaklands Park area is 26.2%), and the rent percentages of the area, give insight on how to best approach land acquisition for the project. Additionally, data on how to best reach the community and other important demographic details can be assisted with the following information. That is, the unemployment rate is only 10% of the two regions together, hence, a large percentage of individuals that need to get to work. Furthermore, the percentage of people in the Warradale area, who choose to get to work by car is 67.5% and, in Oaklands Park it is 64.2%. This means that once the construction begins, a great inconvenience will be caused on the two regions. Thus, it is important to minimize the impact on these people during construction.

6.3 Existing Conditions

The existing project Conditions that the urban team will be analysing is within the area surrounded by Murray terrace, railway terrace and Diagonal Road, as seen in Figure 85. The current conditions illustrate the future impacts in this area, that is, they are subject to substantial traffic management challenges. DPC Engineering predicts that the future impact will stem from the construction of the rail overpass, in particular, the large machines that will be used and the roads that will be blocked. The community will be notified in advance of each interruption, and mitigation measures will be put in place. In addition, near the construction, the project will have a small office space used to solve problems any residents and stakeholders may have, both during and after the completion of the project. This is important because the current analysis of the area shows that there are many business and other significant stakeholders who may be affected by our project. They are; the large number of residents in the areas, the Alsham Supermarket, Coin-op Laundromat / Laundry Splodge Corner, and the SA Aquatic and Leisure Centre.

The magnitude and timing of the interruptions are justified by the fact that after the completion of the railway, the traffic flow will be improved. Additionally, this project will create jobs, improve the current congestion issues in the area, and allow for a more future proof infrastructural system that fits in with the 30-year plan for greater Adelaide. DPC Engineering will take note of the existing conditions to effectively communicate with local residents, business and stakeholder to reduce complaints, agitated residents, and any miscommunication during the projects life cycle.

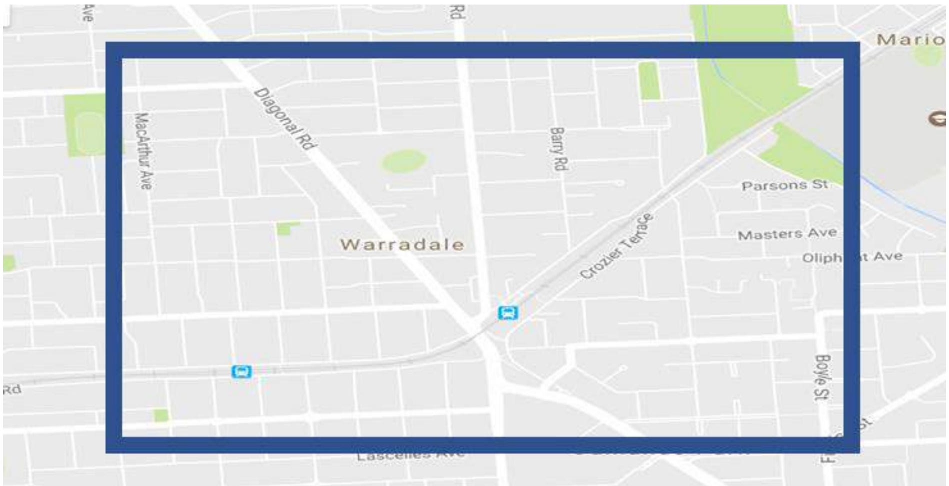


Figure 85: Area Considered for Existing site conditions (Google maps 2017)

6.4 Important Sites

It is in this section that DPC Engineering has analysed the important sites that are relevant to the project, both during and after the projects life cycle. During the construction process, the northern commercial shops: Alsham Supermarket, Coin-op Laundromat / Laundry and Splodge Corner will be affected by a reduction in traffic flow and human traffic along the roads their business are located on. Customers from the north may make a detour by Marion Road or Brighton Road. This is very inconvenient; as these customers may choose other shops to visit, due to traffic problems.

As shown in Figure 86, the SA Aquatic and Leisure Centre and other businesses, highlight above, have customers that travel from Morphett Road and Diagonal Road (south). As mentioned previously these businesses will also be affected, however, when the railway overpass is completed, business will be greatly improved as a result of the project.

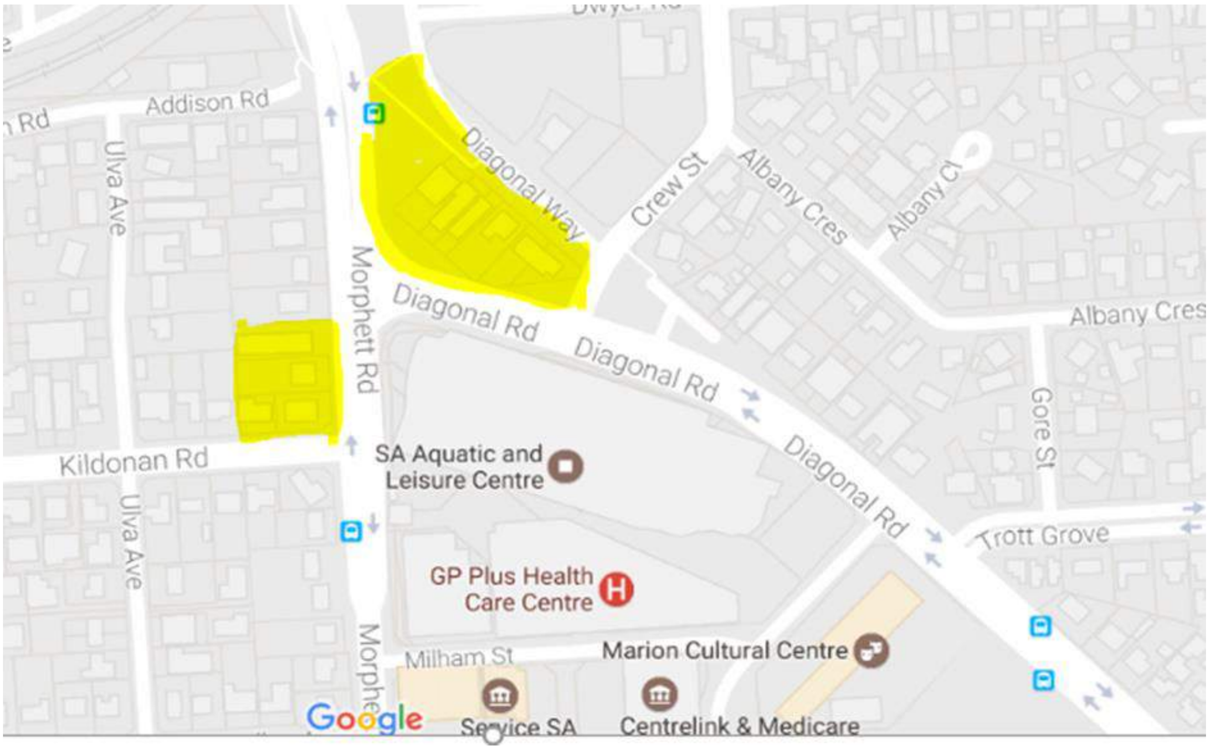


Figure 86: Important sites (Google maps 2017)

To minimize the impact on the for-mentioned important sites, the following mitigation processes and methods will be implemented throughout the project;

- Build temporary roads to reducing the impact of nearby residents.
- Follow recommendations by the environmental team to reduce noise and vibration, as per the legal requirements.
- Tell the local people and stakeholders the construction date in advance, so that the vehicle can choose to bypass in advance to reduce traffic congestion.
- Set up noise barriers at construction site.

- Reasonable adjustment of transport vehicle time and mechanical operation time, where feasible.
- Follow up with communication processes, information events and show status updates on our website.

After the completion of the railway, the north-south traffic capacity will improve. In addition, the project can create an open space below the overpass to increase parking capacity. Furthermore, pedestrian convenience will be improved, stairs and elevators will be built in the overpass. Bicycle lanes will also be added on the north-south direction. Ultimately, the overall community travel will be greatly improved. These will inherently improve the surrounding areas for the businesses and community, and the urban teams input into these areas can be seen further down in the report.

6.5 Stakeholders

Given the sheer size of this project, it is no surprise that there are a large number of key stakeholders within this project. It is an uppermost priority that DPC Engineering will work closely with all the stakeholders, and update information to them as necessary. As DPC Engineering values their input, it will be our company aspiration to get as much feedback to improve the project as practicable. The following are a list of the key stakeholders within this project;

- Primary stakeholders;
- Department of planning, transport and infrastructure
- South Australian state government
- City of Marion
- National parks and wildlife advisory council
- Kaurna nation cultural heritage association
- State aquatic centre

Secondary stakeholders;

- Local home owners
- Local tenants
- Local business owners
- Local employment agency
- Local workers
- Nearby clubs
- Public transport user
- Road user
- Cyclist
- Pedestrians
- And airport traffic

Prior, during and after the construction stages meetings will be conducted with the stakeholders and their opinions and feedback will be noted. Those opinions and feedback will be taken in to consideration and changes will be made to satisfy the stakeholders and community.

6.6 Community Engagement

There are many ways to provide advance notice to the community about projects and transportation conditions during the constructions phase. To provide efficient information and maintain a good relationship with community the following communication systems will be utilized;

- Some effective communication systems are as follows
- Mass media (television and radios)
- Website information
- Public meetings
- Street stalls
- Social media (Facebook, Instagram, twitter)
- Photography and video
- Sign board

6.6.1 Mass media (television and radios)

Although expensive, mass media can be a vital source to spread information in short time. Through radio and television people can get more information in short time. On television, the locations and construction process can also be broadcasted so people from other suburb will also get better information of development.

6.6.2 Website information

DPC Engineering, has constructed a website, as seen in Figure 87, where all the information related to project will be updated, so that, the members of the public can get latest status updates and information about project. this is a great method of community engagement for those who are unable to attend our public meetings and other information sessions.

Figure 87: DPC Engineering Website (DPC Engineering, 2017)

6.6.3 Public Information Events

Public Information events, (Figure 88), are important for us as well and public. These events can be provided to the public in efficient and cost-effective manner, allowing us to gauge the publics reception of the project so far. It will be also good opportunity for us to interact with community and get their feedback, opinions and concerns.

Figure 88: Example Public Information Event (DPC Engineering Feasibility Report 2017)

6.6.4 Street stalls

The street stalls, (Figure 89), will be implemented within the important sites mentioned above. These sites include the supermarkets and aquatic centre, as we can reach a vast majority of the population who may have questions regarding the project. The project will utilize screens and banners, so that, the public and come and get information about the project.

Figure 89: Street stalls (DPC Engineering Feasibility Report 2017)

6.6.5 Social media

Social media plays a very important role to spread information effortlessly. Social media like Facebook (Figure 90), Instagram and twitter will be used to update the project information. It is from social media that the younger generation can be reached, and can comment about their thoughts on the project.

Figure 90: Social media (DPC Engineering Feasibility Report 2017)

6.6.6 Sign boards

Sign boards, (Figure 91), will be in use to give prior information to the road users. Sign boards are very important during construction, it will provide forecast of road conditions and provide detour routes to prevent the public from, entering the construction site. During all public meetings, information sessions, Website updates, and social media will receive the latest information about road conditions. Our company will also update the information on detours for and train and bus routes. It is our aim in this section to maximize the release of information, so that the community and stakeholders are involved and up-to-date on the following;

- Traffic impacts
- Pedestrian and cycling effects
- local access impacts

Complaints from the different communities and stakeholders will be dealt with seriously. Participants in the project will be responsible for community and stakeholder complaints.

Figure 91: Signage (roadsky, 2017)

6.7 Land Acquisition

Land acquisition will be implemented on this project to have safe environment during construction, and to upgrade diagonal road. As per the investigation, some businesses and residential areas will be obtained for the project. The company will purchase all property in accordance with the standard South Australia Legislation – SA Land Acquisition Act 1996.

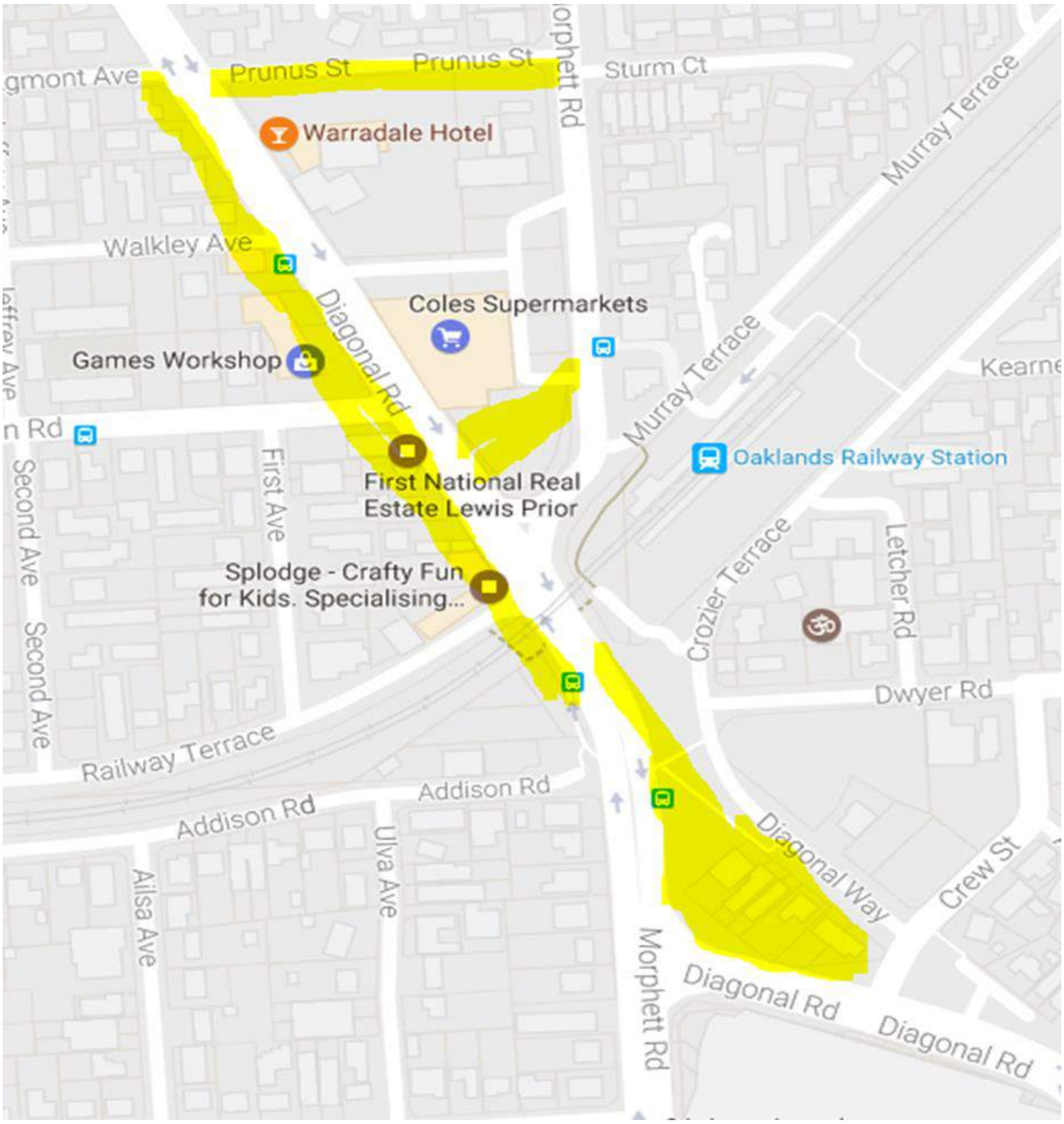


Figure 92: Land Acquisition (Google Maps)

In the above figure, (Figure 92) the areas shaded in yellow are the areas that must be acquired for the project to have enough space. Several investigations and surveys were done to identify the areas that will be affected by this project, and they are listed in the tables below.

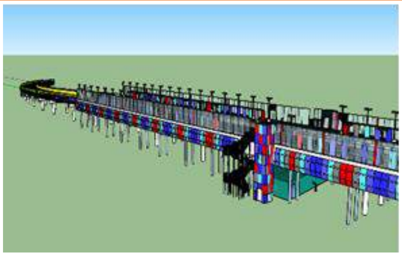
Table 58: Business and residential properties that need to be acquired:

No	Address	Purpose
1	60 Railway Terrace Warradale SA 5046	Business
2	225, 227, 229 diagonal road Warradale SA 5046	Residential
3	231, 233, 235, 237 diagonal road Warradale SA 5046	Residential
4	1 Walkley Avenue Warradale SA 5046	Residential

5	239 diagonal road Warradale SA 5046	Business
6	241, 243 diagonal road Warradale SA 5046	Business
7	245, 247 diagonal road Warradale SA 5046	Business
8	249 – 253 diagonal road Warradale SA 5046	Business
9	2 diagonal way Oaklands park SA 5046	Residential
10	4 diagonal way Oaklands park SA 5046	Residential
11	6 diagonal way Oaklands park SA 5046	Residential
12	8, 8A diagonal way Oaklands park SA 5046	Residential
13	10 diagonal way Oaklands park SA 5046	Residential

There are several business and residential areas that will be affected by this project. According to South Australia land acquisition Act 196 our company will purchase these effected areas. The costing, of the land acquired can be seen in the costing sections of this report, near the end.

6.8 Conceptual Design – Key Structural Focuses



6.8.1 Facade

6.8.1.1 Background

The railway overpass facade design was inspired by the South Australian, Aquatic and Leisure Centre (Figure 93). DPC Urban, planned to ensure that there is synergy with the existing area. This synergy can be seen in the colour pallet, and overall design in the conceptual drawings, the façade in particular, which can be seen in Figure 94. Ultimately, this design reflects Marion's characteristics, its community culture, and community style, but also show harmony with the existing community and pushes a concept of happiness and health. The facade is very important from the design and construction point of view as well, as it can quarantine noise, and define the overall landscape.

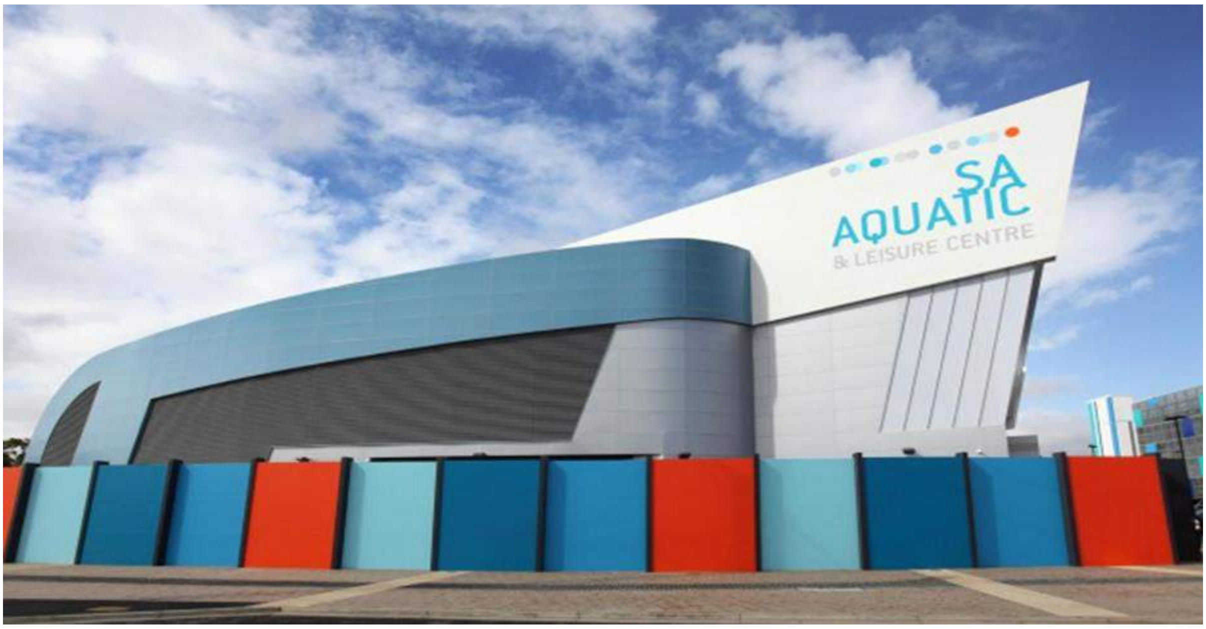


Figure 93: Aquatic centre design (SA Aquatic 2017)

6.8.1.2 Conceptual image Modelled by DPC Urban Planning

Below are the key conceptual draws and inputs for the façade, from the urban planning department. It is our aim to influence the structural team to design these components as envisioned by the community.

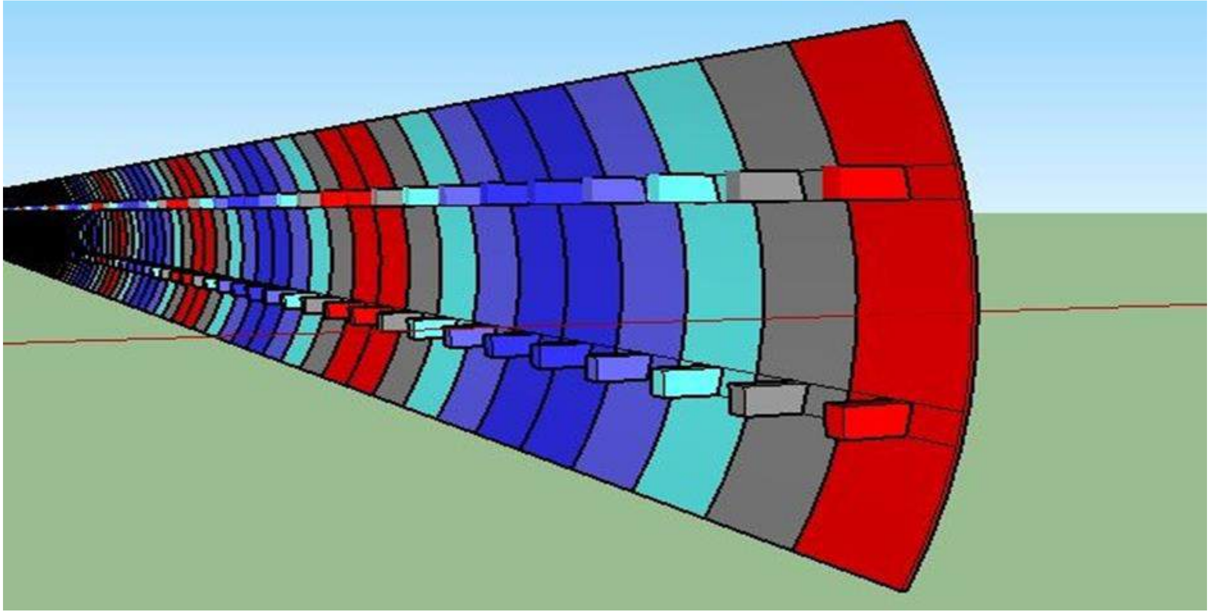


Figure 94: Facade Concept drawing #1 (DPC URBAN PLANNING 2017)

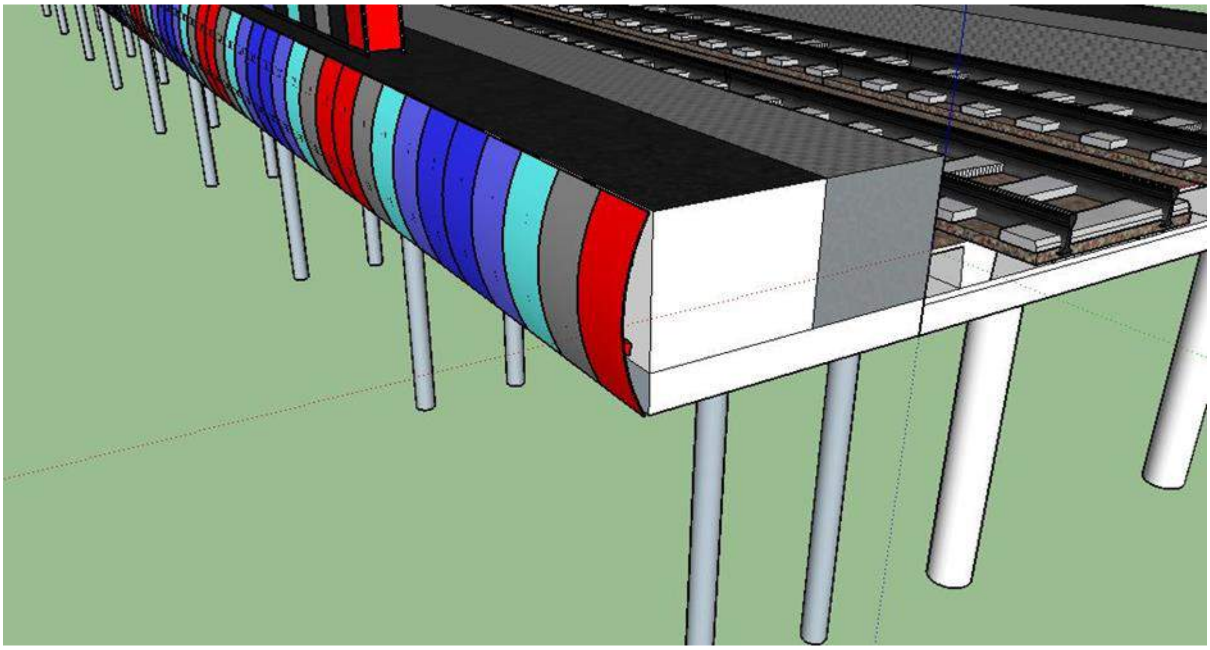


Figure 95: Facade Concept drawing #2 (DPC URBAN PLANNING 2017)

6.8.1.3 Key features & Assumptions

The key features for the rail overpass facades include;

- Spans the whole length of the rail overpass, tying in the greenway and the platform in a harmonious manner.
- Acts as a Sound barrier, that will help minimize the trains noise and vibration output.
- Superior curved design concept over a more traditional "squarer" look in older overpasses.

