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Document 4

Torquay Rail Link - Design Report

Final Report

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Final Report

Client: Public Transport Victoria

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Reviewed by [redacted]

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
a	31-May-2012	For PTV Review		
b	27-Aug-2014	Final Report - New Issue for Hybrid Option	[redacted] Associate Director	

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Executive Summary

This report is an update of a 2012 report entitled *"Torquay Transit Corridor Options Preservation"*, produced for the then Department of Planning and Community Development. It incorporates changes arising from further rail concept design undertaken in 2014 for Public Transport Victoria.

The Torquay Rail Link concept design has been produced for Public Transport Victoria (PTV), along the alignment of the Torquay Transit Corridor (TTC). The Torquay Transit Corridor is planned to link Marshall Railway Station in the southern suburbs of Geelong with Torquay. It is located broadly parallel to the Surf Coast Highway. The corridor is currently planned as a general purpose 'transit corridor', intended for a high quality transit service, either as a busway, or light or heavy rail.

Heavy rail is the most constrained of mass transit modes in terms of engineering requirements and sets the most demanding design parameters. The approach through this concept design is to investigate what land footprint is required in planning for heavy rail, and the subsequent implications on land requirements by providing for additional modes.

Two feasible alignments for the corridor were identified in 2012. Both are preferable from an engineering perspective and are compatible with known land use and environmental constraints. Subsequent design refinements in 2014 have been incorporated and are shown on the alignment shown in Appendix A. It should be noted that this option will need to be further developed, and that fieldwork will be required to quantify important potential impacts. It may be required to modify the option as a result of fieldworks.

The key design features of the alignment are:

- Provision for stations at Armstrong Creek and Torquay North, based on a strategic assessment of connectivity across the region, consideration of land use planning and technical constraints
- Design speed of 100 km/h for rail, except for the approach to Torquay which is 80km/h
- Consistency with land use plans in Greater Geelong and Surf Coast Shire areas
- Grade separation of intersecting roads for rail

Sub-options have been developed for the vertical alignment between Burvilles Road and Lower Duneed Road. The base option raises the rail alignment to provide rail bridges over Warralilly Boulevard (Stewarts Road) and Coastside Drive. Following stakeholder feedback, an alternative vertical alignment has been developed with Warralilly Boulevard and Coastside Drive designed at-grade potentially with level crossings. The base design proposed the rail remaining at ground level where it crosses Lower Duneed Road with a road overpass of the rail line being provided. An alternative vertical alignment has been developed following stakeholder feedback with the rail being placed in a cutting under Lower Duneed Road.

The alignments identified preserve a suite of strategic options, including:

- There is flexibility to refine design in the future, especially through use of steeper gradients, to allow for optimisation following detailed survey and design.
- The corridor retains flexibility to adopt more demanding technical standards, assuming that technology improves over time.
- Torquay Station will be located north of Torquay's urban growth boundary just north of John Pawson Junior Lane as shown in the drawings in Appendix A, however the precise station location is flexible in the design, allowing for integrated transport and land use development planning to occur if required.

Should further project development proceed, AECOM recommends that

- targeted field studies are undertaken along the corridor and the environs, addressing gaps in the data available, including but not limited to:
  - Indigenous archaeology, heritage and cultural values
  - European archaeology, heritage and cultural values
  - Flora and fauna
- alignments are refined in the light of any new constraints identified following field checking.

a risk assessment is undertaken of corridor encroachment in the green belt area versus formal protection.

- If it is determined that formal protection is warranted, then complete a multi-criteria assessment of the route options and undertake the relevant planning scheme amendments based on the content of this study.

1.0 Introduction

1.1 Study context

This Torquay Rail Link concept design has been produced for Public Transport Victoria (PTV), along the alignment of the Torquay Transit Corridor (TTC).

The TTC is planned to link Marshall Railway Station in the southern suburbs of Geelong with Torquay. It is located broadly parallel to the Surf Coast Highway. A map of the Corridor supplied by PTV is shown in Figure 1.

This report is an update of a 2012 report entitled *"Torquay Transit Corridor Options Preservation"*, produced for the then Department of Planning and Community Development, incorporating changes arising from further rail concept design undertaken in 2014 for Public Transport Victoria.

The corridor is a general purpose 'transit corridor', intended for a high quality transit service, either as a busway, or light or heavy rail.

1.2 Study objectives

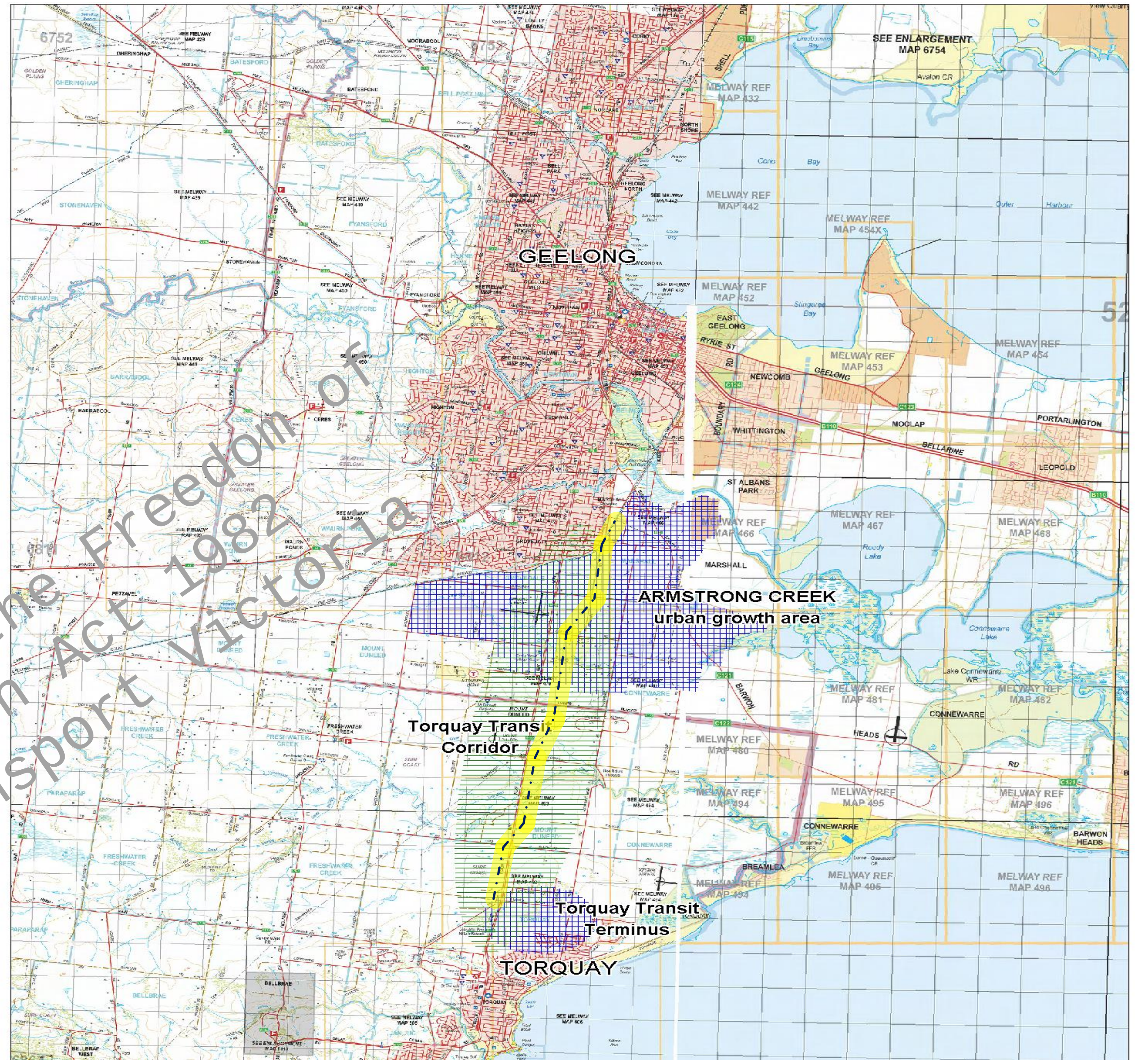
The objectives of study are to:

- Review and refine the previous heavy rail options prepared in 2012
- Review the station location for Torquay in the context of current land availability
- Develop station layouts for Armstrong Creek and Torquay

1.3 Approach to the study

Heavy rail is the most constrained of mass transit modes in terms of engineering requirements and sets the most demanding design parameters. The approach through this study has been to investigate what land footprint is required in planning for heavy rail, and the subsequent implications on land requirements by providing for additional modes.

