10 Air quality

This chapter describes the existing environment in relation to air quality, assesses the potential impacts of construction and operation of the project on air quality, and provides mitigation measures to manage the impacts identified. The technical report which informs this chapter is provided in Technical Report 3 – Air quality impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

10.1 Assessment approach

10.1.1 Methodology

10.1.1.1 Study area

The study area encompasses a 1.5 kilometre radius from the project site. The sensitive receptors to air quality impacts from the project are discussed in section 10.2.2.

10.1.1.2 Key tasks

The air quality impact assessment involved the following tasks:

- a desktop review of site plans, aerial photographs and topographic maps to gain an understanding of the existing environment in terms of local terrain, existing and proposed operations and sensitive receptors
- the applicable air quality assessment criteria was outlined, as defined by the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) (known as 'the Approved Methods') and the *National Environment Protection (Ambient Air Quality) Measure* ('the Air NEPM')
- a review of available background air quality in the local area using NSW Office of Environmental Heritage OEH air quality monitoring data and client provided data
- meteorological modelling for use as model input for atmospheric dispersion modelling
- a construction emissions inventory was created
- an operational emissions inventory was created to include locomotives using the report Diesel Locomotive Fuel Efficiency and Emissions Testing prepared for NSW EPA (ABMARC, 2016) and National Pollutant Inventory (NPI) emission factors
- dispersion modelling to predict construction and operational impacts at nearby receptors in the study area using regulatory approved models was undertaken as follows:
  - using AUSPLUME 6.0 for construction impacts as a 20 metre (width) by 100 metre (length) area along the length of the rail corridor. The 100 metre length is an appropriate interval to calculate the worst case air quality impacts
  - using CALPUFF version 6 for operation impacts using a 200 metre grid resolution as per the meteorological model used for the assessment.
- a screening level dust assessment for construction activities with consideration of the Approved Methods.

10.1.1.3 Project emissions

Construction emission rates were characterised using recommended emission factors for average conditions published in the *Western Regional Air Partnership Fugitive Dust Handbook* (WRAP) (Countess Environmental, 2006). These emissions factors are calculated assuming standard earth moving operations.

Combustion products from diesel locomotives predominantly comprise the following pollutants:

- nitrogen dioxide (NO_2)
- carbon monoxide (CO)
- hydrocarbons (HC)
- sulfur dioxide (SO_2)
- particulate matter with diameter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$).

10.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with air quality. Potential risks were considered according to the impacts that may be generated by the construction and/or operation of the project, pre-mitigation. The purpose of the preliminary environmental risk assessment was to inform the impact assessment. Further information on the preliminary risk assessment, including the approach and methodology is provided in Appendix D.

The assessed risk level for potential air quality risks during construction was low or medium. Risks with an assessed level of medium were:

- generation of dust during construction (from exposed soil/stockpiles, excavation and vehicle movements)
- emissions from vehicles or plant during construction
- generation of dust from transport of uncovered loads during operation.

The assessed risk level for potential air quality risks during operation was low.

These potential risks and impacts were considered as part of the assessment. The assessment also considered matters identified by the SEARs and stakeholders, as described in Chapter 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

10.1.3 How potential impacts have been avoided/minimised

As described in Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has included a focus on avoiding and/or minimising the potential for environmental impacts during all key phases of the project.

Potential air quality impacts have been avoided/minimised where possible by:

- minimising the project footprint
- using areas for compounds and work sites that are already disturbed or have been previously used during the construction of SSFL.

10.2 Existing environment

10.2.1 Ambient air quality

10.2.1.1 General characteristics

Ambient air quality in Sydney is influenced by a number of factors, including topography, prevailing meteorological conditions (such as wind and temperature, which vary seasonally), and local and regional air pollution sources (such as motor vehicles, industrial facilities and bushfires). Consequently, regional air quality can be highly variable and impacted by events occurring a significant distance away.

The NSW OEH operates ambient air quality monitoring stations in selected areas around NSW. The nearest station to the project site is Liverpool, however Chullora has also been included as it contains background data for sulfur dioxide (SO_2). Ambient air pollutant concentrations recorded at Liverpool and Chullora OEH stations include emissions from all regional sources. Cumulative assessment of all regional sources of air pollution are accounted for by including the ambient air quality concentrations measured at the Liverpool and Chullora OEH stations and adding them to incremental site impacts.

Daily pollutant average and maximum ambient concentrations for the modelled year are presented in Table 10.1. This data shows that the maximum recorded PM_{10} and $PM_{2.5}$ background concentrations at the Liverpool OEH station are higher than the assessment criteria. This is consistent with air quality results noted in NSW, which experienced poorer air quality during 2013, mainly due to drier and hotter weather through the middle of the year and the impact of bushfires in September, October and November. Background concentrations of all other pollutants were below the assessment criteria.

Table 10.1 Ambient air quality daily concentrations (2013)

Pollutant concentrations		OEH monitoring site	
		Liverpool	Chullora
SO_2	Average (µg/m^3)	-	2.6
	Maximum (µg/m^3)	-	31.4
Nitrogen oxide (NO)	Average (µg/m^3)	18.4	17.2
	Maximum (µg/m^3)	290.3	413.3
Nitrogen dioxide (NO_2)	Average (µg/m^3)	20.7	24.4
	Maximum (µg/m^3)	105.3	103.4
Ozone (O_3)	Average (µg/m^3)	29.4	27.4
	Maximum (µg/m^3)	229.3	205.8
Carbon monoxide (CO)	Average (µg/m^3)	0.5	0.3
	Maximum (µg/m^3)	4.6	4.0
PM_{10}	Average (µg/m^3)	21.0	18.3
	Maximum (µg/m^3)	98.5	69.4
	70th percentile (µg/m^3)	25.2	20.6
$PM_{2.5}$	Average (µg/m^3)	9.4	8.4
	Maximum (µg/m^3)	73.8	49.1
	70th percentile (µg/m^3)	10.8	9.5

'-'denotes data not sampled at the site

10.2.1.2 Local emission sources

The main local sources of air pollution in the area include:

- vehicle emissions especially from the arterial roads such as Hume Highway, The Horsley Drive, Elizabeth Drive and Newbridge Road
- suspended dust along roadways, from pulverized pavement materials, particles from brake linings and tyres

- residential emissions such as domestic products as well as fuel combustion from domestic machinery such as lawn mowers, etc
- dust and diesel emissions from existing rail movements along the network between Warwick Farm and Cabramatta stations
- secondary particulate emissions from freight and passenger train movement (i.e. wheel and brake action, wagon turbulence in the rail corridor and windblown particulates).

10.2.2 Sensitive receptors

The project site is situated in a mixed residential and commercial area. The land adjacent to the rail corridor is predominantly residential and recreational with smaller sections of business and general industrial.

The project site is surrounded by a wide range of sensitive receptors, including residential properties, businesses, community facilities (such as schools, and sporting facilities), and recreational areas. A number of these receptors are located within or immediately adjacent to the project site. It is expected that the closest receptors will experience the worse-case air quality impacts. If potential air quality impacts from the project comply with the impact assessment criteria at the nearest receptors, then those situated at a greater distance will also likely comply.

Land uses surrounding the project site are described in Chapter 16 (Land use and property). The location of representative sensitive receptors is shown on Figure 10.1.

Figure 10.1 Site and sensitive receptor location

10.3 Assessment of construction impacts

Construction activities, including earthmoving, storage and transport of spoil and waste materials, and exhaust emissions from construction equipment and vehicles, have the potential to impact on local air quality. The main potential impact on air quality during construction is dust and this is described further below.

10.3.1 Dust generation

The processes that have the potential to generate particulate matter during construction are:

- mechanical disturbance − dust emissions as a result of earthworks/excavation and the operation/movement of construction vehicles and equipment
- wind erosion − dust emissions from disturbed soil surfaces and stockpiles in windy conditions

The project activities likely to generate dust include:

- building new rail track – providing a 1.65 kilometre long section
- realigning the track realignment – moving about 550 metres of existing track sideways
- building two new bridges next to the existing rail bridges over Sussex Street and Cabramatta Creek
- reconfiguring Broomfield Street for a distance of about 680 metres between Sussex and Bridge streets
- plant operations in compounds and work areas
- minor works in the form of new signalling installed at a number of locations within the rail corridor outside the project site
- building an embankment at Jacquie Osmond Reserve
- transport, handling, stockpiling, loading and unloading of spoil and imported materials
- temporarily relocating part of the pedestrian footbridge over Cabramatta Creek.

Given the primary air quality concern during construction is dust, a screening level dust assessment was undertaken for proposed construction activities. The modelled scenario assumes construction works occurring along the rail corridor and the results indicate the following:

- all particulate concentrations (daily and annual TSP, PM_{10} and $PM_{2.5}$) are composed of high background concentration and relatively low incremental site impacts
- daily PM_{10} and $PM_{2.5}$ criteria are met at 25 metres from and on the boundary of the project site, respectively
- annual TSP and PM_{10} are met at 2 and 30 metres from the boundary of the project site, respectively. Annual $PM_{2.5}$ results are higher than the criteria as the 9.4 µg/m^3 background concentration from the nearest station is already above the criteria.

A number of sensitive receptors within 25 metres of the project site could experience short term elevated PM_{10} concentrations. This is not anticipated to impact on the local amenity. It is expected that the location of construction works will vary as the project proceeds and consequently, no long term particulate concentration impacts are expected from construction of the project.

Construction works outside the project site boundary (eg utility relocation and protection works) have the potential to impact on nearby receptors. It is expected that these construction works will involve little or minor dust generating activities as only small trenches would be dug for conduits and cables and would therefore result in negligible additional impact. As a result of the limited scale of earthworks and nature of the works proposed, dust emissions are expected to be manageable through the implementation of standard erosion control and dust management measures outlined in section 10.5.

Construction work will be staged through the project site so that impacts on sensitive receptors would be minor and short term.

10.3.2 Vehicle and plant emissions

The main source of emissions would be from the combustion of diesel fuel and petrol from heavy vehicles, mobile excavation machinery, and stationary combustion equipment as well as from the handling and/or on-site storage of fuel and other chemicals. The volume of emissions from construction vehicles and machinery would depend on the type of fuel used, the power output and condition of the engine, and duration of operation. Fine particle emissions associated with exhausts from vehicles and plant used during construction are accounted for in the emission factors for earthmoving and handling used in the dust assessment in section 10.3.1.

Exhaust emissions would involve periodically localised emissions of carbon monoxide, (PM_{10} and $PM_{2.5}$), nitrous oxides, sulfur dioxide, volatile organic compounds, and polycyclic aromatic hydrocarbons associated with the combustion of diesel fuel and petrol.

Exhaust emissions generated during construction would not significantly contribute to emissions in the area, given the existing levels of vehicle use. Construction vehicles are expected to travel along the alignment and resulting emissions will be discontinuous, transient, and mobile.

It is anticipated that these potential impacts could be adequately managed through the implementation of the mitigation measures provided in section 10.5.

10.3.3 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E.

As the impacts from the construction of the project are predicted to be transitory and confined to an area 30 metres from the boundary of the project site, the cumulative impacts would be minimal unless an additional source of dust (to this project) was generated close to receptors. There are no other known construction projects proposed for the area.

10.4 Assessment of operational impacts

10.4.1 Local impacts

10.4.1.1 Dust

Minor quantities of particulate matter would be generated, mainly due to the wear of the train brake pads, vaporisation of metals due to sparking, and wear of steel due to friction between wheels and rail. These emissions would be in very low concentrations, and are not expected to be different from the current operational rail corridor.

Similarly, maintenance activities involving minor earthworks and exhaust emissions would produce minor quantities of particulate matter and would be managed in accordance with ARTC’s standard operating procedures and ARTC’s EPL (EPL #3142). As a result, there is the potential for minor local air quality impacts during operation. However, no long term or adverse health impacts are expected from the project.

10.4.1.2 Locomotive Emissions

The project would increase capacity for locomotive movements from 48 to up to 72 movements within a 24 hour period. Actual volumes are highly dependent on demand, which may not always be consistent. Atmospheric dispersion modelling using the CALPUFF version 6 results show that assuming the highest frequency operation, there will be no incremental or cumulative exceedances of the relevant criteria for $NO_{2,}$ CO, HC as benzene, $SO_{2,}$ or $PM_{10,.}$

The 2013 annual average $PM_{2.5}$ recorded at the Liverpool OEH station was 9.4 µg/m^3. This exceeds the annual $PM_{2.5}$ criteria supplied in the Approved Methods of 8 µg/m^3. Consequently, all predicted annual $PM_{2.5}$ concentrations exceed the assessment criteria. Incremental increases in $PM_{2.5}$ due to the project range from 0 to 0.2 µg/m^3. The predicted exceedances of the annual $PM_{2.5}$ criteria are attributable to the existing sources rather than the project. Notwithstanding, the minor increase is unlikely to be noticeable to nearby receptors.

General mitigation measures which aim to reduce any potential additional impacts as a result of operation are provided in section 10.5.

10.4.2 Regional impacts

The project would not result in any substantial regional air quality impacts as the emissions would be highly dispersed in the local area.

10.4.3 Cumulative impacts

Incremental increases in $PM_{2.5}$ from operation of the project are minor. The predicted exceedances to the annual $PM_{2.5}$ criteria are attributable to the existing sources rather than the project operations. The maximum predicted increase from the operation of the project is identified at the most affected receptor. However, most receptors would experience lower increases. As all increases are relatively minor, the cumulative impact is predicted to be minor.

10.5 Management of impacts

10.5.1 Approach

10.5.1.1 Approach to mitigation and management

Overall, the majority of potential construction related air quality impacts would be short term and temporary in nature. The potential for these impacts would be significantly reduced by:

- effective construction design and planning, including minimising the length of time excavations remain open
- implementation of the mitigation measures provided in Table 10.2.

During operation, air quality would be managed in accordance with ARTC's EPL (EPL #3142) and ARTC's standard operating procedures including those within its Environmental Management System. While it is noted that ARTC do not operate the locomotives, it is assumed these locomotives would be operated in accordance with relevant regulatory requirements to minimise air emissions.

10.5.1.2 Expected effectiveness

ARTC and its contractors have experience managing potential air quality impacts associated with the construction and operational phases of rail development projects.

Weather conditions such as wind direction, wind speed, soil moisture and rainfall or dew would substantially influence the day to day potential for dust generation and suspension. Therefore, project personnel involved in the activities need to consider the factors effecting dust generation in consultation with their environmental representatives to ensure appropriate mitigation measures are adopted.

It is expected that these recommendations, along with any relevant requirements of the project approval, best practice guidelines and applicable legislation would be developed into the CEMP prepared to manage the relevant phases of the project. Routine auditing of the effectiveness of the implementation of the CEMP requirements will be undertaken to ensure that management measures remain adequate, effective and fit for purpose.

Regular monitoring and inspections will be undertaken during construction to confirm the effectiveness of mitigation measures. Monitoring and inspections will include, but not be limited to Project Contractor's supervisory inspections on a daily basis and environmental representative weekly inspections.

10.5.2 List of mitigation measures

The mitigation measures that will be implemented to address potential air quality impacts are listed in Table 10.2.

Table 10.2 Mitigation measures

Stage	Impact	Measure
Construction	Dust deposition and decrease in receptor amenity – minor and temporary	Dust suppression will be undertaken as required using water sprays, water carts or other media on: • unpaved work areas subject to traffic or wind • sand, spoil and aggregate stockpiles • the loading and unloading of dust generating materials.
	Vehicle emissions	Plant and equipment will be maintained in good condition and in accordance with manufacturer's specifications to minimise spills and air emissions that may cause nuisance.
	Dust deposition and decrease in receptor amenity – minor and temporary	If the works are creating levels of dust which significantly impact on residential amenity, the works will be modified or stopped until the dust hazard is reduced to an acceptable level.
	Dust deposition and decrease in receptor amenity – minor and temporary	The size of stockpiles will be minimised, where possible.
	Dust deposition and decrease in receptor amenity – minor and temporary	Construction vehicles with potential for loss of loads (such as dust or litter) will be covered when using public roads
Operation	Emissions - Negligible	The project will be managed in accordance with ARTC's existing EPL (EPL #3142) and ARTC's standard operating procedures including those within the Environmental Management System.

10.5.3 Consideration of the interaction between measures

The major pollutant of concern is dust. As described in Chapter 13 (Hydrology, flooding and water quality), soil and erosion control measures will be implemented during construction in accordance with *Soils and Construction - Managing Urban Stormwater Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008). Implementation of these measures will be guided by a soil and water management plan to be prepared as part of the CEMP.

Chapter 12 (Soils and contamination) concludes that contaminated soils are not likely to be present at the project site. Therefore air quality mitigation measures have not included this issue. Chapter 21 (Climate Change and greenhouse gas) provides measures to be implemented to manage impacts of electricity use during construction and operation Implementation of these measures, together with the requirements of the CEMP, will minimise the potential for air quality impacts.

10.5.4 Managing residual impacts

A residual risk analysis was undertaken following the impact assessment summarised in this chapter. The results of the residual risk analysis are provided in Appendix D. The mitigation and management measures proposed are expected to minimise the potential for impacts to air quality. With the implementation of these measures, residual impacts are expected to be minimal.

11 Biodiversity

This chapter describes the existing environment in relation to biodiversity and assesses the potential impacts of construction and operation of the project on biodiversity, and provides mitigation measures to manage the impacts identified. The technical report which informs this chapter is provided as Technical Report 4 - Biodiversity development assessment report. The report was written to address the relevant SEARs which are outlined in Appendix A.

11.1 Assessment approach

11.1.1 Methodology

11.1.1.1 Study area

The 'study area' refers to the area including and surrounding the project site, with the potential to be directly or indirectly affected by the project (eg by noise and vibration, visual or traffic impacts) and that was the subject of the field surveys and desktop assessment conducted for the BDAR.

The study area has been assessed in accordance with the *Biodiversity Assessment Method* (BAM) (OEH, 2017) and OEH *Biodiversity Assessment Method Operational Manual Stage* 1 (OEH, 2018) in which comprehensive vegetation mapping and habitat assessments were completed. Some field survey techniques were employed outside of the study area, including spotlighting and diurnal bird surveys and surveys targeting Powerful Owl, Bush Stone Curlew and Green and Golden Bell Frog, in order to sample better condition habitats to assist with detection of mobile fauna species that could occur in the study area from time to time. Fauna species detected by these techniques outside of the study area would also be likely to occur in similar habitats within the study area.

11.1.1.2 Key tasks

The biodiversity assessment involved:

- a desktop assessment to describe the existing environment and landscape features of the study area and to identify the suite of threatened biota potentially affected by the project, including searches of:
  - OEH *NSW BioNet* (OEH, 2018) data, including NSW Wildlife Atlas database records and Threatened Species Data Collection profiles of threatened species listed under the BC Act
  - OEH Threatened biodiversity profile search online database for threatened ecological communities listed under the BC Act (2018)
  - Department of the Environment and Energy (DEE) Protected Matters Online Search Tool for Matters of National Environmental Significance (MNES) listed under the EPBC Act and predicted to occur in the locality (DEE, 2018)
  - DEE online Species profiles and threats database (SPRAT) (DEE, 2018)
  - NSW BioNet Vegetation Classification (OEH, 2018) to identify Plant Community Types (PCTs) in the study area
  - aerial photographs and satellite imagery of the study area
  - available regional-scale vegetation mapping of the site (NPWS, 2002)
- field survey in accordance with the NSW OEH (2017) *Biodiversity Assessment Method* (BAM) to describe the biodiversity values of the project site and study area and to determine the likelihood of threatened biota and their habitats occurring in the study area or being affected by the project. The following site visits were completed:

    - 12 October 2018 - preliminary investigation of biodiversity values
    - 14-15 November 2018 - BAM assessment survey, including targeted surveys for candidate threatened species
    - 16 January 2019 - supplementary site inspection.
- assessment of potential impacts to flora, fauna and habitats including:
    - matters of national environmental significance (MNES)
    - serious and irreversible impacts
    - prescribed impacts
    - threatened flora, fauna and ecological communities
    - determination of reasonable actions to avoid and minimise impacts to biodiversity values and assessment of residual biodiversity impacts of the project
    - completion of offset calculations using the BAM credit calculator if required to determine the ecosystem and species credits that would be required to offset these impacts.

A detailed description of the assessment methodology is provided in section 2 of Technical Report 4.

11.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with biodiversity. Potential risks were considered according to the impacts that may be generated by the construction and/or operation of the project, pre-mitigation. The purpose of the preliminary environmental risk assessment was to inform the impact assessment. Further information on the preliminary risk assessment, including the approach and methodology is provided in Appendix D.

The assessed risk level for potential biodiversity risks ranged from low to medium. Risks with an assessed level of medium include:

- potential impacts from tree removal along Broomfield Street and Jacquie Osmond Reserve
- potential impacts on a limited amount of identified vegetation communities and/or threatened flora species, in particular in the vicinity of Cabramatta Creek
- potential impacts on habitat due to vegetation removal
- indirect impacts due to increased dust, sedimentation and erosion, noise, light including disturbance to flying fox habitat
- increased potential for pest plants and animals during maintenance from movement of vehicles, machinery and materials in and out of the rail corridor.

