MOOREBANK INTERMODAL COMPANY

Moorebank Intermodal Terminal Project Environmental Impact Statement

Volume 6

October 2014

PARSONS BRINCKERHOFF

Technical Paper 6
Surface Water Assessment

Technical Paper 6 - Surface Water Assessment

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Moorebank Intermodal Company

Moorebank Intermodal Terminal

Surface water assessment

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PARSONS BRINCKERHOFF
A BALFOUR BEATTY COMPANY

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Abbreviations

AEP	Annual Exceedance Probability
ARI	ARI – Average Recurrence Interval
CERAT	Coastal Eutrophication Risk Assessment Tool
DA	Development Assessment
DGR	Director General's Requirements
DNSDC	Defence National Storage and Distribution Centre
DoD	Department of Defence
EC	Electrical Conductivity
EIS	Environmental Impact Statement
ESA	Environmental Site Assessment
EV	Environmental values
GRCCC	Georges River Combined Council Committee
Ha	Hectares
LCC	Liverpool City Council
OEH	NSW Office of Environment and Heritage
OSD	On-Site Detention
m AHD	Metres Australian Height Datum
MIMT	Moorebank Intermodal Terminal
MIC	Moorebank Intermodal Company
NOW	New South Wales Office of Water
RCP	Reinforced concrete pipe
SEWPaC	Sustainability, Environment, Water, Population and Communities
SSD	State significant development
SSFL	Southern Sydney Freight Line
TN	Total nitrogen
WQOs	Water Quality Objectives

1. Introduction

1.1 The Moorebank Intermodal Terminal Project

The Moorebank Intermodal Terminal (MIMT) Project (the Project) involves the development of approximately 220 hectares (ha) of land at the Project site (refer to Figure 1.1) for the construction and operation of an IMT and associated infrastructure, facilities and warehousing. The Project includes a rail link connecting the Project site to the Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue.

The primary function of the MIMT is to be a transfer point in the logistics chain for shipping containers and to handle both international IMEX cargo, and domestic interstate and intrastate (regional) cargo. The key aims of the Project are to increase Sydney's rail freight mode share including: promoting the movement of container freight by rail between Port Botany and western and south-western Sydney; and reducing road freight on Sydney's congested road network.

The Project proponent is Moorebank Intermodal Company (MIC), a Government Business Enterprise set up to facilitate the development of the Project.

The Project site is currently largely occupied by the Department of Defence's (Defence) School of Military Engineering (SME). Under the approved Moorebank Units Relocation (MUR) Project, the SME is planned to be relocated to Holsworthy Barracks by mid-2015, which would enable the construction of the Project to commence.

The key features/components of the Project comprise:

- an IMEX freight terminal – designed to handle up to 1.05 million TEU per annum (525,000 TEU inbound and 525,000 TEU outbound) of IMEX containerised freight to service 'port shuttle' train services between Port Botany and the Project
- an Interstate freight terminal – designed to handle up to 500,000 TEU per annum (250,000 TEU inbound and 250,000 TEU outbound) of interstate containerised freight to service freight trains travelling to and from regional and interstate destinations
- warehousing facilities – with capacity for up to 300,000 square metres (m^2) of warehousing to provide an interface between the MIMT and commercial users of the facilities such as freight forwarders, logistics facilities and retail distribution centres.

The proposal concept described in the main Environmental Impact Statement (EIS) (refer Chapters 7 and 8) provides an indicative layout and operational concept for the Project, while retaining flexibility for future developers and operators of the Project. The proposal concept is indicative only and subject to further refinement during detailed design.

1.2 Rail access options and layouts

The Project is intended to connect to the SSFL, which was commissioned in January 2013 within the Main South Railway Line corridor. The SSFL connects Port Botany to west and south-western Sydney, and would provide a direct route for freight trains from Port Botany to the Project site.

Three separate rail access options are included as part of the proposal concept as detailed in this EIS, as shown in Figure 1.1 with detailed figures included in Appendix C. These options comprise:

- northern rail access option – with rail access from the north-western corner of the MIMT site, passing through the former Casula Powerhouse Golf Course (which is currently owned by Liverpool City Council (LCC)) and crossing the Georges River and floodplain
- central rail access option – with rail access from the centre of the western boundary of the MIMT site, passing through Commonwealth land on the western bank of the Georges River (referred to as the 'hourglass land')
- southern rail access option – rail access from the south-western corner of the MIMT site, passing through the Glenfield Landfill site (owned by Glenfield Waste Services) and crossing the Georges River and floodplain.