Figure 1 Overview of Torquay Transit Corridor



2.0 Corridor Planning Context

2.1 Existing features relevant to design

Table 1 summarises key existing features of the corridor that influence design.

Table 1 Existing features relevant to design

Feature	Description
Roads	- The corridor is crossed east-west by one major arterial road (Lower Duneed Road) and seven minor roads. - The corridor is parallel to Barwarre Road. Barwarre Road is an unsealed one lane road planned to become a greenway north of Boundary Road. - The corridor runs generally parallel to Surf Coast Highway, a major arterial road. The alignment options cross the Surf Coast Highway once.
Geology	- Generally alluvial materials. Band of basalt between Armstrong Creek and Thompsons Creek.
Topography	- Generally flat to undulating. • Armstrong Creek Town Centre and Torquay North are both located on low ridges. • Mount Duneed is a prominent hill about half-way along the corridor on the west side of the Surf Coast Highway. - Highest point on corridor: at Torquay, approximately 50m above sea level - Lowest point on corridor: at northern extremity, approximately 15m above sea level
Drainage	- From north to south, natural drainage points and lines are located at the northern end of the corridor (south of Reserve Road), south of Armstrong Creek Town Centre (Armstrong Creek proper), Thompsons Creek, at start of the Deep Creek catchment at the southern end of the corridor.
Native Vegetation	- Plains Grassland is known to exist along Barwarre Road. A 10m easement has been recommended in the Framework Plan. There are also known areas of native vegetation along some creek lines.
Established and planned developments	- There are a number of houses and farms in the corridor area. Most of the corridor is currently used for low-intensity farming, with some scattered rural residential development. - A corridor has been described in the Greater Geelong Planning Scheme to traverse through the Armstrong Creek Town Centre. - The existing Torquay urban footprint and future urban expansion as currently planned.

Figure 2 Overview map of the environs of the Torquay Transit Corridor

2.2 Existing and planned rail conditions

2.2.1 Existing infrastructure and possible improvements

The current rail infrastructure at the northern end of the corridor is a single track broad gauge line from Geelong to Warrnambool. Marshall Station is located just north of where the Transit Corridor meets the mainline. The existing railway has a level crossing on Reserve Road south of Marshall Station. The existing constrained single track section south of Geelong station includes a tunnel and long bridge over the Barwon River.

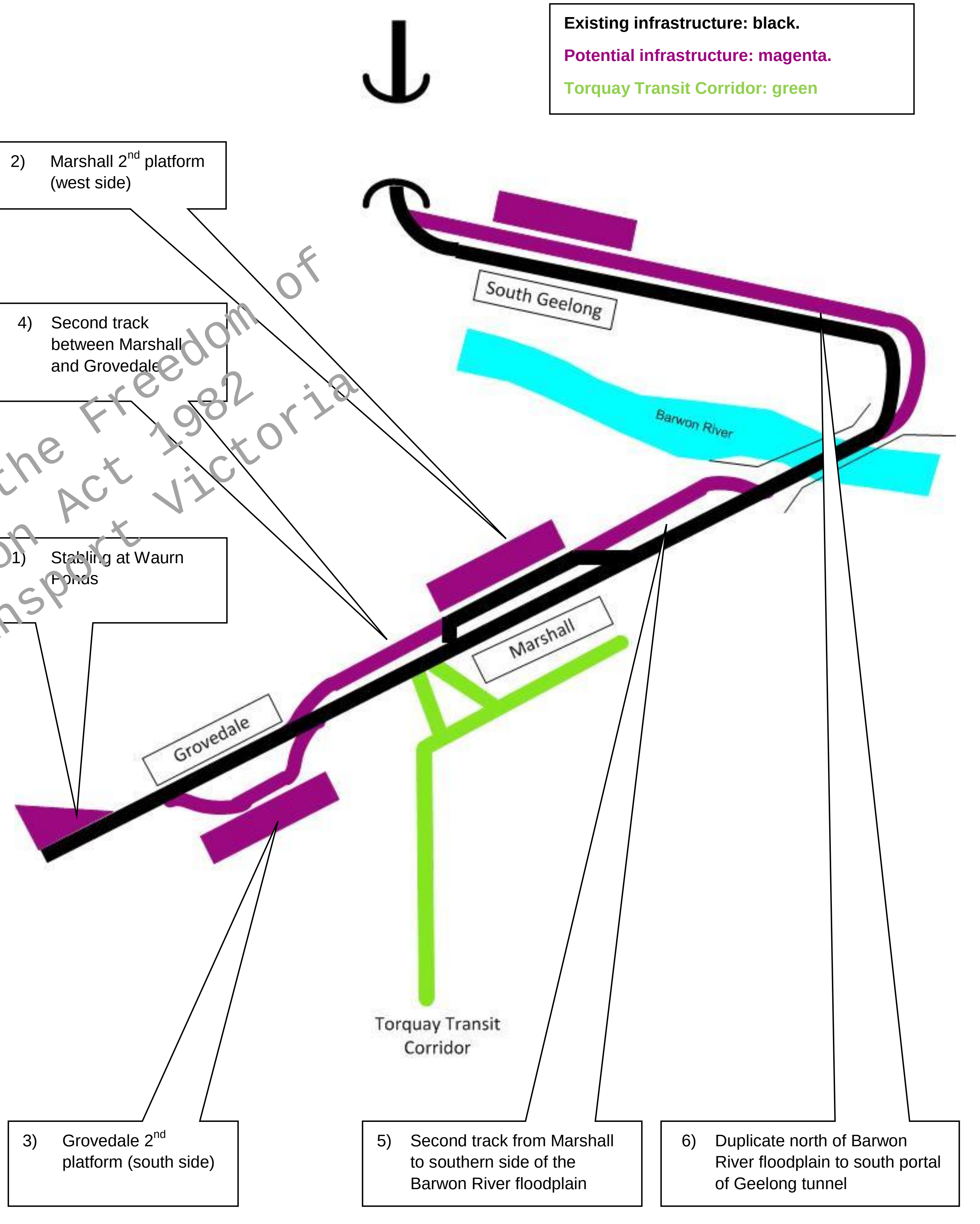
Potential future enhancements envisaged between Geelong and Waurn Ponds are listed below and shown on Figure 3:

2.2.2 Strategic service plans

Grovedale Station is currently under construction and due for completion in late 2014. It is located about 5 kms west of Marshall. Future services on the Geelong corridor will operate via the Regional Rail Link in 2016, so service levels at Marshall may change as operational planning for these projects progress. It is assumed that as many future Marshall trains as possible will start from Grovedale.

Prior to track duplication between South Geelong and Grovedale, , shuttle services are envisaged to operate between Torquay and Marshall, with passenger transfers at Marshall station for onward connection to Geelong / Melbourne and Warrnambool services. The concept design for the Torquay rail link includes a connection to the main line at Marshall to permit access to stabling and maintenance facilities.

Figure 3 Indicative sketch of potential rail capacity upgrades



2.3 Rail design standards

For TTC planning purposes, rail infrastructure shall be designed in accordance with Victorian Rail Industry Operator Group (VRIOG) standards for future electrification as a passenger railway. A major driver of the land use footprint is earthworks. As detailed geotechnical investigations have not been undertaken, it has been assumed that track formation earthworks batter slopes will be at 1 in 2 where possible (i.e. each one metre of depth requires two metres of horizontal width) and a corridor width of 40m. Retaining walls may be required to retain the earthworks within the rail corridor width, but this will be at a greater cost.