- Following this, the management and maintenance will also be considered as an important part of the project. There main issues addressed below include;
- Access management (for cleaning)
- Security measures (make sure people can't hang off them, and insure that the public doesn't try to put posters and other items on the façade.
- Cleaning and building maintenance

6.8.1.4 Analysis of synergy with existing project area

Given the large impact the façade will have on the structures design in terms of; aesthetics, structural integrity, and in its ability to reduce sound and vibrations from the train, an analysis into the how this key element acts within the whole structure is vital. From the outset, the façade ties the surrounding area, in particular, the aquatic centres themes into our project by utilizing the red, blue and grey colour schemes.

Furthermore, it's the first key feature that urban has modelled in its entirety, thus, it has paved the way for the rest of the conceptual design in terms of colour themes and aesthetic choices. To ensure our design best represents the community DPC Urban Planning will consult this design, in the early stages of the project, with the key stakeholder and community.

6.8.2 Staircase & Elevator

6.8.2.1 Background

The stairwell and elevators are an important element for the rail over pass, as they provide access to passengers catching the train from the car park below. DPC Engineering use has chosen this particular staircase and elevator, (Figure 96), because it fits very well with the projects colour scheme. Our staircase is visually interesting, as it has incorporated a contrasting colour to the handrail on each side that will protect people from falling down. It is safer than straight staircase because it provides space to stop and rest while walking up or down, so the community will defiantly like the conceptual design of staircase and elevator.

6.8.2.2 Conceptual image Modelled by DPC Urban Planning

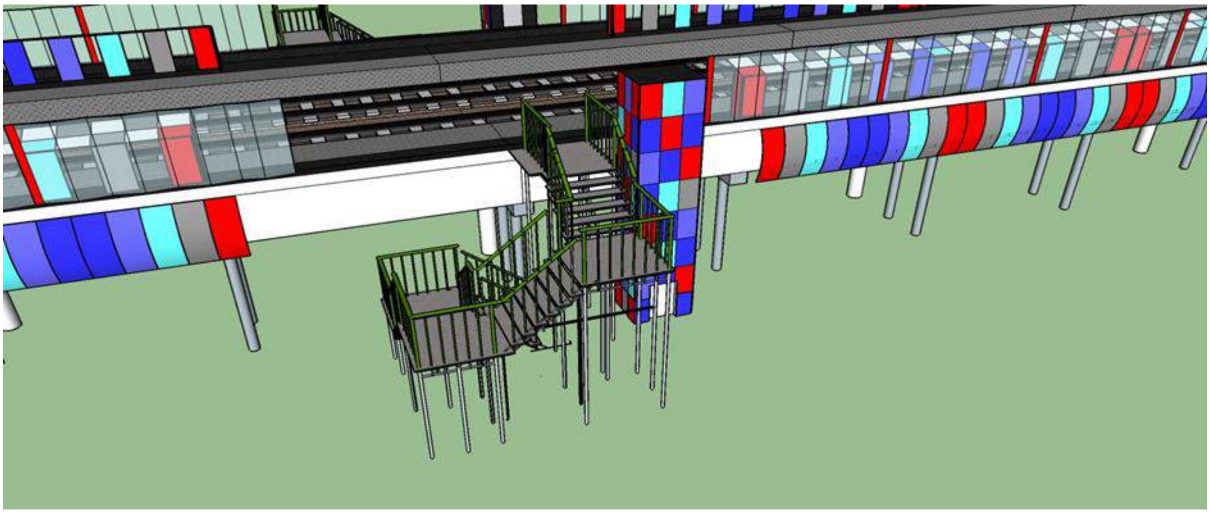


Figure 96: Elevator concept design #1 (DPC Urban Planning 2017)

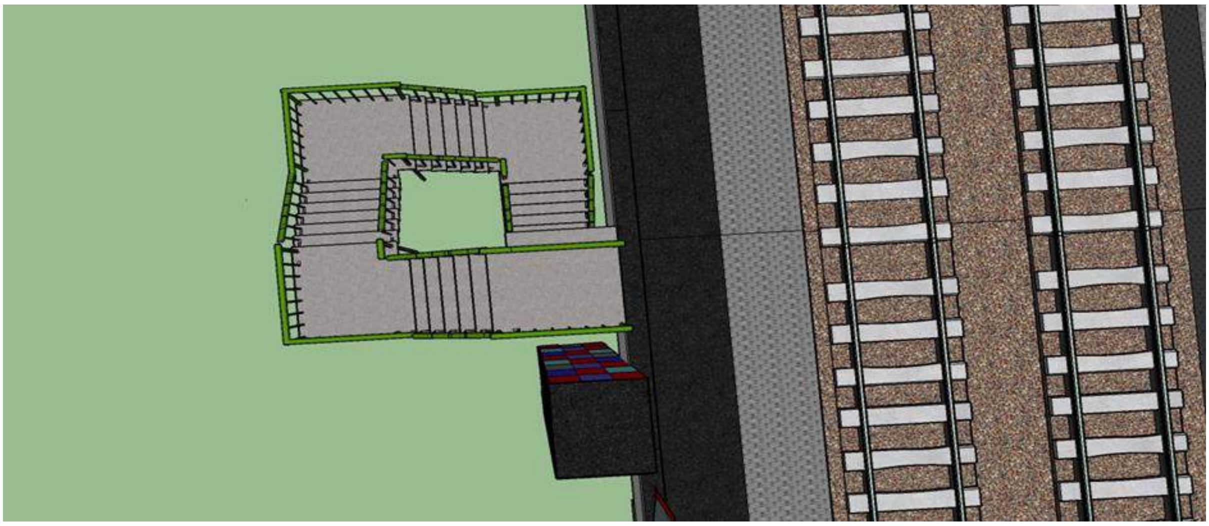


Figure 97: Elevator concept design #2 (DPC Urban Planning 2017)

6.8.2.3 Key features

The staircase and elevator will build, as per the Australian standard guidelines. The design standard that will be using for this structure are AS 1170.1, AS 1657 and AS 1735. Some key features the staircase and elevator Include;

- Elevator will allow differentiable people to use their wheelchair
- These structures are at the midpoint of platform and this will provide easy and quick access to any side of car park.
- Staircase look very interesting and square from top, it occupies less area then some other types of staircase.
- Staircase has stopped and rest space while going up or down.

- Both services are close so if one is busy people can use another quickly and that save time.
- Colour scheme is in harmony with the rest of the project.

6.8.2.4 Analysis of synergy with existing project area

The conceptual design was done to fit in the existing surroundings. The colours utilized in the designs are similar to that of the aquatic centre. Since the colours matches the surrounding structures it will not have alien look. The unique look of structure will attract surrounding suburbs and help to improve the economy by bring a more attractive and vibrant look to the suburb.

6.8.2.5 Final Assumptions and recommendations on design

The Key assumptions for these structures are;

- Both structures will be built close-by
- The colours will match nearby aquatic centre
- The Stairwell and elevator act to brace the structure
- Structure satisfies all safety aspects required

6.8.3 Barriers/Safety screens

6.8.3.1 Background

DPC Engineering, has recognised the functional importance of the safety screens, however, we also recognise that this is a unique opportunity to provide a contrasting visual to our project. By utilizing toughened glass, and coloured columns the Urban Planning department believes that a vibrant and fresh vibe is given to the project. Furthermore, a strong natural look that blends into the environment can be achieved with the glass if implemented successfully.

6.8.3.2 Conceptual image Modelled by DPC Urban Planning

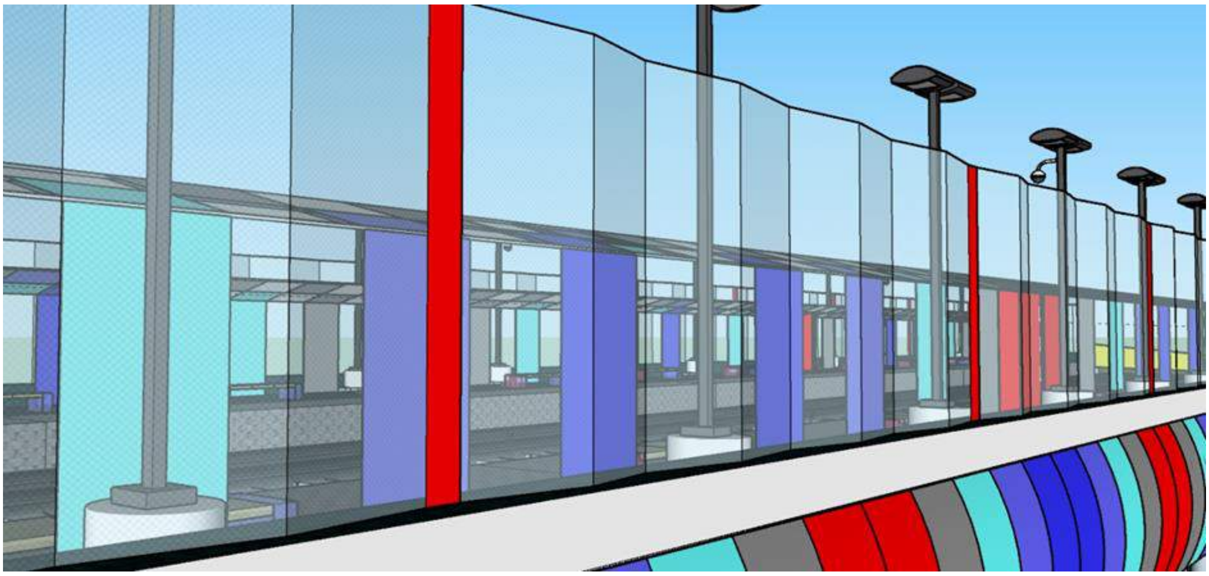


Figure 98 :Barrier concept design #1 (DPC Urban Planning 2017)

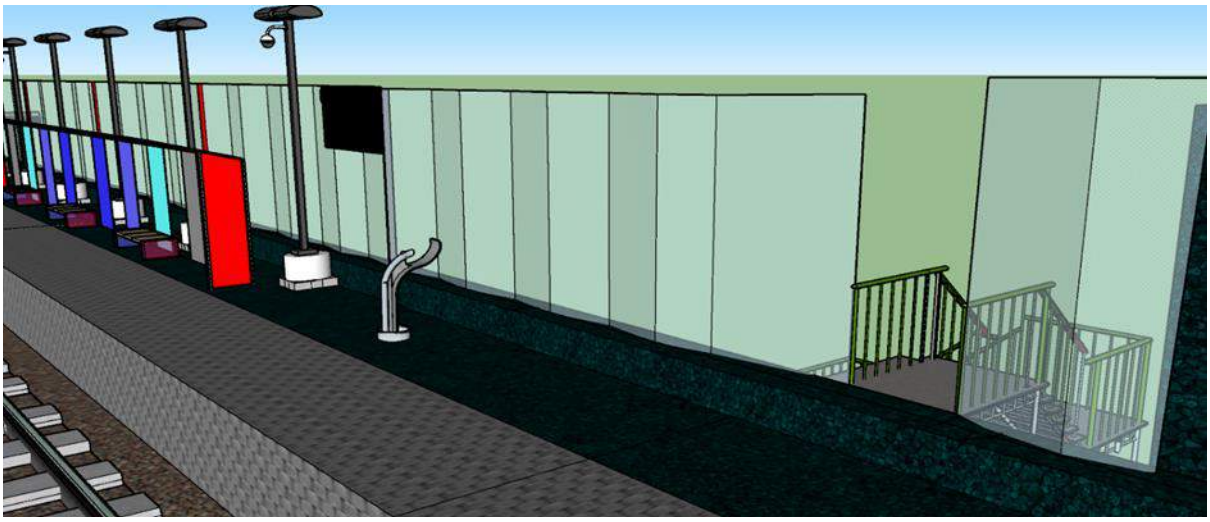


Figure 99: Barrier concept design #2 (DPC Urban Planning 2017)

6.8.3.3 Key features

The safety screens key features include;

- Environmentally sustainable
- Crystal clear display of the surrounding area (no tint), able to see through glass to aquatic centre
- Strong, reliable and able to provide the necessary safety to the public.
- Custom ordered to provide the aesthetic appeasing look required by this project.
- Planes are not straight but on an angle(zig-Zag Patters) as seen in figures above.

6.8.3.4 Analysis of synergy with existing project area

The Urban Planning department has made a conscious choice to match the barriers zig-zag pattern, to refract light in a more natural way, without annoying the general public. The clean look works well with the existing site conditions and synergises well with the rest of the project.

6.8.3.5 Final Assumptions and recommendations on design

The Key assumptions for this structure includes;

- That the angle, size and geometry of the glass can be practically installed.
- The glass is strong enough to be supported by column and joints (nothing supporting it in-between)
- Structure satisfies all safety aspects required

6.8.4 Retaining wall

6.8.4.1 Background

The retaining wall is very significant structure, as it spans over 100 meters and can be visible to everyone in the surrounding area. There are different types of retaining walls, but on this project a cantilever retaining wall will be used. The retaining wall will resist the lateral pressure of running train. To help the environment different species of plants will be planted on both side of retaining wall.

6.8.4.2 Conceptual image Modelled by DPC Urban Planning

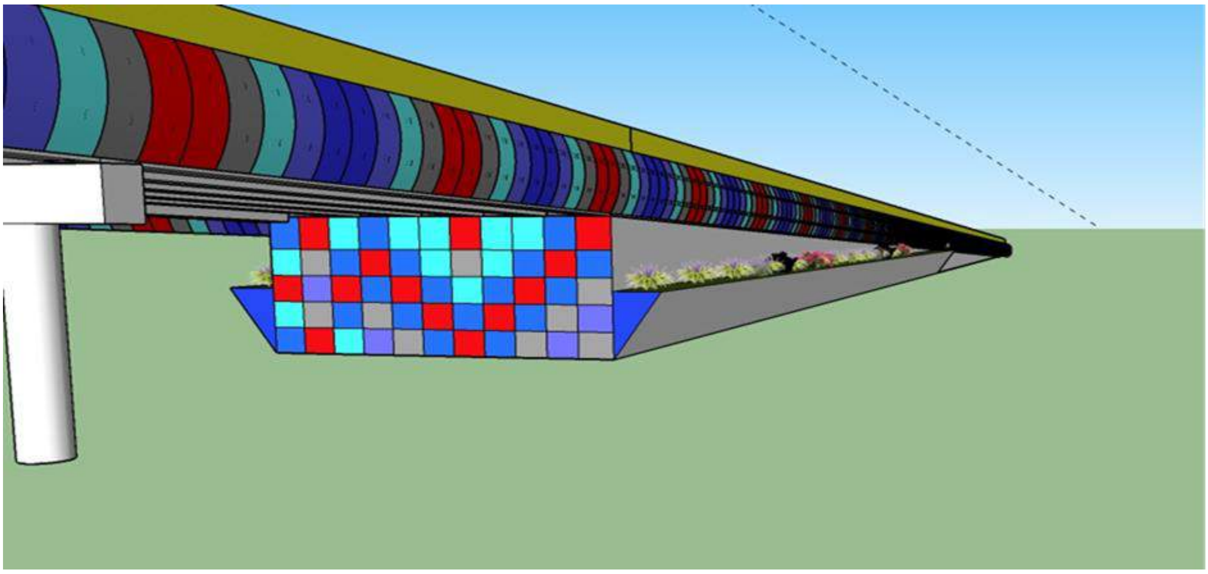


Figure 100: Retaining wall concept design #1 (DPC Urban Planning 2017)

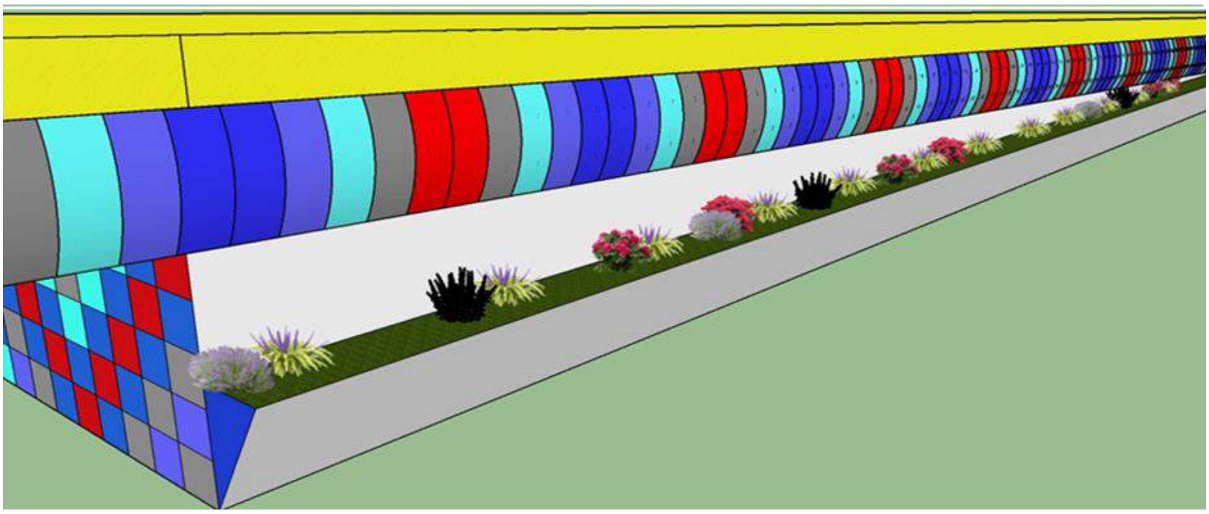


Figure 101: Retaining wall concept design #2 (DPC Urban Planning 2017)

6.8.4.3 Key features

Some key features of retaining wall include;

- It looks colourful and greenery
- At both side, the top part will cover with façade
- On bottom, different species of plants and flowers will be planted

To construct the retaining wall the proper guidelines need to be followed, this project will be designed in accordance with the Australian standard AS 4678, which is standard for earth-retaining structures will be used.

6.8.4.4 Analysis of synergy with existing project area

To match the projects surroundings, the same colours as the façade will be used. Our company aims is to make sustainable and environmental friendly choices, thus, plantation will be done on both sides of the retaining wall.

6.8.4.5 Final Assumptions and recommendations on design

Assumptions made for retaining wall include;

- Plantation will be cared for, after construction (during operation)
- Colours will be similar to the aquatic centre
- The key feature, the garden bed, in the retaining wall is assumed to be designed part way into the wall to prevent it sticking out

6.8.5 Shading Structures

6.8.5.1 Background

The shading structure, (Figure 102), provides the necessary shade for the general public as they wait to take the train. Its design is unique in that it is open enough to ensure that the CCTV cameras can see under and around the structure, but closed enough to provide cover for the elements. The open design was chosen, as the barriers and safety screens provide enough wind resistance that only sun and rain protection is needed. The following subsections will discuss its key features and show our concept design that was modelled by DPC Urban Planning.

6.8.5.2 Conceptual image Modelled by DPC Urban Planning

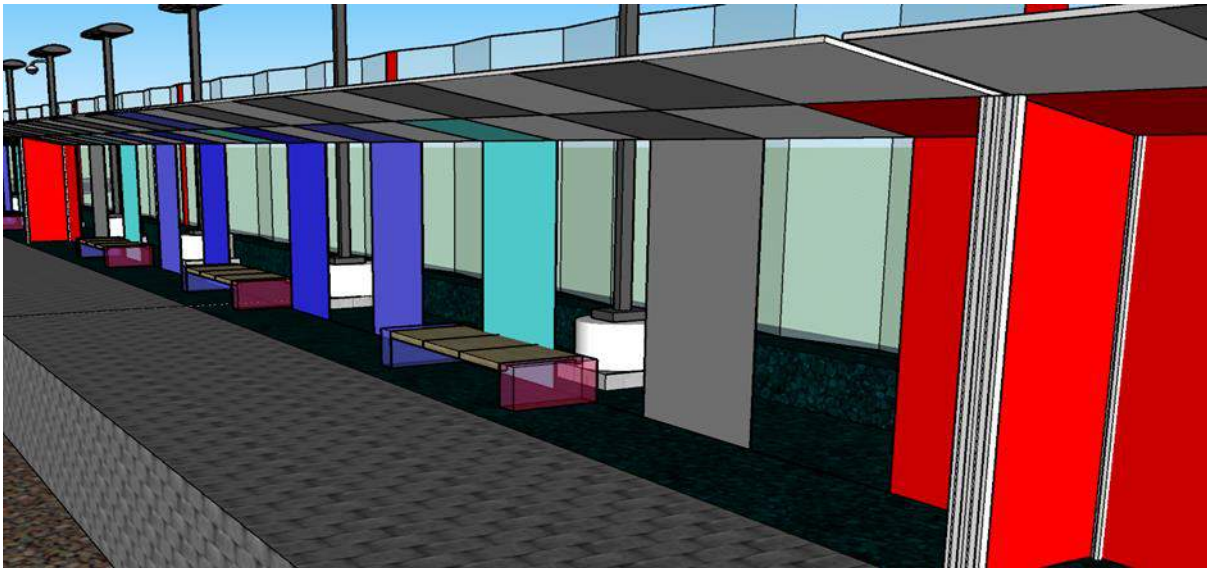


Figure 102: Shelter concept design #1 (DPC Urban Planning 2017)

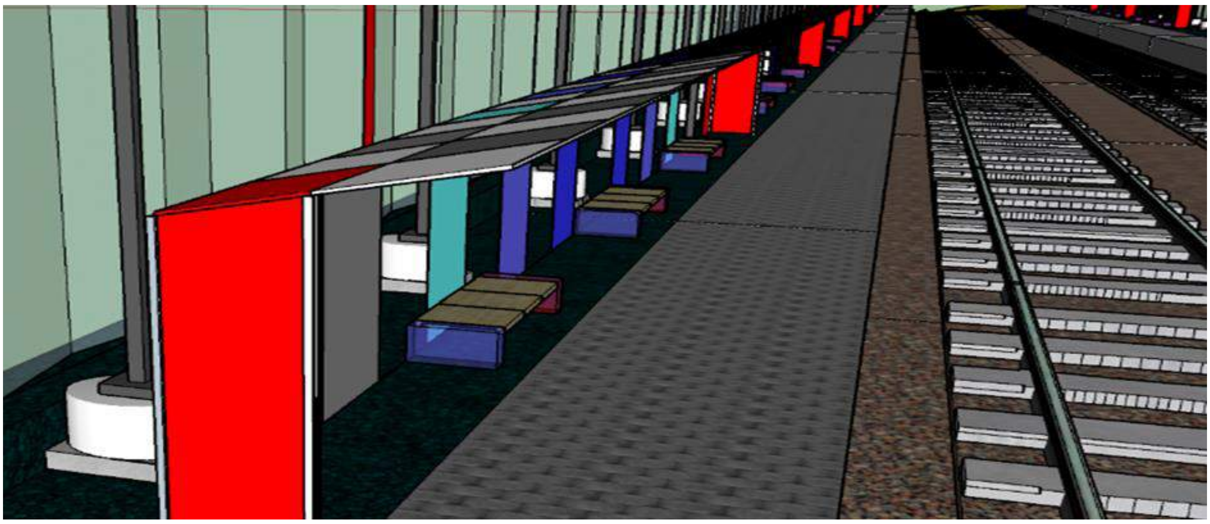


Figure 103: Shelter concept design #2 (DPC Urban Planning 2017)

6.8.5.3 Key features

The key features for this shelter includes;

- Open design to create a vibrant hub for the general public.
- Use of Project colour scheme
- Able to put CCTV on shelter
- Spans the length of the platform
- Future proof

6.8.5.4 Analysis of synergy with existing project area

The shelters design fits within the overall project, however, the span and width is bigger than intended so that it can handle future human traffic capacities. The issue of length can be overcome by implementing a smart use of art work to break up the structure, which has been done and will be discussed in the relevant section below.

6.8.5.5 Final Assumptions and recommendations on design

Assumptions made for retaining wall include;

- Barriers provide shielding from wind.
- Length of structure can be "hidden" by art work to create the illusion of more open space.
- The panels are of sufficient strength, when people lean on them they won't break (panels are polycarbonate, for aesthetic reasons)

6.8.6 Toilets

6.8.6.1 Background

A proper sanitation is important for the community which means the access to toilets, (Figure 104), and established sanitation standards must be achieved. DPC Engineering has designed a parallelogram shaped bathroom, which contains two men's restrooms, two women's restrooms and two disabled restrooms. Different colour of doors was designed to help people distinguish the male and female toilets, the blue colour for men's toilets and purple colour for women' toilets are used in this conceptual design. The toilets will provide convenience for the passengers and surrounding community. Moreover, the toilets are located under the platform and between the elevators, the community will like it because they do not occupy additional space and the toilets will not cause negative influence to surrounding environment.

