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UNIVERSITY OF WOLLONGONG AUSTRALIA

ILLAWARRA FIRST Member

Illawarra Business Chamber

South West Illawarra Rail Link

Directed research: Assessing the economic impacts of better connecting the Illawarra to Greater Sydney and the Western Sydney Aerotropolis

Research partners

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Wollondilly Shire Council

About this document

Document

Research Report

Title

South West Illawarra Rail Link (SWIRL)

Assessing the economic impacts of better connecting the Illawarra to Greater Sydney and the Western Sydney Aerotropolis

Prepared For

Illawarra First, supported by Wollongong City Council and Wollondilly Shire Council.

About Illawarra First

Illawarra First is the peak business leadership group for the region, comprising the heads of its leading organisations as part of a dialogue that incorporates senior decision-makers from across government and the private sector.

Backed by a significant research fund, Illawarra First advances the region's economic development through powerful advocacy that is supported by a rigorous evidence base.

Enhanced transport connectivity is key to the region's economic growth, and previous Illawarra First research has built a clear case for greater investment in key road and rail projects.

SMART Infrastructure has been commissioned to undertake this follow-up research project to the 2017 rail study that will ascertain the benefits to be realised through greater connectivity between the communities - and the economies - of the Illawarra and south-western Sydney.

Date

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Glossary

ABS	Australian Bureau of Statistics
BAU	Business as Usual
BCR	Benefit Cost Ratio
CBA	Cost Benefit Appraisal
CFD	Computational Fluid Dynamics
EDS	Economic Development Strategy
IBC	Illawarra Business Chamber
IA	Infrastructure Australia
INSW	Infrastructure NSW
ISD	Illawarra Statistical District
MSL	Main South Line
MWL	Main Western Line
NFP	National Fire Protection
NPV	Net Present Value
NSRL	North South Rail Line
OSO	Outer Sydney Orbital
ROI	Return on Investment
SMART	Simulation Modelling Analysis Research Teaching
SMEC	Snowy Mountains Engineering Corporation
SWIRL	South West Illawarra Rail Link
TBM	Tunnel Boring Machines
TEU	Twenty-Foot Equivalent Unit (a standard-size shipping container)
TfNSW	Transport for NSW
WCC	Wollongong City Council
WSA	Western Sydney Airport
WSC	Wollondilly Shire Council
WSFL	Western Sydney Freight Line

1 Executive Summary

In 2017 Illawarra First commissioned the University of Wollongong's SMART Infrastructure Facility to undertake a comprehensive study of the limitations of the Illawarra's rail network.

The report entitled 'Upgrading rail connectivity between Illawarra and Sydney' [1] identified measures to improve speed and reliability of rail connectivity between the Illawarra and Sydney and detailed how rail connectivity constraints impact the region's economy.

The South West Illawarra Rail Link (SWIRL) was identified as the most cost-effective freight and passenger solution to the region's constraints on a cost-benefit basis; utilising the rail corridor and partially constructed Maldon-Dombarton Line that was abandoned in the 1980s.

This report extends that research to consider the socio-economic impact of the SWIRL on the broader region, including the future Western Parkland City and the Wollondilly Shire. It also seeks to address alternative passenger and freight proposals, as well as the feasibility of engineering and other logistical elements of the SWIRL.

Addressing Regional Challenges

SMART have identified three key challenges to overcome in order to create a thriving socio-economic growth corridor between Western Sydney and the Illawarra region:

- **Reducing local job deficits in the Illawarra and the Wollondilly Shire through better connectivity;**
- **Reducing commuting time between the Illawarra, the Wollondilly Shire and Western Sydney;**
- **Increasing the regional freight capacity to unlock Port Kembla's potential.**

Better connectivity to Greater Sydney, and more specifically the future Western Parkland City, is recognised as a major enabling factor to the sustainable economic growth of the Illawarra region and the Wollondilly shire.

Wollongong City Council's Economic Development Strategy[2] (EDS) aims to increase local job creation by 1% per annum (p.a.). The report identifies better connectivity to Western Sydney as a major enabling factor to attract enterprises and investors to the region. Based on current patterns of employment between the Illawarra, Western Sydney and Eastern/Northern Sydney; as well as population projections until 2041, our study shows that a Business-as-Usual (BAU) scenario would add, by 2041, another 20,000 commuters to the 26,000 workers currently travelling daily from the Illawarra to Sydney (2016 baseline).

However, doubling job creation within the Illawarra (up to 1% p.a.), would limit the number of commuters to 32,000 by 2041. Similarly, Wollondilly Shire's Economic Development Strategy[3], assumes that a BAU scenario would result in 33,000 workers travelling daily to Western Sydney by 2041, compared to 14,000 commuters in 2016. Under a 'New Future' scenario, involving better road and rail connectivity, Wollondilly Shire aims for an additional 10,000 jobs by 2041, reducing its job deficit from 73% to 65% only.

The regional economic uplift, as a result of better road and rail connectivity (including SWIRL) would contribute to an additional 17,500 jobs in the Illawarra region and Wollondilly Shire, reducing the deficit in economic investment by $892 million p.a. by 2041.

Reducing the loss of productivity due to transport inefficiencies around the Greater Sydney Area has been a high priority for Infrastructure NSW[4] and Transport for NSW (TfNSW)[5]. Based on ABS Census 2016, Sydney Trains timetables, bespoke rail modelling[6] and Google Traffic figures, we have been able to breakdown daily commuting flows by transport mode (car or train), as well as broad travel origins and destinations for the Illawarra and the Wollondilly Shire. Using a 2016 baseline, the BAU and EDS scenarios show that an additional passenger rail link between Wollongong and St Marys, via Wilton, could potentially take 18,500 daily commuters from the road network by 2041. On average, passengers would experience a 15-20 minute faster journey to Western Sydney compared with current road trip.

Overall, a passenger rail link between Wollongong, Wilton and St Marys could result in a productivity gain of $73 million p.a. due to faster commuting time by 2041.

Geotechnical constraints and industrial legacies have shaped the current transport network between the Illawarra and the Greater Sydney Area. It consists of four road corridors (Macquarie Pass, Picton Road, Appin Road and the M1 Motorway) and two rail corridors (Moss Vale-Unanderra Line and South Coast Line). Most experts agree that road freight demand needs to be curbed for safety and environmental issues, while rail freight demand will reach the maximum network capacity by 2036, as both modes will compete with an increasing demand for people's movements by private vehicle or public transport. According to TfNSW projections, traditional freight markets for Port Kembla will continue to grow at a steady pace (manufacturing goods, construction materials, private vehicles, coal and steel), facing increasing rail accessibility issues by 2036 and beyond[7]. Furthermore, the planned activation of a container terminal by NSW Ports at Port Kembla by 2041 will face a massive challenge as the predicted handling of 530,000 Twenty-Foot Equivalent Units (TEU) p.a.[8] will generate an additional 9,300 train paths to the annual rail demand, as well as **1.6 million road trips** to the annual road demand.

1. SMART Infrastructure Facility, University of Wollongong (2017), *Upgrading rail connectivity between Illawarra and Sydney*
2. Wollongong City Council (WCC) (2019) *Economic Development Strategy 2013-2023*, City of Wollongong, NSW
3. Wollondilly Shire Council (WSC) (2020) Wollondilly Economic Development Strategy, Wollondilly Shire, NSW
4. INSW (2018), *State Infrastructure Strategy*
5. TfNSW (2018), *Future Transport Strategy 2056*
6. SMART Infrastructure Facility, University of Wollongong (2019), *Estimating growth impacts for the Illawarra circa 2050 with enhanced access with South West Sydney*
7. TfNSW (2018), *NSW Freight Commodity Demand Forecasts 2016-2056. Transport Performance & Analytics*
8. KPMG (2019) *Quay Conclusions*, 2019

Failing to increase the road and rail capacity (under a BAU scenario), the Illawarra region could face a $229 million p.a. economic loss by 2041.

The SWIRL Solution and Options

The initial SWIRL proposal focused on the original freight line corridor between Maldon and Dombarton. More precisely, the study looked at a dual track electrified line, connected to the Main South Line (MSL) at Maldon (western connection) and connected to the Moss Vale-Unanderra Line at Dombarton (eastern connection). Subsequent policy announcements[9], most notably the Western Sydney City Deal, the Western Sydney Airport (WSA) and the aerotropolis at Badgerys Creek, Future Transport 2056 and the work of the Greater Sydney Commission (particularly on the Western Parkland City) have prompted the need to explore two complementary extensions to the first proposal:

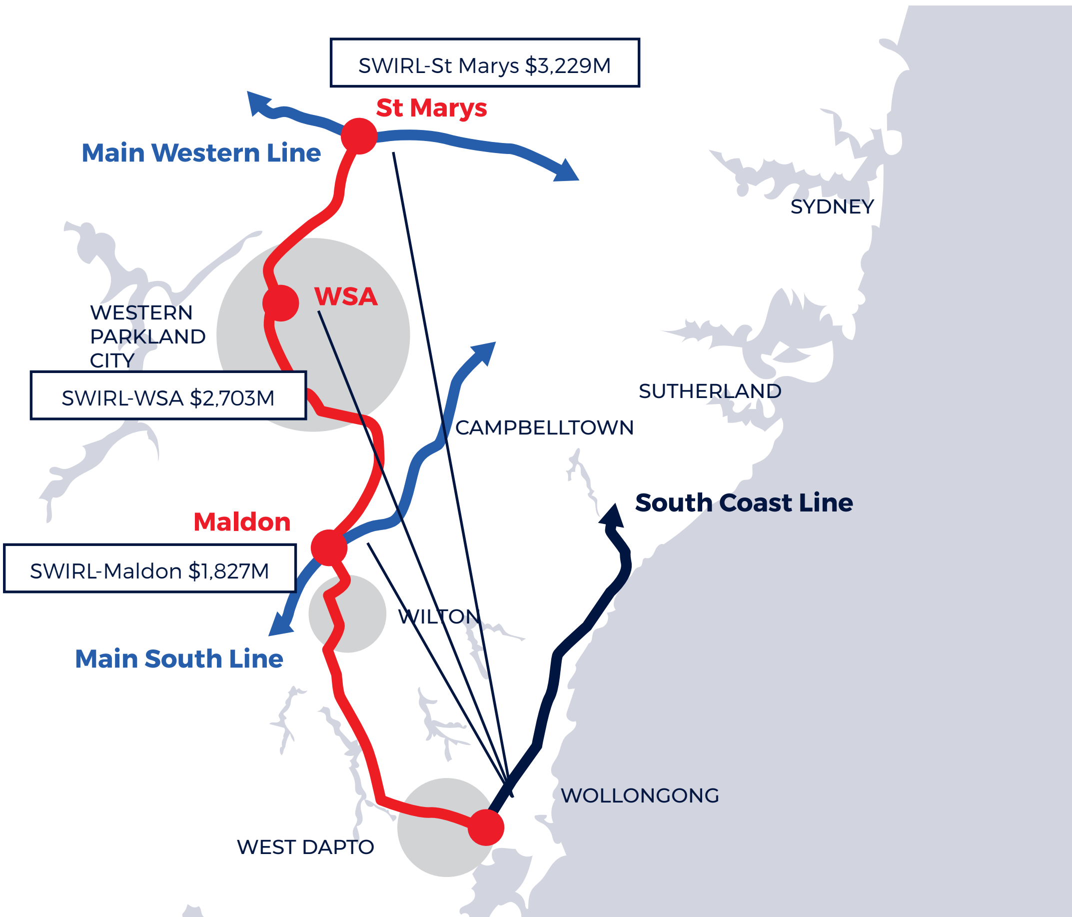
SWIRL-Maldon: The initial proposal includes the completion of a dual purpose (passenger and freight) and dual track electrified line along the pre-existing 35km-long Maldon-Dombarton rail corridor. This base option also includes the electrification of the 7km-long section of the existing Moss Vale-Unanderra Line between Dombarton and Unanderra (connection to the South Coast Line). We expect that passengers would travel from Wollongong station on the South Coast Line (SCL), via the SWIRL Line, to reach Glenfield Station on the MSL, continuing their journey through Sydney Trains network (T2, T3, T5 or T8) and vice-versa. Freight trains would mainly travel between Port Kembla, using the SCL between Coniston and Unanderra, then bifurcating onto the SWIRL and reaching the MSL at Maldon towards intermodal terminals such as Minto or Moorebank (and vice-versa).

SWIRL-WSA: This option includes a 30km-long extension of SWIRL towards the future WSA, following approximately the corridor of the future Outer Sydney Orbital (OSO-M9) from Luddenham (WSA) to the MSL, south of Camden. Unlike the proposed freight-only OSO line, the SWIRL-WSA extension would also be a dual purpose (passenger and freight) and dual track electrified line. With a future rail station located in Wilton and a preserved corridor to cross the Nepean River near Maldon, a reasonable option for the OSO-M9 corridor would be to connect with the MSL at Maldon, rather than Douglas Park, following the Menangle Road alignment (7 km extension).

SWIRL-St Marys: This option would add an 18km-long extension of SWIRL-WSA to St Marys and the future Western Sydney Freight Terminal , which is to be located near Eastern Creek. SWIRL-St Marys would also provide a connection to the Main Western Line for passengers. Unlike the Sydney Metro - Western Sydney Airport, we strongly argue for a dual purpose and dual track electrified line. The alignment would approximately follow the alignment of the northern section of the planned Sydney Metro, between St Marys and WSA.

Figure 1

Options



9. Greater Sydney Commission (2016), *Draft South West District Plan: Co-Creating a Greater Sydney*, TfNSW (2018), *Future Transport Strategy 2056*

Cost Benefit Appraisal and Regional Economic Impact

SMART's updated costing (2019-20 dollars) of the various options shows that **SWIRL-Maldon** would cost **$1,827 million** to be completed, **SWIRL-WSA $2,703 million** and **SWIRL-St Marys $3,229 million** (see section 2.5).

According to our Cost Benefit Appraisal (CBA), the **SWIRL-St Marys option achieves a BCR of 1.05 at a 7% discount rate over a 50-year infrastructure asset life (At a 4% discount rate, the BCR is estimated to be 1.67).** The appraisal assumes that completing the SWIRL extension between WSA and St Marys should be brought forward in order to benefit from early land protection and acquisition. Based on Infrastructure Australia's calculations[10], an early land acquisition along the OSO corridor would save between $933 million and $4,412 million compared with an equivalent scenario for WSFL, with WSFL and OSO corridor protection prioritised for 0-5 years. Infrastructure Australia (2017) tentatively schedules the construction of the WSFL to start in 2027, with completion in 2030. Construction of the OSO would start in 2037 and be completed in 2042. SMART suggests bringing forward the construction of SWIRL-St Marys along the Maldon-Dombarton and OSO corridors, starting in 2027, followed by the completion of the WSFL connection.

At this stage, it is difficult to establish a robust **regional economic impact** of the SWIRL-St Marys option as the development of the Western Parkland City is still characterised by unresolved planning decisions. Henceforth, a more conservative approach was decided, focusing only on the **SWIRL-Maldon** section. An update of the study presented in the SWIRL 2017 report shows that, under a central case scenario (at the standard 7% discount rate), the total regional economic impact is **$2,841 million** in NPV terms by 2036. An estimated 96% of this amount would contribute to the economy of the Illawarra region and 4% to the economy of the Greater Sydney Area ($103 million). As the original study did not take into account population and economic growth in the Wollondilly Shire, we assume that its contribution to the regional economic impact would be proportional to its current and future share of the combined workforce market (19% in 2016 and 29% in 2041). An average 25% contribution is used to estimate that the overall regional economic impact is **$3,551 million** in NPV terms by 2036 (at 7% discount rate), including $142 million for the Greater Sydney Area.

Alternative Solutions

A direct comparison with alternative solutions is difficult to achieve as these initiatives are at various stages of feasibility planning. However, the following comparative elements can be provided:

South Coast Line upgrade: This option has been carefully analysed in the *Upgrading rail connectivity between Illawarra and Sydney* report[11] . The CBA shows that, at the standard 7% social discount rate, the central case BCR was **0.48**, with a low case estimate of **0.35** and a high case estimate of **0.63**.

Moss Vale - Unanderra Line upgrade: A proper CBA analysis of this solution has not been performed, as social and economic benefits would be very similar to the SWIRL-Maldon option. However, an upgrade of the Moss Vale - Unanderra Line to the level proposed for SWIRL would include a duplication and electrification of a 40 km section between Moss Vale and Summit Tank, as well as a partial (re) grading and enlargement of the 10 km section between Summit Tank and Dombarton. Using a $40 million/km costing figure for track duplication and electrification and a $100 million/km for heavy engineering work along the escarpment, the total estimated cost of the Moss Vale - Unanderra Line would approach **$2,000 million**, nearly $200 million more expensive than the SWIRL-Maldon option (see section 2.6).

Outer Sydney Orbital: The proposed 77 km-long Outer Sydney Orbital (M9) would provide Western Sydney with a north-south motorway and rail freight corridor between Box Hill (North West) and Menangle (South West). The preservation of the OSO/M9 corridor is listed as a 0-5 year high priority initiative in the Australian Infrastructure List report without any further information about construction timeline. The Corridor Protection report estimated that construction would cost between **$1,990 and $10,060 million**, in 2016 prices, using a 7% real discount rate (land acquisition not included). Unlike the proposed SWIRL-WSA, the decision to limit the rail alignment to freight trains misses a crucial opportunity to open Western Sydney to commuters from/to Southern Tablelands and the Illawarra (see section 2.6). Offering a suitable rail transport solution for commuters and freight, SWIRL would also allow for a phased construction period of the M9 link.

Sydney Metro - Western Sydney Airport: The Metro will connect the WSA to St Marys and the existing passenger network on the Main Western Line. Under the Western Sydney City Deal[12] , the Australian and NSW governments will deliver the first stage as a metro service. This will become the transport spine for the Western Parkland City, connecting travellers from the WSA and the Aerotropolis to St Marys and the rest of Sydney's rail network. The Australian Government is contributing **$3,500 million** to deliver Stage 1 in collaboration with the NSW Government. A recent Western Sydney Rail Needs Scoping Study[13] estimated that the entire Metro would cost approximately **$15,000-$20,000 million** (see section 2.6).

As Stage 1 will only deliver a metro-style solution, there will be a need to build the **Western Sydney Freight Line** (WSFL) between Twin Creek (connection to the future Outer Sydney Orbital) and Leightonfield (connection to Southern Sydney Freight Line). The Corridor Protection report[14] estimated that construction would cost between **$543 million and $1,310 million**, in 2016 prices, using a 7% real discount rate (land acquisition not included). However, the same report indicates that land acquisition along the WSFL corridor would cost between **$5,120 and $10,520 million**, in 2016 prices, using a 7% real discount rate, depending on the land acquisition strategy implemented by the NSW Government ('Protect and acquire now' or 'Do not protect and acquire at construction').

SWIRL-St Marys is a far more cost effective and integrated solution (passenger and freight) as it would not entail the significant costs that will be associated with the preservation and construction of an East-West freight corridor in an already heavily built (and populated) environment.

10. Infrastructure Australia (2017), *Corridor Protection: Planning and investing for the long term*

11. Ibid SMART (2017)

12. Greater Sydney Commission (2018), *Western Sydney City Deal*

13. Commonwealth of Australia, State of New South Wales (2018), *Western Sydney Rail Needs Scoping Study*

14. Ibid IA (2017)

Recommendations

This study shows that SWIRL-St Marys can contribute to significant job creation, as well as productivity gains in the Illawarra and the Wollondilly Shire, through faster connectivity to Western Sydney. The proposed rail link will also play a crucial role in lifting the regional rail freight capacity by 2036 and unlocking Port Kembla's potential as a second container terminal by 2041. The study also demonstrates that SWIRL-St Marys can achieve a BCR of 1.27 for an estimated cost of $3,220 million.

Recommendation #1

That Infrastructure Australia updates its priority initiative (0-5 year) for 'Freight Rail Access to Port Kembla' and acknowledges the SWIRL-Maldon corridor as a future "alternative rail alignment to the port."

Recommendation #2

That the New South Wales Government commissions a detailed engineering feasibility study and a business case analysis, including land value uplift, of the SWIRL-St Marys option.

Recommendation #3

Considering population growth and increasing freight demand in the Illawarra region and the Wollondilly Shire, Transport for NSW estimates that the South Coast Line will reach capacity by 2036. SMART recommends that planning and design work for the SWIRL-Maldon section commence immediately in order for the line to be operational by 2036, including the Wilton rail station and the connection to the Main South Line at Maldon.

Recommendation #4

Anticipating the opening, by NSW Ports, of a second container terminal in Port Kembla by 2041, SMART recommends that current planning for the Outer Sydney Orbital should take into consideration the concept of a dual freight-passenger alignment up to St Marys, as per the SWIRL-St Marys option. SWIRL-St Marys should be operational by 2041 in order to enable the dispatching of containers from Port Kembla to Western Sydney and beyond.

Recommendation #5

Considering the ambitious mobility and liveability vision put forward by the Greater Sydney Commission for the future Western Parkland City, Infrastructure NSW and Infrastructure Australia should consider SWIRL-St Marys as a unifying and cost-effective solution to the movement of passengers and freight throughout Western Sydney. SMART recommends that the 'Corridor preservation for Outer Sydney Orbital road and rail/M9' should be brought forward as a high priority project (0-5 years) in order to make significant land acquisition savings. In particular, corridor preservation should include an additional section from Douglas Park to Maldon.

