Australian Government

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Sydney Metro – Western Sydney Airport

Chapter 6
Project development and alternatives

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6 Project development and alternatives

This chapter describes the project's strategic alternatives and includes an overview of the project options considered, including alignment options and station options. This chapter also identifies the consequences of not proceeding with the project.

6.1 Rail corridor planning

As discussed in Chapter 2 (Strategic need and justification), Sydney Metro – Western Sydney Airport has been identified in a range of strategic and transport planning documents.

A joint NSW and Australian Government rail needs scoping study described in the *Western Sydney Rail Needs Scoping Study Outcomes Report* (Transport for NSW and Australian Government, 2018) (Scoping Study) identified a north–south rail corridor connecting Schofields/Tallawong in Rouse Hill with Macarthur via St Marys and Western Sydney International as critical for the future of the Western Parkland City. The Scoping Study identified that a separated metro or light metro style of train would suit a north–south rail link.

To improve the economic viability of the recommended north–south rail link, it was determined that it should be built in stages to better match the demand of a growing Western Sydney. The Scoping Study suggested that a connection between St Marys and the Aerotropolis would be a suitable first stage, with subsequent future connections to the north (to Schofields/Tallawong and the Sydney Metro Northwest in Rouse Hill) and to the south (to Macarthur) (see Figure 1-5). This approach to rail connectivity for the Western Parkland City is also reflected in *Future Transport 2056* (Transport for NSW, 2018b), which identifies a range of committed transport initiatives, as well as future transport investment initiatives that will be subject to further investigation.

The *Western Sydney Airport - Airport Plan* (Australian Government, 2016) (Airport Plan) has also taken into account a rail corridor and two potential station locations so that land is preserved to meet the requirements for future rail infrastructure on Western Sydney International.

The *Draft North South Rail Line and South West Rail Link Extension Corridors Strategic Environmental Assessment* (Transport for NSW, 2018) (Corridors SEA) investigated potential rail corridors in accordance with the findings of the Scoping Study and proposed the protection of two rail corridors:

- the recommended North South Rail Line corridor between the Sydney Trains suburban rail T1 Western Line near St Marys and the T8 South Line near Macarthur via Western Sydney International
- a South West Rail Link Extension from Leppington Station to North Bringelly, which was identified as a potential future project (see Figure 1-5).

In June 2020 the NSW Government confirmed the final corridors for the North South Rail Line and the South West Rail Link Extension.

6.2 Project development process

The project has been driven by the strategic need to provide a rail connection between St Marys and the Aerotropolis via Western Sydney International and support the future of the Western Parkland City. It has leveraged the work completed through the Scoping Study and Corridors SEA. Development has been carried out in consultation with a range of stakeholders.

The process to define the project as presented in Chapter 7 (Project description – operation) consisted of the following key stages (see Figure 6-1):

- Stage 1 – assessment of strategic alternatives – strategic consideration of a 'do nothing' option, transport mode alternatives or other alternative solutions (see Section 6.3)
- Stage 2 – options identification and assessment – based on metro rail being the preferred infrastructure solution:
    - Stage 2A – consideration of station precincts and associated alignment (see Section 6.4)

- Stage 2B – further investigation of the preferred project scope to optimise alignment, station location/orientation and ancillary infrastructure (see Sections 6.5 to 6.7).

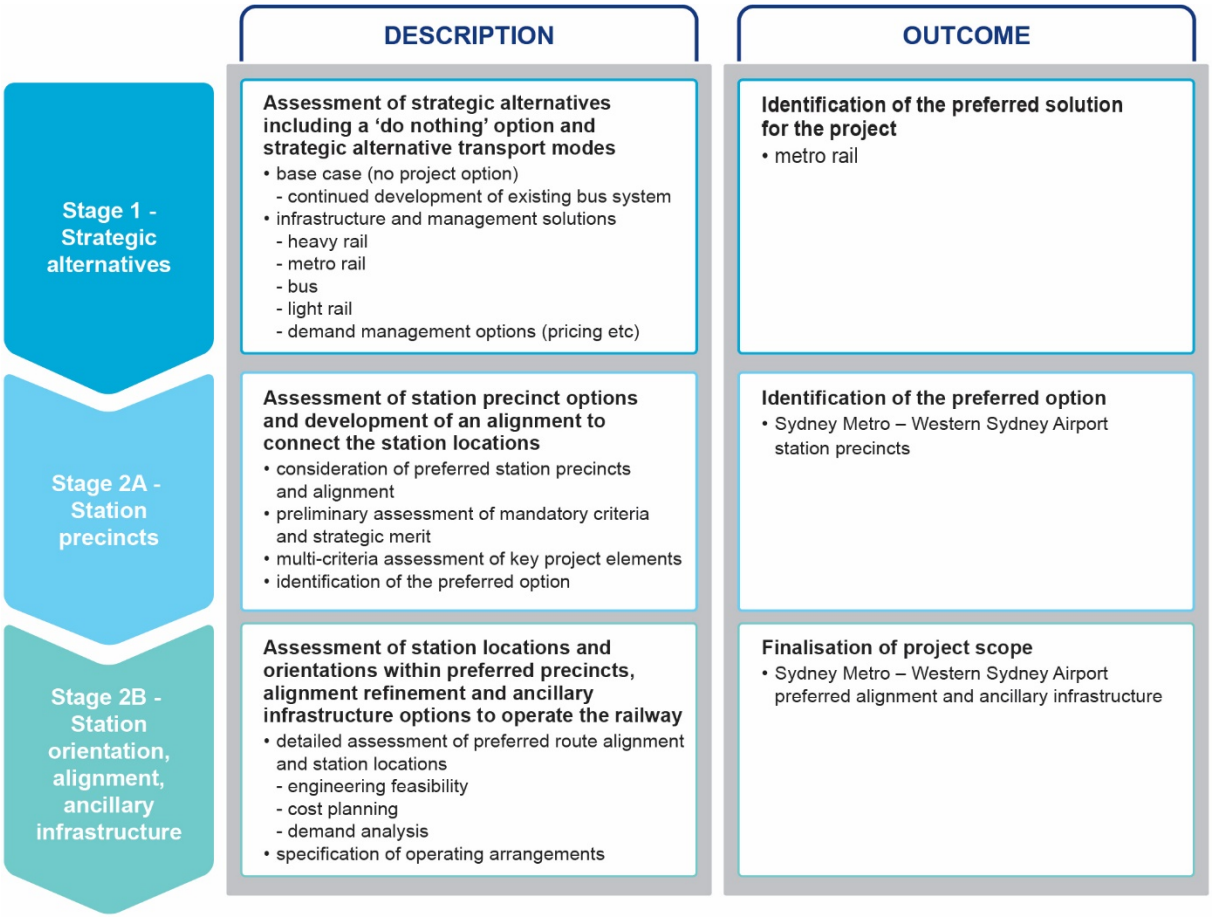

Figure 6-1 Options assessment process

6.3 Strategic alternatives

6.3.1 Strategic alternatives considered

Do nothing

To ensure the success of the Western Parkland City and Western Sydney International, a high-capacity and frequent transport solution must be provided. If the project does not proceed, the sustainable and successful growth of the Western Parkland City would be compromised and the targets for population and employment growth would not be met. In addition, the lack of high quality public transport connection to Western Sydney International would compromise the success of Sydney's newest airport.