In order to maintain flexibility for future developers and operators of the Project, the proposal concept, as presented in this EIS, provides three indicative MIMT internal layouts; one for each of three proposed rail access options. Once the selected developer/operator has been appointed, the Project would progress to the detailed design phase and one of the three rail access options identified above would be selected.

1.3 The project site

The project site is situated on land in the Sydney suburb of Moorebank, NSW. The Project Site is approximately 220 ha in area, and is located within a locality that includes the residential suburbs of Casula, Wattle Grove and North Glenfield, as well as industrial, commercial and Department of Defence (DoD) land (refer Figure 1.1). The proposed Moorebank MIMT would provide connectivity to Port Botany by rail, and would connect to major regional and interstate roads and highways via the M5 and M7 Motorways.

To the north of the site, the local area is generally characterised by industrial and commercial land uses, including the adjacent ABB Australia's Medium Voltage Production Facility.

To the east of the site, land use is predominately industrial and commercial, with extensive DOD land further east (including the Holsworthy military area).

To the west of the site is the Georges River, with a generally well established riparian area, that is heavily vegetated in parts. The Leacock Recreation Park and Casula Powerhouse Arts Centre, recreational areas used by members of the community, are located on the west bank of the Georges River. The areas west and north-west of the Georges River mark a transition to low-density residential development and associated commercial developments and community facilities within the suburbs of Casula and Liverpool.

To the south of the site is the East Hills Railway Line. Further south are large areas of bushland and the DoD's Holsworthy Barracks. The Glenfield Landfill is located to the south-west of the Project.