The following assumptions have been made in preparing the concept design:

- The finest-scale contours supplied have been used.
- Structural depth and road pavement depth of 1.5m for road bridges and 2.0m for rail bridges. This can be refined with detailed design.
- The gradient at the planned station sites is minimal for drainage only.
- Gradients and curves compliant with VRIOG standards.

Table 2 Design parameters

Design element	Rail Design Standard
Minimum gradient Maximum gradient	- Desirable minimum 0.25% in cutting for drainage - Maximum 2.0% for passenger lines.
Vertical curves	- Distance of 25m between curves - Minimum radii for sags: 6,700m - Minimum radii for summits: 3,350m
Maximum horizontal curve radius for speed	- 80km/h: 500m - 100km/h: 800m - 115km/h: 950m - 160km/h: 1,650m
Vertical clearance	5.75m (V2) clearance from rail to underside of road bridges to permit electrification. i.e. 7.25m to allow for structural depth so that roads remain at natural ground level.
Horizontal clearances	- Envelope B in VRIOGS i.e. - Track centres: 4m - Track horizontal clearances: 4m each
Grade separation	Required
Embankment slopes	- 1V:2H preferred - 1V:1.5H maximum
Cutting slopes	1:1 subject to geotechnical conditions
Allowance for rail systems.	2.0m wide verge incorporated.

2.4 Rail corridor design implications

The design implications are summarised in Table 3, in the order in which they generally shape the design strategy.

Wherever possible, the corridor has been identified to be as straight as possible with earthworks reduced to the minimum feasible amount.

The existing structures and buildings, topography, roads, drainage considerations and existing rail interface requirements are constraints throughout the corridor. Land use plans are a constraint between Marshall and the Geelong urban growth boundary, and on the approach into Torquay. A consequence of the land use plan is that deep cuttings are required to achieve the rail engineering requirements.

The permissible line speed in the vicinity of Armstrong Creek station is100 km/h and on the approach to Torquay is 80km/h. Elsewhere the alignment permits 160km/h operations subject to the track being constructed to Regional Fast Rail high performance standards, which include 60kg rail and concrete sleepers.

Table 3 Summary of design implications

Design constraint	Design response
Existing structures and buildings	- Avoid demolition of built structures visible on aerial photography, including houses, farm buildings and high-tension power line towers.
Topography	- Gently undulating topography means that a railway could be developed at close to natural ground levels - Limited earthworks required due to topographical constraints. Default design response would provide embanking on approach to the Armstrong Creek ridge line with limited cut through ridge at Torquay Station.
Existing roads	- Grade separation required where roads remain open. Default design response would raise or lower roads rather than rail corridor, as roads are less constrained than rail in alignment requirements. - Ridge and depression topography can be exploited to achieve grade separations where railway requires a structure or cut to achieve gradient requirements. This applies at two sites – Warralily Boulevard and the Surf Coast Highway near Torquay.
Drainage	- Creek lines impose a very strong preference for rail to be at surface/elevated as tunnelling under watercourses is cost-prohibitive - even if technically possible. The default rail design would ensure a high point at ridgelines, including Armstrong Creek Town Centre [ACTC], draining north and south. - The concept design has a nominal longitudinal slope throughout to allow for drainage. - It is recommended that roads in Armstrong Creek Town Centre, and surrounding properties, be constructed at a higher level to minimise the excavation and cost of a future railway.
Existing rail interface requirements	- An additional platform face at Marshall is proposed for a shuttle service, with a connection available to the main line to access depot and stabling facilities.
Land use plans	- Constrain transit corridor to provide grade separation for planned roads in Horseshoe Bend precinct and master plan area, including existing roads. - Town Centre Master Plan is based around rail-under-road grade separations with roads at natural ground level. - Accounting for the Master Plan means an elevated option has not been developed. - Significant length of cutting through the ACTC. Requires assisted drainage, such as pumps, as the base of cutting is below the surrounding watercourse levels. - Planning for East-West arterial road is still in development. The designs in this interim report will need to evolve, and be coordinated with the east-west road design as the development of both proposals continues. - Torquay Sustainable Futures Plan and stakeholder engagement with Surf Coast Shire indicated a preference for a station north of John Pawson Junior Lane, and west of Surf Coast Highway.
Vertical clearance	- Requires cutting exceeding 9m depth.

3.0 Corridor design

3.1 Horizontal Design

The horizontal alignment follows, for a large part, the Eastern Alignment as described in the 2012 “Torquay Transit Corridor – Options Preservation Report”. The main changes following feedback from stakeholders are:

- Alignment crosses to the west side of the Surf Coast Highway at-grade just north of Blackgate Road, with the Surf Coast Highway raised over the TTC
- Torquay terminus station is just north of John Pawson Junior Lane, as envisaged by Surf Coast Council.

The alignment is relatively fixed by the Armstrong Creek Town in the north and the Torquay terminus station in the south. However, there is scope for alignment alternatives between Lower Duneed Road and Blackgate Road.

Figure 5 provides an overview of the key features along the developed option, together with an alternative horizontal route option between Lower Duneed Road and Blackgate Road. Biosite data from the GIS database is also shown. The developed option has marginally less direct impact on farm dwellings compared to the alternative route. It is emphasised that the developed design has been based on the desktop level data available during the course of the study and is therefore not necessarily the preferred alignment. The alternative route or a hybrid route may be preferred should the developed option not be feasible or economical for environmental or engineering reasons.

Horizontal and vertical concept alignments are given in Appendix A for.

Key features of the designs are highlighted with colour-coded callout boxes.

Orange callouts highlight constraints.

Blue callouts highlight potential impacts.

Green callouts highlight design features.

3.2 Vertical Design options

Options have been developed for the vertical alignment for the section between Burvilles Road and Lower Duneed Road. The developed option raises the rail alignment above the ground level between Armstrong Creek and Coastside Drive, resulting in rail bridge grade separations over Warralilly Boulevard (Stewarts Road) and Coastside Drive. A less intrusive alternative vertical alignment is also shown on the plan SK-0204 in Appendix A which lowers the rail between Burvilles Road and Lower Duneed Road, resulting in Warralilly Boulevard and Coastside Drive being at grade potentially with level crossings.

The developed option proposes raising Lower Duneed Road over the proposed the rail alignment. Following stakeholder feedback an option to place the rail in a cutting under the existing alignment of Lower Duneed Road has been developed, as shown on plan SK-0205.

3.3 Station design

Station layouts have been developed for Armstrong Creek and Torquay.

Armstrong Creek is proposed to be a town centre station. The station layout shown in SK-0005, included in Appendix A, is planned to have an ultimate side platform configuration to minimise the volume of earthworks cut, compared to an island platform configuration. Interchange bus stops are located adjacent to the future Main Street and Connector Road A. No commuter parking is proposed for this station, which is in line with the town centre structure plan and the desire to activate the station precinct to maximise:

- integration with the town centre
- walk-up and cycling patronage
- feeder bus patronage
- safety and crime prevention.

