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Surface Water and Hydrology

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Surface Water and Hydrology

Major Civil and Construction Works - EIS 1

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Prepared for

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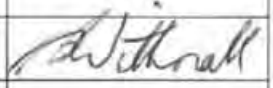
3	26-Mar-2012	Final for Pubic Exhibition	Bruce Withnall Technical Director	

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Glossary

Terminology	Description
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500m^3/s has an AEP of five per cent, it means that there is a five per cent chance (that is one in 20 chance) of a 500m^3/s or larger flood event occurring in any one year (see also average recurrence interval).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as or larger than the selected event, for example, floods with a discharge as great as or greater than the 20 year ARI flood will occur, on average, once in every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site location. It always relates to an area above a specific location.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving, for example metres per second (m/s).
Emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
Floodplain	Area of land that is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in the NSW Floodplain Development Manual (2005). Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning area	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels (FPLs)	Are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.

Terminology	Description
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
Flood prone land	Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into 3 types, existing, future and continuing risks. They are described below: • Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. • Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. • Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Habitable room	In a residential situation: a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
Hazard	A source of potential harm or a situation with a potential to cause loss. In relation to the NSW Floodplain Development Manual (2005) the hazard is flooding which has the potential to cause damage to the community.
Hydraulics	The term given to the study of water flow in waterways, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
Hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river estuary, lake or dam.
Local drainage	Smaller scale problems in urban areas.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purposes of the NSW Floodplain Development Manual (2005) major drainage involves: • The floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows

Terminology	Description
	develop along alternative paths once system capacity is exceeded; and/or • Water depths generally in excess of 0.3m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • Major overland flowpaths through developed areas outside of defined drainage reserves; and/or • The potential to affect a number of buildings along the major flow path.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State's rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into council plans, policy, and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local flood risk management policy and EPIs.
Minor, moderate and major flooding	Both the SES and the BoM use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: • Minor flooding: causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. • Moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. • Major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.
Modification measures	Measures that modify either the flood, the property or the response to flooding.
Overbank	Area outside the top of bank of the main channel of the creek or watercourse.
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable maximum precipitation	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
Probability	A statistical measure of the expected chance of flooding (see AEP).
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the NSW Floodplain Development Manual (2005) it is the likelihood of consequences arising from

Terminology	Description
	the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Stage	Equivalent to water level (both measured with reference to a specified datum).
Stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
Survey plan	A plan prepared by a registered surveyor.
Water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
Note: project description terminology is contained in the project description.	

Executive Summary

A detailed assessment of surface water and hydrology issues, incorporating flooding and water quality, has been undertaken to establish existing baseline conditions and to quantify the nature and extent of any potential impacts associated with the proposed North West Rail Link (NWRL) major civil and construction works. The assessment included in this report has specifically focused on the potential impacts associated with the major civil and construction works, however, some consideration of the ultimate conditions has been discussed as appropriate. Where impacts have been identified, a range of appropriate mitigation measures have been proposed to ensure such impacts are minimised.

This report has been prepared to support the Environmental Impact Statement for Stage 1 (Major Civil Construction Works) of the NWRL (referred to as EIS 1). Proposed construction activities are described in detail in the Project Description of EIS 1 (Chapter 7). Major civil works to be undertaken include the viaduct that spans the Elizabeth Macarthur and Caddies Creek systems, and the bridge crossing of Second Ponds Creek.

The EIS for Stage 2 (Stations, Rail Infrastructure and Systems; EIS 2) will address the operational impacts of the project, including:

- Flood risks to the rail infrastructure (above ground and below ground), station precincts and ancillary facilities (such as substations and tunnel service facilities).
- Flood impacts of proposed rail infrastructure, station precincts and ancillary facilities on the surrounding environment.
- Impacts on stormwater quality and quantity during operation of the rail infrastructure, station precincts and ancillary facilities.

Potential Flooding Impacts

Flooding of the creeks and waterways which traverse the project corridor has the potential to inundate the construction sites and cause damage to the project works, delays in construction programming, pose a safety risk to construction workers and detrimentally impact the downstream waterways through the transport of sediments and construction materials by floodwaters. Furthermore, any proposed works within the floodplain have the potential to change existing flood behaviour and adversely impact on the surrounding environment. It is therefore necessary to manage the nature and extent of works within the floodplain in order to minimise the flood risk to the Project and surrounding environment.

Detailed hydrologic and hydraulic modelling has been undertaken for all of the major creek waterways and associated floodplains to assess the proposed construction sites and works (access tracks, haul roads, work platforms, tunnelling sites and major earthworks) and to quantify the nature and extent of potential impacts. The results generally indicate those areas at greatest risk from potential impacts are associated with the construction works and that, where necessary, these should be manageable with the implementation of appropriate mitigation measures as have been identified.

A summary of the key flooding and drainage related issues and impacts relating to the various elements of the project construction works is provided below.

Tunnel Construction: The NWRL alignment from Epping to Bella Vista is proposed to be underground, involving the excavation of twin tunnels over a distance of approximately 15.2km. While the tunnel excavation arrangement will be designed to accommodate a nominal amount of stormwater runoff, if a significant amount of floodwater ingress into the tunnel excavations was to occur this would flood the tunnel machines with potential risk to personal safety, damage to machinery and delays to the project. It will therefore be necessary to ensure that the potential for ingress of floodwaters into the tunnel excavations is appropriately managed at tunnel entries. The flooding potential at each tunnel entry is summarised in Table 4. At all sites there would also be potential for local runoff to enter the tunnels and this would need to be addressed through local stormwater management of the site.

Earthworks Fill Embankment and Cuttings (Incorporating Sites 8 to 11, 16 and 17): From immediately north of Bella Vista Station through to Balmoral Road (Sites 8 and 9) the rail corridor is located outside the floodplain and therefore, apart from local drainage and overland flow, no flood impacts or risks are expected with regards to the earthworks in these areas. The western fringe of Site 11 is affected by flooding from Elizabeth Macarthur Creek.

The embankments at the Second Ponds Creek bridge are to be located outside the 100 year ARI flood extents. Consequently, flood risks to the project works during embankment construction could be managed through appropriate staging and stabilisation of works.

The western edge of Site 17 bordering the First Ponds Creek tributary is partially flood affected under existing conditions.

Temporary Works: Temporary access tracks and haul roads will be required across the floodplain and creek channels to facilitate construction of the viaduct and bridge structures. Running off the access roads will be a series of construction platforms, one at each viaduct or bridge column, to support machinery and equipment required for the piling and construction of columns and headstocks.

These temporary works will have the potential for significantly greater flood impacts in comparison to the permanent structures alone, albeit the risk exposure will be for a shorter period of time. These potential impacts need to be managed taking into consideration the period of time that the temporary works will be in place.

For the purposes of identifying the potential range of flood impacts, and in the absence of detailed information on the likely haul road arrangements, two possible temporary works arrangements were modelled based on haul road thicknesses of 0.5m and 2m above natural surface, and including the viaduct piers. Provisional waterway openings were provided at the various creek crossings. Working pads at each viaduct column have been modelled, but depending on the final layout these could potentially result in greater impacts than those identified in this assessment.

At the confluence of Caddies Creek, Elizabeth Macarthur Creek and Tributary 5, the hydraulic model results indicate that with a 0.5m thick haul road, localised flood level impacts of up to 0.2m would be expected in the 100 year ARI event. Within the adjacent residential areas the flood level impacts would be up to 0.1m. Under the 2m thick haul road

arrangement flood level impacts on adjacent properties would be 0.25m. The haul road in this area has the potential to cause much greater flood level impacts than the viaduct piers.

At Tributary 4 the flood level impacts would be up to 0.3m for the 0.5m thick haul road and up to 0.7m for the 2m thick haul road. For the 0.5m thick haul road, impacts would be confined to the area between the Transitway and the NWRL alignment if adequate waterway openings are provided. However, for the 2m haul road, impacts would extend to Windsor Road and further upstream.

At Tributary 3 the haul road would run adjacent to, and immediately downstream of the Windsor Road Transitway. The extent of road within the floodplain is relatively small and flood impacts would be minimised by providing an appropriately sized temporary waterway crossing.

Stations and Services Facilities Construction (Sites 1 to 8, 11, 14 and 17): The above ground stations at Kellyville (Site 11), Rouse Hill (Site 14) and Cudgegong Road (Site 17) as well as the stabling facility are located outside the 100 year ARI flood extent and therefore flooding is not expected to pose a significant risk during construction.

Spoil Management and Stockpile Areas (Sites 8 to 11, 16 and 17): The construction of the NWRL will generate a significant quantity of spoil as a result of excavations for tunnels, below ground stations and services facilities, and above ground civil works (including Cudgegong Road Station and Tallawong Stabling Facility). Stockpiles located in the floodplain have the potential to obstruct and alter flood behaviour which can have adverse impacts on the surrounding environment. A summary of the flooding potential at each stockpile site is provided in Table 7.

The location of the concrete batching shed or storage of pre-cast units within the floodplain at the Balmoral Road and Memorial Avenue sites (Sites 8 and 9 respectively) would have the potential to alter flooding patterns and impact on the adjacent development. These sites are predominantly located outside of the 100 year flood extent and consequently flood impacts could be managed appropriately.

Climate Change: The time periods for potential climate change impacts relative to the time period for construction of the major civil works is such that climate change impacts on increased rainfall intensity are not expected to have a significant effect on the construction of the NWRL project.

Potential Water Quality Impacts

The construction phase of the proposal has the potential to impact on the water quality of the receiving environment. The scale and nature of potential impacts are potentially greater than those that may ultimately be experienced under the operational phase.

The major civil construction works would involve excavation in many locations, resulting in disturbance and exposure of the underlying soils. This has the potential to lead to increased erosion and sediment transport and ultimately sedimentation in downstream water bodies. The potential for sediment transport and sedimentation issues is influenced by factors such

as severity of storm events, the slope and footprint of disturbed area and the management controls that are implemented on site.

Works involving excavation would have the greatest potential to result in sediment transport and sedimentation issues. Such works would include:

- tunnel excavation
- station excavation
- construction of viaduct columns and bridge piers
- general civil works associated with the construction of the rail alignment, temporary and permanent roads and ancillary station facilities
- stockpiling and handling of significant spoil associated with the above activities

These works affect all 17 construction sites in one form or another and pose the greatest risk where they occur near waterways (such as Caddies Creek and its tributaries), on steep slopes or on land subject to overland flow or flooding. A management framework and site specific controls would need to be developed and implemented to reduce the risks of sedimentation in down gradient water bodies due to the proposed civil and constructions works.

A preliminary assessment of areas more likely to be prone to erosion due to the construction works has been undertaken based on soil landscapes, ground conditions (rock or soil), erodibility, slope, extent of clearing required, location of works relative to sensitive receiving environments and the type of construction works being undertaken (piers/piling works, fill earthworks or cut slopes). Maps showing the results of this assessment have been produced with the potential risk categorised as either high or medium to low.

A comprehensive range of appropriate management strategies and measures to manage flooding, surface water and water quality issues during the major civil construction works are summarised below.

Mitigation Measures

Flooding

Management of potential flood related impacts associated with the major civil and construction works needs to minimise the risks to the surrounding environment as well as the works themselves. A stormwater management plan that identifies the appropriate design standard for flood mitigation based on the duration of construction, proposed activities and flood risks would be developed for each construction site. The plan would develop procedures to ensure that threats to human safety and damage to infrastructure and surrounding properties are not exacerbated during the construction period.

Appropriate mitigation measures to be implemented will vary depending on the nature of the risks and sensitivity of the particular situation but would include consideration of the typical measures outlined below:

- Minimising the areas of works or site compounds within the identified floodplain areas.

- Programming or staging any construction associated with creek/channel works or the transverse culverts to minimise the total time that works are undertaken in the vicinity of watercourses and thereby minimise the risk exposure.
- Ensuring construction equipment (or excess material) is removed from the waterway or floodplain areas if wet weather is approaching and at the completion of each day's work activity.
- Strategically placing temporary levees or bunds to contain potential impacts and minimise the risk to surrounding properties which might otherwise be affected.
- Consider potential flood proofing of properties where appropriate or necessary.
- Protect entries to tunnel excavations against the potential ingress of frequent flooding.
- For the Caddies Creek and Elizabeth Macarthur Creek floodplain (Sites 10 to 13), and similarly Second Ponds Creek floodplain, the height of any embankments required for construction access tracks and work platforms should be limited to 0.5m maximum for appropriate lengths of floodplain and allow controlled overtopping.
- Temporary embankments or fill platforms should be removed as soon as practical after serving their primary purpose so as to minimise the timeframe of obstructing the floodplain.
- Stockpile sites should be located in areas where frequent flooding is avoided (such as outside the 20 year ARI flood extent).

Water Quality

As a general guiding principle for the major civil and construction works, water quality mitigation and management measures would be implemented in accordance with the requirements of current guidelines and best construction practices. The control and mitigation of potential surface water quality impacts during the construction phase would be defined in a Soil and Water Management Plan (SWMP) prepared as part of the overall Construction Environmental Management Plan (CEMP). This Plan would be continually updated to suit the ever changing needs as the project works progress. Due consideration would also be given to the extent of works and situation relative to the sensitivity of the surrounding environment. Typical mitigation measures to be considered or implemented are outlined below:

- Preparation of soil risk maps under the CEMP based on the nature of the site conditions and the type of construction works being undertaken.
- Management of Site Operations with assistance of a qualified soil conservation officer and engagement of all site staff on soil and water management practices through tool box talks and training.
- Installation of appropriate erosion and sedimentation control measures such as silt fencing, straw bales, check dams, temporary sedimentation basins and soil stabilisation, diversion berms or site regrading.
- Minimising disturbed areas and re-vegetating or stabilising such areas as soon as practical as the works progress.