Transport mode alternatives

Investment in active transport, buses, light rail and other heavy rail was considered as alternatives to the project.

Active modes, the bus network and light rail are all complementary to mass transit modes, bringing customers to and dispersing them from major transport hubs such as those served by Sydney Trains or Sydney Metro. Active modes alone would not serve the demand and customer markets moving along the north–south spine of the project corridor and the destinations it connects. Buses and light rail solutions offer local to medium capacity solutions for transport corridors. However, they do not offer the combination of capacity and frequency to serve the growth planned for the Western Parkland City and Western Sydney International. Heavy rail was investigated and discounted as it does not offer the operational flexibility and reliability compared to a metro product.

Through the City Deal, the NSW Government is currently assessing a rapid bus network to complement the project and serve key centres within the Western Parkland City. These would provide feeder services to the future mass transit spine and serve other key destinations, rather than providing connectivity along the whole corridor.

6.3.2 Preferred product solution

A metro rail mass transit solution was considered to be the preferred solution because it would strongly support the city-shaping objectives of the project, while also delivering transport and productivity outcomes. A metro rail line was considered to be the preferred solution to attract investment as well as unlock and support planned growth in new homes and jobs in the growing Western Parkland City. This is because the metro product offers increased capacity for customers, faster travel times and frequent services.

Overall a metro rail line was considered to be the preferred option as it:

- has the capacity to provide high frequency services to key activity centres with fast travel times and improve access to jobs
- has an ability to form the north–south spine of a fully integrated, multi-modal network
- has the potential to support growth in and serve key residential development areas with high transport amenity and capacity
- provides the greatest ultimate capacity, which will support long term growth and unlock planned growth, supporting the vision for the Western Parkland City
- would support the 30-minute city with superior travel times compared with other options considered such as light rail and other bus transport improvements.

6.4 Station precinct options

6.4.1 Station precinct options assessment

A primary consideration in the project development process was to provide a balance between the number and location of stations, considering drivers such as productivity and land use benefits, accessibility, travel times and project cost. This process of station precinct identification was undertaken independently of the rail corridor alignment development process.

During the development of the *Western Sydney Rail Needs Scoping Study* and the early planning of a north–south rail line, station precincts at Airport Business Park, Airport Terminal and the Aerotropolis Core precinct were confirmed as essential stations for the project.

The options assessment for the identification of the preferred station precincts was undertaken using a three-phase process, as shown on Figure 6-2:

- a long list of station options within the broad corridor between the T1 Western Line and the Aerotropolis, consisting of:
  - connection points to the T1 Western Line
  - intermediate station precincts between the T1 Western Line and Western Sydney International
  - essential station locations (i.e. those stations dictated by the Airport Plan or determined as essential for the viability of the project).

- refinement to a shortlist focusing on the project alignment
- determination of preferred station precincts.

The following sections outline the assessment process undertaken for each of the localities identified.

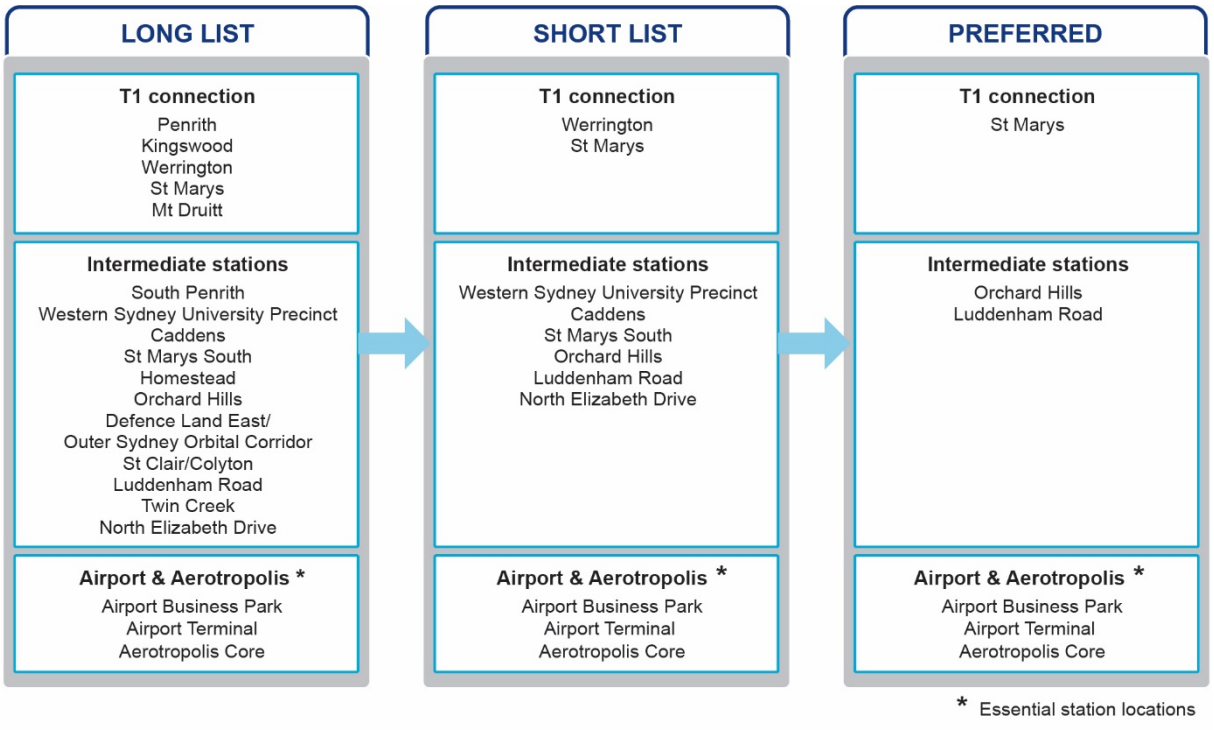

Figure 6-2 Station precincts – options assessment phases

6.4.2 Connection to the T1 Western Line

Consideration of long-list station precincts

As shown in Figure 6-3, six locations were considered for a connection of the project with the T1 Western Line. A connection with the T1 Western Line is required for customer transfer between the Sydney Metro network and the existing Sydney Trains suburban rail network.

Figure 6-3 Station precinct options for the connection to the T1 Western Line

Evaluation of shortlisted options

Of the long list of options considered, both St Marys and Werrington were shortlisted for further assessment. Based on the shortlist evaluation provided in Table 6-1, St Marys was identified as the preferred option for a connection with the T1 Western Line.