2 Building the Evidence

2.1 Background

In 2017, Illawarra First commissioned the SMART Infrastructure Facility to undertake an assessment of options to improve the speed and reliability of passenger and freight rail services between the Illawarra and Sydney. The study, entitled *'Upgrading rail connectivity between Illawarra and Sydney'*, found that there are potentially substantial net economic benefits, in particular to the Illawarra and South West Sydney regions, to be realised from the construction and operation of the South West Illawarra Rail Link (SWIRL).

Following the stage 1 study, Illawarra First has commissioned the SMART Infrastructure Facility to examine the case for the SWIRL in light of the population and economic growth of Western Sydney, the announcement of the WSA at Badgerys Creek with the surrounding 'Aerotropolis' employment zone. The task then is to model any additional economic benefits that will arise from enhanced freight and passenger movements along the corridor between Western Sydney, WSA and the Illawarra, including the planned Wilton Growth Area.

The report is informed by the following recent developments or announcements:

- The Metropolis of Three Cities[15] envisaged a new 'city' will be developed in the current west of the Sydney basin and the Illawarra can help to make this prospect flourish;
- The Western Sydney Airport and its associated zone of economic development (The Aerotropolis);
- Infrastructure NSW's identification of the limitations and risks on the South Coast Line and the potential displacement of freight movements from the line by 2030[16];
- New opportunities inherent in infrastructure commitments contained in the Western Sydney City Deal[17]including the Sydney Metro - Western Sydney Airport;
- The NSW Government's need to identify a viable rail and road corridor for its proposed M9 Outer Sydney Orbital between Macarthur and Wollongong as identified in the Future Transport Strategy 2056[18];
- A recent examination of these issues by the Legislative Council Standing Committee on State Development of the NSW Parliament has recommended that the timeline to construct the SWIRL be brought forward;
- The concerted efforts within "A Fast Rail Future for NSW"[19] and Faster Rail Prospectus[20] for faster rail[21] than currently forecast;
- The latest Infrastructure Priorities report from Infrastructure Australia[22] that lists the improvement of Port Kembla's rail connectivity as a priority initiative (0-5 years).

The recent IA Infrastructure Priority List[23] report includes the improvement of 'Freight Rail Access to Port Kembla' as a priority initiative that needs to be tackled over the next 5-year period. The initiative is described as follows:

"The 2015 Australian Infrastructure Audit identified that Port Kembla would face capacity constraints in the absence of any additional rail network improvements. Port Kembla is a significant economic asset. Maintaining efficient movement of freight to and from the port is a nationally significant challenge.

Additionally, there is a need to improve the efficiency and reliability of freight rail movements between the Illawarra and Greater Sydney, particularly between Port Kembla and the intermodal terminals in Western Sydney.

Around 60% of freight travelling to and from Port Kembla is transported by rail on either the Illawarra Line or the Moss Vale–Unanderra Line. Operations on the Illawarra Line are constrained by passenger rail services in the region, resulting in disruptions to freight scheduling. Freight services are often held for up to 11 hours as passenger services are given priority.*

In the long term, Port Kembla's Outer Harbour development is expected to attract overflow container traffic from Port Botany. The NSW Government has stipulated that Port Kembla should generally not accept more than 120,000 Twenty-foot Equivalent Units per annum by road. This is around 10% of planned Outer Harbour container capacity. This is likely to lead to a significant increase in demand for rail services. Inadequate freight rail capacity may lead to a substantial increase in road freight, further constraining the Illawarra region's road network.

[...] Improve freight rail access to Port Kembla. This could be through enhancements to the Illawarra and/or Moss Vale–Unanderra lines, or through future development of an alternative rail alignment to the port."

* Illawarra Line corresponds to the South Coast Line

15. Greater Sydney Commission (2018), *The Metropolis of Three Cities*
16. Department of Infrastructure Transport Regional Development and Communications (2019), *Western Sydney Airport*,
17. INSW (2018), *State Infrastructure Strategy*
18. Ibid GSC (2018)
19. TfNSW (2018), *Future Transport Strategy 2056*
20. Department of Infrastructure and Regional Development, Australian Government (2018), Faster Rail Prospectus,
21. TfNSW (2018), *A fast rail future for NSW*
22. Infrastructure Australia (2020), *Infrastructure Priorities List 2020*
23. Ibid

2.2 Rationale

Over the next twenty years, the Greater Sydney area will develop into a Metropolis of Three Cities[24] with the Western Parkland City growing around the Western Sydney Airport (WSA) and its Aerotropolis urban core. During the same period, Wollongong will develop as a major growth centre and Gateway City[25] into the Illawarra-Shoalhaven region, alongside Newcastle and the Hunter-Central Coast region. Overall, this Sandstone Megaregion[26] already hosts 75% of the labour force (2.7 million), 70% of residential dwellings (2.4 million), and generates 80% of the Gross Regional Product ($476 billion) in NSW.

SMART have identified three key challenges that need to be overcome in order to create a thriving socio-economic growth corridor between Western Sydney and the Illawarra region:

- Reducing local job deficits in the Illawarra and the Wollondilly Shire through better connectivity;
- Reducing commuting time between the Illawarra, the Wollondilly Shire and Western Sydney;
- Increasing the regional freight capacity to unlock Port Kembla's potential.

Better connectivity to Western Sydney in particular is essential for the Illawarra region and the Wollondilly Shire to overcome these key challenges. In particular, SMART will demonstrate in the following sections how to achieve specific economic targets:

CHALLENGE #1 – HOW TO INCREASE JOB CREATION BY 1% P.A. AND CONSEQUENTLY REDUCE THE REGIONAL DEFICIT OF INVESTMENT BY $892 MILLION P.A. IN 2041?

CHALLENGE #2 – HOW TO INCREASE REGIONAL PRODUCTIVITY BY $73 MILLION P.A. DUE TO FASTER COMMUTING TIME BETWEEN THE ILLAWARRA REGION AND WESTERN SYDNEY BY 2041?

CHALLENGE #3 – HOW TO INCREASE RAIL FREIGHT CAPACITY BY 2036 IN ORDER TO ENABLE THE GROWTH OF PORT KEMBLA AND AVOID A $230 MILLION ECONOMIC LOSS BY 2041?

A key to unlock the regional potential of the Illawarra and the Wollondilly Shire is to improve the road and rail connectivity to Western Sydney in order to facilitate passenger and freight mobility to and from the future population and economic growth centre of the Greater Sydney area.

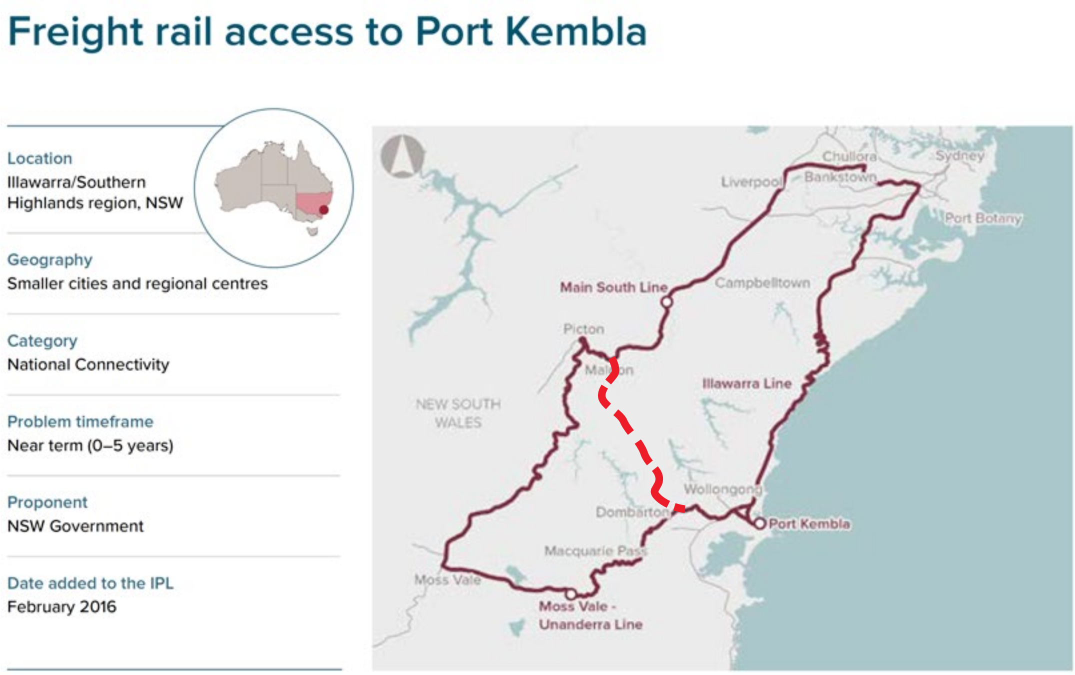
Although Picton, Appin and Menai corridors offer several opportunities of improvement of road connectivity we argue that the Maldon-Dombarton corridor, and its SWIRL passenger and freight solution, is a crucial component of the future rail connectivity to Western Sydney.

CHALLENGE #1 – HOW TO INCREASE JOB CREATION BY 1% P.A. AND CONSEQUENTLY REDUCE THE REGIONAL DEFICIT OF INVESTMENT BY $892 MILLION P.A. IN 2041?

Reducing the local job deficit – In 2016, the Illawarra Statistical District (ISD) included 124,000 employed residents and provided 108,000 local jobs, resulting in a deficit ratio of 0.87 (ABS 2016). Based on the latest regional population projections[27] and estimations of job creation in Wollongong[28] over the last ten years (4,998 between 2008 and 2018 or 0.5% increase p.a.), it is predicted that the ISD will include 158,000 employed residents and provide 122,000 local jobs by 2041, deepening the deficit ratio to 0.77 under a BAU scenario. An increase of job creation to

Figure 2

Infrastructure Priority List 2020 – Priority Initiative 'Freight Rail Access to Port Kembla' (IA 2020). Dashed red link added by authors to represent the "alternative rail alignment to the port".



24. Ibid GSC (2018)
25. Universities of Wollongong, Deakin & Newcastle, Committee for Geelong (2019), *Australia's Gateway Cities: Gateways to Growth*
26. Committee for Sydney (2018), *The Sandstone Mega-Region, Uniting Newcastle – the Central Coast – Sydney – Wollongong*
27. NSW Government (2020), *NSW Population Projections*
28. Ibid WCC (2019)

1% p.a., as stated in Wollongong's EDS, would allow keeping the deficit ratio at its 2016 level and bring the number of local jobs in the ISD to 136,000 by 2041.

Wollondilly's Economic Development Strategy (2020) uses a similar approach to infer that the local job deficit ratio would dive from 0.46 in 2016 (24,000 employed residents for 11,100 local jobs; ABS, 2016) to 0.37 by 2041 under a BAU scenario (assuming 0.5% p.a. job creation and a total population of 99,600 by 2041; ABS ERP 2019). An ambitious EDS scenario (2% p.a. job creation), would see the creation of 10,000 local jobs by 2041, maintaining the job deficit ratio around 0.44.

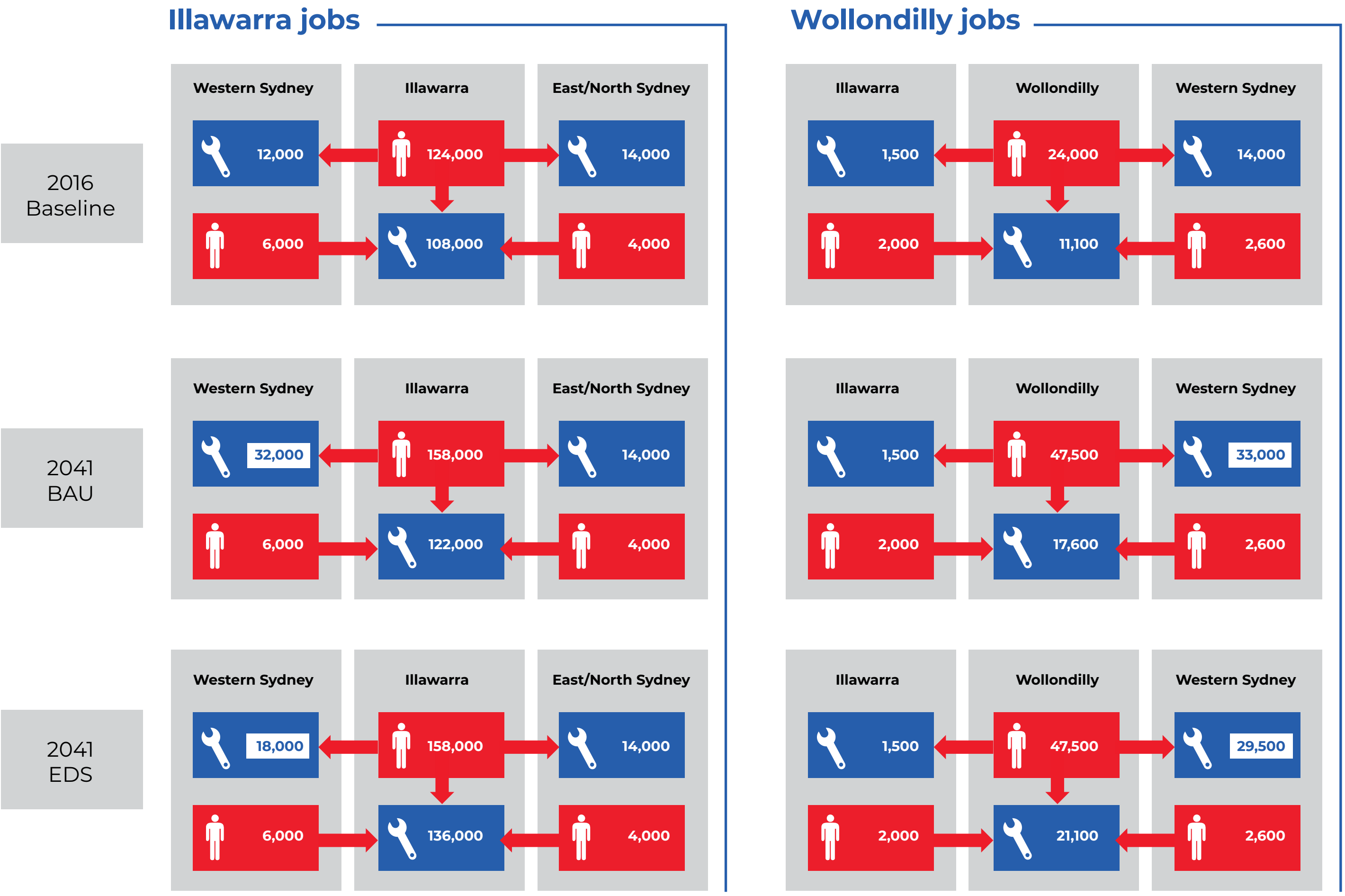
Assuming that the job deficit ratio is a proxy for the lack of economic investment in a region, every additional job contributes to the reduction of this deficit. Under an EDS scenario, the Illawarra region (ISD) would create an additional 14,000 jobs and Wollondilly Shire another 3,500 jobs by 2041, compared with a BAU scenario. Based on a regional average annual salary of $51,000 (ABS 2006), these 17,500 additional jobs correspond to a $892 million p.a. reduction to the deficit of investment in the Illawarra region and Wollondilly Shire.

However both Wollongong Economic Development Strategy (2019) and Wollondilly Economic Development Strategy (2020) identify better connectivity to Western and Central Sydney as a major enabling factor to attract enterprises and investment to the region. Furthermore, even under an EDS scenario, 47,500 workers will still have to commute from the Illawarra and Wollondilly to Western and Central Sydney, putting even more demand on a road and rail network already under pressure. Due to the current lack of convenient rail link to Western Sydney, future residents of West Dapto or Wilton New Town will have no choice but to drive their car to work into an increasingly congested road network.

Figure 3 shows spatial distributions of the number of jobs and active workers for the Illawarra region (left) and the Wollondilly Shire (right). Top diagrams correspond to the 2016 baseline[30], middle diagrams correspond to a BAU scenario and the bottom ones correspond to the EDS scenario. These figures are derived from Community Profiles[31] accessed in February 2020 on the Proflie.id website, a data sharing site as well as Wollongong EDS (2019) and Wollondilly EDS (2020) reports.

Figure 3

Spatial distribution of number of jobs and active workers; 2016 baseline, 2041 Business as Usual (BAU) and Economic Development Strategy (EDS) scenarios; Illawarra (left) and Wollondilly (right) (sources: ABS, NSW-DPI, WCC and WSC)



29. Ibid WSC (2019)

30. ABS Government of Australia (2016), *Census* https://www.abs.gov.au/census.

31. Profile I.D. (2019) https://profile.id.com.au/wollongong/ https://profile.id.com.au/shellharbour/ https://profile.id.com.au/wollondilly

CHALLENGE #2 – HOW TO INCREASE REGIONAL PRODUCTIVITY BY $75 MILLION P.A. DUE TO FASTER COMMUTING TIME BETWEEN THE ILLAWARRA REGION AND WESTERN SYDNEY BY 2041?

Improving the connectivity to Sydney – Reducing the loss of productivity due to transport inefficiencies around the Greater Sydney area has been a high priority for Infrastructure NSW[32] and Transport for NSW.[33]

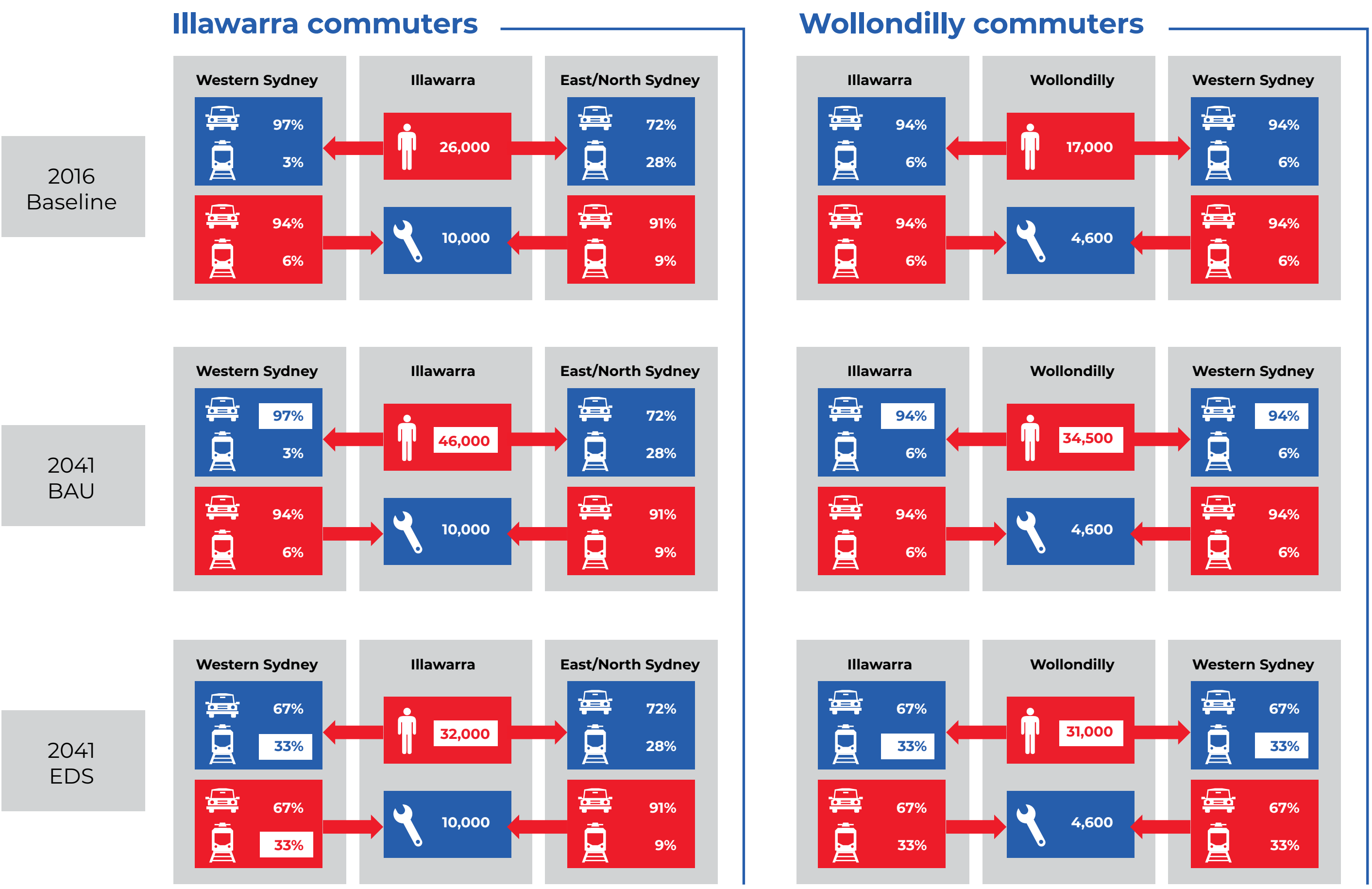
Based on ABS Census 2016[34], Sydney Trains timetables, bespoke rail modelling[35] and Google Traffic figures, we have been able to breakdown daily commuting flows by transport mode (car or train), as well as broad travel origins and destinations for the Illawarra and the Wollondilly Shire (Figure 4).