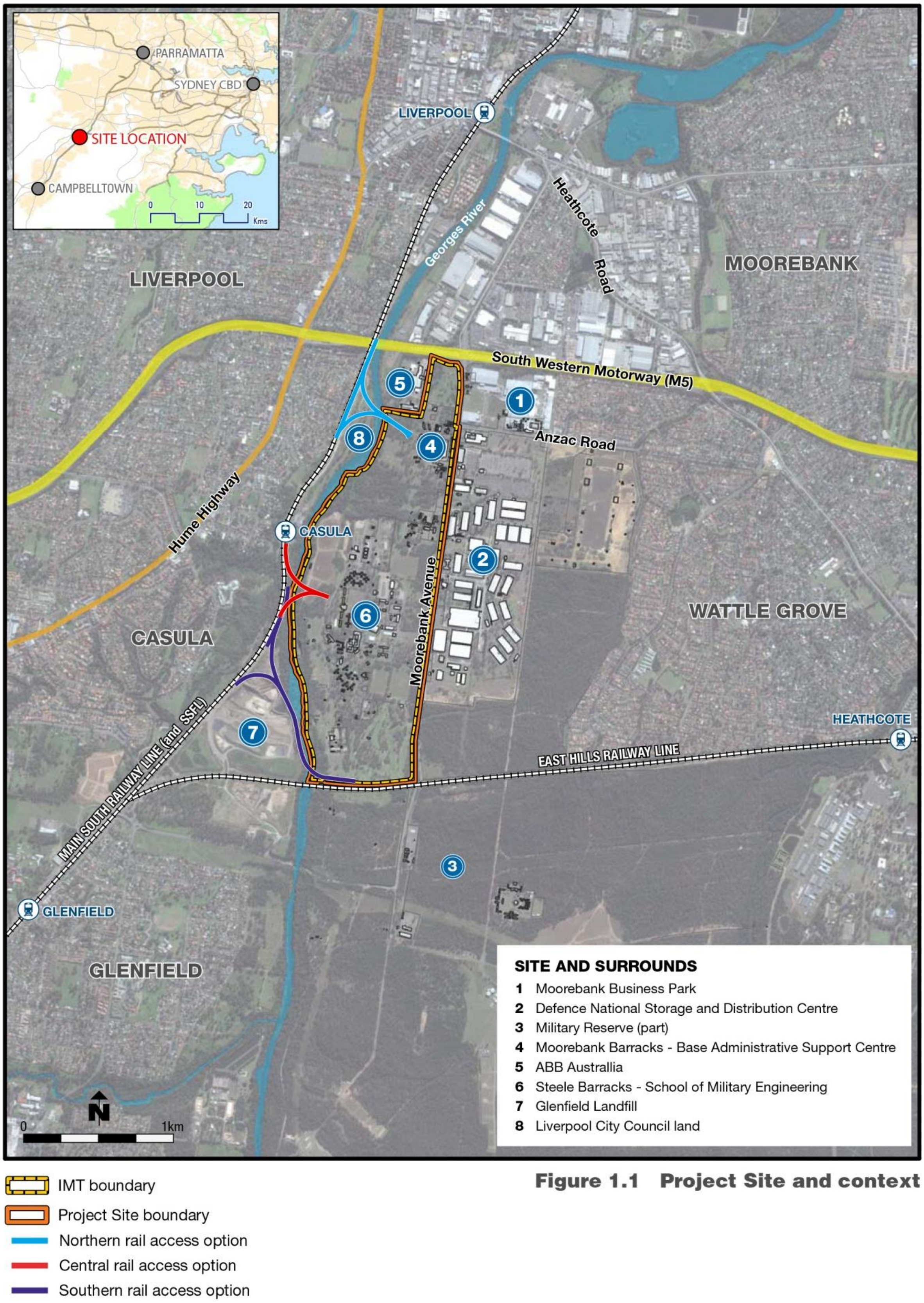


Figure 1.1 Project Site and context

1.4 Project delivery

The Project is proposed to be phased (staged) in its development, as summarised in Figure 1.2. The proposed indicative phasing includes both construction and operational phases, which are likely to overlap at certain times. For the purposes of assessment of the Project, five project development phases have been identified and detailed in this EIS however for this technical assessment only three phases have been assessed, early works, construction and full build. These are indicative only, but illustrate the type of construction and operation activities that would occur over time at the Project site.

The Project would likely commence in 2015 with the Early Works development phase and would progress with concurrent construction and operation through to the Project Full Build Phase (operation of full IMEX terminal, warehousing and interstate terminal) by approximately 2030.

The development phasing is proposed in line with the forecast market demand for processing of containers through the Project.