Table 6-1 Evaluation of shortlisted connections with the T1 Western Line

Location	Customer needs	Support WSI & the Western Parkland City	Productivity & employment	Transport integration	Urban renewal & place making	Sustainable & deliverable solution
St Marys	●	●	●	●	●	●
Werrington	●	●	●	●	●	●

● Strong alignment ● Some or neutral alignment ● Limited or no alignment

A station at St Marys would:

- provide the best location for interchange with the T1 Western Line and other public transport services including buses
- better support planned growth and increased public transport capacity aligned with St Marys' status as a strategic centre, as identified in the *Western City District Plan* (Greater Sydney Commission, 2018b)
- improve travel times for customers travelling towards Greater Parramatta and the Sydney central business district
- build on existing strong transport integration opportunities by providing a high quality, convenient interchange environment for customers from the T1 Western Line to metro, supporting existing and future transport integration
- enhance precinct permeability to support the revitalisation and continued renewal of the St Marys strategic centre both north and south of the T1 Western Line
- provide a more efficient connection to Schofields/Tallawong in Rouse Hill as part of a potential future extension to the north.

6.4.3 Intermediate stations between the T1 Western Line and Western Sydney International

Consideration of long-list station precincts

As described in Section 6.4.1, a number of station precincts were identified based on specific drivers which were independent of the rail corridor alignment process.

As shown in Figure 6-4, there were 11 station precinct locations identified in the intermediate stations long list.

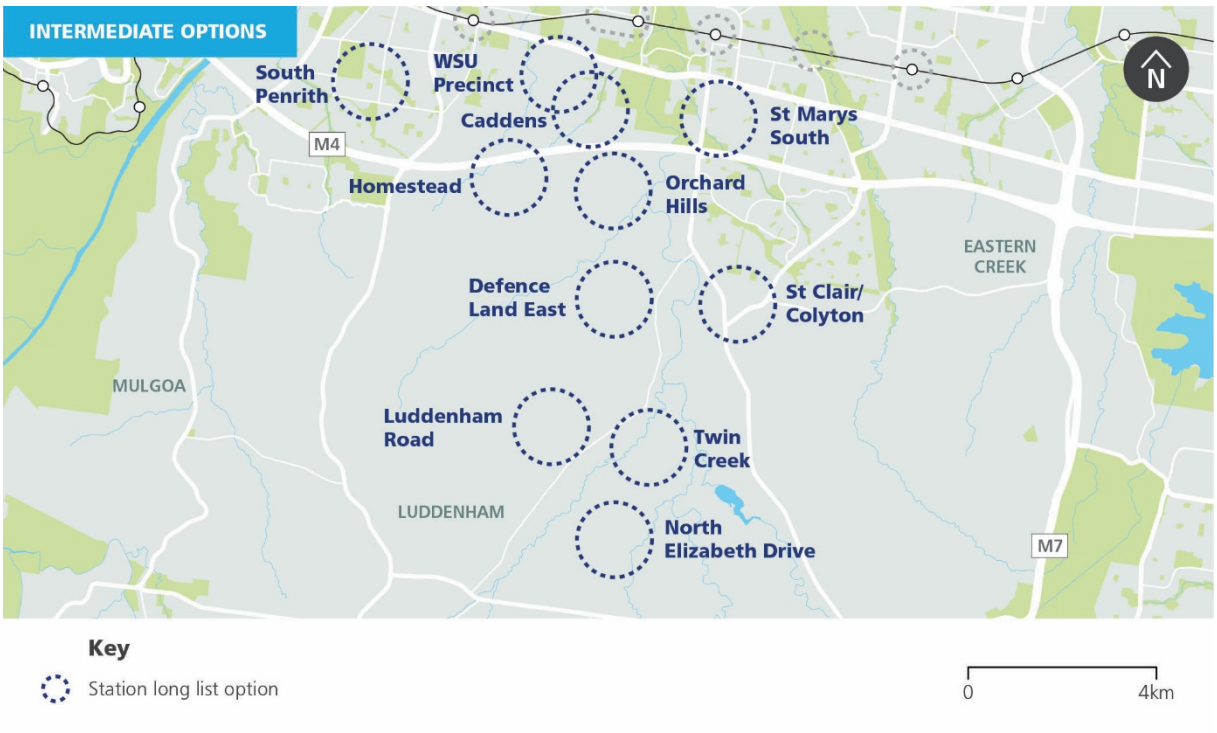

Figure 6-4 Station precinct options for intermediate stations between the T1 Western Line and Western Sydney International

Evaluation of shortlisted options

Key determinants in the identification of the shortlist included: an efficient alignment, absence of natural constraints and land use uplift opportunities.

Of the 11 long list intermediate station locations considered, the following six station locations were shortlisted for further assessment:

- Western Sydney University precinct
- Caddens
- St Marys South
- Orchard Hills
- Luddenham Road
- North Elizabeth Drive.

Additional technical investigations were carried out on the shortlisted station locations and performance of the shortlisted station locations against the project objectives is summarised in Table 6-2.

Orchard Hills and Luddenham Road were the preferred intermediate station location options between the T1 Western Line and Western Sydney International as they were both identified as strongly supporting the project objectives.

Table 6-2 Evaluation of shortlisted station options

Location	Customer needs	Support WSI & the Western Parkland City	Productivity & employment	Transport integration	Urban renewal & place making	Sustainable & deliverable solution
Western Sydney University precinct	🟡	🟡	🟡	🟢	🟢	🔴
Caddens	🟡	🟡	🟡	🟢	🟡	🟡
St Marys South	🟡	🟡	🟡	🟢	🟡	🟡
Orchard Hills	🟢	🟢	🟡	🟢	🟡	🟢
Luddenham Road	🟡	🟡	🟢	🟢	🟡	🟢
North Elizabeth Drive	🔴	🟡	🔴	🟡	🟡	🟡

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or no alignment

The assessment showed that Orchard Hills and Luddenham Road stations provided the following benefits over the other shortlisted intermediate station options:

- a station at Orchard Hills would:
  - be located in the Penrith to Eastern Creek Growth Investigation Area as indicated in the Western City District Plan and would allow the project to support planned growth
  - provide new rail access and support the opportunity of a new town centre within the station catchment
  - provide strong transport integration opportunities (active transport, bus and private vehicle/park and ride) that extend the station catchment and the benefits of the project into surrounding areas
  - be relatively easy to construct (this station would be co-located with the tunnel portal and could be constructed with minimal additional impact).
- a station at Luddenham Road would:
  - provide new rail access to an evolving mixed-use community, supporting planned growth within the Northern Gateway precinct, as identified in the *Western Sydney Aerotropolis Plan* (NSW Government, 2020a)
  - be well located on the alignment to support broader transport network integration opportunities (active transport, bus and private vehicle/park and ride) and expansion of the rail catchment beyond the station walking catchment
  - support a good balance of dwellings and jobs growth compared to other intermediate station options
  - be relatively easy to construct (the station could be built on a north/south orientation that supports an efficient track alignment)
  - require limited property acquisition (limited to a single private property).

The assessment also showed that a station at Western Sydney University would perform poorly against the 'sustainable and deliverable solution' objective and would have considerable construction, program and interface impacts and risk. A station at Western Sydney University would require a fundamentally different construction strategy compared with that described in Chapter 8 (Project description – construction).