In 2016, 26,000 workers commuted from the ISD to the Greater Sydney area on a daily basis[36] while 10,000 workers made the reverse trip. Twelve thousand outbound commuters (46%) headed towards Western or Central Sydney, with 97% of them travelling by car (in comparison, 71% of commuters travelling to Eastern Sydney or further north used a car). Six thousand inbound commuters (60%) came from Western or Central Sydney, with 94% of them travelling by car (in comparison, 90% of commuters travelling from Eastern Sydney or further north used a car). By 2041, under a BAU scenario (see above) – and considering no changes in inbound commuters (10,000 per day) – outbound commuting would increase by 20,000 per day, up to 46,000 in total.

Assuming that most of these workers will fill some of the expected 200,000 new jobs to be created in Western Sydney, it is predicted that **32,000** will commute from the Illawarra to Western and Central Sydney, mainly by car. Equivalent assumptions for the Wollondilly Shire lead to an additional **31,000** commuters to Western and Central Sydney. This significant increase in traffic (+150% from 2016 baseline) will put unsustainable pressure on Picton Road, Appin Road and Heathcote Road that will need major and costly upgrades. However, unlike the northern transit corridor that offers a choice between road (M1) and rail (South Coast Line), the western transit corridor doesn't yet offer any public transport alternative to commuters.

Figure 4

Spatial distribution of daily commuters and transport modes; 2016 baseline, 2041 Business as Usual (BAU) and Economic Development Strategy (EDS) scenarios; Illawarra (left) and Wollondilly (right) (sources: ABS, TfNSW, NSW-DPI, WCC and WSC).



32. Ibid INSW (2018)
33. Ibid TfNSW (2018)
34. Ibid ABS (2016)
35. Ibid SMART (2017)
36. Ibid ABS (2016) *Journey to work* 2016

Using reported travel times between Wollongong and Campbelltown, Liverpool, Parramatta and St Marys[37] by road and rail, as well as Google Traffic estimations, we established that an average trip to/from Western Sydney took 90 minutes by road and 140 minutes by rail in 2016. Equivalent calculations from Picton[38] established that an average trip to/from Western Sydney took 80 minutes by road and 120 minutes by rail (see Table 1, page 13).

Assuming that an additional passenger rail link between Wollongong and St Marys, via Wilton, could capture approximately 33% of commuting trips by 2041, our BAU and EDS scenarios suggest the corresponding **18,500 daily commuters** would experience a 15-20 minute faster journey to Western Sydney compared with current road or rail trips. Assuming an average working time value of $56/hour (2017 SMART/Illawarra First Rail Connectivity Report, adjusted to 2019-20 dollars) and 210 working days per year, **a passenger rail link between Wollongong, Wilton and St Marys could result in a productivity gain of $73 million p.a. due to a faster commuting time by 2041.**

CHALLENGE #3 – HOW TO INCREASE RAIL FREIGHT CAPACITY BY 2036 IN ORDER TO ENABLE THE GROWTH OF PORT KEMBLA AND AVOID A $230 MILLION ECONOMIC LOSS BY 2041?

Increasing the regional freight capacity – Topographic constraints and industrial legacy have shaped the current regional transport network and freight traffic patterns into and from the Illawarra region. Recent modelling from TfNSW[39] shows that rail freight along the SCL and Moss Vale - Unanderra Line will reach its maximum capacity by 2036, while road freight will face a significant increase in traffic along Picton Road, Appin Road and Heathcote Road. Besides, local rail and road freight traffic will continue to grow within the Illawarra region fuelled by population and economic growth. The model shows that the annual rail demand will jump from 7,202 to 19,029 train paths (+164%) between 2036 and 2056. This significant increase will be due to a sustained growth in coal (inbound: 7M tonnes/p.a. by 2056) and steel (outbound: 2.7M tonnes/p.a. by 2056) freight, as well as an estimated 8.3M tonnes/p.a. demand for shipping containers (following the expected opening of the Port Kembla container terminal by NSW Ports[40]).

The annual road demand will also experience an increase from 5.0M trips/p.a. in 2036 to 7.7M trips/p.a. in 2056 (+54%). This increase will be due to a sustained growth in freight for coal (inbound: 10M tonnes/p.a. by 2056), manufacturing goods (inbound: 6.1M tonnes/p.a.; outbound: 11.4M tonnes/p.a. by 2056), construction materials (outbound: 7.2M tonnes/p.a. by 2056) and imported vehicles (outbound: 1.0M tonnes/p.a. by 2056); as well as an additional 7.2M tonnes/p.a. demand for shipping containers. Figures show that movements of shipping containers in and out of Port Kembla terminal will account for 49% rail demand and 21% of road demand for freight by 2056.

A report commissioned by NSW Ports[41] used stronger growth projections compared with those used by TfNSW to estimate that Port Botany would start experiencing significant issues with the handling of containers due to road and rail traffic congestion around the port/airport precinct by 2041. The associated modelling suggests that the Port Kembla container terminal could pick up nearly 11% of the forecasted 5.3 million TEUs handled by NSW Ports, on condition that relevant road and rail infrastructure is built (mainly Picton Road Motorway upgrade, M6 Stage 1, SCL improvement and Maldon-Dombarton corridor). This share of the market would create an additional revenue of $177 million/p.a. for Port Kembla, based on an estimated terminal charge of $302/TEU.[42]

Regardless of the additional pressure on the road and rail networks caused by the future container terminal, the current rail network cannot cope with the 34% increase in rail demand generated by the growth in movements of coal, steel, grains, construction material and manufacturing goods between 2036 and 2056.

This bottleneck will be exacerbated by an increase in demand for passenger trains as the local population grows to half a million people by 2056. The impact on freight travel time and operating costs, alongside risks associated with a major failure on SCL, is estimated around $52.5 million p.a. (2017 SMART/Illawarra First Rail Connectivity Report, adjusted to 2019-20 dollars). Without suitable investment in rail connectivity – assuming that a massive increase in road freight capacity is not a desirable option – the accumulated economic loss for the Illawarra region could reach $1,000 million by 2056.

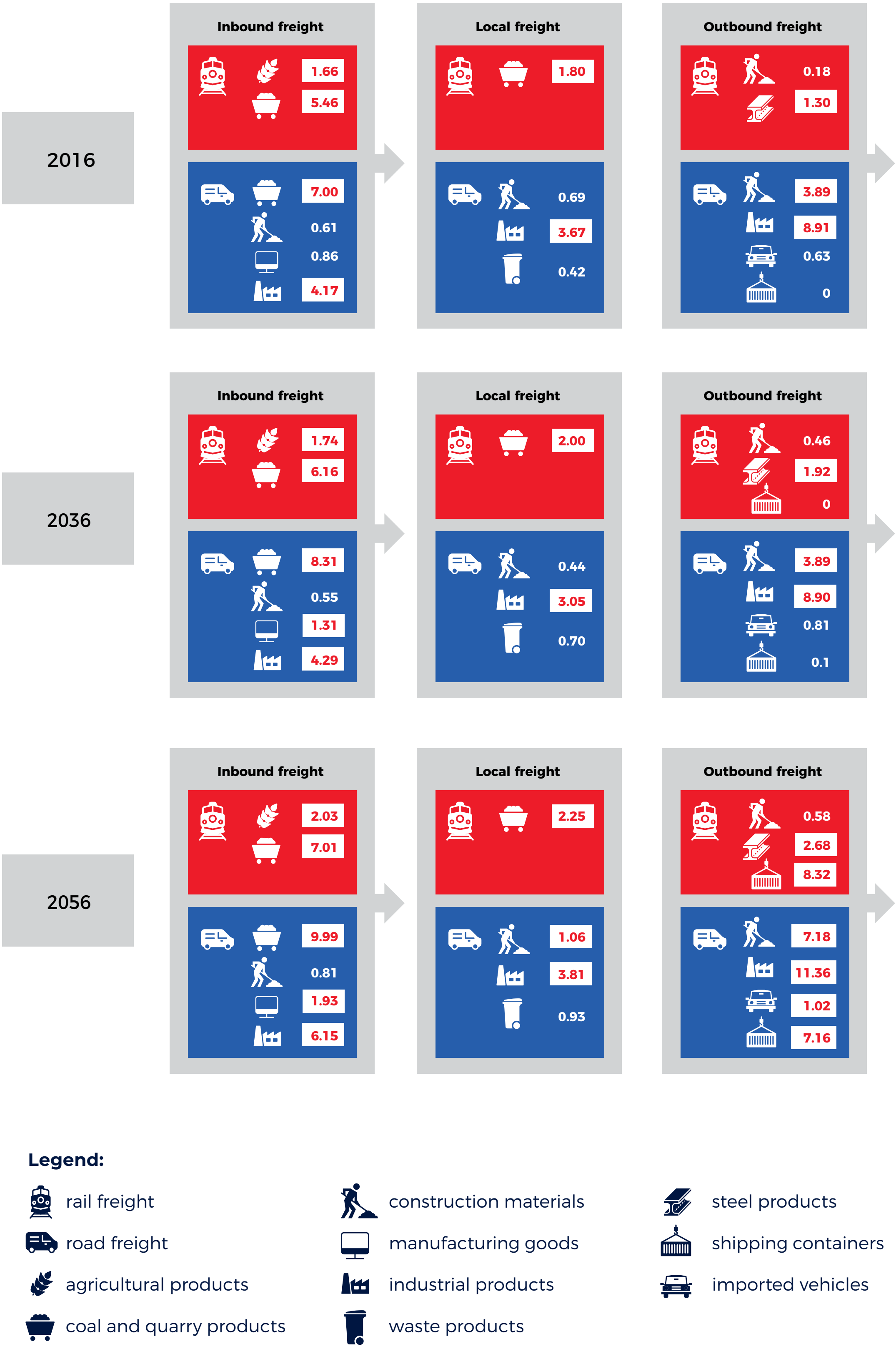
Finally, the development of the WSA[43] and its Aerotropolis urban core will significantly shift the social and economic epicentre of the Greater Sydney area. The Australian and NSW Governments have announced a joint investment of $3,600 million towards the Western Sydney Infrastructure Plan to upgrade and build new roads to support the region's economy and a joint commitment to fund Sydney Metro - WSA - Stage 1. The proposed Western Sydney intermodal freight terminal will complement the existing ones such as Minto, Moorebank or Enfield. This terminal will greatly benefit from a direct freight corridor to Port Kembla, bypassing traditional eastern Sydney's bottlenecks.

Appendix 5.2 provides detailed information on road and rail projections to 2056 according to TfNSW Transport Performance and Analytics modelling[44].

37. Ibid ABS (2016)
38. Ibid WSC (2019)
39. Ibid TfNSW (2018)
40. NSW Ports (2015), *Navigating the Future, NSW Ports' 30-Year Master Plan*
41. Ibid KPMG (2019)
42. Ibid TfNSW (2018)
43. Department of Infrastructure Transport Regional Development and Communications, Australian Government (2019), *Western Sydney Airport*
44. Ibid TfNSW (2018)

Figure 5

Distribution of inbound, outbound and local freight according to transport mode and commodity (in million tonnes) (source: TfNSW)



2.3 The SWIRL Solution

The SWIRL[45] concept proposed in 2017 involves the construction of an electrified passenger and freight line between the Illawarra and South West Sydney utilising the partially constructed Maldon-Dombarton Freight Link (including corridor) abandoned in the 1980s. Although traditional challenges associated with dual purpose rail corridors (timetable, curfew, passing loops) were not addressed in the 2017 SMART/Illawarra First Rail Connectivity Report, a few operational solutions should be considered at a later stage such as possibility to flexibly shift traffic flows depending on demand (for example, two tracks upwards, one for passenger trains and the other for freight trains).

Since this report, the establishment of the WSA/Aerotropolis, together with the announcement of the Sydney Metro - WSA (which has been confirmed as a passenger metro only) requires that the freight and passenger task now be considered from the Illawarra all the way through to the Aerotropolis and on to St Marys to connect with the MWL. Therefore, this report includes new considerations for an enhanced SWIRL concept.

The SWIRL proposal included the completion of the 35km-long Maldon-Dombarton line, connecting the Main South Line (at Maldon) and the Moss Vale-Unanderra dedicated freight line at Dombarton. In order to improve both passenger and freight movements between the Illawarra and Western Sydney, the proposal includes an electrified dual purpose (passenger and freight) and dual track alignment (except for the two main bridges and the 4km tunnel). The proposal also includes the necessary electrification of the 7km-long existing rail section on the Moss Vale-Unanderra Line between Dombarton and the junction to the South Coast Line.

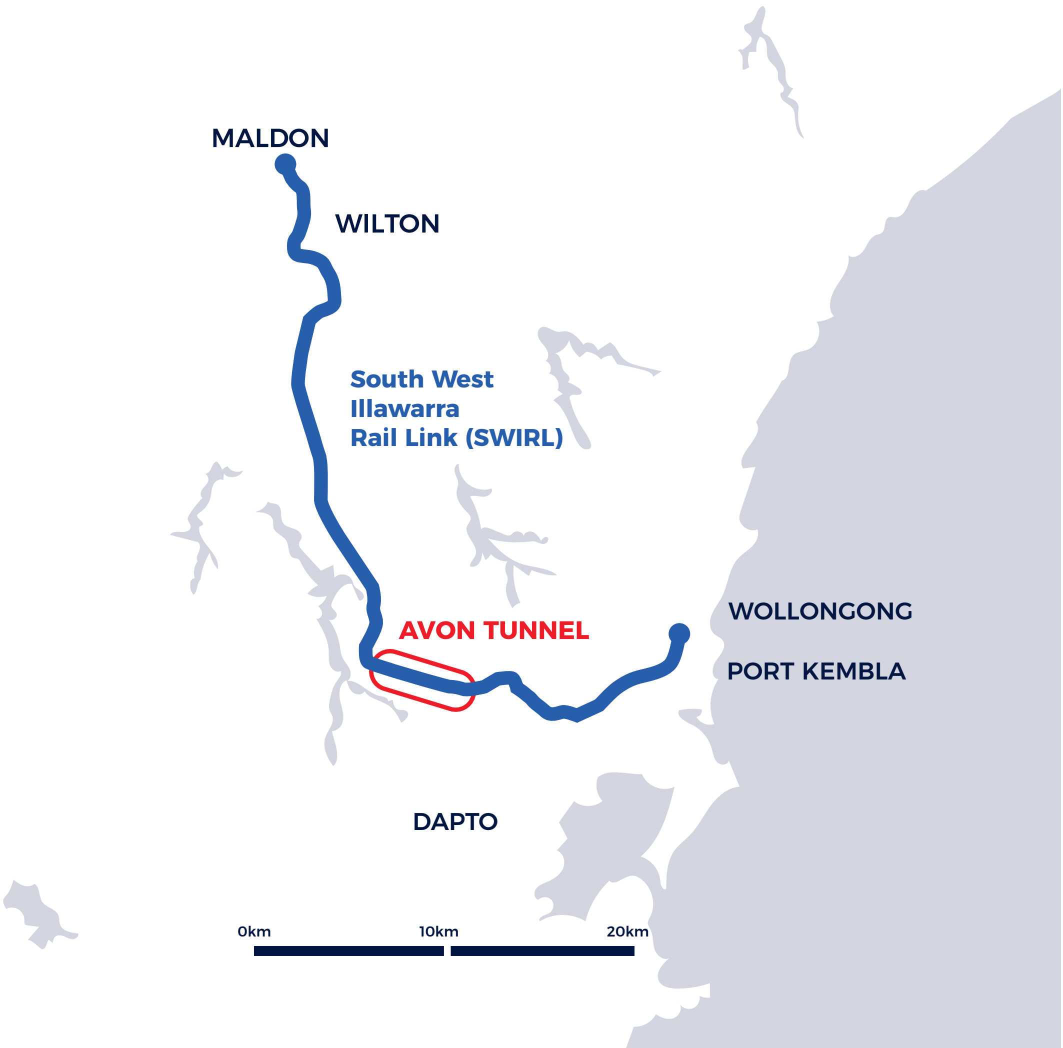
See Appendix 5.3 for detailed geotechnical information.

Based on initial feedback from government and non-government stakeholders to the previous report and recent decisions associated with the development of the Western Parkland City, two new additional options are considered in this report:

- A 30km electrified track between the Main South Rail Line and the WSA, providing a spur connection for passengers to/from the airport and the Aerotropolis.
- An 18km electrified connection between the WSA and the Western Line, which could provide another connection to Port Kembla.

Figure 6

Maldon-Dombarton corridor; SWIRL original alignment (source: SMART, 2020)



45. Ibid SMART (2017)

2.4 SWIRL Options

The initial SWIRL focused on the original freight line corridor between Maldon and Dombarton. More precisely, the study looked at a dual track electrified line, connected to the Main South Line at Maldon (western connection) and connected to the Moss Vale-Unanderra Line at Dombarton (eastern connection). Recent reports and debates about rail and road connectivity around the WSA and the future Western Parkland City have triggered the need to explore two complementary extensions to the first proposal:

SWIRL-Maldon: The initial proposal includes the completion of a dual purpose (passenger and freight) and dual track electrified line along the pre-existing 35km-long Maldon-Dombarton rail corridor. This base option also includes the electrification of the 7km-long section of the existing Moss Vale-Unanderra Line between Dombarton and Unanderra (connection to the SCL). We expect that passengers would travel from Wollongong station and a future Wilton station to reach Glenfield station on the MSL, continuing their journey through Sydney Trains network (T2, T3, T5 or T8) and vice-versa. Freight trains would mainly travel between Port Kembla, using the SCL between Coniston and Unanderra, then bifurcating onto the SWIRL Line and reaching the MSL at Maldon towards intermodal terminals such as Minto or Moorebank (and vice-versa), although the current configuration of MSL forces freight trains to travel up to Flemington loop in order to go back to Minto terminal.

SWIRL-WSA: This option includes a 30km-long extension of SWIRL towards the future WSA following approximately the corridor of the future Outer Sydney Orbital (OSO-M9). Unlike the proposed freight-only OSO line, the SWIRL-WSA extension would also be a dual purpose (passenger and freight) and dual track electrified line. The proposed OSO alignment runs to the west of WSA as freight trains will not need to access the airport terminal. One option for passenger trains would be to create a spur, approximately from current locations of Luddenham and Badgerys Creek in order to offer a direct service to the airport. Alternately, a more cost-effective solution would be to bypass WSA and transfer passengers to the Sydney Metro - WSA at St Marys with acceptable additional time to the journey.

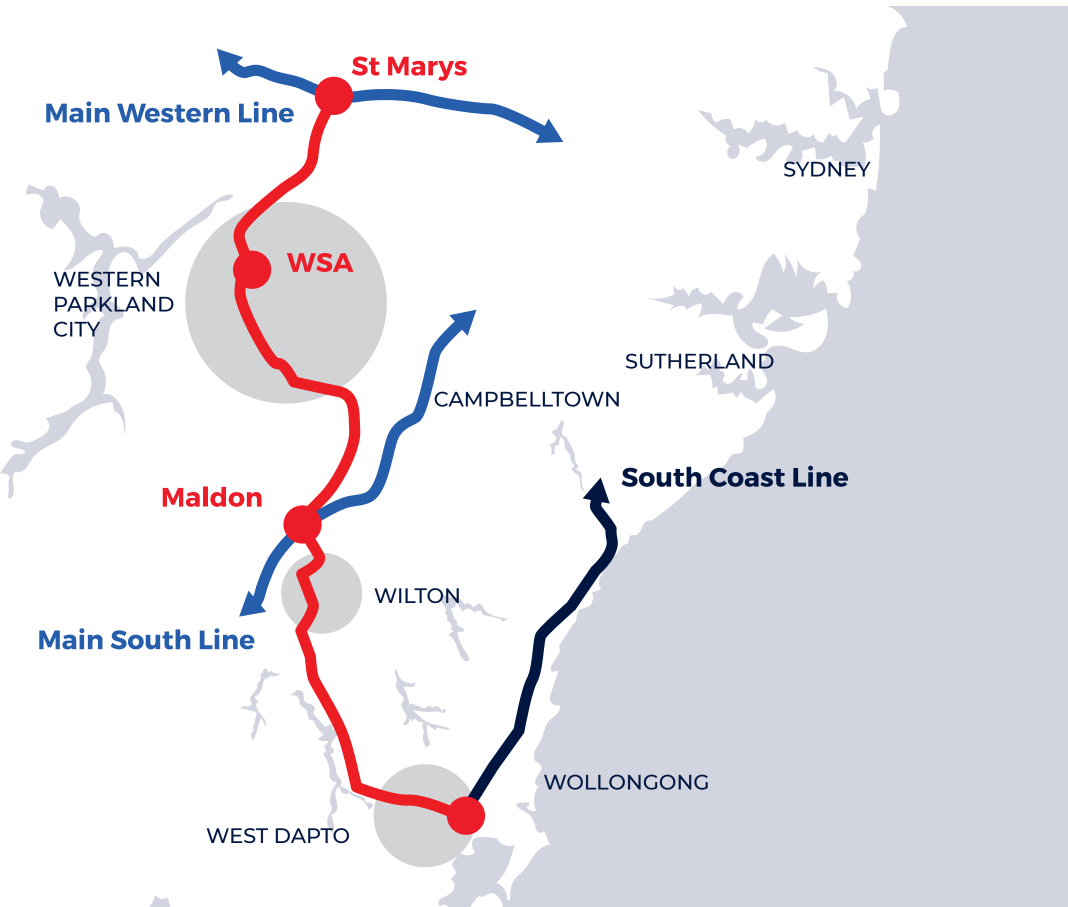
SWIRL-St Marys: This option would add an 18km-long extension of SWIRL-WSA to St Marys and the future Western Sydney Freight Terminal. SWIRL-St Marys would also provide a connection to the Western Sydney Line for passengers. Rather than the planned passenger-only metro, a dual purpose and dual track electrified line is greatly preferable on both an economic and practical basis. The alignment would approximately follow the alignment of the northern section of the previously proposed NSRL, between St Marys and WSA. SWIRL-WSA would run in parallel to Sydney Metro - WSA from Badgerys Creek to St Marys, connecting passengers to the metro at St Marys station.