6.8.6.2 Conceptual image Modelled by DPC Urban Planning

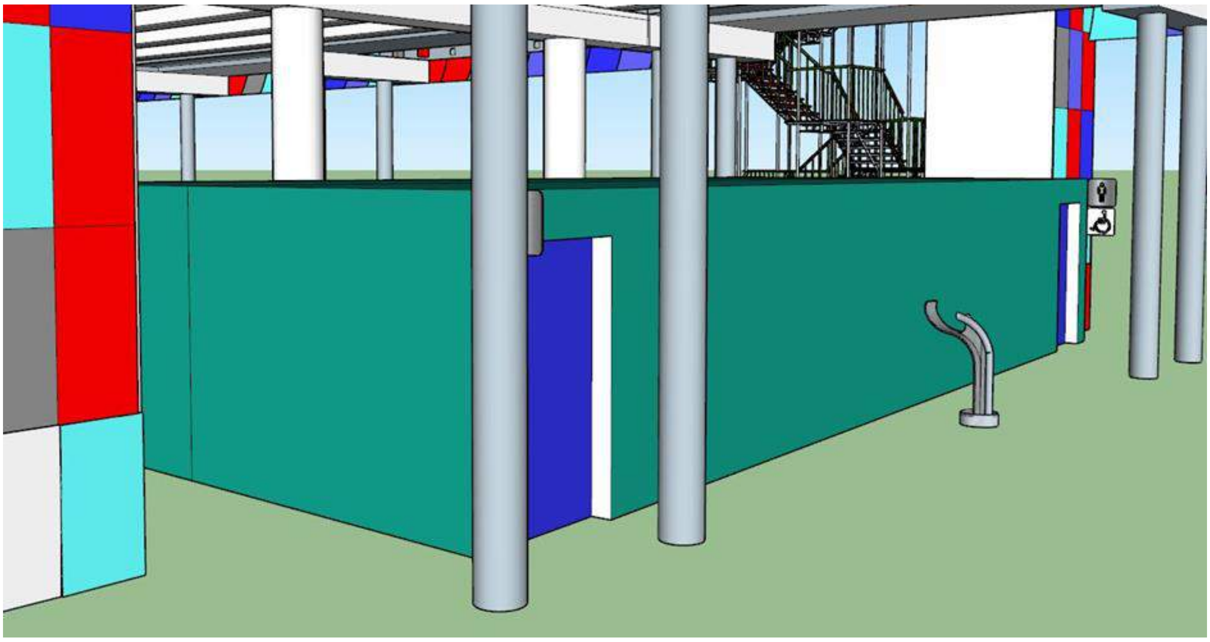


Figure 104: Toilet concept design #1 (DPC Urban Planning 2017)

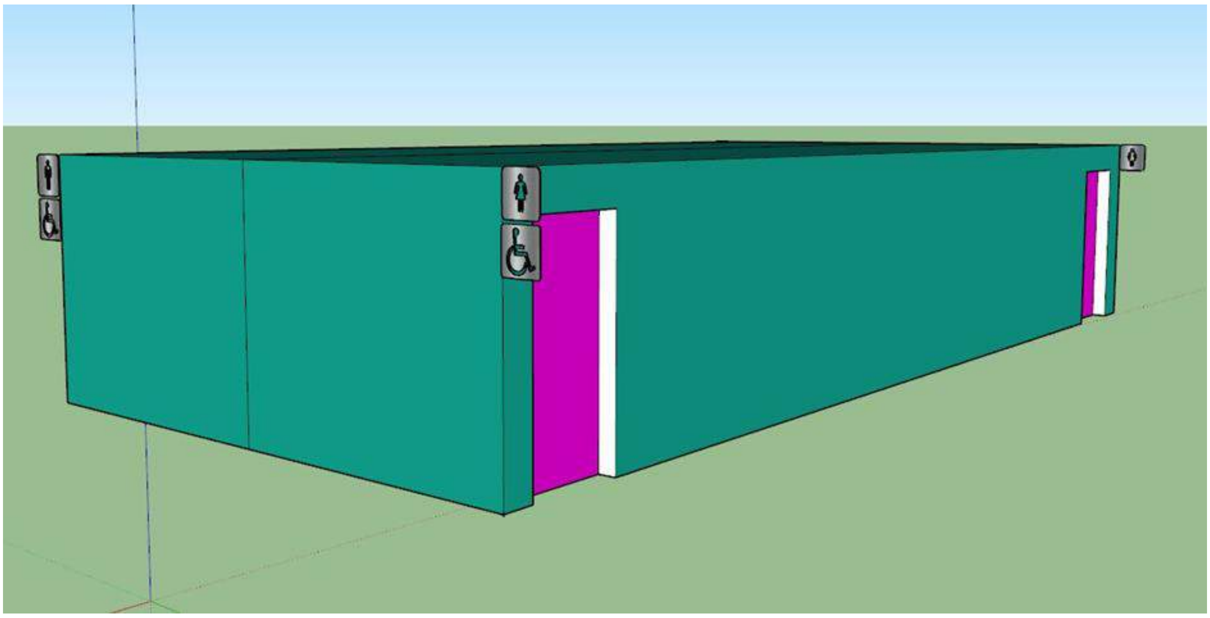


Figure 105: Toilet concept design #2 (DPC Urban Planning 2017)

6.8.6.3 Key features

The standards of toilet design were based on the Public Toilet Design Guidelines from Brisbane City Council. The Size and configuration of toilets were designed in accordance with the guidelines, and the total designed room size is 7000 x 16000mm and 2800mm high with 8 cubicles per restroom. The mean equipment including paper towel dispenser, full-length mirror, sanitary disposal bin, waste disposal bin, washbasin, hand dryer, floor drain, shower unit and alarm pull cord will be provided in the toilets, and the other facilities such as sensor lights, circulating fans and automatic flush system will be installed as well. The lighting includes exterior lighting, interior lighting and signage will meet the requirements of current Australian standard AS.NZS 1158.3.1 and AS1680.

- Energy efficient and vandal-resistant light fittings will be installed.
- LED lamps and compact fluorescent will be used.
- All lamps are designed as easily sourced and replaced.
- Toilets will open 24/7.

Following this, the management, maintenance and security issues will also be considered as an important part of the project. There are some main issues addressed below:

- Access management
- Security measures
- Cleaning and building maintenance
- Risk management

The conceptual design of toilets was originally innovated by DPC engineering. The shape of the building is designed as parallelogram to give users and passengers a strong visual impact. The colour we used are turquois, blue and purple which makes it easy to identify the toilets with gender, and the signage was designed by using LED.

The unique point of this restroom is using touch-free technologies to achieve a new level of sanitary. Touch-free bathroom equipment will be installed such as automatically-opened toilet lids, touch-free hand dryers and sensor-based faucets, which allow people to avoid contact with skin to a minimum level.

6.8.6.4 Analysis of synergy with existing project area

The overall project design utilized five main colours which is dark blue, blue, light blue, grey and red. For the restroom, it used three main colours which is dark green, blue and purple to achieve the synergy without losing the integrity. The colour combination of this project is similar as nearby SA Aquatic & Leisure Centre, therefore the overall visual effect will be harmonious after the completion of this project, and the overall image of Marion city could be taken to a higher level.

6.8.6.5 Final Assumptions and recommendations on design

There are some key assumptions for this design such as transportation of materials, installation of equipment, resource and waste managements.

Furthermore important information that other teams also need to assume in their design. For example, the environmental team needs to consider waste management; the services team needs to consider lighting system and the structural team needs to consider the structural performance of the restroom.

The recommended material for the exposed wall could be rubberized concrete because this material not only has same high strength like conventional concrete but also has more environmental friendly characteristic. Following this, terracotta could be used for the tiles, PVC ceiling panels could be used for the ceiling and the toilets will be made of porcelain.

6.8.7 Lanes & Greenway

6.8.7.1 Background

The greenway is one of the facilities that will be built from the start to end of the rail overpass. It will provide pedestrians an alternate way to get from the ground left to the elevated platform in a quick and efficient manner. It provides Cyclist access for those who will be riding on the greenway. Barriers will be built at side of the greenway to keep cyclist and pedestrian safe.

6.8.7.2 Conceptual image Modelled by DPC Urban Planning

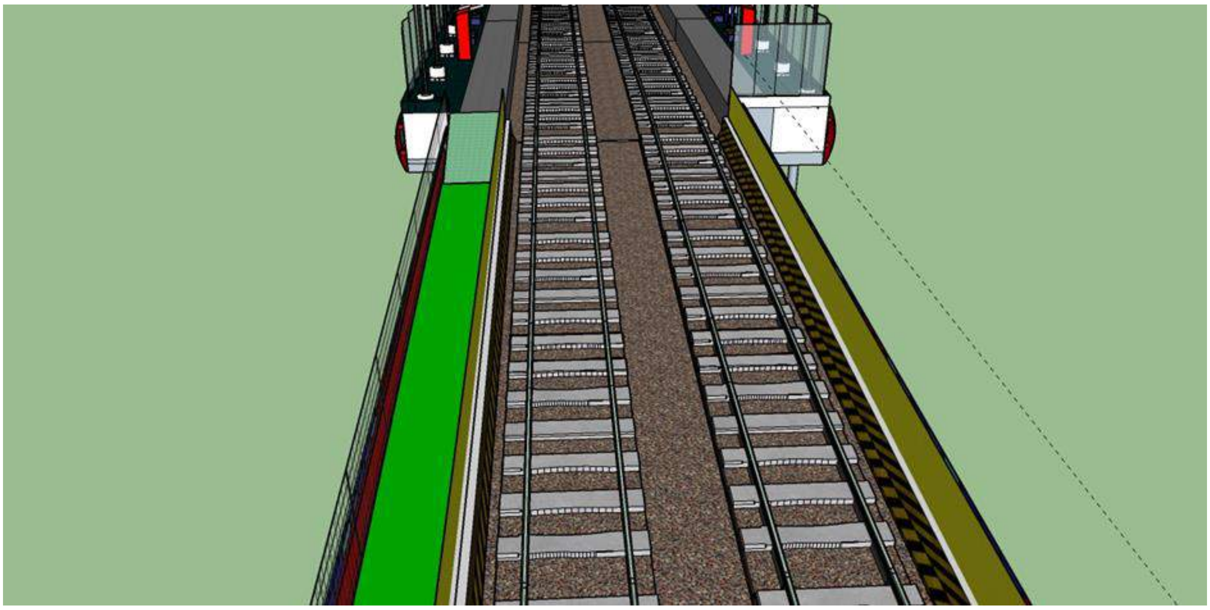


Figure 106: Greenway concept design #1 (DPC Urban Planning 2017)

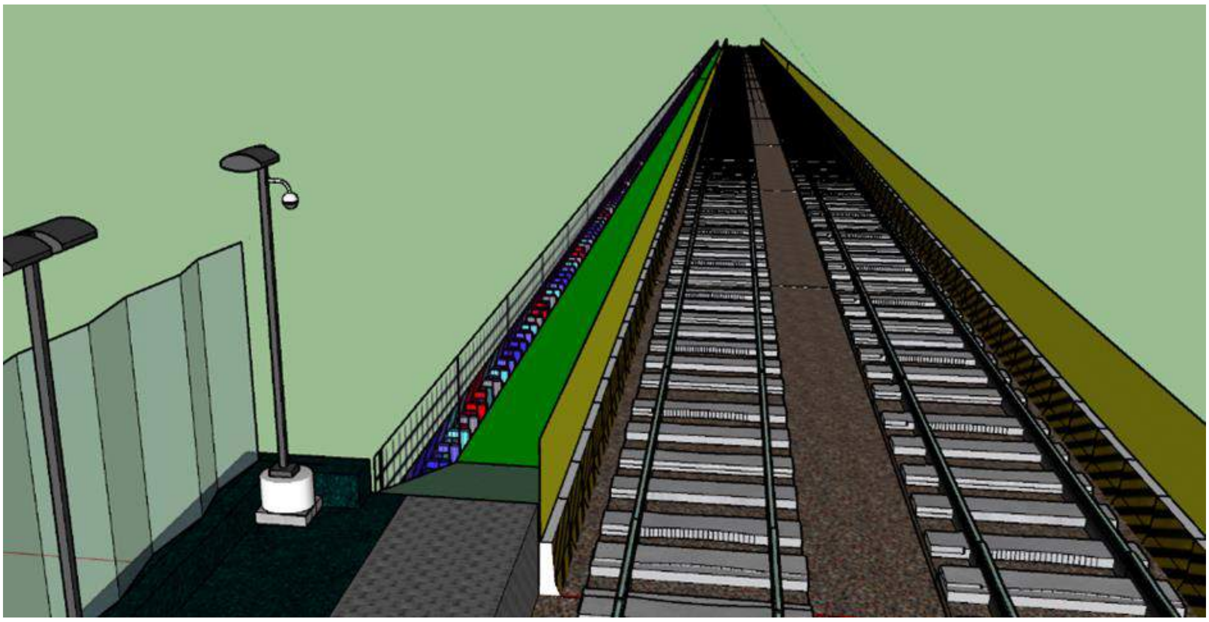


Figure 107: Greenway concept design #2 (DPC Urban Planning 2017)

6.8.7.3 Key features

Key features Include;

- Greenway connects station from both directions
- Designed for cyclists and pedestrians
- To create safe environment barriers are built at both side of greenway
- Built to Australian standards

6.9 Conceptual Design – Key Facility services

6.9.1 Lighting

6.9.1.1 Background

Lighting is an important part of traffic engineering practices. Lighting can prevent issues from occurring and provide a safe environment. Elements such as reducing crime rates, reducing pedestrian risk and improving traffic are all possible if effective lighting is implemented. According to Australia's public space lighting standards, the newly established lights need to focus on sustainability and the environmentally friendly designs. Thus, DPC Engineering has chosen LED lights, (Figure 108), as the design for the light, in order to provide users with a safe and visible environment.

6.9.1.2 Conceptual image Modelled by DPC Urban Planning

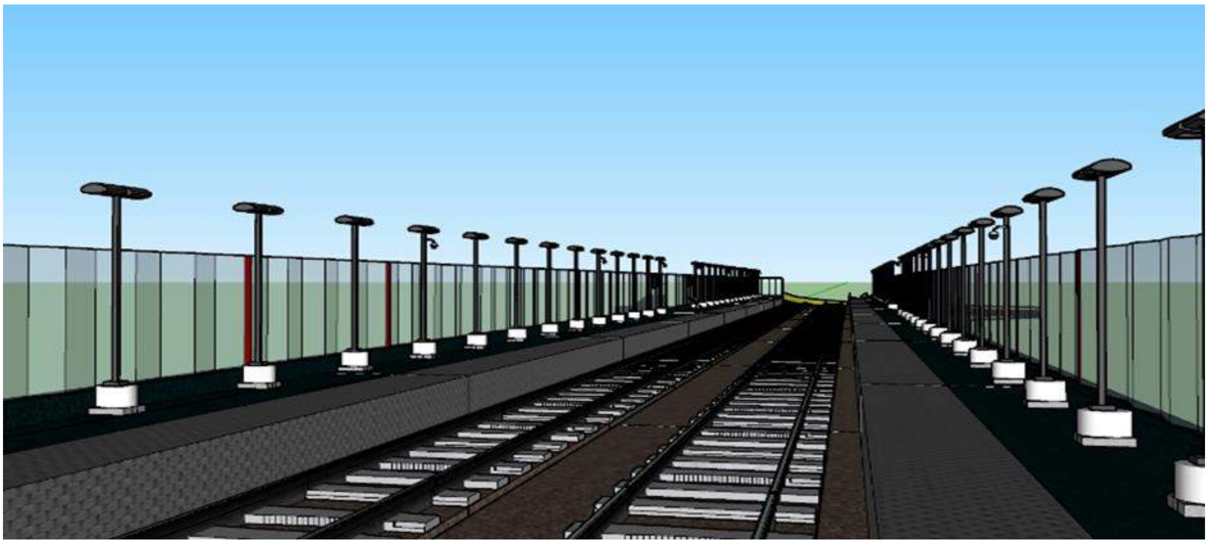


Figure 108: Lighting concept design #1 (DPC Urban Planning 2017)

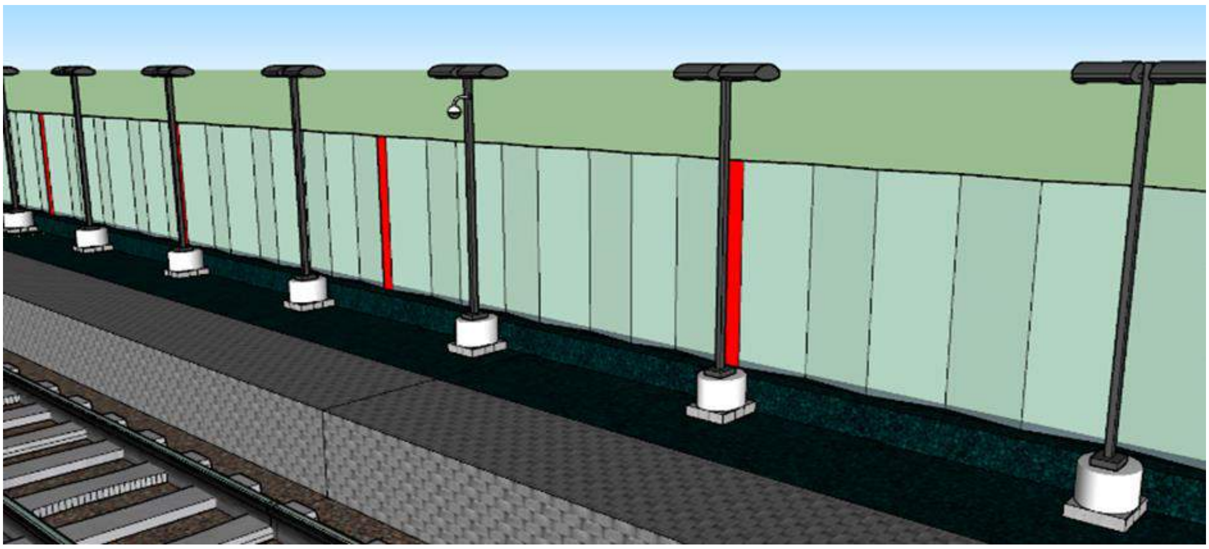


Figure 109: Lighting concept design #2 (DPC Urban Planning 2017)

6.9.1.3 Key features

Upon diligent research, it was commonly found that the most efficient type of light to install, is a solar LED. This LED light has integrated a thermal management system that optimizes the use of LEDs making it power efficient and environmentally friendly. Other features for this light include;

- Adjustable Hight
- Day and night sensor
- Time and brightness is adjustable
- PV street lamps in compliance with UNI11248 and UNI 13201-2
- Stainless steel outside

6.9.1.4 Analysis of synergy with existing project area

It has been asses by DPC Urban Planning that the lighting solution implemented will improve the existing site conditions, by providing an elegant, safe and vibrant community space within the project. Although the lights do not have a matching colour scheme, the black colour was chosen intentionally to help differentiate between the barriers and shelters, as the light are located between them.

6.9.1.5 Final Assumptions and recommendations on design

The following assumptions were made for the lighting;

- Although solar panelled, they still require access to the main power grid.
- Cleaning and maintenance intervals of light are not included in cost estimates.
- It should be noted that the lighting equipment should be inconsistent with the train driver's line of sight.
- That the non-standard 10m spacing of lights is adequate based on the LED light choice.

6.9.2 Benches

6.9.2.1 Background

The bench design aims to provide the necessary convenience and comfort expected by the general public, as they wait for the train. An effort to ensure the right quantity of seating, with consistent design was made to help with the aesthetic appeal of the project. DPC Urban, has completed the conceptual images in, Figure 110, to provide a natural look from the wood top and a more modern look from the transparent plastic sides.

6.9.2.2 Conceptual image Modelled by DPC Urban Planning

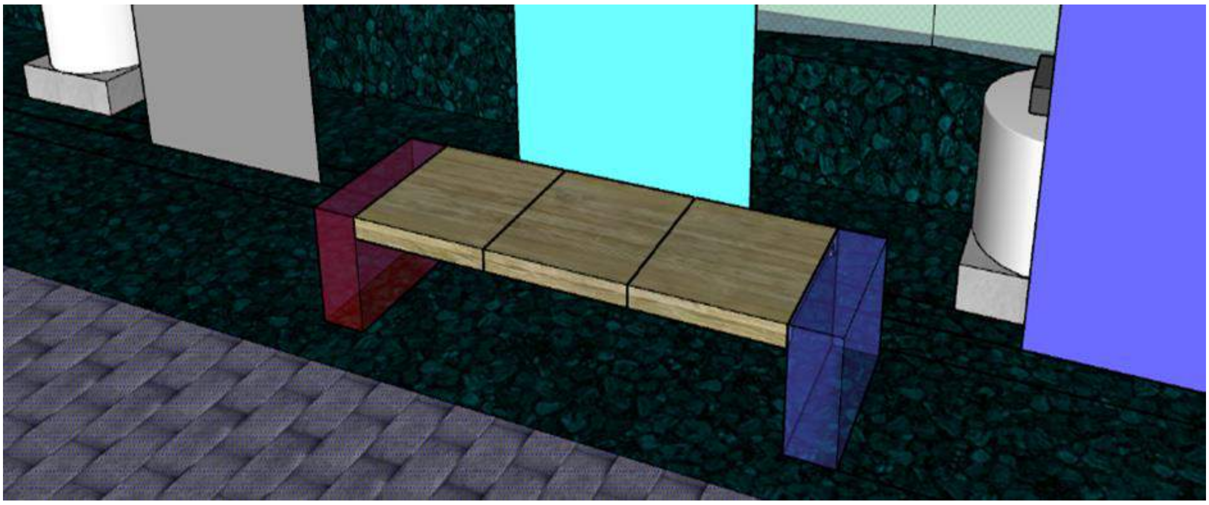


Figure 110: Bench concept design #1 (DPC Urban Planning 2017)

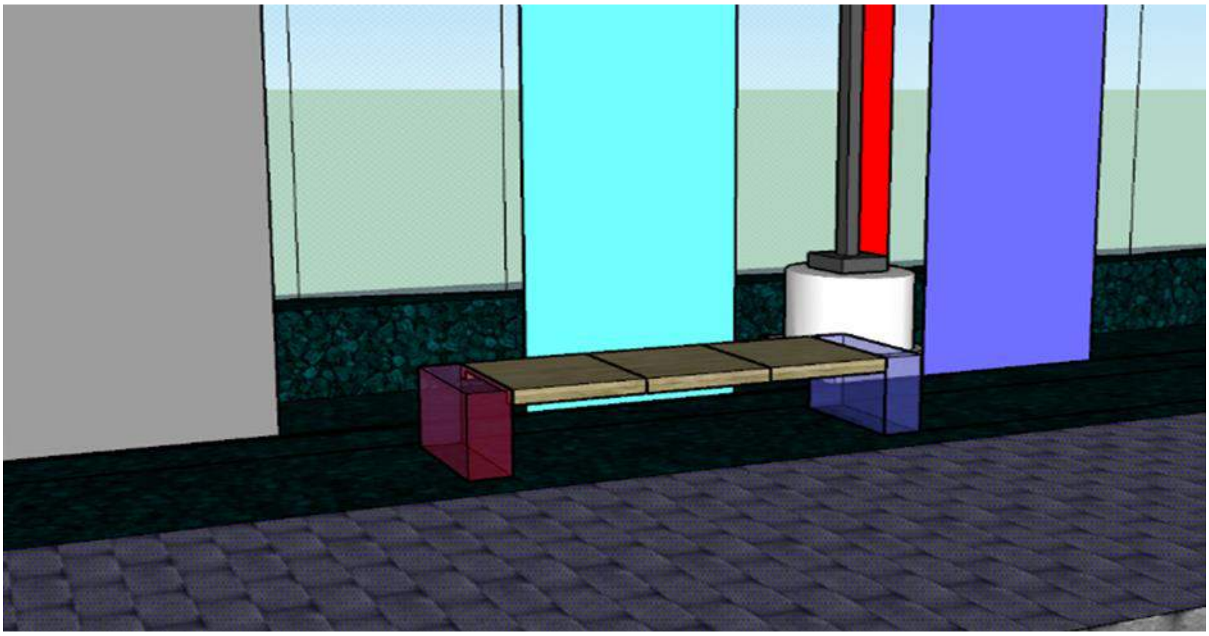


Figure 111: Bench concept design #2 (DPC Urban Planning 2017)

6.9.2.3 Key features

The key feature implemented in this design include;

- Wooden top for a natural look
- Transparent sides to help match colour scheme and keep the design modern
- Simple design to match the open space feel of the project.

6.9.3 TV Screens & Ticket Machines

6.9.3.1 Background

TV screens and ticket machines play an important role in the operation of a rail station. Especially for this project, as TV screens will be planted on the glass barriers for time forecast and the ticket machines will be placed at the centre of platform. The common benefit of these two facilities is convenience, this is because they can both provide an easy approach for the users who want to buy a ticket or check train arrival times. The community will embrace these key facility necessities as will not cause any negative impacts to the environment, and the only thing needed to run these facilities is electricity and technician. There will be four TV screens planted on the both side of platform, near the elevators and stairwells, and two ticket machines will be placed next to the elevators.