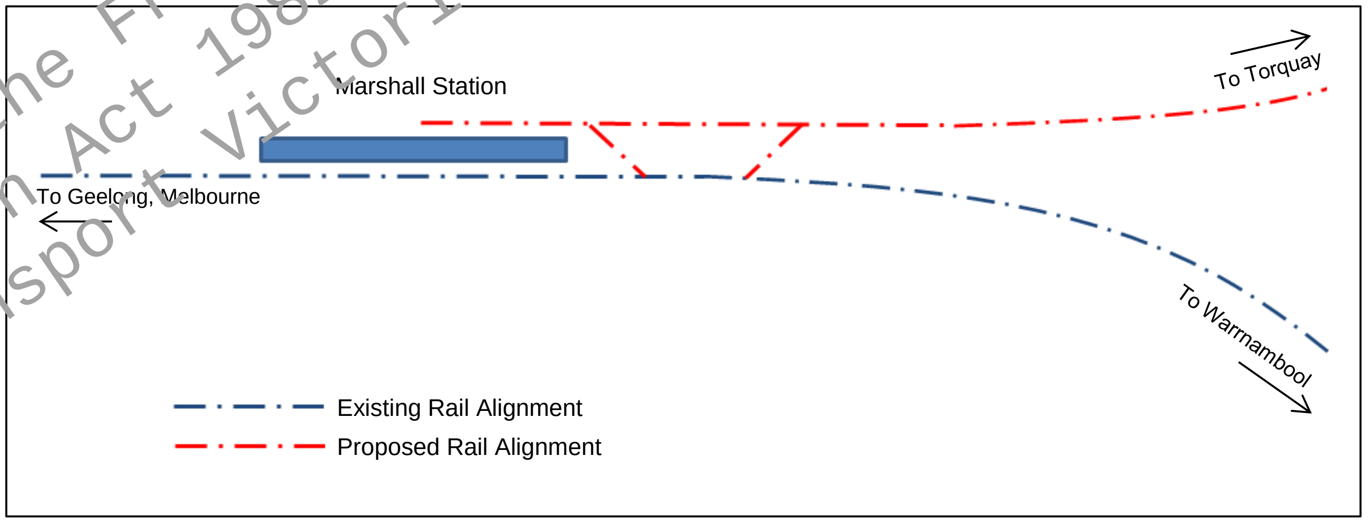
Torquay Station is proposed to be a terminus station and is located just north of the town’s urban growth boundary. A concept layout for the station is shown in drawing SK-0003 in Appendix A, the main features being:

- Station access from John Pawson Junior Lane
- Bus interchange
- Taxi and Kiss ‘n’ ride
- Nominal parking for 200 cars, with future expansion to 400 cars
- Island platform configuration, should a second terminating track be desired.

3.4 Rail configuration

The proposed rail configuration shown in Figure 4 has been developed to enable shuttle services to operate on the single line between Torquay and Marshall without impacting the reliability of the existing services between Warrnambool, Grovedale and Geelong. The existing side platform at Marshall is proposed to be converted to an island platform to enable convenient cross platform transfers. Crossovers are proposed as shown to enable the Torquay line fleet to access depot and stabling facilities. The crossover furthest from Marshall could also permit revenue services to continue through to Geelong subject to train path availability.

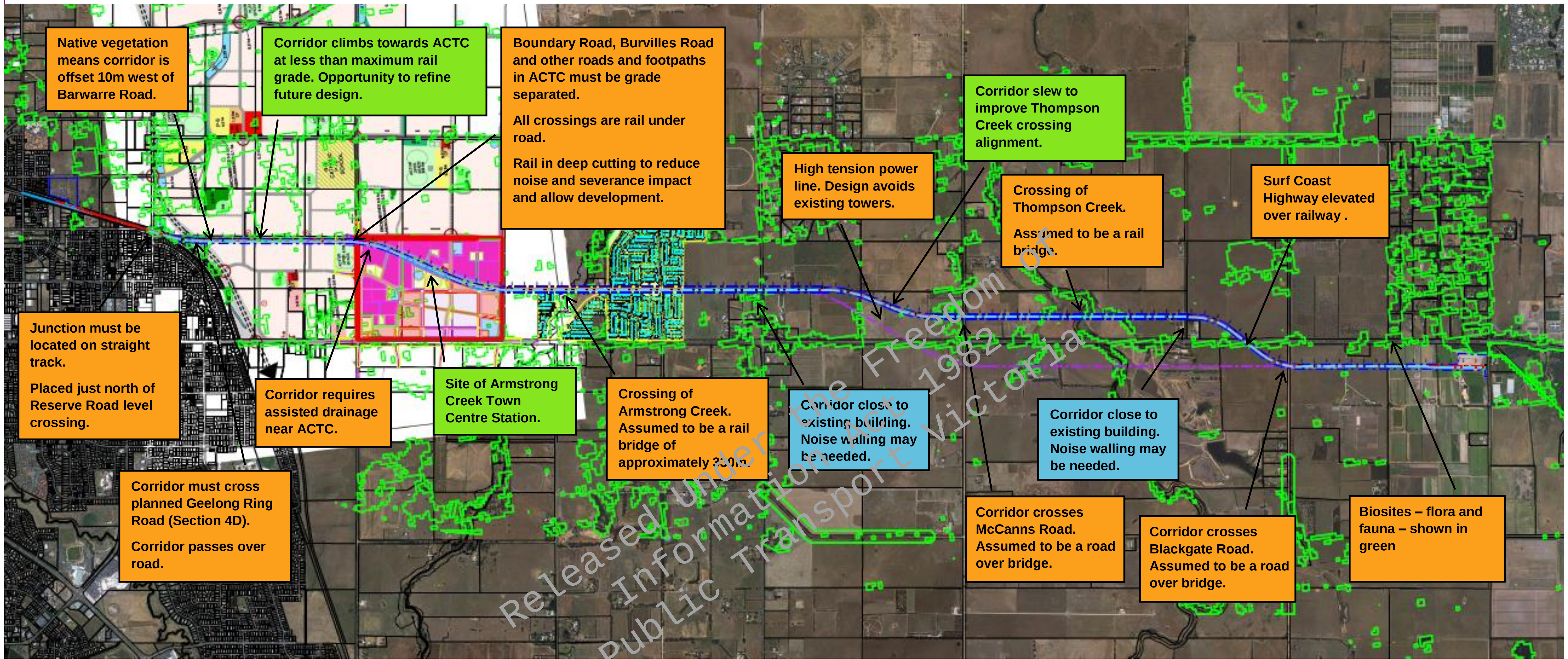
Figure 4 Concept arrangement for the junction between the TTC and Warrnambool line



3.5 Concept design for key grade separations

A number of potential grade separations are required to deliver rail on the TTC, as shown on the drawings in Appendix A. These are listed in Table 4.

Figure 5 Developed Option and Alignment Alternative



Disclaimer added 19/04/2017
An alignment for the corridor between Armstrong Creek and Torquay North has not yet been agreed between stakeholders, nor has the location of a terminus of a transport corridor been fixed within Torquay North.

Table 4 Analysis of road network connectivity considerations

Description of road		Network considerations towards Geelong			Network considerations towards Torquay			Recommendation
Road Name	Function	Nearest alternative if closed	Network suitability of alternative	Additional distance	Nearest alternative if closed	Network suitability of alternative	Additional distance	
East – West Connector Road Chainage 81000	Planned major arterial road.	Not applicable – road is currently in planning phase.						Grade separate (Road over rail) design to be developed in coordination with VicRoads.
Barwarre Road	Local access road through planned urban growth area.	Not applicable – road is proposed to be discontinued and replaced with a 'greenway'.						Note change to road function.
Future Connector Road Chainage 81280	East-west collector road through planned Horseshoe Bend urban area	The Master Plan indicates that this road may be truncated if a railway is developed.						Truncated if a railway is developed
Future Connector Road Chainage 81800	East-west collector road through planned Horseshoe Bend urban area	The Master Plan indicates that this road may have a bridge if a railway is developed.						Design allows for grade separation if desired.
Boundary Road	Local access road through planned urban growth area.	Not applicable – road has a key role in the urban growth land use plans						Assume grade separation. It is recommended the road (and surrounding properties) be constructed at a higher level to minimise the excavation and cost of a future railway, and to remove any drainage issues.
Connector Road B	Local access road through planned urban growth area.	Not applicable – road has a key role in the urban growth land use plans						Assume grade separation. It is recommended the road (and surrounding properties) be constructed at a higher level to minimise the excavation and cost of a future railway, and to remove any drainage issues.
Main Street, Armstrong Creek Town Centre	Planned urban street through activity centre.	Not applicable – road has a key role in the urban growth land use plans						Assume grade separation. It is recommended the road (and surrounding properties) be constructed at a higher level to minimise the excavation and cost of a future railway, and to remove any drainage issues.
Burvilles Road	Local access road through planned urban growth area.	Not applicable – road has a key role in the urban growth land use plans						Assume grade separation. It is recommended the road (and surrounding properties) be constructed at a higher level to minimise the excavation and cost of a future railway, and to remove any drainage issues.
Stewarts Road / Warralilly Boulevard	Local access road through planned urban growth area.	Two options have been prepared. The initial option assumes a grade separated rail over road, but an alternative at grade rail/road crossing option has been prepared at the request of the City of Greater Geelong.						At-grade crossing preferred by City of Greater Geelong
Coastside Drive	Local access road constructed urban growth area.	Two options have been prepared. The initial option assumes a grade separated rail over road, but an alternative at grade rail/road crossing option has been prepared at the request of the City of Greater Geelong.						At-grade crossing preferred by City of Greater Geelong
Lower Duneed Road	Arterial road providing access to Barwon Heads from the Surf Coast Highway.	Horseshoe Bend then Stewarts Road / Warralily Boulevard	Poor. Lower Duneed Road is an arterial but Warralily Boulevard is local access.	0m	Horseshoe Bend Road then McCanns Road	Poor. Horseshoe Bend Road is local access. McCanns is narrow single seal local access.	0m	Assume grade separation