Unlike the proposed OSO and Sydney Metro - WSA, SWIRL-St Marys would offer a coherent and versatile rail solution around Western Sydney and an effective access to Port Kembla and the Illawarra region, without having to struggle too much with Sydney Trains congested network and crowded timetables.

SWIRL-St Marys will provide a more direct route into the industrial heartland of South West Sydney, including the WSA at Badgerys Creek, the Aerotropolis and the growing CBD's of Parramatta and Liverpool. At an average operational speed

Figure 7

SWIRL-St Marys corridor, joining West Dapto, Wilton and Western Parkland growth areas.



of 100km/h (130km/h nominal), SWIRL-St Marys will deliver significant time savings to rail commuters compared with current rail connections between Wollongong and urban centres such as Parramatta (30 min), Liverpool (50 min), St Marys (120 min) and Campbelltown (95 min or 40 min compared with bus route).

SWIRL-St Marys would also deliver time savings between 10 and 50 minutes compared with road trips, except for Liverpool (see Table 1). Equivalent estimations between Wilton and various urban centres in Western Sydney provide time savings between 20 and 120 minutes compared with current rail connections, as well as savings between 5 and 35 minutes compared with road trips (see Table 1).

SWIRL-St Marys will provide the following potential primary benefits to overcome several current or near-future constraints:

- Accommodate increasing freight movements between Port Kembla and Western NSW (for example, inbound coal from Lithgow or outbound steel to Queensland), thus bypassing the Sydney Trains Network.
- Provide significant time savings associated with commuting from Wollongong and the future Wilton New Town to Western Sydney (see Table 1).
- Address near-term passenger and freight capacity on the SCL by providing an alternative corridor into the Sydney Trains Network.
- Deliver a cost-effective passenger rail solution for Wilton New Town development in the Wollondilly Shire.
- Reduce road congestion and safety issues due to heavy vehicle traffic on Mt Ousley Road, Picton Road and Heathcote Road, as well as access roads to Port Kembla.

Additionally, the following secondary benefits will be realised in the near to mid-term future:

- Encourage investment in the Illawarra region and the Wollondilly Shire economies by increasing their connectivity.
- Support land and housing developments in the Illawarra region and the Wollondilly Shire.
- Enable upgrading of the SCL to occur without relying on alternative transport options.
- Indirect benefits such as reduced noise and pollution in urban areas in Wollongong and South Sydney.

In summary, SWIRL will address the three challenges facing the Illawarra region and Port Kembla (see section 1.1):

Challenge #1: SWIRL-St Marys will provide better connectivity to Western Sydney for freight and passengers. It will also provide a welcome redundancy solution for rail access to the Illawarra and Port Kembla, currently dependent on two corridors notorious for their geotechnical risks. This additional capacity will also allow for a long-term and progressive upgrading of the Moss Vale-Unanderra Line and the SCL. In line with Wollongong EDS[46] and Wollondilly EDS[47] reports, SWIRL-St Marys will contribute, amongst other factors, to the creation of 17,500 additional jobs to the region (EDS scenario), resulting in a reduction of $892 million p.a. to the deficit of economic investment in the region by 2041.

Challenge #2: SWIRL-St Marys will drastically reduce commuting time between Wollongong, Wilton and Western or Central Sydney, providing an attractive alternative to road transport, the only viable option currently available to people working in Parramatta, Liverpool or Campbelltown. With a realistic daily objective of 18,500 commuters (33% of total), SWIRL-St Marys will contribute – through faster and safer commuting – to the saving of $73 million p.a. in productivity losses due to road commuting by 2041.

Table 1

Travel times from Wollongong and Wilton to various localities in Western Sydney

Wollongong to... (minutes)	**Wilton**	**Campbelltown**	**Liverpool**	**Parramatta**	**St Marys**
CAR (C)	35	65	80	130	110
Train - now (T)	--	90[a]	140	130	180
SWIRL (S)	25	55	90	100	60
Δ (S,T)	--	40	50	30	120
Δ (S,C)	**10**	**15**	**-10**	**30**	**50**

Wilton to... (minutes)	**Wollongong**	**Campbelltown**	**Liverpool**	**Parramatta**	**St Marys**
CAR (C)	35	35	100	80	110
Train - now (T)[b]	--	50	90	115	155
SWIRL (S)	25	30	70	75	35
Δ (S,T)	--	20	20	40	120
Δ (S,C)	**10**	**5**	**5**	**25**	**35**

a. duration based on bus trip from Wollongong to Campbelltown (150 min by train)

b. duration based on South Rail Line timetable at Picton +15 min drive from Wilton

(Source: ABS-Journey to work 2016; Google Traffic 2020)

46. Ibid WCC (2019)

47. Ibid WSC (2020)

Challenge #3: SWIRL-St Marys will provide an efficient and durable solution to a dual challenge facing freight transport in the Illawarra region. First, based on current trends in inbound (coal, grains, manufacturing goods) and outbound (steel, vehicles, construction materials) freight traffic, most experts assume that rail freight demand will reach the network capacity (maximum number of rail paths) by 2036. Then by 2041, NSW Ports will activate its container terminal at Port Kembla which should progressively capture 11% of Port Botany traffic, approximately 530,000 TEU p.a., and add around 9,300 train paths to the annual rail demand, as well as 1.6 million road trips to the annual road demand. As a large percentage of this additional traffic will aim for Central and Western Sydney, the SWIRL will contribute – through additional rail freight capacity – to the saving of $230 million p.a. in economic losses due to capacity shortage by 2041.

Figure 8

Commuters by mode of travel

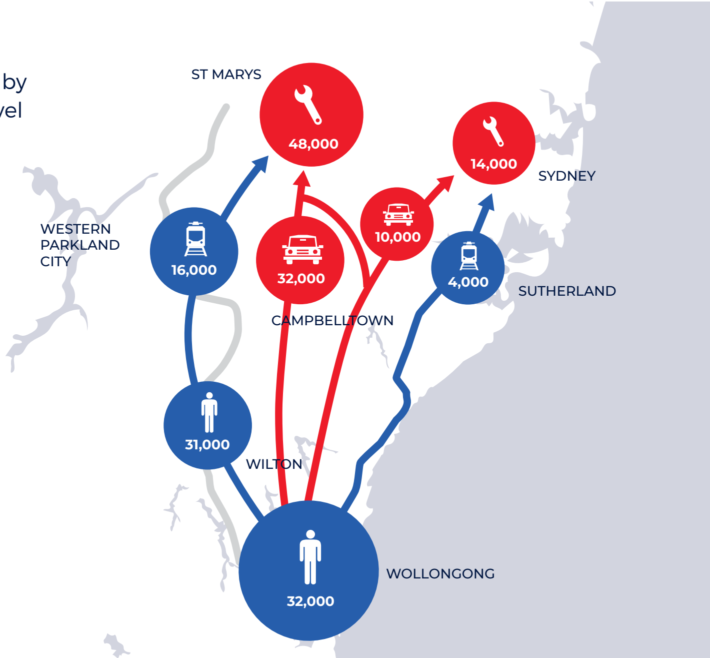
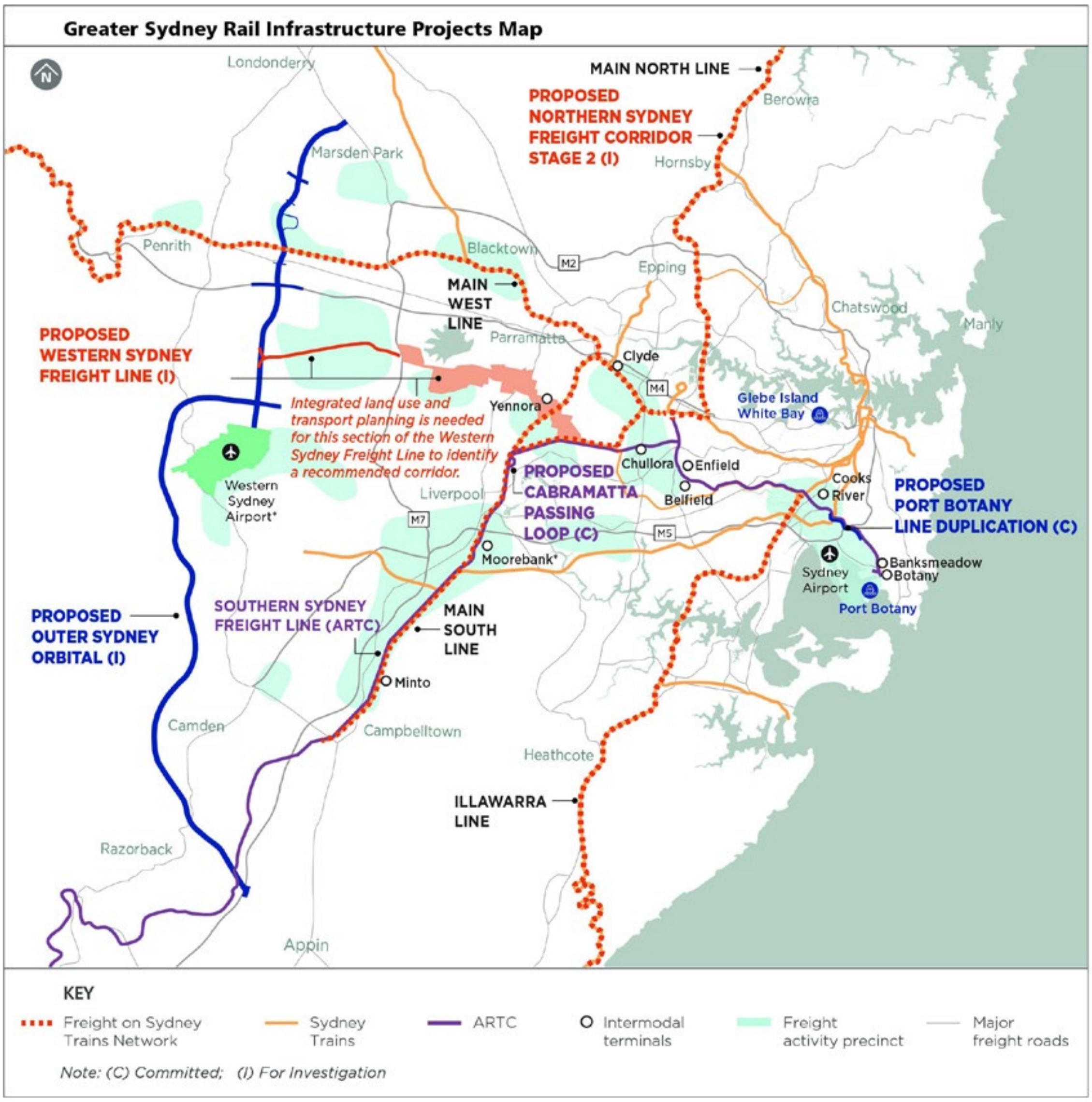


Figure 9

Greater Sydney Rail Infrastructure Projects Map

Impact of SWIRL-St Marys on commuting from the Illawarra region and the Wollondilly Shire to Eastern and Western Sydney by 2041 (source: SMART, 2020)

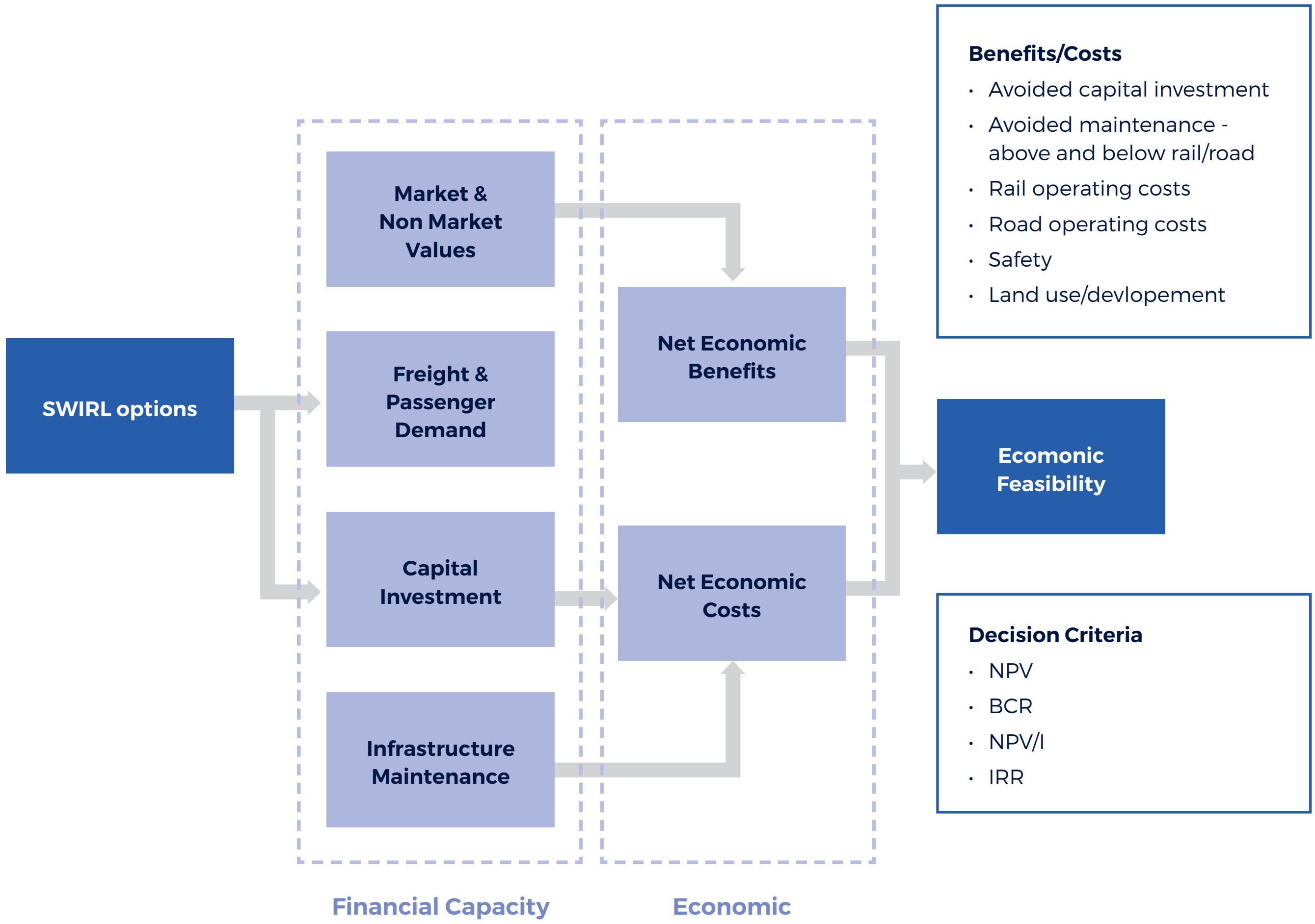


2.5 Cost Benefit Appraisal

A Cost Benefit Appraisal (CBA) approach has been used to assess the various options associated with the development of the SWIRL. The evaluation analyses the economic, environmental and social costs and benefits associated with the project. It provides a decision-making framework that considers the net impacts on all stakeholders, both positive and negative. SMART has selected this approach specifically because it mirrors that used by NSW Treasury to evaluate major infrastructure proposals of government departments. A commitment of the current government is that funding from Restart NSW (the fund created from the proceeds of asset recycling) can only be used to fund projects with a Benefit-Cost Ratio (BCR) of more than one. It is important that both market impact and non-market impacts are captured within an economic evaluation. The process of the economic evaluation is shown in the figure below. More specifically, the following diagram illustrates the process involved in undertaking the CBA for the proposed SWIRL options.

Figure 10

Approach to cost-benefit analysis



Appendix 5.1 summarises the detailed CBA analysis undertaken in the initial SWIRL report (2017). The resource costs taken into account are listed in Table 2 (below).

Table 2:

Categorisation of resource costs

TYPE OF COST	SWIRL
Infrastructure costs	Line completion Electrification Additional train sets New signalling technology Labour Disruption costs Environmental costs
Operating costs	Running costs such as diesel, electricity and labour costs Maintenance costs Depreciation

Likewise, benefits considered by the study are listed in Table 3 (below).

Table 3:

Potential benefits of rail investments or upgrades

BENEFITS	DESCRIPTION
PASSENGERS	**DIRECT BENEFITS**
Rail user cost savings	Reduced waiting time penalties Reduced travel time penalties Reduced modal shift penalties Reduced accessibility costs, where 'accessibility' is broadly defined as the variety of opportunities provided to people through efficient arrangement of land use and various modes of transport
Rail user benefits	Improvements in service reliability due to reaching the destination in a consistent journey time Improved passenger comfort due to improvements in amenities
Benefits to the broader community	Induced and generated rail trips: – Reduced car use / road congestion by shifting some car trips to public transport – Vehicle operating cost savings – Accident (crash) cost savings Reduced environmental externalities
	INDIRECT BENEFITS
Community development benefits	Transport investment improves the accessibility for new and existing transport users in catchment areas, which is often translated into enhanced land values.
Low-income mobility benefits	Availability of affordable transportation to low income people Budgetary savings arising from reduced social service outlays on home based health and welfare services such as home health care and unemployment benefits
Wider Economic Benefits	Wider economic benefits arising from: – Agglomeration economies – Increased competition as a result of better transport – Increased output in imperfectly-competitive markets – Economic welfare benefits arising from improved labour supply
FREIGHT TRAFFIC	**DIRECT BENEFITS**
Improved productivity	Reduced waiting time penalties Reduced travel time penalties Reduced modal shift penalties Improvements in service reliability Better coordination with attendant impact on inventories and spatial location with changing distribution network
Benefits to the broader community	Induced and generated rail trips (as above): – Reduced car use / road congestion – Vehicle operating cost savings
	INDIRECT BENEFITS
Wider economic benefits	Contribution to economic growth: – Reduced logistic costs that can be passed on to consumers thereby increasing product demand or increased production thereby lower product costs Wider economic benefits (as above): – Agglomeration economies – Increased competition as a result of better transport – Increased output in imperfectly-competitive markets – Environmental benefits

The updated costings (central case, 2019-20 dollars) of the three options (SWIRL-Maldon, SWIRL-WSA and SWIRL-St Marys) are summarised in Table 4 (below).

Table 4:

Estimated costs for various SWIRL options

SWIRL DETAILED COSTS	**COST ESTIMATE** (2019-20 DOLLARS)
Unanderra-Dombarton (7km) – dual track electrification	$140.0 million
Dombarton-Maldon (35km) – dual track electrification	$768.5 million
Dombarton-Maldon – Tunnels, bridges and embankments	$918.4 million
Maldon-WSA (30km) – dual track electrification	$600.0 million
Maldon-WSA – Tunnels, bridges and embankments	$271.1 million
WSA-St Marys (18km) - dual track electrification	$360.0 million
WSA-St Marys – Tunnels, bridges and embankments	$165.6 million
SWIRL-Maldon Total Cost	**$1,827 million**
SWIRL-WSA Total Cost	**$2,703 million**
SWIRL-St Marys Total Cost	**$3,229 million**

The updated potential benefits and Benefit-Cost Ratios (central case, 2019-20 dollars) of the three options (SWIRL-Maldon, SWIRL-WSA and SWIRL-St Marys) are summarised in Table 5 (below).

Table 5:

SWIRL estimated benefits and Benefit-Cost Ratios for various options

DESCRIPTION (2019-20 DOLLARS)	**SWIRL-Maldon ($ millions)**	**SWIRL-WSA ($ millions)**	**SWIRL-St Marys ($ millions)**
Freight travel time savings	124.207	128.1	128.1
Freight operating cost savings	329.148	330.4	330.4
Avoided externalities	188.104	188.8	188.8
Option value of South Coast Line failure	207.011	209.0	209.0
Passenger travel time savings & other benefits	928.025	1,347.4	1,347.4
Land use and development	0.0	22.0	22.0
Land Acquisition Benefits	0.0	0.0	145.4
Total private and social benefits (NPV 7%, 50 years)	1,776.495	2,225.72	2,371.2
Total private and social costs	**1,572.097**	**1,989.19**	**2,249.4**
BCR (7%, 50 years)	**1.13**	**1.12**	**1.05**
BCR (4%, 50 years)	**1.56**	**1.50**	**1.67**

Freight travel time savings remain the same between SWIRL-WSA and SWIRL-St Marys options as we assume that freight trains won't access and stop at the airport (Table 5). All SWIRL options presented at Table 5 return a BCR value greater than 1.0 over a 50-year period, regardless of the discount rate considered (4% or 7%), which it should be noted is a very conservative basis.