6.9.3.2 Conceptual image Modelled by DPC Urban Planning

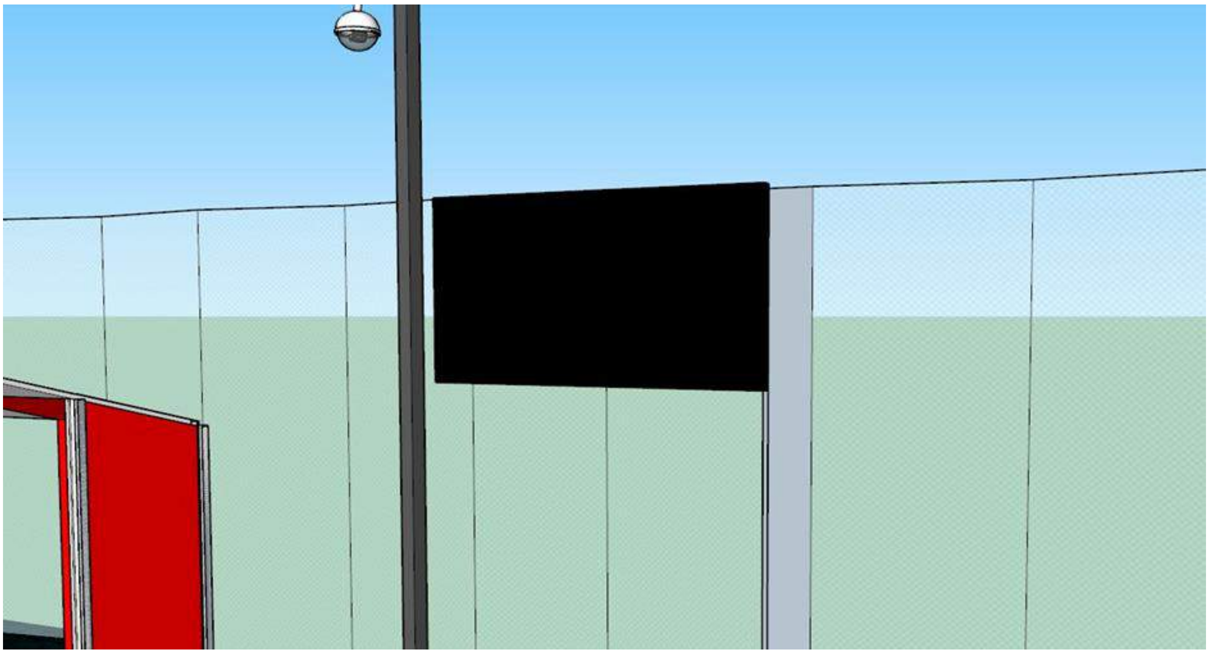


Figure 112: TV screen concept design #1 (DPC Urban Planning 2017)

6.9.3.3 Key features

There are no specific standards used for TV screen during this stage, but high definition television with 1080p FHD resolution will be used in order to broadcast train timetables. Four 85" HDTV will be chosen in this case for better viewing distance and range. Moreover, dynamic advertisements could be applied on the platform to create revenue should it be deemed ethically appropriate.

For the ticket machines, the rail authorities' standards will be consulted in this design stage. The figure showed above is just a conceptual drawing without any brand or model which means the figure is only for reference.

The installation of TV screens and ticket machines is compulsory for a train station. DCP engineering designed the height and location of the TV screens, the HDTV will be planted 2.5m above the platform floor to maximise coverage rate.

6.9.3.4 Analysis of synergy with existing project area

This is only a small part of overall project design, but they are essential for the train platform. These facilities will be installed so that the outward appearance of the whole project design will not be affected. Furthermore, the synergy with existing project area will not consider in this section.

6.9.4 Community Spaces

The project has acquired land, as shown in Figure 113, for community space. Thus, our company has ambitiously designed a park and tennis court. It is advised to have two tennis courts, given the space that is available. This is an opportunity to promote healthy activities within the community.

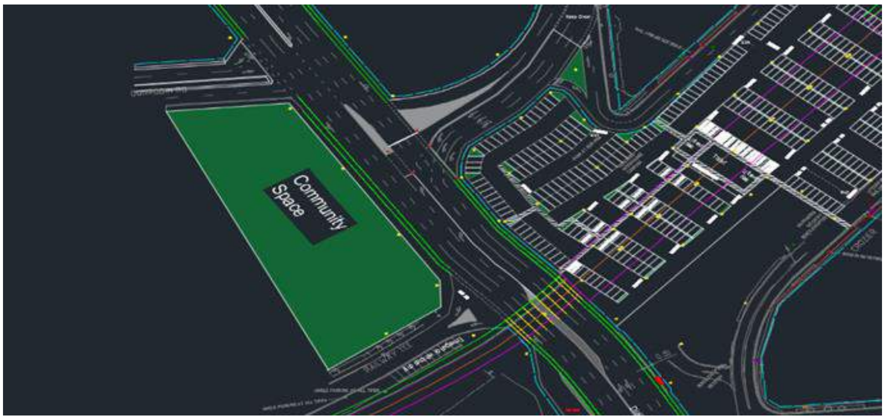


Figure 113: Community Space (DPC Transport Alignment 2017)

6.9.5 Drinking Fountains

6.9.5.1 Background

Although many train stations such as Mawson lakes don't have drinking fountains, DPC engineering has implemented this facility in the hopes that it can provide the public with a free water source. We aim to promote a healthy life style through this project and will include posters encouraging people to drink water over fizzy drinks. To prevent damage to these facilities they will be placed near CCTV cameras.

6.9.5.2 Conceptual image Modelled by DPC Urban Planning

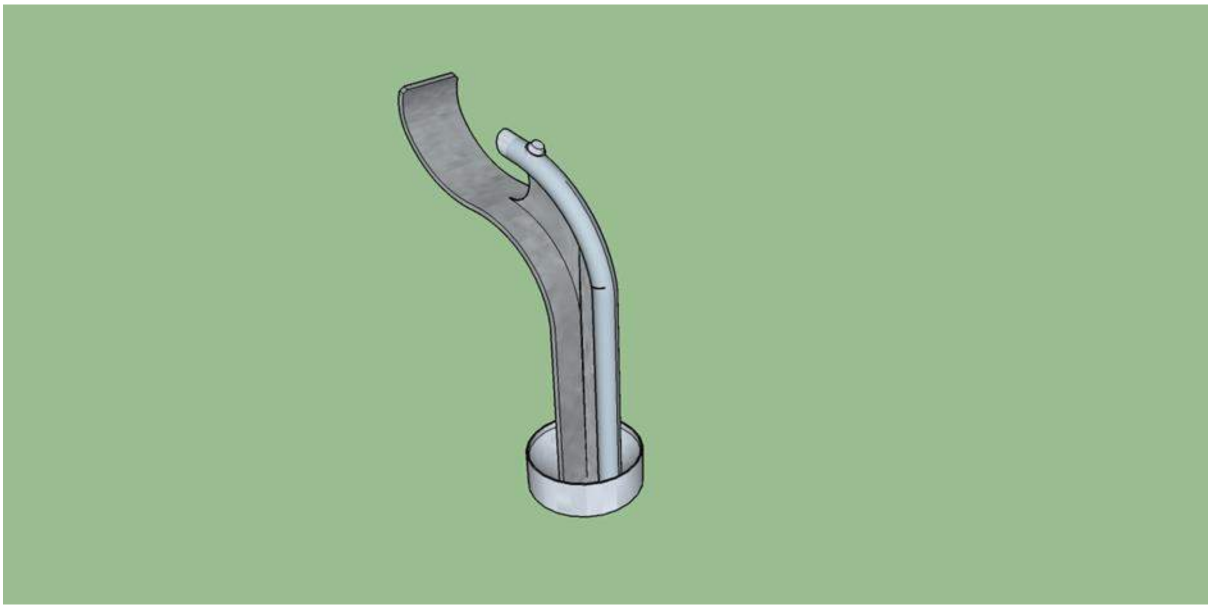


Figure 114: Drinking fountain concept design #1 (DPC Urban Planning 2017)

6.9.6 Art work

6.9.6.1 Background

Art work is a key facility feature that will help DPC Urban achieve the vibrant community hub that the project hopes to achieve, in accordance with the 30-year plan for greater Adelaide. The project has implemented a large range of art work, to help promote community involvement, such as the arrangement to build a community art wall, supplemented by a professional design that is themed across the entire project. The wall will be mounted on the barriers, for the length of the platform to target a larger viewing audience. Furthermore, the architectural firm HASSELL, responsible for key design choices on the Sydney convention centre will also be consulted throughout the project to implement a sound design.

6.9.6.2 Analysis of synergy with existing project area

The art work will both compliment and synergize well with the project, as intended by the design. Despite the different works produced by the community the way in which it is displayed, in particular the design of the wall will be paramount in ensuring that this synergy is successfully employed within the project.

6.10 General Safety

Safety is a vital aspect to all projects both from a legislative requirement and from an ethical viewpoint. Thus, DPC Engineering has ensured that training and inductions are a compulsory aspect given to all staff, furthermore, audits will be carried out to ensure contractors are working within standards. To ensure a safe construction site signage will be utilized with temporary construction barriers to mitigate the risks that the project places on the community during construction.

In terms of safety from a project design viewpoint DPC Engineering has ensured that fire hydrants, CCTV, and other essential safety requirements are incorporated within the design. The stairwell, elevator and green way entrances have also been optimised for efficiency in safe design, allowing people easy access to evacuate in case of an emergency. Additionally, CPTED (Crime prevention through environmental design), has been incorporated in each elements of the design from the openly deigned shelters and benches to the placement of CCTV cameras around the platform and overpass.

6.11 Incentives

DPC Engineering has provided the community, staff and stakeholders incentives to help progress the project. The following table lists the suggestions that DPC Engineering would like to implement should the budget allow.

Table 59: Incentives

Incentive	Target
Community prize draws for giving feedback	Aim increase the amount of feedback obtained, by allowing them a chance to win either a cash prize or site tour. Can set-up in local shopping centre, etc.
Bonus for contractors	Aim to finish tasks quicker. Not uncommon for companies to try and improve the project timing and cost by offering incentives.
Environmental Incentives	Aims to provide encouragement for environmentally sustainable planning and design.

6.12 Costing

The following tables contain the total costing for the pre-mentioned conceptual design elements. The costing is subject to market fluctuations and further change, however, an estimate from the Australian Construction Handbook yields the following results;

Table 60: Costing estimation for land acquisition

No	Address	Purpose	Cost ($ AUD)
1	60 Railway Terrace Warradale SA 5046	Business	453k
2	225, 227, 229 diagonal road Warradale SA 5046	Residential	1179k
3	231, 233, 235, 237 diagonal road Warradale SA 5046	Residential	2985k
4	1 Walkley Avenue Warradale SA 5046	Residential	884k
5	239 diagonal road Warradale SA 5046	Business	588k
6	241, 243 diagonal road Warradale SA 5046	Business	3927k
7	245, 247 diagonal road Warradale SA 5046	Business	1092k
8	249 – 251 diagonal road Warradale SA 5046	Business	1785k
9	2 diagonal way Oaklands park SA 5046	Residential	348k
10	4 diagonal way Oaklands park SA 5046	Residential	394k
11	6 diagonal way Oaklands park SA 5046	Residential	655k
12	8, 8A diagonal way Oaklands park SA 5046	Residential	1177k
13	10 diagonal way Oaklands park SA 5046	Residential	599k
Total cost estimation		**$16,066,000**	

Table 61: Conceptual Design Elements Costing

Item	Source	Cost ($ AUD)
Façade for retaining wall		200,000
Art works	Australian construction hand book	3000
Drinking fountains		8000
Benches	Australian construction hand book	15000
Facade for platform		300,000
Cctv		2050
Lighting	Australian construction hand book	20,000

Tv screen for timetables		5000
Ticket machines	Adelaide metro	Adelaide metro will installed the machine
Shading/ shelters	Australian construction hand book	5000
Barriers	Australian construction hand book	120,000
Total		$678050

Table 62: Community Engagement Costing

Item	Cost ($ AUD)
Community information events	10,000
Stall cost	5000
Printing cost (brochures/posters)	2000
General community Engagement (surveys/feedback forumsn)	15000
Total	$ 32000

The total cost estimation is $16,776,050

6.13 Urban Planning– Structural Design of Barriers

6.13.1 Overview

The barriers as modelled in the concept design stage, require a transition from the concept design into an engineer design, which can be implemented into practice. The barriers must take into consideration the live loads such as people leaning on the barrier, and the dead load such as mounting equipment like CCTV, speakers and screens. The intended dimensions dictated by the architectural design and safety requirements are, a glass screen that is 2.4 metres high and 4 metres wide, supported by columns either side.

6.13.2 Loads

The following loads were determined, as shown in the hand calculations in appendix I, in accordance with AS 1170.0, AS 1170.1 and AS 1170.2.

- Wind – Refer to appendix I (hand calc. pg 3) – 1.085 KPa
- Live - Refer to appendix I (hand calc. pg 4) – 0.25 KPa
- Dead - Refer to appendix I (hand calc. pg 4) – .93 kpa KPa
- Earthquake – Assume non-critical (time constraint)
- Vibration - Assume non-critical (time constraint)

The critical load case for the bending moments and shear force diagrams was 1.2G + 1.5Q + Wu.

6.13.3 Design elements, Design method and summary of results

The following elements in, Table 63, will be considered for design. It will be necessary to assume that the glass is able to transfer all the load to the columns, thus, the columns will act as a cantilever, under wind load. It is assumed that the reinforcement is able to be practicably tied into the slab of the platform and that concrete columns are an acceptable design choice based on the aesthetical concept this project wishes to achieve (although in-efficient to use concrete columns in this case). Furthermore, as advised the joints will not be detailed nor, designed.

Table 63: Design elements for barrier (DPC Urban Planning 2017)

Design element	Material
Barrier Column	Concrete column
Glass Screen	Glass (defined by environmental team)

The Design was designed in accordance with AS 1170.0-2, and AS 3600, as shown in appendix I. Although SpaceGass is available to use, it was not necessary given the simplicity of the design requirements. All assumptions, design choices and references to the standards and design specification sheets are provided in an easy to read format, within the hand calculations (appendix I). A Summary along with the final design drawings are shown below.

Table 64: Design Summary for Barrier

Design element	Summary
Barrier Column	• Concrete • F'c = 40 mpa • 350 * 350 cross section • R6 ties at 350 centres. • N10 Bars The design is over 100 times greater than needed, however, there is an unlimited budget, thus, further iterations of the column isn't needed.
Glass Screen	Glass (defined by environmental team)

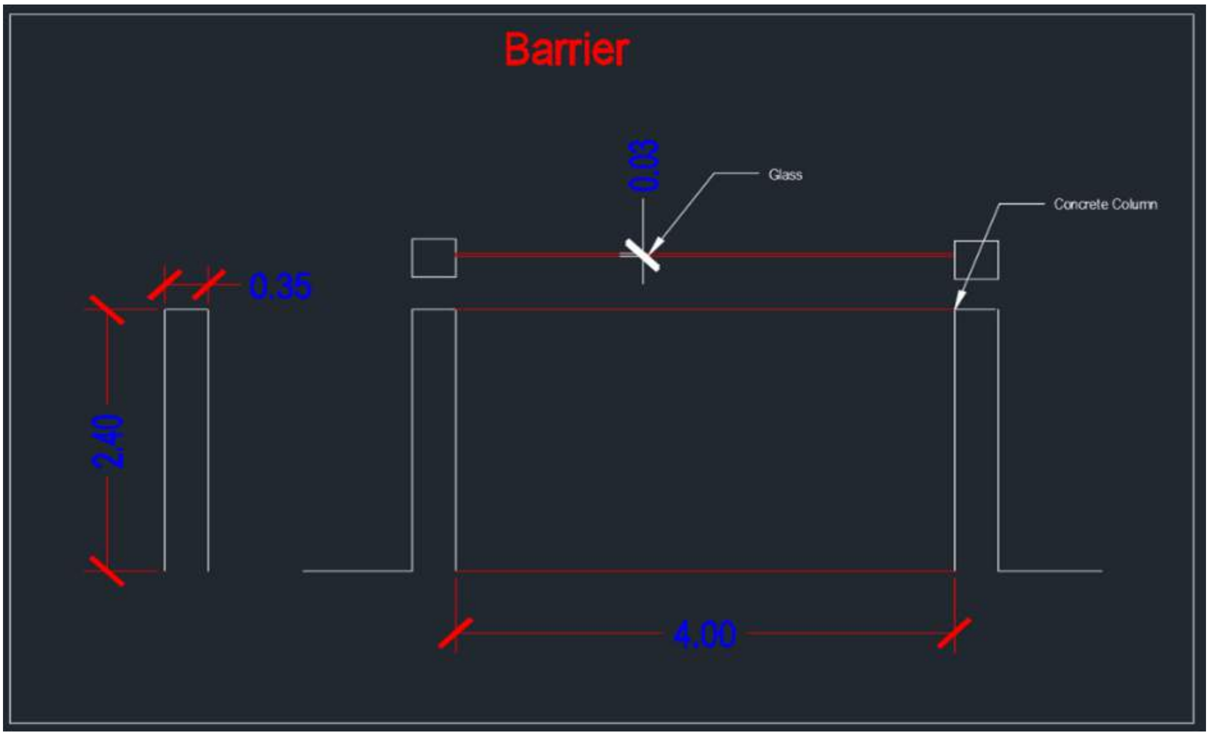


Figure 115: Engineering Drawing of Barrier (DPC Urban Planning 2017)

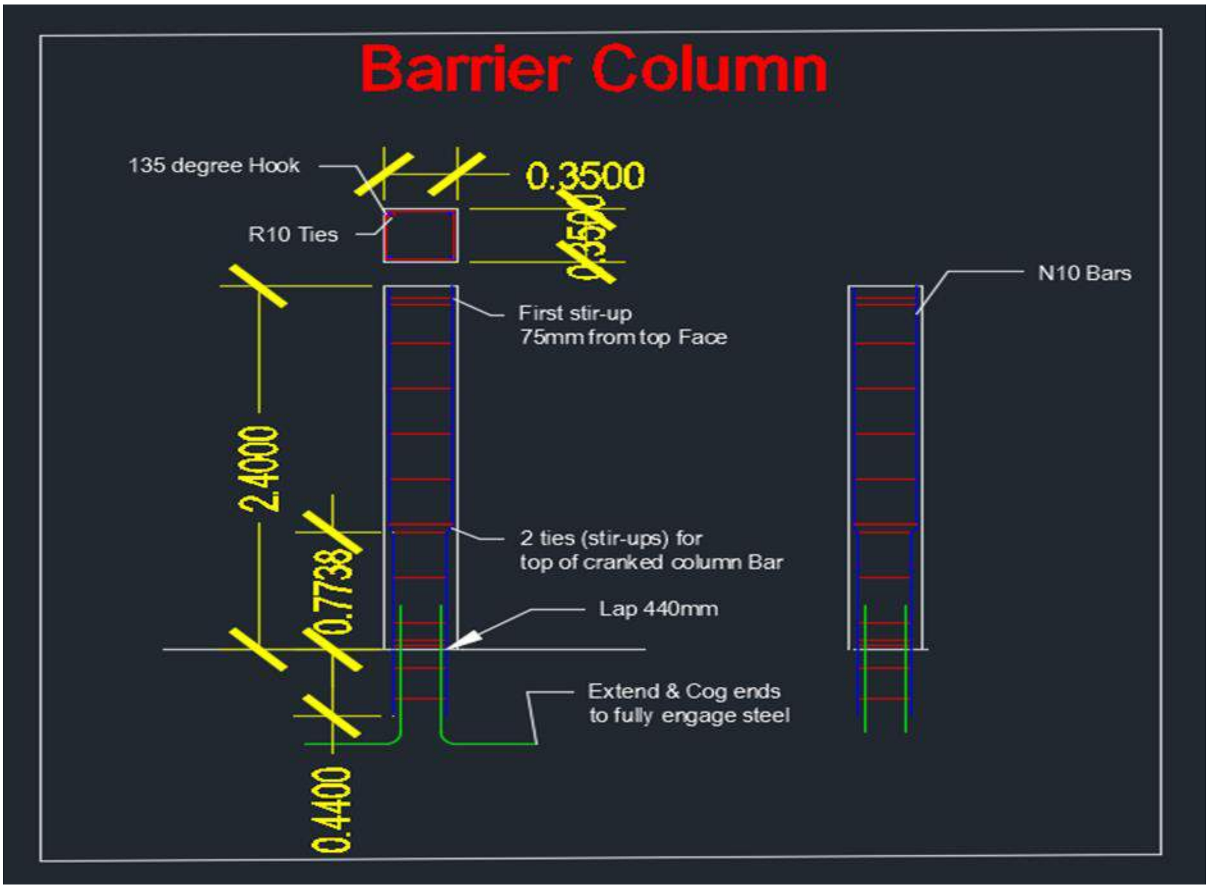


Figure 116: Engineering Drawing of Column Reinforcement (DPC Urban Planning 2017)

6.14 Urban Planning – Structural Design of Shelter

6.14.1 Overview

Although there are pre-installable shelters that can be implemented for the train station, the concept design calls for a unique engineering design to be implemented. The structural design is the same every 20 meters, for the entire span of the platform with only 2 breaks in between the elevators. The shelters will need to support solar panels placed on the roof, along with the usual dead, live and wind loads.

6.14.2 Loads

As previously mentioned the same assumptions and considerations are taken for the barrier and shelter in terms of earthquake, vibration and thermal conditions; below are the summarized loads as calculated by AS 1170.0-2 in appendix J.

- Wind – Refer to appendix J (hand calc. pg 5) – 0.82 KPa (shielded by barrier so its less)
- Live - Refer to appendix J (hand calc. pg 7) – 0.25 KPa
- Dead - Refer to appendix J (hand calc. pg 7) – 117 N

6.14.3 Design elements, Design method and summary of results

The following elements in, Table 65, will be considered for design. It will be necessary to assume that the polycarbonate sides are able to transfer all the load to the beams. The structures main component will act a simply supported beam (holding all the weight over 20m), thus, will be designed with AS 4100 Steel standards and the OneSteel Specification sheets for Universal Beams. It is assumed that the connections are not necessary to consider, as advised in meetings.

Table 65: Design elements for Shelter (DPC Urban Planning 2017)

Design element	Material
Beam	Steel Beam
Column	Steel Column (can use the same type as beam if its strong enough)
Polycarbonate Sheeting	Polycarbonate Sheeting (defined by environmental team)

The Design was designed in accordance with AS 1170.0-2, and AS 4100, as shown in appendix J. Although SpaceGass is available to use, it was not necessary given the simplicity of the design requirements. All assumptions, design choices and references to the standards and design specification sheets are provided in an easy to read format, within the hand calculations (appendix J). A Summary along with the final design drawings are shown below.