- Stockpiling of materials would only be in designated areas which are above a nominated flood level.
- Work Method Statements would be prepared for all waterway works with particular emphasis on the early implementation of erosion and scour protection requirements.
- Any work platforms or access tracks required through waterway areas would be constructed of large clean rock material wrapped or underlain with geofabric.
- Provision of appropriate scour protection at all temporary waterway crossings while minimising disturbance within the riparian area.
- Provision of bunded areas for storage of hazardous materials such as oils, chemicals and refuelling areas.
- Treatment of tunnel generated water during excavation works at all sites.
- Implementation of a surface water quality monitoring program prior to and during the construction period.

Monitoring would be carried out periodically and after rainfall events to assess the operation of water quality mitigation measures.

1.0 Introduction

1.1 The Project

The North West Rail Link (NWRL) comprises the provision of new electrified passenger railway between Epping and Tallawong Road extending the rail network to North West Sydney. It would be a two track rail corridor 23km in length, comprising the following main components:

- A direct underground connection into the existing Epping to Chatswood Rail Line at Epping
- A service facility at Epping
- A service facility at Cheltenham
- Two tunnel stubs to safeguard for Parramatta to Epping Rail Line
- Eight stations – Cherrybrook Station, Castle Hill Station, Hills Centre Station, Norwest Station, Bella Vista Station, Kellyville Station, Rouse Hill Station and Cudgegong Road Station
- An underground section of route comprised of 15.5km of two track railway in a twin tunnel configuration with cross passages at regular intervals between Epping and Kellyville
- The remaining 7.5km surface section of route from Kellyville to Tallawong Road stabling facility would be a combination of viaduct, embankment, at grade and cutting
- A stabling facility at Tallawong Road for 16 eight-car trainsets with provision for later expansion to 24 eight-car trainsets.

The proposed NWRL alignment is shown in Figure 1.

Figure 1 Proposed NWRL Alignment

1.2 Study Objectives

The purpose of this report is to identify and document potential hydrologic impacts associated with the proposed major civil construction works component of the NWRL. Recommended mitigation measures are provided to develop a framework for managing construction related impacts. The hydrologic impacts to be considered include:

- Flood impacts on the surrounding environment,
- Flood risks to the construction works,
- Water quality impacts,
- Stream ecology (including impacts on stream flows and riparian corridors).

1.3 Director-General's Requirements, Conditions of Approval and Statement of Commitments

Following the public exhibition of the NWRL Environmental Assessment and Concept Plan between November 2006 and February 2007, a Supplementary Submissions Report was prepared by the Transport Infrastructure Development Corporation (now Transport for New South Wales) documenting and responding to submissions received. As part of this Submissions Report an updated Statement of Commitments was prepared to incorporate any proposed changes or requirements of the Project.

Supplementary Director General Requirements were received on the 3 February 2012 covering the proposed modification to the Staged Significant Infrastructure (SSI) approval and the SSI application for the NWRL - Major Civil Construction Works.

The supplementary Director General's Requirements, combined with the Minister's Conditions of Approval and the Statement of Commitments, form the compliance requirements for the Project. Requirements relating to the surface water and hydrologic assessment addressed in this report are outlined in Table 1.

Table 1 Conditions of Approval and Statement of Commitments

Supplementary Director General Requirements	Description	Addressed
Soils and Minerals Resources		
	Spoil and waste generation and associated impacts, including: storage, handling and disposal; soil erosion and associated water course impacts, soil salinity and acid sulphate soils; and potential mineral resource and mine subsidence impacts, including consultation with NSW Trade and Investment and the Mine Subsidence Board.	Soil erosion and potential watercourse impacts are discussed in Section 5.2. Potential for soil salinity and acid sulphate soils and associated impacts on water quality are discussed in Section 5.2. For spoil and waste generation impacts refer to the Soils and Groundwater chapter of the EIS. For potential mineral resource and mine subsidence impacts refer to the Soils and Groundwater chapter of the EIS.

CoA Reference	Description	Addressed
Surface Water and Hydrology		
3.9	For surface components of the project located on floodplains, the Proponent shall identify flood design criteria in accordance with the Floodplain Development Manual (2005), describing risks to existing and planned future receivers and infrastructure based on the modelling of a full range of flood sizes up to and including the probable maximum flood.	Flood related criteria to manage impacts and risks associated with the major civil construction works have been established based on the guiding principles listed in Section 2.7, including the Floodplain Development Manual (2005). Under the major civil construction works that form EIS1, flood design criteria need to be considered in the context of the duration of the construction works and therefore the period of time of risk exposure. This is discussed further in Section 2.7.1. Operational flood design criteria relating to the rail infrastructure, stations and ancillary facilities will be addressed in EIS 2. Flood related risks and impacts under the scope of EIS 1 are discussed in Section 5.1. Assessment has been based on the flood modelling (hydrology and hydraulics) outlined in Appendices A and B. Associated criteria to manage identified impacts are outlined in Section 6.1.
3.10	For temporary construction sites located on floodplains, the Proponent shall identify reasonable and feasible mitigation measures for mitigating flood risk, including procedures for restoring and monitoring any temporary creek diversions consistent with pre-construction conditions.	Mitigation measures for managing flood risks during construction are outlined in Section 6.1. The need for temporary creek diversions has been reduced through the removal of cut and cover tunnel previously proposed at Cattai Creek (Hills Station) and Cadies Creek Tributary 3 (Rouse Hill). Measures for managing impacts in riparian areas, including temporary works within creeks, are outlined in Section 6.2.6.
3.11	For cut and cover tunnel components which cross creek lines, the Proponent shall describe the proposed construction methodology, identifying measures to minimise the risk of bed cracking and loss of surface flow and contingency measures for restoring and monitoring waterways, consistent with pre-construction conditions.	The need for construction of cut and cover tunnel components across creek lines has been engineered out of the design. The cut and cover tunnel crossing previously proposed at Cattai Creek has been removed by shifting the track alignment and location of the Hills Station away from the creek. The need for a cut and cover tunnel crossing at Caddies Creek Tributary 3 has been removed by the viaduct design, which elevates the rail line above the creek at this location. Refer to the Project Description of the main EIS (Chapter 7) for further details.
3.12	The Proponent shall identify impacts to riparian and instream ecology from any direct disturbances to waterways and to flora and fauna from changes to creek flow or flood behaviour, during construction or operation.	Water quality impacts are addressed in Section 5.2. Impacts on riparian vegetation and stream ecology relating to changes in flow regimes are addressed in the Riparian Assessment (Eco Logical Australia, 2012a)

Statement of Commitments	Description	Addressed
Hydrology and Surface Water		
Action 36	A detailed flood assessment would be undertaken in accordance with appropriate NSW Government guidelines and in consultation with Councils and relevant Government agencies. This would include a two dimensional model of the Caddies Creek confluence to facilitate a better understanding of the discharges at the confluence of the creeks and associated design requirements.	A detailed flood assessment has been carried out, including 2 dimensional modelling of the Caddies Creek confluence. The flood assessment carried out has been tailored to the nature of extent of the project, and is outlined in Section 3.1 and Appendices A and B.
Action 37	Investigations into the construction and operational impacts on Elizabeth Macarthur Creek would be undertaken in accordance with relevant NSW Government guidelines.	Investigations have been undertaken to assess flood and water quality related impacts of the project on Elizabeth Macarthur Creek. Relevant guidelines used in the assessment are listed in Section 2.2. Flood and water quality related impacts are discussed in Sections 5 1 and 5.2 respectively.
Action 38	The floodplain storage impacts would be defined during design development in accordance with the relevant NSW Government guidelines.	Floodplain storage impacts are discussed in Section 5.1.10. Flood impacts in general have been assessed through detailed modelling that, where appropriate, has taken into account floodplain storage impacts (refer Section 3.2and Appendices A and B).
Action 39	Further investigations into the location, size and treatment levels of a water treatment plant(s) would be undertaken in consultation with DECC, Councils and RailCorp. Investigations would include identifying discharge points, determining the receiving water quality and water re-use/recycling opportunities.	Water treatment plant requirements to collect, treat and discharge groundwater and other water from the tunnels and below ground stations will be addressed in EIS 2 as part of the Geotechnical and Groundwater investigations.

1.4 Study Scope

Surface water and hydrology assessments have been carried out in relation to the Major Civil and Construction Works for the NWRL. Potential impacts include:

- Flood impacts on the surrounding environment due to the proposed construction activities.
- Flood risks to the construction activities based on the potential for flooding and the consequences of flood inundation to the construction sites.
- Environmental impacts on the existing stream ecology in terms of potential changes in water quality.

This report has been prepared to support the Environmental Impact Statement for Stage 1 (Major Civil Construction Works) of the NWRL (referred to as EIS 1). Proposed construction activities are described in detail in the Project Description of EIS 1 (Chapter 7). Major civil works to be undertaken include the viaduct that spans the Elizabeth Macarthur and Caddies Creek systems, and the bridge crossing of Second Ponds Creek.

The EIS for Stage 2, Stations, Rail Infrastructure and Systems (EIS 2), will address the operational impacts of the project, including:

- Flood risks to the rail infrastructure (above ground and below ground), station precincts and ancillary facilities (such as substations and tunnel service facilities).
- Flood impacts of proposed rail infrastructure, station precincts and ancillary facilities on the surrounding environment.
- Impacts on stormwater quality and quantity during operation of the rail infrastructure, station precincts and ancillary facilities.

Refer to the Project Description chapter of the EIS for a full definition of the scope of EIS 1.

Stream ecology impacts relating to changes in flow regimes and removal of riparian vegetation are addressed in the Riparian Ecology Report (Eco Logical Australia, 2012a).

Surface water and hydrologic impacts during the operational phase of the NWRL project are to be addressed in EIS 2: Stations, Rail Infrastructure and Systems. This will include an assessment of operational flood and water quality related impacts and risks at the stations and ancillary facilities such as substations, stabling yards and services facilities.

To satisfy the requirements of EIS 1 the following tasks have been undertaken:

- Collation and review of background information (previous studies, survey and mapping data) relevant to the project.
- Consultation with government agencies and stakeholders. Consultation has been carried out during the EIS process by TfNSW. Government authorities have also been consulted by the Department of Planning and Infrastructure in reviewing the requirements for EIS 1. Comments from government authorities were provided with the Supplementary Director General requirements and have been taken into consideration in the preparation of the hydrologic assessment.
- Identification of guiding principles for the assessment of hydrologic impacts during construction, including floodplain management, water quality and stream ecology.
- Flood modelling (combination of hydrologic and hydraulic models) to quantify existing flood behaviour and identify potential flood impacts and risks during major civil and construction works.
- Water quality impact assessment through the collation and review of available information to define existing conditions and identify potential impacts during the major civil and construction works.
- Identification of mitigation measures to manage flood and water quality impacts.

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2.0 Background

2.1 Project Area

The proposed North West Rail Link (NWRL) extends from Epping in the south-east, to Rouse Hill in the north-west. Between Epping and Bella Vista the alignment is below ground. From Bella Vista to Rouse Hill the alignment consists predominantly of viaduct as well as a mixture of cutting, embankment and at grade sections.

2.2 Waterways

The NWRL corridor crosses a number of named and unnamed tributaries of Parramatta River and Hawkesbury River. Major waterways in the vicinity of the Project are shown on Figures 1a and 1b. The waterways traversed by the construction sites that form EIS1 are summarised in Table 3 (refer Section 3.1).

2.3 Topography

Between Epping and Hills Centre the rail corridor passes through an area of established suburbs and relatively hilly terrain, with ground levels varying between 50m Australian Height Datum (AHD) and 190m AHD. Mostly commercial or industrial development exists from Hills Centre north-west to Bella Vista. This area is typified by gently rolling hills and valleys. From Bella Vista the alignment follows Old Windsor Road and Windsor Road north-west towards Rouse Hill, traversing relatively flat or gently undulating terrain with relatively broad floodplains.

2.4 Rainfall and Evaporation

The project area is characterised by generally high summer-autumn and low winter-spring rainfall. For the south eastern section of the Project (Epping to Bella Vista) average monthly rainfall ranges from approximately 80-140 millimetres in the summer-autumn months to approximately 60-110 millimetres in the winter-spring months. For the north-western section of the Project (Bella Vista to Rouse Hill) average monthly rainfall ranges from approximately 70-120 millimetres in the summer-autumn months to approximately 40-110 millimetres in the winter-spring months.

Average annual rainfall across the project area varies from 1140 mm in the south east, to 870 mm in the north west. (Source: Bureau of Meterology (BOM) monthly rainfall data for Macquarie Park, Pennant Hills, Seven Hills and Prospect). Average monthly evaporation in the region ranges from less than 100 millimetres in the winter months to over 400 millimetres in the summer months (Source: BOM monthly average pan evaporation map, 2006).

2.5 Geology

The project area lies within the Sydney Basin and generally on elevated terrain known as the Hornsby Plateau. The rocks, which comprise the upper part of the Basin, consist largely of Triassic aged sedimentary rocks with occasional Jurassic aged volcanic intrusions. This bedrock geology is overlain by residual soils, and locally by Quaternary alluvium, slope wash and fill.