These potential risks and impacts were considered as part of the assessment. The assessment also considered matters identified by the SEARs and stakeholders, as described in Chapter 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

11.1.3 How potential impacts have been avoided/minimised

As described in Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has included a focus on avoiding and/or minimising the potential for environmental impacts during all key phases of the process.

The project has adopted the following ‘avoid, minimise and offset’ approach to mitigate impacts to biodiversity values in accordance with the BAM, the *Biodiversity Conservation Act 2016* (BC Act) and associated policy. In line with this approach, potential biodiversity impacts have been avoided or minimised where possible by:

- avoiding impacts on habitat, through the project planning and design process
- minimising impacts on habitat, through the use of a range of environmental management and impact mitigation measures
- identifying offset requirements for any residual impact that could not be avoided or mitigated.

The location of construction compounds, work sites and the construction footprint were finalised following field survey. This enabled the location of these construction sites to be located outside of areas of biodiversity value.

The most sensitive portion of the study area with respect to potential impacts on biodiversity values is the area around Cabramatta Creek. Potential impacts from bridge construction and associated construction access, crane pads and a temporary shared pathway are a potential risk to biodiversity in this location. This portion of the project will be constructed as follows to ensure that impacts to biodiversity values are avoided:

- The shared pathway temporary detour route will be located through non-native vegetation. This will include continuous use of the existing shared path bridge over Cabramatta Creek to avoid impacts associated with construction of a temporary creek crossing.
- The size of the work sites for bridge installation will be limited to ensure that the disturbance footprint is entirely limited to cleared land or non-native vegetation.
- The design of the new bridge over Cabramatta Creek will match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and associated potential for biodiversity impacts. There would be no earthworks or other direct disturbance within the main channel. Existing flow widths will be maintained. The proposed bridge design will minimise the footprint of the project in this area. The proposed bridge will partially interrupt flow during high flow events (ie periods when water is flowing outside and above the main channel) however this interruption to flow would be in line with the existing bridge pylons and would comprise a very minor impact in the context of the existing degree of modification of the catchment.
- Cabramatta Creek is mapped as Key Fish Habitat (DPI, 2007). Mitigation measures will be implemented during construction to mitigate potential impacts to water quality. The inclusion of structures including the bridges, and the drainage design of Broomfield Street is predicted to generally not worsen existing flooding and flood velocity conditions (refer to Chapter 13 (Hydrology, flooding and water quality) for further information).
- There will be some ancillary works undertaken outside of the defined project site. These include signalling works and utility relocation/protection works. These works will be undertaken within the rail corridor and will affect only cleared land or exotic vegetation within this highly modified environment. The final location and design of the ancillary works will consider and avoid impacts to any areas of native vegetation or other biodiversity values, including specific avoidance of the *Acacia pubescens* identified in the rail corridor.

11.2 Existing environment

11.2.1 Terrestrial flora

11.2.1.1 Database search results and mapping

The Protected Matters Online Search Tool (DEE, 2018) results did not identify any World Heritage properties, National Heritage places or Wetlands of International Importance within the project site or study area. As such, these particular MNES are not relevant to this biodiversity assessment report and are not considered further in this report.

A desktop assessment was undertaken to identify threatened flora and fauna species, populations and ecological communities (threatened biota) listed under the BC Act, *Fisheries Management Act 1994* (FM Act), and EPBC Act, that could be expected to occur at the project site, and to obtain the necessary data to perform BAM calculations.

No native vegetation was mapped in the project site. There are three non-native vegetation map units in the project site: planted native species; exotic vegetation; and cleared lands. The channel floor and banks of Cabramatta Creek where it intersects the project site have been mapped as non-native vegetation because this reach of the creek is confined by concrete or gabions and has a gravel or concrete bed.

There is native vegetation outside of the project site, within the study area, comprising Cumberland River-flat Forest and Coastal Freshwater Wetland.

Figure 11.1 shows the vegetation mapping for the study area. Table 11.1 lists the mapped habitat and their associated condition, conservation significance and the area of the habitat located within the project site.

Table 11.1 Vegetation in the study area

Vegetation m	PCT/NSW Veg. Type ID (OEH, 2016c)	Condition	Conservation significance	Area in project site (hectares)
Cumberland River-flat Forest	835 / HN526	Medium	EEC[2] listed under the BC Act (River-flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney basin and South East Corner Bioregion)	0
Coastal Freshwater Wetland	1071 / HN630	Medium	EEC listed under the BC Act (Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions).	0
Planted native species	n/a	Cleared/non-native vegetation		0.5
Exotic vegetation	n/a	Cleared/non-native vegetation		3.0
Cleared land	n/a	Cleared/non-native vegetation		3.4
			Total	**6.9**

Searches of threatened species databases and the output from the BAM calculator were completed to determine any threatened flora species that are known or predicted to occur in the locality. A full list of species identified in the desktop study is provided in Appendix 1 of Technical Report 4.

The results from the desktop study were refined to identify flora species likely to occur in the project site based on the habitat types present, known distribution, and the knowledge and experience of the assessor. These species are listed in Table 11.2. Field surveys were conducted for each of these species in November 2018, which was an optimum survey season.

Table 11.2 Candidate threatened species and survey time – flora

Common name	Scientific name	BC Act	EPBC Act	Surveyed in optimum season
Downy Wattle	Acacia pubescens	V	V	Yes
Netted Bottle Brush	Callistemon linearifolius	V		Yes
Marsdenia viridiflora R. Br. subsp. viridiflora population	Marsdenia viridiflora subsp. viridiflora	EP		Yes
Tall Knotweed	Persicaria elatior	V	V	Yes
Spiked Rice-flower	Pimelea spicata	E	E	Yes
Rufous Pomaderris	Pomaderris brunnea	E	V	Yes
	Pultenaea parviflora	E	V	Yes
Matted Bush-pea	Pultenaea pedunculata	E		Yes

Notes: V – vulnerable species; E – endangered species; EP – endangered population

11.2.1.2 Flora survey results

A total of 94 flora species from 37 families were recorded within the study area, comprising 43 native and 51 exotic species. The Poaceae (grasses, 17 species, seven native) Fabaceae (12 species, 8 native) and Myrtaceae (10 species, all native) were the most diverse families recorded. A full list of flora species recorded within the study area is provided in Appendix B of Technical Report 4. Threatened flora species identified are discuss below.

11.2.1.3 Threatened flora species

The desktop study identified eight threatened flora species predicted to occur in the project site (see in Table 11.2).

During field survey the following flora species were recorded within the study area:

- Downy Wattle (*Acacia pubescens*)
- Narrow-leaved Black Peppermint (*Eucalyptus nicholii*)

Downy Wattle (*Acacia pubescens*) was recorded in the study area; a single stem in slashed open space in the rail corridor just north of Warwick Farm station; and a patch of six individuals in an area of exotic grassland on the outside edge of the rail corridor, south of Warwick Farm station (refer to Figure 11.1). *Acacia pubescens* is listed as a vulnerable species under the BC and EPBC Acts. This species is endemic to the Cumberland Plain (OEH, 2018c) and is possibly a naturally occurring or regenerating population within the rail corridor in the study area. No *Acacia pubescens* were recorded in the project site.

A Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) was recorded in the project site. *Eucalyptus nicholii* is listed as a vulnerable species under the BC and EPBC Acts. This species naturally occurs only in the New England Tablelands from Nundle to north of Tenterfield but is widely planted as an urban street tree (OEH, 2018c). The project site is well outside the species' natural distribution and the individual at the project site and other records in the locality are clearly of planted individuals of uncertain provenance and outside of natural habitat. In this context, the *Eucalyptus nicholii* at the project site has not been treated as a threatened species requiring assessment under the BAM.

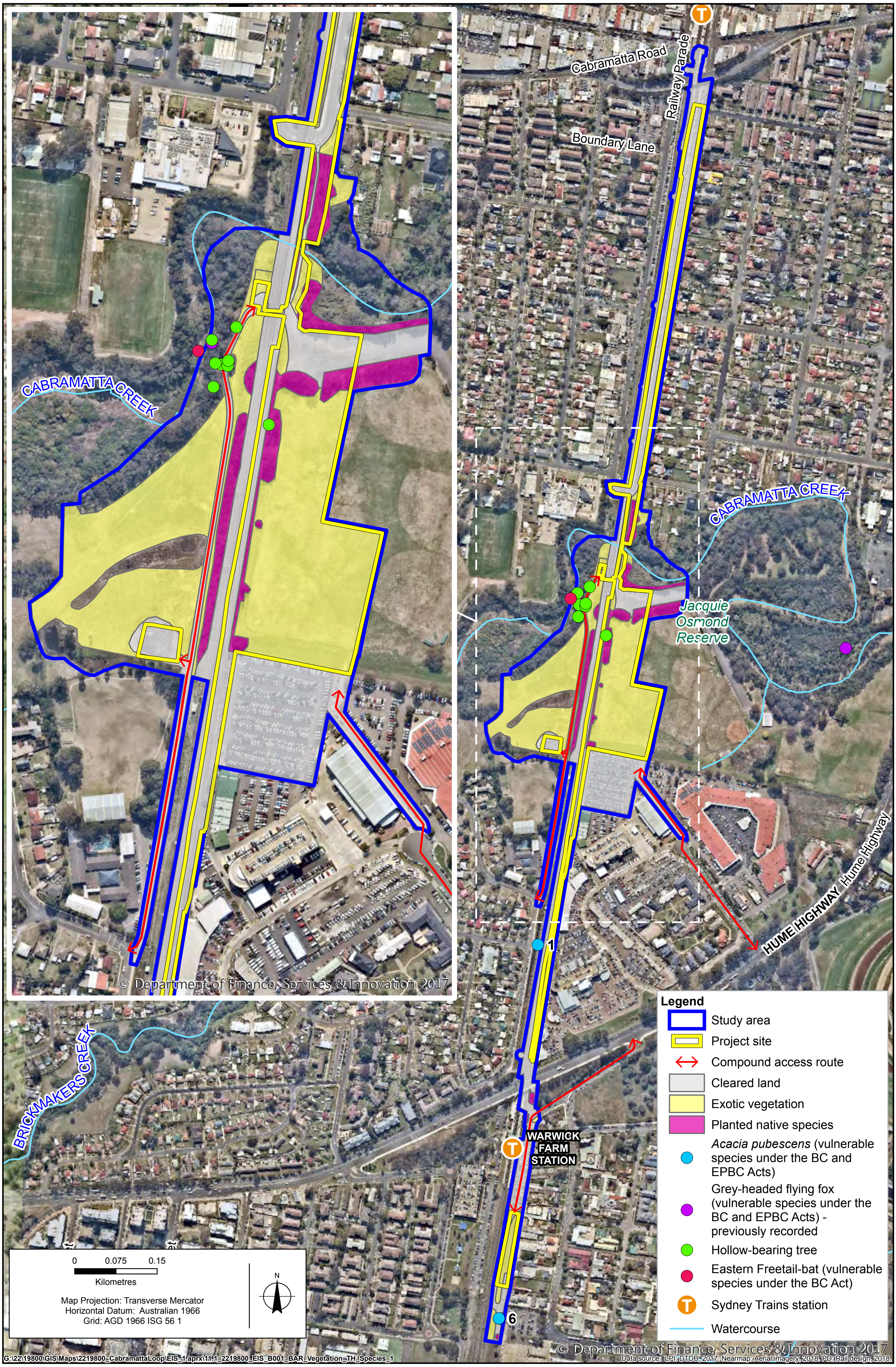

Figure 11.1 Vegetation and threatened species

11.2.1.4 Threatened ecological communities

Cumberland River-flat Forest in the riparian corridor of Cabramatta Creek comprises a local occurrence of 'River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions' (River-Flat Eucalypt Forest) which is listed as an endangered ecological community (EEC) under the BC Act and the subject of a preliminary listing as a critically endangered ecological community (CEEC) under the EPBC Act.

The boundary of the project site has been set to avoid direct impact to this habitat. Therefore there are no Threatened ecological communities listed under the EPBC Act located in the project site.

11.2.1.5 High threat weeds

High threat weeds predicted to occur in the project site from the desktop study and following site surveys are listed in Table 11.3.

Table 11.3 High threat weeds related to the study area

Vegetation	Weeds predicted from the desk study
Cumberland River-flat Forest	High threat weeds were recorded in this vegetation map unit and include Kikuyu Grass, Rhodes Grass, Green Cestrum, Moth Vine, Small-leaved Privet, Bridal Creeper (*Asparagus asparagoides*), Fireweed (*Senecio madagascariensis*), Madeira Vine (*Anredera cordifolia*), Wandering Jew, African Lovegrass and Panic Veldt Grass (*Ehrharta erecta*).
Coastal Freshwater Wetland	High threat weeds recorded in this vegetation map unit and include Alligator Weed.
Planted native species	High threat weeds were recorded in this vegetation map unit and include Kikuyu Grass, Rhodes Grass, Green Cestrum, Moth Vine (*Araujia sericifera*) and Small-leaved Privet.
Exotic vegetation	High threat weeds were recorded in this vegetation map unit, including Alligator Weed (*Alternanthera philoxeroides*), Kikuyu Grass, Rhodes Grass, Balloon Vine (*Cardiospermum grandiflorum*) and Green Cestrum.
Cleared land	N/A

11.2.2 Terrestrial fauna

11.2.2.1 Database search results

A desktop assessment was undertaken to identify threatened fauna species, populations and fauna habitat listed under the BC Act, FM Act, and EPBC Act, that could be expected to occur at the project site and to obtain the necessary data to perform BAM calculations.

Searches of threatened species databases, the Protected Matters Online Search Tool (DEE, 2018) and the output from the BAM calculator were also completed to determine any threatened fauna species that are known or predicted to occur in the locality. A full list of species identified in the desktop study is provided in Appendix A of Technical Report 4.

The results from the desktop study was refined based on the habitat types present, known distribution, and the knowledge and experience of the assessor. The refinement resulted in a list of fauna species likely to occur in the study area listed in Table 11.4.

11.2.2.2 Fauna survey results

A total of 61 species of fauna were recorded across the study area during field surveys, comprising 48 bird species, six mammals, three frogs, two fish and two reptiles. Fauna observed included common and widespread species of suburban environments as well as some small woodland birds that rely on dense vegetation and large patch size. A full list of species identified in the field surveys is provided in Appendix B of Technical Report 4.

During field survey four threatened species were identified. These are listed in Table 11.5.

11.2.2.3 Threatened fauna species and populations

Predicted threatened species identified from the desktop study are listed in Table 11.4. Table 11.4 identifies the protected status of the species, whether the species was surveyed and what type of offset credit type the species relates to.

Table 11.4 Predicted threatened species – fauna species

Common name	Scientific name	BC Status	EPBC Status	Surveyed in optimum season	Credit type
Australasian Bittern	*Botaurus poiciloptilus*	E	E	N/A	ECS
Barking Owl	*Ninox connivens* (foraging)	V		N/A	ECS
Black Bittern	*Ixobrychus flavicollis*	V		N/A	ECS
Black-chinned Honeyeater (eastern subspecies)	*Melithreptus gularis*	V		N/A	ECS
Brown Treecreeper	*Climacteris picumnus victoriae*	V		N/A	ECS
Diamond Firetail	*Stagnopleura guttata*	V		N/A	ECS
Dusky Woodswallow	*Artamus cyanopterus*	V		N/A	ECS
Eastern Bentwing-bat	*Miniopterus schreibersii oceanensis* (foraging)	V		N/A	ECS
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		N/A	ECS
Eastern Freetail-bat	*Mormopterus norfolkensis*	V		N/A	ECS
Eastern Osprey	*Pandion cristatus* (foraging)	V		N/A	ECS
Flame Robin	*Petroica phoenicea*	V		N/A	ECS
Gang-gang Cockatoo	*Callocephalon fimbriatum* (foraging)	V		N/A	ECS
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		N/A	ECS
Grey-headed Flying-fox	*Pteropus poliocephalus* (foraging)	V	V	N/A	ECS
Hooded Robin	*Melanodryas cucullata*	V		N/A	ECS
Koala	*Phascolarctos cinereus* (foraging)	V	V	N/A	ECS
Little Bentwing-bat	*Miniopterus australis* (foraging)	V		N/A	ECS
Little Eagle	*Hieraaetus morphnoides* (foraging)	V		N/A	ECS
Little Lorikeet	*Glossopsitta pusilla*	V		N/A	ECS
Masked Owl	*Tyto novaehollandiae*	V		N/A	ECS
Painted Honeyeater	*Grantiella picta*	V	V	N/A	ECS
Powerful Owl	*Ninox strenua* (foraging)	V		N/A	ECS
Regent Honeyeater	*Anthochaera phrygia* (foraging)	CE	E	N/A	ECS
Scarlet Robin	*Petroica boodang*	V		N/A	ECS

Common name	Scientific name	BC Status	EPBC Status	Surveyed in optimum season	Credit type
Speckled Warbler	*Chthonicola sagittata*	V		N/A	ECS
Spotted-tailed Quoll	*Dasyurus maculatus*	V	E	N/A	ECS
Square-tailed Kite	*Lophoictinia isura* (foraging)	V		N/A	ECS
Swift Parrot	*Lathamus discolor* (foraging)	E	CE	N/A	ECS
Turquoise Parrot	*Neophema pulchella*	V		N/A	ECS
Varied Sittella	*Daphoenositta chrysoptera*	V		N/A	ECS
White-bellied Sea-Eagle	*Haliaeetus leucogaster* (foraging)	V		N/A	ECS
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V		N/A	ECS
Bush Stone-curlew	*Burhinus grallarius*	E	-	Yes	SCS
White-bellied Sea-Eagle	*Haliaeetus leucogaster* (breeding)	V	C	Yes	SCS
Little Eagle	*Hieraaetus morphnoides* (breeding)	V	-	No	SCS
Square-tailed Kite	*Lophoictinia isura* (breeding)	V	-	Yes	SCS
Eastern Osprey	*Pandion cristatus* (breeding)	V	-	Yes	SCS
Green and Golden Bell Frog	*Litoria aurea*	E	V	Yes	SCS
Cumberland Plain Land Snail	*Meridolum corneovirens*	E	-	Yes	SCS
Southern Myotis	*Myotis macropus*	V	-	Yes	SCS
Grey-headed Flying-fox	*Pteropus poliocephalus* (breeding)	V	V	Yes	SCS

Notes: V – vulnerable species; E – endangered species; C - migratory under the China-Australia migratory bird agreement; CE – critically endangered species. ECS - ecosystem-credit species; SCS - Species credit species

The November field survey was just outside of the nominated September-October field survey period for Little Eagle. As the project site contained very few potential nest trees it was considered that if the project site contained occupied Little Eagle breeding habitat then the preceding season's nest (or candidate nests of other similar sized birds such as raptors or ravens) would be detected in the field surveys.

Three migratory species were predicted by the Protected Matters Online Search Tool (DEE, 2018) to have the potential to occur within the study area on an occasional or transient basis. These are the Satin Flycatcher (*Myiagra cyanoleuca*), Rufous Fantail (*Rhipidura rufifrons*) and Yellow Wagtail (*Motacilla flava*).

During field survey four threatened fauna species were recorded on site. These species and their protected status are listed in Table 11.5.

Table 11.5 Threatened fauna species recorded in the study area

Common name	Scientific name	Observation type	BC Act status	EPBC Act status	Credit type
Grey-headed Flying-fox	*Pteropus poliocephalus*	Seen	V	V	ECS (foraging) / SCS (roosting)
Eastern Freetail-bat	*Mormopterus norfolkensis*	Probable Anabat recording	V	Not listed	ECS
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	Species group Anabat recording	V	Not listed	ECS
Southern Myotis	*Myotis macropus*	Species group Anabat recording	V	Not listed	SCS

Notes: V – vulnerable species; ECS - ecosystem-credit species; SCS - Species credit species

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act. The Grey-headed Flying-fox is a large, nomadic fruit and blossom-feeding bat. The Cabramatta Creek Grey-headed Flying-fox roost camp is located around 500 metres to the east of the rail corridor and around 350 metres to the northeast of the outer edge of the construction site boundary, with at least 250 metres of dense vegetation between the camp and the project site (refer to Figure 11.1). The camp is a roosting habitat which is critical to the survival of the species as identified in the recovery plan for the species (DECCW, 2009). A full profile of the camp is provided in section 6.7 of Technical Report 4. This colony was identified as requiring specific consideration in the project SEARs with a particular focus on potential effects of noise and lighting.

The Grey-headed Flying-fox was recorded foraging within the study area and was regularly observed flying above it, including several thousand individuals seen flying from east to west of the project site after dusk each evening. The project site contains some foraging resources for this species associated with mature fruit or blossom-bearing trees in mapped areas of planted native species and exotic vegetation.

It is not always possible to confidently identify microbat species based on Anabat call recordings because of short or poorer quality recordings or similarities between species. The Eastern Freetail-bat (*Mormopterus norfolkensis*), Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) and Southern Myotis (*Myotis macropus*) may potentially be present in the study area based on identification of recorded calls to 'probable' or 'species group' level. The study area contains aerial foraging habitat and potential roost sites for these and other microbat species in hollow bearing trees, bridges and culverts.