Table 66: Design Summary for Barrier

Design element	Summary
Barrier Beam / Column (same beam used for column)	150 UB 14 (40 times stronger than what's needed, however, the design looks good and we have an unlimited budget as discussed)
Polycarbonate Sheeting	Refer to spec sheet in appendix J

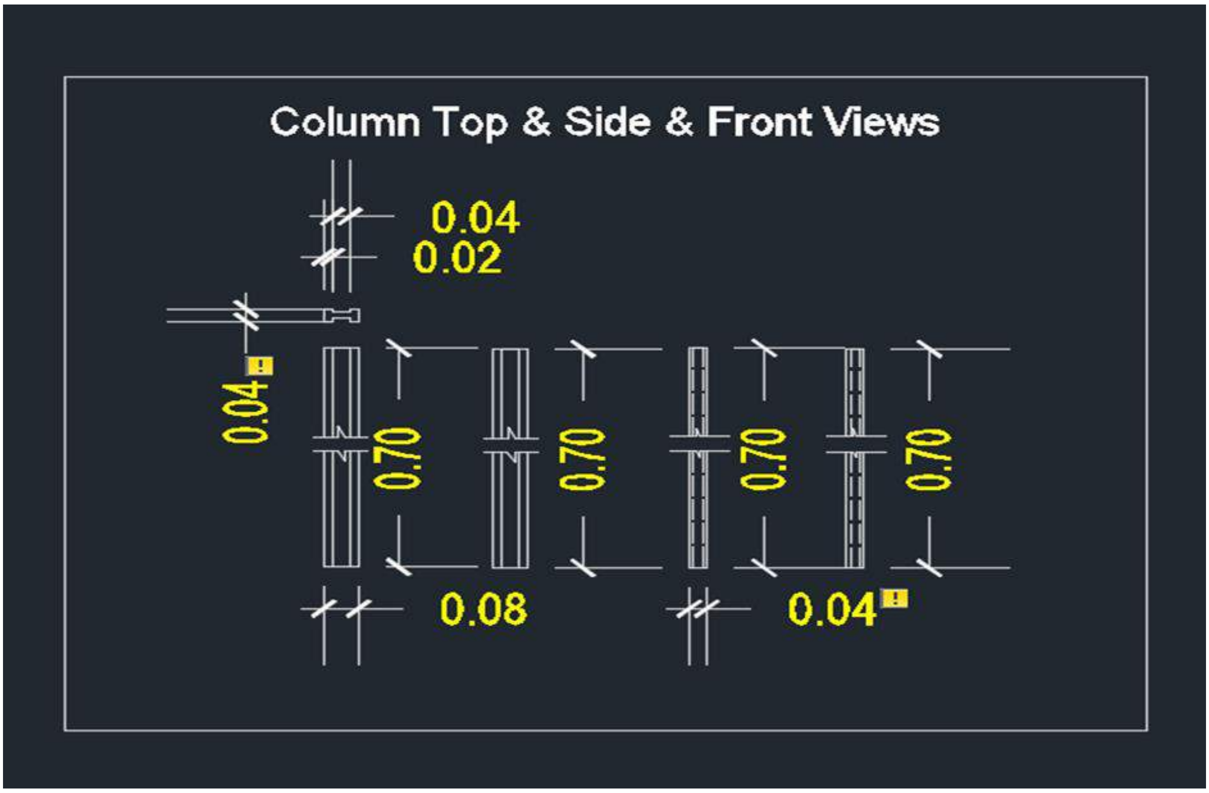


Figure 117: Engineering Drawing of Shelter Column (DPC Urban Planning 2017)

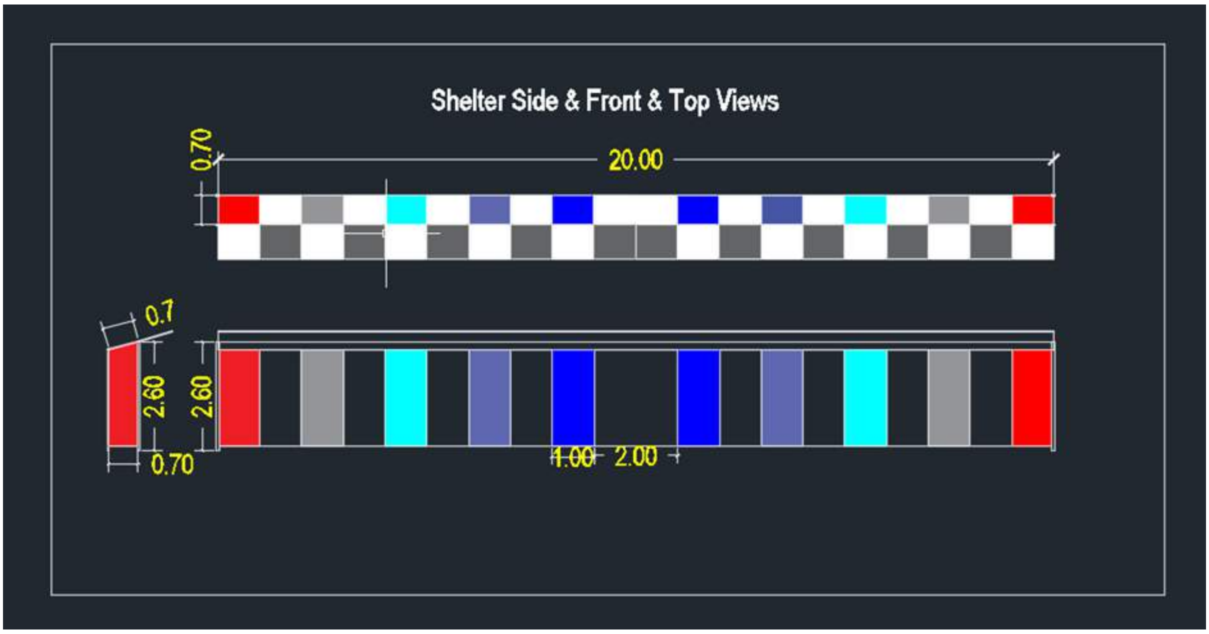


Figure 118: Engineering Drawing of Shelter (DPC Urban Planning 2017)

6.15 References:

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ENVIRONMENTAL

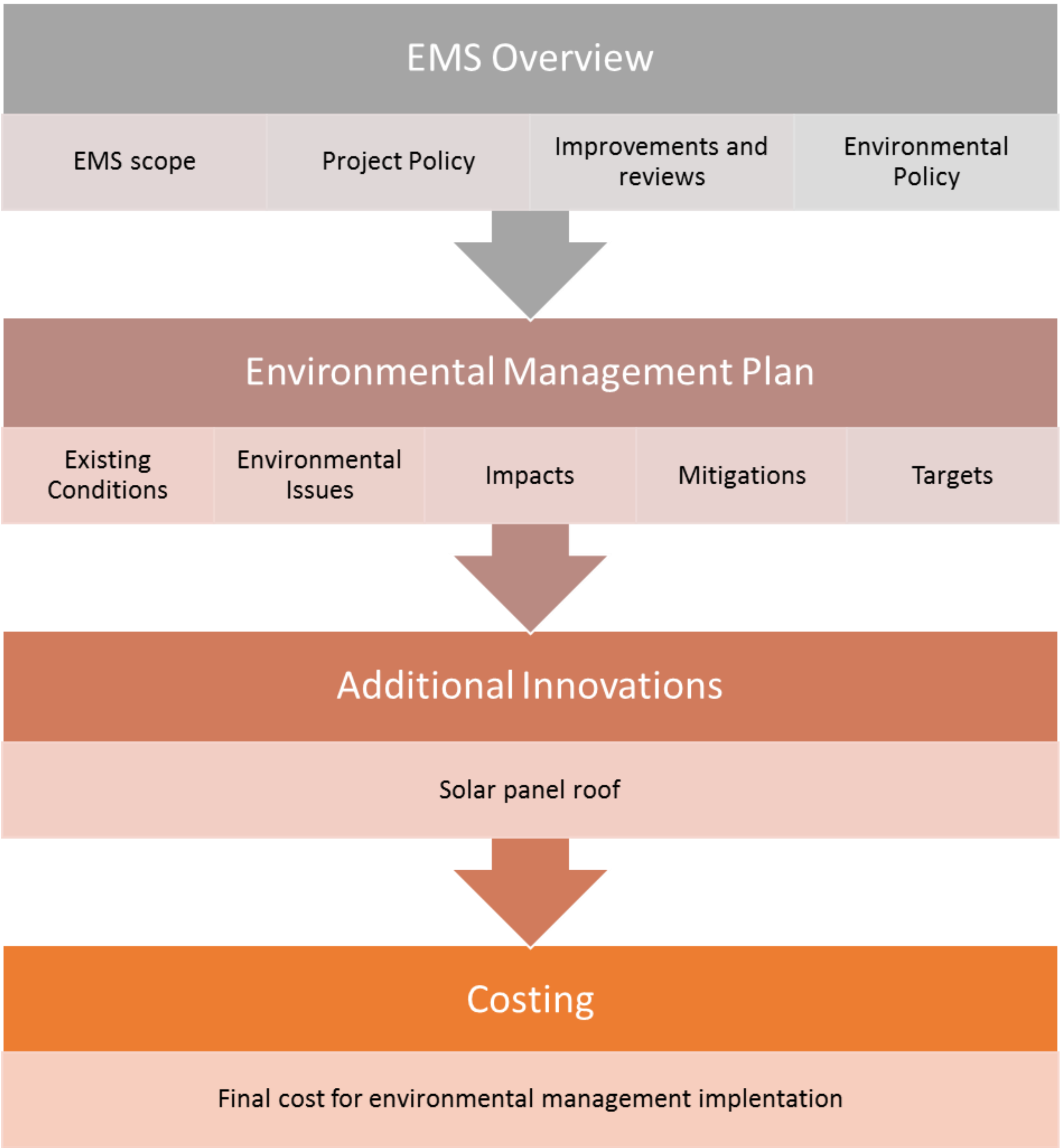
7 ENVIRONMENTAL

ABBREVIATION LIST

Abbreviation	Description
DPTI	Department of Planning, Transport and Infrastructure
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
SA	South Australia/n
VOC	Volatile Organic Compound
VMS	Variable Message Sign
WHO	World Health Organisation

7.1 Environmental Management System Structure

This Environmental Management System document follows a specific order of processes which will be applicable to the Oaklands Park Rail Overpass project.



7.2 Management System Overview

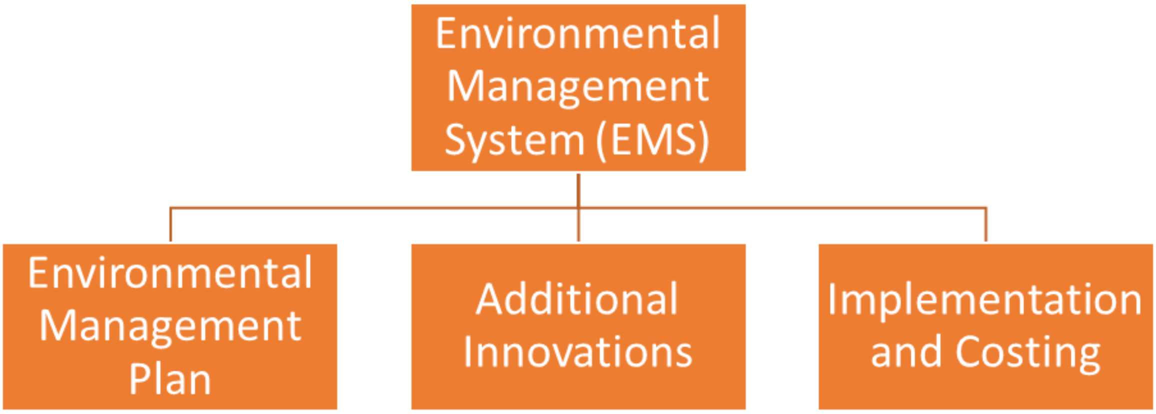
7.2.1 Scope of EMS

As a civil engineering company, DPC Engineering employees work directly with sub-contractors and other companies. The Environment Management System (EMS) will be applied to all employees of DPC Engineering as well as sub-contractors

7.2.2 Purpose of EMS

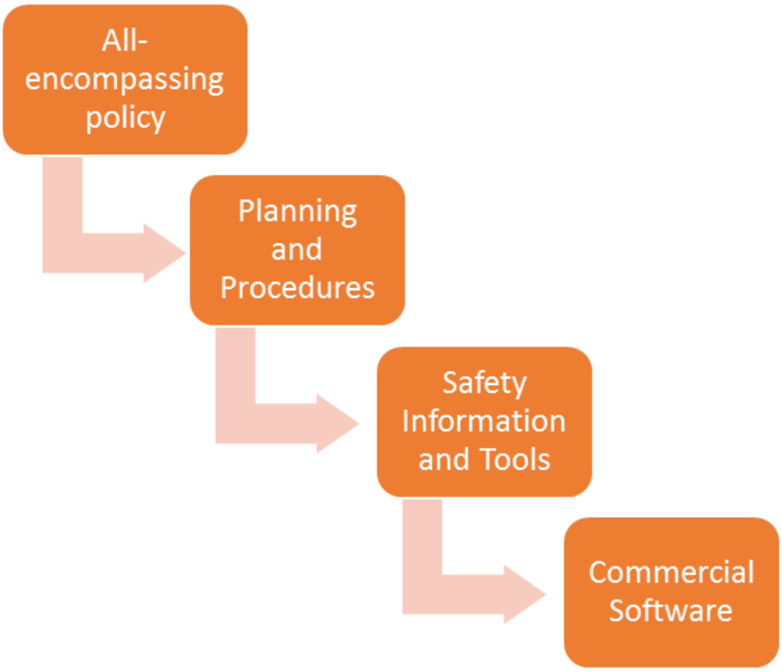
In conjunction with the client, Department of Planning, Transport and Infrastructure (DPTI), DPC Engineering produces the EMS for Oaklands Park Grade Separation which is aimed at providing a specific plan and framework for the implementation of environmental management practices. This plays a key role in ensuring that all aspects of negative environmental impacts will be minimised as much as possible, where elimination is not possible.

The EMS will include headings and sub-headings as illustrated below:



7.2.3 Management System

Since DPC Engineering works consistently with DPTI, the EMS has been designed to make sure that the work processes comply with the requirements of the client. The diagram below illustrates how DPC Engineering operates to meet these requirements:



7.2.4 Project Specific Policy

The EMS is developed and maintained individually and specifically for each and every project. The EMS describes the steps and relevant actions which need to be taken for each project in accordance with government environmental legislations and guidelines. Every task associated with the project will be completed according to the environmental guidelines and appropriate standards. The steps below indicate the requirements for this specific project according to the EMS:

- Legislated requirements and guidelines related to environment will be conformed at the time of construction.
- Prevention or minimising of pollution into the air.
- Actions to mitigate and minimise impacts will be strictly followed to reduce the impacts on the environment and community.
- Compliance with environmental regulations by the constructing authorities to eliminate or control the risks associated with the environment.

7.2.5 Environmental Policy

DPC Engineering's Environmental Department provides environmentally friendly engineering solutions. For each specific project DPC Engineering is involved in, both long-term and short-term problems in terms of environment will be taken into account. Being consistent with the various types of environmental issues is important for the company. The application of the company's environmental policies aims to reduce the significant long and short-terms impacts. The EMS is also designed to reduce the environmental impacts after the construction phase.

By improving the environmental quality of the project, DPC Engineering complies with environmental laws, legislations and policies. For each individual project, appropriate training will be held for employees working under the supervision of the environmental and other related departments.

DPC Engineering's Environmental Department team will focus on the following aspects:

- Compliance with environmental laws, legislations and policies from the South Australian government.
- Preventing or minimising pollution including GHG emissions, reducing the construction waste, and practicing efficient usage of water, electricity and other resources.
- Clearly identifying the objectives and targets of the project.
- Conveying the environmental policies as well as the EMS to workers on the project including DPC Engineering employees.
- Improving the awareness of environmental responsibilities through appropriate training.
- Frequently supervising the company's environmental performance and efficiency achievements and reporting it to the local government, and contractors.

7.2.6 Continual Improvement

DPC Engineering acknowledges that people are not perfect, and therefore their policies are not perfect. Also, laws and legislations are constantly changing to ensure that its systems remain relevant and effective for every project involving environmental management. That's why DPC engineering takes responsibility for ensuring its management strategies are up-to-date with the latest requirements, and its people are informed about any changes to the existing systems. DPC Engineering does this by following a simple 4 step model shown by Figure 119:

1. Plan – ideas, objectives and processes.
2. Action – Implement ideas, objectives and processes.
3. Review – Monitoring and evaluate ideas, objectives and processes.
4. React – Improve the current systems based on new ideas, objectives and processes arising from the reviewing stage

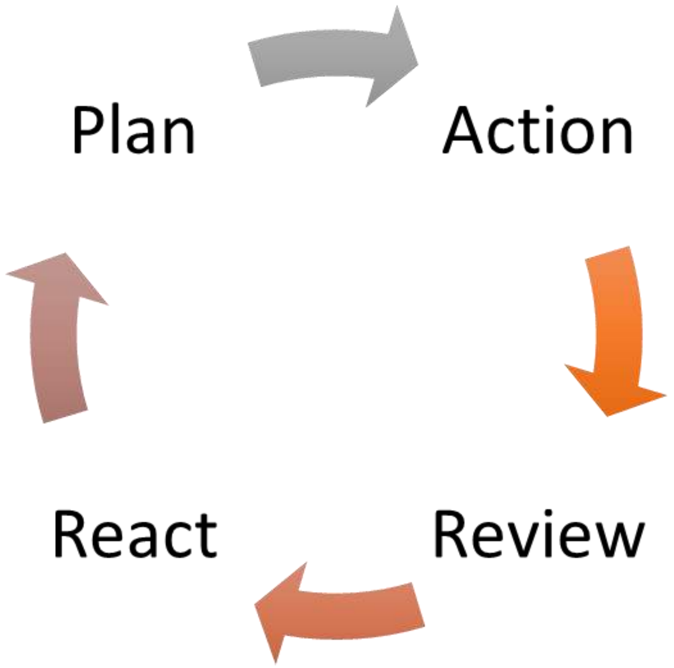


Figure 119: DPC Engineering Continuous Improvement Cycle

7.2.7 EMP Reviews

In addition to the Continuous Improvement Policy, for the smooth and safe working of the project, the Environmental Management Plan will be reviewed quarterly to check that the progression of the project is compliant with proper environmental standards. The progress will be monitored according to the proposed guidelines to find out the related environmental issues in the project. Amendments will be made to the EMP on identification of any issues related to the plan.

7.2.8 Objectives

The objectives of Environmental Management Plan are outlined as follows:

- To understand the relevant legislations and prepare a sustainable environmental management plan;
- To prevent or minimise potential environmental threats;
- Take corrective action in case of environmental emergency situations;
- To identify and prevent risks and hazards during the construction phase;
- To ensure all employees are well trained and aware of the environmental programs;
- To plan a system to monitor and inspect the data;
- To prepare audits to monitor the compliance with the environmental regulations;
- Define roles and responsibilities and allocate essential resources;
- To prepare environmental improvement plans for the operation phase.

7.3 ENVIRONMENTAL MANAGEMENT PLAN – SUBPLANS

7.3.1 Significant Environmental Hazards Identification

The team has identified several environmental hazards, which has been shown in Table 67.

Table 67: Identified environmental hazards

Identified Environmental Hazards	Associated Environmental Impact	Environmental Sub-plans
Air Pollution	Production of dust, which impacts community health	Air quality sub-plan
Noise and vibration	Community annoyance, property damage	Noise and vibration sub-plan
Soil contamination	Health risk due to the exposure to toxins	Soil sub-plan
Stormwater runoff and ground water interception	Erosion, ground and water contamination	Soil and water resources sub-plan
Trees and other vegetation	Loss or damage of fauna	Fauna sub-plan
Storage and handling disposal processes	Contamination of land or water	Waste management sub-plan
Hazardous substances	Land or water pollution due to leakage	Hazardous material sub-plan
Greenhouse gas emissions	Air pollution	Energy use sub-plan

7.3.2 Water Quality Management

This sub-plan will investigate the water quality issues related with the construction process of the rail overpass. This sub-plan will also include the impacts on the water systems and bodies and their mitigation and control measures as well how to minimise the risks of contamination of water bodies.

7.3.2.1 Issues

During the construction phase, there are some identified issues in relation to the water quality. The following points are the potential issues which this project can present:

- Hazardous chemicals and heavy metals,
- Oils and fuels used in machinery,
- Clearing of land can cause soil erosion which can end up in waterways

- Construction activities like bore construction for accessing groundwater can cause pollution to the groundwater,
- Litter, plastics and other construction material waste can also create problems in the drainage systems if they are allowed to enter into the systems.

7.3.2.2 Legislative Requirements

For water management, there is a need to follow legislated requirements which are listed below:

Table 68: Relevant legislation for water management

Relevant Legislation	Key Requirements
Environmental Protection Act 1993 (SA)	This act provides the environment protection from all types of pollutants.
Environmental protection (Water Quality) Policy 2003	The aim of this policy is to allow the economic and social development in the society in accordance with protecting the water bodies and attaining the sustainable management of waters.

7.3.2.3 Impacts and Mitigation

7.3.2.3.1 Hazardous chemicals, heavy metals and oils and fuels

The hazardous chemicals, heavy metals, oils and fuels used on the construction site have a potential to pollute the water quality. Substances like diesel, paint, solvents, cleaning agents, and building materials such as concrete can be harmful to the water bodies if they enter the drainage systems. These types of substances are pollutants to the waterways which can poison the water life. In addition, these harmful materials can soak into the groundwater and harm nearby vegetation.

7.3.2.3.2 Clearing of land

Clearing of land for the construction of the structures are major cause of soil erosion which further enhance the sediment pollution. Construction activities release concentrated sediment in the water bodies. The entrance of the sediments in the stormwater system can lower the water quality and affect drinking. There is a major risk of flooding if stormwater drainage systems are blocked by sediments. Pollutants in sediments also cause harm to the aquatic life and vegetation in the water bodies. The presence of sediments makes the water treatment process more difficult and costly.

7.3.2.3.3 General litter from construction materials

There are two main sources of litter on the project site which can affect the stormwater drainage system. Firstly, due to storms or running water, building materials can be washed away and get deposited in the stormwater drainage system. Secondly, the rubbish thrown in the water ways produced from building material packaging such as polyethylene and cardboards or tissues used by the construction workers.

The table below specifies the mitigation and control measures for improving and monitoring the water quality for various kinds of impacts.

Table 69: Water quality mitigations

Type	Mitigation
Hazardous Chemicals	• Routine testing of site runoff. • Installation of water treatment system on the site to make the water safe before releasing into the water bodies. • Reduction of site runoff where possible. • Routine testing of machines to check the leakage of the oils and diesel. • Minimal use of solvents and other chemicals wherever possible.
Clearing of Land	• Minimal land disturbance if possible. • Maximum vegetation cover to prevent soil erosion and runoff.
General litter	• Setup of appropriate clearly marked bins on site for the litter such as cardboards, plastic and metal. • Weekly collection of waste from site with the help of waste collecting agencies. • Covering of drains with mesh to minimise the blockage caused by the general waste. • Routine cleaning of the site to clear the waste materials from the site. • Request that the suppliers don't provide any unnecessary packaging.

7.3.2.3.4 Operation

During operation phase of the project, the stormwater and water ways should be inspected to check the impacts of the construction on the water quality.

7.3.2.4 Targets

Water quality targets during construction and operation are shown in the table below:

Table 70: Targets for water management

Objective	Target	Timeframe
On site runoff	Zero	Construction
Storm water/ drainage system contamination	Zero	Construction
Storm water/ drainage system stuck waste solids	Zero	Project lifecycle

7.3.3 Soil Quality Management

This subplan will investigate soil quality issues, in particular, soil erosion and soil contamination, which may arise during the construction and operation phases of the rail overpass. It will detail the impacts of the issues on the environment, followed by the mitigation methods which will minimise these impacts as much as possible.

7.3.3.1 Existing Conditions

The impact of soil erosion on the environment is permanent. At the project site, when considering the current conditions, there appears to be no areas with exposed soil with the potential of becoming eroded due to wind. The majority of the surrounding area is made up of pavement and buildings, and only a small section is grass. The grassy area has a high potential of dying in the summer season if not watered adequately, however this will not cause erosion as the roots hold the soil together.

7.3.3.2 Issues

7.3.3.2.1 Erosion

During the construction phase, it is highly likely that soil erosion will occur because of the lifting, removal and relocation of vegetation. However, the most significant case of erosion will occur during the construction phase involving the digging of the soil for the foundations of the railway bridge, new widened road, new carpark, and relocation of services. Erosion can also occur when water passes over the soil, for example, storm water or rainwater, or man-induced water flow from water hoses, emptying of water containers etc.

7.3.3.2.2 Contamination

Soil contamination is an undesired event where chemicals which cause harm to vegetation and humans are allowed to enter the soil. Any contamination to the soil is a serious event, and must not occur under any circumstance. Currently in and near the project area, there is a Coles supermarket on Diagonal Road, and further south on Morphett Road is the SA Aquatic and Leisure Centre and

Westfield Marion. These locations are potentially at risk of releasing toxic chemicals into the ground. In particular, the chemicals may include cleaning products from waste water, for example bathroom cleaners and a dry-cleaning chemical called tetrachloroethylene. In addition, due to the large volume of traffic passing through the site each day, there is a potential that some older cars may leak fluids on to the road which may enter the soil or the stormwater system. However, the management of any contamination issues due to the above will not be the responsibility of DPC Engineering or its contractors.

During the construction phase, there is the potential for contaminants to become present in the site area, for example, fluid leaks from machinery and trucks, including fuel, coolant and break fluids, as well as bearing lubricating fluids such as oil and grease. Contamination may also occur due to construction waste materials. This management plan for the construction phase aims to eliminate or minimise contamination.

7.3.3.2.3 Legislative Requirements

During the construction phase, there are legislated requirements will be obeyed, such as:

Table 71: Relevant legislation for soil management

Relevant Legislation	Key Requirements
Environment Protection Act 1994	Must not undertake an activity that pollutes or might pollute, the environment without mitigation measures
Environment Protection Regulations 2008 (SA)	Identify potentially contaminating activities, conduct site contamination auditors
National Environment Protection (Assessment of Site Contamination) Measure 1999	Identify the uncommenced provisions and amendments, modifications and provisions

7.3.3.3 Impacts

7.3.3.3.1 Erosion

The issue of erosion is predicted to arise during the construction phase. In the area of the existing carpark, there are existing trees and shrubs and grass. Some of this area will be cleared to increase the carpark size to allow for the predicted increase in train passengers as part of the 30-year Greater-Adelaide plan. In addition to the already-vegetated land, a new carpark will also be constructed under the new railway bridge. Naturally, these works will require that the vegetation is lifted and relocated as the ground is dug prior to the laying of the pavement. This type of activity will cause the soil beneath to become exposed, disjointed and loose. As a result, it becomes vulnerable to shifting and spreading out due to wind and/or water moving over it. However, in this

Management Plan it will be assumed that wind will be the main cause of soil erosion, and rain will be the cause of water erosion. Wind can cause erosion can have the following effects on the soil and environment: It can cause large soil clumps to separate from each other, mid-sized soil particles may cause abrasion as they pass over surfaces, for example, the ground. If this disruption of the environment is allowed to occur, dirt may cover the road, footpaths and surrounding buildings, which is aesthetically displeasing, and results in significant clean-up costs. More seriously, excessive wind speeds can create dust storms, amplifying the problem, and an addition, causing respiratory irritation or harm to nearby pedestrians.

7.3.3.3.2 Contamination

Soil contamination due to harmful liquids poses a significant risk to the life of the vegetation whose roots lie within that soil, and to humans if they come into direct contact with the soil. Once a harmful chemical enters the soil, it is difficult and costly to clean the soil and the roots of the vegetation, and even then, there is no guarantee that the vegetation will avoid chemical-induced harm. Some chemicals also release vapours which are harmful for humans to breath in. Although a tiny amount may not be enough to cause a noticeable problem for most people, for asthmatics however, it may be enough to trigger an attack.

7.3.3.3.3 Mitigation

The mitigation methods for controlling the effects of wind and water erosion and chemical contamination are summarised in Table 72 below:

Table 72: Soil impact mitigations

Type	Mitigation
Erosion (wind and water)	Earth piles created during construction will be covered with a tarp held by weights if stored for over 24 hours, to prevent the uncontrolled spreading and relocation of soil. Some areas of exposed soil during construction will be paved to cover soil completely. Exposed soil must be wetted frequently during hot weather to combine soil and prevent from become loose. In the event of rain, earth piles created during construction will be covered with a tarp held by weights. If erosion is not preventable, silt fences may be erected to contain erosion within the project area. In the event of heavy rain, construction work will cease.