AECOM

North West Rail Link EIS

Major Waterways - West

Source: AECOM

0 0.5 1 2 km

27 MAR 2012

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1a

AECOM

North West Rail Link EIS

Major Waterways - East

Source: AECOM

0 0.5 1 2 km

27 MAR 2012

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1b

The geological materials present within the project area are defined below and in Table 2:

- Alluvium and colluvium, comprising soils deposited in stream beds or formed as a result of erosion or mass movement processes;
- Residual soil (completely weathered rock);
- Wianamatta Group, (Bringelly Shale, Minchinbury sandstone and Ashfield Shale) comprising siltstones, interbedded siltstones and fine-grained sandstone, and fine-grained lithic sandstone;
- Mittagong Formation, comprising interbedded siltstone and fine-grained sandstone; and
- Hawkesbury Sandstone, a fine to medium and course grained quartz sandstone with some interbeds of laminated siltstone and very fine to fine sandstones ("shales lenses").

Table 2 Geological Stratigraphy along NWRL Alignment

Location	Down Track Chainage Interval (m)	Geological Unit
Epping Station Stub Tunnels to West Pennant Hills	Ch24980 to Ch30400	Hawkesbury Sandstone - Ashfield Shale
West Pennant Hills to Old Northern Road	Ch30400 to Ch33000	Ashfield Shale
Old Northern Road to Norwest Boulevard	Ch33000 to Ch 38600	Hawkesbury Sandstone - Ashfield Shale
Norwest Boulevard to Celebration Drive	Ch38600 to Ch40480	Ashfield Shale
Celebration Drive to Memorial Road	Ch40480 to Ch41680	Residual soil and Ashfield Shale
Memorial Road to Kellyville Station	Ch41680 to Ch42530	Residual soil and Ashfield Shale
Kellyville Station to Windsor Road	Ch42530 to Ch43630	Alluvium, Residual soil and Ashfield Shale
Windsor Road to Sanctuary Drive	Ch43630 to Ch44590	Alluvium, Residual soil and Ashfield Shale
Sanctuary Drive to Terry Road (including Rouse Hill Station)	Ch44590 to Ch46200	Residual soil and Ashfield Shale
Terry Road to end of Stabling Yard	Ch46200 to Ch 48035	Residual soil, Bringelly Shale and Ashfield Shale

Note: Mittagong Formation occurs with variable thickness between the Ashfield Shale and underlying Hawkesbury Sandstone.

Within the extent of the Project corridor there are two major geological formations being Hawkesbury Sandstone and the overlying Ashfield Shale member of the Wianamatta Group. The interface between the two formations may be marked by the presence of the Mittagong Formation.

Hawkesbury Sandstone is a medium to coarse grained quartz sandstone with minor lenses of shale and laminate. The Wianamatta Group Shales comprise Ashfield and Bringelly Shale Formations. The Ashfield Shale consists of black to dark grey shale and laminate. Bringelly Shale is comprised of shale, calcareous claystone, laminate and fine to medium-grained lithic-quartz sandstone. The Mittagong Formation is comprised of alternating bands (and lenses) of sandstone and black siltstone of variable thickness. The quartz sandstone is of a finer grain than the Hawkesbury Formation.

The Hawkesbury Sandstone relief tends to be fairly rugged with rolling to very steep hills with steep or benched side slopes. Relief in the Ashfield Shale is generally undulating with rounded ridges and hill crests.

2.6 Soils

2.6.1 Soil Landscapes

There are six major soil landscapes occurring throughout the corridor, shown on Figure 2. The Glenorie Landscape (gn) is the main soil landscape on the Wianamatta Group Shales. Typically these soils have a depth of up to 2m approximately with the topsoil consisting of a friable dark brown loam. This soil is present across the majority of the eastern section of the project.

Other soils within the south-eastern section of the Project include Hawkesbury (ha) and Gymea (gy) Landscapes. Soils within the Hawkesbury Landscape (ha) are typically less than 0.5m deep. These shallow soils in conjunction with the steep terrain are classified as an extreme erosion hazard. The Gymea Landscape is typified by soil depths of up to 1m and has a high to extreme erosion hazard.

The north-western section of the Project is dominated by the Blacktown (bt) group and bordered by the Luddenham (lu) group. These alluvial soils are classified as a high erosion hazard and can be expansive.

Key characteristics of the soil landscapes experienced across the Project are:

- Glenorie (gn). Present across the south eastern portion of the Project, including Epping, Cherrybrook and Castle Hill. High soil erosion hazard, localised impermeable highly plastic subsoils, moderately expansive. Soil Hydrologic Group C (Sediment Type F/D).
- Blacktown (bt). Experienced in the Bella Vista, Kellyville and Rouse Hill area. Poorly drained soils with low fertility, localised high plasticity and expansive subsoils. Soil Hydrologic Group C (Sediment Type F/D).
- Gymea (gy). Relatively local presence in the vicinity of the Epping and Cheltenham Services Facility sites. Shallow, highly permeable soils with very low fertility and rock outcropping, localised steep slopes with high erosion hazard. Soil Hydrologic Group C/D (Sediment Type F/D).
- Hawkesbury (ha). Predominantly experienced around the Hills Centre Station. Shallow, highly permeable soils with low fertility, steep slope with rock outcrops high soil erosion and high mass movement hazard. Soil Hydrologic Group D (Sediment Type F/D).

- Luddenham (lu). Present around Bella Vista and Norwest Business Park. Localised mass movement hazard, seasonal waterlogging, high foundation and erosion hazard. Soil Hydrologic Group C (Sediment Type F/D).
- South Creek (sc). Experienced in the Kellyville area. High flooding hazard, localised permanently high water tables, low fertility with localised salinity. Soil Hydrologic Group C/D (Sediment Type F/D).

The Soil Hydrologic Group relates to permeability and runoff potential of the soil. Soils in Groups C and D have high to very high runoff potential. The Sediment Type of a soil relates to the particle size and therefore the potential for suspension and transport of sediments. Smaller grain size soils are more readily suspended in runoff and require a longer time to deposit and settle in a sediment basin. Type F soils are fine grained, Type D soils exhibit a combination of fine and coarse grained soils.

2.6.2 Soil Salinity

Salinisation is the process where salts stored in soils are mobilised by the movement of water. Evaporation of water leaves salt residues, and a continuation of the process can lead to a buildup of salt concentrations.

Salt occurs naturally within many parts of the Australian landscape. However, urbanisation or agriculture practices can increase the movement of water through the soil profile and thus exacerbate salinity.

Excess salt levels can affect vegetation and building materials such as concrete and steel. The accumulation of salt can be exacerbated by human practices that increase the rate of water movement in soils.

Soil salinity has been identified as a growing problem in the Western Sydney region. Salinity potential maps have been prepared by the former Department of Infrastructure, Planning and Natural Resources (DIPNR, 2002) that identify the potential risk of soil salinity. Based on these maps, areas around Caddies Creek, First Ponds Creek and Second Ponds Creeks show high salinity potential or known salinity.

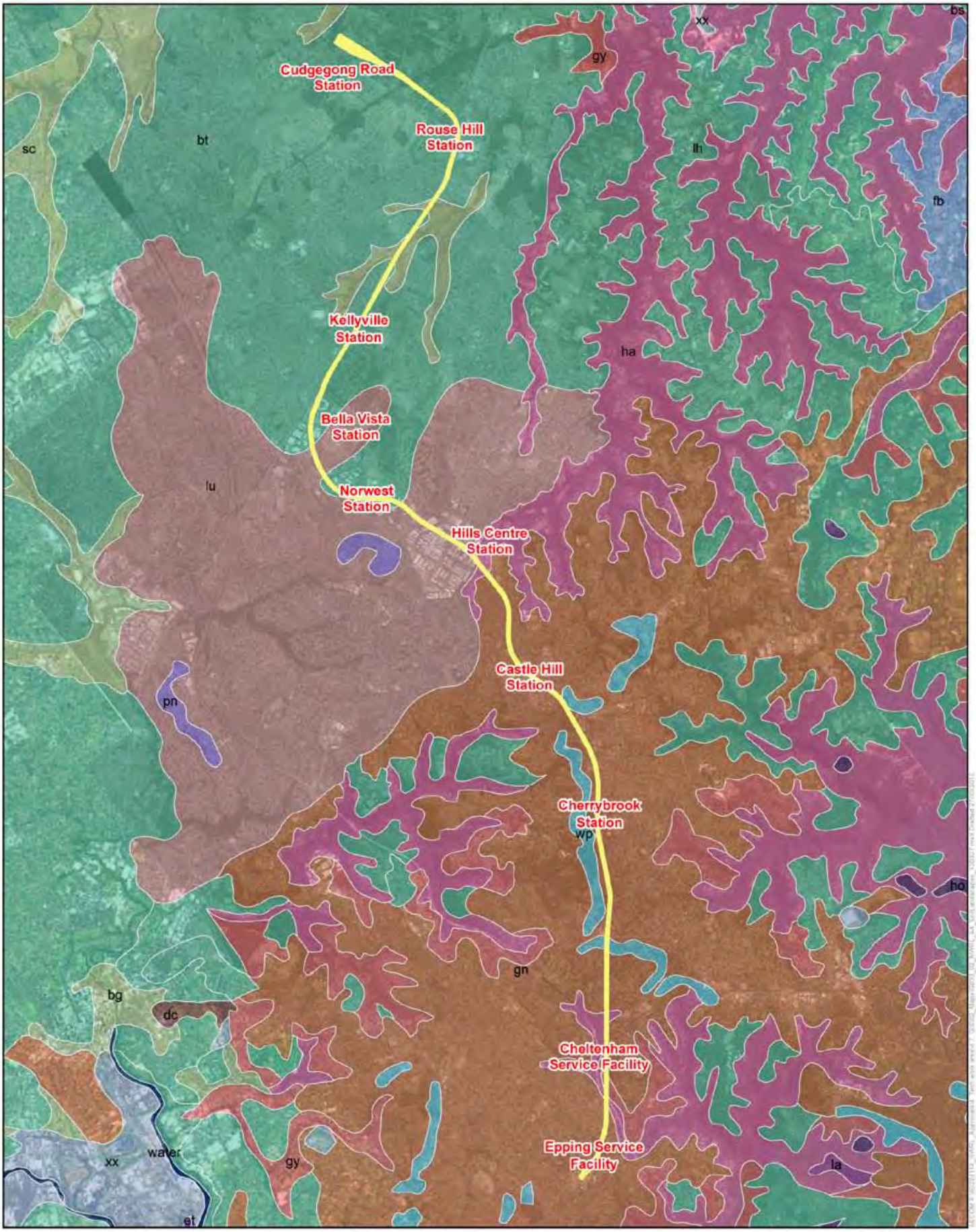
2.6.3 Acid Sulfate Soils

Acid sulfate soils are associated with marine or estuarine areas in NSW. Acid sulfate soils are naturally occurring soils containing pyrite (iron sulphides) which, on exposure to air, causes oxidisation and creates sulfuric acid. The increased acidity can lead to mobilisation of aluminium, iron and manganese from the soils. Other impacts include the deoxygenation of water. Potential acid sulfate soils are soils containing pyrite that have not yet been exposed to air and oxidised to form sulfuric acid.

Acid sulfate soils can weaken concrete and steel infrastructure, which can increase maintenance and replacement costs. In addition, sulfuric acid can damage aquatic environments, if allowed to be released during construction.

Acid sulfate soil risk mapping has been undertaken by the former Department of Land and Water Conservation (DLWC). These maps show that the project lies within areas designated as ‘no known risk’ of acid sulphate soil or potential acid sulphate soil (DLWC, 1998).

AECOM



Landscape type

- bg, Birrong
- bp, Berkshire Park
- bs, Burralow Swamp
- bt, Blacktown
- dc, Deep Creek
- et, Ettalong
- fb, Faulconbridge
- gn, Glenorie
- gy, Gymea
- ha, Hawkesbury
- ho, Hornsby
- la, Lambert
- lh, Lucas Heights
- lu, Luddenham
- of, Oxford Falls
- pn, Picton
- sc, South Creek
- water,
- wp, West Pennant Hills
- xx, Disturbed Terrain

NORTH WEST RAIL LINK

SOIL LANDSCAPES

Source: DIPNR, 2003

0 0.75 1.5 3 km

27 MAR 2012

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Fig 2

2.7 Guiding Principles

2.7.1 Floodplain Management Requirements

Relevant guidelines and standards that have been considered in this assessment include:

- Floodplain Development Manual (NSW Government, 2005)
- Australian Rainfall and Runoff (Institute of Engineers Australia, 1987; AR&R)
- Floodplain Risk Management Guideline – Practical Considerations of Climate Change (Department of Environment, Climate Change and Water, 2007)

Key guiding principles that have been derived from these references include:

- Hydrologic and hydraulic assessments should be undertaken in accordance with current Australian practice.
- Consideration of drainage system failure through blockage is an integral part of a hydraulic assessment under major storm conditions.
- Consideration of climate change is an integral part of a hydraulic assessment.
- Major drainage works and waterway crossings should *"carry and … control the passage of floods up to some high magnitude, without overflowing and causing damage"* and *"in addition to the ARI used for design, the performance of larger trunk drainage systems should be evaluated for extreme events such as probable maximum floods. This is to ensure that systems will fail in a predictable and relatively safe manner in such events, although significant damages should be expected."* (AR&R, 1987)
- Changes in flood behaviour and potential impacts need to be managed in the context of the nature of the surrounding environment and existing and future development.
- Flood risks to new development need to be managed and flood protection provided that is commensurate to the consequences of flooding, including the potential damage to infrastructure and risk to personal safety.