According to our Cost Benefit Appraisal, the SWIRL-St Marys option achieves a BCR of 1.05 at a 7% discount rate over a 50-year infrastructure asset life (at a 4% discount rate, the BCR is estimated to be 1.67).

SMART suggests that SWIRL-St Marys could be brought forward in order to benefit from early land protection and acquisition. Based on Infrastructure Australia's calculations (2017), an early land acquisition along the OSO corridor would save between $933 million and $4,412 million.

Assumptions used to calculate potential benefits are very conservative in comparison to the broader economic benefits stated in Challenges (section 1.1):

- SWIRL will contribute - through improved connectivity - to an increase of job creation by 1% p.a., preventing a potential deficit in economic investment of $745 million p.a. by 2041.
- SWIRL will contribute - through faster and safer commuting – to the saving of $75 million p.a. in productivity losses due to road commuting by 2041.
- SWIRL will contribute - through additional rail freight capacity - to the saving of $229 million p.a. in economic losses due to capacity shortage by 2041.

2.6 Alternative Solutions

South Coast Line upgrade

Currently, the main rail line between the Illawarra and Sydney is the South Coast Line. The SCL runs from Bomaderry (Nowra) to Waterfall station at the southern edge of the Sydney Trains Network. The SCL continues through to Central station and terminates at Bondi Junction.

The SCL is shared between passenger and freight services, with significant freight movement between Port Kembla and Sydney (up to 23 slots per day. It has been estimated that the SCL will reach capacity in the mid-to late-2020s.[48] Infrastructure NSW indicated in its State Infrastructure Strategy (2018) that freight movements will be completely displaced by passenger movements by 2030. More recent studies undertaken by TfNSW estimate that demand will meet capacity by 2036[49].

In theory, rail commute times can be reduced by:

- shortening the distance travelled (via line straightening, reducing steep gradients, and tunnelling),
- increasing train speeds safely (which often requires line straightening and/or investment in new signalling technology), or
- investing in line duplication to reduce bottlenecks and congestion. Often, a combination of these measures is required to make a significant difference to commuting times.

SMART found that reducing passenger commute times on the SCL is severely challenged by the geological conditions of the Illawarra escarpment and the consequent engineering challenges, such as tunnelling[50]. Freight trains face additional challenges such as the bypass loop at Thirroul that cannot accommodate trains longer than 800 meters. If a train misses the path, it cannot wait at Thirroul and must remain in Wollongong or Waterfall, using a later 'unallocated' path, which also matches its power to weight ratio.

The recent IA Infrastructure Priority List report[51] includes the SCL upgrade as a 10-15 year priority initiative (alongside the Newcastle-Sydney Rail Line):

"The proposed initiative includes a range of options for improvements to the lines:

(1) an initial set of operational and fleet improvements;

(2) targeted fixed infrastructure improvements (for example, new deviations to eliminate curvatures and flatten grades); and

(3) station improvements and capacity enhancing track amplifications. The Newcastle-Sydney and Wollongong-Sydney rail corridors were identified in the Australian Government's Faster Rail Connecting Capital Cities and Orbital Regional Centres prospectus, which was announced as part of the 2017–18 Budget."

SMART's high-level cost benefit analysis indicates that, in order to achieve a significant reduction in commute times between Wollongong and Central stations, an investment in the order of $2,000 million is required. This high cost is driven by the fact that the SCL is built on the Illawarra escarpment and significant line straightening by way of tunnelling is necessary to improve commute times. Previous work on infrastructure cost drivers by SMART indicates that tunnelling costs would be in the order of $150 million per kilometre. On this basis the 13 kms of tunnelling required would cost up to $2 billion.

At the standard 7% social discount rate, the central case BCR was **0.48**, with a low case estimate of **0.35** and a high case estimate of **0.63**.

Moss Vale - Unanderra Line upgrade

The Moss Vale-Unanderra Line connects Port Kembla to the Sydney Trains Network via Moss Vale (which is on the Main South Line) and Unanderra (near Port Kembla). The line is used for bulk freight such as grain, limestone from southern New South Wales and coal from Tahmoor. Connecting Port Kembla to Sydney, the Moss Vale-Unanderra Line is an alternative to the SCL for freight. Assuming no network delays and a clear path, the Moss Vale route takes 75 minutes longer than the SCL due to a longer distance to Sydney (the route is approximately 100 kilometres longer) and the steeper downhill gradient (3.3%) in the loaded direction, which requires a slow descent. Conversely, the opportunity for freight out from Port Kembla (manufacturing goods, construction material or shipping containers) to use the Moss Vale-Unanderra Line to reach Western Sydney's intermodal

48. ACIL Tasman (2011), *Maldon-Dombarton Rail Link Feasibility Study - Final Report*, Australian Government Department of Infrastructure and Transport
49. Ibid TfNSW (2018)
50. Ibid SMART (2017)
51. Ibid IA (2020)

terminals will be drastically constrained by the extra power needed to haul the train up to Summit Tank, on top of the escarpment.

The recent IA Infrastructure Priority List[52] report includes the Moss Vale-Unanderra Line upgrade as a 0-5 year priority initiative as part of the Freight Rail Access to Port Kembla initiative:

"In the long term, Port Kembla's Outer Harbour development is expected to attract overflow container traffic from Port Botany. The NSW Government has stipulated that Port Kembla should generally not accept more than 120,000 Twenty-foot Equivalent Units per annum by road. This is around 10% of planned Outer Harbour container capacity. This is likely to lead to a significant increase in demand for rail services. Inadequate freight rail capacity may lead to a substantial increase in road freight, further constraining the Illawarra region's road network […] Improve freight rail access to Port Kembla. This could be through enhancements to the Illawarra and/or Moss Vale–Unanderra lines, or through future development of an alternative rail alignment to the port."

An upgrade of the Moss Vale - Unanderra Line to the level proposed for SWIRL would include a duplication and electrification of a 50 km section between Moss Vale and Unanderra, as well as a partial (re) grading and enlargement of the 10 km section between Summit Tank and Dombarton. Using a $20 million/km costing figure for track duplication and electrification and a $100 million/km for heavy engineering work along the escarpment, the total estimated cost of the Moss Vale-Unanderra Line would approach $2,000 million. A cheaper option, keeping the single track climbing at 3% along the escarpment would not offer a viable option for outbound traffic of container trains from Port Kembla. Finally, a fully upgraded Moss Vale-Unanderra Line could face social backlash from local communities in Robertson and Moss Vale as the level of noise pollution would increase with higher traffic.

Outer Sydney Orbital

The NSW Government proposal for an Outer Sydney Orbital (M9) would provide a future north-south motorway and freight rail line, as described in Figure 11. The 70 km-long corridor will support the growth of Western Sydney and the distribution of freight across Sydney and regional NSW.

The purpose of the future motorway and freight rail line would be to:

- Provide for a major transport link between the North West and South West Growth Areas
- Provide connections to the planned Western Sydney Airport and future employment lands
- Support growing communities, businesses and new jobs in Western Sydney
- Provide a freight rail connection between Port Botany, Western Sydney and regional NSW
- Support the further separation of freight and passenger rail
- Move freight more rapidly, efficiently and safely by rail

The preservation of the OSO/M9 corridor is listed as a 0-5 year high priority initiative in the Australian Infrastructure List[53] report without any further information about construction timelines:

"In March 2018, the NSW Government publicly exhibited a planning study to identify and ultimately preserve a preferred alignment for a multi-modal transport corridor in Western Sydney, comprising a motorway, a north–south freight rail line, and, where practical, integrating a north–south passenger rail line. The NSW Government has confirmed the preservation of the Castlereagh corridor (originally reserved in 1951) to allow for future improvements to road connectivity and transport efficiency within Greater Sydney and to regional areas west of Sydney."

The Corridor Protection report[54] estimated that construction would cost between **$1,990 and $10,060 million**, in 2016 prices, using a 7% real discount rate (land acquisition not included). Unlike the proposed SWIRL-WSA, which follows the OSO corridor the decision to limit the rail alignment to freight trains misses a crucial opportunity to open Western Sydney to commuters from/to Southern Tablelands and the Illawarra. Offering a suitable rail transport solution for commuters and freight, SWIRL would also allow for a phased construction period of the M9 link.

Sydney Metro - Western Sydney Airport

The Sydney Metro - WSA will connect the WSA to St Marys and the existing passenger network on the Main Western Line. Under the Western Sydney City Deal, the Australian and NSW governments will deliver the first stage of the Sydney Metro - WSA. This will become the transport spine for the Western Parkland City, connecting travellers from the Western Sydney Airport and the Aerotropolis to St Marys and the rest of Sydney's rail network. The Australian Government is contributing $3,500 million to deliver Stage 1 in collaboration with the NSW Government. A recent Western Sydney Rail Needs Scoping Study[55] estimated that the Sydney Metro - WSA would cost approximately **$15,000 - $20,000 million**.

As Stage 1 will deliver a metro-style solution, there will be a need to build the WSFL between Twin Creek (connection to the future Outer Sydney Orbital) and Leightonfield (connection to Southern Sydney Freight Line). The Corridor Protection[56] report estimated that construction would cost between **$543 million and $1,310 million**, in 2016 prices, using a 7% real discount rate (land acquisition not included). The most recent evaluations estimate the total cost of WSFL around $1,000 million, based on 30 km of single line track with connection into the metropolitan freight network. The cost estimate includes a single crossing loop and connection with the Main West Line at St Marys:

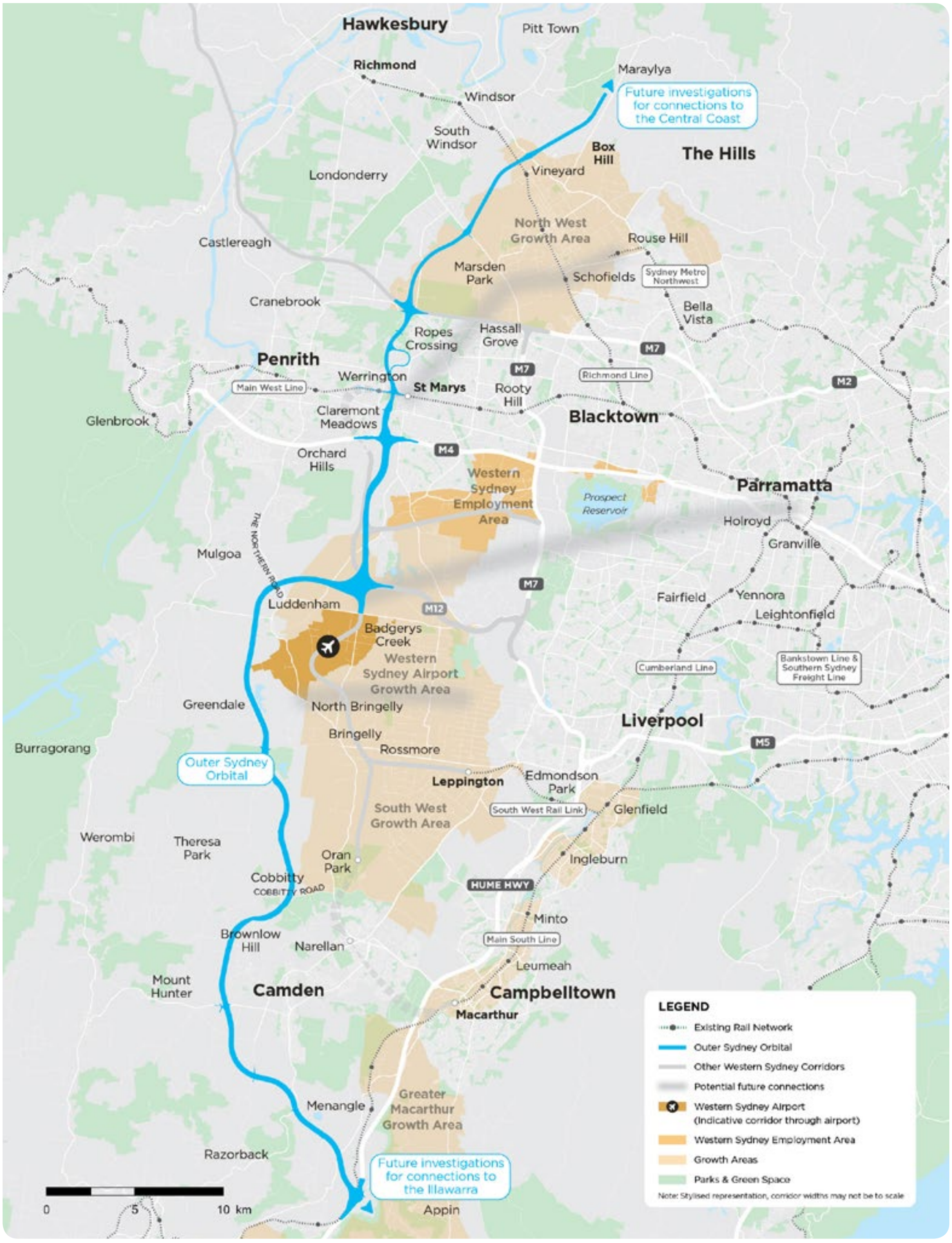
• Trackwork	$186 million
• Cuttings/embankments	$180 million
• Crossings & Utilities	$180 million
• Signalling	$224 million
• Design & Management	$231 million
• **Total**	**$1,000 million**

52. Ibid
53. Ibid IA (2020)
54. Ibid IA (2017)
55. Ibid *Western Sydney Rail Needs Scoping Study* (2018)
56. Ibid IA (2017).

Figure 11

Outer Sydney Orbital proposed corridor (source: TfNSW)

Map of the recommended corridor for the Outer Sydney Orbital

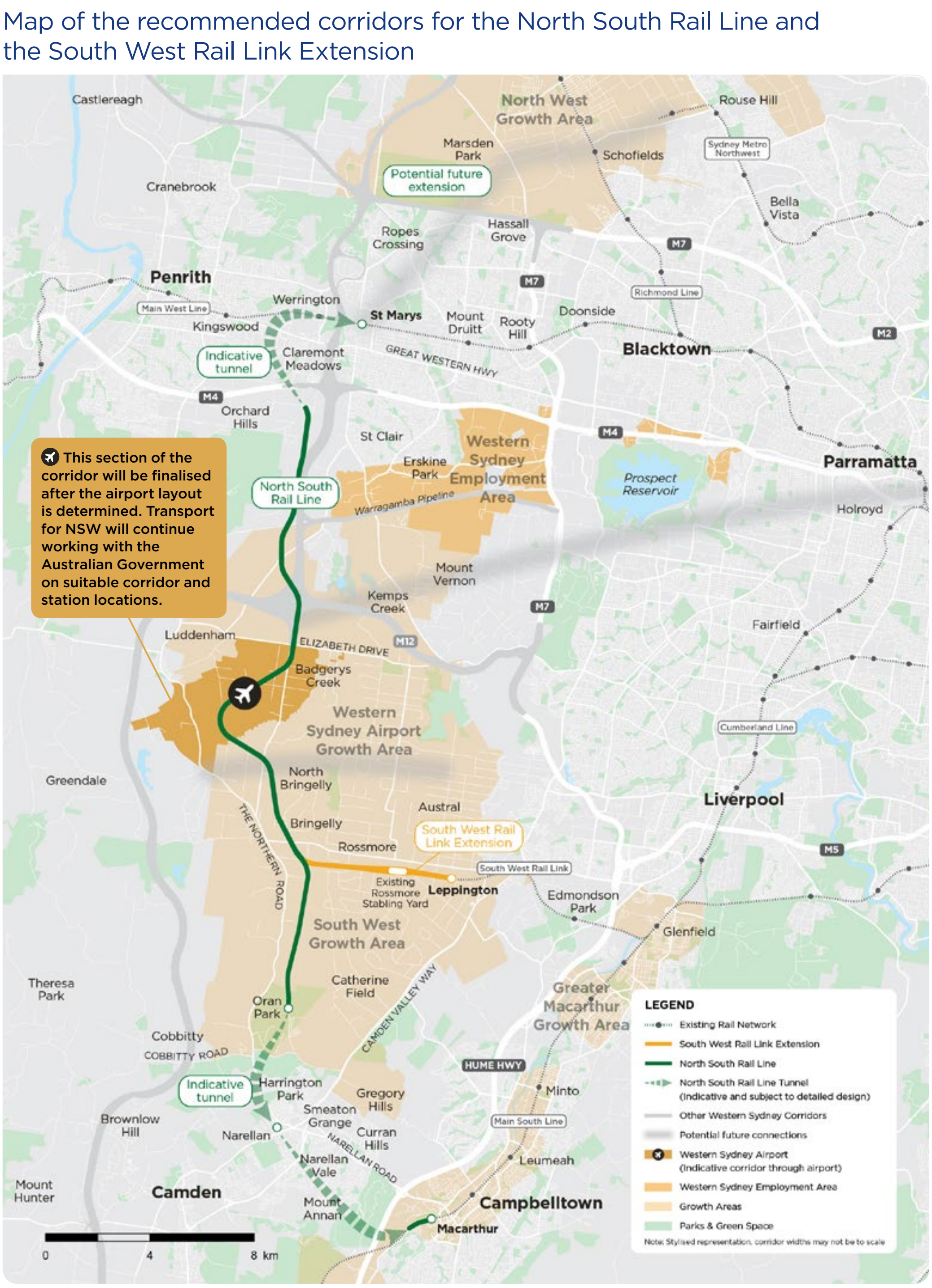


NSW GOVERNMENT

Transport for NSW will continue working with the Greater Sydney Commission, Department of Planning and Environment, local councils, community and stakeholders to refine the recommended corridor.

Figure 12

North South Rail LIne corridors (source: TfNSW)



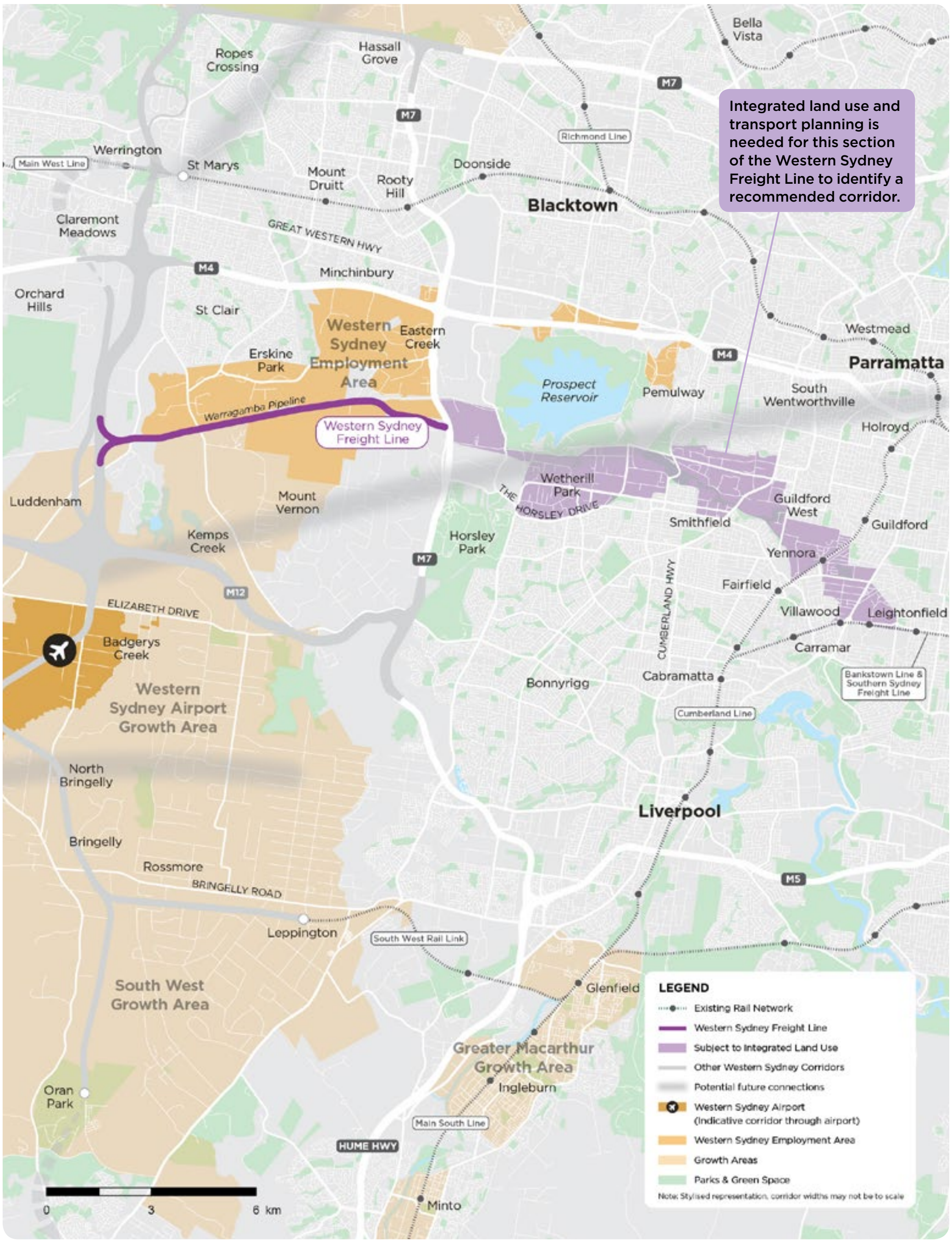
NSW GOVERNMENT

Transport for NSW will continue working with the Australian Government, Greater Sydney Commission, Department of Planning and Environment, local councils, community and stakeholders to refine the recommended corridor.