Compared with a station (and associated tunnel infrastructure between St Marys and Orchard Hills), a station at Western Sydney University would:

- need to be constructed concurrently with tunnelling activities that would also need to be located at the station site, resulting in a very large property impact requirement
- require the launch and support of four tunnel boring machines (instead of two) in addition to station construction requirements
- result in greater travel times for customers travelling between Western Sydney International and St Marys
- require an additional three kilometres of tunnel length that would require two tunnel portal facilities (compared with up to one as part of the tunnel between St Marys and Orchard Hills), increasing comparative costs and affecting overall value-for-money.

6.4.4 Essential stations on-airport and at the Aerotropolis Core precinct

The on-airport stations and the Aerotropolis Core Station were identified as essential station precincts in order for the project to meet its objectives. The two airport stations were identified during the development of the Airport Plan for Western Sydney International. In particular, the indicative Airport Business Park and Airport Terminal station locations are identified in the approved airport site layout in the *Western Sydney Airport Stage 1 Construction Plan* (Western Sydney Airport, 2019).

A station within the Aerotropolis Core precinct was also identified as part of the current master planning for this precinct, however some optimisation regarding the final location of this station within the precinct has occurred as part of the development of the project. These essential station locations were therefore not subject to further options assessment from a precinct perspective.

6.4.5 Summary of preferred station precinct locations

Based on the assessment of the short-listed station precinct locations, the following were identified as preferred station precincts for development as part of the project:

- St Marys
- Orchard Hills
- Luddenham Road
- Airport Business Park
- Airport Terminal
- Aerotropolis Core.

The design of these stations is detailed further in Chapter 7 (Project description – operation).

6.5 Station optimisation

After selection of the preferred station precinct locations, design refinement and optimisation was undertaken to determine the layout and orientation of the station to best serve the precinct within which each station would be located. This was determined by considering the criteria outlined in Table 6-3.

Table 6-3 Technical and operational considerations

Technical and operational considerations	Evaluation measures
Customer, product, environment and planning approvals	• Easy customer access and travel times (including interchange) • Transport integration opportunities and facilities • Heritage and environment considerations • Community impact considerations.
Design and engineering	• Constructability • Engineering and design effort required to achieve outcome • Safety • Technical constraints (such as flooding, major existing infrastructure, or geotechnical features) • Interfaces with planned infrastructure (such as the Outer Sydney Orbital Stage 1).
Land use and property	• Potential property impacts • Alignment with transport corridors process • Supporting planned growth and precinct planning outcomes.
Program and cost	• Implications for construction program • Relative cost impacts (capital expenditure and operating expenditure).

6.5.1 Off-airport stations

St Marys Station

Background and key considerations

St Marys is an established local centre within Western Sydney. The suburb has been identified as a future strategic centre as part of the *Greater Sydney Region Plan* (Greater Sydney Commission, 2018a) and Western City District Plan. There is a bus interchange and layover to the south of the existing Sydney Trains station that serves a semi-regional role, with other major bus-rail interchanges located at Penrith and Mt Druitt. Both the town centre and existing interchange encourage significant private vehicle access and parking within St Marys, largely accommodated in a multi-storey car park to the north of the station, and a number of at-grade parking areas to the south of the station.

While serving the immediate catchment around St Marys, the metro station must allow for easy and efficient customer transfer between metro and T1 Western Line rail services (which services the north shore, parts of the inner west and western suburbs including Parramatta and Penrith and interchanges with other transport modes) as well bus services at the existing Sydney Trains station. The design of the station also needs to support a potential future extension of the metro rail line to the north to Schofields/Tallawong in Rouse Hill.

There are also heritage constraints at St Marys Station, with the site listed on the State Heritage Register as part of the St Marys Station Group. Optimisation of the station design therefore also considered the potential direct and indirect impacts of the project on the station group as a whole, as well as significant heritage elements within the station group (including the Goods Shed, station buildings on Platforms 3 and 4, the signal box and jib crane).

Description of feasible options

Design optimisation at St Marys considered five main station design options:

- Option 1 – a cut-and-cover station (east–west orientation) located to the south of the T1 Western Line, generally between the T1 Western Line and Station Street. This station design would consist of a station platform up to 25 metres below the ground surface and would interface with the existing heritage Goods Shed and bus interchange

- Option 2 – a cut-and-cover station (east–west orientation) located to the north of the T1 Western Line, between the T1 Western Line and Harris Street. This station design would consist of a station platform up to 25 metres below the ground surface. The design would also interface with the existing park-and-ride structure to the north of the station and T1 Western Line rail operations
- Option 3 – a deep cavern station (north–south orientation) below the T1 Western Line. This station design would consist of a station platform up to 45 metres below the ground surface
- Option 4 – a cut-and-cover station (north–south orientation) to the south of the T1 Western Line, generally between East Lane and Gidley Street. This station design would consist of a station platform up to 25 metres below the ground surface
- Option 5 – a cut-and-cover station (north–south orientation) generally to the south of the T1 Western Line, generally between Carinya Avenue and West Lane. This option would consist of a station platform up to 25 metres below the ground surface.

Assessment of feasible design options

The assessment of the station design options is provided in Table 6-4.

Table 6-4 St Marys Station design options assessment

Design options	Criteria			
	Engineering and design	Customer, environment and planning approvals	Land use and property	Program and cost
Option 1	🟡	🟢	🟢	🟡
Option 2	🟡	🟡	🟡	🟢
Option 3	🔴	🟡	🟡	🔴
Option 4	🟢	🟢	🟡	🟡
Option 5	🟢	🔴	🟡	🟡

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or no alignment

Selection of preferred design option

The assessment of St Marys Station design options against the criteria indicated that:

- Option 1 and Option 4 would have relatively reduced impacts on the heritage elements of St Marys Station compared with other options
- Option 1 and Option 4 would deliver an efficient, easy connection to the T1 Western Line
- Option 1 and Option 4 best support St Marys as a strategic centre and reinforce the activation of Queen Street.

Further technical assessment focussed on Option 1 and Option 4, with Option 1 identified as the preferred option because it would:

- best support precinct outcomes including the creation of an integrated public plaza and efficient transport integration with all transport modes
- consolidate construction impacts on predominantly government-owned land and minimise private property acquisition and business impacts
- result in reduced environmental impacts, in particular to the fabric of the State Heritage listed elements of the station building and supporting structures
- be less disruptive during construction, including reduced impacts on local roads and reduced local community impacts (including reduced severance of the town centre and relatively less removal of existing at-grade car parking than would be required by Option 4).

Orchard Hills Station

Background and key considerations

Orchard Hills currently consists of low density residential and rural residential land uses with limited public and active transport networks. The M4 Western Motorway forms a northern boundary to the area and there is a large Defence establishment to the southwest. The location provides an opportunity for a compact, high-amenity and walkable new community.