Construction related flood risks and impacts are outlined in this EIS 1 report. In relation to the above guiding principles, flood risks and impacts during construction need to be evaluated in the context of the construction period in order to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks and impacts associated with each construction practice such that informed decisions can be made on the flood criteria that should be set.

Major civil works covered under EIS 1 include the viaduct that spans the Elizabeth Macarthur and Caddies Creek floodplain, and the bridge crossing of Second Ponds Creek. A 100 year ARI flood standard was adopted for the assessment and design of the viaduct and bridge waterway crossings. However, in accordance with the above guiding principles, consideration was also given to the full range of flood events up to and including the Probable Maximum Flood (PMF). Detailed assessment of flood risks in excess of the design standard is particularly relevant in the context of the potential for floods to impact on critical infrastructure adjoining the viaduct and bridge. This includes key transport links such as Windsor Road, Old Windsor Road, Schofields Road and the Tallawong Road electricity substation. Refer to Sections 5.1.4 and 5.1.5 for an assessment of potential flood impacts associated with these structures.

Operational flood risks and impacts will be addressed in EIS 2 and will include the establishment of appropriate floodplain management measures and requirements to manage:

- flood risks to the rail infrastructure (above ground and below ground), station precincts and ancillary facilities such as substations, sectioning huts and tunnel servicing facilities.
- flood impacts on the surrounding environment at station precincts and ancillary facilities.

2.7.2 Water Quality and Environmental Requirements

Relevant guidelines and standards that have been considered in this assessment are outlined below.

- Water Quality:
  - *Managing Urban Stormwater: Soils and Construction* (Landcom, 2004)
  - *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC, 2000)
  - *Australian and New Zealand Guidelines for Water Quality Monitoring and Reporting* (ANZECC, 2000)
  - *Australian Runoff Quality* (Institute of Engineers Australia, 2005)

The design, construction and operation of the NWRL project needs to consider the relevant environmental protection requirements, including those listed above. The NWRL has the potential to impact on water quality during both the construction and operational phases of the project. Construction related impacts are addressed in this report for EIS 1. Operational related water quality impacts will be addressed in the Surface Water and Hydrology Report to be prepared for EIS 2.

- Water management:
  - *Water Act 1912*
  - *Water Management Act 2000*
- Stream ecology and riparian management:
  - *Fisheries Management Act 1994*
  - *NSW State Rivers and Estuaries Policy* (NSW Water Resources Council,1993)
  - *Guidelines for Design of Fish and Fauna Friendly Waterway Crossings* (Fairfull and Witheridge, 2003)
  - *Fish Passage Requirements for Waterway Crossings* (Fairfull and Witheridge, 2003)
  - *Controlled Activities – Guidelines for Riparian Corridors* (NSW Office of Water, 2011)
  - *Controlled Activities – Guidelines for Watercourse Crossings* (NSW Office of Water, 2010)

- *Controlled Activities – Guidelines for Instream Works* (NSW Office of Water, 2010)
- *Controlled Activities – Guidelines for Laying Pipes and Cables in Watercourses* (NSW Office of Water, 2011)
- *Controlled Activities – Guidelines for Outlet Structures* (NSW Office of Water, 2010)

The above guidelines inform the design and construction of waterway crossings giving consideration to fish and fauna passage and riparian corridor conditions. The adopted design and construction measures should also consider factors that influence the environmental significance of the waterways such as existing and proposed development upstream and downstream, catchment area, nature of riparian habitat, connectivity constraints and stream classification. Catchment characteristics and existing and proposed development is discussed in Section 4.0. Riparian habitat and stream classification are described in the Riparian Assessment Report (Eco Logical, 2012a).

2.8 Available Data

2.8.1 Previous Studies and Reports

A number of surface water related studies have been undertaken on behalf of Sydney Water, the Growth Centres Commission, TIDC (now TfNSW), RTA (now RMS) and local Councils within the vicinity of the project area. Studies reviewed as part of the NWRL project are listed below:

- Area 20 Precinct, Rouse Hill Water Cycle Management Strategy Report Incorporating Water Sensitive Urban Design Techniques, J. Wyndham Prince, October 2010
- Blacktown City Council Water Quality and Quantity Monitoring Program 2008 − 2012 (BCC, 2008)
- Hornsby Shire Council Water Quality Monitoring Program – 2008-2009 Annual Report Water Catchments Team (HSC, 2009)
- Hornsby Shire Council Water Quality Monitoring Program – 2009-2010 Annual Report Water Catchments Team (HSC, 2010)
- M2 Upgrade Environmental Assessment – Surface Water Assessment, AECOM April 2010
- North West Metro Feasibility Design Report Volume 1 Part 2, October 2008
- North West Rail Link Environmental Assessment – Flooding and Surface Water Management, GHD October 2006
- North West Transitway Section 5: Drainage Southern End Final Design Revision 03, Maunsell Australia, 28 September 2005
- North West Transitway Section 5: Drainage Northern End Final Design Revision 03, Maunsell Australia, 13 December 2005
- Report for Riverstone and Alex Avenue Precincts Post Exhibition Flooding and Water Cycle Management (incl. Climate Change impact on Flooding), GHD, May 2010
- Report for Schofields Road Concept Design Creek Crossing Preliminary Design Report, GHD, February 2010

- Rouse Hill Integrated Stormwater Strategy Review – Hydrology, Hydraulics and Water Quality Review (Final Report), SKM, 10 July 2009
- Surface Water Quality Assessment of the Hawkesbury-Nepean Catchment - 1995-1999 - Data Information Report (NSW Department of Land and Water Conservation / Australian Water Technologies, 2001)

2.8.2 Available Survey and Mapping Data

At the time of preparing this study the following survey and mapping data was available for use in undertaking the hydrologic and hydraulic assessment:

- Airborne laser survey of the project area, collected for TfNSW in 2008 and 2009.
- Aerial photogrammetry of the project area and associated watercourses, collected for TfNSW in 2011 and 2012.
- Sydney Water data used in flood modelling of Caddies Creek:
    - Airborne Laser Survey of the Caddies Creek catchment, flown in 2006 and 2007.
    - Detailed survey of culvert and bridge crossings within the study area, collected for Sydney Water in 2008.
- Detailed field survey to supplement available survey data, collected for TfNSW in 2011 and 2012 and including:
    - Devlins Creek Tributary between Beecroft Road and Ray Road.
    - Cattai Creek between Showground Road and Carrington Road.
    - Strangers Creek at Norwest Boulevard.
    - Elizabeth Macarthur Creek between Celebration Drive and Samantha Riley Drive.
    - Caddies Creek between Old Windsor Road and Windsor Road.
    - Second Ponds Creek at Schofields Road.
    - First Ponds Creek between Schofields Road and Gordon Road.
- DIPNR Soil Landscape Maps, 2003.
- DIPNR Salinity Potential in Western Sydney Maps, 2002.
- DLWC Acid Sulphate Soil Risk Maps, 1998.

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3.0 Methodology

3.1 General

The seventeen (17) construction sites that comprise the extent of the project traverse eight main waterway catchments as shown in Table 3.

Some of the surface water impacts are dependent on the specific characteristics of these catchments and their associated floodplains in the vicinity of the sites. Other impacts, particularly those relating to the management of site runoff, are more generic.

The surface water assessment presented in the following sections of this report has been divided according to the eight major catchments listed in Table 3. Assessment is also provided for general impacts that are relevant to all catchments. The approach to the assessment of flooding and water quality related impacts are outlined in Sections 3.2 and 3.3 respectively.

Table 3 Major Waterway Catchments and Construction Sites

Catchment	Construction Site
Devlins Creek	1. Epping Services Facility
	2. Epping Decline
	3. Cheltenham Services Facility
Pyes Creek	4. Cherrybrook Station
Cattai Creek	5. Castle Hill Station
	6. Hills Centre Station
Strangers Creek	7. Norwest Station
Elizabeth Macarthur Creek	8. Bella Vista Station
	9. Balmoral Road
	10. Memorial Avenue
	11. Kellyville Station
Caddies Creek (including Tributaries 3, 4 and 5)	12. Windsor Road/Old Windsor Road
	13. Old Windsor Road/Whitehart Drive
	14. Rouse Hill Station
	15. Windsor Road Viaduct
Second Ponds Creek	16.Windsor Road Viaduct to Cudgegong Road
First Ponds Creek	17. Cudgegong Road and Tallawong Stabling Facility

3.2 Flooding

The assessment of the surface water catchments draining to and through the Project corridor has involved:

- Hydrologic modelling to determine peak flow estimates applicable for design and flood assessment.
- Hydraulic modelling to quantify flood behaviour (levels and velocities) as well as identify potential flood impacts and risks during construction.
- Quantification and assessment of flood impacts and risks associated with the major civil construction works proposed under EIS 1.
- Identification of appropriate mitigation measures that are commensurate to the potential for and consequences of flood inundation to the proposed works and construction sites.

The hydrologic modelling of the catchments within the Project area has been based on the WBNM runoff-routing software. Details of the hydrologic modelling are presented in Appendix A.

Hydraulic modelling has involved a combination of approaches that have been tailored to the size, complexity and nature of the floodplains that are traversed by the Project. Details of the hydraulic modelling are presented in Appendix B.

Outcomes of the flood assessment have been used to:

- define flood behaviour under existing conditions (refer Section 4),
- quantify the nature and extent of flood risks to the proposed works as part of Stage 1 of the NWRL, and potential flood impacts of the proposed works on the surrounding environment (refer Section 5).
- identify appropriate mitigation measures required to manage risks to the Project and impacts on the surrounding environment (refer Section 6).

Flood assessment has included consideration of existing and future catchment conditions. By the time the construction works proposed under EIS 1 commence, it is possible that further development will occur in the catchments, particularly those in the North West Growth Centre area. For this reason quantification of flood behaviour and impacts on the EIS 1 construction works has taken into consideration ultimate catchment conditions. These conditions would be applicable to the operational life of the project but may be conservative in the context of peak flows during the construction phase. Details of catchment conditions under existing and ultimate conditions and the impact on flow behaviour are included in Appendix A.

Further flood modelling and assessment that would be required during the detailed design phase of the Project should consider catchment conditions at the time of the proposed construction activities.

3.3 Water Quality

The assessment of surface water quality impacts from proposed construction works under EIS 1 has involved:

- Collation and review of available data on stream condition, water quality and soils to define the existing environment within the catchments and watercourses.
- Assessment of proposed construction activities for impacts on the water quality of receiving environments.
- Identification of required mitigation measures, including type of controls and design criteria required to manage potential impacts.

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4.0 Existing Environment

4.1 Flooding

4.1.1 General

The seventeen (17) construction sites that comprise the extent of the Stage 1 works traverse the catchments of:

- Devlins Creek (including the Beecroft Road tributary)
- Pyes Creek
- Cattai Creek
- Strangers Creek
- Caddies Creek (including Elizabeth Macarthur Creek and Caddies Creek Tributaries 3, 4 and 5)
- Second Ponds Creek
- First Ponds Creek

Development within the catchments in the south east portion of the project (including Devlins Creek, Pyes Creek and Cattai Creek) is typically well established. This includes the suburbs of Epping, Cherrybrook and Castle Hill.

For catchments within the North West Growth Centre (covering Strangers Creek, Caddies Creek and tributaries, Elizabeth Macarthur Creek, First Ponds Creek and Second Ponds Creek) a considerable degree of development is underway and ongoing. To manage changes in flow behaviour as a result of urbanisation, water management strategies have been incorporated into the planning of these growth areas that include the provision of detention basins to offset potential increases in runoff.

Particular areas within the North West Growth Centre where significant future development has been identified include Balmoral Release area, Area 20 Precinct, Alex Avenue, Riverstone, The Ponds and Beaumont Hills. Many of these areas are largely undeveloped under existing conditions.

The following sections provide an overview of each major waterway crossed or bordered by the proposed works. Where relevant, flood mapping is provided for the 20 year and 100 year ARI flood events. Further details of flood behaviour, including other events, can be found in Appendices A and B.

4.1.2 Devlins Creek (including the Beecroft Road tributary) – Sites 1, 2 and 3

Site 1 (Epping Services) and Site 2 (Epping Decline) are located adjacent to the Devlins Creek tributary (referred to herein as the Beecroft Road tributary) that runs parallel to and between Edensor Street and Beecroft Road before joining Devlins Creek downstream of the Beecroft Road and Kandy Avenue intersection.

The Beecroft Road tributary has been significantly modified by urbanisation. The watercourse consists of a concrete and brick channel with concrete box culvert crossings at Ray Road and the Kandy Avenue. The Beecroft Road tributary drains a catchment area of

approximately 230 hectares at Kandy Avenue. There is considerable existing development on the floodplain in the vicinity of the project corridor, consisting mainly of medium density residential development and commercial development. These areas of existing development would be sensitive to changes in flood behaviour.

Flood extent mapping for Beecroft Road tributary is provided in Figure 3 for the 20 and 100 year ARI events. As shown in the figure, Site 1 is in close proximity to the watercourse. A small proportion of the site lies within the defined flood extents. Site 2 is located outside the 100 year ARI flood extent.

Site 3 (Cheltenham Services Facility) is located within the middle reaches of the main Devlins Creek catchment. In this area Devlins Creek is relatively incised, running in an easterly direction between the M2 (north of the creek) and residential development (south of the creek). With the M2 located between Site 3 and Devlins Creek the potential for impacts from mainstream flooding is low. Local catchments drain through the southern and northern ends of the site. Figure 4 presents local topography at the Cheltenham Services Facility site.