Figure 13

Western Sydney Freight Line corridors (source: TfNSW)

Map of the recommended corridor for the Western Sydney Freight Line between the M7 and the planned Outer Sydney Orbital



Transport for NSW will continue working with the Greater Sydney Commission, Department of Planning and Environment, local councils, community and stakeholders to refine the recommended corridor.

3 Recommendations

According to Minister Hon. Rob Stokes MP, Minister for Planning and Public Spaces,[57] to facilitate 'good growth' it is imperative to plan for and invest in key infrastructure that can both support population growth and unlock economic opportunities. The SWIRL solution meets both criteria as confirmed by the recent Australian Infrastructure Priority List.[58]

"IN THE LONG TERM, PORT KEMBLA'S OUTER HARBOUR DEVELOPMENT IS EXPECTED TO ATTRACT OVERFLOW CONTAINER TRAFFIC FROM PORT BOTANY...

THIS IS LIKELY TO LEAD TO A SIGNIFICANT INCREASE IN DEMAND FOR RAIL SERVICES....

THIS COULD (BE MANAGED) THROUGH ENHANCEMENTS TO THE ILLAWARRA AND/OR MOSS VALE–UNANDERRA LINES, OR THROUGH FUTURE DEVELOPMENT OF AN ALTERNATIVE RAIL ALIGNMENT TO THE PORT." [59]

Although SWIRL-Maldon can be seen as an opportunity limited to a better accessibility of people and freight from the Illawarra and Southern Tablelands to South West Sydney, SWIRL-St Marys has a far more ambitious objective to create a long-term social and economic bond between the core of the future Western Parkland City and the southern regions of Wollondilly and the Illawarra. Overall, SWIRL-St Marys brings forward the concept of the future Outer Sydney Orbital in order to benefit from a relative preservation of the relevant corridors, instead of focusing on East-West corridors that are already very costly to preserve and develop. A dual-purpose freight-passenger rail alignment will allow for a greater flexibility and will lower investment costs associated with non-interoperable solutions such as Sydney Metro - WSA and the proposed OSO/M9 (freight only).

Our recommendation is for SWIRL to undergo a proper engineering feasibility study including future design resolution and full costings, led by the NSW Government, as well as a business case addressing broad societal benefits and a whole of life cycle assessment. These documents should constitute the core of a submission to Infrastructure Australia aiming to update the Rail Freight Access to Port Kembla priority initiative (0-5 year) and move it to the project portfolio in the next Australian Infrastructure Priority List report.

The cost of inaction is high. By 2036, road and rail demand for freight will reach network capacity as people's movement increases with population growth in the region. By 2041, the activation of a container terminal at Port Kembla by NSW Ports will require a fully completed set of road and rail upgrades in order to cope with a 49% increase in rail path demand and 21% of road trips between Wollongong and, mainly, Western Sydney.

SMART Infrastructure Facility recommends the following:

Recommendation #1

That Infrastructure Australia updates its priority initiative (0-5 year) for 'Freight Rail Access to Port Kembla' and acknowledges the SWIRL-Maldon corridor as a future *"alternative rail alignment to the port".*

Recommendation #2

That the New South Wales Government commissions a detailed engineering feasibility study and a business case analysis, including land value uplift, of the SWIRL-St Marys option.

Recommendation #3

Considering population growth and increasing freight demand in the Illawarra region and the Wollondilly Shire, Transport for NSW estimates that the South Coast Line will reach capacity by 2036. SMART recommends that planning and design work for the SWIRL-Maldon section commence immediately in order for the line to be operational by 2036, including the Wilton rail station and the connection to the Main South Line at Maldon.

Recommendation #4

Anticipating the opening, by NSW Ports, of a second container terminal in Port Kembla by 2041, SMART recommends that current planning for the Outer Sydney Orbital should take into consideration the concept of a dual freight-passenger alignment up to St Marys, as per the SWIRL-St Marys option. SWIRL-St Marys should be operational by 2041 in order to enable the dispatching of containers from Port Kembla to Western Sydney and beyond.

Recommendation #5

Considering the ambitious mobility and liveability vision put forward by the Greater Sydney Commission for the future Western Parkland City, Infrastructure NSW and Infrastructure Australia should consider SWIRL-St Marys as a unifying and cost-effective solution to the movement of passengers and freight throughout Western Sydney. SMART recommends that the *'Corridor preservation for Outer Sydney Orbital road and rail/M9'* should be brought forward as a high priority project (0-5 years) in order to make significant land acquisition savings. In particular, corridor preservation should include an additional section from Douglas Park to Maldon.

57. Stokes, R., (2019), NSW Minister for Planning and Public Spaces, *Good Growth Summit*

58. Ibid IA (2020)

59. Ibid Stokes, R., (2019), NSW Minister for Planning and Public Spaces, *Good Growth Summit*

4 References

- ABS (2016), Census, Government of Australia https://www.abs.gov.au/census
- ACIL Tasman (2011), *Maldon-Dombarton Rail Link Feasibility Study - Final Report*, Australian Government Department of Infrastructure and Transport
- ACIL Tasman (2011), *Maldon-Dombarton Rail Link Feasibility Study – Working paper 1 and 2*, Australian Government Department of Infrastructure and Transport
- BHP Billiton (2007), *Illawarra Coal. Dendrobium mine –Area 3 : Prediction of subsidence parameters and the assessment of mine subsidence*
- *Brady, Barry HG, and Edwin T. Brown. Rock mechanics: for underground mining. Springer science & business media, 1993.*
- Chaabat, F., et al. "Smoke control in tunnel with a transverse ventilation system: An experimental study." Building and environment 167 (2020): 106480
- Commonwealth of Australia, State of New South Wales, (2018), *Western Sydney Rail Needs Scoping Study*
- Department of Infrastructure Transport Regional Development and Communications, (2019) *Western Sydney Airport* https://www.westernsydneyairport.gov.au/
- Committee for Sydney (2018), *The Sandstone Mega-Region, Uniting Newcastle – the Central Coast – Sydney – Wollongong*
- Department of Infrastructure and Regional Development (2017), *The National Rail Program: Investing in rail networks for our cities and regions*, Canberra
- Department of Infrastructure and Regional Development(2020), *Faster rail prospectus*, Canberra
- Fewings, Peter, and Christian Henjewele. Construction project management: an integrated approach. Routledge, 2019
- Greater Sydney Commission (2016), *Draft South West District Plan: Co-Creating a Greater Sydney*, Sydney
- Greater Sydney Commission (2018), *The Metropolis of Three Cities*
- Greater Sydney Commission (2018), *Western Sydney City Deal*
- Guglielmetti, Vittorio, et al., eds. Mechanized tunnelling in urban areas: design methodology and construction control. CRC Press, 2008
- Harrison, M (2010), *Valuing the Future: the social discount rate in cost-benefit analysis*
- Infrastructure Australia (2018), Project Business Case Evaluation, Maldon-Dombarton Rail Link,
- Infrastructure Australia (2017), *Corridor Protection: Planning and investing for the long term*
- Infrastructure Australia (2020), *Infrastructure Priorities List 2020*
- Infrastructure NSW (2018), *State Infrastructure Strategy*
- KPMG (2019), *Quay Conclusions*, Sydney
- Kuesel, Thomas R., Elwyn H. King, and John O. Bickel. Tunnel engineering handbook. Springer Science & Business Media, 2012
- Legislative Council Standing Committee on State Development of the NSW Parliament (2018), *Final Report – Regional Development and a Global Sydney*
- Martin, S., (2012) 'Costing Australian passenger rail projects 2000-2012: how much did we pay and what did we get?', paper presented to Conference On Railway Engineering, Brisbane, Australia 10 – 12 September 2012
- Neil, DM., (1987), 'The Avon tunnel on the Maldon to Dombarton railway', paper presented to Annual Convention of the NSW Section of the Permanent Way Institution.
- NFPA (2017), *Standard for Fixed Guideway Transit and Passenger Rail Systems*
- NSW Government (2020), *NSW Population Projections, Sydney*
- NSW Government (2018), *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, Sydney
- NSW Department of Planning, Industry and Environment (2019), *Population Projections*, Sydney
- NSW Government, Transport for New South Wales (2019), *A Fast Rail Future for NSW*, Sydney
- NSW Government, Transport for New South Wales (2018), *NSW Freight Commodity Demand Forecasts 2016-2056*, Sydney
- NSW Government Transport for New South Wales (2018), *Future Transport Strategy 2056*, Sydney
- NSW Ports (2015), *Navigating the Future, NSW Ports' 30-Year Master Plan*
- Palmer, D (1973), 'Seismic refraction investigations for the Avon-Berkeley pipeline, West Dapto, R00022566 (GS1973/462)'
- Procter, T, Henderson, L. (2016), 'Rail Tunnel Fire Safety System Design in a SFAIRP Context', in CORE: *Conference on Railway excellence, Safety and Risk session*
- Profile I.D. (2019) *Community Profiles* .idCommunity, viewed 2020

  https://profile.id.com.au/wollongong/

  https://profile.id.com.au/shellharbour/

  https://profile.id.com.au/wollondilly
- SMART Infrastructure Facility, University of Wollongong (2017), *Upgrading rail connectivity between Illawarra and Sydney*
- SMART Infrastructure Facility, University of Wollongong, (2019), *Estimating growth impacts for the Illawarra circa 2050 with enhanced access with South West Sydney*
- Snowy Mountains Engineering Corporation (1984), *Report on Geotechnical Analysis*
- Snowy Mountains Engineering Corporation (1987), *Geological Report of the Avon Tunnel*
- Standards Australia (2011), *Tunnel Fire Safety, SAI Global*, , Geological Report of the Avon Tunnel, Sydney Australia
- Stokes, R., (2019), NSW Minister for Planning and Public Spaces, *Good Growth Summit*
- Universities of Wollongong, Deakin & Newcastle, Committee for Geelong (2019), *Australia's Gateway Cities: Gateways to Growth*,
- Wollondilly Shire (2019) *Wilton New Town* https://www.wollondilly.nsw.gov.au/planning-and-development/growth-in-wollondilly/wilton-new-town/
- Wollongong City Council (2019), *Economic Development Strategy 2013-2023*
- *https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/assess_unit_cost_rail/annex_13_case_study_tunneling.pdf*
- *https://tunnel.ita-aites.org/en/component/seoglossary/1-main-glossary/679-ventilation-semi-transverse-ventilation*
- *https://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/54792/Road-Tunnels_TP04_Road-Tunnel-Ventilation-Systems.pdf*

5 Appendices

5.1 SWIRL CBA (2017 report)

Martin[60] offers two estimates for the cost of electrification of railway lines of $8.8 million per route-kilometre (Sydenham Line) and $12.6 million per route-km (Craigieburn Line). Martin's central estimate for the cost of electrification is $10.7 million per route-kilometre in 2012 dollars, or around $11.8 million per route-kilometre in 2016-17 dollars.

The central estimate of the costs of the original Maldon-Dombarton freight line is $849,100 million. The costs of making the line a dual track (except of the two main bridges and 4 km tunnel) with electrification and other modifications costs are estimated to be $840.0 million (essentially at $20 million per km on average over 42 km of electrified track). Adding these two cost components, our central estimate of total costs is $1,689,100 million.

5.1.1 Benefits relating to rail freight services

Infrastructure Australia[61] has recently undertaken a cost-benefit appraisal of the SWIRL that focused exclusively on freight benefits and did not consider any wider economic benefits arising from the investment. The proponents (the NSW Government) considered that the Maldon-Dombarton rail link would address constraints in freight rail access to Port Kembla, and would provide a faster link between the main SCL and Port Kembla. Specifically, the aim of completing the SWIRL would be to:

- meet capacity for rail freight to and from Port Kembla and the Illawarra region in the longer term and support economic development
- improve efficiency of the rail freight supply chain to and from Port Kembla by providing greater flexibility in train arrival and departure times, improved reliability, shorter cycle times, separation of freight and passenger services and support future intermodal movement
- maintain or improve the level of safety risks to the rail network
- minimise impacts on the environment, surrounding land users, and the community; and
- optimise overall rail network investment for the NSW freight task.

5.1.2 Benefits relating to passenger services

Passenger benefits resulting from rail upgrades and investment include faster travel times, reduced travel costs and wait times. In the case of upgrades to the SCL, SMART analysis and discussions with various experts indicate that commute times between Illawarra and Sydney may be improved, but significant reductions in travel times are limited owing primarily to topography.

For the SWIRL, passengers using that line would be able to reach southwest Sydney stations more quickly than using the SCL, although Parramatta station would still be closer via the SCL. The average time difference to key stations in Western Sydney, assuming the passenger service travels at an average speed of 90 km/h, is as follows:

- Parramatta station (9 mins quicker by SCL)
- Leppington station (29 minutes quicker by SWIRL)
- Liverpool station (30 mins quicker by SWIRL)
- Campbelltown station (64 minutes quicker by SWIRL)

SWIRL estimated costs

	ACIL TASMAN (2011) ESTIMATE[63] (2016-17 DOLLARS)	**INFRASTRUCTURE AUSTRALIA ESTIMATE** (2013-14 DOLLARS	**SMART CENTRAL COST ESTIMATE** (2016-17 DOLLARS)	**ESTIMATE COST RANGE** (2016-17 DOLLARS
Complete Maldon-Dombarton freight route (35 km)	$686.6 to $733.6 million	$805.9 million	**$849.1 million**	$764 million / $934 million
Complete SWIRL with additional passenger track (electrification), including Dombarton to Unanderra Line (42 km)			**$840.0 million**	$714 million / $966 million
Total costs			**$1,689 million**	$1,478 million / $1,900 million

Source: ACIL Tasman (2011), IA (2017) and SMART estimates.

60. Martin, S., (2012) 'Costing Australian passenger rail projects 2000-2012: how much did we pay and what did we get?', paper presented to Conference On Railway Engineering, Brisbane, Australia 10 – 12 September 2012

61. Infrastructure Australia (2018), *Project Business Case Evaluation, Maldon-Dombarton Rail Link*

For the purpose of assessing infrastructure projects, the NSW Government (2013) applies various 'value of travel' time estimates that correspond to the opportunity cost that passengers on trains or buses attach to the time they are required to spend while travelling, whereby:

- The value of private travel time is estimated at $15.14 per hour ($16.65 in 2016-17 dollars), and applies to private car occupants, onboard train time, onboard bus time, and other modes of transport; while
- The value of business travel time is estimated at $48.45 per hour ($53.3 in 2016-17 dollars), and is applicable to all business travel.

It is difficult to forecast the amount of 'latent demand' for passenger rail travel between the Illawarra and south-west Sydney. Nonetheless, SMART has constructed a high-level scenario where an additional 3,000 to 9,000 commuters use the SWIRL. Based on this scenario, we estimate the travel time savings to be 30 minutes (on average) relative to alternative options of driving or taking the Illawarra Line to Sydney and then the Bankstown Line to south-west Sydney. Based on these assumptions, we estimated a total private benefit of $70.5 million per year, or $939.5 million over the 40-year benefit period (being from 2021-22 to 2041-42) in NPV (2017-18) terms.

The above estimates of travel time savings represent only one aspect of a range of different direct and indirect benefits that the SWIRL may deliver.

Our high-level CBA incorporates estimates of passenger travel time savings, as well as estimates of freight travel time and operating cost savings, which are derived from the ACIL Tasman (2011) study. We also estimated the benefit of avoiding a proportion of the costs of the SCL failing in the event of geological disturbances. In our central case, we found total private and social benefits of building the SWIRL to be $1,776 million and total private and social costs to be $1,572 million (NPV 7%, 40 years). With estimated costs slightly above estimated benefits, our calculated Benefit Cost Ratio is 1.13 in the central case.

About one-half of the total private and social benefits of the SWIRL are derived from passenger travel time savings, both by taking the SWIRL but also those remaining in cars who will drive on less congested roads

5.1.3 Cost Benefit Appraisal Methodology

A standard method for evaluating large public infrastructure projects is by undertaking a cost benefit appraisal (CBA). A CBA involves the estimation of the economic costs and benefits of a particular project. Economic costs and benefits are different from financial costs and benefits in the sense that economic measurements are broader and try to capture all of the costs and benefits of a project that will accrue to society as a whole, including the financial aspects. The results of the analysis can be measured as a ratio of benefits to costs (BCR) or in dollar terms as a net benefit (or net cost).

The breakeven point for the BCR is 1, in that a BCR between 0 and 1 represents a net cost, while a BCR above 1 represents a net benefit. A positive dollar value (in net present value NPV terms) represents a benefit, while a negative dollar amount represents a cost. The NPV of benefits is the discounted value of the net benefit stream. It is obtained by discounting the stream of net benefits back to its value in the chosen base period, in this case 2017-18. The general NPV formula can be represented by:

$NPV = \Sigma\,(t = 0 \text{ to } n)\; Bt - Ct\,/\,(1 + r)t$, where:

Bt is the benefits from project in period t, Ct is the expenditure on the project in period t, r is the economic discount rate (generally set at 7%), n is the number of years the benefits and costs from projects are accrued.

The ROI calculates the net return on an investment, relative to the costs invested, and is expressed as a percentage. The general ROI formula is represented by:

$ROI = \{[NVPB - NPVC]\,/\,NPVC\} \times 100$, where:

NPVB is the NPV of the benefits and NPVC is the NPV of the costs.

Indicative CBA for the SWIRL

DESCRIPTION (2016-17 DOLLARS)	**LOW CASE $ MILLIONS**	**CENTRAL CASE $ MILLIONS**	**HIGH CASE $ MILLIONS**
Freight travel time savings	111.786	124.207	136.627
Freight operating cost savings	296.233	329.148	362.063
Avoided externalities	169.294	188.104	206.915
Option value of South Coast Line failure	186.310	207.011	227.712
Passenger travel time savings and other benefits	835.223	928.025	1,020.828
Total private and social benefits (NPV, 7%, 40 years)	1,598.846	1,776.495	1,954.145
Total private and social costs (NPV 7%, 40 years) (Central estimate)	1,572.097	1,572.097	1,572.097
BCR (7%, 50 years)	**1.02**	**1.13**	**1.24**
BCR (4%, 50 years)	**1.40**	**1.56**	**1.71**

Source: SMART estimates.

5.2 Road and Rail Freight Task to 2056

Figure 14

Road Freight Task*

Direction	Market	Commodity grouping	Annual road demand ('000 tonnes)			Annual road demand (number of trips)				
			2016	2036 (f)	2056 (f)	2016	2036 (f)	2056 (f)	% change	
Northbound from South Coast / Illewarra towards Sydney	Domestic and export	Coal	-	-	-	-	-	-		
	Domestic	Concrete & Cement	550	658	836	31,601	37,867	48,071	52%	
	Export/import	Containers	55	89	7,163	4,555	7,397	596,915	13005%	Massive increase
	Domestic	Fly Ash	357	462	587	22,766	29,519	37,472	65%	
	Domestic	Quarry materials	2,982	3,509	4,455	255,053	301,562	382,816	50%	
	Domestic	Motor Vehicles	632	811	1,017	69,385	88,999	111,515	61%	
	Domestic	Steel	322	387	335	29,820	35,908	31,058	4%	
	Domestic	Manufactures	8,906	8,904	11,363	954,536	891,205	1,136,869	19%	
		Total Loaded Northbound	13,808	14,822	25,756	1,367,714	1,392,456	2,344,715	71%	Many full inbound
		Total Empty Return	-	-	-	1,765,361	1,223,119	1,651,608	[illegible]	
		Total	13,808	14,822	25,756	3,133,075	2,615,575	3,996,323	28%	
Southbound from Sydney towards South Coast / Illewarra	Domestic and export	Coal	7,004	8,308	9,987	622,610	738,466	887,726	43%	
	Domestic	Concrete	268	284	361	14,983	16,108	20,443	37%	
	Export/import	Containers	44	51	2,615	3,298	3,847	206,027	6148%	Massive increase
	Domestic	Quarry materials	602	732	930	60,233	76,199	96,730	61%	
	Domestic	Manufactures	6,098	5,440	7,654	785,831	680,571	950,445	21%	
	Domestic	Food	346	528	788	25,377	38,664	57,666	127%	Large increase
	Domestic	Non_Food	152	267	397	10,750	18,808	28,006	161%	Large increase
		Total Loaded Southbound	14,504	15,610	22,731	1,523,032	1,572,659	2,247,043	48%	
		Total Empty Return	-	-	-	832,985	836,362	1,460,472	75%	Many empties return
		Total	14,504	15,610	22,731	2,356,017	2,409,021	3,707,515	57%	
Total Northbound and Southbound		Total	28,307	30,431	48,487	5,489,092	5,024,597	7,703,838		

* Data for the 2 key SA3s in the South Coast / Illawarra area: Dapto - Port Kembla SA3 and Kiama - Shellharbour SA3

The most important highlight in the road task is the change in containers inbound and outbound between 2036 and 2056. While cement transport by road will change upwards 52% and motor vehicles transport from Port Kembla by 61%, container traffic from Port Kembla - on road – is expected to grow by 13,000%.