Description of road		Network considerations towards Geelong			Network considerations towards Torquay			Recommendation
Road Name	Function	Nearest alternative if closed	Network suitability of alternative	Additional distance	Nearest alternative if closed	Network suitability of alternative	Additional distance	
McCanns Road	Local access serving ~7 residence between SCH and Horseshoe Bend Road	Horseshoe Bend Road, then Lower Duneed Road	Adequate. Alternatives are of similar or higher standard.	Up to 2.5 km	Horseshoe Bend Road	Adequate, although Horseshoe Bend Road has a sharp curved alignment over Thompsons Creek.	Up to 1.5 km	**Possible closure.** Alternatively, grade separation delivered by raising/lowering road.
Surf Coast Highway	Major arterial road between Geelong and Torquay.	Anglesea Road (to west)	Poor. Surf Coast Highway is a major arterial road with substantially more capacity than Anglesea Road.	n/a	Anglesea Road (to west)	Poor. Surf Coast Highway is a major arterial road with substantially more capacity than Anglesea Road.	n/a	Assume grade separation by raising road.
Blackgate Road (west of Surf Coast Highway)	Local access serving ~10 residences between SCH and Ghazeepore Rd	Ghazeepore Road	Poor. Alternative routes to access Torquay are limited by Thompsons Creek.	Up to 6km	Ghazeepore Road	Adequate	Up to 5km	Assume grade separation delivered by raising road.

4.0 Impacts of Designs

4.1 Noise

A noise policy framework for rail is now active. It is principles-based. The principles are:

- Integrated early consideration
- Affordability and equity
- Balancing objectives
- Best fit solutions

Some features of the design that reduce noise impacts include:

- extensive sections of cutting through the planned development area
- alignment selection avoiding buildings on the east side of Surf Coast Highway south of Blackgate Road.

To further mitigate noise, strategies that can be considered in further development of the design include:

- Design and alignment refinement
- Targeted noise walling. A nominal allowance for noise barriers around established buildings at the locations shown on Figure 4 has been assumed in cost estimation.

Further investigations and noise modelling need to be undertaking in the next stage of the project.

4.2 Minimising Structure Impacts

The design includes rail bridges with embankments at creek crossings and trenched sections in Armstrong Creek Town Centre[1]. These designs address the design parameters of rail whilst reducing the visual and amenity impact of the corridor.

The proposal for a sunken corridor through Armstrong Creek Town Centre is crucial to enable connectivity across the rail corridor at various locations. The trench would extend from approximately 500m north of Boundary Road to 200m south of Main St, including ACTC station location.

The crossing of Thompsons Creek has a lower visual impact as it is located in the green belt between Armstrong Creek and Torquay. Its design will need to be reviewed based on hydrological studies.

4.3 Cost Estimate

High level capital cost estimates for various options have been prepared and are given in Appendix B. The infrastructure for the rail alignment shown in Appendix A is similar to the Eastern Option.

AECOM has estimated the railway to cost in the range of [redacted] to build.

Assumptions used in preparing these costs include:

- Capital cost estimates have been prepared by a cost estimator based on benchmark rates for civil construction and advice from experienced rail engineers.
- The cost estimates are based on 2014 rates and **include** the following general scope elements, with more details included in Appendix B:
  - Land acquisition
  - Demolition
  - Rail construction, including civil works, rail/roadway construction, electrical works, stations and platforms at Armstrong Creek and Torquay North, and structures
  - Shared pathway
  - Grade separations and intersection treatments
  - Drainage
  - Noise barriers
  - Fencing
  - Public utility diversion
  - Indirect costs
  - Client costs
  - Risk items
- The following **exclusions** apply:
  - Bridges for future connector roads (approx. chainages 81000, 81270, 81800)
  - Potential bridge for local access at approx. chainage 90700
  - Works for temporary bus interchanges
  - Franchisee costs
  - GST
  - Upgrades to surrounding roads
  - Fauna treatment
  - Carbon offset allowances
  - Rolling stock

[1] The rail design software assumes that corridor sections more than 7m depth are cut and cover tunnel and these sections are shown accordingly on the design plans in Appendix A. The optimal technical solution would be determined in detailed design.

5.0 Network Planning Considerations

5.1 Staging of Corridor Development

The ability to supply rail service on the TTC is constrained by operational limitations, with a number of strategic issues to consider:

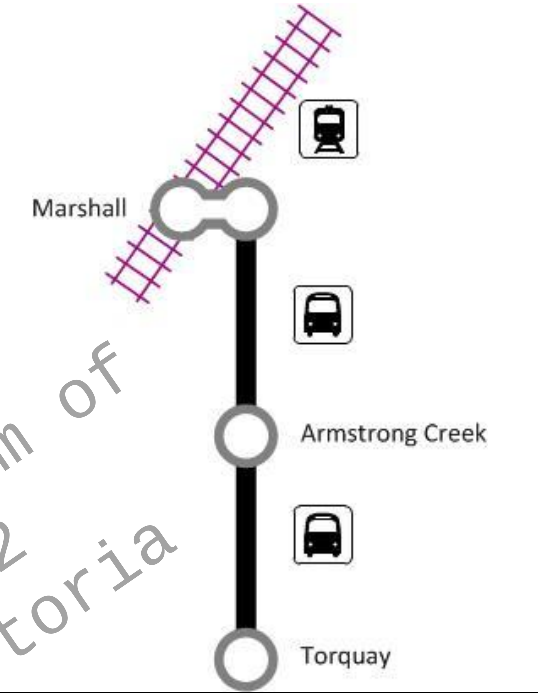
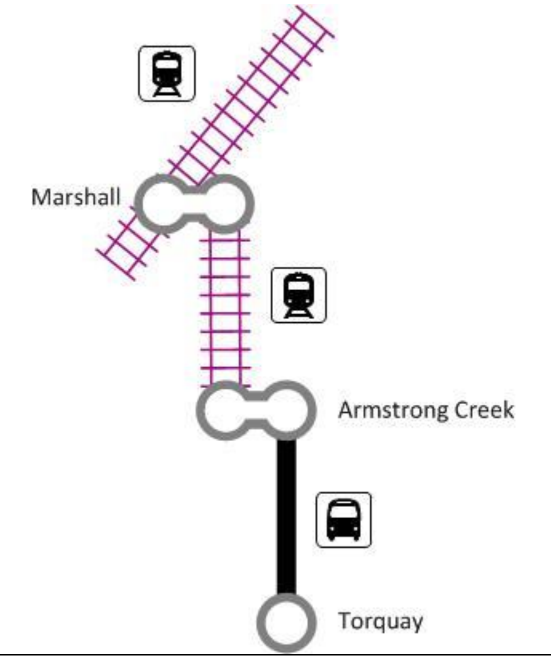
- To provide services to either Armstrong Creek Town Centre or Torquay as well as to Grovedale, the normal approach would be to operate half of these on the TTC. The demand forecasting report shows patronage by branch to be broadly similar for strategic planning purposes.
- The alternative of dividing train sets at Marshall to serve one or two stations on each branch (e.g. Grovedale and Armstrong Creek) would be a significant constraint, complicating operations and driver management, and adding journey time. This is not recommended.
- A shuttle from Marshall has been considered, although this would add a transfer for most passengers because Marshall is not a major destination. The concept design assumes this as the initial stage for the proposal. This option will require a reconfiguration at Marshall to provide an additional platform for the terminating shuttle.