4.1.3 Pyes Creek – Site 4

Site 4 (Cherrybrook Station) lies in the upper reaches of Pyes Creek, which is a tributary of Berowra Creek. The site is located at the top of the catchment and therefore is not affected by mainstream flooding. The existing topography is characterised by a local depression that runs south to north across the proposed location of the station and would be the predominant flowpath for runoff from the site. Figure 5 presents local topography at the Cherrybrook Station site

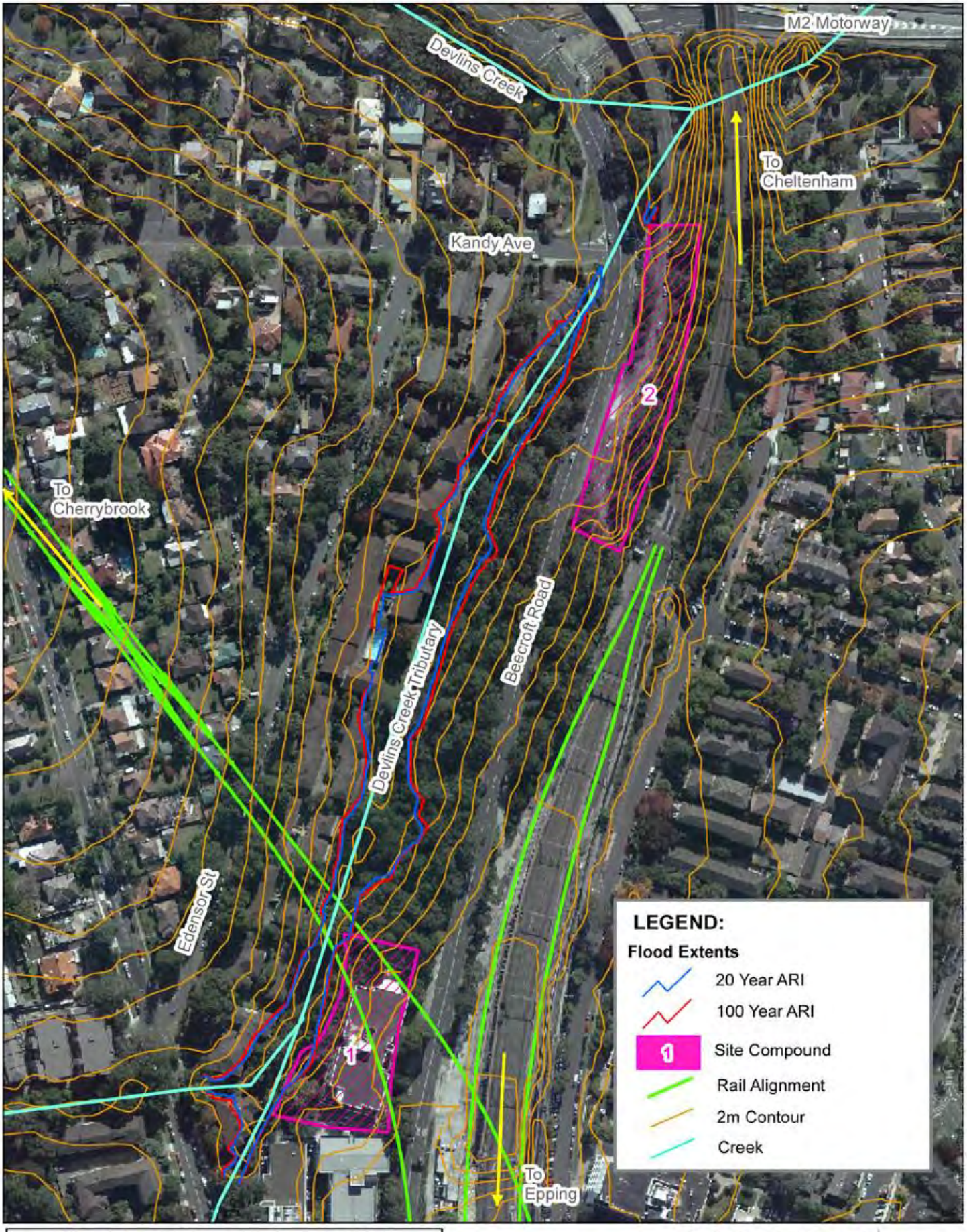
4.1.4 Cattai Creek – Sites 5 and 6

Site 5 (Castle Hill Station) is located in the upper reaches of a tributary to Cattai Creek. The site is located at the top of the catchment and is not affected by mainstream flooding.

Site 6 (Hills Centre Station) is located adjacent to, and partially crosses Cattai Creek. At Site 6 Cattai Creek drains a catchment area of approximately 327 hectares and is deeply incised. Development in the upstream catchment is well established, consisting of a mix of residential and industrial. Immediately adjacent to the site lies the Castle Hill showground and Civic Centre and Council administration.

While development within the catchment is well established the creek line is heavily vegetated. These factors combined have the potential to generate large amounts of debris in flood waters (such as trees, cars, shopping trolleys and other floatable items which may be washed from upstream) and consequently any structures placed within the banks are likely to have blockage issues during flood events. Anecdotal evidence suggests that parts of Carrington Road are currently subject to flooding and therefore would be sensitive to any changes in flood behaviour.

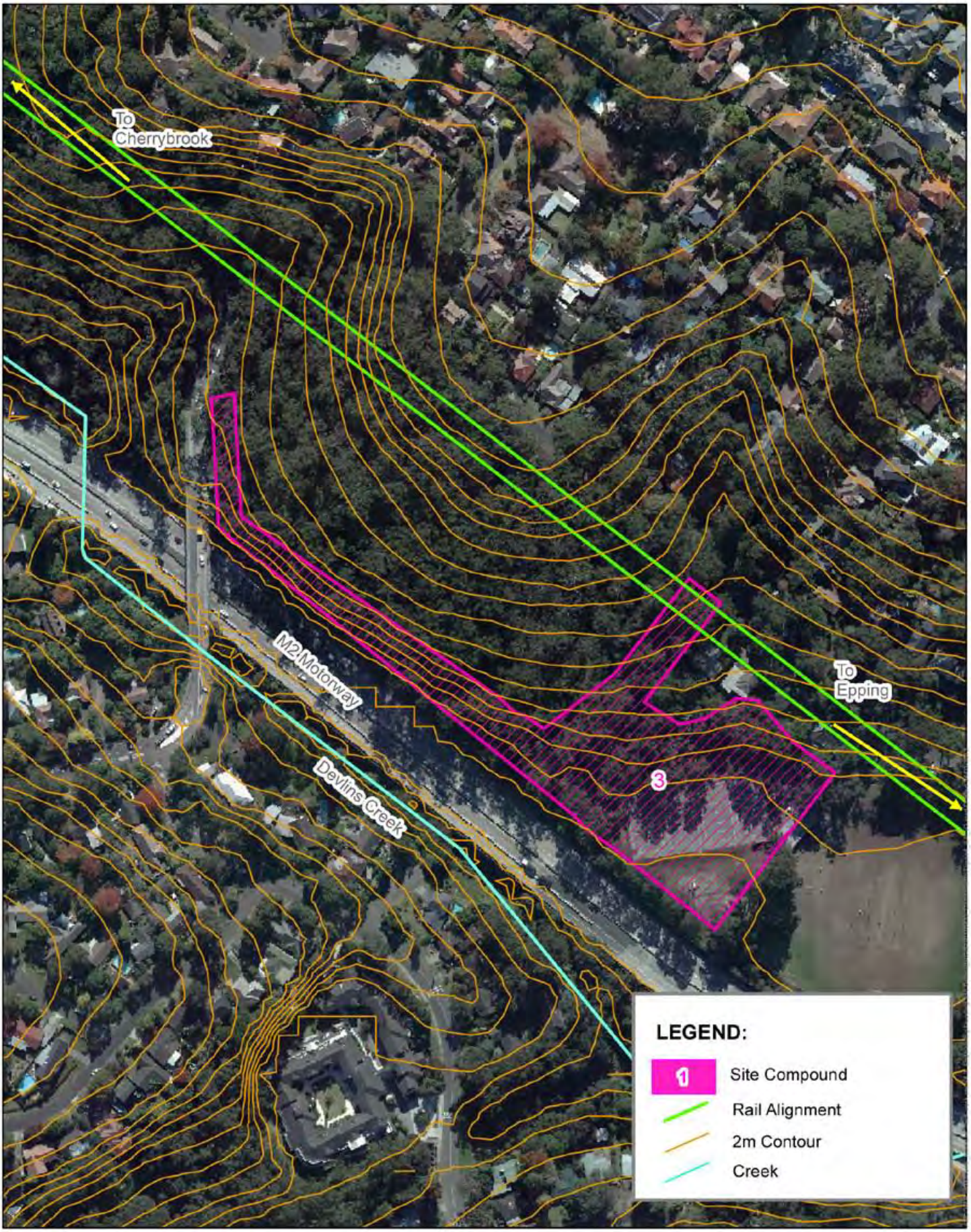
Flood extent mapping for Cattai Creek is provided in Figure 6 for the 20 and 100 year ARI events. Site 6 straddles both sides of Cattai Creek and is therefore partially flood affected.



North West Rail Link EIS | 24 FEB 2012
Construction Sites 1 & 2 | 60224114
Source: AECOM