Likewise, containers being shipped back to Port Kembla is expected to increase by 6,000%. From circa 3000 container trips per year to 206,000.

Figure 15

Rail Freight Task

1. South Coast / Illawarra rail line

Direction	Market	Commodity grouping	SA3 origin to destination	Annual rail demand ('000 tonnes)			Annual rail demand (numbers of paths)			
				2016	2036 (f)	2056 (f)	2016	2036 (f)	2056 (f)	% change
Inbound to South Coast / Illawarra	Export	NonCoal_Min (concentrates)	Orange:Dapto - Port Kembla	340	340	340	155	155	155	0% Same
	Export	NonCoal_Min (concentrates)	Lachlan Valley:Dapto - Port Kembla	160	160	160	73	73	73	0% Same
	Export	Coal	Wollongong:Dapto - Port Kembla	1,798	2,452	3,344	521	711	969	86% Almost doubling
	Export	Coal	Lower Hunter:Dapto - Port Kembla	340	458	617	99	133	179	81%
	Export	Coal	Lithgow - Mudgee:Dapto - Port Kembla	1,410	132	140	409	38	40	-90% Big decrease
	Export	Coal	Wollongdilly:Dapto - Port Kembla	1,863	2,559	3,515	540	742	1,019	89% Almost doubling
	Domestic	Flour	Tamworth - Gunnedah:Shoalhaven	204	280	384	110	151	208	89% Almost doubling
	Domestic	Flour	Orange:Shoalhaven	485	666	914	262	360	494	89% Almost doubling
		Total Loaded Inbound		6,599	7,046	9,414	2,168	2,361	3,137	45%
		Total Empty Return		-	-	-	2,168	2,361	3,137	45%
		Total		**6,599**	**7,046**	**9,414**	**4,335**	**4,723**	**6,273**	
Outbound from South Coast / Illawarra	Export/import	General containers	Dapto - Port Kembla:Mount Druitt	-	-	3,657	-	-	2,060	
	Export/import	General containers	Dapto - Port Kembla:Strathfield - Burwood - Ashfield	-	-	160	-	-	90	
	Export/import	General containers	Dapto - Port Kembla:Campbelltown (NSW)	-	-	197	-	-	111	Combined
	Export/import	General containers	Dapto - Port Kembla:Liverpool	-	-	3,737	-	-	2,106	Containier path
	Export/import	General containers	Dapto - Port Kembla:Merrylands - Guildford	-	-	574	-	-	323	4,690 task
	Export	Starch containers	Shoalhaven:Botany	266	366	502	150	206	283	89% Almost doubling
	Domestic	Cement	Dapto - Port Kembla:Merrylands - Guildford	-	230	292	-	184	233	27% From 2036
	Domestic	Steel	Dapto - Port Kembla:WA	195	332	518	76	129	201	165% Big increase
	Domestic	Steel	Dapto - Port Kembla:SA	65	84	105	25	33	41	61%
	Domestic	Steel	Dapto - Port Kembla:VIC	650	892	1,162	252	346	451	79%
	Domestic	Steel	Dapto - Port Kembla:QLD	390	612	893	151	238	347	129% Big increase
	Domestic	Quarry materials	Kiama-Shellharbour:Marrickville - Sydenham - Petersham	180	228	290	82	104	132	61%
		Total Loaded Outbound		1,746	2,745	12,088	737	1,240	6,378	Overall 106%
		Total Empty Return		-	-	-	737	1,240	6,378	
		Total		**1,746**	**2,745**	**12,088**	**1,473**	**2,479**	**12,756**	
Total Inbound and Outbound		**Total**		**8,345**	**9,790**	**21,502**	**5,809**	**7,202**	**19,029**	

Rail Freight Task

2. Moss Vale / Unanderra rail line

Direction	Market	Commodity grouping	SA3 origin to destination	Annual rail demand ('000 tonnes)			Annual rail demand (numbers of paths)			
				2016	2036 (f)	2056 (f)	2016	2036 (f)	2056 (f)	% change
Inbound to South Coast / Illawarra	Domestic	Grain	Wagga Wagga:Shoalhaven	475	609	742	257	329	401	56%
	Export	Grain	Lachlan Valley:Dapto - Port Kembla	829	871	1,011	448	471	547	22%
	Export	Grain	Goulburn - Yass:Dapto - Port Kembla	110	115	134	59	62	72	22%
	Export	Grain	Griffith - Murrumbidgee (West):Dapto - Port Kembla	79	83	97	43	45	52	22%
	Export	Grain	Wagga Wagga:Dapto - Port Kembla	482	507	589	261	274	318	22%
	Export	Coal	Wollongdilly:Dapto - Port Kembla	1,863	2,559	3,515	540	742	1,019	89% Almost doubling
	Export	NonCoal_Min (concentrates)	Lachlan Valley:Dapto - Port Kembla	160	160	160	133	133	133	0%
	Domestic	Limestone	Goulburn-Yass:Dapto - Port Kembla	440	506	582	189	218	250	32%
		Total Loaded Inbound		4,438	5,411	6,830	1,930	2,274	2,793	
		Total Empty Return		-	-	-	1,930	2,274	2,793	
		Total		**4,438**	**5,411**	**6,830**	**3,860**	**4,548**	**5,586**	
Outbound from South Coast / Illawarra		**Total**		-	-	-	-	-	-	
Total Inbound and Outbound		**Total**		**4,438**	**5,411**	**6,830**	**3,860**	**4,548**	**5,586**	

The most important highlight in the road task is the change in containers inbound and outbound between 2036 and 2056. While cement transport by road will change upwards 52% and motor vehicles transport from Port Kembla by 61%, container traffic from Port Kembla - on road – is expected to grow by 13,000%.

Likewise, containers being shipped back to Port Kembla is expected to increase by 6,000%. From circa 3000 container trips per year to 206,000.

5.3 Geotechnical Assessment

Whilst the proposed Maldon-Dombarton rail alignment crosses some challenging terrain, past studies, relevant case studies and construction projects both in Australia and around the world have shown that there are technical options to address all challenges. Engineering solutions in regard to ventilation, grade and length of tunnel, to purchasing suitable rolling stock, show that this is a technically viable line option.

Before cancellation the existing Maldon-Dombarton alignment including the Avon Tunnel had been thoroughly investigated, particularly in terms of its geotechnical design. Both the eastern and western portals were prepared, with the eastern portal being excavated and supported, although the tunnel only proceeds about 50m.

The Tunnel investigation included numerous route options but a final route between the two chosen portal sites included a proposed tunnel length of 4025m, which at that time would have been the longest rail tunnel in Australia. Today there are several rail tunnel of greater length in Brisbane. The proposed tunnel grade is about 3.3%, or about 1:30 from an elevation of about 295m at the eastern portal to approximately 427m at the western portal. The proposed route does include significant challenges including tunnelling over and above and or near to multiple levels of bored and pillar and longwall mining, numerous geological structures and within catchments of creeks that flow into Avon or Cordeaux Reservoirs. Engineering improvements over the last 30 years, including changes to rolling stock, now provide greater certainty to the technical viability of the project.

Case studies below highlight improved tunnelling and ventilation processes which could be incorporated in new tunnel designs and overcome past limitations in relation to length of tunnel, appropriate ventilation and gradient required.

5.3.1 Maldon-Dombarton Line

The Maldon-Dombarton alignment crosses the Triassic formations composed mainly of Hawkesbury sandstone (surface – Rs formation), Narrabeen group with shales, greywakes and Illawarra coal measures (i.e. greywakes, shales, claystones, and tuff with coal seams) developed in depth. Hard beddings of high strength sandstone followed by soft layers of coal reveal possible practical challenges in tunnelling. Shallow tunnels excavated in sandstone require less supporting systems as its obvious advantage yet subsidence caused by lower layer compaction and uplifts caused by excavation forces on the ground surface remain common challenges in shallow tunnelling. Excavation in the soft coal layer might seem to be less effort; however ground convergence in shale layers, stress concentration of upper high strength sandstone and stronger supporting systems during the excavation might be practical obstacles. Hence, it is not easy to decide certainly about the excavation host media. Geological properties will be a continued challenge, thus the best and most efficient engineering decision in tunnelling through a preferred geological layer may not be possible.

Figure 16

Regional Surface geology: Maldon-Dombarton line (noted in red) (Source Geoscience Australia).

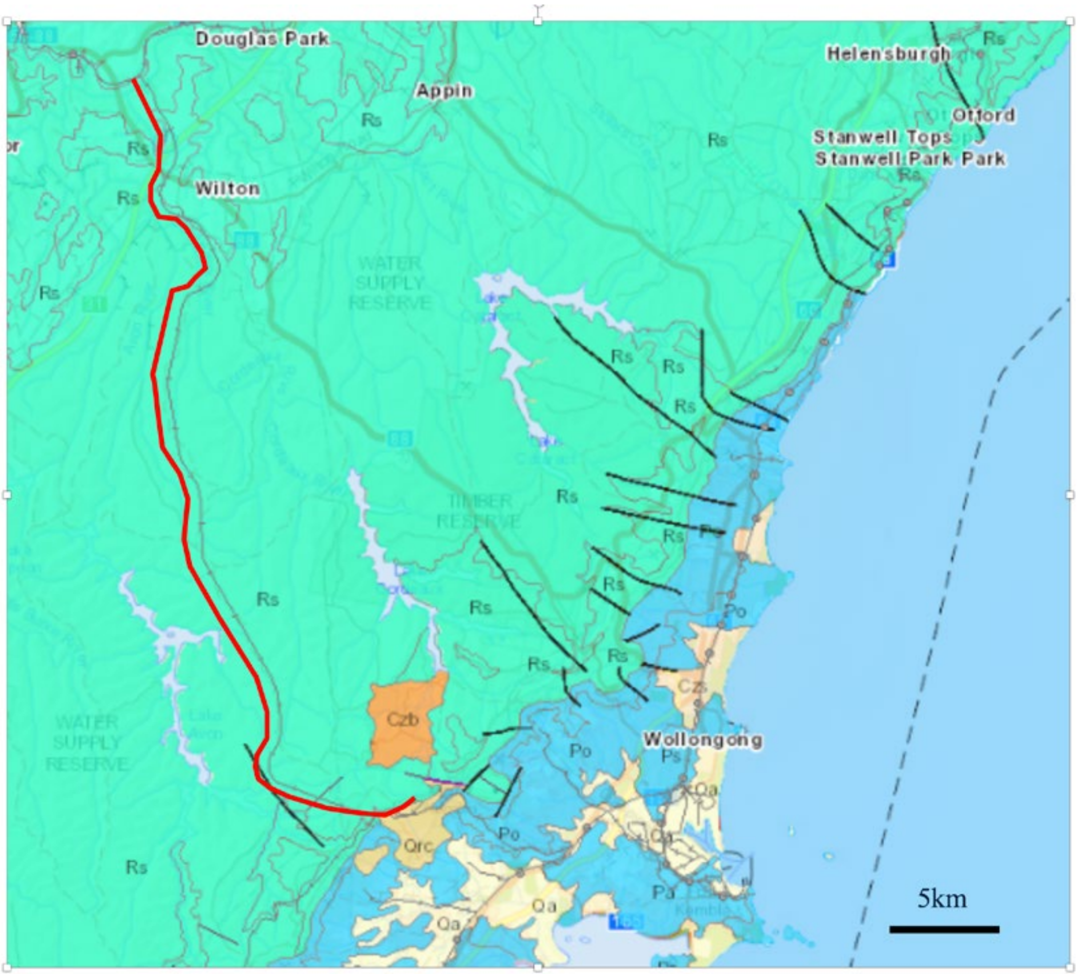
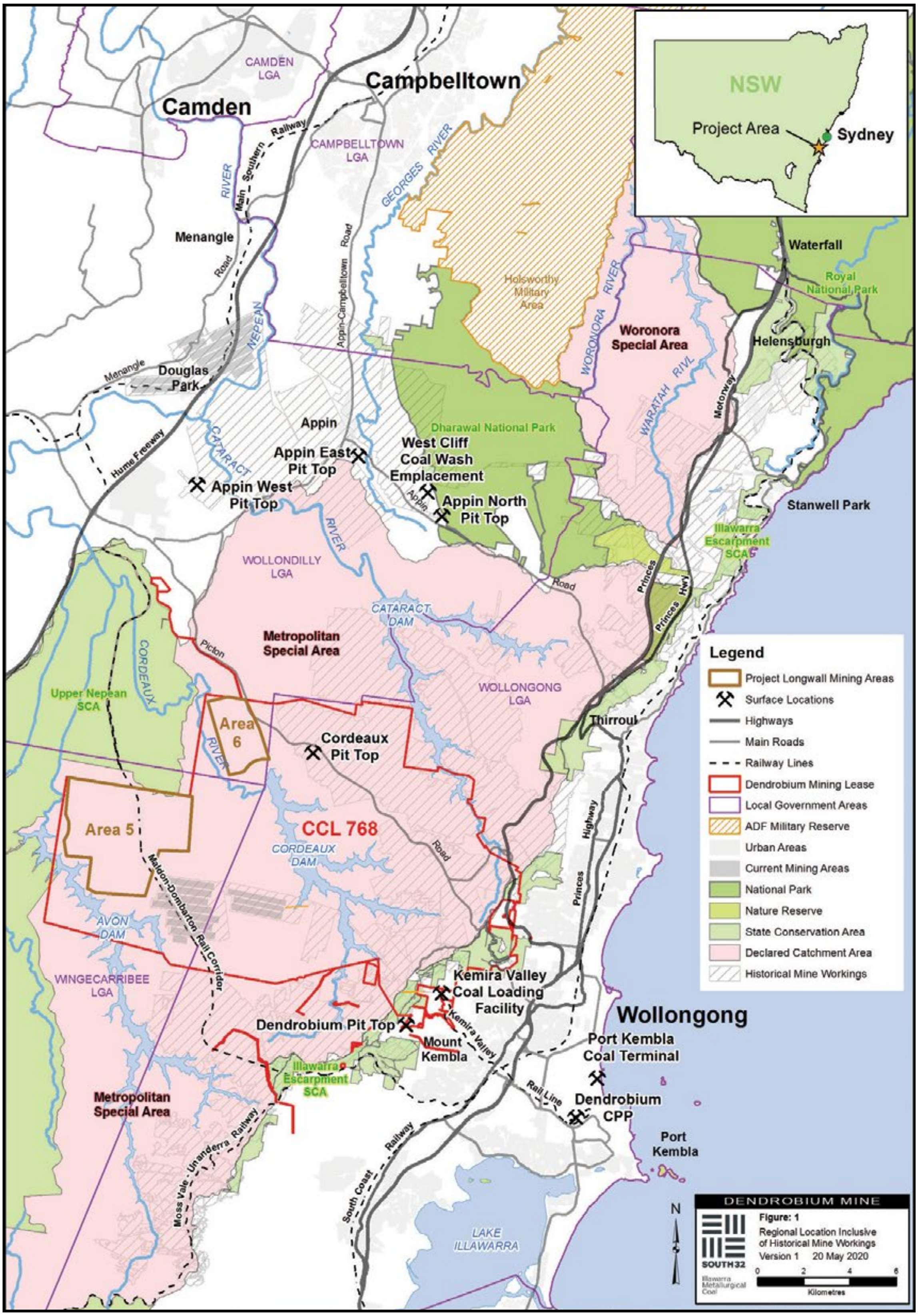


Figure 17

Area 3 of Illawarra Coal with Maldon-Dombarton line (noted in red)[62]



62. BHP Billiton (2007), Illawarra Coal. Dendrobium mine –Area 3 : Prediction of subsidence parameters and the assessment of mine subsidence impacts on natural features and surface infrastructure resulting from the extraction of proposed longwalls 6 to 10 in Area 3A and future longwalls in areas 3B and 3C at Dendrobium mine.

5.3.1.1 Existing sections of the alignment

The sections that have been completed are developed mainly in Hawkesbury sandstone (outcrops). Photographic illustrations provided by ACIL Tasman/Hyder[63] report seem to indicate relatively steep slopes with moderately weathered sandstone cuttings. The installation of surface drainage systems in the sections already constructed may be necessary to avoid water-logging conditions that may be detrimental to rail track bed and traffic operation. Where the degree of sandstone weathering is more severe, localized treatment (e.g. shotcrete) may be required to stabilize the cuttings. As they have already been installed, water drainage systems must actively keep the water level lower than section of the tunnel and cutting unless waterproof sealing layers are added to the supporting system. In case of water presence, which lead to weathered sandstone with lower bearing capacity, a more conservative supporting system might be required. The installation of surface drainage systems will be necessary to avoid water-logging conditions that may be detrimental to the rail track bed and traffic operation. Where the degree of sandstone weathering is more severe, localized treatment (e.g. shotcrete) may be required to stabilize the cuttings.

In addition, a section of the alignment crosses Area 3B of the Dendrobium coal mine (Figure 17). This area is to be excavated using long wall methods[64] which may result in subsidence in the Maldon-Dombarton line. Since long-wall mining is based on free subsidence of upper bedding layers, a simultaneous collaboration between the mining and tunnelling industry is needed in order to evaluate and mitigate the potential impact of mining on the serviceability of the line.

5.3.1.2 New proposed section

The new tunnel (Avon tunnel) is projected to be 4km long at 3.3% grade. The feasibility study by ACIL Tasman/Hyder[65] proposes a single track, and a size of the tunnel to accommodate two rolling stock types.

A detailed geotechnical study was conducted by SMEC[66] in 1984 and then again in 1987 which was then cited by Neil.[67] This study reported that the rock mass through which the tunnel is to be driven include sedimentary rocks (e.g. Hawkesbury sandstone and sandstone with narrower interlayers of siltstone and claystone – Narrabeen group). Dykes, sills (dolorite or syenite) and faults are likely present throughout the alignment. Two inactive faults, with displacements ranging from 0.3 to 1.6 m have been projected from colliery workings to the tunnel level. In section 5.8 a simple geotechnical model for the tunnel alignment reported in Neil[68] is shown.

Neil[69] also reported that part of the tunnel is located 80 to 250 meters above old mine workings. While there was some numerical analysis carried out by SMEC in 1984 that indicated a change in elevation of 4mm, a detailed study of the impact of any potential subsidence or convergence that may result from mining activities is vital.

Based on these results, it is anticipated that open face tunnelling (drill and blast) through the sandstone formations should not pose significant problems but additional localized tunnel support (e.g. shotcrete, rockbolts, steel ribs) may be considered in locations where weathering is more significant and where geological faults are detected.

This is further corroborated by a seismic refraction survey conducted in an nearby location of the Illawarra escarpment;[70] which indicates the presence of weathering products for which velocities of 300-600m/s were measured, underlined by moderate weathered Narrabeen group and Illawarra coal measures formations (2160-3200m/s) and stiffer formation (4000m/s) that underlies the Illawarra coal measures.

5.4 Tunnelling

As one of the efficient transportation options especially for highlands and mountainous areas, tunnelling is faces the uncertainty of underground excavation. In recent decades technology developments have made available geological, hydrogeological and geotechnical information increasingly more accurate. All the same, tunnelling still can be considered as a daily challenge due to quick, unwanted and compelled geological variations. Hence, unlike constructing a bridge or a tower, costing in tunnelling is mainly dependant on numerous geological, geotechnical and operational variables.

Like any other construction project, sources of costs are distributed in five main phases[71]:

Phase 0: Study and investigations

In tunnelling projects, due to the nature of underground uncertainties, investing money and time invested in phase 0, leads to a more accurate overview of the whole project.

Phase 1: Planning and design

Gathered information from phase 0 assists in better decision making about final design parameters including, optimum excavation profile, optimum length, optimum depth and path and excavation method.

63. ACIL Tasman, Hyder Consulting (2011), *Maldon-Dombarton Rail Link Feasibility Study – Working paper 1 and 2*, Australian Government Department of Infrastructure and Transport

64. BHP Billiton (2007), *Illawarra Coal. Dendrobium mine –Area 3 : Prediction of subsidence parameters and the assessment of mine subsidence impacts on natural features and surface infrastructure resulting from the extraction of proposed longwalls 6 to 10 in Area 3A and future longwalls in areas 3B and 3C at Dendrobium mine*

65. Ibid ACIL Tasman/Hyder (2011)

66. Snowy Mountains Engineering Corporation (SMEC) (1984), Report on Geotechnical Analysis. Snowy Mountains Engineering Corporation (1987), Geological Report of the Avon Tunnel

67. Neil, DM., (1987), 'The Avon tunnel on the Maldon to Dombarton railway', paper presented to Annual Convention of the NSW Section of the Permanent Way Institution.