Contamination	Plant must be well maintained according the manufacturer specifications. Inspections of all plant will take place to ensure that no fluid leaks exist to contaminate the soil. Contaminated soil will be shifted away from the project area and placed on plastic liners to prevent cross contamination. Soil which is known to be contaminated will be transferred to EPA licensed landfills unless it is guaranteed to be re-used on site.

7.3.3.4 Targets

The following soil management targets shall be met during the course of project:

Table 73: Targets for soil quality management

Objective	Target	Timeframe
Infringement notices or complaints received	Zero	Project lifetime
Erosion due to wind or project activates	Zero	Lifetime
Contamination due to harmful chemicals	Zero	Lifetime

7.3.4 Air Quality management

7.3.4.1 Issues

The management of air quality is one of the most important aspects for this project. The construction processes combined with the high density of traffic volume produce several toxic chemicals which is the primary reason for air pollution. Therefore, mitigations and controls for the amount of dust and GHG play a key role in reducing the negative impacts on the surrounding environment.

7.3.4.1.1 Construction

During the construction phase, a couple of activities that will release dust and greenhouse gases on the site are shown in-detail below:

1. The use of machinery

The majority of machinery used during construction are powered by diesel engines. According to the World Health Organisation (WHO), diesel exhaust is said to be carcinogenic. Particularly, diesel machines cause 12% and 15% of nitrogen dioxide (NO2) emissions and fine particles respectively from land-based sources (European Federation for Transport and Environment (AISBL) 2017). The air pollution from the use of diesel machines can result in health issues such as cardiovascular and respiratory illnesses for local residents (Concerned Scientists 2016).

2. Transportation of machinery, materials and waste

The transportation of machinery, materials and waste causes a significant environmental impact due to the fuel consumption from vehicles. This results in air pollution, comprising of particulates and nitrous oxides which are known as two of the major contributors to global warming.

3. Use of Solvents

It is announced that the use of solvents is identified as one of the major contributors to VOC emissions, which are said to be a trans-boundary air pollutant. In Europe for example, solvent use contributes to approximately 25% of the total anthropogenic emissions of VOCs (Environmental Protection Agency (EPA) 2013). In regard to the project, solvents can be used during the painting of the structure. As a consequence, is identified as a main cause of air pollution.

4. Waste Materials from site

According to the Department of Sustainability, Environment, Water, Population and Communities from Australian Government, building materials take up nearly a half of the solid waste generated worldwide. Dust from waste materials, which were a result of the demolition of old structures, are produced, which negatively impacts the air pollution of the environment.

5. Wind erosion

Wind erosion is recognized as one of the seriously environmental problems. It damages in land and natural vegetation by removing soils from one place and depositing them to other places. This contributes to the creation of a huge amount of dusts. As a consequence, it causes the dryness and the deterioration of soil structure, the losses in nutrient and productivity and air pollution.

7.3.4.1.2 Legislative Requirements

The legislated requirements for the management of air quality during the construction phase are shown in the table below:

Table 74: Relevant legislation for air quality management

Relevant Legislation	Key Requirements
National Environment Protection Measure for Ambient Air 2003	Carbon monoxide, nitrogen dioxide, sulphur dioxide and particulate matter must not exceed the diameter of 10μm or less or 2.5μm or less.
National Environment Protection Measure for Air Toxics 2004	The specification of the concentration of air toxins from specific sources is required.

Environment Protection Act 1993 (SA)	The toleration of activity that causes environmental pollutions is no longer allowed unless taking appropriate control measures.
Environment Protection (Air Quality) Policy 2016	Records regarding pollutant concentration and the method used for reducing is required.

7.3.4.2 Impacts and Mitigation

The table below details the impacts and the corresponding mitigation strategies that will be implemented during the project to ensure that the project meets the requirements from the client.

Table 75: Air quality mitigations

Type	Mitigation
Dust Generation	Maintain presence of vegetation as much as possible. Use dust collector systems. Wet any dust producing materials prior to undertaking dust generation tasks.
Greenhouse Gas Emissions	Use clean energy including gas fuel and electricity. Diesel machinery, must be checked and regularly serviced.

7.3.4.2.1 Operation

After completion of the rail overpass option, the amount of greenhouse gas emissions will be significantly decreased since road users will not need to stop and start due to red traffic signals at the intersection. Moreover, the use of green walls, which can be seen below, contributes to enhancing the air quality by reducing airborne pollutants. Green walls act as an air-filter, which can create a cleaner and more refreshing surrounding environment.

Figure 120: An example of use of green walls (Designerpages 2011)

7.3.4.3 Targets

The table below points out the targets that are expected to reach for the air quality management during the project timeline.

Table 76: Targets for fauna management

Objective	Target	Timeframe
Notice of infringement from regulating body	Nil	Project lifetime
Non-compliance of legislated requirements for air pollution	Nil	Project Lifetime

7.3.5 Flora Management

7.3.5.1 Issues

At the project site, there is existing flora along the rail line and Morphett Road. Flora is required to be removed prior to the construction of the rail bridge. A revegetation option should be taken considered as it will help with preserving of the vegetation on the area. In the next section, the revegetation will be discussed to identify which types of vegetation will meet the requirements of the project.

7.3.5.1.1 Vegetation selection

1. Land use

DPC Engineering acknowledges the importance that revegetation plays in this project. The satellite map below outlines the locations of existing flora.

Figure 121: Location of current flora (Google Maps 2017)

As shown in the above figure, Eucalyptus cladocalyx and E. camaldulensis trees, which are highlighted in yellow, are located in the rail corridor and adjacent area. These types of trees are said to be high ecological as well as amenity value (DPTI 2010 p. 2). While, the vegetation in the private front garden and some areas, which are highlighted in red, comprised of planted ornamentals with areas of lawn. As required, these types of vegetation must be removed under the Native Vegetation Act 1991 legislation.

2. Tree selection

The Marion Council Australian native and exotic tree species to suit with the soil profile and conditions of the project area. Most of the area is also covered in green grass, therefore, it is highly recommended to choose green-leafed trees (Botanic Garden of South Australia, 2017). There are a wide range of tree species that suit the soil profiles and meet the requirements of the client. However, after considering all of the options, Jacaranda and Japanese Elm trees will be chosen for planting due to their significant benefits, for example, producing shade, and acting as a windbreak. Also, they are tolerant to drought and air pollution. Therefore, this type of tree is an ideal option for urban areas.

Figure 122: Example of Jacaranda trees (Fast-Growing-Trees 2017)

Figure 123: Example of Japanese Elm trees (Jeff, W 2015, Youtube)

3. Plant Selection

After considering all possible types of grass, Zoysia macrantha grass has been selected for plantation in the project area on both sides of the rail corridor. The picture below illustrates Zoysia macrantha grass:

Figure 124: Example of Zoysia Macrantha grass

oysia macrantha is suited to most parts in Australia including Adelaide. Its performance is said to be ideal for local Australian lawn. Furthermore, there are a lot of benefits from the use of Zoysia macrantha. First, the maintenance cost for Zoysia macrantha is ow. It requires less mowing and fertilising. Moreover, Zoysia macrantha is more drought tolerant compared to other types of grass such as Buffalo and Couch, therefore; it is not expected to be affected in a future case of water restrictions. Finally, Zoysia macrantha rarely gets disease. This is important for maintaining the aesthetics for the population within the project area (Nara Native Turf, 2017).

4. Tree plantation

The reclaimed land has been allocated for revegetation. The above two tree species will be planted. The remaining land will be covered with Zoysia macrantha grass for reducing the impacts from erosion. During the revegetation progress, due to the removal of a large number of trees, the density of trees will decline. This causes an unbalance of surrounding environment and landscape; therefore, two or three trees will be planted for each tree removed. To ensure the quality of tree species which will be transported to the reclaimed areas, only 2-year-old trees or older will be used for plantations.

Japanese Elm trees will be chosen for plantation on both sides of the rail corridor, while Jacaranda trees will be planted along Morphett Road and Diagonal Road. This will be consistent with the current landscape. For other reclaimed areas, both types of trees will be used regardless of the current landscaping.

The map below describes the locations of the revegetation:

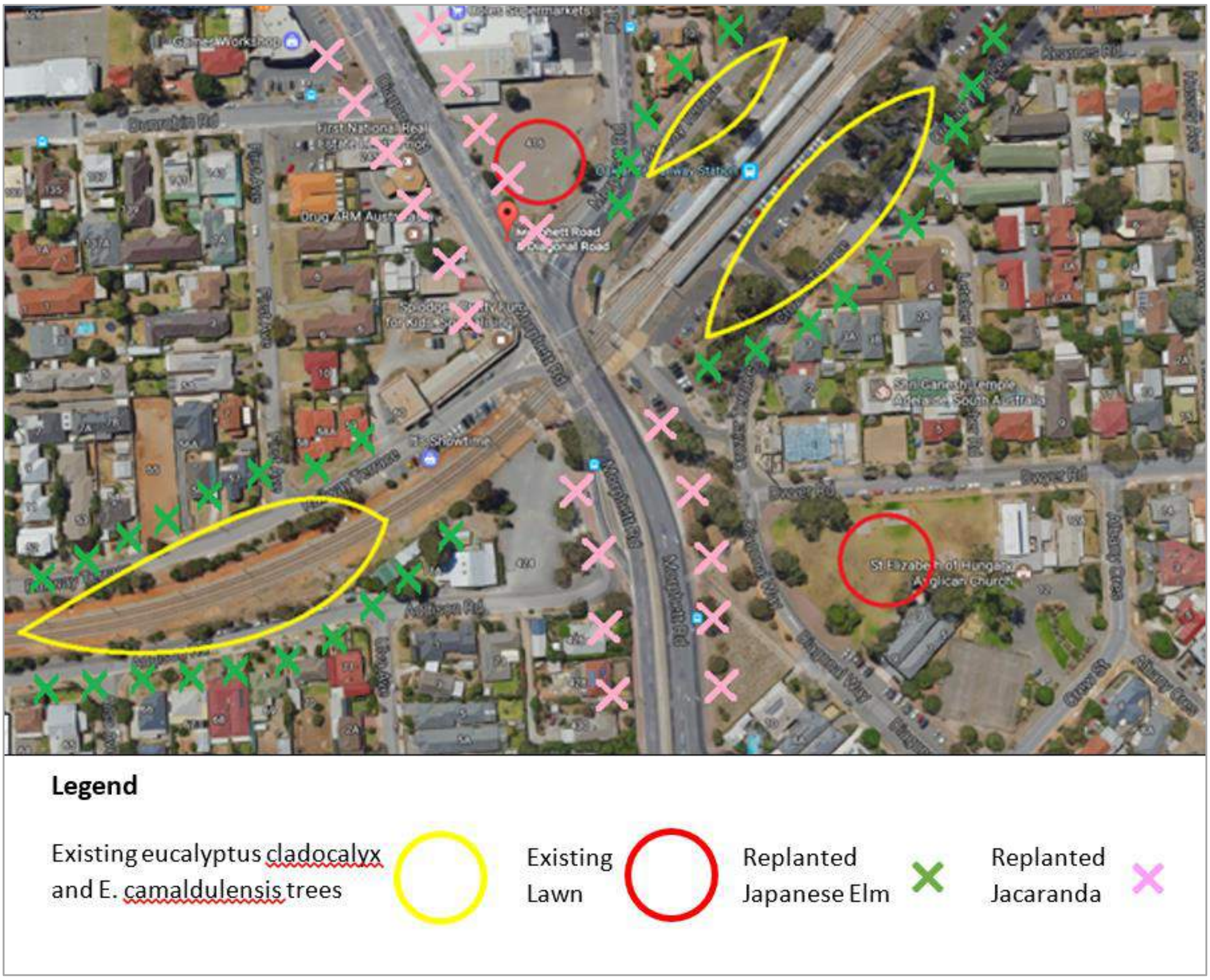


Figure 125: Locations of revegetation (Google Maps 2017)

As seen in the image above, the areas which are highlighted in green and pink, will be the locations of new Japanese Elm and Jacaranda trees respectively. In regard to Japanese Elm trees, these areas are located next to the affected areas and along the railway. While the Jacaranda trees will be located along both sides of the Morphett Road linked to Diagonal Road.

7.3.5.1.2 Legislative Requirements

The legislated requirements for the management of flora during the construction phase are shown in the table below:

Table 77: Relevant legislation for flora management

Legislation	Legislated requirements
Natural Resources Management Act 2004	A "Water Affect Activities Permit" must be required for any works that impact on the waterway, including vegetation.
Native Vegetation Act 1991	If there is no permit granted, Native South Australia Plant must no longer be disrupted. For the removal of the native vegetation, a permit is required.

7.3.5.2 Impacts and Mitigation

The table below points out the impacts and the corresponding mitigation strategies for the flora management that will be implemented during the project to ensure that the project meet the requirements from the client.

Table 78: Flora management mitigations

Type	Mitigation
Impacts on the quantity and quality of current flora	Revegetation with the appropriate vegetation species.
Vegetation soil, water and root quality impacts	All machinery is required to be clean before entering the construction site.
Soil contamination due to the leakages of hazardous chemicals impact on floras' survivability	Monitor periodically the soil's conditions when leakages are reported, pre-cautions must be in place at all times.
Soil compaction due to the movements of machinery impacts flora	➢ Routes which are used for moving around the construction site are required to be appropriately designed to minimise the area of impacts. ➢ After terminating the project, the process of soil aeration should be carried out for the revegetation.
Physical impacts on the flora, which are located along the railway, caused by the construction of super T beam	Flora in affected areas must be re-located before construction.

7.3.5.2.1 Operation

In the operation phase, the impacts on the flora will be minimised compared to the construction phase. If possible, the selection of using hardy vegetation will occur to maximise its survivability. In the future event where water restrictions may apply, the life of the selected trees and grass will not be impacted.

7.3.5.3 Targets

The table below details the targets that are expected to be reached for the flora management during the project timeline.

Table 79: Targets for flora management

Objectives	Target	Timeframe
Removal of plant in the site	Permit must be granted before removing the plant	Entire Project
Introduction of foreign species	Zero	Entire Project

7.3.6 Fauna Management

7.3.6.1 Issues

The location of the project is surrounded by a high density of traffic and population. Most ground surfaces are paved and contain little vegetation, therefore this location is not ideal for animals. However, it is vital to take into account the management of fauna, which still exists but with insignificant amounts. By carrying out further investigation, it is noted that there are no rare or endangered fauna species within the project area.

7.3.6.1.1 Legislative Requirements

The legislated requirements for the management of fauna during the construction phase are shown as follows:

Table 80: Relevant legislation for fauna management

Legislation	Legislated Requirement
National Park and Wildlife Act 1972	The fauna on the construction site must be studied before the project. Also, a removal/relocate plan must be achieved with permission from the government.

7.3.6.2 Impacts and Mitigation

Although there are no rare or endangered fauna species within the project area, some impacts exist during the construction phase. The table below summarises these impacts and the corresponding mitigations:

Table 81: Fauna control

Type	Mitigation
Fauna displacement	• A fauna inspection report will be developed and will assess bird life and other inhabitants in either trees or bushes. • Consult with wildlife experts for advice with minimising the impacts on fauna.
Chemical poisoning of fauna caused by the use of hazardous materials	• Limitations in the use of hazardous materials must be applied. The attendance of experts is required while using hazardous materials. • Store chemicals safely and correctly.
Noise pollution from construction site impacts on the fauna	• Fauna must be removed or relocated before starting construction. • Apply appropriate precautions in order to minimise noise on the construction site.

7.3.6.2.1 Operation

In the operation phase, the impacts on fauna must be minimised. Concrete barriers will be used between land-based fauna and the construction site, and the speed for travelling vehicles will be reduced. As a result, the safety of fauna in surrounding areas will be significantly improved. Regarding bird-life, their flight can be hindered by the use of fences in the construction site. Therefore, it is highly recommended that fences with opaque coloured panels be used instead of clear ones to maintain clear visibility.

7.3.6.3 Targets

The table below points out the targets that are expected to be reached for the fauna management during the project timeline.

Table 82: Targets for fauna management

Objectives	Target	Timeframe
Fauna relocation before construction commenced	100%	Entire Project
Animals disrupted and harmed during the construction period	Nil	Entire Project

7.3.7 Noise and Vibration Management

7.3.7.1 Existing Conditions

It is essential to monitor the level of noise and vibration prior to the construction in order to have a numerical value of loudness to help set as a limit to avoid disruptions in the neighbourhood. It has been observed that average daily noise and vibration pollution caused by daily train operation ranges from 65-75 dB(A) (Brinckerhoff 2007). Keeping this value in consideration, all construction tasks will be monitored in order to avoid exceeding the limit.

7.3.7.2 Noise and Vibration Sensitive Commercial Areas

As discussed earlier, the construction site is surrounded by businesses and residential properties (refer to Figure 126), which needs special consideration in order to minimise adverse effects to the neighbourhood. Table 83, outlines the properties within 100m of site corridor.

Table 83: Noise and vibration sensitive areas

Non- residence areas	Location
Coles supermarket	Next to the site corridor
Warradale Hotel	Within 100m of site corridor
SA aquatic centre	Within 100m of site corridor
Shri Ganesh Temple	Within 100m of site corridor
Splodge	Next to the site corridor
Christ the king school	Within 100m of site corridor
Lewis Prior	Next to the site corridor

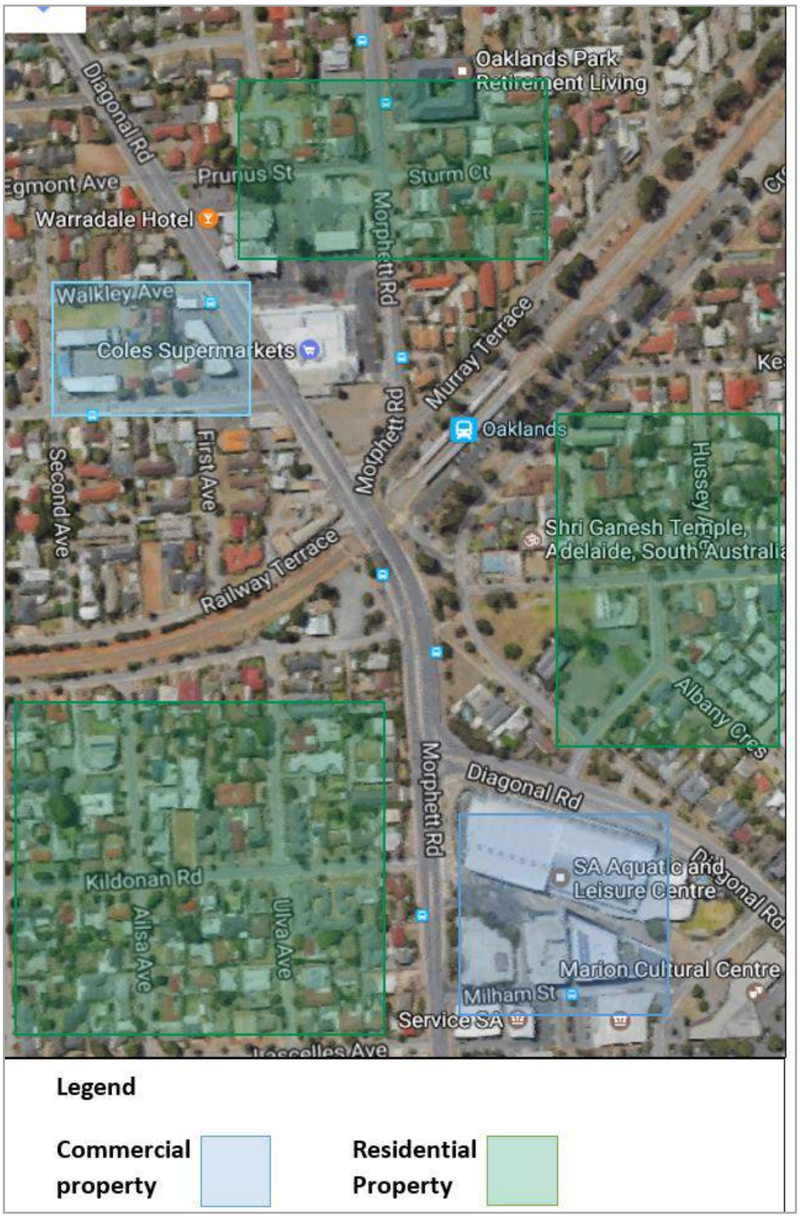


Figure 126: Noise sensitive residential and commercial areas (Google Maps 2017)

7.3.7.3 Issues

Control of noise is essential for this project due to the presence of noise and vibration sensitive areas close to the rail corridor. DPC Engineering will take reasonable precautions during the construction phase but it is vital to consider permanent noise barriers to reduce noise during the operation of the rail overpass. In addition, there are no numerical value set for the maximum allowable vibration but the team will consult and review various policies and standards throughout the construction process.

Due to the intense construction procedure and use of constructions plants, the rail corridor will be affected by noise and vibrations issues because of which DPC Engineering will implement appropriate environmental safeguards. Several issues have been predicted due to the vibration caused by the equipment such as damage of the nearby properties, which could also result in the failure of the structure. In addition, it also radiates noise as it propagates, which causes annoyance to the people with hearing issues.

DPC Engineering sets the following objectives as benchmark criteria:

- Minimise sleep disturbance and general discomfort due to the noise
- Minimise discomfort and damage to the properties due to the vibrations

7.3.7.3.1 Construction: Legislative Requirements

Table 84, outlines the relevant legislation requirements for the construction phase of the Oaklands Park grade separation project.

Table 84: Relevant Legislation for noise and vibration management

Relevant Legislation	Key Requirements
Environmental Protection Act 1993	General environmental duty
Environment Protection (Noise) Policy	Compliance with AS-1259-1990
EPA Noise Information Sheet- Construction Noise April 2014	Working hours and recommended controls
AS 2436- Guide to noise and vibration control on construction, demolition and maintenance sites	General requirements

7.3.7.4 Impacts

As discussed above, construction site is surrounded by residential and non-residential properties, which needs special consideration and mitigations to avoid any disruptions to the community. Several problems arise from noise and vibration pollution such as effects on mental health, hearing loss, interference with speech communication and disturbance of work and. As it can be seen from Figure 127, there are a few non-residential properties and on the other hand the majority of the project location is surrounded by residential properties. This could be a major issue during the construction phase since it can cause annoyance to the nearby neighbourhood, especially to the people living in the retirement building located on the Morphett Rd. Another problem that could affect the community would be the use of equipment for piling and excavation, which causes strong waves of vibration and could also result in damage of properties.

As it has been illustrated in Figure 127, there are a few heritage buildings, which needs special considerations are listed as follows:

- Shri Ganesh Temple
- Warradale Lutheran Church

Figure 127: Oaklands park railway station (Google Maps 2017)

7.3.7.5 Mitigation and Control

It is essential to examine all possible factors that could result in affecting the neighbourhood, which ultimately affects the quality of the construction phase. In this case, DPC Engineering will be implementing noise management program in order to minimise the potential negative impacts, refer to Figure 128. The program works in conjunction with the control measures analysed for the process and a few techniques to monitor the issues refer to Table 85.

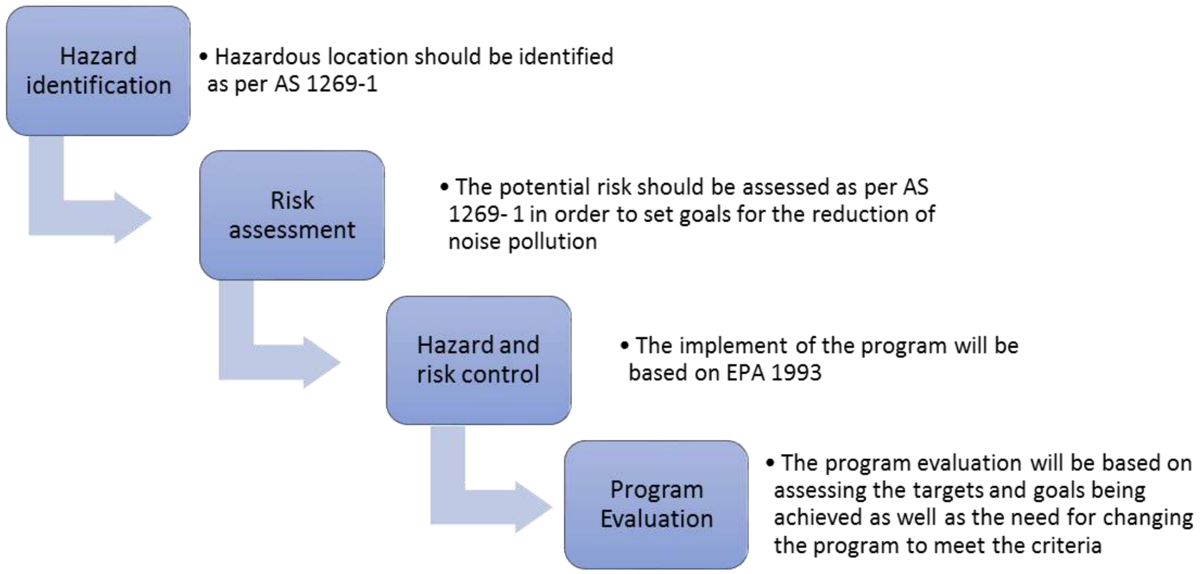


Figure 128: Noise management program

Table 85: Noise and vibration control

Control Measures	Monitoring and Inspections
Where possible, avoid the use of equipment that generates impulsive noise and vibration	Noise caused during construction should be monitored and assessed every day to ensure minimum impact on noise sensitive areas. AS 1269-3 should be referred in order to implement noise management program.
Minimise truck movement	
Minimise vehicle noise by developing access routes for the delivery trucks	
Temporary noise barriers should be installed for construction	
Construction hours should be scheduled when it is expected to have less impact on noise and vibration sensitive areas	
Replacing a high vibration energy source with a lower energy source is recommended where possible	
It is also recommended to minimise vibration by damping methods or effective maintenance	Vibration can be monitored by mounting transducers on the required location. Refer to AS 2775 for guidance for methods of mounting of transducers.