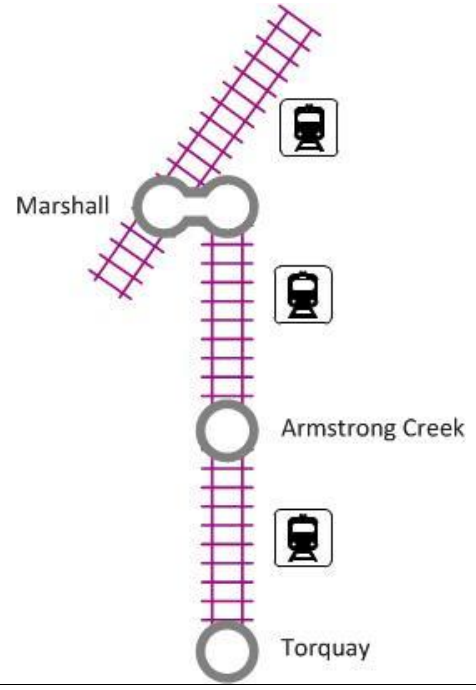
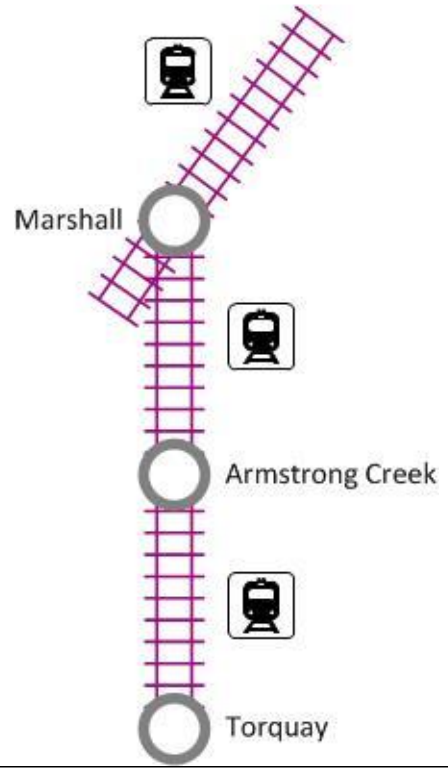
Potential scenarios are summarised in sketch form in Table 5. In the sketches, transfers are shown with 'interchange' station iconography and the modes are reflected by pictograms and line styles.

AECOM recommends the following staging strategies to be considered further in developing a business case for the TTC's construction:

- **Staged through rail services to Armstrong Creek with connecting buses:** Rail between Marshall and Armstrong Creek, with rail services operating through to Geelong and Melbourne, and with two services per hour delivered using bus between Armstrong Creek and Torquay.
- **Rail shuttle:** Rail between Marshall and Torquay, connecting to Grovedale – Geelong – Melbourne services at Marshall.
- **Direct through rail:** Rail between Marshall and Torquay, operating through to Geelong and Melbourne.

Table 5 **Summary of potential staging strategies**

	Scenario (in sketch form)	Comments
Stage 0: Pre-rail connection		- Bus shuttle service between Marshall and Torquay - One transfer required at Marshall - Good coordination - Lowest cost option - 'Premium' service at turn up and go headway
Stage 1: Extension to Armstrong Creek		- Rail shuttle service between Marshall and ACTC; bus shuttle between ACTC and Torquay - Two transfers required - Premium level of service between Torquay and ACTC - Poor coordination at Armstrong Creek

	Scenario (in sketch form)	Comments
Stage 2: Extension to Torquay		- Shuttle service on Transit Corridor - One transfer required at Marshall between rail services - High capital cost
Ultimate Stage		- Direct service from Melbourne/Geelong along full length of corridor - No transfers - Good integration with clockface headways - Negative impact on proposed services to Grovedale, until track duplication between Geelong and Marshall

A design that requires transfers at Marshall and Geelong is unlikely to be a competitive alternative to private car travel to central Geelong.

A bus-to-train, or train-to-train transfer will be acceptable for travel between the TTC and greater Melbourne. This is because the transfer is a small share of the total generalised journey time, indicatively 15 percent, and the total generalised journey time is likely to be competitive with car.

By contrast transfers will be around 40 percent of the generalised journey time for a passenger travelling between the TTC and central Geelong. The trip will be perceived to be about twice as long as the comparable trip by car.

5.2 Light Rail Alternatives

Should a heavy rail connection to Armstrong Creek and Torquay be found not to be achievable, alternative rail connections to Torquay have been looked at. This has been developed into a report, included as Appendix D Light Rail Alternatives to this report.

6.0 Recommendations and next steps

6.1 Options preserved as a result of this study

The design developed in this study preserves a number of options:

- There is flexibility to refine design in the future, especially through use of steeper gradients, to allow for optimisation following detailed survey and design
- The corridor retains flexibility to adopt more demanding technical standards assuming that technology improves over time
- The station location footprint at Torquay North should be preserved.

6.2 Next Steps

AECOM recommends a number of additional steps to advance the protection of a corridor:

1) Undertake targeted field studies along the identified corridors and their environs, addressing gaps in the data available to appraise each corridor, including but not limited to:
   a. Indigenous archaeology, heritage and cultural values
   b. European archaeology, heritage and cultural values
   c. Flora and fauna
2) Revise the alignments in the light of any new constraints identified following field checking.
3) Undertake a risk assessment of corridor encroachment in the green belt area versus formal protection for the predominantly rural land adjacent to Blackgate Road, between Lower Duneed Road and Torquay.
4) If it is determined that formal protection is warranted, then complete a multi-criteria assessment of the route options and undertake the relevant planning scheme amendments between Lower Duneed Road and Blackgate Road.
5) Roads in Armstrong Creek Town Centre, and surrounding properties, be constructed at a higher level to minimise the excavation and cost of a future railway.

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Appendix A

Design drawings

Pages 21 through 34 redacted for the following reasons:
- -
30(1)

Exemptions used:

Appendix B

Cost estimates

Pages 36 through 37 redacted for the following reasons:
- -
s25 - Not relevant

Exemptions used:

Appendix C

Light Rail Alternatives Report

Light Rail Alternatives

Interurban light rail is a hybrid operational model between a city 'tram' and a conventional heavy-rail train. There are notable examples in the United States and Europe that demonstrate some of the key characteristics of contemporary interurban operations: slow running in the centre of streets, tight-radius turns in town, fast running on private right-of-way outside of town, and various forms of 'infrastructure sharing'.

The key advantage of light rail in the context of the Torquay corridor is that it can be incorporated more effectively into roads, running in medians or roadsides, without the policy-driven need for heavy rail grade separation. Accordingly, light rail can be integrated into urban design and provide direct access to town centres.

Three technologies are explored here for their suitability to the Torquay (or Drysdale) corridor:

- Conventional electrified interurban light rail
- Diesel light rail
- Tram-trains

The applicability of these technologies to Torquay is summarised in the table below.

Table 6 Overview of the advantages and disadvantages of light rail models

	Conventional electrified interurban light rail	Diesel light rail	Tram-trains
Advantages	- Demonstrated and supported technology - Scalable into urban networks	- Potential precursor to electrification - Lower capital cost for initial build - Demonstrated examples of lightly built fixed infrastructure	- Single seat service to Geelong station - Intensified use of existing infrastructure - Strategic opportunity for wider deployment in Geelong where extensive current and former rail infrastructure exists
Disadvantages	- High cost for electrification - High cost for stand-alone operation - Potential at-grade crossing issues with broad gauge passenger rail at Marshall - Easement required into central Geelong and interchanges required to access other modes	- Slower acceleration and deceleration - High cost for stand-alone operation	- Requires broad gauge tram, which is unusual but not unprecedented - Bespoke rolling stock - Not feasible if no capacity exists on the railway line - Complex technical interfaces - Long lead time to prove concept under local safety rules

The review found that there is a range of alternatives to the narrow definition of 'tram' and 'passenger train' that usually applies in Victoria. Should a dedicated rail service to Torquay or Drysdale not be feasible, then one of these alternatives may offer a way forward to provide fixed-rail infrastructure on the corridor. Although this is an initial appraisal only, the key constraint on the use of tram-trains is likely to be track capacity on the railway; a new route might be required in which case a diesel light rail may be an initial option, with long-term electrification.