There are a number of constraints across the broader Orchard Hills catchment which influenced the identification and consideration of potential location refinements and layout/orientation options for this station. These constraints include:

- significant areas of vegetation (including Cumberland Plain Woodland) and riparian corridors that have the potential to contain critically endangered ecological communities
- 1 in 100-year flooding and probable maximum flood extents associated with South Creek
- access from the existing street network.

Description of feasible options

Four Orchard Hills Station options (all generally with a north–south station orientation) were explored. These included:

- Option 1 – an in-cutting station in the vicinity of Homestead Road and Darvill Road
- Option 2 – an in-cutting station located in the vicinity of Lansdowne Road and Kent Road
- Option 3 – an in-cutting station in the vicinity of Homestead Road and Calverts Road
- Option 4 – an in-cutting station located on Samuel Marsden Road.

Assessment of feasible design options

An assessment of the station design options undertaken against the identified assessment criteria is provided in Table 6-5.

Table 6-5 Orchard Hills Station design options assessment

Design options	Criteria			
	Engineering and design	Customer, environment and planning approvals	Land use and property	Program and cost
Option 1	🟡	🔴	🔴	🟢
Option 2	🟢	🟢	🟢	🟢
Option 3	🟡	🟡	🟡	🟢
Option 4	🟡	🔴	🔴	🟢

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or no alignment

Selection of preferred design option

Based on the assessment of the options, Option 2 was identified as the preferred option as it would:

- provide the most efficient alignment (and reduced tunnel length) from St Marys while avoiding potential constraints to the east and west
- be more centrally located within the precinct and with a north–south orientation that would enable future renewal without substantial changes to existing road access
- best integrate station and tunnel portal infrastructure (construction efficiency) while minimising impacts on the existing road network
- avoid areas of probable maximum flood levels associated with the tributaries of Blaxland Creek.

Luddenham Road Station

Background and key considerations

Luddenham Road Station would be located within the Northern Gateway precinct of the Aerotropolis. The Northern Gateway precinct is currently a greenfield location to the south of the Warragamba to Prospect Water Supply Pipelines and west of Luddenham Road. The station is intended to support the Northern Gateway precinct to transition from a semi-rural landscape to more intensive urban development. The area around Luddenham is intended to comprise flexible employment and mixed flexible employment and urban land, with other significant transport infrastructure such as the future M12 Motorway project and the project. The station location and layout would therefore be integrated with the strategic master planning being undertaken for this precinct.

Description of feasible options

Two similar options (both with a north–south station orientation) were investigated for the refinement of the Luddenham Road Station location. These were:

- Option 1 – a station towards the eastern side of the Northern Gateway precinct near Luddenham Road
- Option 2 – a station around 200 metres to the west of Option 1.

Assessment of feasible design options

An assessment of the station design options undertaken against the identified assessment criteria is provided in Table 6-6.

Table 6-6 Luddenham Road Station design options assessment

Luddenham Road Station location	Criteria			
	Engineering and design	Customer, environment and planning approvals	Land use and property	Program and cost
Option 1	●	●	●	●
Option 2	●	●	●	●

● Strong alignment ● Some or neutral alignment ● Limited or no alignment

Selection of preferred design option

Based on the assessment of the options, Option 1 was identified as the preferred option as it would:

- provide a more efficient overall north–south alignment
- result in reduced impacts on the Warragamba to Prospect Water Supply Pipelines and existing Defence land at Orchard Hills
- be closer to Luddenham Road therefore better supporting customer access to the station
- be optimally located to support planned growth, as outlined in the Western Sydney Aerotropolis Plan.

Aerotropolis Core Station

Background and key considerations

The Aerotropolis Core precinct is located to the south of Western Sydney International and is bordered by Badgerys Creek Road to the west and Thompsons Creek to the east and south. The Aerotropolis Core precinct is proposed to be part of a new metropolitan cluster within the Western Parkland City. The precinct is therefore anticipated to be developed as a thriving and productive employment, residential and mixed use city centre, attracting higher order jobs and businesses. Due to the scale of development proposed, the precinct will need to be accessible and require an integrated multi-mode transport network. The Aerotropolis Core Station is expected to interchange with other transport modes in future including rail, regional buses and active transport networks.

Description of feasible options

Three options (all generally north–south station orientations) were investigated for the refinement of the Aerotropolis Core Station location. These were:

- Option 1 – a station located towards the northern part of the Aerotropolis Core precinct
- Option 1A – a station located centrally in the Aerotropolis Core precinct (around 300 metres south of Option 1)
- Option 2 – a station around 600 metres to the south of Option 1.

Assessment of feasible design options

An assessment of the station design options undertaken against the identified assessment criteria is provided in Table 6-7.

Table 6-7 Aerotropolis Core Station design options assessment

Aerotropolis Core Station location	Criteria			
	Engineering and design	Customer, environment and planning approvals	Land use and property	Program and cost
Option 1	🟡	🟢	🟡	🟢
Option 1A	🟡	🟢	🟢	🟡
Option 2	🟡	🔴	🟡	🔴

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or no alignment

Selection of preferred design option

Based on the assessment of the options, Option 1A was preferred as it would:

- better support proposed future land uses within the Aerotropolis Core precinct
- be located outside the Thompsons Creek probable maximum flood level, avoid associated engineering and land use constraints, and have reduced environmental impacts by avoiding the need for significant operational rail infrastructure close to the riparian corridor of Thompsons Creek
- optimise the station catchment and provide stronger customer and transport integration opportunities.

6.5.2 On-airport stations

Airport Business Park and Airport Terminal stations

The Airport Plan for Western Sydney International contemplates rail stations at the terminal and business park. The Airport Business Park Station location as well as the overall station layout and orientation was generally fixed within the airport's site layout and was not subject to further optimisation. The Airport Terminal Station location was optimised as part of design development of the vertical alignment (see Section 6.6.2) and to more centrally locate the station between the proposed airport terminals.

6.6 Project alignment options

6.6.1 Horizontal alignment

Transport for New South Wales exhibited a draft North South Rail Line corridor between St Marys and the Aerotropolis in March 2018 for community consultation (see Section 6.1 for further discussion). During development of the project, Sydney Metro worked closely with Transport for New South Wales to align project outcomes with the North South Rail Line corridor planning process.

A number of alternative horizontal alignments to the draft corridor were investigated during the project's development, including using the Outer Sydney Orbital Stage 1 corridor and alternative T1 Western Line connections (e.g. to Werrington).

The draft North South Rail Line corridor was found to respond to major environmental constraints and physical interfaces including Defence land along the western side of the corridor, South Creek along the eastern side of the corridor and the requirements to connect Western Sydney International and the Aerotropolis Core precinct. The draft corridor also connected to locations suitable for development opportunities to support the Western Parkland City, including Luddenham Road, within the Northern Gateway precinct.

The horizontal alignment for the project was therefore broadly determined as a result of the previous corridor planning for the project. Refinements to the horizontal alignment were largely in response to optimised station locations, as described in Section 6.5, which identified a direct connection between St Marys and Orchard Hills as the preferred alignment. The North South Rail Line corridor south of Orchard Hills was found to be the most direct option to connect Western Sydney International and St Marys and optimal from an operations, travel time, cost and program perspective.