7.3.7.5.1 Vehicle Movement

DPC Engineering will undertake appropriate measures to minimise noise and vibration caused due to the movement of vehicles. The team will construct an alternate route to minimise disruptions of the public, considering sensitive noise and vibration receivers.

7.3.7.5.2 Operation

Table 86 shows noise and vibration control during the operation phase of the structure.

Table 86: Target for noise and vibration during operation

Objective	Target	Timeframe
Noise levels during operation	Not to exceed the level prior to construction	From the beginning of the construction till 6 months of the operation

7.3.7.5.3 Noise barriers

As a permanent solution to minimise noise after the construction phase and during the operation, DPC Engineering has investigated a few aspects of the noise barrier types and designs for this project. The aim is to design an environmental friendly barrier, which reduces the carbon footprint and serves both the community as well as the environment.

For this purpose, the team has considered two options for the noise barrier:

The two options have several advantages and disadvantages because of which it is essential to assess both options and choose one to design for this stage. Timber has several environmental benefits such as reducing carbon emissions since it is absorbed by it. But it is vital to consider durability and maintenance of the structure as well, due to which timber has been observed to be less durable compared to transparent barriers.

Glass barriers could be beneficial for this structure since it increases road safety by allowing sunlight to pass and not casting shadow on the road. It is also very resistant to extreme weather conditions as well as it is visually pleasing. The cost of the installation is also minimised since the installation has been proved to be easy. It is essential to consider various transparent barrier materials since the design requires a specific material which is not only environmental friendly but also feasible to construct and install. For this case, the team has chosen glass as the material for the design of noise barrier. In the following sections the details of the material has been explained elaborately.

7.3.7.5.4 Glass barriers

As mentioned earlier the team has chosen glass barrier for the final design of the noise barrier and have compiled specific details of the material in order to assure that it is beneficial for the environment as well as for the project. Glass barriers are acrylic products called Plexiglass, and are fabricated in various grades depending on the size and thickness of the required design (Plastral 2017). It is important to know that the material used for the project is easily fabricated according to the required design, Figure 129 shows an example of the use of glass barrier for the bridge. The use of this material is beneficial for this project due to its super lightweight and high resistance towards extreme weather conditions. Glass barriers are impact resistant, which makes its maintenance easy and cost effective.

Figure 129: PLEXIGLASS sound stop noise barriers (Plastral 2017)

7.3.8 Waste Management

7.3.8.1 Existing Conditions

The Oaklands Park rail way station is surrounded by residential properties, car parks, shopping centre and an aquatic centre. It is logical to assume that there is a high chance of contamination due to the use of chlorine in aquatic centre and dry cleaners present in the shopping centre. The contaminants caused by chlorine and other toxic materials released into the ground ultimately results in the contamination of the stormwater and soil. Residential and commercial properties are the main causes of the pollution of land in that location. Since Oaklands Park is a busy area with traffic congestion, the team believes that there could be other toxins present in the area, which needs special consideration prior to the construction.

7.3.8.2 Issues

Waste management is a critical issue during construction phase of the project because of which it is essential to apply reasonable measures to minimise its impacts on the surrounding.

Some general waste stream has been identified and are outlined as follows:

- Construction and demolition waste
- Concretes, Asphalts, Metals and timbers
- Fauna and Flora
- Contaminated soil
- Clean fill
- Grease and oils
- Hazardous waste
- Rubber and plastics
- Wastewater

All wastes mentioned will be recovered, disposed or recycled following the guidelines complying with South Australian Environmental Protection Act 1993. The construction of the rail overpass bridge can be challenging in terms of minimising waste impacts on the surroundings. One of the main issues will be in regards to the leakage into the land and stormwater, which could result in soil and water contamination. Once the waste has been infiltrated into water and soil, it would be difficult to mitigate and stop the contamination, that's why it is vital to regularly monitor soil and water in order to minimise further propagation of the contaminants.

In order to successfully minimise negative impacts on the environment, DPC Engineering will be considering an environmental management plan through which appropriate mitigations will be applied. The plan includes monitoring the types of the wastes and tracking the volumes and disposal of waste locations. This will ensure all waste is recovered and disposed properly and the plan for future waste can be undertaken. DPC Engineering aims to maximise recycling waste and minimise wastewater and soil contamination as well as waste generation.

7.3.8.2.1 Construction

The team has identified some general waste, which has been outlined in Table 87. The sources of the waste have been identified by assessing the work flow of the project.

Table 87: Source of the waste

Source	Hazard	Risk
Construction Stage	Generation of waste	Soil and water contamination
Machinery maintenance	Generation of grease and oil	Soil and water contamination
Operation and maintenance	Generation of waste	Soil and water contamination

of site facilities		

7.3.8.2.2 Legislative Requirements

Table 88, outlines the relevant legislation requirements for the construction phase of the Oaklands Park grade separation project.

Table 88: Relevant legislation for waste management

Relevant Legislation	Key Requirements
Environmental Protection Act 1993	No tasks will be undertaken which could result in pollution, unless appropriate measures are taken to prevent or minimise harm to environment
Environment Protection (Waste Resources) Policy	➢ All waste should be disposed at licensed or approved depots, Council kerbside waste collection services, EPA authorised incinerations, specified sites provided there is no risk of land contamination. ➢ All prohibited waste should be disposed of at a landfill depot approved by EPA. ➢ All waste should be covered, contained or secured and ensure no leakage during the transport. ➢ Ensuring the waste is transported by an authorised waste transporter, and steps are taken to transport waste to an appropriate licensed or approved depot.
Natural Resources Management Act 2004	A permit is required for the transportation of the waste

7.3.8.3 Impacts and Mitigation

As discussed above, waste produced during the construction may cause several issues such as pollution of air, water and soil. The aim of DPC Engineering is to maintain a clean and healthy environment for the workers as well as the community to eliminate the potential risk of adverse effect on the environment. There is a high chance of leakage of oil and grease from the equipment into the ground, which ultimately contaminates the soil. This may impact the surrounding vegetation as well as the integrity of the structure, which is being constructed. The leakage may also enter the stormwater, which could have a significant impact on the neighbourhood.

In addition, waste produced due to the excavation of land can also have additional adverse effects on the environment due to the presence of soil contaminants. Hence why the team will examine the waste to estimate potential risk to human health and ultimately propose a suitable use of the soil. Due to this the team will follow the hierarchy of control as shown in Figure 130.

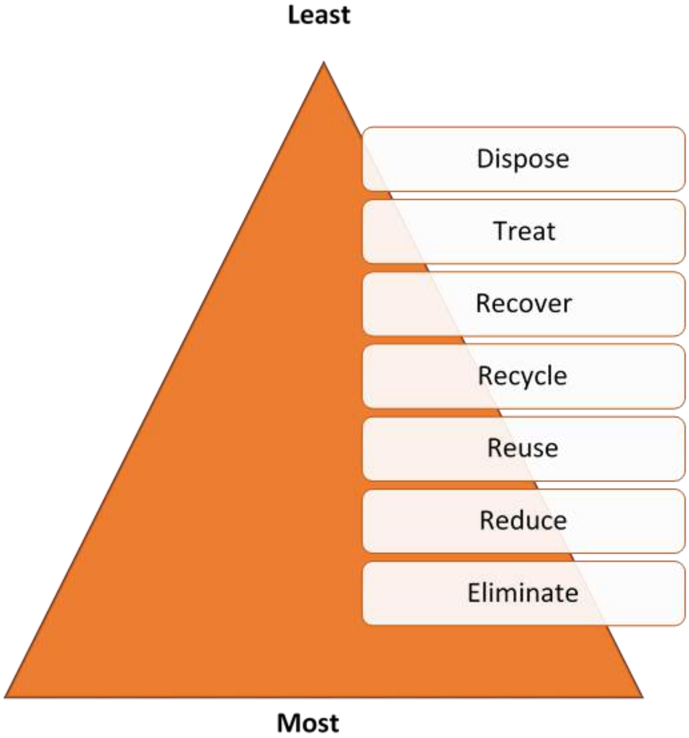


Figure 130: Hierarchy of waste control

Table 89 represents control measures and monitoring, which will be undertaken during construction in order to prevent negative impacts on the environment.

Table 89: waste management control

Control Measures	Monitoring and Inspections
All wastes should be removed regularly from site and disposed according to local state legislation, EPA 1993.	• Volume and types of waste will be monitored and sent to landfill • Volume of waste which is recycled or reused will be monitored • All records conforming the transport and disposal of waste
Contractors are to provide waste data statements.	
Avoiding discharge of waste water and grease into the land or stormwater.	

All waste storage should be labelled such as hazardous and non-hazardous wastes.	
Waste management plan should be prepared prior to the commencement of the project.	
Where applicable, all on site wastes should be reused.	
Soil sampling should be done in order to confirm its suitability for on-site reuse.	

7.3.8.4 Targets

As per legislative requirements for the management of waste during the construction phase, the team has detailed targets as shown in Table 90.

Table 90: Targets for waste management

Objective	Target	Timeframe
Waste transport certificates	100%	Ongoing
Infringements/penalties received	Zero	Ongoing
Volume of spoiled diverted from landfill	90%	Project lifecycle
Volume of non-hazardous materials diverted from landfill	Approx. 90%	Project lifecycle

7.3.9 Energy Usage Management

7.3.9.1 Existing Conditions

As the project site is on a main road, and surrounded by residential housing, a shopping centre and an aquatic centre. Therefore, traffic is usually heavy on Diagonal Road and Morphett Road, also especially since this is a popular route for southern suburbs residents to travel to the city centre for work. The heavy traffic flow causes a significant amount of GHG and the residential and commercial area in the project site contribute to this through the large amount of combined electricity usage.

7.3.9.2 Issues and Impact

Electricity usage and fuel consumption are costly activities which release a large amount of Green House Gas into the atmosphere. Naturally for this kind of project, these effects are unavoidable. The project specific equipment and activities which will contribute to GHG emissions are summarised in the table below. Transport of construction materials, earthmoving machines, other plant, and generators all rely on diesel (and potentially unleaded) fuel, while project site floodlights, VMS and security devices require 240-volt electricity.

Table 91: Source of energy

Emission Source	Energy Type
Transport of materials: Trucks	Diesel
Earthworks Machinery: • **Profiling machine,** • **Piling rig,** • **Tamper,** • **Excavator,** • **Front-end loaders,** • **Concrete truck/pump** • **Compaction machine**	Diesel
Power generators	Diesel
Lighting / Security Electronics: • **Site office lighting,** • **Site lighting,** • **Site security system,** • **VMS**	Electricity

7.3.9.2.1 Legislative Requirements

The following legislation is required by the SA Government:

Table 92: Relevant legislation for energy management

Relevant Legislation	Key Requirements
Greenhouse Gas Accounting Tool for Construction Guidelines 2012sa	During the construction of any rail project, Green House Gas assessments must be undertaken

7.3.9.3 Mitigation

Part of the strategy for monitoring energy usage is based on the Greenhouse Gas Accounting Tool for Construction Guidelines which employs the use of DPTI Microsoft Excel worksheets which "provides input fields for stationary energy, transport fuel, materials, vegetation clearance and waste. These fields can be populated to account for emission sources" (DPTI, 2012). These worksheets will be completed and reported in conjunction with the following:

- All energy use will be recorded, tracked and evaluated,
- Opportunities for improving energy usage are assessed and a report is prepared,
- Contractors are required to implement energy saving initiatives, and are required to provide regular energy usage reports for analysis by DPC Engineering.

During the span of the project, it will be required all energy usage including fuel is monitored and recorded and analysed to easily identify areas of excess energy usage and to quickly put into action reduction strategies.

For other practical mitigations, the following requirements shall be adhered to at all times whenever practicable. One method includes energy auditing. A compulsory audit will be beneficial in reducing the energy costs of the project, and also by reducing GHG emissions. All construction workers will undergo a pre-work induction around environmental awareness and energy saving actions, and will be informed of new cost saving practices to be adopted. It is required that all workers will practice energy saving practices at all times.

Table 93: Energy efficiency control

Energy source	Requirements
Plant and stationary engines	• Not revved excessively or unnecessarily with zero load. • No unnecessary idling. • Serviced regularly and full service history must be kept with vehicle/machine at all times. • Engines are shut down when not in use for periods of greater than 5 minutes at a time.
Electrical appliances (Computers and monitors, VMS, lighting, kitchen appliances)	• Computers, monitors or site office main power switched off completely at the end of each day (no standby). • VMS functioning only when required and switched off immediately when no longer required. • Site office kitchen and other appliances will remain switched off completely when not in use.
Energy auditing	• Determine all resources used • Locate sources of wasted energy • Investigate cost saving options

	• Review and discuss awareness and further recommendations

7.3.9.4 Targets

The following soil management targets shall be met during the course of project:

Table 94: Targets for energy efficiency

Objective	Target	Timeframe
Implementation of electrical efficiency requirements	All appliances powered off when not in use	Project lifecycle
Fuel records	Record fuel and runtime at each refuelling interval	Project lifecycle
Service history	History checked at beginning of project and after every service	Project lifecycle
Identify and implement new improvements to energy efficiency	As soon as recognised	Project lifecycle

7.3.10 Hazardous Materials

The aim of this sub plan is to identify the hazardous materials associated with the project construction and to suggest mitigation measures and controls to minimise the risks and impacts to the environment and community.

7.3.10.1 Issues

There are several kinds of hazardous materials can be found in the phases of the project which are listed below:

- Chemicals or dangerous goods usage on the site during construction
- Oils and fuels used in machineries
- Presence of asbestos on the site

7.3.10.1.1 Legislative Requirements

This sub plan there is a need to follow some legislated requirements and guidelines which are listed below in table:

Table 95: Relevant legislation for hazardous materials management

Relevant Legislation	Key Requirements
Environment Protection Act 1993	Any Individual must not undertake any activity that have potential to pollute the environment unless providing the preventions and controls to minimise the environmental harm.
Dangerous Substances Act 1979	• An individual or organisation must hold a valid license to keep prescribed dangerous materials. • AS 1940 must be followed for the storage of flammable liquids.

7.3.10.2 Impacts

7.3.10.2.1 Chemicals and building materials

Use of chemicals and toxic materials used on the site can pose a major risk to the environment in various ways. Materials like toxic paints, solvents and other building materials can create the pollutions related to water and air.

7.3.10.2.2 Oils and fuels

Oils and fuels used in the machineries can also contribute the environmental pollution. Risks associated with the oils and fuels include spillage and runoff into the drainage system which is harmful to the water quality. Fuels like petrol and diesel are flammable liquids and need proper handling to eliminate the risk of fire.

7.3.10.2.3 Presence of asbestos

Although asbestos is also known as one of the most versatile minerals due to its properties like flexibility, tensile strength, act as an insulator for heat and electricity and easily affordable material but on the other hand they are also responsible for posing many health risks. Asbestos is responsible for many types of diseases such as mesothelioma, asbestosis and lung cancer, all of which are almost incurable. There are chances of presence of asbestos in existing services such as old pipes, pits and electric equipment which can occur during the excavation on site (Asbestos Diseases Society of Australia 2017).

7.3.10.3 Mitigations

The following mitigations will be put in place to minimise the impacts of the hazardous materials.

Table 96: Hazardous materials control

Type	Control
Chemicals and building materials	• Holding compulsory inductions for the workers training for handling and storing the chemicals and dangerous construction materials. • Worker must undergo a spill response training. • Implementation of Material Safety Data Sheet and applicable legislation requirements for the handling and storage of the chemicals and dangerous goods. • Hazardous materials must be stored in proper storing area to prevent undesired exposure to the environment. • Routine inspection of the construction machineries to prevent the leakage of the oils and fuels • Use of non-toxic paints on the site.
Asbestos	• Proper induction and practical training to the employees in dealing with asbestos. • Contractors must have valid license for working with asbestos. • Removal, disposal and transportation of asbestos must be in accordance with WHS regulations. • Air monitoring and testing of the work site to prevent inhalation of asbestos fibres in air. • Pre-construction check for asbestos presence on the work site to prevent the health risks

7.3.10.4 Targets

Based on impacts and risks of hazardous materials, the important targets have been set to prevent harmful substances impacting the environment. The assigned targets are listed in table below:

Table 97: Targets for hazardous materials management

Objective	Target	Timeframe
Toxic spills occurrences	Zero	Construction
Hazardous material polluting water quality	Zero	Construction
Asbestos health and soil impacts	Zero	Construction

7.4 Additional Environmental Innovations and Design

DPC Engineering has put an effort on reducing global warming pollution by analysing the idea of using solar panels for the rail bridge. The aim of this concept is to overcome the future energy expenses of the rail overpass as well as reducing carbon emissions.

There are several aspects to this design such as:

- Type of solar system to be used
- Initial costs
- Average daily output
- Installation

It is vital to consider all the above aspects in order to be able to predict any future and present complexities regarding the design. The following sections illustrates all details of the solar panels and its benefits for the project.

7.4.1 Solar Panels

The team has investigated various aspects in order to confirm the idea of using solar panels will be beneficial for the project and the community. Initially, one of the main aspect considered was the type of the solar panel, which led to the question of its average daily output and how much it would cost to install the panels. Each of the aspect has been investigated one at a time, to ensure all factors has been examined and all gaps have been filled to avoid future problems.

The design has been further examined and finally the team has agreed to use LG NEON R solar panels for the project. According to the manufacturer, the solar panel is very strong and resistant to wind and cyclones as well as it provides maximum output per m^2 compared to other 260W solar panels (LG 2017). Some of the specific features of the NEON R solar panel has been detailed as follows:

- Proven field performance
- Cyclone wind load resistance
- Corrosion resistance certifications
- Multi –ribbons and low light induced degradation have proven to increase power

7.4.1.1 Solar Panel System

Due to the large scope of the project, the panels should be strong enough to generate power for the rail station. The power generated by the solar panels depends on the type of solar system which are also referred as solar modules and generally ranges from 1.5 KWH-100KWH. The selection of the solar system depends on the location and the estimated usage. Due to this, the team has evaluated average output of one panel during the day, according to which number of solar panel system will be provided.

The team has estimated average output of a single panel and calculated the area as follows:

$$\text{power} = \text{watts} \times \text{maximum hours of sunlight}$$

$$= 350 \times 4 = 1400 \text{ watts}$$

$$\text{power} = 1.4 \text{ KW per day , per panel}$$

$$\text{Power for 470 panels} = 470 \times 1.4 = 658\text{KW per day}$$

$$\text{Area of the panel} = \text{L} \times \text{W}$$

$$= 1.016 \times 1.7$$

$$\text{Area of the panel} = 1.72 \text{ m}^2$$

Using the above evaluated area of the panel, the team has estimated that 470 panels will be used on one side of the platform, which is 800 m2., using all available area on the roof, which is 800 m2. In addition, the average daily output has been evaluated as 1316KW for 940 solar panels used for both sides of the rail bridge. Therefore, all 940 solar panels will be placed on the platform roof, as an inclined structure. The power provided by 940 solar panels is assumed to be adequate for all usage required during the operation of the station and any excess will be transferred to the grid. On the other hand, in case of insufficient power the electricity will be fed into the structure from the grid. For more clarity and visualization, refer to the following figure.

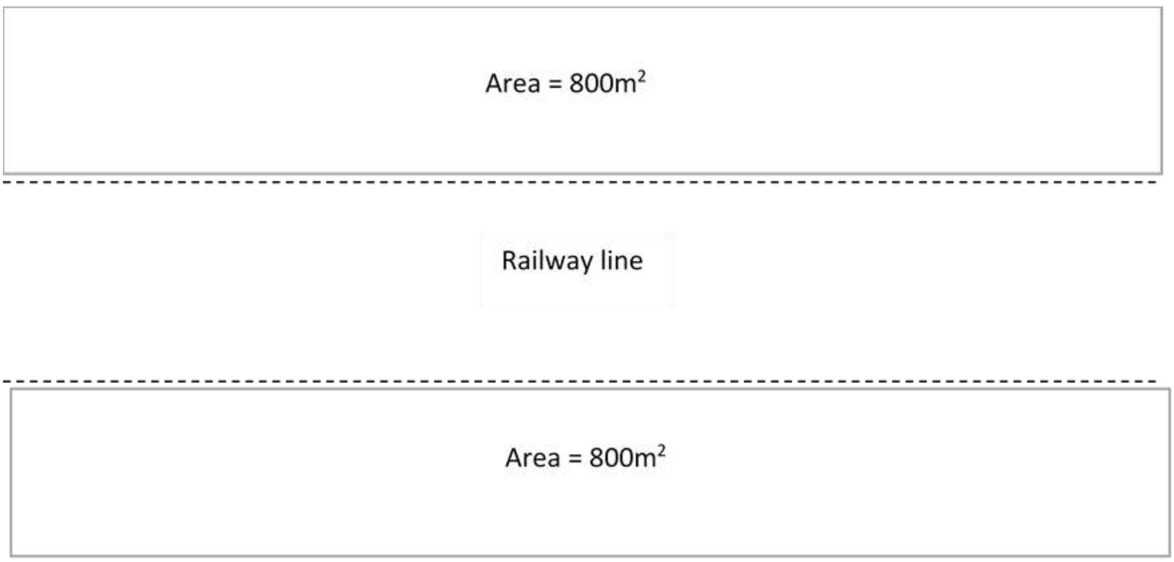


Figure 131: Plan view of rail over pass with area required for the solar panels

7.5 Implementation Costing

The following tables list the implementation costs for each subplan. All costs are estimates based on Rawlinson's Australian Construction Handbook 2017.

7.5.1 Water Quality Management

Table 98: Water Quality management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Onsite runoff testing	50		250	12,500
Stormwater testing unit	50		1,080	54,000
Wastewater cleaning unit	2		18,000	36,000
			Total	**$102,500**

7.5.2 Soil Quality management

Table 99: Soil quality management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Silt fencing	400	meters	14.50	5,800
Soil stockpile tarps	80	Days	16	1280
Soil wetting	80	Days	1500	120,000
			Total	**$127,080**

7.5.3 Air Quality Management

Table 100: Air quality management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Air quality and gas emission testing during construction	50	Tests	411	20,550
Dust removal when vehicles enter or leave the construction site	500	Occurrences	15	7500
Air quality and gas emission testing after construction	50	Tests	411	20,550
Air-filter systems (Dusts collectors)	2	Quantity	26147	52,294
			Total	**$100,894**

7.5.4 Flora Management

Table 101: Flora management cost

Item	Number of units	Units	Price/Unit	Cost ($)
2-year-old or more trees	89	Trees	350	31,150
Planting the trees	89	hours	30	2670
Zoysia macrantha grass	4760	m^2	72.6	345,576
Laying the grass	80	hours	30	2400
Sprinkler installation system				15,000
Fertilizing for new vegetation				5000
			Total	**$401,796**

7.5.5 Fauna Management

Table 102: Fauna management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Inspection report of fauna	1	Quantity	5000	5000
Relocation of fauna	1	Occurrences	15000	15,000
			Total	**$20,000**

7.5.6 Noise and Vibration Management

Table 103: Noise and Vibration management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Temporary noise barriers	2000	m^2	37	74,000
Monitor noise and vibration				100,000
Use of alternative equipment/activities				200,000
			Total	**$284,000**

7.5.7 Waste Management

Table 104: Waste management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Induction to waste management requirements				52,000
Waste management control	2000	m^2	300	600,000
Removal of waste and dumping	1600	m^2	27	43,200
Site inspection				40,000
			Total	**$735,000**

7.5.8 Energy Usage Management

Table 105: Energy use management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Energy efficiency pre-work induction				20,000
Audit of energy usage				40,000
			Total	**60,000**

7.5.9 Hazardous Materials

Table 106: Hazardous materials management cost

Item	Number of units	Units	Price/Unit	Cost ($)
Chemical handling and storage training			220	24,500
Spill response training			250	27,500
Hazardous materials storing cabinets	5		5539	27,695
Spill Kits	10		715	7150
Respirator units	10		405	4050
Removal of asbestos if required				125,000
			Total	**$215,895**

7.5.10 Solar Panels

Table 107: Solar panels cost

Item	Number of units	Units	Price/Unit	Cost ($)
Solar panels (installed)	658	KWh	1000	658,000
			Total	$658,000

7.5.11 Cost Summary

Area	Sub total
Water quality management	$102,500
Soil quality management	$127,080
Air quality management	$100,894
Flora management	$401,796
Fauna management	$20,000
Noise and Vibration management	$284,000
Waste management	$735,000
Energy usage management	$60,000
Hazardous materials management	$215,895
Solar panels	$658,000
GRAND TOTAL:	**$2,795,000**

The grand total cost for implanting this environmental management system is AU $2,795,000.