11.2.2.4 Terrestrial fauna habitats

Vegetation within the project site is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. As such, potential habitat in the study area is not 'important habitat' for migratory species, as defined in DotE (2013).

Fauna habitat value within the project site is very low, reflecting the highly modified environment in the rail corridor and adjoining land. Habitat value is higher across the study area, despite its suburban context and the presence of human disturbance and edge effects. There are valuable fauna habitat resources associated with Jacquie Osmond Reserve and the riparian corridor of Cabramatta Creek, including permanent water, wetland and aquatic environments and a relatively large patch of mature, productive native vegetation. The project site is connected to a larger patch of habitat in the riparian corridor of Cabramatta Creek.

The study area contains potential habitat for a range of native animals, including threatened fauna and migratory species known or predicted to occur in the locality. In addition to the habitat types listed in Table 11.1, the following provide habitat resources for a range of native fauna, including:

- scarce woody debris and leaf litter
- mature canopy trees that provide nectar, fruits, leaves and foraging, roosting or nesting substrates
- habitat trees with hollows and/or decorticating bark
- occasional small patches of dense understorey shrubs
- a range of fruiting and flowering small trees and shrubs and grass seeds.

One hollow-bearing tree is located in the project site (refer to Figure 11.1). This is within the disturbance footprint for the proposed retaining wall located between the new rail track and sports fields in Jacquie Osmond Reserve.

11.2.3 Groundwater dependent ecosystems

Native vegetation within the study area is not mapped as vegetation with a potential for being reliant on the subsurface presence of groundwater. It is also unlikely to be an in-flow dependant ecosystem, i.e. an ecosystem that is "*accessing a water source in addition to rainfall, such as water stored in the unsaturated zone, surface water or groundwater*" (Australian Government, 2012). Based on the field observations, experience and judgement of the assessor, the vegetation in the study area is likely to be reliant on rainfall and on surface water associated with Cabramatta Creek and areas of surface water accumulation on its floodplain. Groundwater dependent ecosystems are not considered further in this assessment.

11.2.4 Aquatic ecology

Cabramatta Creek is located within the project site and study area. No endangered aquatic communities, aquatic fauna or marine vegetation listed under the FM Act or EPBC Act occur in the project site.

The channel floor and banks of Cabramatta Creek where it intersects the project site have been mapped as non-native vegetation because this reach of the creek is confined by concrete or gabions and has a gravel or concrete bed.

11.3 Assessment of construction impacts

11.3.1 Terrestrial flora

11.3.1.1 Removal of vegetation

The project will result in direct impacts on 3.5 hectares of non-native vegetation as summarised in Table 11.6 and shown on Figure 11.1. This vegetation has low biodiversity value given its context and habitat value for threatened species. The impacts on this vegetation are associated with clearing for the new rail track and associated infrastructure and for construction compounds. Residual direct impacts would be restricted to the project site. Construction access would be via existing formed roads.

Table 11.6 Extent of residual impacts in the project site

Vegetation type	Condition	Area within project site (ha)
Planted native species	Non-native vegetation	0.5
Exotic vegetation	Non-native vegetation	3.0
Total area of vegetation		**3.5**
Cleared land	Cleared land	3.4
Total direct impact		**6.9**

The clearing of non- native vegetation would involve the removal of some individual native plants, including mature planted street trees and trees in parkland. Mature trees have particular value within plant populations because they take longer to replace and are sources of pollen and seed.

An arboriculture assessment (see Appendix C of Technical Report 10 – Landscape and visual impact assessment) has assessed the number and quality of trees that would require removal as a result of the project. The project would result in the removal of 43 planted trees which are indigenous to the Fairfield and Liverpool LGAs and 77 exotic specimens. The majority of these are along Broomfield Street.

Indirect impacts on trees to be retained may include loss of or damage to roots and branches of trees located near the project site.

The project would remove a small proportion of individual plant species and associated habitat resources compared to the extent of both species and resources in the surrounding area.

11.3.1.2 Threatened flora species

The study area contains some land with biodiversity value, including around seven stems of *Acacia pubescens*. *Acacia pubescens* is listed as a vulnerable species under the BC and EPBC Acts. The project has been designed to avoid direct or indirect impacts on any *Acacia pubescens*. No *Acacia pubescens* would be removed or otherwise affected by the project.

The design and placement of any associated ancillary works such as utilities or signalling outside of the project site would purposefully avoid impacts to these *Acacia pubescens* or other biodiversity values.

A Narrow-leaved Black Peppermint (*Eucalyptus nicholii*) was recorded in the project site. *Eucalyptus nicholii* is listed as a vulnerable species under the BC and EPBC Acts. The project site is well outside the species' natural distribution and the individual at the project site and other records in the locality are clearly of planted individuals of uncertain provenance. In this context, the *Eucalyptus nicholii* at the project site has not been treated as a threatened species requiring assessment under the BAM.

Impacts to threatened ecological communities

There is an occurrence of the EEC River-flat Eucalypt Forest in the study area. The project site has been purposefully designed to avoid any vegetation removal in the area of occupancy of this ecological community and environmental management measures (refer to section 11.8) are likely to mitigate against any substantial indirect impacts to this community.

11.3.2 Terrestrial fauna

11.3.2.1 Habitat impacts

Construction of the project would remove a very small area of fauna habitat, as most of the project site is already cleared land. The vegetation that would be removed or modified would have little value for native fauna species given its structure, condition and proximity to the heavy rail corridor.

There is one hollow-bearing tree in the project site (refer to Figure 11.1). This hollow-bearing tree is within the disturbance footprint for the proposed retaining wall between the new rail track and sports fields in Jacquie Osmond Reserve. This is an essential element of the project design at this location and so there was no potential to avoid impact to this habitat resource. Given its context and surrounding land uses this hollow-bearing tree is highly unlikely to be occupied by a threatened species of owl, parrot or microbat. Individuals of these threatened species are more likely to roost or nest in larger patches of vegetation away from human disturbance than in an isolated tree adjacent to a heavy rail corridor.

Other fauna habitat resources that would be removed include foraging and shelter resources for widespread and generalist native fauna typical of urban environments. It is highly unlikely that any threatened species or any fauna populations would rely on the habitat resources within the project site for their survival. Removal of fauna habitat resources would include:

- up to 0.5 hectares of planted native species which would provide foraging habitat for the threatened Grey-headed Flying-fox, Eastern False Pipistrelle, Southern Myotis and other threatened fauna species with known or potential habitat in the study area (comprised entirely of planted native species)
- up to 3.0 hectares of exotic vegetation, including both grassland and forest and scrub structural forms, which provides nesting and foraging habitat for small birds, as well as shelter and foraging habitat for reptiles and frogs
- an additional 3.4 hectares of shelter substrate for small ground dwelling fauna such as reptiles and frogs and foraging substrate for generalist birds of open country associated with woody debris, railway ballast etc in cleared land.

11.3.2.2 Impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act. A description of the camp is provided in section 11.2.2.

Given the distance of the Cabramatta Creek Grey-headed Flying-fox roost camp from the project site (350 metres to the northeast of the outer edge of the construction site boundary with at least 250 metres of dense vegetation between the camp and the project site), the project would not result in any direct impacts to the roost camp. Instead, consideration has been given to the potential for indirect impacts, namely impacts associated with construction noise and lighting.

A noise and vibration assessment of construction activities associated with the project has been undertaken (see Technical Report 2 – Noise and vibration impact assessment). The likely maximum construction noise levels of up to 55 to 60 dBA at the roost camp are likely to be equivalent or less than current ambient noise levels which would include traffic noise levels of 60-65 dBA from the Hume Highway, located about 100 metres east of the camp. Individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp appear to be habituated to human activity and to elevated noise levels, including traffic noise from the Hume Highway. Construction noise impacts of the project would not exceed current noise levels at the roost camp and are therefore unlikely to alter the temporal activity patterns of flying-foxes on a diurnal or seasonal basis and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Temporary lighting would be used during night time work for brief periods during construction of the project. The roost camp is located around 350 metres to the northeast of the outer edge of the construction site boundary separated from the project site by at least 250 metres of dense vegetation in the Jacquie Osmond Reserve. Light from the project site would not reach the roost camp. Further, individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp would be habituated to artificial light, including from sources associated with the Hume Highway, a hotel adjoining the roost camp and sports field lighting in the Jacquie Osmond Reserve. Construction light impacts of the project would not exceed current levels at the roost camp and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Given the distance of the Cabramatta Creek Grey-headed Flying-fox roost camp from the project site and the minor magnitude of noise and lighting impacts arising from the project as described above, no particular measures to further minimise impacts to the roost camp are required.

11.3.2.3 Direct impacts to fauna

The project site provides limited habitat resources for native fauna species and these resources are more likely to be utilised by common and widespread species of urban environments.

Some individual possums or native birds may nest or shelter in vegetation within the rail corridor. Groundcover vegetation, leaf litter and woody debris would provide shelter and foraging substrate for reptiles, frogs and invertebrates. Construction may result in the injury or mortality of some individuals of these less mobile fauna species and other small terrestrial fauna that may be occupying habitat within the project site during clearing or construction activities. The potential injury or mortality of individuals within a maximum of 6.9 hectares of poor quality habitat is highly unlikely to affect an ecologically significant proportion of any local populations.

The project would not create any significant or new barriers to the movement of native biota.

Impacts resulting from the project would increase gaps in habitat within the landscape by removing planted native species and exotic vegetation along the edge of a large patch of intact native vegetation in the Cabramatta Creek riparian corridor. This would comprise a very minor impact on the degree of habitat fragmentation in the local area given the limited extent and quality of habitat to be removed and because the project site is parallel to an existing significant barrier to fauna movement associated with the rail corridor and associated fencing. The design of the new bridge over Cabramatta Creek (adjacent to the existing bridge) would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge.

The remainder of the project site adjoins cleared and developed land that would not have any value as a fauna movement corridor.

The study area is not considered important habitat for any migratory species according to the significant impact criteria for migratory species (DotE, 2013). The project would result in very minor residual impacts on native biota and their habitats in general, and would not substantially fragment or isolate any areas of habitat Based on the above considerations the project is unlikely to impose ‘a significant effect’ on any of the listed migratory fauna species that may occur at the study area.

Given the scale and context of the project there are unlikely to be any substantial impacts on threatened species and their habitats beyond those associated with the removal of non-vegetation and habitat resources in the project site. There is no evidence that the non-native vegetation and other habitat resources in the project site would have any particular value to any threatened biota. The project is unlikely to result in any other significant direct or indirect impacts to threatened biota. Notably, there would be minor, if any impacts, on aquatic habitat downstream of the project site and there is no evidence that aquatic habitat in the vicinity of the project site would be occupied by any threatened biota

11.3.2.4 Indirect impacts to fauna

The following indirect impacts may also occur as a result of the project:

- edge effects
- introduction and spread of weeds, pests and pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid fungus (*Batrachochytrium dendrobatidis*)

- noise and light impacts on fauna.

There is a moderate risk of construction activities increasing the degree of weed infestation in adjoining vegetation and a negligible risk of any new weeds being introduced. Management measures including the development of a weed management sub-plan as part of the project CEMP will be implemented to mitigate potential impacts.

The potential for significant or new impacts associated with pathogens is relatively low, given the suburban context and extent of human visitation across the project site.

The generation of construction noise is unlikely to reduce the value of habitat in the study area or otherwise significantly affect any fauna species that occur in the study area.

Construction activities would not substantially increase the extent or intensity of artificial lighting above current background artificial light levels associated with the rail corridor, pedestrian and bike track across Cabramatta Creek, street lighting and sports fields in Jacquie Osmond Reserve. Artificial lighting is unlikely to reduce the value of habitat in the study area or otherwise significantly affect any fauna species that occur in the study area.

11.3.3 Aquatic ecology

The potential introduction of pollutants such as vehicle fuel or mobilised sediments from the project into the surrounding environment, if uncontrolled, could potentially impact on water quality further downstream. There is minor potential for water quality impacts on Cabramatta Creek within the project site or reaches downstream. Potential water quality impacts will be managed through the implementation of mitigation measures, including the provision of sedimentation basins, silt fences and other structures to intercept runoff. Mitigation measures to minimise water quality impacts are provided in Chapter 13 (Hydrology, flooding and water quality).

No endangered aquatic communities, aquatic fauna or marine vegetation listed under the FM Act or EPBC Act occur in the project site and no significant impacts on riparian vegetation or habitats downstream of the project site are anticipated as a result of the project. There would be minor, if any impacts on Key Fish Habitat in Cabramatta Creek as a result of the project.

The project would not result in any impacts on biodiversity values not covered by the BAM (i.e. marine mammals; wandering sea birds; Lord Howe Island biodiversity; and category 1 – exempt land).

11.3.4 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E.

The project would make a negligible impact to the cumulative impacts on biodiversity values arising from other developments in Western Sydney. The project would not involve the removal of any native vegetation or important habitat resources that would require the provision of biodiversity offsets. The project is unlikely to increase the extent, duration or magnitude of any of the cumulative impacts on biodiversity values occurring in the study area and region to the extent that would result in a significant negative effect on biodiversity values.

Other indirect impacts such as noise are predicted to be transitory and confined to an area near the boundary of the project, the cumulative impacts would be minimal unless additional sources (to this project) of dust, emissions or noise was generated close to receptors. There are no other known construction projects proposed in the vicinity of the project site that would result in an increase of these impacts.

11.4 Assessment of operation impacts

Impacts on biodiversity values would be largely restricted to the construction phase of the project. Some potential impacts that would occur as a result of the operation of the project include:

- generation of additional light and noise
- erosion and sedimentation as a result of runoff from hard stand areas
- introduction of weed propagules by vehicles or maintenance staff
- overshadowing of vegetation by noise walls
- fauna mortality as a result of collision with trains.

The project site is located within or immediately adjoining the existing rail corridor which is dominated by infrastructure and highly modified environments. Potential operational impacts of the project are already occurring in the project site and affecting the surrounding study area. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

11.4.1 Terrestrial flora

Each of the potential operational impacts listed above would already be occurring in the project site and affecting the surrounding study area. Vegetation adjoining the project site is already subject to weed infestation and other edge effects.

11.4.2 Aquatic disturbance and impacts on fish habitat

The design of the new bridge over Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge. Construction work methods have been prescribed that would ensure that there are no direct impacts to the creek bed or to aquatic habitat. There would be minor, if any, impacts on Key Fish Habitat in Cabramatta Creek as a result of the project.

11.4.3 Fauna

Fauna that occupy habitats within the project site and adjacent areas are likely to be accustomed to existing noise originating from trains, road traffic and the urban environment. Additional train movements are unlikely to significantly increase the risk of fauna mortality from collisions above current levels, given the highly modified habitats present.

In this context, the project is likely to comprise only a minor increase in any of these potential negative effects. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

11.4.3.1 Impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp

The Grey-headed Flying-fox is listed as a vulnerable species under the EPBC Act and the BC Act as described in section 11.2.2. The Cabramatta Creek Grey-headed Flying-fox roost camp is located around 500 metres to the east of the existing rail corridor and the operational project site. As per the construction impact assessment, there would be no direct impacts to the roost camp due to operation, therefore potential indirect impacts have been considered.

A noise and vibration assessment of operational activities associated with the project has been undertaken (see Technical Report 2 – Noise and vibration impact assessment). There is predicted to be a very minor increase in noise impacts arising from operation of the passing loop. The likely operational noise levels of 54 dBA at the roost camp are only marginally above the modelled ‘no build’ noise levels of 53 dBA. This is considered to be less than current ambient noise levels which include traffic noise from the Hume Highway. The likely maximum operation noise levels would be 74 dBA under the ‘build’ and ‘no build’ scenarios. Values of greater than 74 dBA associated with near-continuous daytime traffic noise have been recorded in monitoring of the Balgowlah camp beside the Burnt Bridge Creek deviation (DPE, 2018). This shows that Grey-headed Flying-foxes will tolerate loud and prolonged noise in the vicinity of roost camps once they have become habituated to these noise levels. Individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp appear to be habituated to human activity and to elevated noise levels, including traffic noise from the Hume Highway. Operational noise impacts of the project would not exceed current noise levels at the roost camp and are therefore unlikely to alter the temporal activity patterns of flying-foxes on a diurnal or seasonal basis and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

Trains and signals would generate light during the operational life of the project. The roost camp is separated from the rail corridor by at least 250 metres of dense vegetation in the Jacquie Osmond Reserve. Light from the rail corridor would not reach the roost camp. Further, individuals within the Cabramatta Creek Grey-headed Flying-fox roost camp would be habituated to artificial light, including from sources associated with the Hume Highway, a hotel adjoining the roost camp and sports field lighting in the Jacquie Osmond Reserve. Operational light impacts of the project would not exceed current levels at the roost camp and would not threaten the continued occupancy of the roost camp by the Grey-headed Flying-fox.

11.4.4 Cumulative impacts

Operational impacts of the project would comprise a minor addition to the existing activities in the rail corridor and extent of development in the locality. The project is unlikely to increase the extent, duration or magnitude of any of the cumulative impacts on biodiversity values occurring in the study area and region to the extent that would result in a significant negative effect on biodiversity values.

Cumulative impacts and risks connected to the project would occur in the context of human induced climate change, which is recognised as a serious threat to biodiversity values. Human induced climate change is recognised as a threat to the EEC River-Flat Eucalypt Forest, particularly if change leads to altered flood regimes (OEH, 2018c). Climate change is recognised as a threat, in the recovery plan for the Grey-headed Flying-fox due to the potential for changes in the distribution or reproduction of some Eucalyptus food tree species or the increased occurrence of extremely high temperatures (DECCW, 2009). Overall climate change is likely to have a relatively minor effect on ecosystem resilience and potential cumulative impacts on biodiversity values at the study area when compared to more immediate threats such as removal of vegetation and habitat.

11.5 Key threatening processes relevant to the project

A key threatening process is as an action, activity or project that:

- adversely affects two or more threatened species, populations or ecological communities
- could cause species, populations or ecological communities that are not currently threatened to become threatened.

Key threatening processes listed under the BC Act, FM Act and/or EPBC Act, relevant to this project are listed in Table 11.7.

Table 11.7 Key threatening process

Key threatening process	Status	Comment	Project phase
Loss of hollow-bearing trees	BC Act	The project would remove one hollow bearing tree. As a single tree, in an area of planted native species surrounded by exotic grassland and immediately adjacent to the existing rail corridor this would comprise a very minor increase in the operation of this KTP.	Construction
Removal of dead wood and dead trees	BC Act	The project site contains very little fallen timber. The project may result in the removal or disturbance of small amounts of woody debris, during construction of the project. The implementation of habitat management procedures is recommended to limit impacts on fauna and their habitats and to at least partially maintain the value of these resources by reinstating woody debris in revegetation areas	Construction
Human-caused climate change	BC Act EPBC Act	Combustion of fuels associated with construction and operation of the project would contribute to anthropogenic emissions of greenhouse gases. The project does not pass through any areas mapped as coastal corridors for climate change that provide for the latitudinal movement of species. The increase in greenhouse gases as a result of the project may impact climatic habitat elsewhere in NSW over the long-term. This contribution is likely to be minor in the context of regional and global anthropogenic emissions of greenhouse gases.	Construction and operation
Clearing of native vegetation	BC Act EPBC Act	The project does not include the clearing of any native vegetation. Concept design of the project has ensured that there is no native vegetation within the project site	N/A
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	BC Act	The design of the new bridge over Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek, and would maintain habitat connectivity under the bridge. Construction work methods have been prescribed that would ensure that there are no direct impacts to the creek bed or to aquatic habitat.	N/A
The degradation of native riparian vegetation along NSW water courses	BC Act	The project does not include the clearing of any native vegetation, including riparian vegetation.	N/A

11.6 Impacts on biodiversity related matters of national environmental significance

The Protected Matters Online Search Tool (DEE, 2018) results did not identify any World Heritage properties, National Heritage places or Wetlands of International Importance within the locality. As such, these particular Matters of National Environmental Significance are not relevant to this biodiversity assessment report and are not considered further in this report.

Three migratory species were predicted by the Protected Matters Online Search Tool (DEE, 2018) and have the potential to occur within the study area on an occasional or transient basis: the Satin Flycatcher (*Myiagra* *cyanoleuca*), Rufous Fantail (*Rhipidura rufifrons*) and Yellow Wagtail (*Motacilla flava*). Habitat resources for these migratory species are mainly associated with Cumberland River-flat Forest adjacent to Cabramatta Creek. They are unlikely to rely on any habitat resources associated with the planted native species and exotic vegetation in the project site.

There is no potential habitat for migratory shorebird species at the study area.

Vegetation within the project site is highly modified, fragmented and would have only limited value for migratory species listed under the EPBC Act. Habitat in the study area is not likely to support an ecologically significant proportion of the population of any of these species, be of critical importance to the species at particular life-cycle stages, is not located at the limit of any of the species' range, and/or located within an area where the species is declining. As such, potential habitat in the study area is not 'important habitat' for any of these species, as defined in DotE (2013).

11.7 Assessment of serious and irreversible impacts

Under the BC Act, a determination of whether an impact is serious and irreversible must be made in accordance with the principles set up in Section 6.7 of the Biodiversity Conservation Regulation 2017.