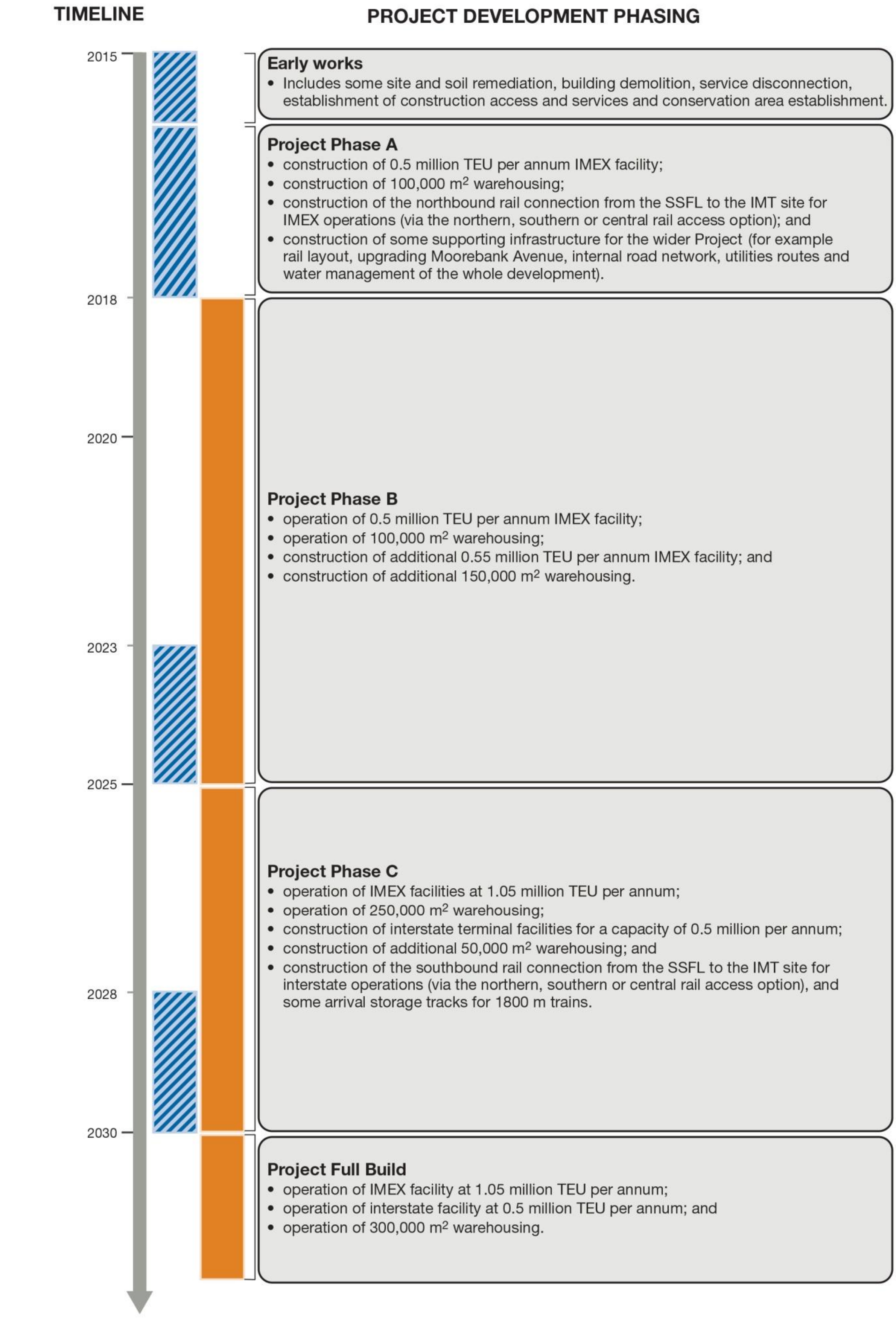


Figure 1.2 Project development phasing

1.5 Planning and assessment process

The Project is subject to both Commonwealth and NSW State Government approvals, and this technical assessment has been prepared to support the Environmental Impact Statement (EIS). The Project is a 'controlled action' under the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Therefore, MIC is seeking approval for the construction and operation of the Project from the (Commonwealth) Department of the Environment (DoE) under Part 9 of the EPBC Act.

Under the (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act), MIC is seeking a staged development approval for the Project as State significant development (SSD). At this stage, MIC is seeking Stage 1 SSD development approval for the proposal concept (as described in EIS) from NSW Planning and Infrastructure (NSW P&I) under Part 4, Division 4.1 of the EP&A Act (hereafter referred to as the Stage 1 SSD development approval). The Stage 1 SSD development approval application also includes a package of 'early works' that comprises remediation, clean-up and demolition or relocation of existing buildings, and establishment of a conservation area. The EIS is seeking approval for these early works without the need for any further approvals. Subject to Stage 1 SSD development approval being received, the Project (with the exclusion of the early works) will be subject to further development applications and environmental assessment under the EP&A Act (hereafter referred to as the Stage 2 SSD development approvals).

This Technical Paper and accompanying appendices assesses the impacts of the proposed development at full build to a concept level. Both construction and operation phase impacts based on the concepts for the three options have been assessed and are presented. Further details of the Project would be the subject of future development applications as those details are developed, with environmental impact assessments to be conducted in detail at that time.

1.6 Report outline

This report provides a surface water assessment to address the requirements defined in the Secretary for the NSW Department of Planning and Environment's (NSW DP&E's) Environmental Assessment Requirements (NSW SEARs) (refer Section 1.7.1) and the Commonwealth EIS requirements (refer Section 1.7.2). The report covers surface water related aspects such as flooding, stormwater and water quality of surface water resources. In addition, the impacts of climate change for each of these aspects of the assessment have been considered. Other water related aspects such as water supply, wastewater management and sewerage servicing are not covered in this assessment.

This assessment has been based on concept design layouts for three alternative site and rail access layouts. These are presented below and have been prepared in order to allow flexibility in the site layout and obtain final approval for an early works package under Part 4.1 of the EP&A Act. The concept designs consider and address the requirements of Liverpool City Council and particular requirements relating to discharge of stormwater to the Georges River and surface water management relating to the proposed rail corridors. These relevant requirements are included in section 1.7.4 below. It is anticipated that impacts and mitigation measures relating to surface water would be confirmed following detailed design and during future phases of the project.