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CONSTRUCTION MANAGEMENT

8 CONSTRUCTION PLAN

8.1 Introduction

Construction planning is an essential and critical activity in any projects within the engineering sector. Elements such as choice of machinery and technology usage, tasks that will be carried out, estimation of required spaces, identifying the connection between the tasks, and duration to complete each task will have to be taken into consideration while carrying out a construction plan. Even though the construction planning is followed concurrently throughout a project, unexpected events such as weather condition or accidents will affect the project progress and makes it a critical task for all occupancies during construction. The Oaklands Park Grade Separation Project involves public as a major stakeholder in this upgrade. Hence DPC Engineering has proposed a preliminary construction plan in order to carry out the project in a safe manner and comply with community engagement policies. Please note the purpose of this plan is to demonstrate our design is practically feasible and consideration of safety in design. However, construction related issues are far greater than what have been identified in this plan. Further development will be required together with head contractor for a more comprehensive construction plan.

8.2 2nd review of 60 hours rail shutdown

From feasibility study, DPC has proved the maximum 60 hours track shutdown requirement is hard to achieve and proposed the temporary close train services between Marion and Warradale station during the entire construction period of rail overpass. As this will cause major impacts to the public transportation users. This requirement has been reviewed again prior to further detail design to see if there is any alternative construction methodology can reduce the hours of shutdown. The following issues have been identified in a construction point of view:

- It is impossible to build alternative railway overpass route parallel to existing railway line due to the space limitation of current available site
- To provide enough space to build railway overpass route while maintaining existing train service requires more land acquisition (all residential lands along railway). This will require significantly large change of current residential area planning and not economical
- The overall construction duration will be longer. Upon finish new railway overpass, the old railway line needs to be demolished with new planning to the land. This will continue causing traffic delay at the intersection of the roads even after the overpass is completed
- Stringent safety requirements are the major concern when carry out construction near railway line. Hefty fine will incur if train was stopped due to construction related issues.
- Community safety when access to railway station near construction site during construction

As a result, DPC would like to insist with our original proposal. The train services between Marion and Warradale railway station will be temporary closed during construction. The transport department of DPC Engineering has provided alternative express bus service operation between these stations for the public to continue to use Seaford Railway Line. More details can be found in the traffic management plan in section 2 of this report.

8.3 Project Staging

DPC Engineering has identified the connection between the work order that involved in this project and categories the construction planning into different stages in order. It is assumed the lands required have already acquired prior to following stages.

8.3.1 Staging for Railway overpass

8.3.1.1 Stage 1: Rail line closure and removals

The total structure length of the railway overpass concept in this project is about 800 meters and all the track elements have to be removed to prepare for the further construction. The railway service needs to be closed between Marion and Warradale stations. Once the railway closed, the construction site of overpass bridge needs to be fenced up immediately for demolition. Railway track element including ballast, sleepers, rails, and fastenings will be removed before proceeding to any further construction. The proposed boundary of construction site for overpass bridge is shown in Figure 132 below:

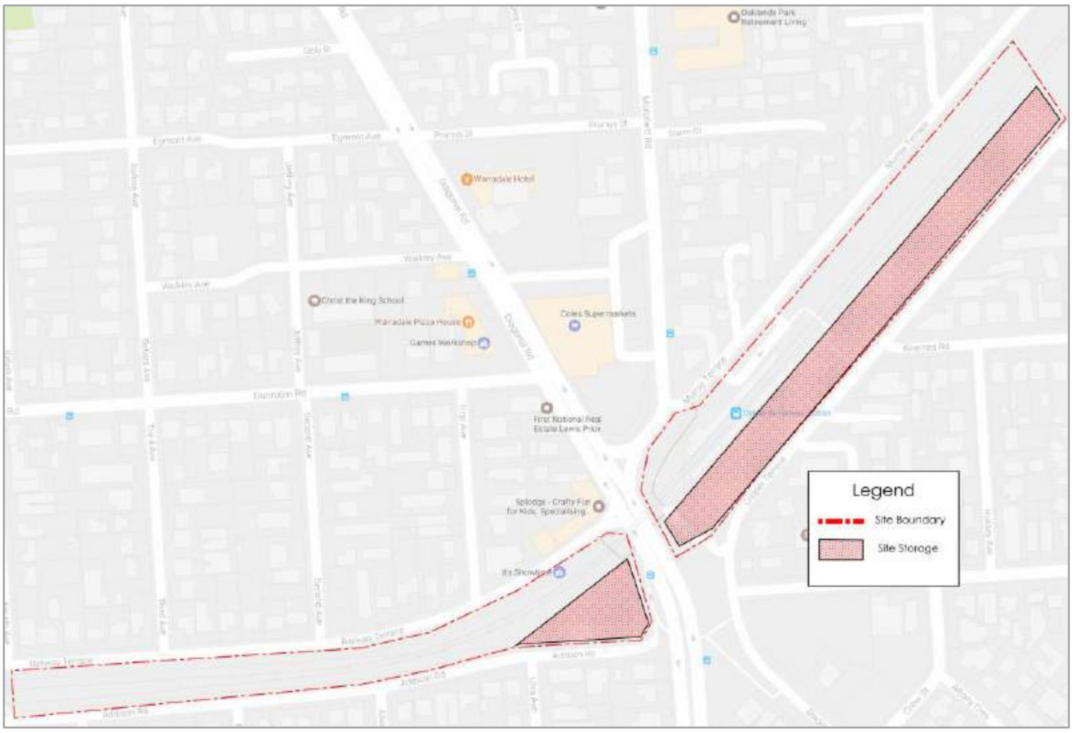


Figure 132: Rail overpass proposed construction site

8.3.1.2 Stage 2: Services relocation

The services department has identified a wide range of services that will be affected by this project which will be relocated after the railway track removals are done. The list of affected services includes:

- National Broadband Network (NBN)
- APA Gas Transmission Services
- SA Water Pipelines
- South Australia Power Network Cables

The service contractors need to start their relocation works as soon as the removal of railway tracks have completed. For detailed relocations, refer to section 5 of this report.

8.3.1.3 Stage 3: Piling

The geotechnical department has reviewed the existing soil profile in Marion area and computed the required number of the piles that will be driven into the ground and the location of these piles. Piling may be undertaken together with service relocation to shorten the over duration of construction programme. However, coordination will be required between service contractor and piling contractor to avoid common conflict. This will be reviewed again by the head contractor. The pile construction shall be undertaken concurrently from either side of the overpass and build toward the middle at the Morphett road intersection.

8.3.1.4 Stage 4: Embankment & Retaining Wall

Embankment for both ends of the railway overpass structure may be constructed concurrently with service relocation and piling if there is no conflict between these works. The length of the embankment is approximately 150 meters on each side and retaining wall height would be 3 meters. The retaining wall will adopt in-situ reinforced concrete.

8.3.1.5 Stage 5: Installation of substructure of the bridge

At this stage, capping beams, columns and headstocks will be constructed or installed. The capping beam will be in-situ reinforced concrete; while both columns and headstocks will be precast concrete. The capping beams can only be constructed after the piles have gained enough strength. The precast columns and headstocks will be stored in precast yard and transport to site when needed; and can only be placed after the concrete of capping beams reach enough strength. Due to the relatively narrow site, mobile crane will be adopted for all liftings. The most challenging area will be the overpass structures in the middle of the Morphett road. Temporary roads will be used to divert traffics to avoid the road closure during the construction of this part of the overpass. The transportation department has provided a detour plan for the traffic during the construction that takes place at the proposed railway bridge site. This will be discussed in detail in section 8.3.1.11.

8.3.1.6 Stage 6: Installation of superstructure of the bridge

Once the substructure is in place, the super T beam and railway deck will be installed. The super T beams are precast and decking will be poured in-situ. Due to the size and weight of super T beams, dual lift crane is proposed for lifting. It is anticipated there will be enough space for lifting equipment on east side of Morphett road where all the carparks are (as the site storage area in Figure 132); but will be tight on the west side of the Morphett road. It is possible to lift from the adjacent residential roads: Railway terrace and Addison road. But the trees along the site boundary need to be chopped off for clear access and extra safety shall be provided during lifting as it's very close to residential houses. The environmental team has addressed the tree removal issues and proposed mitigation strategy in their subplans.

8.3.1.7 Stage 7: Platform and new tracks installation

Once the main structure of the overpass is completed and concrete slab deck gain sufficient strength, new tracks are ready to be placed. The platform is a separate structure to the overpass bridge which can be constructed while placing the tracks. It is assumed the foundation piles have been placed during stage 3.

8.3.1.8 Stage 8: Stairs, lift shaft and storage rooms

These structures will be attached to the platform once the base structure of platform is completed. Other amenities will be installed at the same time

8.3.1.9 Stage 9: Services reconnection

The electricity, gas and water services need to be connected from existing service lines to the new station. Electrification structures shall be constructed and connected for the train operations. This can be carried out concurrently with stage 8 if there is no conflict.

8.3.1.10 Stage 10: Architectural screens

Noise barriers, anti-suicide screens and architectural façade panels will be installed in this stage. Most of these items will be able to install from the decking except for the façade panels. These modular panels will need to be bolted on via a scissor lift from the ground level.

8.3.1.11 Overpass construction over Morphett Road

As mentioned in section 8.3.1.5, Morphett road will be temporary closed for the construction of this part of the overpass. As per traffic management plan, the traffics from northbound of Diagonal road will be diverted through detour 1 as shown in Figure 133 below; and traffics from northbound of Morphett road will be diverted through detour 2. The red shaded area will be closed for construction. Once the construction zone is fenced, the foundation and the substructure of the overpass will be started. During this time, the road upgrade within this area can also be taken place concurrently. This includes a new intersection jointing Morphett road and Diagonal road. After the Super T girders have been lifted in place, a temporary work platform can be formed for slab deck pouring and any further works. The Morphett road can be then reopened after the temporary work platform is formed. It is anticipated the detours will slow the traffics down significantly, thus the Morphett road closure time needs to be minimised. Early strength concrete will be adopted to ensure the foundation and substructure can be built up sooner. DPC also suggests road upgrade is to be constructed on the 24 hours work shift to match the progress of overpass structure.

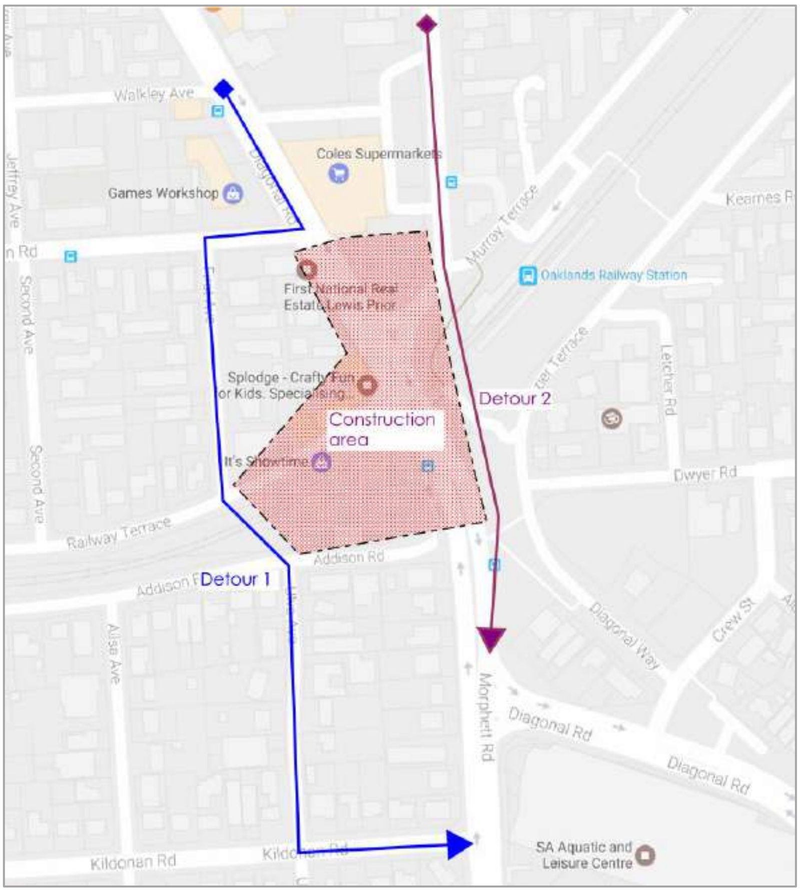


Figure 133: Detours for overpass construction over Morphett road

8.3.2 Staging for Road

8.3.2.1 Stage 1: Building temporary roads

Temporary roads shall be constructed whenever available to prepare for the Morphett road closure as detailed in section 8.3.1.11. The challenge will be the road construction across the construction zone under the railway overpass between Railway terrace and Addison road of detour 1; and between Murray terrace and southbound of Morphett road of detour 2. It is important to ensure the temporary road construction won't slow down the progress of main overpass construction and maintain safety for traffics across the construction zone.

8.3.2.2 Stage 2: Traffic diversions

Throughout this project, the transport department has proposed with traffic control plan and traffic diversion plan to make sure the road users have a reasonable connectivity from major roads to minor roads located in the Marion area. This stage has to be carried out throughout the project and risk management plan also will be developed that can be applied according to different situation.

8.3.2.3 Stage 3: Building new roads

The new roads construction will be spilt into two sub-stages. The road upgrade at Morphett road and Diagonal road intersection and surrounds will be undertaken during the Morphett road closure. The rest of the northbound of Diagonal road as well as the Prunus street will be constructed after the Morphett road reopened. The Diagonal road will be closed into two lanes (one lane each way) for the upgrade. The traffics will be expected to be carried by the Morphett road through the new Morphett road and Diagonal road intersection. It is also important to ensure Diagonal road and Prunus street upgrade won't occur at the same time, so the traffic can be diverted into one or the other.

8.3.2.4 Stage 4: Amenities installation and testing

This stage will install all amenities which include traffic signs and signals. Amenities along the roads can be installed along with stage 3 of the road construction.

8.4 Project Sequencing

The project construction involves railway bridge and surrounding major road upgrade, thus the construction site is relatively large. DPC engineering proposes to divide the overall construction zone into 3 sectors as shown in below figure. The purpose of it is to minimise the traffic congestion during construction, shorten overall programme duration and make the project construction easy to manage.

Figure 134: Proposed project sectors

For sector 1 construction as shown in the blue shaded area, the railway has to be closed so the demolition can start to removal all the existing rails and structures. There will be an express bus service to transport passenger from Marion station to Warradale station as detailed in traffic management plan. After all the existing structures have been removed, construction team can start their foundation works, at the same time, service relocation and retaining wall can be carried out concurrently, but coordination between contractors will be required.

When substructure works start, the temporary road construction can start at the same time. This temporary roads as indicated in red arrow is to provide detours to traffics when sector 2 is closing down for construction. Once the super T beam has been lifted in place and temporary work platform has been built up. It is assumed the temporary road is completed and sector 2 can be shut down for construction.

The rest of this sector's construction is relatively linear, once the slab deck formed enough strength, the new tracks can be put in, at the same time, the new platform can be constructed as it is a separate structure to the main bridge. And the whole sector finished with service reconnection and façade installation and car parks. A detailed sequencing is shown in Figure 135.

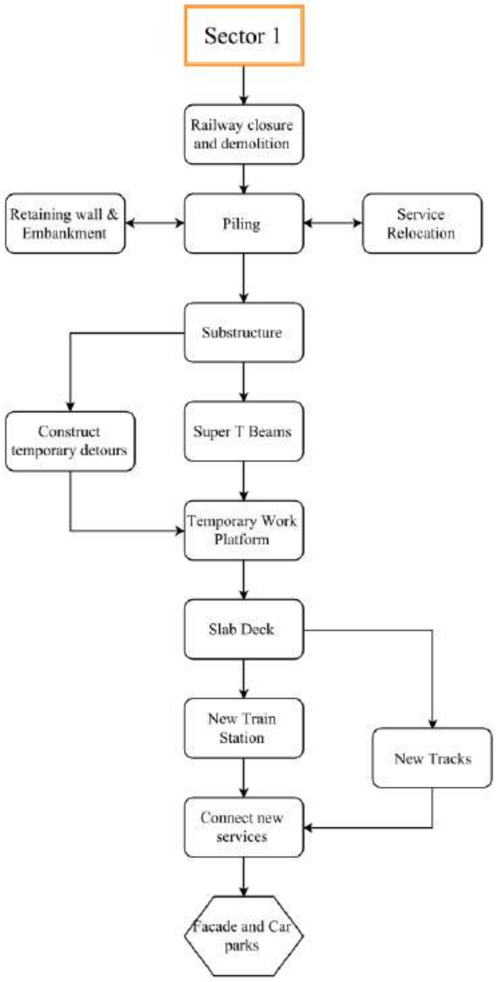


Figure 135: Sector 1 sequencing

Sector 2 construction as shaded in red area can be started as soon as the detour is finished and the temporary work platform is up. The intersection of Morphett road and Diagonal road will be closed for upgrade. At the same time, the construction team can start doing foundation, substructure of the overpass above the intersection. Same as in section 1, once the super T beams lifted in place and temporary platform is up, the road can be reopened. The challenge here is to have road upgrade finished at the same time as the bridge structure. The whole sector 2 construction also needs to have a very compact timeline, because the close down of Morphett road and Diagonal road will cause major traffic congestion in this area. It is preferred to have a 2 – 3 weeks construction period. A detailed sequencing of sector 2 is shown in Figure 136.

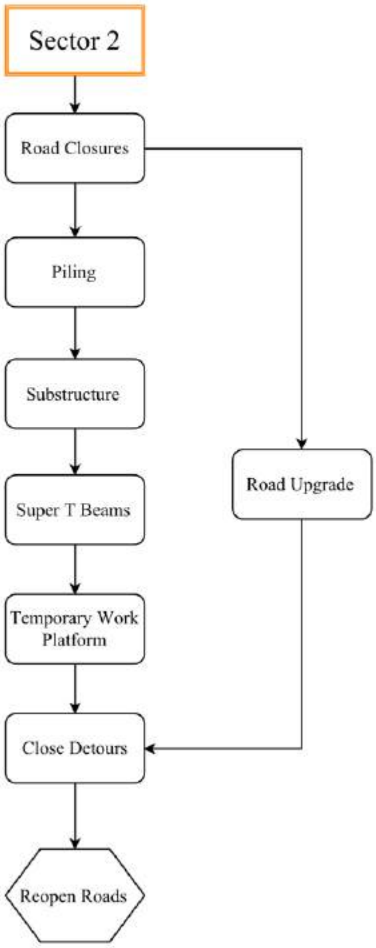


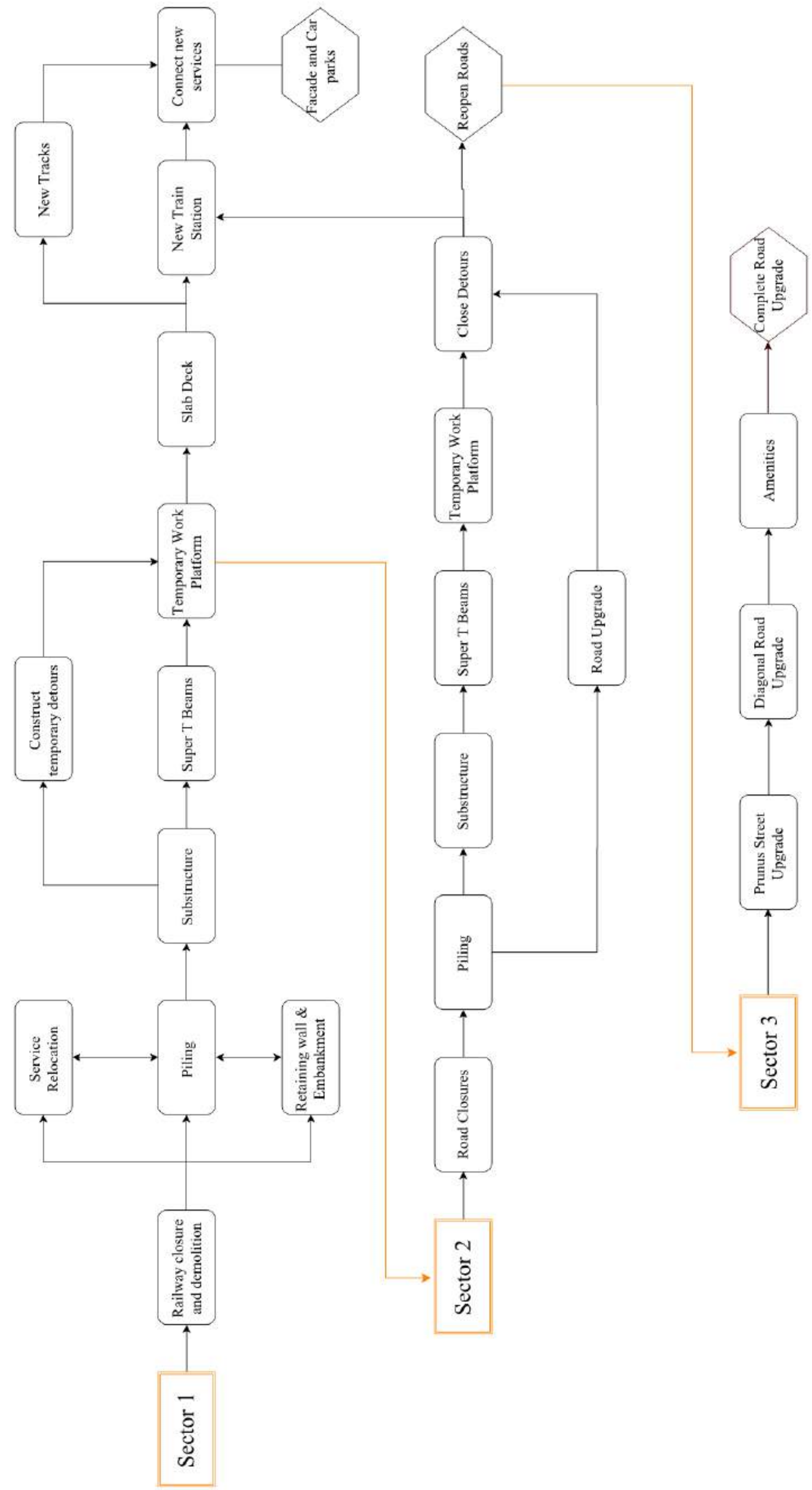
Figure 136: Sector 2 sequencing

After the sector 2 is finished, the sector 3 works can start. This is mainly just the road upgrade for both Diagonal road and Prunus St. It is important to maintain one road open while the other one is under construction to minimise the traffic impacts. We propose to have Prunus St upgrade first, once it completed, Diagonal road upgrade can start. The Diagonal road will be down to 1 lane per direction during construction, half of the traffic flow will be diverted to Morphett road through newly upgraded Prunus ST. A detailed sequencing of sector 2 is shown in Figure 137.

Figure 137: Sector 3 sequencing

It is anticipated sector 1 construction will continue even after the sector 3 works have done as it covers 80% of the project. However, the road under the overpass is fully upgraded and traffic flow is improved.

The relationship of overall sequencing is summarised and shown on next page:


Sector 1
Railway closure and demolition
Service Relocation
Piling
Retaining wall & Embankment
Substructure
Construct temporary detours
Super T Beams
Temporary Work Platform
Slab Deck
New Train Station
New Tracks
Connect new services
Facade and Car parks
Sector 2
Road Closures
Piling
Substructure
Super T Beams
Temporary Work Platform
Close Detours
Road Upgrade
Reopen Roads
Sector 3
Prunus Street Upgrade
Diagonal Road Upgrade
Amenities
Complete Road Upgrade

8.5 Safety

In Australia under the construction work understanding the work health and safety regulation ACT 2012, to create a safe work environment is a mandatory safety obligation. Due to the high risk of work-related injuries and health issues work health and safety regulation is priority nominated for the construction industries. Several investigations mentioned that main cause of the injuries and illness could be risk taking, not using the right equipment and using alcohol and drugs. It is the main duty of construction and other work industries to provide health and safety training as induction for employees and make sure all workers have a white card. In this project safety measures before construction, during construction and after construction will be considered. The management of work health and safety are described below:

- Informing the affected community along the route about road upgrade and procedure by holding meetings with them.
- Sending a letter about progress, changes and route restrictions along work site.
- The road signs and advertisement will be used to provide information road closed during the construction period and to divert traffic.
- From health and safety team to provide information about health and safety procedure and does a regular site visit to make sure health and safety procedure has used in a construction site and make sure worker has a white card.
- The team will make sure that workers are wearing personal protective equipment (PPE) and highly visibility clothing.
- Identifying the risk and hazard and do risk assessment for risk mitigation.
- Allocate the dumping area for disposal of waste material used in construction to reduce the health issue.
- Put a barrier around construction area to avoid entrance of uninvited people like children.
- The weekly information meeting with workers and health and safety team to provide any changes in safety procedure.
- Report any incident or accident happen in construction, to health and safety team and take immediate action eliminate it and provide health care if needed.
- Report any hazard like naked wear and spoil of chemical.
- Use appropriate PPE to reduce the consequence of having falls, slips or trips on a construction site.

9 COSTINGS

The total estimated project cost is shown as below with breakdown in areas. This price is subject to a fluctuation of 10% as most of the costs were taken from "Rawlinsons Quantity Surveyors and Construction Cost Consultants" book and does not necessarily reflect the market value of the project. DPC Engineering recommends the client to run through a proper tender process and to obtain a more competitive price from the market.

Table 108: Project total costing breakdown

Area	Sub total
Transportation	$7,520,000
Structures	$19,934,000
Geotechnical	$7,767,000
Services and stormwater	$2,995,000
Urban design and community	$16,777,000
Environmental	$2,795,000
GRAND TOTAL:	**$57,788,000**

DPC expected the final cost of the project to be around $58 million dollars. This total cost of the project is based on the evaluations and costing from the 6 design teams.