The principles are aimed at capturing impacts which are likely to contribute significantly to the risk of extinction of a threatened species or ecological community in New South Wales. A set of criteria have been developed and are included in the OEH Guidelines to assist a decision-maker to determine serious and irreversible impacts (OEH, 2017). Threatened biota that meet the criteria under one or more of the above principles have been identified as serious and irreversible impact entities.

There are no serious and irreversible impact entities at the project site or likely to be affected by the project.

11.8 Management of impacts

11.8.1 Approach

11.8.1.1 Approach to mitigation and management

ARTC is committed to minimising the environmental impact of the project and is investigating opportunities to reduce actual impact areas where practicable. The area that would be directly impacted by construction activities would depend on factors such as presence of significant vegetation, constructability, construction management and safety considerations, land form, slopes and anticipated sub-soil structures. Direct impacts would be reduced as far as practicable. The exact amount of clearance (within the project site) would be refined during detailed design.

The project has adopted the following 'avoid, minimise and offset' approach to mitigate impacts to biodiversity values in accordance with the BAM, the BC Act and associated policy. In line with this approach, the project has where possible:

- avoided impacts on habitat, through the project planning and design process
- minimised impacts on habitat, through the use of a range of environmental management and impact mitigation measures
- considered offset requirements.

ARTC has, where possible, altered the project to avoid and minimise ecological impacts in the project planning stage (refer to section 11.1.3), and a range of impact mitigation strategies have been included in the project to mitigate the impact on ecological values. Further refinement will be made during detailed design, where possible, to minimise ecological impacts.

11.8.1.2 Offset requirements

Under the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPaC, 2012) (the EPBC Act Environmental Offsets Policy) biodiversity offsets are required to compensate for significant residual impacts on Matters of National Environmental Significance.

There is no native vegetation in the project site. Construction of the project would remove 3.5 hectares of non-native vegetation (comprising 3.0 hectares of exotic vegetation and 0.5 hectares of planted native species) within an overall disturbance footprint of 6.9 hectares. This vegetation has low biodiversity value given its context and habitat value for threatened species. Much of the project site (3.4 hectares) is cleared land, comprising existing rail infrastructure, concrete paths, bitumen roads and other infrastructure. Impacts on non-native vegetation and cleared land do not require the provision of biodiversity offsets according to the BAM. No biodiversity offsets for impacts on MNES are therefore required in accordance with the EPBC Act Environmental Offsets Policy.

The project would not remove or otherwise impact any native vegetation or threatened species and as such would not result in any impacts requiring offsets. Impacts on non-native vegetation do not require the provision of biodiversity offsets according to the BAM. As such, no BAM credit calculations need to be completed and submitted to accompany this assessment.

The project site is located within or immediately adjoining the existing rail corridor which is dominated by infrastructure and highly modified environments. Potential operational impacts of the project are already occurring in the project site and affecting the surrounding study area. The project is unlikely to increase the extent, duration or magnitude of any of these impacts to the extent that would result in a significant negative effect on biodiversity values.

The design and placement of any associated ancillary works such as utilities or signalling outside of the project site would purposefully avoid impacts to *Acacia pubescens* or other biodiversity values. These works would be undertaken within the rail corridor and would affect only cleared land or exotic vegetation within this highly modified environment. The construction and environmental control measures proposed to mitigate impacts are considered sufficient to manage any potential indirect impacts of ancillary works.

11.8.1.3 Expected effectiveness

ARTC have experience in managing potential biodiversity impacts as a result of developments of similar scale and scope to this project.

The project was design to avoid impacts arising in the first instance and has been very effective in preventing the clearance of native vegetation.

The location of construction compounds, work sites and the construction footprint were finalised following field survey. This enabled the location of these construction activities to be located outside of areas of biodiversity value. These are detailed further in section 11.1.3.

A CEMP will be prepared prior to construction. The plan will be prepared to address the requirements of the project approvals, the environmental management measures outlined in this EIS (refer to Table 11.8) and all applicable legislation.

As such, the measures to avoid impacts during development of the reference design and outlined in the CEMP are considered to be proven effective in managing potential impacts to biodiversity.

11.8.2 List of mitigation measures

The mitigation measures that would be implemented to address potential biodiversity impacts are listed in Table 11.8.

Table 11.8 Mitigation measures

Stage	Impact	Measure
Construction	Vegetation clearance	Impacts to *Acacia pubescens* will be avoided. The locations of Acacia pubescens will be marked on plans, outlined in the CEMP, fenced on site, and avoided. Signage will be placed on relevant fencing to inform of prohibited activities in that area as part of the works.
	Vegetation clearance	Disturbance of vegetation will be limited to the minimum necessary to construct works. Micro-siting of infrastructure will be undertaken during detailed design where practicable to minimise or avoid impacts on planted native species.
	Vegetation clearance	Where the project site adjoins native vegetation, the limits of clearing will be marked and temporary fencing or flagging tape installed around the vegetated area prior to the commencement of construction activities to avoid unnecessary vegetation and habitat removal or damage.
	Vegetation clearance	Equipment storage and stockpiling of resources will be restricted to designated areas within compound sites in cleared land.
	Vegetation clearance	The design and placement of any associated ancillary works such as utilities or signalling outside of the project site will avoid impacts to *Acacia pubescens* or other biodiversity values. These works will affect only cleared land or exotic vegetation.
	Revegetation	Following removal of the temporary shared path between Sussex Street and Cabramatta Creek, revegetation will be undertaken to stabilise the site. Opportunities to work with local groups such as the Fairfield Creeks and Wetlands Group will be explored where possible. Revegetation will aim to be consistent with the pre-existing vegetation and surrounding vegetation.
	Weeds	Weed management actions will be included in the CEMP to manage weeds in accordance with the *NSW Weed Control Handbook* (DPI, 2018). This will include the management and disposal of the weeds that were recorded within the project site including priority weeds in accordance with the biosecurity duties under the *Biosecurity Act 2015*.
	Weeds	Vehicles and other equipment to be used within the rail corridor will be cleaned to minimise seeds and plant material entering the project site to prevent the introduction of further exotic plant species or disease. This will include the use of vehicle wash bays or portable vehicle wash equipment such as high pressure wash units, shovels, crow bars or stiff brushes.
	Fauna habitat	The CEMP will include the locations of potential roost sites as identified in this report (eg. hollow-bearing trees, disused buildings, bridges and culverts). The CEMP will include measures to manage potential impacts to roost sites such as: • any potential roost sites that will be removed or modified will be checked for roosting bats immediately prior to work • culverts are to remain open on at least one side at all times to allow any roosting bats to fly in or out • habitat to be identified for the release of mibrobats or any fauna encountered during clearing surveys

Stage	Impact	Measure
		• habitat trees will be felled using equipment that allows the trees to be lowered wo the ground with minimal impact (eg claw extension) • animals that emerge from felled trees will be captured, inspected for injury, then relocated to pre-determined habitat identified for fauna release. Where the presence or potential presence of roosting bats is noted then management measures for managing bats will be implemented in accordance with the CEMP.
	Fauna habitat	An unexpected finds procedure will be developed specifying measures for the management of any threatened biota or habitat resources identified during construction. The unexpected finds procedure will include the requirement for work to stop immediately if any threatened fauna is encountered and the Construction Environmental Manager to be notified. Work will recommence only once relevant approvals have been obtained as required. The species will be included in subsequent toolbox talks.
	Fauna habitat	Protocols to prevent introduction or spread of chytrid fungus will be implemented following *OEH Hygiene Protocol for the Control of Disease in Frogs* (DECC, 2008b).
	Fauna habitat	A suitably qualified person will be present during the removal of potential fauna habitat (i.e. the hollow-bearing tree in Jacqui Osmond Reserve and areas of planted native species) to avoid impacts on resident fauna and to salvage habitat resources as far as is practicable. Clearing surveys will include: • inspections of vegetation for resident fauna and/or nests or other signs of fauna occupancy • capture and relocation or captive rearing of less mobile fauna (such as nestling birds) by a trained fauna handler and with assistance from Wildlife Information Rescue and Education Service (WIRES) as required • inspection and identification/marking of hollow-bearing trees or other habitat resources adjacent to the project site to help ensure against accidental impacts • salvage of habitat features such as mature tree trunks and woody debris within the project site and placement within revegetation areas as far as is practicable (e.g. if vegetated areas are not separated by fences).
Operation	Weeds	Maintenance activities within the rail corridor and weed management during operation will be undertaken in accordance with ARTC's standard operating procedures and the relevant requirements of the *Biosecurity Act 2015*.

11.8.3 Consideration of the interaction between measures

In addition to the measures for biodiversity described above, there are interactions between the mitigation measures for noise and vibration (Chapter 9), soils and contamination (Chapter 12), and hydrology and water quality (Chapter 13).

All mitigation measures for the project will be consolidated and described in the CEMP. The plan would identify measures that are common between different aspects. Common impacts and common mitigation measures will be consolidated to ensure consistency and implementation.

11.8.4 Managing residual impacts

A residual risk analysis was undertaken following the impact assessment summarised in this chapter. The results of the residual risk analysis are provided in Appendix D and are summarised below.

Despite measures taken to avoid and mitigate impacts, the project would result in some unavoidable residual adverse impacts imposed upon some elements of the natural environment, including removal of a single hollow-bearing tree, other native plants and habitat resources, and imposition of edge effects on adjoining areas of native vegetation. These residual impacts are small in extent and magnitude and would comprise a minor reduction in biodiversity values in the study area.

The project would remove a very small proportion of available habitat resources for local populations of native fauna. Impacts would include the removal of 0.5 hectares foraging habitat for mobile threatened fauna species, including the Grey-headed Flying-fox, birds and microbats. The site is unlikely to contain any important breeding, roosting or nesting habitat for native fauna. No wetlands, permanent aquatic habitat, rock outcrops, woody debris or any other important habitat resources would be removed.

The impact and offset assessment has been completed in accordance with the BAM and concluded that the project would only result in ‘impacts not requiring offset’, comprising clearing of non-native vegetation and construction within previously cleared land. A supplementary assessment of potential direct or indirect impacts on the Cabramatta Creek Grey-headed Flying-fox roost camp has concluded that the project would have a minor effect on this roost camp.

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12 Soils and contamination

This chapter describes the existing environment in relation to soils, topography, geology and contamination, and assesses the potential impacts of construction and operation of the project on these factors. Mitigation measures are provided to manage the impacts identified. The technical report which informs this chapter is provided as Technical Report 6 - Soils and contamination impact assessment. The report was written to address the relevant SEARs which are outlined in Appendix A.

12.1 Assessment approach

12.1.1 Methodology

12.1.1.1 Study area

The study area for the desktop review component of the assessment encompassed a one kilometre radius around the project site, while the study area for the field investigation encompassed the project site.

12.1.1.2 Key tasks

The assessment involved the following:

- a review of Environmental Risk and Planning Reports prepared for the project site by Lotsearch Pty Ltd (provided in Appendix A of Technical Report 6)
- a review of previous environmental assessments undertaken within the project site (Parsons and Brinckerhoff, 2006) (Parsons and Brinckerhoff, 2009)
- a review of publicly available data and web-based information searches, including:
    - the Contaminated Sites Register and Record of Notices under Section 58 of the *Contaminated Land Management Act 1997*, maintained by the NSW Environment Protection Authority
    - environment protection licences, applications, notices, audits or pollution studies and reduction programs
    - Australian Soil Resource Information System (ASRIS) (maintained by the Commonwealth Scientific and Industrial Research Organisation (CSIRO))
    - NSW Government Sharing and Enabling Environmental Data (SEED) website
    - Penrith 1: 100 000 Soil Landscape Series – Sheet 9030 (Bannerman SM and Hazelton PA, 1990)
    - Penrith 1 : 100 000 Geological Map 9030 (NSW Department of Mineral Resources, 1991)
    - Liverpool City Council LEP and Fairfield City Council LEP – acid sulphate soils maps
    - Water bore records held by NSW Office of Water
- a site inspection to identify potential sources of contamination based on existing land use
- identification of the potential for acid sulphate soils and saline soils within the project site
- a limited contamination assessment undertaken as part of a geotechnical investigation to inform design which included:
    - sampling of soils from eight boreholes and four test pits within the rail corridor, three test pits along Broomfield Street and three test pits within Jacquie Osmond Reserve

  - analysis of selected soils samples for contaminants of potential concern including heavy metals (arsenic, cadmium, chromium, copper, lead, nickel zinc and mercury); benzene, toluene, ethyl-benzene and xylene (BTEX), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), phenols, pesticides and asbestos
  - comparison of the analytical results to health and environmental screening criteria
  - preliminary waste classification of soils within the project site.
- recommendations for additional investigations, where necessary
- identification of mitigation measures to address potential soil and contamination impacts.

A detailed description of the assessment methodology is provided in section 3 of Technical Report 6.

12.1.1.3 Assessment criteria

The assessment criteria (investigation levels) for the contamination assessment were taken from the following guideline levels provided by the National Environment Protection Council (NEPC, 1999) (Amended 2013). *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM, 2013) (refer to Schedule B1 of the NEPM):

- Health investigation levels:
  - to assess human health risk via all relevant pathways of exposure
  - the level adopted for this assessment was D – commercial/industrial use, based on ongoing use of the majority of the project site as a railway and road corridor.
- Health screening levels:
  - for hydrocarbon vapour intrusion under different land use scenarios
  - the level adopted for this assessment was D – commercial/industrial use.

Given that construction activities including establishment of site compounds, construction of a retaining wall and embankment and bridge construction will be undertaken in public recreation areas (Jacquie Osmond Reserve and Warwick Farm Recreation Reserve) and near Cabramatta Creek the following environmental screening levels were also adopted from the NEPM:

- Ecological investigation levels:
  - for a range of metals and organic substances to assess risk to terrestrial ecosystems
  - the levels adopted for this assessment were commercial/industrial use and urban residential/public open space.
- Ecological screening levels:
  - for selected hydrocarbon compounds and total recoverable hydrocarbons to assess risk to terrestrial ecosystems
  - the levels adopted for this assessment were commercial/industrial use and urban residential/public open space for course-grained soils.

12.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with soils and contamination. Potential risks were considered according to the impacts that may be generated by the construction and/or operation of the project, pre-mitigation. The purpose of the preliminary environmental risk assessment was to inform the impact assessment. Further information on the preliminary risk assessment, including the approach and methodology is provided in Appendix D.

The assessed risk level for the majority of potential soils and contamination risks was medium. Risks with an assessed level of medium or above include:

- increased erosion and sedimentation due to excavation activities and vehicle movement during construction
- impacts associated with the disturbance of contaminated, ASS or soil salinity/saline soils during construction
- contamination of soils/groundwater due to spills and leaks during construction
- increased erosion and sedimentation due to excavation activities and vehicle movement during maintenance activities
- contamination of soils/groundwater due to spills and leaks during maintenance.

These potential risks and impacts were considered as part of the assessment. The assessment also considered matters identified by the SEARs and stakeholders, as described in Chapters 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

12.1.3 How potential impacts have been avoided/minimised

As described in Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has included a focus on avoiding and/or minimising the potential for environmental impacts during all key phases of the process.

Potential soils and contamination impacts have been avoided/minimised where possible by minimising the area of disturbance.

12.2 Existing environment

12.2.1 Topography and geology

The project site gently slopes from Cabramatta Station to Cabramatta Creek. From Cabramatta Creek to Warwick Farm Station the land is fairly flat.

Surface levels across the project site vary from 13.59 metres Australian Height Datum (AHD) near Cabramatta Station to 5.02 metres AHD on the southern side of Cabramatta Creek.

The project site is underlain by Bringelly Shales consisting of shales, carbonaceous claystones, medium grained siltstone and clay in the northern end of the project site, near Cabramatta Station, and Quaternary and Tertiary alluvial deposits consisting of silts, clays, fluvial sands and gravels in the rest of the project site.

Based on the geotechnical investigations undertaken to inform the design, the site is generally underlain by variable fill material of gravel, sand and clay, typically of a depth of one metre. The fill is underlain by a deep alluvial profile that generally consists of alluvial clay, extending to a depth of over six metres below ground surface within the project site.

12.2.2 Soils

12.2.2.1 Soil types

The following soil types underlie the project site:

- Blacktown residual landscape – mapped across the majority of the project site
- South Creek alluvial landscape – located along the floodplains of Cabramatta Creek.

As discussed above there is a substantial amount of fill material within the project site, including railway ballast and fill consisting of gravel, sand and clay.

12.2.2.2 Acid sulfate soils

Acid sulfate soils are naturally occurring soils containing iron sulfides, which, on exposure to air, oxidise and create sulfuric acid. This increase in acidity can result in the mobilisation of aluminium, iron, and manganese from the soils. The release of sulfuric acid and heavy metals to the environment can have potentially adverse effects on the natural and built environment as well as human health. The majority of acid sulfate soils are formed by natural processes under specific environmental conditions. This generally limits the occurrence of acid sulfate soils to low lying sections of coastal floodplains, rivers and creeks where surface elevations are less than 5.0 metres Australian Height Datum (AHD).

A review of the NSW Government Sharing and Enabling Environmental Data (SEED) website and both the Fairfield City Council and Liverpool City Council LEP acid sulfate soils maps indicated there are no known occurrences of acid sulfate soils (ASS) within the project site. Proposed signalling works located near Liverpool Station (refer to Figure 7.2) are in an area classified as Class 5, however acid sulfate soils are not typically found within Class 5 areas.

A review of ASRIS indicated that there was a low probability of acid sulfate soils occurring within the project site. The closest mapped occurrence of acid sulfate soils to the project site is about one kilometres east where Cabramatta Creek feeds into the Georges River.

12.2.2.3 Salinity

Areas prone to salinity are usually at low positions in the landscape, such as in valley floors and along floodplains. The Salinity Potential in Western Sydney map (2002) indicates that the project site is located in an area of moderate salinity potential. However, electrical conductivity testing undertaken as part of the geotechnical assessment found that the electrical conductivity of soils in the project site were significantly less than would be expected if the area contained saline soils (between 39 – 740 μS/cm compared to 4000 μS/Cm or over (DLWC, 2002)). Therefore the presence of saline soils within the project site is considered unlikely and has not been considered further in this assessment.

12.2.3 Areas of contamination concern

12.2.3.1 Sites listed or licensed by the EPA

No sites listed on the EPA's contaminated land register are located within one kilometre of the project site. Two sites which have been notified to the EPA are located within one kilometre of the site, as listed in Table 12.1.

Table 12.1 Sites notified to the EPA

Site	Address	Activity	Contamination status	Location in relation to project site
Caltex Service Station	168 John Street Cabramatta	Service Station	Regulation under CLM Act not required	100 metres west of Cabramatta Station
Warwick Farm Public School	95 Lawrence Hargrave Road, Warwick Farm	Former landfill	Under assessment	550 metres west of Peter Warren Automotive

A number of industrial premises or activities within one kilometre of the project site are either currently licensed by the EPA through provision of an environment protection license, or have previously been. These sites and activities are listed in Table 12.2 and include ARTC's and Sydney Trains' activities within the rail corridor.

Table 12.2 Industrial sites or activities currently or previously licensed by the EPA

License number	Address	Activity	License status	Location in relation to project site
3142	Australian Rail Track Corporation Limited	Railway systems activities	Active	On site
12208	Sydney Trains	Railway systems activities	Active	On site
372	Sydney Water Corporation	Sewage treatment processing by large plants	Active	590 m southeast
12535	CPB Contractors Pty Ltd	Liverpool – Ashfield pipeline. Sewage treatment processing by small plants	Surrendered	On site
12971	Australian Rail Track Corporation	Railway systems activities	Surrendered	On site
4653	Lurhmann Environnent Management Pty Ltd	Non-Scheduled Activity – application of pesticides	Surrendered	On site
4838	Robert Orchard	Non-Scheduled Activity – application of pesticides	Surrendered	On site
5150	Fairfield City Council	Non-Scheduled Activity – application of pesticides	Surrendered	Onsite
5176	Liverpool City Council	Non-Scheduled Activity – application of pesticides	Surrendered	On site
6630	Sydney Weed and Pest Management Pty Ltd	Non-Scheduled Activity – application of pesticides	Surrendered	On site
13316	John Holland Pty Ltd	Railway System Activities	Surrendered	504 m south

12.2.3.2 Other identified areas of contamination

Based on the land uses immediately surrounding the project site, as described in Chapter 2 (Location and setting) and Chapter 17 (Landscape and visual amenity), and the findings of the desktop review and site inspection, potential sources of contamination in the vicinity of the project site are considered to include:

- imported fill and ballast within the existing rail corridor – which may be associated with asbestos, hydrocarbons, heavy metals, and polycyclic aromatic hydrocarbons
- former rail haulage activities within the rail corridor leading to potential spillages of oils and lubricants from locomotive engines, metal dust and asbestos from wheel abrasion –which may be associated with asbestos, hydrocarbons, heavy metals, and polycyclic aromatic hydrocarbons
- unknown fill and waste materials within the road corridor – which may be associated with various hazardous materials, including asbestos, heavy metals, pesticides and hydrocarbons
- weed control within the rail corridor and in recreational areas including Jacquie Osmond Reserve and Warwick Farm Recreation Reserve – which may be associated with herbicides and pesticides
- industrial activities adjacent to the rail corridor – which may be associated with hydrocarbons, oils, chemical storage, heavy metals, and hazardous building materials. However, given the proximity to the project site and/or current status of the industrial activities identified in Table 12.1 and Table 12.2, the potential for contamination from the majority of these activities is considered to be low.