0 0.025 0.05 0.1 km

AECOM



North West Rail Link EIS | 24 FEB 2012

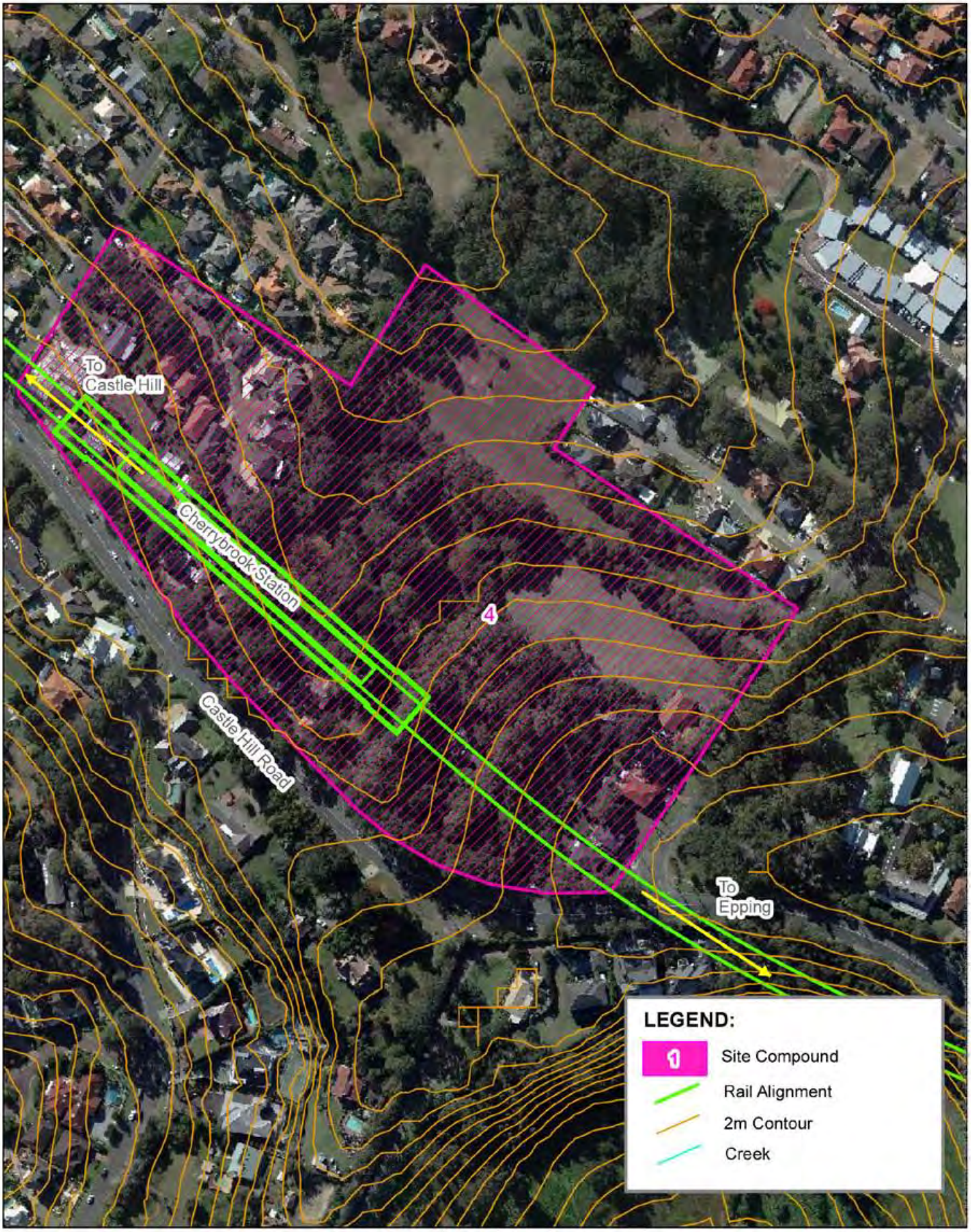
Construction Site 3 | 60224114

Source: AECOM

0 0.025 0.05 0.1 km

Fig 4

AECOM



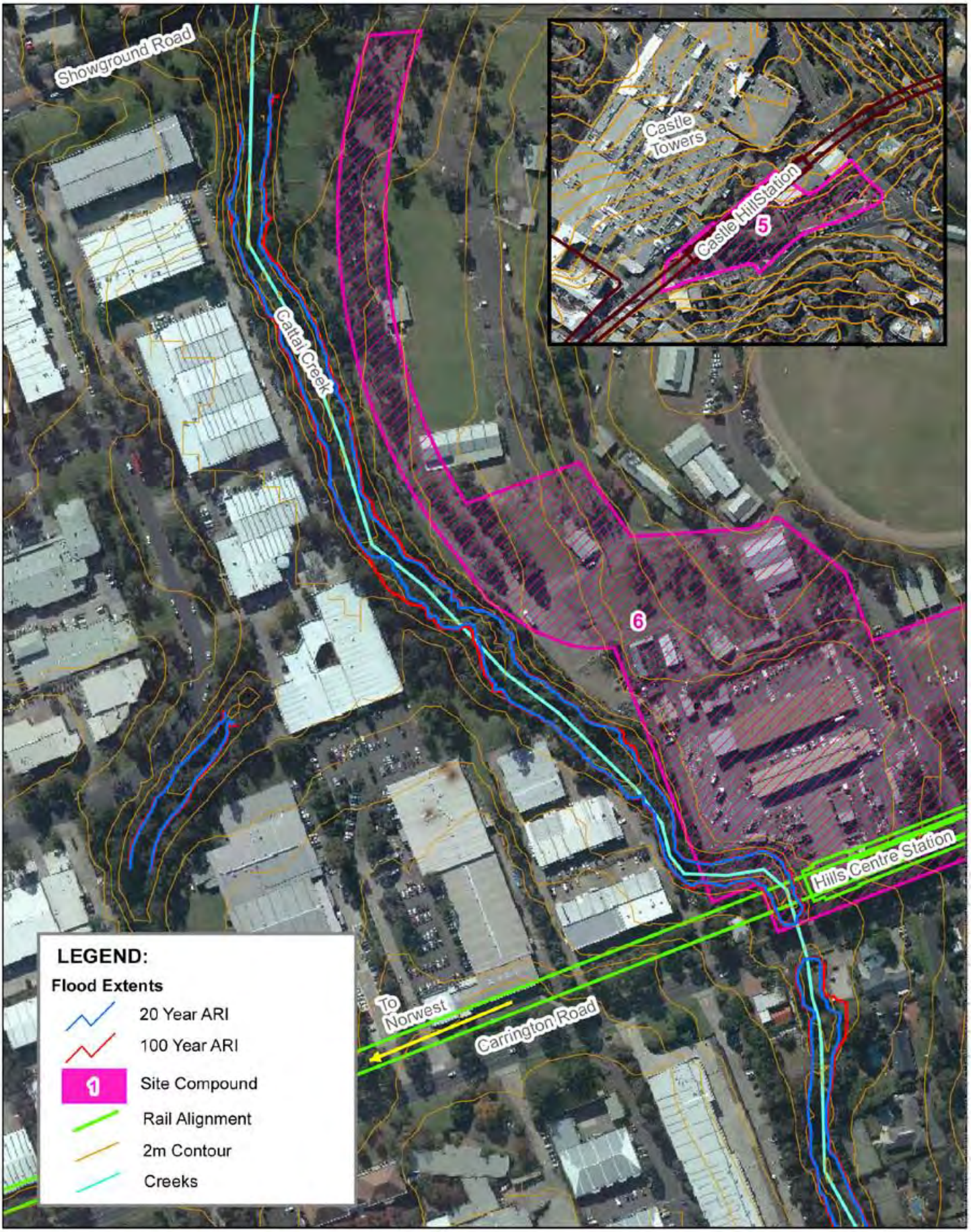
North West Rail Link EIS | 27 MAR 2012

Construction Site 4 | 60224114

Source: AECOM

0 0.025 0.05 0.1 km

Fig 5



North West Rail Link EIS | 27 MAR 2012
Construction Sites 5 & 6 | 60224114
Source: AECOM

0 0.03 0.06 0.12 km

Fig 6

4.1.5 Strangers Creek – Site 7

Site 7 (Norwest Station) is located on Norwest Boulevard, west of Strangers Creek. Strangers Creek in the vicinity of Norwest Boulevard is a highly modified system consisting of a series of ponds interconnected with drainage culverts, draining a catchment area of approximately 36 hectares. In larger flood events the ponds would overtop and flows would travel across Norwest Boulevard. Site 7 is elevated above Strangers Creek and is not affected by mainstream flooding. However, the local road drainage system runs through the site from the west via Norwest Boulevard and Brookhollow Avenue. The existing road drainage network layout is shown in Figure 7.

4.1.6 Elizabeth Macarthur Creek – Sites 8 to 11

Sites 8 to 11, from Celebration Drive to Samantha Riley Drive, run parallel and in close proximity to Elizabeth Macarthur Creek. Development in the upstream catchment (south of Celebration Drive) is well established, consisting of a mixture of residential and commercial development. The catchment draining to Elizabeth Macarthur Creek between Celebration Drive and Samantha Riley Drive is currently largely undeveloped. However, significant urbanisation is currently underway and ongoing as part of the North West Growth Centres. A particular area of future development is the Balmoral Release area.

Flood extent mapping for Elizabeth Macarthur Creek is provided in Figure 8 for the 20 and 100 year ARI events. As shown, Sites 8 to 11 are typically located clear of the 100 year ARI flood extent. However, there are localised areas of the sites that lie within the defined flood extents.

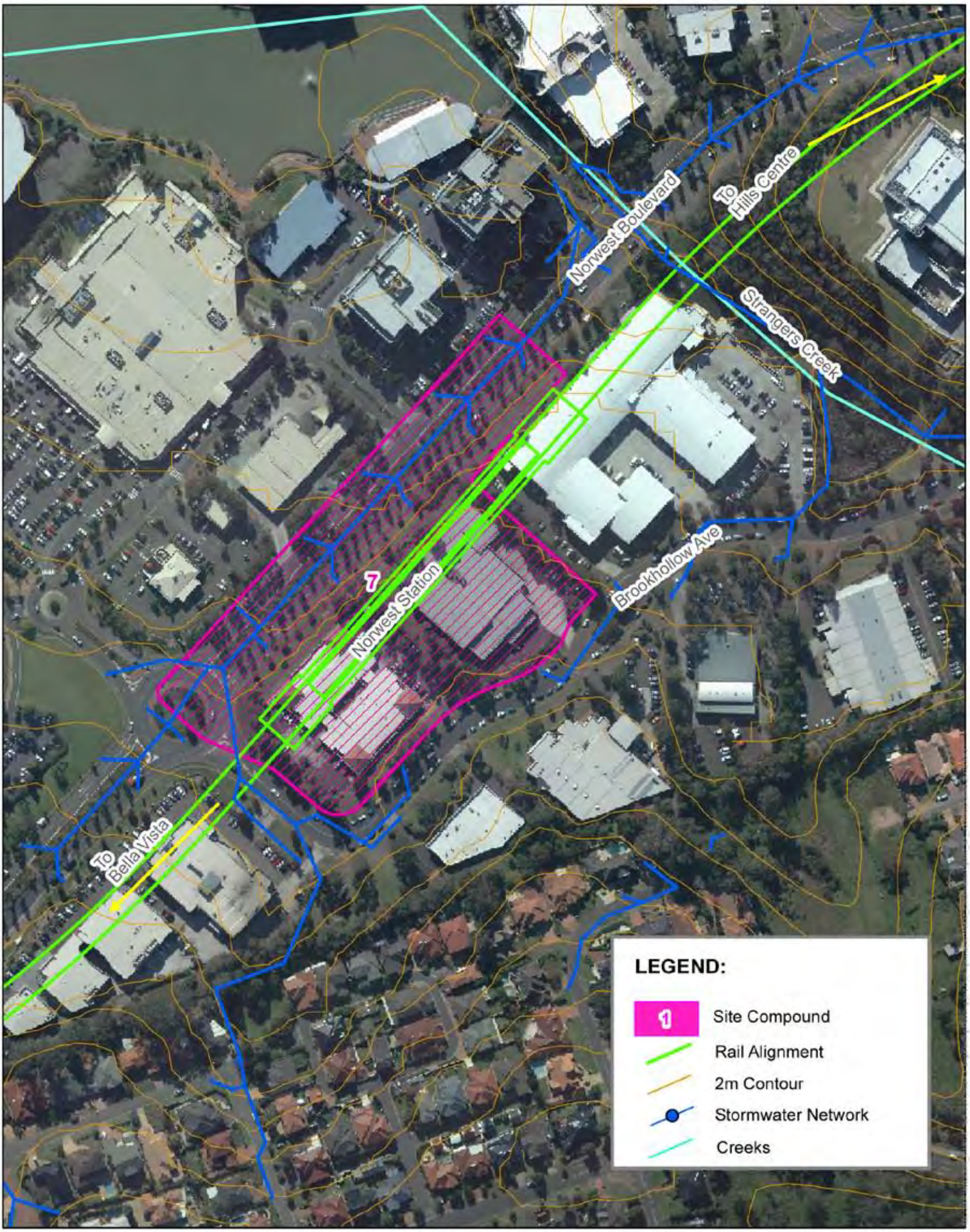
4.1.7 Caddies Creek (including Tributaries 3, 4 and 5) – Sites 12 to 15

Sites 12 to 13 span the broad floodplain of Caddies Creek, including its confluence with Elizabeth Macarthur Creek and Caddies Creek Tributaries 3, 4 and 5. The creek lines in this area are moderately incised with well vegetated main channel and overbank areas.

Flood extent mapping for Caddies Creek is provided in Figure 9 for the 20 and 100 year ARI events. Site 12 straddles both sides of Caddies Creek and incorporates the confluence with Tributary 5 and Elizabeth Macarthur Creek. As can be seen from the flood extent mapping, a significant proportion of the site is flood affected, even in the 20 year ARI event. Site 13 traverses Caddies Creek Tributary 3 and 4 and therefore parts of the site are flood affected in the vicinity of these creek lines.

Site 14 is located to the north of Caddies Creek Tributary 3. The site would be susceptible to inundation from flows overtopping Windsor Road at the Tributary 3 culverts. Previous hydraulic studies undertaken for the Windsor Road T-way Project (Maunsell 2005a and 2005b) show that the Tributary 3 culvert crossing has in excess of a 100 year ARI capacity. Consequently, Site 14 is not expected to be affected by flooding up to the 100 year ARI event, apart from runoff from the local drainage network.

Site 15 is located within the Caddies Creek catchment but is outside the floodplain.



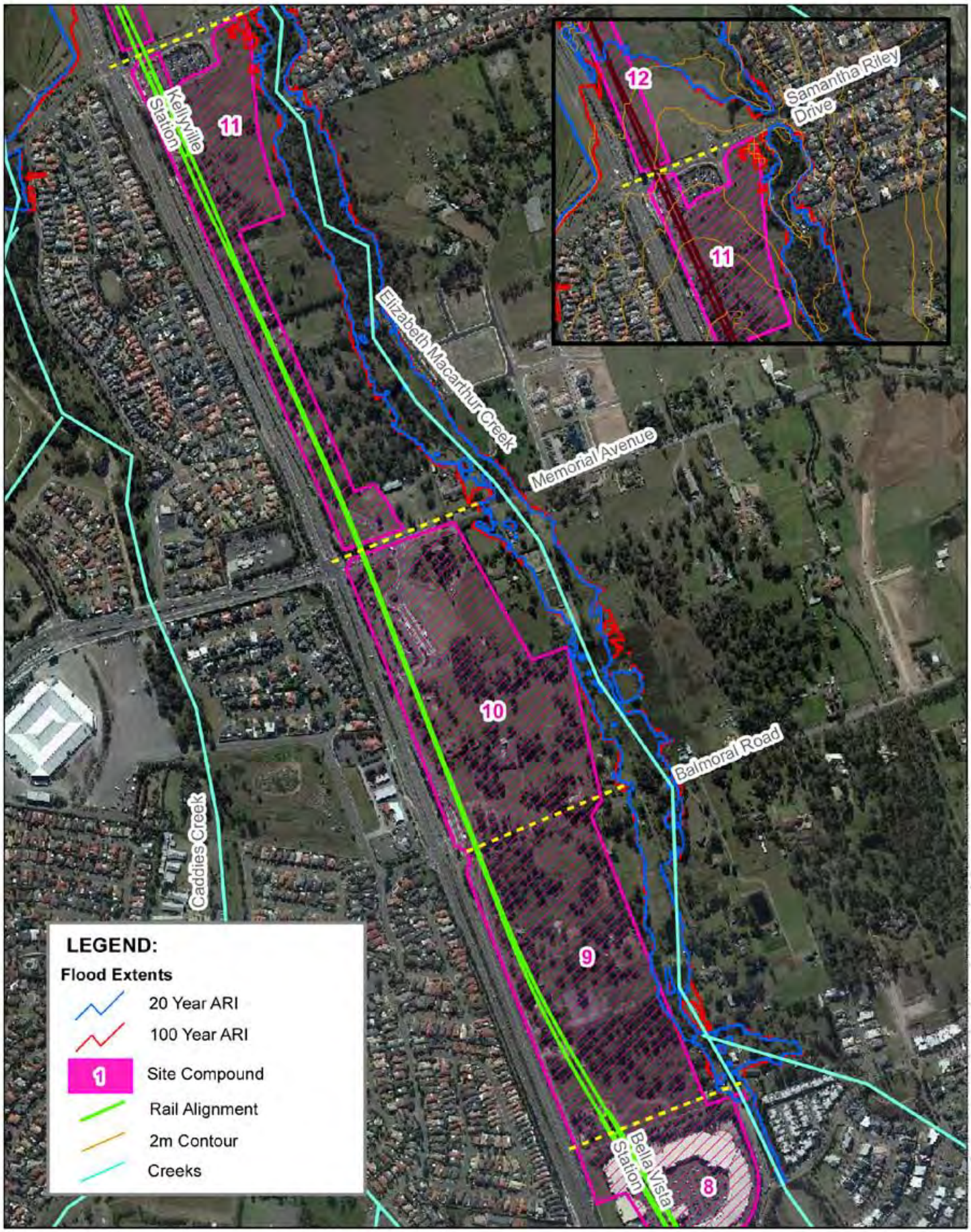
North West Rail Link EIS
Construction Site 7
Source: AECOM