In addition to the refinement of the horizontal alignment to optimise station locations, the horizontal alignment between Orchard Hills Station and Luddenham Road Station was also considered as part of the refinement of the project design. This resulted in a slight shift of the project alignment (and a corresponding revision of the North South Rail Line corridor) to the west in order to optimise operational effectiveness of the project and minimise potential environmental impacts.

The refinement of the horizontal alignment at this location would provide a number of benefits, including:

- reduced impacts on Blaxland Creek (and the associated vegetation at this location) as the revised alignment would reduce the number of crossings of this waterway
- allowing for an improved configuration, site area and access arrangement to the stabling and maintenance facility.

In June 2020 the NSW government confirmed the final corridor for the North South Rail Line.

6.6.2 Vertical alignment

A range of natural constraints, existing or planned infrastructure and property constraints throughout the corridor also informed the vertical alignment for the project. These included:

- interface with existing and proposed transport infrastructure including:
  - the existing Great Western Highway, M4 Western Motorway, Lansdowne Road, Patons Lane, Luddenham Road, Elizabeth Drive, Derwent Road and Badgerys Creek Road
  - the proposed Outer Sydney Orbital Stage 1 corridor (road and freight rail) and the future M12 Motorway project
- the Warragamba to Prospect Water Supply Pipelines corridor
- existing electrical infrastructure including 330kV and 500kV high voltage power lines
- Western Sydney International Stage 1 layout in the Airport Plan
- major creek crossings including Blaxland Creek, Cosgroves Creek and Badgerys Creek
- a desire for the alignment to be located within a tunnel through the planned new city centre at the Aerotropolis Core precinct.

The proposed construction strategy for the project and construction efficiency was also considered in the assessment of alignment options.

As a result of these constraints, the project alignment is a mixture of tunnel, in-cutting, elevated/ viaduct, and surface.

A summary of the vertical alignment options considered is provided in Table 6-8.

Table 6-8 Summary of vertical alignment options analysis

Location	Design considerations				
	In-cutting	Viaduct	Tunnel	Surface	Consideration of options
St Marys to Orchard Hills	🔴	🔴	🟢	🔴	This section of the alignment, in particular around St Marys, has a predominantly urban land use. A tunnel alignment would avoid substantial land use and property impacts (including the requirements for property acquisition), as well as environmental and social impacts associated with surface options (e.g. impacts on endangered ecological communities, riparian zones, heritage impacts and potential conflicts with other transport infrastructure including the Great Western Highway and the M4 Western Motorway). A tunnel is therefore preferred for this highly constrained section of the corridor.
Orchard Hills to Patons Lane	🟡	🟡	🔴	🟢	Vertical alignment constraints in this section include Blaxland Creek, 330kV and 500kV high voltage power lines, and crossing of existing roads including Lansdowne Road and Patons Lane. Apart from a bridge to cross Blaxland Creek, this section of the alignment was preferred as a surface alignment as it would avoid key constraints including the 330kV and 500kV power lines and would support the preferred at surface entry arrangement to the stabling and maintenance facility (see Section 6.7.1).
Warragamba to Prospect Water Supply Pipelines, Luddenham Road Station and Luddenham Road crossing	🟡	🟢	🔴	🔴	Vertical alignment constraints in this section of the alignment include the Warragamba to Prospect Water Supply Pipelines, the development of the Northern Gateway precinct and the Luddenham Road corridor. A viaduct was the preferred option as it would potentially reduce impacts on areas of endangered ecological communities and Aboriginal archaeological sensitivity and would avoid potential flooding constraints. It would also reduce potential impacts on the Warragamba to Prospect Water Supply Pipelines during construction. This option would also provide improved connectivity across the future Northern Gateway precinct, opportunities for activation of open space and/or commercial land uses and would support the preferred Luddenham Road Station location. This option would also enable the crossing of Luddenham Road at this point.

Location	Design considerations				
	In-cutting	Viaduct	Tunnel	Surface	Consideration of options
Outer Sydney Orbital Stage 1 /M12 Motorway interface to Elizabeth Drive	🟡	🟡	🟡	🟢	This section of the project alignment considered options where the project would interact with the future M12 Motorway project, including alternatives for the project to travel under or over the future M12 alignment. A preferred surface alignment was developed for this section of the project (resulting in a rail over road configuration) in consideration of the ongoing development of the future M12 Motorway project and consultation with Transport for NSW. Specifically, the future M12 Motorway project would be in cut at this location and the rail corridor would be at-grade, on a bridge above the road. The surface option was preferred due to balance achieved between extent of earthworks and civil structures required for both projects. At Elizabeth Drive, the alignment would continue to be at surface, passing under the proposed Elizabeth Drive overbridge (part of the future M12 Motorway project) at this location.
Elizabeth Drive to Airport Terminal	🟡	🔴	🟢	🔴	This section of the alignment would travel through the Western Sydney International including the Airport Business Park Station, under the future cross-field taxiway, Airport Terminal Station and then turning south east to cross under the future second runway. A predominant tunnel alignment was selected to avoid key constraints (such as the taxiway and future second runway), better meet the requirements of Western Sydney International and support the land use and transport outcomes of Western Sydney International.

Location	Design considerations				
	In-cutting	Viaduct	Tunnel	Surface	Consideration of options
Badgerys Creek to Aerotropolis Core precinct	🟡	🟢	🟢	🔴	Constraints for this section of the alignment include Badgerys Creek (and associated on-airport Environment Conservation Zone), Derwent Road, Badgerys Creek Road and ongoing development of master planning and land use outcomes for the future Aerotropolis Core precinct. A tunnel alignment was selected to improve land use outcomes including providing additional developable land and flexibility for transport integration, reducing community impacts, avoiding substantial property acquisition and providing the opportunity for the development of a city centre well integrated with the station. The tunnel option would also provide the opportunity to create a civic focus, a vibrant city heart and high-quality public domain for the public and pedestrians on arrival to the Aerotropolis Core precinct. A tunnel option would allow for unimpeded public and pedestrian connection between the built urban fabric. A tunnel through this section was also considered to provide an opportunity to optimise the alignment between the Airport Terminal Station and Aerotropolis Core Station, improving the journey time for customers. The tunnel option would reduce environmental impacts compared to the previously proposed viaduct option. These include avoiding the need to have infrastructure within Badgerys Creek, reduced potential for flood impacts, reduced impacts to areas of endangered ecological communities (including Cumberland Plain Woodland), local heritage items and an area of Aboriginal archaeological heritage, as well as reduced impacts to private properties.

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or no alignment

6.6.3 Consideration of the Outer Sydney Orbital Stage 1 corridor

One of the identified options for the project was for the alignment to be within the Outer Sydney Orbital Stage 1 corridor, which has been identified by Transport for NSW as a future freight rail and motorway corridor between Richmond Road in the north and the Hume Motorway near Menangle in the south. A section of the Outer Sydney Orbital Stage 1 corridor is located between the T1 Western Line and Orchard Hills/Luddenham Road.