Conventional electrified interurban light rail

The examples outlined below represent some typical electrified interurban light rail operations. They are characterised by high levels of intercity, commuter or tourist traffic; long histories; and significant amounts of recent investment.

These lines are genuine intercity lines, having substantial lengths of rural or semi-rural running, although given many examples are European the areas served are densely settled by Australian standards.

The closest example to this model in Australia is the Glenelg tram in Adelaide, which operates almost entirely in its own reservation on a former railway. However it is primarily a suburban tram service, having continuous suburban development along its route.

Table 7 Key parameters for exemplar interurban light rail operations

	Belgian Coastal Tram	Forchbahn	Norristown	Upper Rhine
Length	68km	16km	22km	~50km
Number of stops	70	20	22	~65, plus shared stops
Service level	10 min summer 20 min winter	7.5 min peak 15 min daytime Express operations in peak	5 min peak 20 min daytime Express operations in peak	10 min
Track	Double throughout, single end trams	Single and double track sections	1 to 3	Single and double track
Gauge	1000 mm	1000 mm	1435 mm (standard)	1000 mm
Voltage	600 V DC	600 / 1200 V DC. Dual voltage (600 V tram, 1200 V 'train').	Third rail	750 V

Belgian Coast Tram

The Belgian Coast Tram is the longest single tram line in the world as well as one of the few interurban tramways in the world to remain in operation. It connects the cities and towns along the entire Belgian coast, between De Panne near the French border, and Knokke-Heist. The service makes 70 stops along the 68 km long line, with a tram running every ten minutes during the peak summer months (every 20 mins in the winter months), during which it is used by over 3 million passengers.

The line is metre gauge and fully electrified at 600 V DC. Current rolling stock is high floor but a new generation of low-floor stock is on order. Trams operate in extensive sections of reserved track both in rights-of-way and centre of road, as well as street running sections in townships. The line's topography is generally very flat, with no significant gradients on the line.

Figure 6 Belgian Coast Tram map

Figure 7 Coastal tram (Kusttram), southern Oostende, Belgium

Forch Railway (Forchbahn)

The Forchbahn (Forch railway) is a light railway in Zürich, comprising 13km of segregated railway and 3km of embedded tramway track. It links the towns of Esslingen and Forch to Rehalp, an outer suburb of the city of Zürich. From Rehalp, trains continue over the Zürich tram system to a terminus outside Zürich Stadelhofen railway station in central Zürich.

The line has a gauge of 1,000 mm and is fully electrified through 600 and 1200 V DC overhead line, serving 20 stations.

Figure 8 Stadler - articulated motor cars with a cab at one end and doors on both sides

Figure 9 Forchbahn and city trams at the Stadelhofen terminus

Figure 10 The station and depot at Forch

Figure 11 A train on roadside single track in the countryside

Norristown High Speed Line

The Norristown High Speed Line is a 21.6 km interurban line, operated by SEPTA, running between Upper Darby and Norristown, Pennsylvania, USA. The service is an outer-suburban commuter operation. The rail line runs entirely on its own right-of-way, inherited from the original Philadelphia and Western Railroad line, referred to as SEPTA Route 100. The line has full grade separation, third rail electrification and high platforms, characteristic of rapid transit systems, but uses smaller cars with on-board fare collection.

Figure 12 SEPTA N-5 car #144 of the Norristown High Speed Line, Route 100, as it enters the Gulph Mills Station in Upper Merion, Pennsylvania

The Upper Rhine Railway

The cities of Heidelberg, Mannheim and Weinheim are linked by the Upper Rhine Railway, an interurban light rail service. The network incorporates many of the features of contemporary interurban light rail operation including single-track roadside working, low floor vehicles, and relatively high speed operation (up to 80 km/h).

Figure 13 Single track operation through the village centre of Großsachsen

Figure 14 New low floor tram rolling stock on the Upper Rhine Railway

Figure 15 Roadside operations, Upper Rhine Railway

Emerging developments

'High speed' intercity trams are being developed for operations in densely settled parts of Europe. For example:

- An international line of some 35 km is planned between Maastricht (The Netherlands) and Hasselt (Belgium), with a fleet of 12 40m long trams capable of 100km/h operation. The planned end-to-end journey time is 39 minutes.
- A 60km peri-urban network on the northern fringe of Brussels has recently been announced for implementation by 2020, with extensive high-speed alignment adjacent to a motorway.
- The Randstadrail network in Rotterdam / Den Haag, The Netherlands, has seen the conversion of lightly used passenger rail services to light rail with a combination of underground and street running.

Applicability of this model to Torquay and Drysdale

The principle elements of this operational model applicable to Torquay or Drysdale are:

- Flexibility to operate on-street where dedicated reservations are not cost-effective or feasible
- Wide stop spacing, with an average spacing of 1km typically, but with closer stops in townships and wider spacings on the intertown sections
- Full operational flexibility regarding single track working, provided safeworking is addressed
- Potential for high maximum operating speeds to provide attractive journey times

The principal limitations on this model for Torquay and Drysdale are:

- Conventional use of electric traction adds capital costs (however, see following sections).
- Networks are commonly either the residual parts of an historic network, rather than newly built systems. Only in recent times have new large scale networks been proposed and generally they are able to be integrated with an urban network, for example in Rotterdam and Brussels.

Diesel light rail

SPRINTER

The SPRINTER is a DMU-operated 35km light rail line operating between Oceanside and Escondido, California, United States.

Sprinter service is operated with Desiro-class diesel multiple units (DMU) manufactured by Siemens in Germany, where they are widely used by main-line regional railways. The Sprinter line forms part of a wider network of railway services using a mixture of technologies.

Figure 16 Sprinter map (with other lines included)

Figure 17 Sprinter at Oceanside

Regio Sprinter

The Regio Sprinter is a lightweight German diesel railcar. It has the best acceleration of any multiple unit or railbus in Germany. The Regio Sprinter is used on two lightly-built regional lines in Germany and one in Denmark:

- Rurtalbahn: 17
- Vogtlandbahn: 18 – this operation includes a Tram-Train service in central Zwickau, discussed below.
- Nærumbanen: 4

Key characteristics of the Regio Sprinter rolling stock are summarised in Table 8 below.

Table 8 Key characteristics of Regio Sprinter rolling stock

Characteristic	Specification
Manufacturer:	Siemens AG / DUEWAG
Year(s) of manufacture:	1995-1999
Axle arrangement:	A+2+A
Gauge:	1,435 mm
Length over couplers:	24,800 mm
Height:	3,350 mm
Service weight:	49.2 t
Top speed	120 km/h
Acceleration	1.1 m/s^2
Motor make / model	2x MAN D2865 LUH05
Brakes	Electromagnetic rail brake retarder
Capacity	74 seats, 84 standing places (158 total)

Figure 18 RegioSprinter on the Rurtalbahn at Düren

Figure 19 Regio Sprinter on the Vogtlandbahn

Figure 20 RegioSprinter at the Nærumbanen terminus at Jægersborg

Applicability of this model to Torquay and Drysdale

The principle elements of this operational model applicable to Torquay or Drysdale are:

- Avoiding the cost of electrification required for the conventional intercity tram outlined above
- Wide stop spacing, with an average spacing of 1km typically, but with closer stops in townships and wider spacings on the intertown sections
- Full operational flexibility regarding single track working, provided safeworking is addressed

The principal limitations on this model for Torquay and Drysdale are:

- This operating model has mainly been developed to sustain passenger services on lightly used lines or on freight railways, rather than on newly constructed railways.

Tram-Trains

Tram-trains vs Train-trams

A 'tram-train' is a hybrid operational model that reflects an adaptation of trams to operate on railway infrastructure, and in some cases for trains to operate on tramway infrastructure. Trams run through from an urban tramway to main-line railway lines which are shared with conventional trains. This combines the tram's flexibility and accessibility with a train's greater speed, and bridges the distance between a main railway station and a city centre.