1.7 Assessment criteria

1.7.1 NSW SEARs

Table 1.1 below details the NSW SEARs specific to the Project and addressed by this surface water assessment.

Table 1.1 Secretary for the NSW DP&E's Environmental Assessment Requirements

Secretary for the NSW DP&E's Environmental Assessment Requirements	Relevant section(s) of surface water assessment
Key Issues: Hydrology – including but not limited to: ▪ changes to the site's hydrology and an assessment of the hydrological impacts of the development and the development effects on flood characteristics on and off the site (in particular Cambridge Avenue), including the consideration of effects associated with climate change, such as changes to rainfall frequency and/ or intensity	3.2, 3.3, 4.1, 4.2
▪ surface water and stormwater quality, erosion, spill, and sedimentation impacts, on and off site	2.2, 3.4, 4.2
▪ taking into account the Managing Urban Stormwater Soils and Construction, Vol. 1, 2A and 2D (DECC), National Water Quality Management Strategy Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) Georges River Floodplain Risk Management Study and Plan, Anzac Creek Floodplain Risk Management Study and Plan and Floodplain Development Manual (DIPNR)	3.2, 3.3, 3.4, 4.1, 4.2

1.7.2 Commonwealth EIS requirements

Table 1.2 below details the Commonwealth EIS requirements addressed by this surface water assessment.

Table 1.2 Commonwealth EIS requirements

Commonwealth EIS requirements	Relevant section(s) of surface water assessment
All construction and operational components of the action must be described in detail. This must include the precise location of all works to be undertaken, structures to be built or elements of the action that may have impacts on matters of National Environmental Significance (NES). The information must include: ▪ water quality management at the proposed action area during and after construction ▪ details regarding water supply, waste water management, sewerage management, stormwater management and any other relevant public works ▪ full details of risk assessments which have been undertaken regarding potential threats from flood and fire and strategies to address these risks.	Sections 3.4 and 4.2 Stormwater management addressed in section 4.2 and Appendix B. Flooding risk is addressed in sections 3.2 and 4.1. The bushfire risk assessment is addressed in the EIS.
The EIS must provide a detailed and comprehensive analysis of the existing environmental conditions, likely changes. The following should be addressed in relation to impacts to the environment: ▪ provide an assessment of the hydrological impacts of the project and the project efforts on flood characteristics on and off the site and the likely impacts of changes to surface water and stormwater quality, erosion and sedimentation impacts, on and off site	Sections 3.2 and 4.1 address flooding. Sections 3.4 and 4.2 and Appendix B address surface water and stormwater quality.

Commonwealth EIS requirements	Relevant section(s) of surface water assessment
▪ provide an assessment of the likely and potential impacts on all aspects of the environment associated with spills, floods, fire and release of contaminants. The assessment needs to consider all hazardous items that will or could potentially be transported and/or stored at the intermodal terminal. Discuss the likelihood of hazardous materials being illegally transported using rail infrastructure and stored at the Moorebank Intermodal.	Section 3.4 addresses potential impacts to surface water associated with spills and release of contaminants. Detail on hazardous materials being transported as part the Project is addressed in the EIS.

1.7.3 Liverpool City Council requirements

Liverpool City Council (LCC) is the local government authority responsible for setting development controls for the Project Site. Development on the site is subject to the following development instruments:

- LCC Development Control Plan, 2008
- Liverpool District Stormwater Management Plan
- LCC Development Control Plan no.49
- LCC NSW Development Design Specification D5: Stormwater Drainage Design
- LCC, NSW Development Design Specification D7: Erosion Control and Stormwater Management
- LCC Development Control Plan no. 49 for Amiens, Yulong and DNSDC sites Moorebank International Technology Park Moorebank Avenue, Moorebank
- LCC On-Site Stormwater Detention Technical Specification.

1.7.4 Rail-related requirements

With the inclusion of the rail line to connect the Project Site to the SSFL, stormwater management infrastructure for the connecting rail line within the Project Site will be subject to RailCorp and Australian Rail Track Corporation design specifications. RailCorp drainage design standard TMC 421 is particularly relevant to this assessment.