The Outer Sydney Orbital Stage 1 corridor was assessed as a potential viaduct option for the project but was not preferred for the following reasons:

- an above ground metro line through the Outer Sydney Orbital Stage 1 corridor would require relocation, potentially underground, of critical high-voltage power lines, increasing the construction program by over one year and adding to project costs
- there would be no viable station locations for customers to access the rail line between St Marys and Luddenham Road, which is a distance of around 10.5 kilometres because access would be constrained into the future by freight rail and motorway carriageways for the Outer Sydney Orbital. This proposed future infrastructure would present the following disadvantages:
    - close proximity of the freight rail, motorway corridors and a metro corridor would result in poor customer outcomes
    - some areas of the Outer Sydney Orbital corridor are in floodplain which would reduce opportunities for future placemaking and development adjacent to station precincts
- a high viaduct would be required to cross the M4 Western Motorway and Great Western Highway resulting in complex construction requirements, cost and program challenges and substantial visual impacts
- arriving in St Marys on a viaduct would require additional property acquisition for both this project and for a future extension to the north towards Schofields/Tallawong in Rouse Hill
- the key strategic purpose of Outer Sydney Orbital Stage 1 is to provide a freight rail corridor and a new motorway, which could potentially be displaced if the corridor was used for passenger rail.

6.6.4 Public safety considerations at Western Sydney International

The *National Airport Safeguarding Framework Guideline* (Department of Infrastructure, Transport, Cities and Regional Development, 2018) (NASF Guideline) outlines the requirements for Public Safety Areas (PSAs) at federal airports and therefore applies to Western Sydney International.

PSAs defined under the NASF Guideline are designated areas of land at the end of an airport runway within which development may be restricted to control the number of people in the area. The size and shape of a PSA typically depends on the likelihood of an aircraft accident occurring (for example, a plane overshooting the runway). Generally, this likelihood decreases with increasing distance from the runway.

The Western Sydney Aerotropolis Plan has adopted a PSA based on the UK Public Safety Area model. The PSA extends from the runway ends, beyond the boundary of the airport site. The project crosses through the PSA for Runway 1 for approximately 400 metres.

Potential risks and options for the realignment of the project (both horizontal and vertical) have been considered in determining the project alignment presented in this Environmental Impact Statement. It was determined that the project alignment is optimal considering the identified constraints including the need to cross the future M12 Motorway and Elizabeth Drive north of Western Sydney International and the vertical alignment of the rail corridor within Western Sydney International. No physical risk mitigation (such as barriers) is considered necessary as part of the design.

Chapter 23 (Hazard and risk) further discusses the potential impacts of the project and includes additional consideration of controls applicable to Western Sydney International such as:

- extent of the PSA
- obstacle limitation surface requirements
- guidance for risks including wildlife strikes, distractions to pilots from spill lighting and landscaping associated with the construction and operation of the project
- requirements for any other airspace declared to be prescribed for the airport under the Airspace Regulations.

6.7 Ancillary facility options

6.7.1 Stabling and maintenance

Background

The operation of the project would require both heavy and light maintenance operations, as well as an operational control centre for the ongoing operation of the system. The most efficient way to accommodate these activities is to bring them together at one site, ideally combined with the overnight stabling of trains so that all these operations can occur at one location.

In order to determine potentially suitable locations for the stabling and maintenance facility, the various functional requirements of the stabling and maintenance facility were considered (refer to Section 7.5.1). In addition to the functional requirements, a number of other engineering and environmental considerations were used to identify potential stabling sites. These included:

- being located along the project alignment (for efficiency of access)
- generally, centrally located between St Marys and the Aerotropolis Core precinct (to allow for efficient operation as part of any proposed future expansion of the network to the north and/or south)
- avoiding or minimising changes in height between the project alignment and the stabling and maintenance facility (thereby promoting at-grade transition between the stabling and maintenance facility and the project alignment)
- future strategic planning and land use context
- flooding (i.e. generally located above the 1:100 annual recurrence interval flood level)
- value of land and uplift potential
- proximity to sensitive receivers
- minimising impact on significant biodiversity assets and heritage items
- potential to accommodate the future expansion of services.

Description of feasible options

Ten potential stabling and maintenance sites were identified between St Marys and the Aerotropolis Core precinct. When assessed against the identified functional requirements and other engineering and environmental considerations, seven of these sites were removed from further assessment.

The remaining three sites were then subject to further consideration as part of a multi-criteria analysis:

- Option 1 – this site would be located to the south of Blaxland Creek, to the east of the project alignment and north of Patons Lane
- Option 2 – this site would be located to the south of Luddenham Road, to the west of the proposed project alignment and north of Cosgroves Creek
- Option 3 – this site would be located immediately to the north of Elizabeth Drive, to the east of the project alignment and west of Badgerys Creek.

Assessment of feasible design options

An assessment of the stabling and maintenance facility location options undertaken against the identified site assessment criteria is provided in Table 6-9.

Table 6-9 Stabling and maintenance facility location options

Site Option	Criteria						
	Land-use	Operational flexibility	Engineering and constructability	Environmental considerations	Maintainability	Access to facility	Project interfaces (risks)
Option 1	🟢	🟢	🟢	🟡	🟢	🟡	🟡
Option 2	🟡	🟡	🟡	🟡	🟡	🟡	🟢
Option 3	🟢	🟡	🟡	🟢	🟢	🟡	🟡

🟢 Strong alignment 🟡 Some or neutral alignment 🔴 Limited or misalignment

Selection of preferred design option

Based on the assessment of the shortlisted site location options, Option 1 was identified as the preferred stabling and maintenance facility location.

While each of the shortlisted sites were capable of allowing expansion of the facility to accommodate potential future fleet requirements, Option 1 was identified as preferred as it would:

- provide a relatively flat site with the lowest requirement for earthworks compared with the other options considered
- be the least constrained from an engineering and constructability perspective
- offer the most operational flexibility in comparison to the other options
- provide good utilisation of a parcel of land that would otherwise be between the proposed Outer Sydney Orbital Stage 1 corridor and the project alignment, and would therefore have limited redevelopment potential for other uses.

6.7.2 Services facilities

The project includes two tunnel sections comprising a northern tunnel section (around 4.3 kilometres long) and a southern tunnel section (around 6.3 kilometres long). Service facilities are typically required for tunnel sections of these lengths to facilitate safe and effective ventilation during normal and emergency operation.

The siting of each of the services facilities for these tunnels was based on a number of criteria, including:

- immediately above or in close proximity to the proposed tunnel alignment
- appropriate spacing to reduce the need for multiple services facilities for the tunnel alignment
- property impacts
- easy access for maintenance purposes

- minimising environmental and social impacts associated with:
  - areas of known contamination
  - highly vegetated areas
  - areas of high archaeological or built heritage significance.