0 0.025 0.05 0.1 km

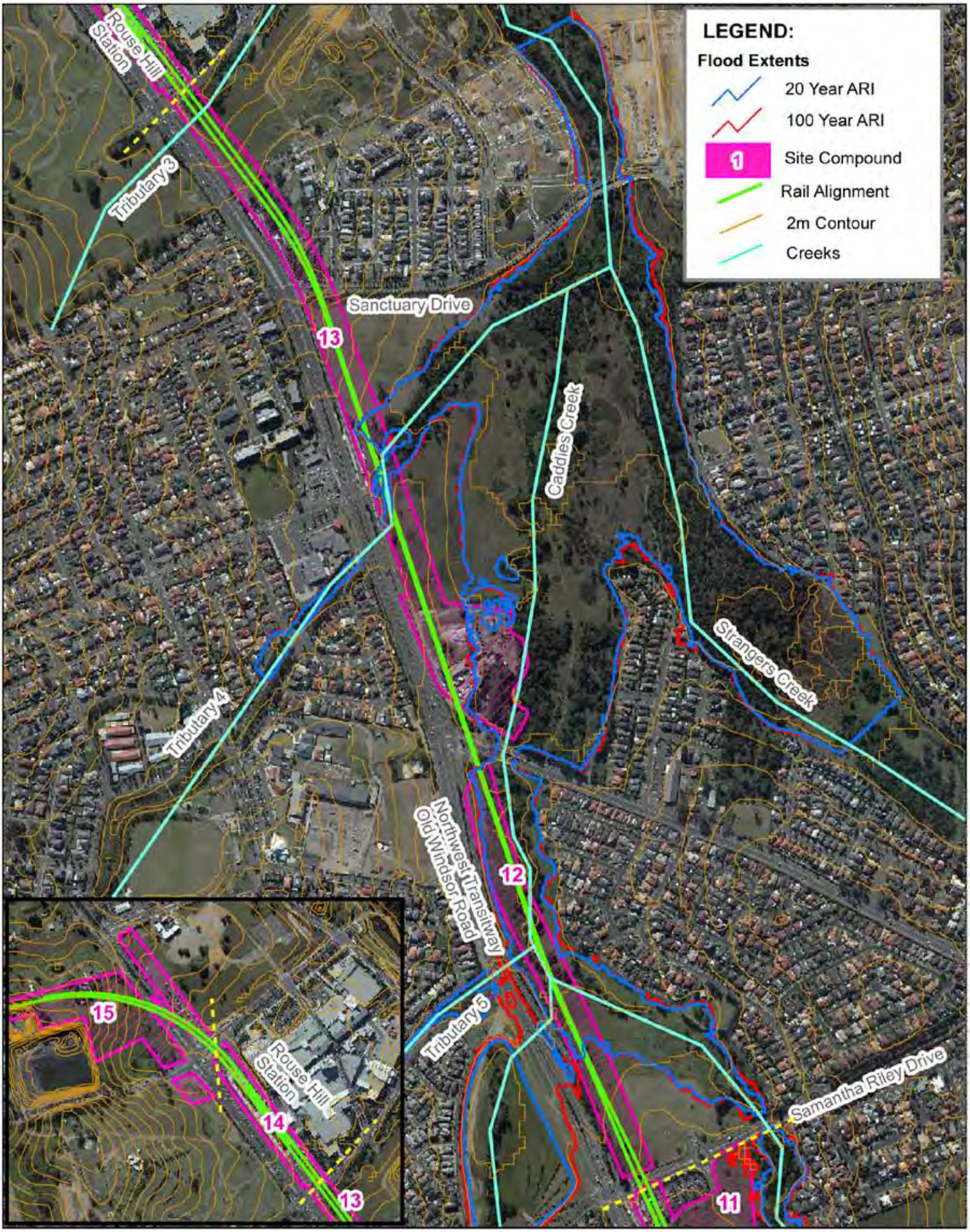
24 FEB 2012
60224114

Fig 7

AECOM



North West Rail Link EIS | 19 MAR 2012
Construction Sites 8 to 11 | 60224114
Source: AECOM
0 0.075 0.15 0.3 km
Fig 8



North West Rail Link EIS | 19 MAR 2012
Construction Sites 12 to 15 | 60224114
Source: AECOM

0 0.075 0.15 0.3 km

Fig 9

4.1.8 Second Ponds Creek – Site 16

Second Ponds Creek at the NWRL alignment has an upstream catchment area in the order of 620 hectares. The catchment has undergone significant urban development over recent years. Parts of the catchment, particularly in the immediate vicinity of the Project corridor, are largely undeveloped and consists mainly of rural residential. Urban development in the catchment is ongoing. Existing areas of rural development are earmarked for urbanisation as part of the Area 20 Precinct.

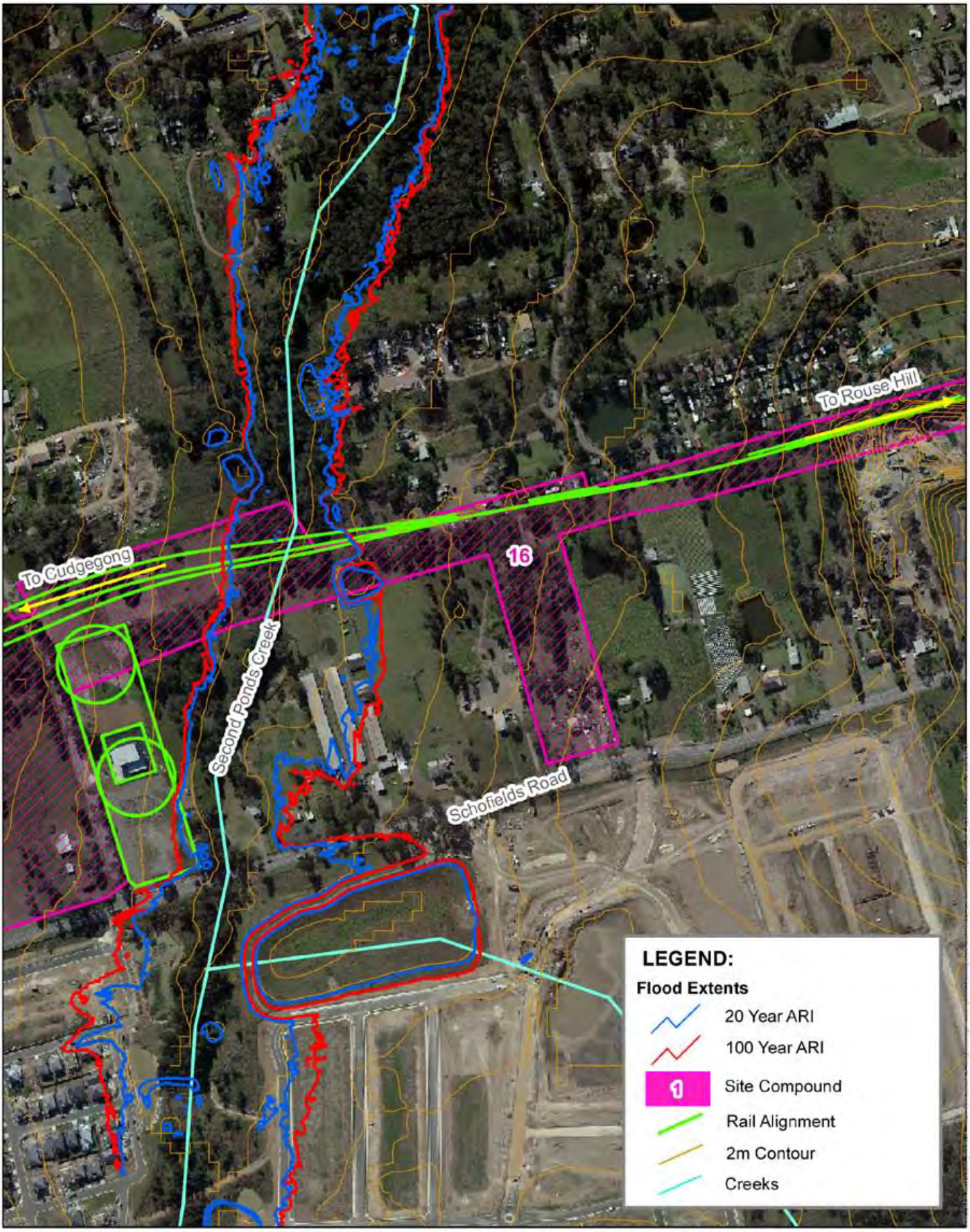
Flood extent mapping for Second Ponds Creek is provided in Figure 10 for the 5, 20 and 100 year ARI events. Site 16 straddles both sides of Second Ponds Creek and therefore is partially flood affected.

4.1.9 First Ponds Creek – Site 17

The western edge of Site 17 borders a tributary of First Ponds Creek. The tributary drains a catchment area of approximately 55 hectares to the Project corridor. The junction with First Ponds Creek is approximately 150m further downstream (to the north) at which location the catchment area draining to First Ponds Creek is approximately 300 hectares.

The First Ponds Creek catchment is currently largely undeveloped, consisting of rural residential development. Future urbanisation is proposed as part of the Alex Avenue Precinct.

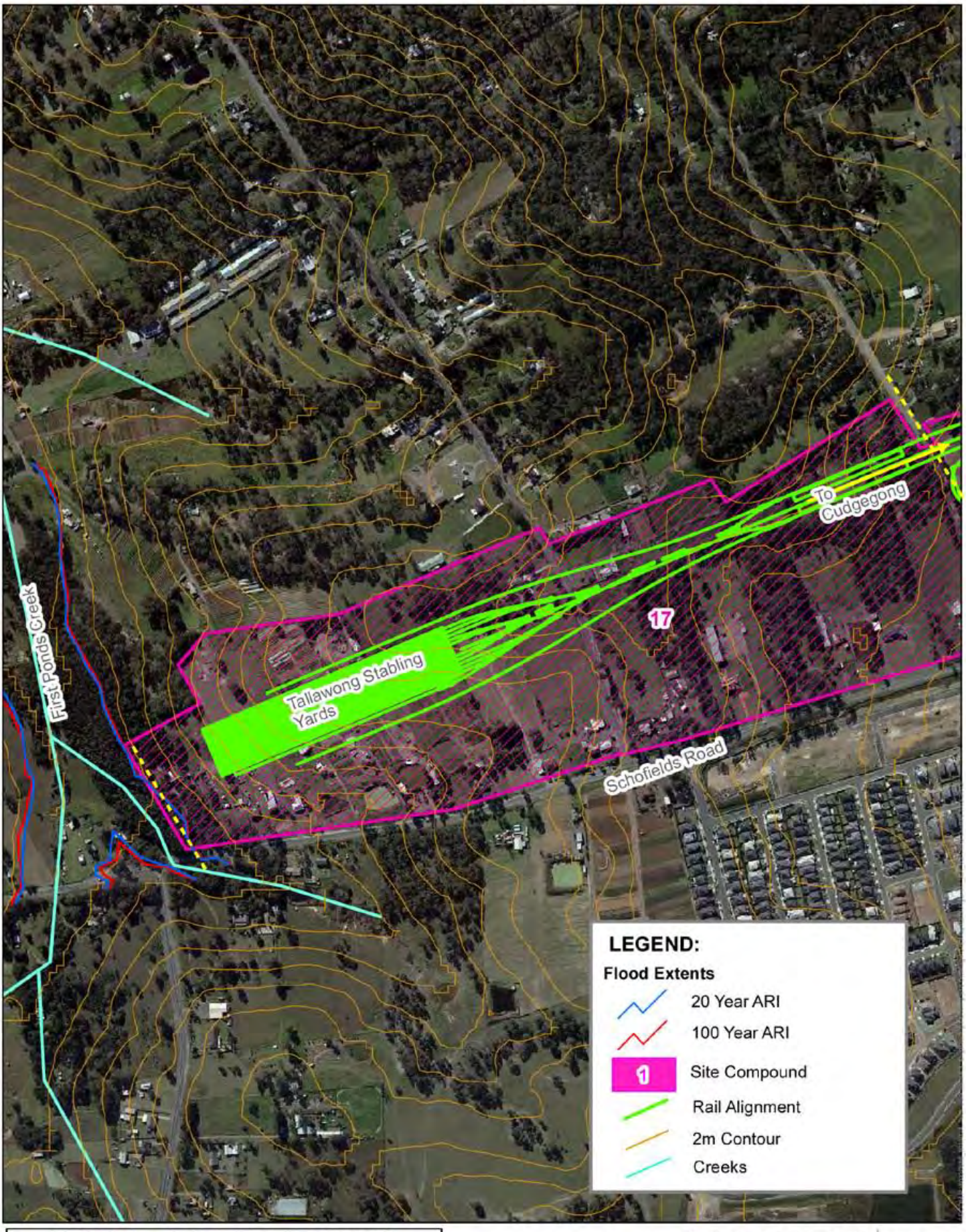
Flood extent mapping for First Ponds Creek is provided in Figure 11 for the 20 and 100 year ARI events. The western edge of the Site 17 bordering the First Ponds Creek tributary is partially flood affected.