1.7.5 Other regional planning instruments

Other relevant policies and planning controls include:

- Regional Environmental Planning Policy (REP) No.2 – Georges River catchment.
  - The REP has specific planning principals that are relevant for the development of the site. The most relevant aim from this plan for the surface water assessment is ‘to maintain and improve the water quality and river flows of the Georges River and its tributaries, and ensure that development is managed in a manner that is in keeping with the national, state, regional and local significance of the catchment.’
- Georges River Strategic Bank Stabilisation Plan (primarily related to river banks downstream of Liverpool weir), Liverpool City Council, 2012.

1.8 Assessment methodology

In order to address the NSW SEARs and Commonwealth EIS requirements an assessment of the impacts of the project on the surface water environment was undertaken. To understand the impacts of the proposed development a series of investigations were undertaken.

These investigations have been based on the three concept site layouts provided. As required, assumptions have been made in order to identify all potential impacts for each concept and therefore identify mitigation measures in order to ensure the development has the least impact.

The latest advice outlined in the *Floodplain Risk Management Guideline: Practical Consideration of Climate Change (*DECC, 2007 regarding climate change predictions has also been considered in this impact assessment.

With respect to the NSW SEARs and Commonwealth EIS requirements, the following key potential impacts need to be assessed, both within the site and external to the site:

- change in hydrologic regime, in particular, change in flooding, stormwater runoff quantity
- impact of project on water quality, including sediment and erosion, stormwater quality, stormwater pollution (accidental spills etc.).

These key potential impacts are addressed in this report for the early works, the construction and operational phases of the project. Assessment of the operational phase impacts has been based on conceptual proposed stormwater management measures and assumed bridge configurations for the crossing of the Georges River.

The methodology primarily involved desktop assessments supplemented by site walkover inspections. The desktop assessments utilised information and analyses from the available concept designs and flood data and water quality data available from the local council and other organisations. Impacts on the surface environment were assessed at the regional scale, which addressed the Georges River floodplain and catchment adjacent to the site, and at the local scale, which addressed the surface water environment on the site itself.

Regional scale flooding impacts were identified from the flood impact assessment for the three options for bridge crossing locations – refer to Appendix A. This involved development of a hydraulic model of the Georges River and floodplain system local to the site and simulation of existing and developed scenarios to determine the impact of the crossing on flood levels and velocities.

Regional scale water quality impacts and mitigation measures were identified and a series of stormwater management features are proposed in order to detain and treat site runoff. Details of these are included in Appendix B.

Local scale impacts and mitigation measures relating to the surface water environment of the site itself were also identified. Where possible stormwater management features have been located as part of the site layout and specific design criteria detailed to avoid adverse impacts on the local environment.

Construction phase impacts were assessed based on assumed worst case disturbance of the local surface water catchments.

The assessment of operational phase impacts has been undertaken to identify the potential worst case impacts of the Project as opposed to identification of impacts from each development phase. For all three conceptual layout options the potential worst case impacts would occur for the Project once full build is completed and the project is operating to full capacity.

2. Existing environment

This chapter provides an outline of the existing environment and the surrounding catchment for the proposed project site.

2.1 Regional surface water environment

The project site is located within the Georges River catchment, with the river forming the western boundary of the site. The Georges River rises approximately 60 km south-west of Sydney near Appin. From here the river flows north towards Liverpool, through the Chipping Norton Lakes Scheme, then east until it reaches Botany Bay.

The total catchment area for the Georges River is 960 km^2 and lies between the altitudes of 440 m AHD and sea level. Land use within the catchment is mixed and includes residential, industrial, agricultural, mining, Defence land and protected areas such as drinking water catchments and conservation areas. The catchment area contains nearly 1.2 million people (GRCCC 2011) and approximately 45% of the catchment remains in natural or near natural conditions.

The project site is located in the upper section of what is referred to as the mid Georges River. The catchment area upstream of the project site is largely undeveloped but is under development pressures. The mid Georges River catchment begins at Cambridge Avenue (upstream of the Project Site and immediately to the south) and from here development within the catchment continues and increases through to Botany Bay. The section of river adjacent to the project site is not subject to tidal influences, with the Liverpool weir, located approximately 2 km downstream (to the north of the site), governing minimum water levels. Flooding in this reach of the river is therefore a fluvial process, i.e. it is caused by the catchment's runoff response to rainfall.