Based on the criteria identified, a site along the proposed St Marys to Orchard Hills tunnel alignment was determined to best meet these requirements. The site for the Claremont Meadows services facility is located in a cleared area on the eastern side of Gipps Street, immediately to the south of the Great Western Highway. As discussed in Chapter 7 (Project description – operation), the need for the Claremont Meadows services facility is subject to investigation. For the Bringelly services facility, a site was identified on Derwent Road (between Airport Terminal Station and Aerotropolis Core Station) as the preferred location which would support the overall project requirements.

Further detail regarding the proposed services facilities is provided in Section 7.5.3.

In addition to the proposed services facilities, tunnel services buildings are required at tunnel portals to support operations. The location of these facilities was determined by the final tunnel portal locations.

6.8 Design refinements for impact minimisation

The construction planning and design of the project has been influenced by a number of factors including environmental and transport constraints.

Key environmental aspects that have influenced the project, together with how the project has been refined to avoid/minimise potential environmental impacts, are summarised in Table 6-10. Ongoing project planning would continue to be undertaken to ensure these outcomes would be retained in design development where possible.

Table 6-10 Environmental considerations during design refinement

Environmental aspect	Design refinements
Biodiversity	• the positioning of the station at Orchard Hills and the associated construction footprint has been refined to minimise impacts on threatened ecological communities and to avoid large areas of higher quality (intact) contiguous vegetation that provides fauna habitat and movement corridors • vertical and horizontal alignment optimisation has resulted in improved fauna connectivity, due to improved clearances underneath bridge and viaduct structures that improve light penetration and encourage fauna movement (such as at Blaxland Creek and Cosgroves Creek) and provision of tunnel alignments (such as the crossing under Badgerys Creek) • areas of ecological sensitivity have been avoided (where feasible) as a result of straightening of the project alignment (for example the area south of Lansdowne Road, resulting in a more perpendicular crossing of Blaxland Creek, minimising the infrastructure footprint around the creek and associated vegetation impacts) • the project would cross Claremont Creek and South Creek (to the west of St Marys) in tunnel to avoid impacts on riparian vegetation along these creek corridors • the Claremont Meadows services facility is proposed on cleared land at the corner of the Great Western Highway/Gipps Street to avoid impacts on nearby areas of existing vegetation • reduced impacts to Cumberland Plain Woodland and the Badgerys Creek Environment Conservation Zone have resulted from the proposed tunnel alignment from Western Sydney International to the Aerotropolis Core precinct (see Chapter 11 (Biodiversity)).

Environmental aspect	Design refinements
Construction traffic and transport	• by producing and storing tunnel segments and viaduct segments at Western Sydney International, the project would reduce traffic movements associated with trucking these materials from a remote location to the project • during construction, some sections of the rail corridor would be used for construction vehicle traffic to minimise the number of new access road connections to the existing road network • the project is continuing to investigate spoil management options, including permanent fill placement areas within Western Sydney International and spoil reuse in areas close to the project alignment (for example use by the future M12 Motorway project) to minimise road-based spoil haulage (see Chapter 18 (Resource management)).
Operational noise and vibration	• the project would be in tunnel through the most built-up area of the corridor between the T1 Western Line and the M4 Western Motorway, minimising operational noise and vibration in these built-up residential areas • reduced operational noise impacts on existing and future communities in the Western Sydney Aerotropolis, due to the tunnel alignment from Western Sydney International to the Aerotropolis Core precinct.
Non-Aboriginal heritage	• the design has specifically sought to avoid and/or minimise impacts on heritage items, specifically St Marys Station Group (State Heritage listed). Impact mitigation at St Marys has included consideration of: - options for the design of the new metro station that retained the Goods Shed in-situ rather than requiring its removal - options for the above ground pedestrian concourse to avoid direct impacts to the heritage significant St Marys station building on Platforms 3 and 4 - options to minimise above ground station infrastructure where possible, to limit impacts on the heritage context and setting of the existing Sydney Trains station • the tunnel design at the Aerotropolis Core precinct would also minimise impacts on heritage items in this area including visual impacts on the State Heritage-listed Kelvin Park Group (see Chapter 12 (Non-Aboriginal heritage)).
Aboriginal heritage	• a westward shift of the initial horizontal alignment has avoided the need for a section of the alignment to travel parallel to, and through (above), Blaxland Creek, minimising impacts on an area of potential Aboriginal archaeological sensitivity • optimisation of the vertical alignment has resulted in longer sections of tunnel (in particular for the section of the alignment south of Western Sydney International) and additional viaduct and bridge structures over creek crossings, substantially reducing the extent of potential impacts on areas of Aboriginal archaeological sensitivity.

Environmental aspect	Design refinements
Property and land use	• the project has, where feasible, remained within the nominated North South Rail Link corridor, thereby minimising impacts on properties outside this corridor not previously identified as impacted • construction footprints have been developed to be consistent with the final operational footprint as far as feasible, to minimise additional property impacts and avoid, where possible, property impacts only required during construction • reduced property impacts and improved land use outcomes at Western Sydney International and the Aerotropolis Core precinct have been identified due to the introduction of a tunnel alignment between these two locations (although the land within the North South Rail Line Corridor remains protected for potential longer term transport infrastructure use under the provisions of the *State Environmental Planning Policy (Major Infrastructure Corridors) 2020*).
Visual and landscape	• optimisation of the vertical alignment has resulted in longer sections of tunnel (in particular for the on-airport and Aerotropolis sections of the alignment) reducing the extent of potential visual and landscape sensitivity impacts.
Contamination	• the tunnel alignment under Gipps Street has been selected to avoid interaction with the former Gipps Street landfill.
Social impacts and community facilities	• optimisation of the vertical alignment and tunnel sections has resulted in longer sections of tunnel (in particular for the on-airport and Aerotropolis sections of the alignment) and additional viaduct and bridge sections improving connectivity and minimising severance of land and associated access impacts. For example, the refined project alignment would provide increased opportunity for connected and walkable precincts at the Luddenham Road and Aerotropolis Core stations • the safety of customers, staff and areas surrounding stations would continue to be considered in station design in accordance with Crime Prevention Through Environmental Design principles.
Hydrology and flooding	• the design has sought to avoid the placement of piers within watercourses and has optimised viaduct and bridge lengths to achieve this, where possible • the design has sought to avoid the location of tunnel portals in areas of identified flood zones, where possible • the stabling and maintenance facility has been located and designed to avoid, to the extent possible, the probable maximum flood level associated with Blaxland Creek • avoid the need for a viaduct over Badgerys Creek and reduced potential for flood impacts due to the tunnel alignment between Western Sydney International and the Aerotropolis Core precinct.

Environmental aspect	Design refinements
Waste management and resource use	• selection of tunnel boring machines to excavate the twin tunnels because these cut the ideal circular profile for a rail tunnel, thereby minimising spoil generation • optimising the vertical alignment (outside of the tunnel section) to avoid ongoing transition between surface and viaduct sections, which provides construction efficiencies and minimises associated resource use • identifying potential areas for permanent fill placement within Western Sydney International that could substantially reduce the volume of heavy vehicles on the local road network, minimising resource use (i.e. fuel etc).

During future design development, opportunities to avoid and/or further minimise project impacts would continue to be identified.