The limited contamination assessment found no evidence of staining or odour that may indicate the presence of contamination in any of the test pits or boreholes.

All samples reported laboratory results either below the limit of reliability or below the relevant human health based screening criteria. Additionally, the majority of samples reported laboratory results either below the limit of reliability or below the relevant environmental screening criteria, with the exception of some samples collected at locations within the rail corridor at the southern extent and within Broomfield Street. However, soil concentrations at these locations are not deemed to have the potential to impact ecological receptors given the current land use and distance to ecological receptors. Soil samples collected from test pits within Jacquie Osmond Reserve reported concentrations below the relevant environmental criteria.

The preliminary waste classification undertaken as part of the limited contamination assessment indicated that soils within the project site would likely meet the classification of General Solid Waste, in accordance with the NSW EPA *Waste Classification Guidelines Part 1: Classifying Waste* (EPA, 2014).

The limited contamination assessment confirmed that the soils are considered suitable to remain within the project site for the uses proposed during operation (rail corridor and road corridor). Based on the findings of the desktop review, site inspection and limited contamination assessment no evidence of gross or widespread contamination was identified within soils in the project site. Therefore, the project site is not considered to meet the criteria requiring it to be notified to the EPA under Section 60 of the *Contaminated Land Management Act 1997*.

No sampling of groundwater was undertaken as part of the assessment. However, based on the results of the limited contamination assessment which did not identify any gross contamination in soils, and the type and proximity of activities which have the potential to contaminate groundwater located near the project site, the potential for groundwater within the project site to be contaminated is considered low.

12.3 Assessment of construction impacts

Excavation and ground disturbance activities would expose and disturb soils, which, if not adequately managed, could result in:

- erosion of exposed soil and stockpiled materials
- dust generation
- an increase in sediment loads entering the stormwater system and/or local runoff, and therefore nearby receiving waterways, namely Cabramatta Creek and associated drainage lines
- increase in salinity levels in soil
- acid sulfate soil conditions
- mobilisation of contaminated sediments, with resultant potential for environmental and human health impacts.

Potential impacts as they relate to soils and contamination are considered below. Potential water quality impacts, including impacts caused by increased sediment loads, are considered in Chapter 13 (Hydrology, flooding and water quality), air quality (dust) impacts are considered in Chapter 10 (Air quality), and health and safety risks, including as a result of contamination and hazardous materials, are considered in Chapter 20 (Health, safety and hazards).

12.3.1 Soils

12.3.1.1 Soil erosion

Construction of the project would temporarily expose the natural ground surface and sub-surface through the removal of vegetation and excavation and/or the removal of hardstand surfaces including roads and footpath during the following construction activities:

- earthworks associated with construction of the retaining walls and embankment, bridges, road works and ancillary infrastructure
- clearing/grubbing of trees and vegetation along Broomfield Street, near Cabramatta Creek and in Jacquie Osmond Reserve.

These activities can lead to exposure of soil to runoff and wind which can increase soil erosion potential, particularly where construction activities are undertaken in soil landscapes characterised by a high and extreme erosion hazard. Of the soil landscapes present within the project site the Blacktown residual landscape can range from low to very high erosion hazard, while the South Creek alluvial landscape has potentially a very high to extreme erosion hazard.

Soil erosion impacts are expected to be minimal for the project as a result of the relatively limited areas of excavation and earthworks, the generally flat topography of the project site, and the temporary nature of exposure.

Regardless of the amount of excavation required, the potential for erosion impacts would be minimised by implementing standard soil erosion management measures during construction, as described in section 12.5.

12.3.1.2 Acid sulfate soils

Sulfuric acid is produced when drainage or excavation brings soils to the surface that were previously located below the water table. Previous investigations undertaken as part of the SSFL EIS (Parsons Brinckerhoff, 2009), identified groundwater depths ranging from three metres below ground surface near the southern end of the project site to 0.5 metres below ground surface near Cabramatta Creek in the centre of the project site, and two metres below ground surface at the northern end. However, during the geotechnical investigation undertaken to inform the project's design, groundwater was only identified in locations in the south of the project site at depths between three and six metres below ground surface. It would be expected that groundwater levels would be shallower near Cabramatta Creek.

The majority of excavation during construction is unlikely to exceed depths of two to three metres below ground surface. Therefore, the potential to encounter water logged soils would only be likely during piling activities associated with the retaining walls and bridge construction and underboring associated with relocation of the Sydney Water gravity main.

12.3.1.3 Contamination

Excavation may disturb any contamination and hazardous materials present in soil. If inadequately managed, the disturbance of areas of contamination has the potential for:

- direct contact and/or inhalation by site workers, users, and visitors
- impacts to surrounding environmental receivers (including surrounding ecosystems and flora and fauna, where present)
- mobilisation and migration of surface and subsurface contaminants via leaching, runoff and/or subsurface flow, impacting nearby soils, surface water, and groundwater.

Based on the results of the desktop review and limited contamination assessment the potential to disturb contamination resulting in impacts to human health and the environment is considered low. Regardless, the potential for the impacts due to the potential disturbance of contamination would be minimised by implementing the mitigation measures provided in section 12.5.

Construction activities have the potential to result in the contamination of soil and groundwater due to spills and leaks of fuel, oils, and other hazardous materials. In addition, there is the potential to introduce contamination to the project site through the acceptance of imported fill that has not been properly verified. These potential impacts would be minimal with the implementation of standard mitigation measures, provided in section 12.5.

12.3.2 Site assessment and remediation

The limited contamination assessment confirmed that the soils are considered suitable to remain within the project site for the uses proposed (rail corridor and road corridor). Although it should be noted, sampling was not undertaken in accordance with the *Contaminated Sites Sampling Design Guidelines* (EPA, 1995). Therefore, the findings of the limited contamination assessment can only be used to determine the presence of gross contamination within the project site.

Based on the findings of the limited contamination assessment, the project site does not meet the criteria requiring it to be notified to the EPA under section 60 of the CLM Act and further assessment or remediation of soils within the project site is not required as part of the project.

12.3.3 Cumulative impacts

Cumulative impacts may result from the disturbance of soils and contamination from other projects occurring concurrently to the project, resulting in an increased potential for the mobilisation of contaminated sediments, and an increase in erosion and hence sediment loads entering nearby receiving waterways. Other projects that have the potential to occur at the same time as the project and in the vicinity of the project are described in Appendix E.

The potential for impacts due to erosion and sedimentation would be readily managed with the implementation of standard erosion and sedimentation control measures. As such, it is not expected that the project would have a material impact on erosion and sedimentation at the scale that cumulative impacts could occur.

The overall risk of encountering or generating contamination is low, and the project would be unlikely to generate impacts at a scale that would interact with other projects.

12.4 Assessment of operation impacts

12.4.1 Soils

Maintenance and repair activities may require excavation and ground disturbance, which could result in short-term impacts similar to those described in section 12.3.1. These impacts would be managed by implementing the mitigation measures described in section 12.5 ARTC’s Environmental Management System contains processes such as the Task Based Environmental Impact Assessment (TBEIA), where the risk of contamination is considered prior to activities which would require excavation and ground disturbance. ARTC’s contaminated land database and map provides information for these risks to be considered on a site specific basis. In addition, ARTC’s standard operating procedures provide sufficient guidance on managing risks as they relate to maintenance activities on potentially contaminated lands.

During operation, there is a risk of accidental spillage of petroleum, chemicals or other hazardous materials as a result of leakages during maintenance activities or rail accidents. Spills could contaminate soils and pollute downstream waterways and groundwater if unmitigated. The potential for contamination is considered to be low, based on the amount of vehicles and equipment which would likely be used during maintenance related activities. This impact would be minimised by implementing existing ARTC procedures to manage spills.

12.4.2 Cumulative impacts

Given that any maintenance activities would likely be limited in nature and extent the potential for cumulative impacts due to maintenance activities during operation would be negligible.

12.5 Management of impacts

12.5.1 Approach

12.5.1.1 Approach to mitigation and management

Soil

Construction erosion and sediment control measures would be developed and implemented in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Managing Urban Stormwater: Soils and Construction Volume 2A* (Department of Environment and Climate Change, 2008), (commonly known as ‘the Blue Book’).

A soil and water management plan would be prepared as one of the components of the CEMP. The soil and water management plan is required to define the management and monitoring measures that would be implemented to manage, in accordance with relevant guidelines:

- surface and groundwater impacts

- contaminated material
- erosion and sediment control.

Further information on the approach to environmental management during construction is provided in section 22.2.

Auditing and monitoring would be undertaken during construction to ensure that the CEMP and relevant sub-plans are being implemented.

Contamination

An unexpected finds protocol would be developed as part of the soil and water management sub-plan to ensure that any unexpected contamination encountered during construction does not expose workers, site users, and/or the environment to contamination in excess of regulatory guideline levels.

The unexpected finds protocol would outline the activities to be undertaken in the event that previously undetected contamination is identified, which would include making the site safe, carrying out an assessment of the finds, and managing the finds based on the results of the assessment.

A waste management procedure would also be developed as part of the CEMP, as described in Chapter 19 (Waste management).

Health and safety risks to on-site workers associated with normal construction operations are regulated by workplace health and safety legislation (including the *Work Health and Safety Act*, 2011), and are not relevant to approval of the project under Division 5.2 of the EP&A Act. In accordance with relevant workplace health and safety regulatory requirements a health and safety plan would be prepared for the project and would also include measures to help minimise the exposure of workers to potentially contaminated soil, including material containing asbestos, if encountered.

Further information on the approach to environmental management during construction is provided in Chapter 22 (Approach to environmental management).

Expected effectiveness

For impacts associated with soil the erosion and sediment control measures to be implemented would be in accordance with the requirements of the Blue Book. The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective. In general, the implementation of measures in accordance with the Blue Book would either result in a reduced potential for the impact to be realised through either the use of engineered controls (eg hay bales, covers on stockpiles etc) or avoidance completely (eg not undertaking works during wet weather). Therefore, there is no reason the proposed mitigation measures should not be moderately to highly effective, if implemented in strict accordance with the Blue Book.

For impacts associated with contamination the implementation of management measures proposed including an unexpected finds protocol and spill procedures to manage spills would reduce the impact. However, given that the unexpected finds protocol relies on a person's ability to identify contamination and spills management would still result in some impact, these measures are considered moderately effective.

12.5.2 List of mitigation measures

The mitigation measures that will be implemented to address potential soils and water quality impacts are listed in Table 12.3.

Table 12.3 Mitigation measures

Stage	Impact	Measure
Construction	General soil and erosion management	A soil and water management plan will be prepared as part of the CEMP for the project and implemented for the duration of construction, in accordance with

Stage	Impact	Measure
		Soils and Construction - Managing Urban Stormwater Volume 1 (Landcom, 2004) and Volume 2D (DECC, 2008a) (commonly known as 'the Blue Book) The soil and water management plan will include but not be limited to: • a primary erosion and sedimentation control plan and a maintenance schedule for ongoing maintenance of temporary erosion and sediment controls. The erosion and sedimentation control plan will include site-specific details for managing sediment and erosion near Cabramatta Creek and associated drainage lines • measures and controls for the management of disturbed and stockpiled soils, including surface stabilisation of disturbed ground, covering of stockpiles where appropriate and implementation of clean-water diversions • an incident emergency spill procedure which will include measures to avoid spillages of fuels, chemicals, and fluids onto any surfaces or into any adjacent/nearby waterways.
	Acid sulfate soils	A field pH testing and field peroxide pH testing regime will be undertaken prior to piling work around Cabramatta Creek, in accordance with the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998). Should ASS or potential ASS be identified during the testing, then measures to manage the potential impacts associated with encountering ASS or potential ASS will need to be developed and implemented in accordance with the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998).
	Unexpected contamination	An unexpected findings protocol pertaining to contamination will be included in the soils and water management plan. The protocol will include procedures for the assessment and management of unexpected contamination encountered (if any) during construction.
	Unexpected contamination	Awareness training will be provided for all onsite staff to assist in the identification of potentially contaminated material. In the event that indicators of contamination are encountered during construction (such as odours or visually contaminated materials), work in the area will cease, and the finds will be managed in accordance with the unexpected contamination finds protocol.
	Contamination of soils	Prior to the acceptance of any imported fill onsite (regardless of volume), the following actions will be taken to reduce the risk of receiving contaminated material: • all fill used will be checked to confirm it is virgin excavated natural material (VENM) (e.g., clay, gravel, sand, soil or rock) or excavated natural material (ENM) (e.g. naturally occurring rock and soil) that is not mixed with any other waste • the supplier will provide formal certification that the fill material is clean VENM or ENM • the supplier will provide information on what activities previously occurred onsite where their fill was sourced • signs of contamination will be checked for, such as odours (chemical/petrol), staining from chemicals, and rubbish such as bricks, timber, and masonite • the delivery of the material will be supervised to check the material received matches the material ordered. • all required documents and records will be maintained.

Stage	Impact	Measure
	Contamination incident management	Spill containment kits will be present and maintained on site during all activities.
	Contamination incident management	All staff will be inducted about incident and emergency procedures in accordance with the incident emergency spill procedure and made aware of the locations of spill containment kits. Information regarding the correct and safe storage and handling of fuels and chemicals will be communicated to personnel.
Operation	Soil erosion and sedimentation	Erosion and sediment controls will be implemented during maintenance activities where soils are exposed, in accordance with ARTC's standard environmental management measures included within its Environmental Management System.
	Contamination	ARTC's existing spill response procedures will be complied with to minimise the potential for impacts on the local community and the environment as a result of any leaks and spills. Additionally, leaks and spills will be managed in accordance with ARTC's EPL #3142.

12.5.3 Consideration of the interaction between measures

There are interactions between the mitigation measures for soils and contamination (summarised in section 12.5.2) and those for water quality (Chapter 13), waste (Chapter 19), and hazardous materials (Chapter 20). Together, all these measures would ensure appropriate management of soil and potentially contaminated soils and groundwater, to minimise the potential for impacts to the community and environment.

The implementation of erosion control measures and devices during construction has the potential to result in some potential impacts on overland flow paths (as discussed in Chapter 13 (Hydrology, flooding and water quality)). Impacts on overland flow paths are considered to be manageable, as all measures would be installed in accordance with the Blue Book.

12.5.4 Managing residual impacts

A residual risk analysis was undertaken following the impact assessment summarised in this chapter. The results of the residual risk analysis are provided in Appendix D. The mitigation measures provided in section 12.5.2 are expected to reduce the potential for soil and contamination impacts during construction and operation. With the implementation of these measures, residual impacts are expected to be minimal.

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13 Hydrology, flooding and water quality

This chapter provides a summary of the hydrology, flooding and water quality impact assessments undertaken by GHD. A full copy of the assessment reports is provided as Technical Report 5 – Hydrology and flooding impact assessment and Technical Report 7 – Surface water and groundwater quality impact assessment, respectively. The report was written to address the relevant SEARs which are outlined in Appendix A.

13.1 Assessment approach

13.1.1 Methodology

13.1.1.1 Study area

The study area includes the entire Cabramatta Creek catchment including upstream areas and continuing downstream to the confluence with the Georges River.

13.1.1.2 Hydrology and water quality

The hydrology and water quality assessment involved:

- reviewing background information relevant to the study area to define the existing environment, including previous studies, mapping, survey data, and topography
- identifying water quality objectives for the catchment in which the project site is located, based on the NSW Water Quality and River Flow Objectives website
- identifying and assessing construction and operational activities that may impact on the surface water hydrology and water quality of watercourses within the study area
- calculating groundwater inflows for construction elements that may intercept groundwater using the analytical equations and approach outlined in Marinelli and Niccoli (2000)
- identifying potential impacts on groundwater
- identifying mitigation measures to minimise potential impacts on surface water and groundwater hydrology and water quality.

13.1.1.3 Water quality objectives and criteria

The NSW Water Quality and River Flow Objectives provide water quality objectives for the Georges River catchment (the downstream receiving waterway for flows from Cabramatta Creek), for the protection of the following (within waterways affected by urban development, or estuaries):

- aquatic ecosystems
- visual amenity
- secondary contact recreation
- primary contact recreation.

Waterways affected by urban development are defined as streams within urban areas, which are frequently substantially modified and generally carry poor quality stormwater. The majority of watercourses within the study area meet this definition.

The water quality objective for aquatic ecosystems is to 'maintain or improve the ecological condition of waterbodies and their riparian zones over the long term'. The indicators and criteria (trigger values) for this objective are listed in Table 13.1. While it is likely that watercourses within the study area would be classified as highly disturbed systems (being urban streams receiving road and stormwater runoff), the ANZECC 2000 guidelines recommend that the guideline trigger values for slightly to moderately disturbed systems should also apply to highly disturbed ecosystems wherever possible. Therefore, the water trigger values provided in Table 13.1 are based on the ANZECC 2000 guideline default trigger values for the protection of aquatic ecosystems in slightly disturbed river ecosystems in south-eastern Australia.

A detailed list of the indicators and criteria for the other water quality objectives for the Georges River catchment is provided in Technical Paper 7.

Table 13.1 Water quality trigger values for aquatic ecosystems

Indicator	Criteria (lowland rivers)
Total phosphorus	25 ug/L
Total nitrogen	350 ug/L
Chlorophyll-a	5 g/L
Turbidity	6-50 NTU
Salinity (electrical conductivity)	125-2,200 uS/cm
Dissolved oxygen (per cent saturation)	85-110%
pH	6.5-8.5

13.1.1.4 Flooding

The project involves providing new rail and road infrastructure in an area subject to existing flooding. As a result a flooding assessment was undertaken as an input to the design of the project. The flooding assessment involved:

- a desktop review of:
  - flood studies and floodplain risk management studies, including Georges River Floodplain Risk Management Study and Plan (Bewsher Consulting Pty Ltd, 2004), Cabramatta Creek Flood Study and Basin Strategy Review (Liverpool City Council, 2011) and Georges River Floodplain Risk Management Study & Plan (Georges River Floodplain Management Committee, 2004)
  - existing and future flooding conditions
  - existing drainage infrastructure.
- hydraulic modelling to quantify flood behaviour, using ground survey undertaken during design development and the existing Cabramatta Creek flood model provided by Liverpool City Council, and updating it to reflect changes to the area as a result of the project, including the addition of structures such as the bridges and the Broomfield Street drainage infrastructure
- assessing flooding impacts and risks associated with the project which involved:
  - updating the existing TUFLOW flood model from Liverpool City Council to simulate a post development scenario for a range of different annual exceedance probability (AEP) storm events
  - comparing the flood impacts against the base case scenario to identify the extent of the flood impacts
  - identifying any potential impacts on flooding during construction stage
  - identifying any potential impacts on flooding of neighbouring properties and assets due to changes to ground levels.
- developing measures to minimise potential changes to the flood regime as a result of the project.

To assess the potential impacts associated with constructing the bridges and other structures near Cabramatta Creek a full range of flooding events, from the 0.2 per cent to the five per cent AEP event, were modelled for the existing case and the developed case (what would occur with the project in place). The AEP represents the likelihood of occurrence of a flood of given size or larger occurring in any one year. A one per cent AEP event is a rainfall event with a one per cent chance of being exceeded in magnitude in any year. Modelling of existing and developed case flood conditions was also undertaken for the one per cent AEP event, with a ten per cent allowance for an increase in peak rainfall intensity (to account for climate change). This is referred to as the one per cent AEP climate change event. Additionally the probable maximum flood (PMF) event was modelled for the existing and developed case. The PMF is considered to be the worst case flood event for an area. The PMF represents extreme flooding conditions and defines the extent of flood prone/liable land.

In addition, the one per cent, five per cent and ten per cent AEP flooding events were modelled for the existing case and developed case for drainage in Broomfield Street (due to the road realignment works), to assess compliance with the flooding criteria adopted for the project.

The flooding criteria that has been adopted the project against which flooding impacts have been assessed, is summarised in Table 13.2. This flooding criteria has been adopted based on current practices for similar infrastructure projects in an urban setting and aims to minimise impacts on surrounding properties, taking into consideration the current flood affectation of that property.

Table 13.2 Design criteria for flooding impacts on adjoining lands

Flooding characteristics	Proposed criteria
Duration of flooding during a one per cent AEP event	Maximum increase in flood duration of on hour
Maximum increase in flood level at properties where flood levels are already exceeded during the one per cent AEP event	10 millimetres
Maximum increase in flood level at properties where flood levels are currently not exceeded during the one per cent AEP event	50 millimetres

13.1.2 Risks identified

The preliminary environmental risk assessment undertaken for the project included potential risks associated with hydrology, flooding and water quality. Potential risks were considered according to the impacts that may be generated by the construction and/or operation of the project, pre-mitigation. The purpose of the preliminary environmental risk assessment was to inform the impact assessment. Further information on the preliminary risk assessment, including the approach and methodology is provided in Appendix D.