The project site is generally flat to gently undulating and is bounded by the Georges River to the west, into which the majority of the site currently drains. Adjacent to the project site the river is well defined with vegetated banks on both sides of the river (see Photograph 2.1). The eastern floodplain of the river (part of the project site) has a terrace area at a relatively low elevation. East of this terrace area the ground levels rise steadily up to the higher level where the developed part of the site is locate.

A small portion of the south eastern part of the site drains to Anzac Creek, which is an ephemeral tributary of Georges River with a catchment area of 10.6 km^2. This creek flows in a north-westerly direction and ultimately drains to Lake Moore on the Georges River, some 3 km downstream of the project site. In the south-west corner of the site a number of linked ponds form the headwaters of Anzac Creek within the existing Royal Australian Engineers golf course. From these ponds the creek flows east under Moorebank Avenue via culverts.

The area has historically been subject to flooding from the Georges River. Regionally, historical flood records date back as far as the 1860s, with most records relating to flood levels recorded at Liverpool Weir. The most recent major flood occurred in 1988 and was estimated to have an annual exceedance probability (AEP) of 5%. The 1988 flood resulted in over 1,000 properties being inundated along the Georges River and an estimated $18 million in damages.

Photo 2.1 Georges River adjacent to project site (looking north downstream)

2.1.1 Georges River flood risk

The project site is at risk of flooding from the Georges River; however, the main flood risk is confined to the lower level terrace area as indicated by the LCC flood risk map (refer to Figure 2.1). Peak 1% AEP flood levels range from 11.7 to 10.4 m AHD along the western boundary of the site.

Additional investigations have been undertaken as part of the assessment to understand the flood risk to the site and the potential impacts of the development on flood risk in the adjacent floodplain. The results of these investigations are provided in Appendix A. The LCC flood data has been used to assess flood risk zones within the project site, as summarised in Table 2.1.

Table 2.1 Project site flood risk zones

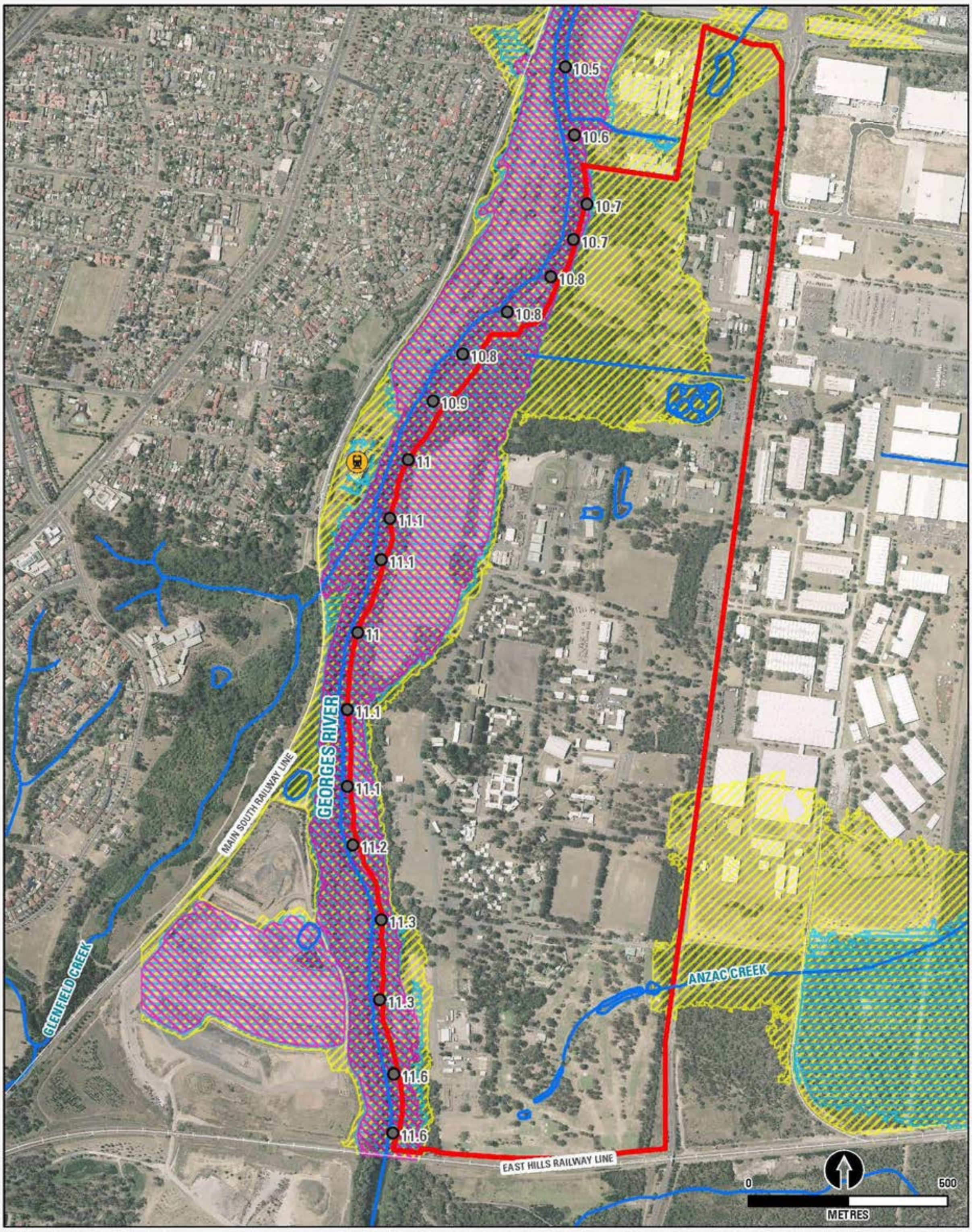
Flood risk category	Category definition	Project area affected (ha)	Percentage of project site affected
High flood risk	Areas within 1% AEP flood extent and subject to high hydraulic hazard or evacuation difficulties	23.6	12%
Medium flood risk	Areas within 1%AEP flood extent and not subject to high hydraulic hazard or evacuation difficulties	25.5	13%
Low flood risk	All other flood liable land, i.e. within the Probable Maximum Flood (PMF) extent	56.8	29%
No flood risk	All other areas, i.e. all areas outside the PMF extent.	90.9	46%