68. Ibid Neil (1987)

69. Ibid

70. Palmer, D (1973), 'Seismic refraction investigations for the Avon-Berkeley pipeline, West Dapto, R00022566 (GS1973/462)

71. Fewings, Peter, and Christian Henjewele. Construction project management: an integrated approach. Routledge, 2019.

Phase 2: Implementation

Excavation method, supporting systems, drainage and ventilation, regular labour costs and maintenance in addition to Challenges faced with tunnelling operation are some of the sources of cost in implementation phase.

Phase 3: Monitoring and quality control

Constant monitoring of regulations related to safety, quality control and risk management protects tunnelling Integrity and prevent unexpected delays, which substantially reduce the risk of increased costs.

Phase 4: Finalization

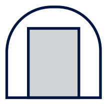
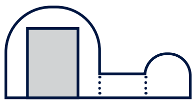
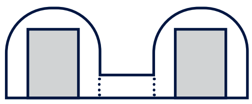
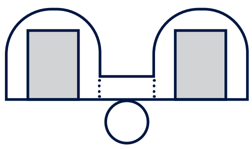
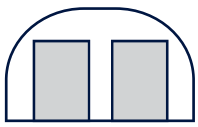
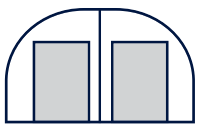
Documentation, dismantling of cutting machines and tunnelling facilities and finalising the project is the last step of a tunnelling project, which account for a considerable portion of the project cost.

Some of the other possible sources of costs are:

- End-Use
- Locality
- Labour Cost
- Health and Safety
- Regulations
- Market
- Competition
- Client Knowledge
- Government and Public Support
- Cost of Bidding

From a tunnelling engineering point of view, technical bottlenecks of designing can be briefly summarised in length and cross section of the tunnel. These are the two key factors in selection of tunnelling method and consequently, control a great share of costs of tunnelling[72].

The cross section of the tunnels are mainly selected based on their application and geological condition of the host medium. From a geological point of view, the more stable the rock medium surrounding the tunnel, the greater chance of a traditional excavation using self-supported cross sections[73]. Although conventional methods are still applicable in very unstable rock mass, soft rock and soils; mechanised tunnelling and lining supports are considered to be more efficient and faster. Train tunnels can generally have one of the following sections[74]:

TUNNEL TYPE	SECTION	COST $000S PER KM (single bored single track =100)
Single bored single-track tunnel		100
Single bored single-track tunnel with service tunnel		160
Double bored single-track tunnel with connections		220
Double bored single-track tunnel with connections and service tunnel		250
Single bored double-track tunnel		130
Single bored double-track tunnel with safety walls		140

72. Guglielmetti, Vittorio, et al., eds. Mechanized tunnelling in urban areas: design methodology and construction control. CRC Press, 2008.
73. Brady, Barry HG, and Edwin T. Brown. Rock mechanics: for underground mining. Springer science & business media, 1993.
74. https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/assess_unit_cost_rail/annex_13_case_study_tunneling.pdf

According to aforementioned factors, tunnelling methods can be categorised in two main conventional and mechanised methods:

Conventional:

Drill & Blast (hard rock)

Sequential Excavation (medium to soft rock and soil)

Mechanised:

TBM (Tunnel Boring Machines) (Hard rock)

Shielded Machines (medium to soft rock and soil)

Both conventional and mechanised methods are applicable in all geological conditions, however, excavation rate per unit of time, project time limitation and length of tunnel are determinative in the selection of a preferred method. Since mechanised tunnelling has longer site preparation, it is not recommended and cost-effective for short length tunnels. On the other hand, according to studies, mechanised tunnelling can be done at least 3 to 10 times faster in hard rock and soft rock respectively[75].

The selection of the proper tunnelling method depends on several parameters and requires a comprehensive geological and geotechnical study in phase 0 of the project, however, in this case study both conventional drilling and blasting, or shielded machine seem to be practical. Based on previous conducted studies, it is anticipated that open face tunnelling (drill and blast) through the sandstone formations should not pose significant problems but additional localised tunnel support (e.g. shotcrete, rockbolts, steel ribs) may be considered in locations where weathering is more significant and where geological faults are detected.

5.5 Ventilation

As one of the most crucial safety prerequisites of tunnelling from the very first days of excavation to the last moment of tunnel's life, a ventilation system must be capable of circulating air in tunnels. Aside from the safety of labourers and engineers during excavation and passengers during the service life of the tunnel, gas emissions from vehicles has a serious erosive chemical effect on rock mass or concrete lining which substantially endangers stability of the tunnels.

Modern rail tunnel systems design will be bound by a number of critical criteria for safety and additionally, in the case of passengers, comfort. Dominant among these will be the fire life safety needs of passenger trains where tenability criteria will be assessed by fire services regulators at early stages of the design.[76]

Requirements for tunnel ventilation, smoke suppression and extraction will need to be designed to best practice. Modern standards and practices such as NFP 130[77] for stations, and for tunnels the Japanese guidelines on comfort and UIC 779-11, all contain guidelines which are generally accepted by regulatory authorities.

In the case of natural or piston ventilation for tunnels, simulation will be required to demonstrate comfort levels in the case of stalled or stuck trains in tunnel at summer conditions. There will be similar requirements from regulatory authorities in the case of tunnel fire where tenable conditions for passenger egress need to be achieved.

Life Safety & Ventilation requirements are major contributors to tunnel costs and it is essential that design criteria for these are declared at a very early stage of development to provide opportunities for cost minimisation.

From a tunnelling perspective, depending on the length and depth of tunnels both natural (passive) or mechanical (active) ventilation system are applicable. Generally, ventilation systems can be categorised as:

Natural (passive)[78]:

Piston effect:

Applicable in short length and shallow tunnels where air can be pressurised into the tunnel by movement of vehicles.

Wind:

Applicable for very short length and shallow tunnels where air can freely flow into the tunnel.

Chimney effect:

Applicable in long and deep tunnels where air pressure difference between the tunnel and ground surface naturally circulates fresh air into the tunnel.

Mechanical (Active):

Longitudinal:

Applicable for very long tunnels and high traffic tunnels with gas emissions. Fans are installed a specific distance from each other to replace the polluted air with fresh air.

Transverse:

Suitable for long bidirectional tunnels or congested unidirectional traffic tunnels[79]. In this method, polluted air is extracted by dampers on the ceiling and fresh air is replaced either due to air pressure difference or supplied by another fan.

Semi transverse:

A system in which a separate ventilation duct is used for the supply of fresh air through many supply vents along the tunnel. The polluted air is discharged through the end of the tunnel. Also used to describe a system where fresh air is supplied from the end of the tunnel and polluted air is drawn out over the length of the tunnel by exhaust fans[80].

Since air circulation can be effortlessly controlled, mechanised ventilation systems are more common in tunnels with a risk of

75. https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/assess_unit_cost_rail/annex_13_case_study_tunneling.pdf
76. NFPA (2017), *Standard for Fixed Guideway Transit and Passenger Rail Systems*
    Procter, T, Henderson, L. (2016), 'Rail Tunnel Fire Safety System Design in a SFAIRP Context', in *CORE: Conference on Railway excellence, Safety and Risk session*
    Standards Australia (2011), Tunnel Fire Safety, SAI Global, , Geological Report of the Avon Tunnel, Sydney Australia
77. Ibid NFPA (2017),
78. Kuesel, Thomas R., Elwyn H. King, and John O. Bickel. Tunnel engineering handbook. Springer Science & Business Media, 2012.
79. Chaabat, F., et al. "Smoke control in tunnel with a transverse ventilation system: An experimental study." Building and environment 167 (2020): 106480.
80. https://tunnel.ita-aites.org/en/component/seoglossary/1-main-glossary/679-ventilation-semi-transverse-ventilation

danger especially for tunnels with fire throttling risk. According to the standards for road tunnel ventilation system (TP04, NSW Government) in the last 20 years the majority of tunnels in Australia have been designed with longitudinal ventilation system[81].

A key factor in the case of fire, rescue and escape to a place of safety will be the assessed fire load.[82] Where freight and passenger mixed traffic is concerned freight loadings may require limitations. However in the case of single track tunnels combined with strict operating procedures only one maximum scenario of single traffic may suffice for tunnel ventilation design.

Ventilation simulation can be carried out to confirm comfort levels for the annual maximum summer temperature and/ or stalled train conditions to verify that tenable conditions can be maintained for passengers.

In the particular scenarios of stalled train or fire in tunnel, for both freight and passenger trains, three dimensional modelling, CFD modelling such as Star-CD can be utilised through project to demonstrate that the particular design will provide tenable conditions.

The design will cater for air-conditioned trains and tunnel crown temperatures may have to be limited to 50 C to ensure that in the case of stalled trains air-conditioning equipment can continue to operate for up to one hour. This in turn places pressure on the designer to include tunnel ventilation fans within the design scheme and this report makes that assumption at this very preliminary stage.

5.6 Tunnel Case Studies

5.6.1 Gotthard Base Tunnel

$107m per km

The Gotthard Base Tunnel is, at 57km, the longest in the world. It runs under the Swiss Alps between Berne and Valais.

It is actually twin 9.5m diameter tunnels, so the total length of rail tunnel is about 114km, but there's also 38 km of access tunnels, plus crossover chambers and two large emergency evacuation stations.

Because the twin tunnels are used by high-speed trains travelling at 250km/h they can each carry only one track, but being around the same diameter as Sydney's Airport Line tunnel they could easily accommodate two conventional standard gauge suburban rail tracks.

The Gotthard Base Tunnel is a vastly more challenging undertaking than the North-West Rail Link. Final cost was $12.3 billion. This means an equivalent per km single tunnel cost of $107m per km. In other words, if the Swiss were building the North-West Rail Link it would come in for much less than $1.9 billion.

5.6.2 Airport Rail Line

$112.5m per km

Completed just in time for the 2000 Sydney Olympics the Airport Rail Line (ARL) tunnel is eight km long and the world's fourth-largest diameter bored tunnel. Because much of the route is below the water table – 6km of the job was through saturated sand – it was mostly constructed using a giant tunnel-boring machine (TBM) and involved state-of-the-art techniques. There are five stations and construction of four of them was an unusual and difficult engineering task. Most accounts put the total cost at $900m.

5.6.3 Melbourne-Brisbane Inland Rail Alignment Tunnels

$55m per km plus fit out

A detailed 2008 cost-assessment for a proposed inland rail line from Melbourne to Brisbane, developed by consultants Parsons Brinkerhoff, Connell Wagner and Halcroft for the Australian Rail Track Corporation, settled on a standard estimate of $55m per km for 9.3m diameter tunnel construction. The estimate was based on recent Australian experience. Conservatively, the consultants assumed that tunnels would have to be lined because of poor geological conditions. The estimate did not include fit out – track laying, signalling and power supply. It is clear that tracklaying would add not more than $5m (and more likely $l-3M) per track kilometre to the basic tunnel price. Of course this estimate does not include the construction of stations which would be a feature of an underground suburban railway but it makes clear that a robust rule-of-thumb for a fitted-out two-track rail tunnel is $100m per kilometre or less.

5.6.4 Caracas Metro

$90.2m per km

A new 12.3 km section of the Caracas, Venezuela, metro system, was completed in 2004 at a cost of $1.1 billion. If the Venezuelans were building the North-West Rail Link it would come in for $1.9 billion.

5.7 Technical Conclusions

The existing alignment of the SCL has been effectively engineered and landslide risk managed over the last 30 years, particularly in the Wollongong to Clifton section. Future potential upgrades via tunnelling (e.g. Waterfall to Coalcliff) will minimise operational risk and travel time reduction but new tunnels mean substantial investment.

The current existing Maldon-Dombarton alignment, including the Avon tunnel, has been investigated in the past, particularly in terms of its feasibility and geotechnical design. In fact, there is a wealth of information already available, particularly on the Avon tunnel in reports prepared by SMEC.[83] Further consideration of this alignment could benefit from careful analysis of those reports and supplemented by some site investigation if appropriate, particularly in the section crossing area 3B of the Dendrobium mine, which potentially can induce subsidence along the intersected section of the alignment.

In terms of ventilation requirements, all type of electric hauled trains could operate safely in either direction, however there would be limitations on diesel-electric locomotives. These limitations could be overcome by the use of 'on demand' reversible axial flow jet fans.

81. https://www.chiefscientist.nsw.gov.au/__data/assets/pdf_file/0009/54792/Road-Tunnels_TP04_Road-Tunnel-Ventilation-Systems.pdf
82. Ibid Procter (2016)
83. Ibid SMEC (1984) (1987)


Central
21:26:49

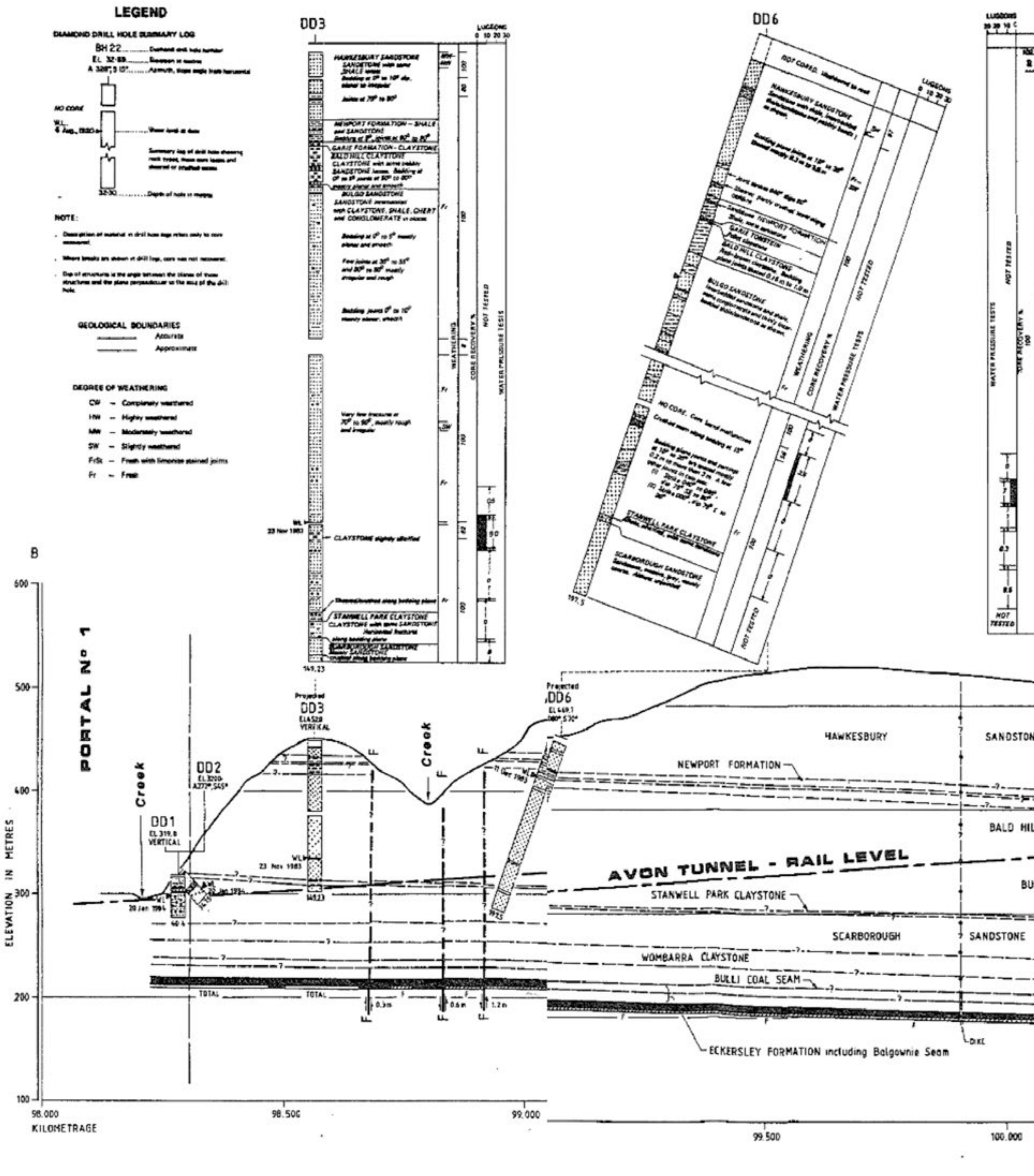
5.8 Simplified Geotechnical Model for the Avon Tunnel

The Avon Tunnel was proposed as part of the Maldon to Dombarton rail line. Comprehensive geotechnical investigations were undertaken by SMEC through 1983 to 1987. Neil referenced these studies in development of the simplified geotechnical model shown in Figure 18. The Tunnel investigation included numerous route options but a final route between the two chosen portal sites included a proposed tunnel length of 4025m, which at that time would have been the longest rail tunnel in Australia.

The proposed route does include significant challenges including tunnelling over and above and or near to multiple levels of bored and pillar and longwall mining, numerous geological structures and within catchments of creeks that flow into Avon or Cordeaux Reservoirs.

Figure 18

Simplified geotechnical model for the Avon tunnel. Source (Neil 1987)



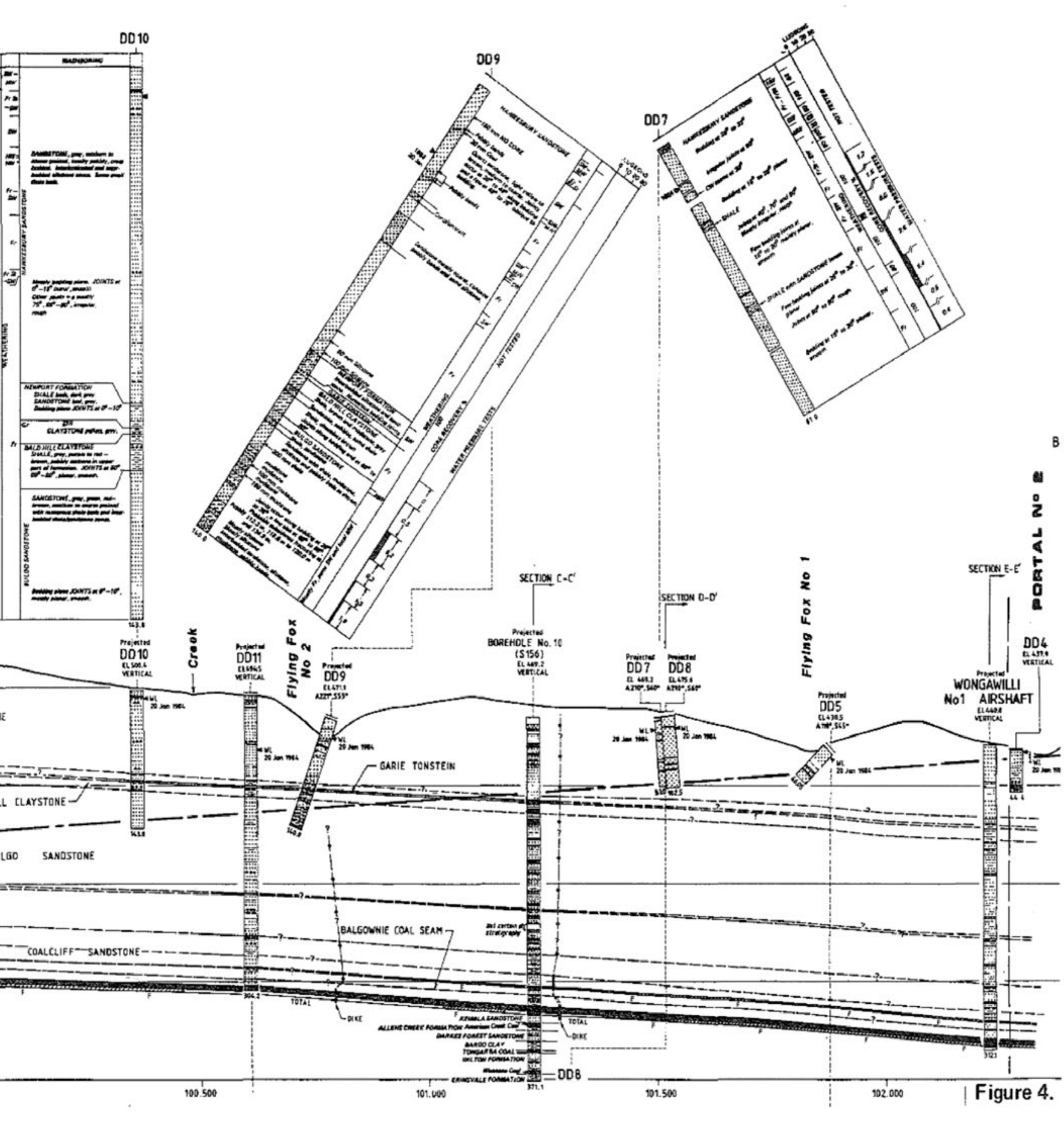

DD10
DD9
DD7
SECTION C-C'
SECTION D-D'
SECTION E-E'
PORTAL No 2
B
Creek
Flying Fox No 2
Flying Fox No 1
Projected DD10
Projected DD11
Projected DD9
Projected BOREHOLE No. 10 (S156)
Projected DD7
Projected DD8
Projected DD5
Projected WONGAWILLI No1 AIRSHAFT
DD4
GARIE TONSTEIN
CLAYSTONE
SANDSTONE
BALGOWNIE COAL SEAM
COALCLIFF SANDSTONE
TOTAL
DIKE
DD8
100.500
101.000
101.500
102.000

Figure 4.

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