The assessed risk level for the potential hydrology, flooding and water quality risks ranged from low to high. Risks with an assessed level of medium or above include:

- presence of or change to structures associated with the project could impact upstream and downstream local flood behaviour
- blockages of flow paths affecting low flows through construction within Cabramatta Creek and through erosion and sedimentation control structures
- sedimentation and changes to geomorphology (aggradation in bed channels) in Cabramatta Creek
- impacts on upstream and downstream drainage due to the introduction of built structures such as the Jacquie Osmond embankment and bridges
- reduced water quality (increased total suspended solids and turbidity) due to earthworks and erosion and sedimentation near watercourses
- impacts on water quality from contamination from spills and leaks during construction and operation
- impacts on groundwater quality and quantity during drawdown/extraction
- impacts on water quality from discharge of excess water from dewatering
- impact to surface water quality and receiving environments due to increased runoff from increase in impervious surfaces.

These potential risks and impacts were considered as part of the assessment. The assessment also considered matters identified by the SEARs and stakeholders, as described in Chapters 3 (Approval and assessment requirements) and Chapter 4 (Consultation).

13.1.3 How potential impacts have been avoided/minimised

As described in Chapter 6 (Project features and operation) and Chapter 7 (Construction), design development and construction planning has included a focus on avoiding and/or minimising the potential for environmental impacts during all key phases of the process.

Potential hydrology, flooding and water quality impacts have been avoided/minimised where possible by:

- designing the new bridge over Cabramatta Creek so that it matches the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek and associated potential for water quality impacts
- designing the new bridge to minimise the footprint of the project in this area
- designing drainage infrastructure for Broomfield Street to match the existing conditions.

13.2 Existing environment

13.2.1 Catchments and watercourses

The project site is located in the Cabramatta Creek catchment, which has an area of about 74 square kilometres. Most of the catchment is located within the Liverpool LGA, however the northern side of Lower Cabramatta Creek is located with the Fairfield LGA and a small proportion of the upper catchment is also located within the Campbelltown LGA.

Major tributaries of Cabramatta Creek include:

- Hinchinbrook Creek
- Maxwells Creek
- Brickmakers Creek.

The Cabramatta Creek catchment and watercourses in the area are shown on Figure 13.1. This figure also shows the stream order of watercourses in the area (based on the Strahler stream classification system). Stream order is a measure of the relative size of the watercourse, with a first order stream being the largest and a fifth order being the smallest.

Cabramatta Creek begins in the rural/residential suburb of Denham Court, located at the southern extent of the catchment boundary. From there it flows in a northerly direction towards Hoxton Park. The Cabramatta Creek and Carnes Hill Urban Release Areas are located within the Upper Cabramatta Creek subcatchments and substantial residential development has already occurred in these areas.

Cabramatta Creek then flows in an easterly direction towards the Fairfield LGA and the creek's confluence with Georges River. Within the lower catchment, a more prominent creek corridor becomes evident (up to 200 metres wide). This area primarily consists of public open space, playing fields and golf courses.

Cabramatta Creek flows through a number of established suburbs including Miller, Cartwright, Sadler, Ashcroft, Mount Pritchard and Warwick Farm. Major transport (road and rail) routes that cross the catchment include Hoxton Park Road, Elizabeth Drive, the Cumberland Highway, the Hume Highway and the SSFL and Main Southern railway line.

Tributaries of the creek have been modified from their natural state. This includes Maxwells Creek which has been turned in to a grassed trapezoidal channel downstream of Jedda Road, continuing through to the confluence with Cabramatta Creek.

At the location where the project site crosses Cabramatta Creek, the creek is a fifth order stream.

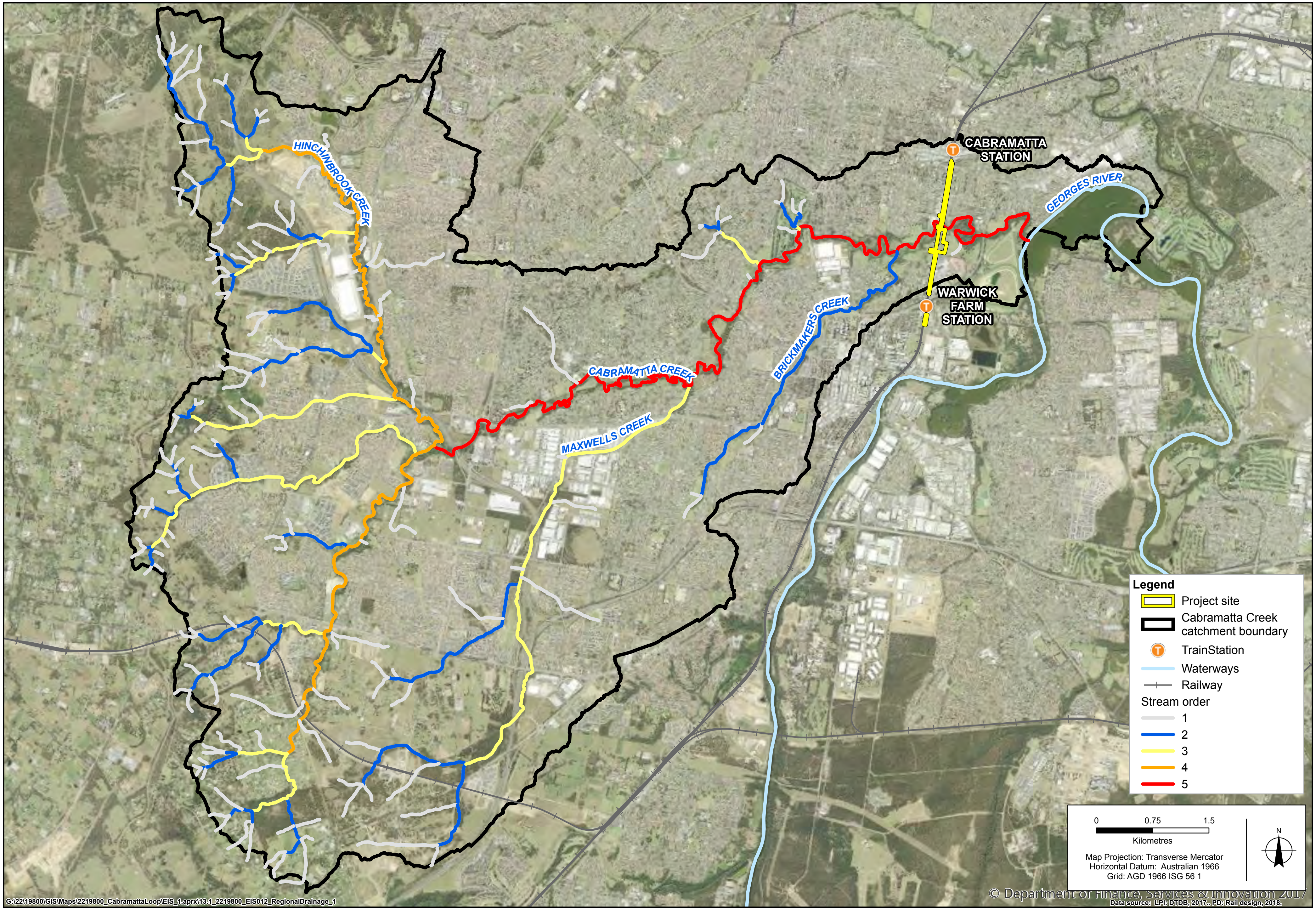

Figure 13.1 Catchment area and watercourse locations

13.2.2 Existing flooding and drainage conditions

The Cabramatta Creek catchments is typical of many urbanised catchments in that the predominance of impervious surfaces means that rainfall is quickly converted into surface water runoff. The rainfall runoff response means that floods may develop quickly following the onset of intense rainfall events. Flood waters in the main Cabramatta Creek rise within a matter of hours following the onset of intense rainfall, making advance warning difficult.

The rail corridor has a track drainage system that conveys water to the local drainage network and then to Cabramatta Creek where it drains to Georges River and Botany Bay. Drainage within the rail corridor consists of a number of open drainage channels that drain in to the track drainage network. The open channels are both earth lined and concrete open dish drain type elements. The capacity of the existing elements within the rail corridor is currently unknown but they only cater for rainfall runoff that falls within the rail corridor.

Drainage within Broomfield Street consists of a stormwater drainage line that collects and conveys stormwater runoff from the immediate surrounding area as well as runoff from the rail corridor. The drainage line discharges at the southern end of Broomfield Street to an open channel, located adjacent to 10 Sussex Street, which discharges to Cabramatta Creek.

13.2.3 Surface hydrology and identified project-specific flooding conditions

The extent and depth of existing flooding for the one per cent AEP climate change event and the PMF is shown in Figure 13.2 and Figure 13.3, respectively.

The mapping shows that the project site, from the Cabramatta Road West overbridge to the Hume Highway overbridge, is affected by flooding from Cabramatta Creek during the 0.5 per cent AEP flood event and above. The majority of the project site is located within a high flood risk precinct, and in Jacquie Osmond Reserve flood levels during the one per cent and five per cent AEP flood events are about 7.2 metres Australian Height Datum (AHD) and 6.2 metres AHD, respectively.

During the one per cent and five per cent flood events, houses on the following streets have existing flooding issues:

- Sussex Street
- Church Street
- Broomfield Street
- Railway Parade
- Lawrence Hargrave Road.

The rail corridor is largely unaffected by flooding except in rare events.

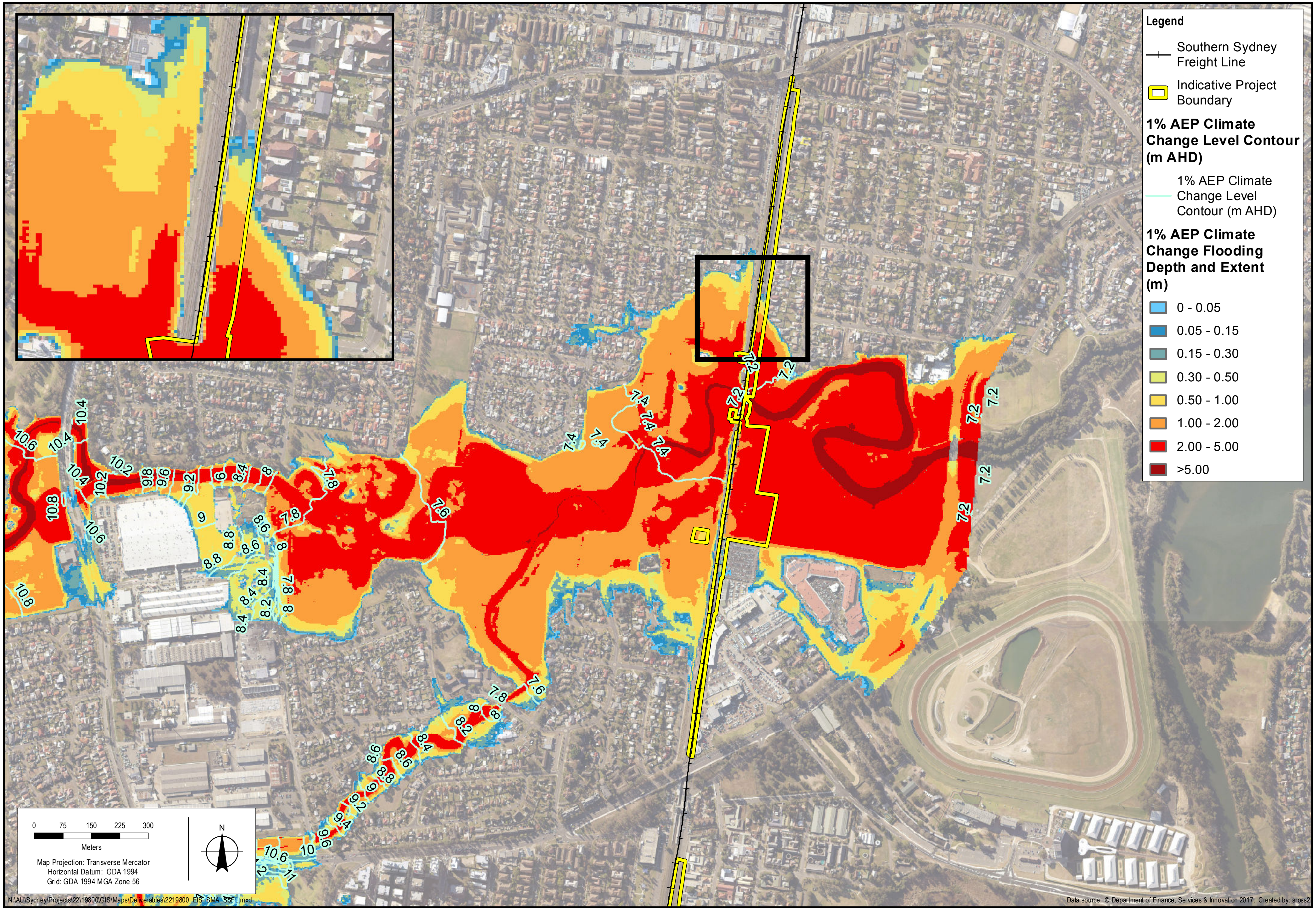

Figure 13.2 - Existing flood depth and extent – one per cent AEP plus climate change

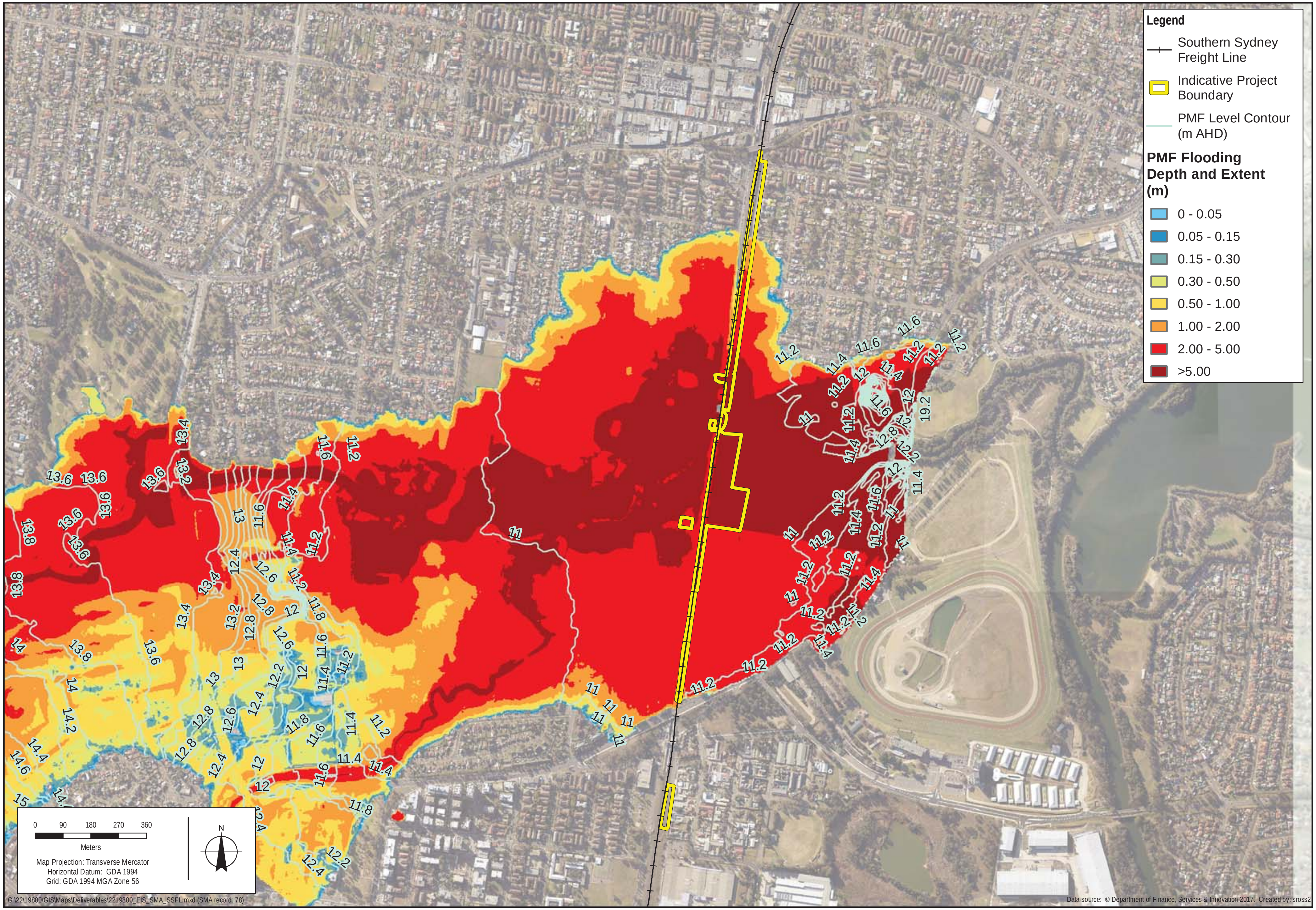

Figure 13.3 – Existing flood depth and extent – probable maximum flood

13.2.4 Water quality

According to the *Cabramatta Creek Floodplain Management Study and Plan* (Bewsher, 2004), Cabramatta Creek was noted to have the poorest water quality in the Georges River system in 2004. The major sources of pollution in Cabramatta Creek includes urban runoff and sewage effluent, most likely due to sewage overflows from the sewerage system during wet weather.

Detailed water quality monitoring data specific to the project site was not identified during the desktop review. However, the most recently available local report, the *2016-2017 River Health Report Card for the Georges River* (Georges River Combined Councils Committee (GRCCC), 2018), identified the overall water quality health of Lower Cabramatta Creek as “good” (A-) which is considered ‘good’ as defined by the GRCCC when assessing against environmental guidelines.

13.2.4.1 Sensitive receiving environments

A sensitive receiving environment is one that has a high conservation value, or supports human uses of water that are particularly sensitive to degraded water quality (DECC, 2008). With regard to the study area, sensitive receiving environments are considered to include:

- threatened ecological communities associated with aquatic ecosystems
- known and potential habitats for threatened fish
- Key Fish Habitats
- recreational swimming areas
- areas that contribute to drinking water catchments.

Cabramatta Creek is mapped as Key Fish Habitat, however, as described in the biodiversity development assessment report (Technical Report 4- Biodiversity development assessment report) it does not comprise habitat for any threatened species. The other watercourses in the study area are considered unlikely to contain any significant sensitive environments.

13.2.5 Groundwater

During a geotechnical investigation undertaken to inform the project design groundwater levels in boreholes drilled between Jacquie Osmond Reserve and the southern extent of the project site ranged from three metres to six metres below ground level (mbgl). Previous geotechnical investigations (Parsons Brinckerhoff, 2009) undertaken within the project site identified groundwater in the northern section at depths of between 1.5 to 2 mbgl, decreasing to 0.5 mgbl in the vicinity of Cabramatta Creek, and increasing to a depth of 3 mbgl south of the creek near Peter Warren Automotive. In the southern end of the site between Jacquie Osmond Reserve and Warwick Farm Station, alluvial groundwater flow is to the south based on monitoring of groundwater levels during the geotechnical investigation, while in the rest of the project site alluvial groundwater flow is expected to be towards Cabramatta Creek.

A search of the NSW Water Register was undertaken on 7 September 2018 to identify existing users and extraction rates. The search identified 28 registered bores within approximately 1,500 metres of the project site. The majority (22) were registered as monitoring bores. Of the remaining bores, two were identified as registered for groundwater exploration and irrigation and two for recreation. The two irrigation bores are located in Warwick Farm Racecourse to the east of the site. The two bores registered for recreation are located on the eastern side of the Georges River.

Quaternary and Tertiary alluvium underlies the Cabramatta Creek and its tributaries and forms an aquifer. Groundwater salinity within the Quaternary and Tertiary alluvium is expected to vary from lower salinity in the upper reaches of the Cabramatta Creek, to higher salinity in the lower reaches due to mixing and tidal influences.

The NSW Groundwater Quality Protection Policy outlines a number of beneficial use categories for groundwater resources. Based on the groundwater quality, the beneficial use of groundwater resources can be classified as ecosystem protection (environmental water), recreation, drinking water, agricultural water or industrial water.

While there is no groundwater quality data available as part of this assessment, a beneficial use category has been assigned based on potential groundwater receptors. Based on a review of groundwater receptors groundwater use within and surrounding the project site is expected to be limited and the primary beneficial use of groundwater in the vicinity of the site would be environmental (i.e. providing base flow to waterways).

13.3 Assessment of construction impacts

13.3.1 Flooding

13.3.1.1 Impacts on flood behaviour and overland flows during construction

The majority of construction activities and the presence of construction compounds and work sites have the potential to impact local overland flows and flood behaviour. Runoff or rainfall within the project site has the potential to cause localised flooding issues and adverse downstream impacts if not appropriately managed.

Potential impacts on flood behaviour and overland flows include:

- changed flood behaviour due to the construction of Cabramatta Creek bridge
- blocking of drainage networks through increased sedimentation of surface water
- interruption of overland flow paths by the installation of temporary construction ancillary facilities, erosion and sediment controls or construction hoarding
- changed flood behaviour as a result of changes to site topography and installation of temporary buildings/site offices and other structures within the floodplain, resulting in increased flooding of adjacent areas due to temporary loss of floodplain storage or conveyance of floodwaters
- small increase in impervious areas, including from site compounds and work sites, which would have the potential to increase the volume of water flowing to watercourses.