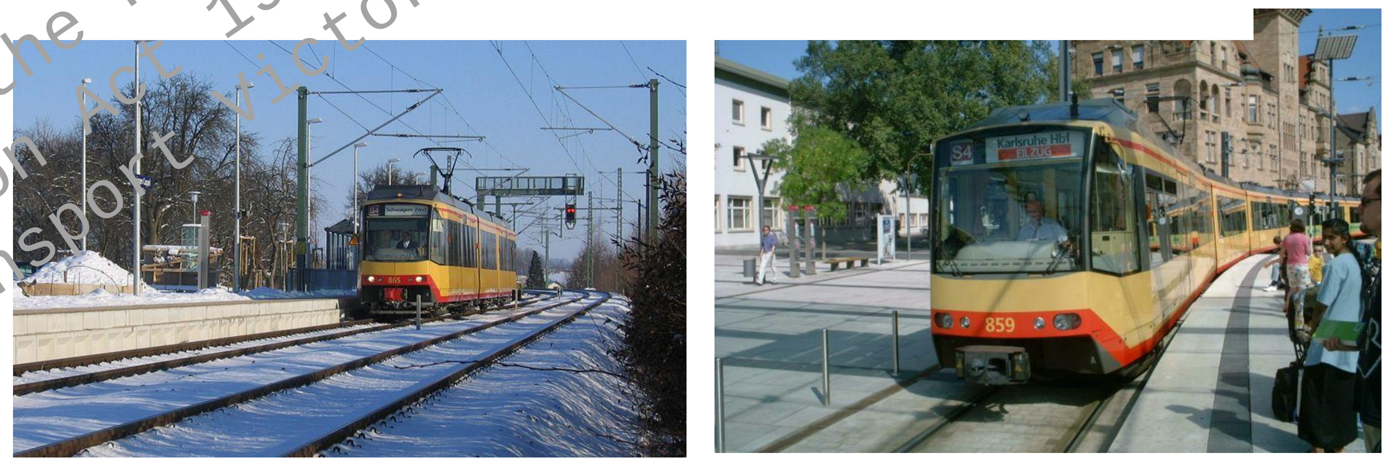
Most tram-trains are standard gauge, which facilitates sharing track with main-line trains. Exceptions include Alicante Tram and Nordhausen which are metre gauge.

Tram-train vehicles are often dual-equipped to suit the needs of both tram and train operating modes, with support for multiple electrification voltages if required and safety equipment such as train stops and other railway signalling equipment.

Karlsruhe model

Karlsruhe in Germany pioneered the modern 'tram-train' when its urban tramway network was extended onto the mainline rail system. The first line was introduced in 1992, operating between Karlsruhe Marktplatz and Grötzingen like a tram, following BOStrab German tramway specifications, and then at Grötzingen there is a DC to AC voltage change and operation as a heavy rail vehicle, following EBO heavy rail specifications, on 18 km of track towards Bretten. In addition to the voltage change and specification shift, safeworking is also transferred from the AVG tram driver to the Deutsche Bahn AG train control.

Figure 21 Demonstrating interworking from rail to street



The model has been highly successful, expanding to cover over 260 kilometres and serving 188 stations across 12 lines, although not all of these are operated in tram-train mode.

The 'Karlsruhe model' has now been deployed at four other cities in Germany and in the Netherlands, and has been considered for deployment in Adelaide. Some operations are shown below. A very high level of technical interoperability has been achieved in Kassel, for example, where a mixed fleet of dual-voltage trams and diesel/DC electric trams provide through running between tramway and railway.

Figure 22 A Nordhausen 'DUO' Combino on the track linking the urban tramway, where it is electrically powered via overhead wires, and the HSB (Harzer Schmalspurbahn) rural railway, where it is powered by an on board diesel engine

Figure 23 RegioTram Kassel dual voltage DC/AC Alstom Regio-Citadis next to a KVG Bombardier Flexity Classic tram at Königsplatz

Figure 24 RegioTram Kassel dual mode diesel/electric Alstom Regio-Citadis approaching Wolfhagen using diesel power

Capital MetroRail

Capital MetroRail is a diesel commuter rail system that uses tram-train operation. It connects Austin's northern suburbs to downtown. The line operates on 51km of existing freight tracks, and consists of nine stations operating on-street in downtown Austin. The service is relatively infrequent, with approximately 30 minute service in the peak and an hourly off peak service.

Figure 25 Austin Metrorail train at Downtown Station

Figure 26 Interiors of the Capital MetroRail rolling stock

Zwickau Train-Tram

The Zwickau model sees lightweight diesel Train-Trams extended from the mainline railway through urban streets and part of a pedestrianised zone. The tracks are segregated from the normal road traffic.

These TrainTrams are operated by the VogtlandBahn railway, outlined above. Because the trams are metre gauge and the train is standard gauge, where the trams and trains share tracks, they use dual gauge with a shared rail, as shown below.

Figure 27 The Zwickau Model has main-line lightweight diesel tram-trains running through urban streets.

Applicability of this model to Torquay and Drysdale

The principle elements of this operational model applicable to Torquay or Drysdale are:

- The opportunity to make use of the established passenger rail infrastructure between Marshall and central Geelong, and also to add spurs from that infrastructure to provide direct access to central Geelong. For example, the level crossing at South Geelong Railway Station would provide an opportunity to run a tram-train into Geelong CBD *and* avoid the bottleneck of the single-track Geelong tunnel (see Figure 3). Using the rail corridor between Marshall and South Geelong would avoid tram/vehicle separation issues at the Barwon River road crossings in Geelong that are an issue for busway routings.
- The flexibility of existing passenger rail extends to potentially using maintenance, cleaning and stabling facilities established for heavy rail.
- Traction power flexibility, with diesel and electric options both proven technologies
- Gauge flexibility – the technology is not gauge sensitive and could in principle operate on broad gauge.

The principal limitations on this model for Torquay and Drysdale are:

- Very long lead times for development and completion of a railway safety case. For example, a Victorian standard for tram-train rolling stock would need to be developed in conjunction with rolling stock manufacturers. Tram-trains are not an 'off-the-shelf' solution, despite proof of concept being well established.
- The Geelong rail corridor would likely require significant upgrades to enable a tram – train from Torquay; the short length of corridor sharing on the Drysdale route is unlikely to warrant the effort as conventional street-based intercity light rail is an alternative option.

Potential application of light rail to the Torquay and Drysdale corridors

As these case studies indicate, there is a wide range of technological features that can potentially be applied in developing a light rail solution for Torquay or Drysdale corridors. However, the two most fundamental choices in the case studies reviewed are:

- Does the service interwork with heavy rail, either passenger or freight?
- Is the light rail electric or diesel traction?

The technologies in turn create opportunities and impose limitations on the transport outcomes that can be achieved. A summary of key considerations is provided in Table 9.

Table 9 Light rail technology options and transport outcome influence

Technology choice	Transport outcome influence
Electric vs diesel	Better acceleration of electric trams supports closer stop spacing, which in turn is better for suburban and township services.
Tramway only vs tram-train	'Tramway' operations – on street, in reservation or on a dedicated easement – is relatively simple and a well-proven model in Australia. Tram-train adds flexibility of route options, but substantial regulatory and operational complexity.

Conclusion

There are a wide range of intercity light rail technologies available. Using tram-train on the Drysdale corridor would need to be critically considered, given the constraints in the short section it would share into central Geelong and the complexity of introducing the technology for the first time in Australia.

The Torquay corridor has more strategic opportunity, but is nevertheless very constrained. It is very difficult to compare the cost of securing a conventional separated light rail route into central Geelong through Belmont to the unknown cost of completing a regulatory assessment of introducing tram-train and using the railway corridor.

As currently conceived, diesel traction power would be adequate for the corridors given the wide station spacing. However, consideration of light rail itself would warrant a critical rethinking about the route and station spacing, making it not possible to say definitively what would be the optimal traction solution.

AECOM recommends that PTV consider these technologies further in the event that enhanced bus services and heavy rail solutions are considered unfeasible.