North West Rail Link EIS
Construction Site 16
Source: AECOM

0 0.05 0.1 0.2 km

24 FEB 2012
60224114
Fig **10**



North West Rail Link EIS
Construction Site 17
Source: AECOM

0 0.05 0.1 0.2 km

07 MAR 2012
60224114
Fig **11**

4.2 Water Quality

4.2.1 General

A considerable amount of water quality monitoring has been undertaken within the catchments traversed by the project. Local Councils within the area (namely Hornsby Shire Council, The Hills Shire Council and Blacktown City Council) have extensive water quality monitoring and reporting programmes. Water quality monitoring data is or has previously been collected by various government agencies including Sydney Water, the former Department of Land and Water Conservation (DLWC), the Environmental Protection Agency, the Sydney Catchment Authority and the Hawkesbury Nepean Catchment Management Trust.

As part of the original approval conditions for the M2 Motorway a water quality monitoring program was established in 1997-98 following the commencement of operation in May 1997. The aim of the program was to monitor water quality in the receiving systems to check for conformance with recommended quality limits and identify any long term impacts associated with the M2 Motorway. Since that time, water quality data has been collected and analysed by HLA-Envirosciences at 16 locations on waterways upstream and downstream of the M2 Motorway corridor. Four of these sites are relevant to the North West Rail Link Project. These are located on Devlins Creek in the vicinity of the Epping Service Facility (Site 1), Epping Decline (Site 2) and Cherrybrook Service Facility (Site 3).

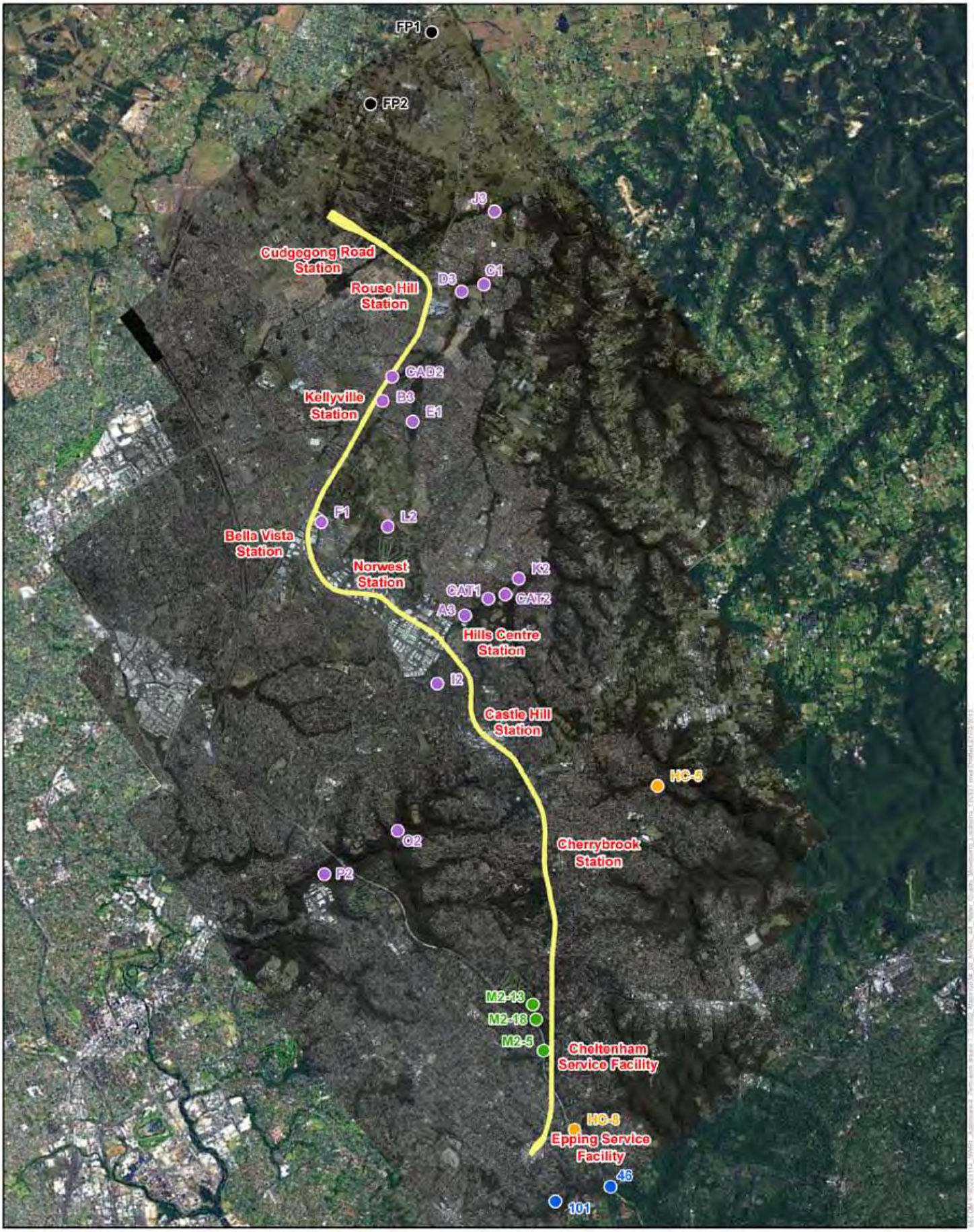
Hornsby Shire Council established a water quality monitoring program in 1994 to assess the impact of land use on waterways within the Council area and assess the performance of Council's Catchments Remediation Rate program. Hornsby Shire Council publishes an annual water quality report, which is made available to the community and interested authorities through the Council's web site. Monitoring includes Devlins Creek and Pyes Creek.

The Hills Shire Council's Health and Environmental Protection Team routinely monitors the water quality of major creek systems in the Council area. This includes monitoring sites upstream and downstream of the Project Area within:

- Cattai Creek
- Strangers Creek
- Elizabeth Macarthur Creek
- Caddies Creek
- Second Ponds Creek

These monitoring locations are presented in Figure 12. At each location Council officers test water samples for a range of parameters including Dissolved Oxygen (DO), temperature, pH and conductivity. Samples are also collected at each site and sent to a National Association of Testing Authorities (NATA) accredited laboratory for analysis of Faecal Coli forms, E.coli, Total Nitrogen, Total Phosphorous, Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS). Caddies Creek, being situated downstream of a former landfill site, is also tested for heavy metals. All results are compared to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

AECOM



Water monitoring locations by council

- Baulkham Hill Council
- Blacktown Council
- Hornsby Council
- M2 Locations
- Ryde City Council

NORTH WEST RAIL LINK

WATER QUALITY MONITORING LOCATIONS

27 MAR 2012

60224114

0 0.75 1.5 3 km

Blacktown City Council has an ongoing water quality monitoring program that was established in 2008 covering significant watercourses in the Council area. While monitoring sites are located on First Ponds Creek, they are situated at Riverstone Road and Windsor Road and therefore are not directly applicable to the project area.

4.2.2 Devlins Creek (including Beecroft Road tributary) – Sites 1, 2 and 3

Hornsby Shire Council have established a monitoring station on Devlins Creek, approximately 200m downstream of the Cheltenham Services Facility (Site 3). The monitoring station is shown on Figure 12 (referred to as Hornsby Monitoring Location 8) and is adjacent to Sutherland Road at Cheltenham. The catchment draining to this monitoring site is approximately 823 hectares with about 8% falling in the Parramatta City Council area. Approximately 77% of the catchment is zoned residential with the remaining area consisting of a mix of special uses and open space, with a smaller proportion of commercial/industrial and business. Monitoring commenced in October 1994. Results of Council's monitoring is presented in Hornsby Shire Council (2009 and 2010).

At Hornsby Monitoring Location 8 occasional high levels of faecal coliforms have been encountered, particularly after storms. The source of elevated levels is reported to be from stormwater runoff and/or sewer pipe overflows. Results exceeded the ANZECC Guidelines for Ammonium Nitrogen (NH_3) and phosphorous concentrations in the majority of samples taken. However, because faecal coliforms were low sewer leaks were not suspected. The levels of turbidity and suspended solids in urban sites were generally acceptable. Test results showed typically low DO levels, especially at low flow conditions when the pools tend to turn black.

The M2 Motorway monitoring sites for Devlins Creek sites are labelled M2-13, M2-18, M2-5 and M2-8 on Figure 12. These sites are located upstream of the Cheltenham Services Facility. Samples are collected following storm events where rainfall is greater than 10mm in the 24 hour period prior to sampling and are analysed for Total Suspended Solids (TSS). Suspended solids loadings are used as an important indicator in relation to nutrient transport and aesthetic appearance. AECOM (2011) tabulated the sampling data obtained for numerous events dating from January 1998 for the M2 project. The calculated long term average and median values for each of the sites are also included.

Comparison of the M2 Motorway monitoring results for pre and post construction of the Motorway indicates that construction of the existing motorway has not had any significant impact on the water quality of the downstream receiving systems.

4.2.3 Pyes Creek – Site 4

Hornsby Monitoring Location 5 is located on Pyes Creek at Cherrybrook (refer Figure 12). The catchment draining to the monitoring site is approximately 380 hectares of which 79% is zoned residential. The monitoring site is located in a section of creek that has extensive patches of exposed bedrock. Monitoring by Hornsby Shire Council commenced in October 1994.

The monitoring site is located approximately 3km downstream of Cherrybrook Station and is therefore not suitable to provide a direct analysis of potential changes in runoff quality from the Project. However, results do provide a useful background to the nature of the broader downstream receiving system.

Monitoring results exceeded the ANZECC guidelines for Ammonium Nitrogen (NH3) and phosphorous concentrations in the majority of samples taken. The levels of turbidity and suspended solids in Pyes Creek were generally acceptable. Sewer leaks were not suspected due to low faecal coliform readings.

4.2.4 Cattai Creek – Sites 5 and 6

The Hills Shire Council operates three monitoring locations on Cattai Creek (referred to as Hills A3, Hills I2 and Hills K3) as shown on Figure 12. Location I2 is located upstream of the Hills Centre station (Site 6), Location A3 is approximately 200m downstream of the site on Showground Road and Location K2 is a further 1.2km downstream. Additional monitoring locations have previously been operated by the EPA, SCA, Sydney Water, DLWC and the Hawkesbury Nepean Catchment Management Trust.

In general, *E. Coli* and nutrients Total Nitrogen and Total Phosphorous were found to be above the ANZECC guidelines in over half the samples, with dissolved oxygen readings below recommended guidelines.

4.2.5 Strangers Creek – Site 7

The Hills Shire Council operates two monitoring locations on Strangers Creek (referred to as Hills E1 and Hills L2) as shown on Figure 12. Location L2 is approximately 1.5km downstream of the Norwest Station (Site 7). Location E1 is a further 2.5km downstream and is therefore not suitable to provide a direct analysis of runoff quality from the Project.

Results of monitoring at Station L2 indicate nutrient levels below ANZECC guidelines, with dissolved oxygen readings below recommended guidelines.

4.2.6 Elizabeth Macarthur Creek – Sites 8 to 11

Two monitoring sites operated by The Hills Shire Council are located on Elizabeth Macarthur Creek, (Hills F1 and Hills B3 in Figure 12). Sampling location F1 is off Celebration Drive upstream of the proposed Bella Vista Station. Location B3 is off Clovelly Crescent, upstream of the confluence with Caddies Creek.

Location F1 has generally shown readings within acceptable limits for secondary contact recreation under the ANZECC guidelines. Slightly more than half the samples showed elevated Total Nitrogen levels. Results at the downstream monitoring site (Location B3) indicate poorer quality, with elevated levels of Total Nitrogen and Total Phosphorous in nearly all the samples taken, along with elevated *E. Coli* in approximately half the samples. Dissolved Oxygen at this location was below recommended levels within the ANZECC guidelines.

4.2.7 Caddies Creek (including Tributaries 3, 4 and 5) – Sites 12 to 15

The Hills Shire Council's Health and Environmental Protection Team operate two monitoring sites on Caddies Creek (Hills D3 and Hills C1 on Figure 12). Hills D3 is located approximately 1km downstream of the proposed Rouse Hill Station, with Hills C1 located a further 500m downstream.

Results from both sites indicate E. Coli and nutrients Total Nitrogen and Total Phosphorous are above the ANZECC guidelines in over half the samples, with dissolved oxygen readings below recommended guidelines.

4.2.8 Second Ponds Creek – Site 16

The Hills Shire Council's Health and Environmental Protection Team operate one monitoring site on Second Ponds Creek (Hills J3 on Figure 12). Hills J3 is located approximately 2.5km downstream of the Project corridor and therefore not suitable to provide a direct indication of the existing runoff quality relevant to the Project.

4.2.9 First Ponds Creek – Site 17

Blacktown City Council has two water quality monitoring sites in First Ponds Creek. The nearest of these is approximately 2.3km downstream of the Project and is therefore not suitable for use as a monitoring location.