During construction, there may also be a need to temporarily disconnect or divert existing stormwater drainage pipes if:

- existing drainage pipes are interfering with proposed railway corridor works
- there are constructability issues with constructing new infrastructure
- possible safety concerns during construction.

This could result in localised modifications to existing flooding patterns, flow volumes, and velocities, which could also result in the scouring of downstream areas, particularly where soil has been exposed during construction.

Any flood impacts during construction are expected to be localised and relatively minor and would be effectively managed through the implementation of mitigation measures provided in section 13.5. The locations of compounds, work sites and undertaking of activities within designated flood hazard areas would not result in flood affectation of other properties, assets and infrastructure.

13.3.1.2 Impacts of flooding on construction

Works in Jacquie Osmond Reserve and near Cabramatta Creek, including the presence of compounds C2 and C3 and works W1 to W3 sites, would be undertaken where there is an existing flood hazard.

Flooding during construction could impact the following:

- safety of workers
- integrity of erosion and sediment control measures
- access to work and compound sites
- plant and equipment used during construction
- temporary drainage structures

- integrity of material stockpiles.

The layout of construction compounds and work sites would be undertaken with consideration of overland flow paths and avoid flood liable land where practicable. The location of compounds and work sites would be reviewed during construction planning to avoid, where possible, high hazard areas. Following completion of construction, no further impacts would occur.

13.3.1.3 Consistency with Council floodplain risk management plans

The *Georges River Floodplain Risk Management Study and Plan* (Bewsher, 2004) and the *Cabramatta Creek Flood Study and Plan* (Bewsher, 2004) discussed a number of potential floodplain management measures. However, no specific measures were recommended within the project site. Therefore, construction of the project would not prevent or comprise any of the works proposed in these plans. The construction works are therefore considered to be consistent with Council's floodplain risk management plans.

13.3.1.4 Impacts on existing emergency management arrangements

With the implementation of mitigation measures provided in section 13.5, no impacts on existing emergency management arrangements are expected during construction. Ongoing liaison with NSW SES and relevant stakeholders would be undertaken during detailed design and the construction period to achieve this.

13.3.2 Hydrology

13.3.2.1 Groundwater

The majority of construction activities are not expected to be greater than 3 metres in depth and are therefore not expected to intercept groundwater. The exception to this is piling as part of construction of new bridges over Sussex Street and Cabramatta Creek, the bored pile retaining wall from Bridge Street to Sussex Street Bridge and underboring as part of the relocation of the Sydney Water rising main in Jacquie Osmond Reserve. Dewatering would be undertaken during these activities to facilitate the works.

Due to the generally clayey, low yielding nature of the alluvial aquifer, the alluvial aquifer has been classified as a less productive fractured rock groundwater source under the NSW Aquifer Interference Policy. The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, be assessed against the minimal impact considerations outlined in the policy. If the predicted impacts are less than the Level 1 minimal impact considerations for less productive fractured rock groundwater sources, then the potential groundwater impacts of the project are acceptable.

Based on calculations undertaken as part of the groundwater assessment within Technical Report 7, it is predicted that the groundwater impacts from the project would be less than the Level 1 minimal impact considerations specified in the NSW Aquifer Interference Policy. The project is not predicted to result in any decline in groundwater pressure or groundwater head at any water supply work and is not predicted to alter the beneficial use of the alluvial groundwater. There are no culturally significant sites or groundwater dependant ecosystems in or immediately near the study area. Further information is provided in section 5.3 of Technical Report 7.

Piling works as part of the construction of Cabramatta Creek could result in the connection of surface water with deeper aquifers during pile shaft excavation, depending on the depth of the piles and the presence of perched water. These potential impacts are considered to be relatively minor as a result of the nature of the works and the limited excavation/piling required. Mitigation measures are provided in section 13.5.

13.3.2.2 Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses

The project would involve the removal of vegetation near Cabramatta Creek to facilitate building of the temporary shared path, as well as the removal of trees along Broomfield Street and in Jacquie Osmond Park, and the excavation and removal of hardstand throughout the project site, which would expose soils. Excavation would involve the disturbance of the existing ground cover and stockpiling of spoil prior to reuse or disposal off site. These and other related construction activities would result in the potential for erosion of unconsolidated material through entrainment by runoff and the subsequent transport off site. Soils transported into the local drainage network, including Cabramatta Creek, could result in the following impacts:

- reduced hydraulic capacity of Cabramatta Creek due to the deposition of material
- degraded water quality including increased nutrients, increased turbidity, lower dissolved oxygen levels and altered pH. The potential for water quality impacts is considered further in section 13.3.3
- increased sedimentation smothering aquatic life and affecting aquatic ecosystems.

Changes to surface water can occur from stream diversions and the construction of culverts and bridges. The project would involve the potential diversion of a small drainage line (through construction of a temporary culvert) adjacent to Cabramatta Creek, to facilitate the construction of the temporary shared path. Additionally a new bridge would be constructed over Cabramatta Creek and the project would install new drainage in some locations.

Changes to the natural flow of water and small increases in impervious surfaces due to construction of the project (from compounds and work sites) have the potential to increase flow velocity and the volume of stormwater runoff. This could lead to the scouring of downstream areas, and potential bank instability within Cabramatta Creek.

Water would be required for dust control, soil compaction, and vegetation establishment. The required volume of water would depend on climatic conditions during construction. It is expected that either water from dewatering of excavations (piling works and underboring) or potable or recycled water (preferably) would be used for this purpose, with the construction contractor to investigate the various sources of water available and obtain any necessary approvals.

Water usage during construction could also increase infiltration rates and surface water runoff in the project site. The impact of this additional discharge is expected to be minimal, as the additional flow and infiltration would be negligible compared to regional rainfall levels. Any impacts would be short term.

The impacts detailed above would be effectively managed through the implementation of the mitigation measures provided in section 13.5.

13.3.3 Water quality

Construction presents a risk to downstream water quality if standard construction management measures are not implemented, monitored and maintained throughout the construction period. If inadequately managed, construction activities can impact water quality if they disturb soil or watercourses, result in uncontrolled discharges of substances to watercourses, or generate contamination. The project would involve subsurface excavations, horizontal drilling works (associated with the Sydney Waters main relocation), works near watercourses and the use of water from dewatering activities for irrigation or dust control. Water from dewatering of excavations is proposed to be reused within the project site for dust suppression and/or irrigation. Therefore, potential sources of water quality impacts include:

- increased sediment loads from exposed soil transported off site to downstream watercourses during rainfall events increased sediment loads from discharge of sediment laden water from dewatering of excavations
- increased sediment loads or contaminants from uncontrolled discharges or reuse of untreated water from dewatering activities to surface water/stormwater
- increased levels of nutrients, metals, and other pollutants, transported in sediments to downstream watercourses or via discharge of water to watercourses
- chemicals, oils, grease, and petroleum hydrocarbon spills from construction machinery directly polluting downstream watercourses
- litter from construction activities polluting downstream watercourses.

The downstream effects of water quality impacts include:

- smothering aquatic life and/or inhibiting photosynthesis conditions for aquatic and riparian flora
- impacts to breeding and spawning conditions of aquatic fauna
- changes to water temperature due to reduced light penetration

- impacts to the ecosystems of downstream sensitive watercourses and floodplains.

The potential for soil and contamination impacts during construction, including the potential for contamination of surface water and groundwater due to spills and leaks, is considered in Chapter 12 (Soils and contamination). Potential water quality impacts are considered in this section.

13.3.3.1 Changes to surface water flows

Changes to surface water flows can impact water quality. An increase in flow rate and volume can lead to increased erosion and turbidity. The potential impacts of changes to surface water flows are considered in section 13.3.2.

13.3.3.2 Works in watercourses

The project would involve works in and around Cabramatta Creek. These works could disturb the bed and banks, and potentially lead to localised erosion and sediment transport downstream. The NSW Department of Primary Industries (Water) *Guidelines for controlled activities on waterfront land – Riparian corridors* (2018) would be considered when undertaking the construction of Cabramatta Creek bridge to minimise the potential for impacts to water quality.

13.3.3.3 Earthworks, demolition, stockpiling and general runoff from construction sites

Construction can impact water quality in downstream watercourses as a result of erosion. Runoff from stockpiles has the potential to impact downstream water quality during rainfall if stockpiles are not managed appropriately. Sediments from the stockpiles could wash into watercourses, increasing levels of turbidity.

Stockpiling cleared vegetation creates a risk of tannins leaching into watercourses, resulting in an increased organic load. Discharge of water high in tannins can increase the biological oxygen demand of the receiving environment, which may in turn result in a decrease in available dissolved oxygen. Once discharged to the environment, tannins may also reduce visibility, light penetration, and change the pH of receiving waters. These impacts may affect aquatic ecosystems in receiving environments.

Sediment loads in watercourses can increase in the vicinity of hard surfaces (such as roads) and compacted areas due to increased surface runoff.

Although the project has the potential to temporarily reduce water quality from pollutants and runoff, it would not be expected to cause significant impacts to the overall condition of surrounding waterways. Construction is unlikely to result in any long-term water quality impacts in the study area.

The mitigation measures provided in section 13.5 would be implemented to minimise the potential for water quality impacts during construction.

13.3.3.4 Minimising the effects of proposed stormwater and wastewater management during construction on natural hydrological attributes

Surface water at construction sites would be managed by implementing standard erosion and sediment control measures in accordance with Managing Urban Stormwater: Soils and Construction volumes 1 and 2A.

13.3.3.5 Groundwater quality

Potential risks to groundwater quality during construction include:

- contamination by hydrocarbons from accidental fuel and chemical spills
- contaminants contained in turbid runoff from impervious surfaces.

Surface water from site runoff may infiltrate and impact groundwater sources. As the infiltration process is generally effective in filtering polluting particles and sediment, the risk of contamination of groundwater from any pollutants bound in particulate form in surface water runoff, such as heavy metals, is generally low.

Soluble pollutants, such as pH altering solutes, salts and nitrates, as well as soluble hydrocarbons, can infiltrate soils and contaminate the groundwater system. Under certain pH conditions, metals may also become soluble and could infiltrate groundwater.

The mitigation measures provided in section 13.5 would be implemented to minimise the potential for groundwater quality impacts.

13.3.4 Cumulative impacts

Other projects that have the potential to occur at the same time as the project are described in Appendix E.

There are no other substantial or major projects proposed which could potentially impact hydrology, flooding and water quality in the project site.

There is a minor development proposal current for a multi-storey residential development on the corner of Broomfield Street and Cabramatta Road East. This proposal could potentially impact on the study area given it sits upstream with part of the site within the same surface water catchment as the project. Given the existing nature of the site is urban development, this development would not be expected to have a large additional impact on flooding, hydrology and water quality in the area. The potential for cumulative impacts would be negligible with implementation of the mitigation measures provided in section 13.5.

13.4 Assessment of operation impacts

13.4.1 Flooding

13.4.1.1 Impacts on flood behaviour during operation

Based on the flooding assessment undertaken the inclusion of structures as part of the project (with the exception of the proposed drainage works) would have a minimal impact on the flooding of Cabramatta Creek for the full range of flood events. Minimal increases (of less than 11 millimetres) in flood levels are expected in the majority of the study area for the one per cent AEP and the one per cent AEP plus climate change event. Where increases of greater than this are expected (up to 16 – 17 millimetres) this would generally be in flood events up to the 0.2 per cent AEP event. However, in the PMF event, an extremely rare event, these impacts are more pronounced at around 75 mm, but occur only in areas where the rail formation is already predicted to be flooded by several metres depth.

The key outcomes in relation to flooding in Cabramatta due to the addition of bridges at Sussex Street and Cabramatta Creek are summarised in Table 13.3 and shown on Figure 13.4 to Figure 13.7.

Table 13.3 Design performance against flooding criteria (Cabramatta Creek)

Key criteria	Cabramatta Creek	Adjacent lands	Public roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No increase in flooding in the majority of the study area for one per cent AEP climate change event. 2) Where there is increase in flood level, increase is 11 mm or less up to the one per cent AEP climate change event 3) Floor level survey required to confirm above floor impacts at ±10 mm level.	No adjacent roads impacted in one per cent AEP climate change event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event	Floor level survey not available. Any potential flooding above-floor will be confirmed during detailed design		
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Achieved		
Increase in flood velocities – identification of mitigation measures	A number of locations benefit from flood velocity decrease. Selected locations of velocity		

Key criteria	Cabramatta Creek	Adjacent lands	Public roads
	increases are generally <0.25 m/s for flood events up to one per cent AEP plus climate change event. Events in excess of this see some wider spread velocity increases but <0.35 m/s (also noted this is in a 0.2 per cent AEP event, a very rare to extremely rare flooding event).		

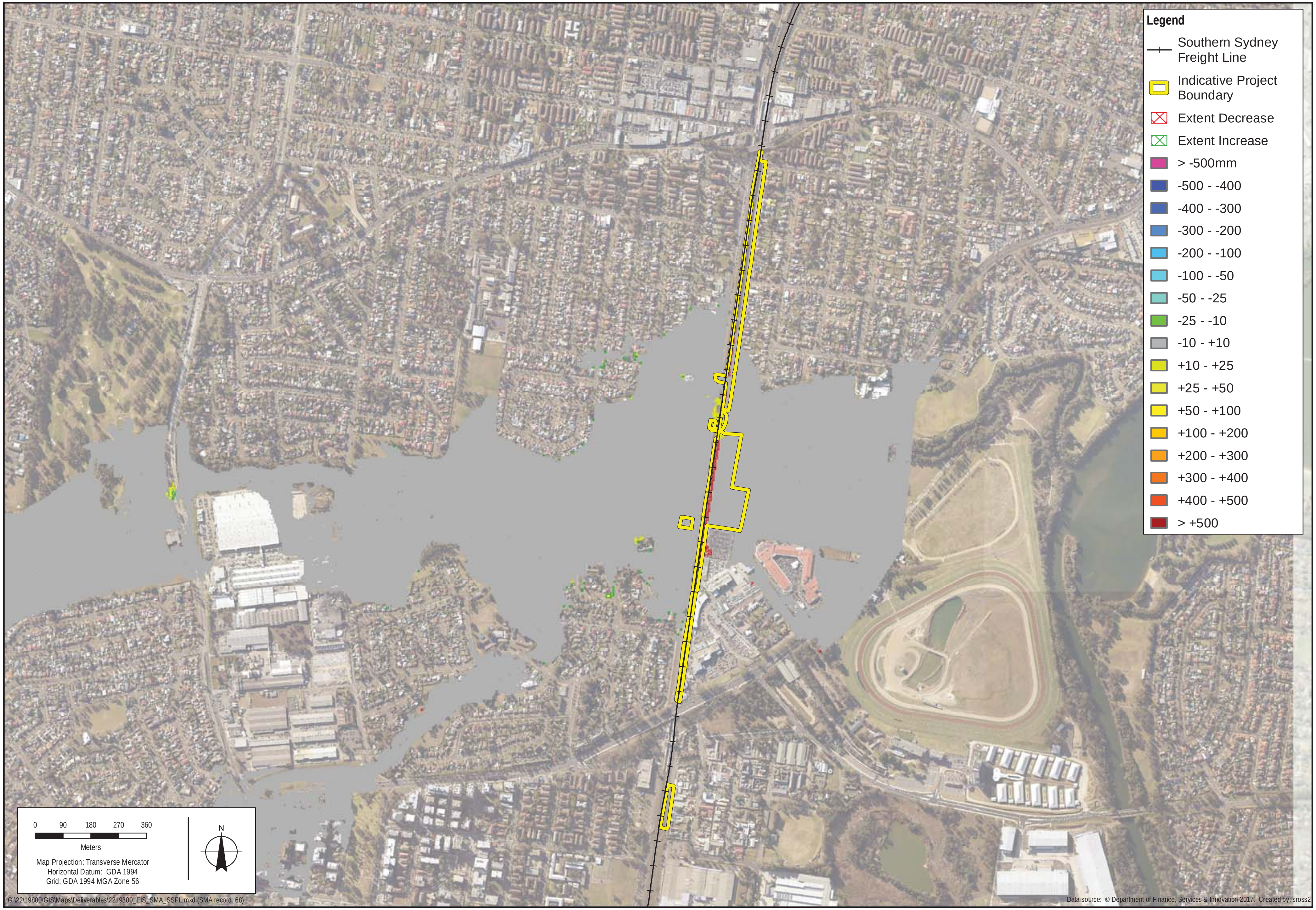

Figure 13.4 - Change in flood depth and extent with the project – one per cent AEP plus climate change

Figure 13.5 - Change in flood velocity with the project - one per cent AEP plus climate change

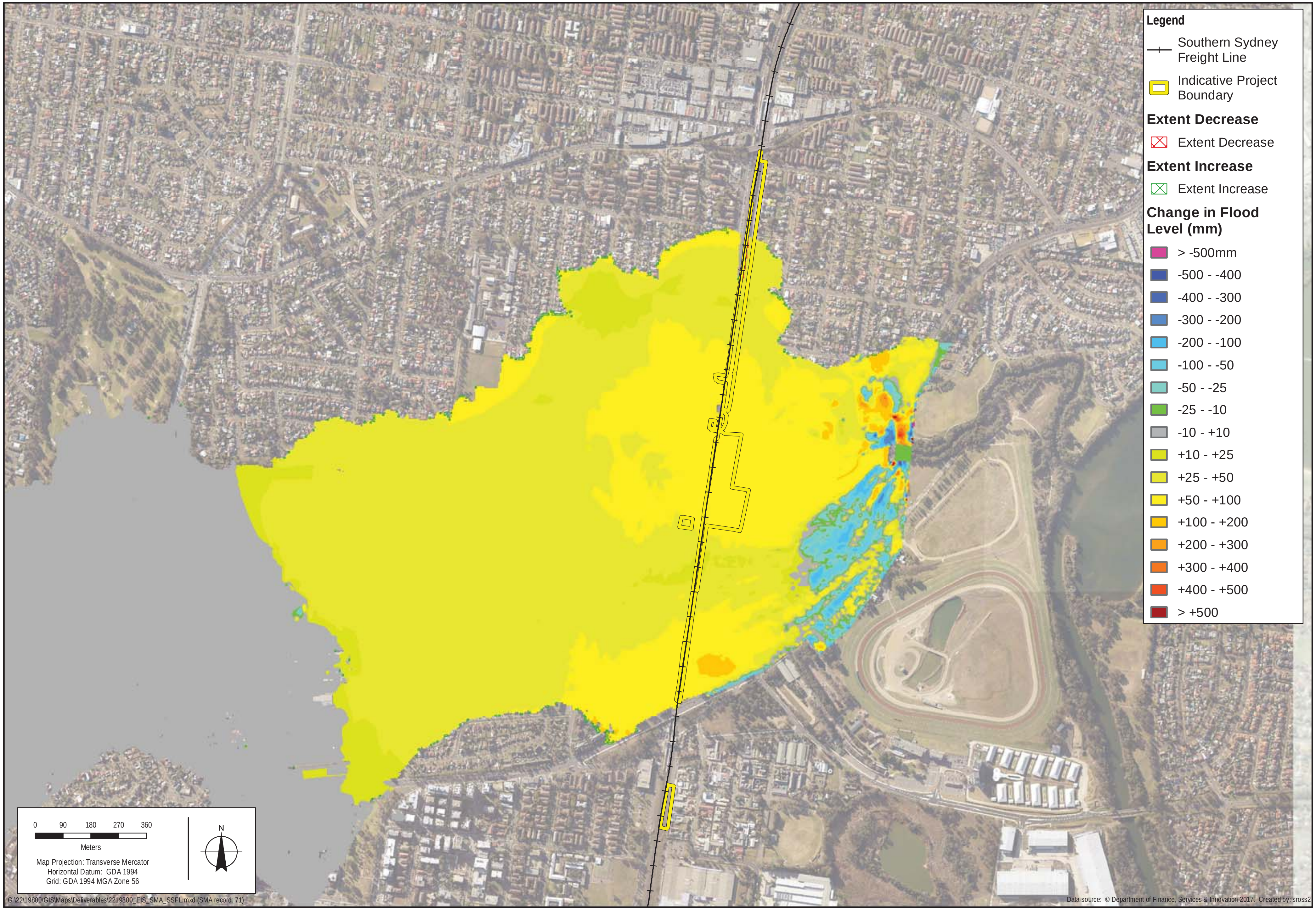

Figure 13.6 – Change in flood depth and extent– probable maximum flood

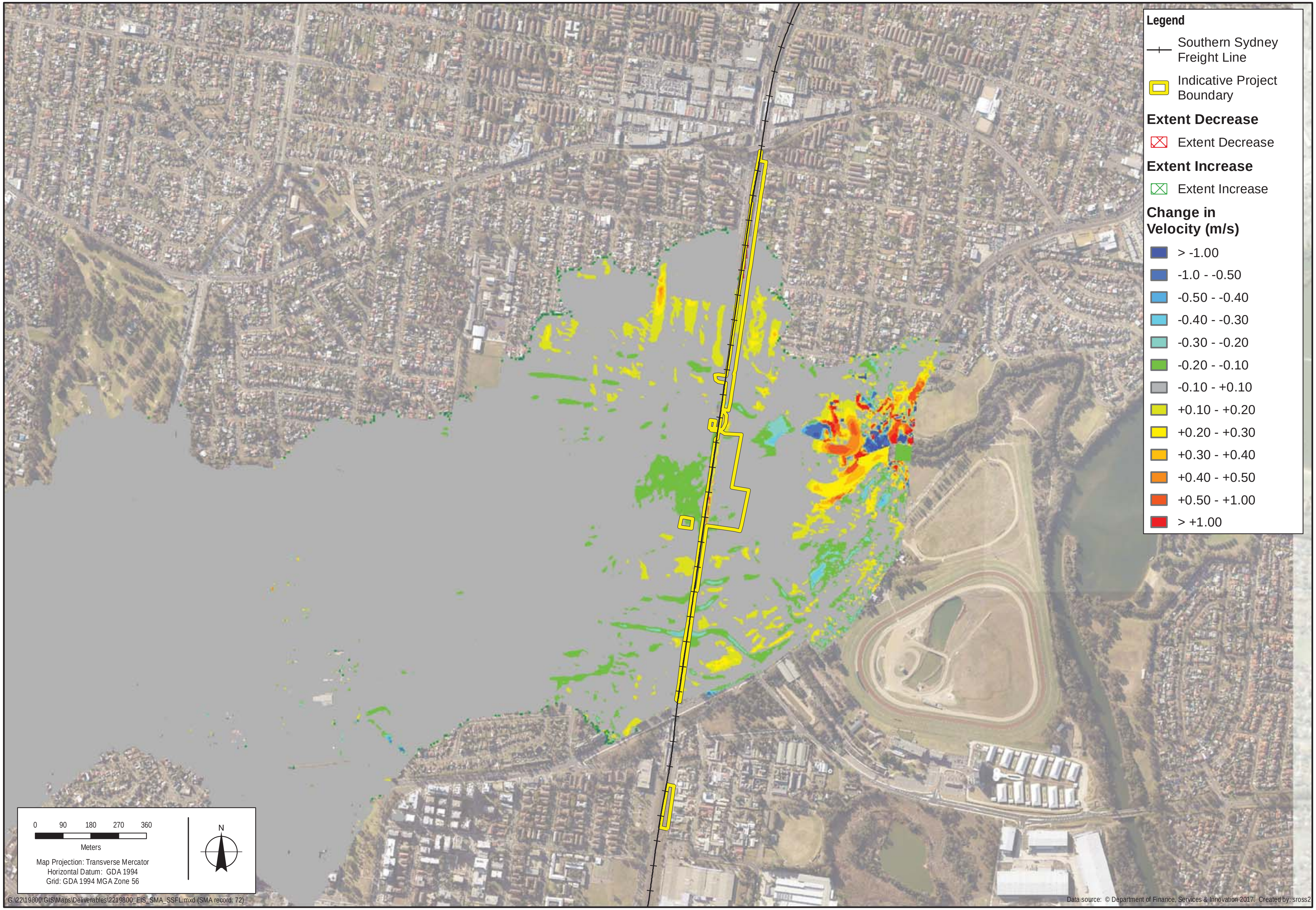

Figure 13.7 – Change in flood velocity – probable maximum flood

With regards to the proposed drainage changes along Broomfield Street the flooding assessment indicated that the project would have a minimal impact on the flooding of the majority of properties along Broomfield Street during the one per cent AEP flood event.

Eight properties that currently experience flooding along Broomfield Street would experience flooding levels beyond the criteria noted in Table 13.2. However, for the majority of these eight properties the flooding impact due to the project would be confined to the front yard of and the flood level increase would be marginal (up to 58 millimetres). That is an increase of up to eight millimetres greater than the proposed criteria. One property (168 Broomfield Street) would potentially experience an increase in flood levels of 175 millimetres (125 millimetres above the proposed criteria) however the area of this increased impact would be small and also only confined to the front yard. Two of the eight properties would experience flooding level increases closer to the front of the dwelling, however these two dwellings are high set and based on existing information would be also unlikely to experience local over floor flooding.

Further refinements of the drainage design will be undertaken during detailed design to mitigate the flood impacts noted above. These design refinements could include changing the proposed level of Broomfield Street to match the existing grading and other similar design refinements.

No adverse impacts due to the proposed drainage changes were noted during the five per cent and ten per cent AEP food events.

The key outcomes in relation to flooding in Broomfield Street due to the proposed project's drainage design and are shown on Figure 13.8 and Figure 13.9 and are summarised in Table 13.4.

Table 13.4 Design performance against flooding criteria (Broomfield Street)

Key criteria	Broomfield Street	Public roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No adjacent roads impacted in one per cent AEP event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event.	Detailed floor level survey not available. However based on available information, over floor flooding in a local 1 per cent AEP event is unlikely for dwellings along Broomfield Street. This is due to be confirmed during detailed design.	
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Increase beyond this criteria was noted at 8 properties along Broomfield Street. Generally the impact is up to 58 mm and within the front yard and away from the dwelling, with exception of two dwellings. However these dwellings are high set, and based on existing information, do not experience local over floor flooding.	
Increase in flood velocities – identification of mitigation measures	A number of locations would experience a decrease in flood velocity. Where increases are noted this would be generally <0.25 m/s for flood events up to the one per cent AEP event.	

13.4.1.2 Increased velocity and scouring of existing waterways

Increases in the velocity of watercourses can occur during flooding events resulting in scouring and erosion. This generally occurs when there is an increase in impermeable surfaces, resulting in additional rainwater running off into stormwater drainage and entering waterways.

The assessment concluded that increases in velocities due to the project are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event (for the inclusion of structures) and for the one per cent AEP event (for the Broomfield Street drainage changes).

Existing velocities in these locations are generally less than two metres per second which is considered slow enough that any increases won't cause adverse impacts on surrounding environments.

13.4.1.3 Consistency with Council floodplain risk management plans

Drainage and structural works associated with the project are compatible with local floodplain risk management plans, and would result in generally minimal increases in existing flood extent and depth.

13.4.1.4 Compatibility with the flood hazard of the land

The project would require minimal works within high hazard areas, and would be limited to the placement of piers within Cabramatta Creek and the presence of an embankment and retaining wall in Jacquie Osmond Reserve. The piers in Cabramatta Creek would match the pier arrangement of the existing bridge to minimise hydraulic impacts on flow along the creek.

The results of flood modelling indicate that the project would not result in a change to existing flood hazard in or surrounding the rail corridor.

Further information regarding the existing flood hazard and the flood hazard post-development, including figures showing the existing and post-development provisional flood hazard mapping, is provided in Technical Report 5.

13.4.1.5 Impacts on existing emergency management arrangements

Impacts on existing emergency management arrangements are expected to be minimal during operation and would be effectively managed through the implementation of the mitigation measures provided in section 13.5.

Figure 13.8 - Change in flood depth and extent with the project (Broomfield Street drainage only)– one per cent AEP

Figure 13.9 – Change in flood velocity with the project (Broomfield Street drainage only)– one per cent AEP

13.4.2 Hydrology

13.4.2.1 Groundwater

Any excavations that may intercept groundwater will be backfilled after construction. Therefore no long term impacts from interception of groundwater are expected.

The installation of piles associated with the retaining walls and bridges are expected to have a negligible impact on groundwater flow paths, given the relatively small footprint of the proposed piling compared to the overall extent of the alluvial aquifer. Additionally, the proposed piling associated with the bridges will match the existing bridge pile layout.

Widening the rail corridor would slightly increase impervious areas in the project site, namely where there was previously permeable surfaces (Jacquie Osmond Reserve and grassed verges along Broomfield Street). The minor increase in impervious areas may result in some local changes to the rates of rainfall infiltration into the alluvial aquifer. As outlined in section 13.2.5 the main groundwater receptor is considered to be base flow to waterways. Runoff from impervious/semi-impervious areas such as Broomfield Street and the rail corridor will continue to flow to Cabramatta Creek and Georges River. Therefore a minor reduction in rainfall infiltration into the alluvial aquifer is likely to have negligible effect on the flows available to groundwater receptors such as Cabramatta Creek and Georges River.

Due to the lack of long term interaction of the project with groundwater, the project will not result in long term impact on groundwater level or quality. Therefore it is predicted that the groundwater impacts from the project would be less than the Level 1 minimal impact considerations specified in the NSW Aquifer Interference Policy.

13.4.2.2 Direct or indirect increases in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses

Increases in the velocity of watercourses can occur during flooding events resulting in scouring and erosion and a reduction in the stability of river banks or watercourses. This generally occurs when there is an increase in impermeable surfaces, resulting in additional rainwater running off into stormwater drainage and entering waterways.

As discussed above the project would result in minimal increases in impermeable surfaces. Hydraulic modelling undertaken for the project determined that increases in velocities are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event. Existing velocities in these locations are generally less than two metres per second which is considered slow enough that any increases won't cause adverse impacts on surrounding environments.

Appropriate scour protection measures would be incorporated into the design of the project, particularly at the new Cabramatta Creek bridge structures, to protect the piers and abutments, and at new stormwater outlets.

13.4.3 Water quality

During operation, the project has the potential to result in water quality impacts mainly from changes in hydrology leading to an increase in erosion and sedimentation, and the mobilisation of pollutants from the rail corridor. Widening the rail corridor would slightly increase the impervious areas of the rail corridor (and potentially surrounding areas as well). This could result in increased generation of surface runoff, litter and other pollutants being conveyed to receiving waterways. The increase in impervious area due to the proposed rail corridor widening is very small relative to the total catchment area and therefore the overall impact on surface water quality would be minimal.

13.4.3.1 Change in pollutants entering watercourses

Contamination of watercourses could occur through increased stormwater runoff containing typical pollutants, such as oils and greases, petrochemicals, and heavy metals, as a result of the operation of rolling stock, track operational wear, and any uncontrolled spills during maintenance activities. Any contamination of watercourses could result in a reduction in water quality, which could impact biodiversity in downstream areas. However, as the proposed use of the railway corridor would be similar to the existing, the potential increase in contamination from these types of pollutants is expected to be very small. Maintenance activities would be undertaken in accordance with ARTC's standard operating procedures.

13.4.3.2 Erosion and sedimentation

An increase in impervious areas could also result in increased flow volumes and velocities, which have the potential to result in erosion and sedimentation at discharge locations if not adequately mitigated.

The change in impervious areas resulting from the project would be very small compared with the level of urbanisation which already exists in the catchment as a whole. Additionally, the design would provide necessary flow retardation structures, including scour protection, to minimise the erosion potential of stormwater flows. As such, potential impacts would be limited and localised in nature.

13.4.3.3 Minimising the effects of proposed stormwater and wastewater management during operation

Increases in impervious surfaces could result in the build-up of contaminants in dry weather, which during rainfall events would be mobilised to surrounding watercourses as stormwater and wastewater. The generation of additional pollutants are directly attributable to the increased impervious surface area. As discussed above the increases in impervious areas are very small, compared with the level of urbanisation which already exists in the catchment as a whole. Therefore any changes to stormwater and wastewater within and surrounding the project site are likely to be insignificant.

13.4.3.4 Achieving water quality objectives

The main pollutants of concern relating to surface runoff include:

- sediments from impervious surfaces from atmospheric deposition
- oils, greases, petrochemicals and heavy metals as a result of the operation of rolling stock, track operational wear and any uncontrolled spills during maintenance activities
- litter from the rail corridor including wind-blown litter
- nutrients such as nitrogen and phosphorus (organic compounds) from biological matter and from natural atmospheric deposition of fine soil particles.

The emphasis in stormwater quality management for surface runoff includes managing the export of suspended solids and associated contaminants (heavy metals, nutrients, hydrocarbons and organic compounds) as well as litter and oils and grease where necessary. Stormwater quality management for Broomfield Street and the rail corridor would be incorporated at detailed design, with the aim of replacing existing management devises with like for like.

It is noted that the water quality outcomes have not yet been assessed against the ANZECC 2000 guideline criteria. An assessment against these criteria would be undertaken during the detailed design.

Provision of water quality treatment measures as per the existing situation is expected to contribute to improved water quality overall, although further analysis would be required during detailed design to confirm this. Implementation of effective water quality treatment measures would mean that the project would not impact on the ability of the catchment to meet the water quality objectives over time.

13.4.4 Cumulative impacts

A number of other projects are either currently occurring within the Liverpool and Fairfield LGAs or are scheduled to occur at the same time as the project (refer to Appendix E). Of these the following two projects are located within 500 metres of the project site and have the potential to occur at the same time as the project:

- a multistorey residential centre at the corner of Broomfield Street and Cabramatta Road adjacent to Cabramatta Station which would be developed by Moon Investments. The site is zoned B4 Mixed Use and consists of 22 privately owned lots and a section of public laneway owned by Fairfield City Council and has a total area of approximately 12,487 square metres. The site is currently being rezoned to mixed use high density for up to 600 residential/commercial units.

- a new car park is proposed in the Cabramatta town centre by Fairfield City Council, on the corner of Hughes Street and Dutton Lane. Work on the new car park is expected to start in mid-2019 and take around nine months to complete. The 220 space car park connects to the existing multi-deck car park with access to a new lift and pedestrian connection to the existing Dutton Plaza lifts.

It is assumed that all buildings and/or infrastructure would be designed in accordance with relevant council standards and guidelines with respect to flooding.

Considering that the study area is already highly urbanised, it is expected that redevelopment near the project site would not have any significant impacts in terms of increased runoff and flow velocities. On this basis, no adverse cumulative impacts are expected.

13.5 Management of impacts

13.5.1 Approach

13.5.1.1 Approach to mitigation and management

The detailed design of the project would continue to take into account necessary measures to minimise the potential for hydrology, flooding, and water quality impacts. This would include further refinements of the drainage design to mitigate the flood impacts noted above. These design refinements could include changing the proposed level of Broomfield Street to match the existing grading, changing the gutter invert levels to increase capacity, installation of berms to divert local flows or duplicating the proposed drainage pipes.

Mitigation measures are provided in this section to mitigate the potential impacts that have not been avoided by the project design to date.

The main water quality risks are associated with erosion and sedimentation, and works within or near Cabramatta Creek. A soil and water management plan would be prepared as part of the CEMP, as discussed in Chapter 12 (Soils and contamination). This would define the management and monitoring measures that would be implemented to manage water quality impacts, erosion, and sediment control in accordance with relevant guidelines. Soil and water management measures would be developed and implemented in accordance with the Blue Book. In accordance with these guidelines, management measures would be designed to manage a 10 per cent AEP rainfall event.

A monitoring program would be implemented prior to and during construction to establish baseline water quality conditions in Cabramatta Creek and monitor water quality outcomes during construction against the water quality objectives for Cabramatta Creek and Georges River. Indicative requirements for the monitoring program would include monitoring at Cabramatta Creek at points both upstream and downstream of the project site for the duration of construction or as otherwise determined, at monthly intervals. Monitoring parameters would be as per the water quality objectives defined in section 13.2.4.

During operation, water quality would be managed to comply with ARTC's EPL (EPL #3142).

13.5.1.2 Expected effectiveness

ARTC has experience in managing potential hydrology, flooding and water quality impacts as a result of rail developments of a similar scale and scope to this project. Project-specific mitigation measures provided in section 13.5 have been developed with the aim of minimising or mitigating, as far as practical, construction and operational impacts to water quality or from changes to the existing hydrological regime of the project site.

The potential impacts to flooding of the project site and of flooding on the project as a result of the project have been modelled. As outlined in section 13.3 and section 13.4 the project structure design, drainage design and flood mitigation strategy for construction and operation is effective at mitigating the potential flooding and hydrological impacts of the project as well as generally providing a one per cent AEP plus climate change level of flood immunity to the project. Where potential flooding impacts were noted due to the proposed drainage changes along Broomfield Street, the design of the project would be further refined to minimise these impacts.

Construction of the project may result in minor and temporary impacts that would be effectively managed through the implementation of standard construction techniques and protection measures.

Audits and reporting of the effectiveness of environmental management measures employed during construction is generally carried out to show compliance with management plans and other relevant approvals and would be outlined in detail in the CEMP prepared for the project.

13.5.2 List of mitigation measures

The mitigation measures that would be implemented to address potential hydrology, flooding and water quality impacts are listed in Table 13.5.

Table 13.5 Mitigation measures

Stage	Impact	Measure
Design	Stormwater runoff	Where feasible and reasonable, detailed design will result in no net increase in stormwater runoff rates in all storm events, unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.
	Scour potential	Any existing rip rap that is impacted or removed during construction would be reinstated. This would include the provision of rip rap around the piers and abutments of Cabramatta Creek bridge. The design of the rip rap will take into consideration the size, quantity and type of rip rap with the aim of not causing additional impacts to water quality.
	Water quality	The project will be designed to ensure there is minimal potential for water quality impacts, including incorporating water sensitive urban design elements.
	Groundwater	A water license will be obtained as necessary in accordance with Part 5 of the *Water Act 1912* if dewatering of excavations is required.
	Flooding	Further assessment and design refinement will be undertaken during detailed design with the objective of not exceeding the following flooding characteristics during the one per cent AEP event: • a maximum increase in time of inundation of one hour in a one per cent AEP event • a maximum increase in 50 mm in inundation at properties were floor levels are currently not exceeded • a maximum increase in 10 mm in inundation at properties were floor levels are currently exceeded. In the event this cannot be met further mitigation would be proposed in consultation with the relevant councils.

Stage	Impact	Measure
Construction	Flooding, changes to surface water and water quality	A flood management procedure will be prepared as part of the soil and water management plan. It will include specific controls to be implemented during wet weather or forecasts of heavy rainfall for works undertaken near Cabramatta Creek and Jacquie Osmond Reserve and appropriate monitoring strategies following the flood to verify design performance and impact predictions It will also include a flood warning and evacuation procedure for emergency management of flooding up to the PMF event. Development of a flood warning and evacuation procedure for the project will be undertaken in consultation with stakeholders including Liverpool City Council and Fairfield City Council and the NSW SES.
	Flooding	The site layout and staging of construction activities will: • avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required • consider how the works will affect the existing stormwater network such that alternatives are in place prior to any disconnection or diversion of stormwater infrastructure.
	Flooding	Detailed construction planning will consider flood risk for compounds and work sites near Jacquie Osmond Reserve and Cabramatta Creek. This will include identification of measures to not worsen existing flooding characteristics. Not worsen is defined as: • a maximum increase in flood levels of 50 mm in a one per cent AEP event • a maximum increase in time of inundation of one hour in a one per cent AEP event • no increase in the potential for soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.
	Watercourse impacts	Works within or near Cabramatta Creek will be undertaken with consideration given to the NSW Department of Primary Industries (Water) *Guidelines for controlled activities on waterfront land – Riparian corridors* (2018).
	Water quality	Dewatered groundwater will be stored and reused on site for wetting down and reducing dust in disturbed areas (within existing erosion and sediment controls), or for irrigation in grassed areas. Requirements for testing will be included in the soils and water management plan and will include the following at a minimum: • No visible sheen or odour is noted. • Water pH is between 6.5 and 8.5. • Total suspended solids are less than 60 mg/L (approximately equivalent to a turbidity level of 50 NTU). Water may be dosed with gypsum, alum or a similar product to reduce sediment levels if required. • All litter and debris must be filtered out and removed prior to reuse.

Stage	Impact	Measure
		• Pump-out events are supervised at all times, and the pump is positioned to prevent reuse of sediment-laden water settled at the bottom of the trench or tank. • Sludge from the bottom of the trench or tank can be placed in a shallow pit lined with heavy duty plastic sheeting to dry out (evaporation pit). Once the sludge has dried out sufficiently to allow it to be spaded this waste can be stored with excess excavated spoil and disposed in accordance with the findings of the preliminary waste classification assessment (refer to Technical Report 6 – Soils and contamination impact assessment).
	Water quality	A water quality monitoring program will be developed and implemented, to monitor water quality due to the proximity of construction activities to surface water receiving environments. The program will include relevant water quality objectives, parameters, and criteria and specific monitoring locations identified in consultation with DPI (Water) and the EPA.

13.5.3 Consideration of the interaction between measures

In addition to the measures for water quality measures described above, there are interactions between the mitigation measures for soils and contamination (Chapter 12 (Soils and contamination), waste (Chapter 19 (Waste management)), and hazardous materials (Chapter 20 (Health, safety, and hazards)). Together, all these measures would ensure appropriate management of water quality, to minimise the potential for impacts to the community and environment.

13.5.4 Managing residual impacts

A residual risk analysis was undertaken following the impact assessment summarised in this chapter. The results of the residual risk analysis are provided in Appendix D and summarised below.

It is expected that with the appropriate mitigation measures in place, residual impacts during construction are likely to be negligible.

Residual operational impacts of the project could include increases in flood level in rare to extreme flood events. This could include impacts to surrounding properties, including increased flood depth, potential flood damages during a flood event, and emergency access during times of flooding. Further consultation with relevant stakeholders and consideration of these potential impacts during the detailed design phase will reduce any residual impacts to an acceptable level.

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