Figure 2.1 shows these flood risk zones for the Project Site. The flood risk zone mapping is based on LCC's flood modelling results (using the MIKE11 software package) from the Upper Georges River Flood Study (Department of Land and Water Conservation and Liverpool City Council, 2000) and the modelling of Anzac Creek completed for the Anzac Creek Floodplain Risk Management Study and Plan (BMT WBM 2008).

The Georges River Flood Study predicts that the critical storm duration for flooding at the Project Site is 36 hours for the 1% AEP flood event. Thus, flood levels resulting from the critical storm would persist for a relatively long duration in the medium and high flood risk zones within the site. For this storm duration, a reasonable warning time is available and the close proximity of the river would allow visual warning of rising flood levels.

Currently evacuation of the Project Site under extreme flood events is possible via the portion of the site that lies outside the probable maximum flood (PMF) extent as there is direct access to Moorebank Avenue which remains flood free under this maximum event.

MOOREBANK INTERMODAL TERMINAL



* Flood risk based on data supplied by Liverpool City Council (January, 2011)

Figure 2.1: Existing flood risk probability map

2.1.2 Anzac Creek flood risk

Flood extents and potential flood risks from Anzac Creek on the existing project site were also considered through a review of the *Anzac Creek Floodplain Risk Management Study and Plan* (BMT WBM 2008). The project site is at the headwaters of Anzac Creek. The BMT WBM report presents a series of flood risk maps that have been developed from detailed modelling of the hydrological characteristics influencing the Anzac Creek catchment, including peak flood levels, flows and inundation extents for a range of events including the PMF.

The *Anzac Creek Floodplain Risk Management Study and Plan* (BMT WBM 2008) identifies that flooding is generally confined within the main channel of Anzac Creek upstream of the M5 Motorway. Effective conveyance of flood discharges in the main channel up to the 1% AEP flood event results in very little floodplain inundation. Existing culverts through the M5 Motorway embankment can convey the 1%AEP flood event to the downstream reaches of the Anzac Creek catchment, without causing substantial backwater accumulation assuming no blockage of the culverts.

Only a minor portion of the existing project site (approximately 9%) lies within and drains to the Anzac Creek catchment. Under existing conditions the flood risk to the project site from Anzac Creek is negligible, as documented in the BMT WBM report, which states 'Even up to the 100 year ARI flood event there is very little floodplain inundation' (BMT WBM 2008).

2.2 Local surface water environment

This section describes the local stormwater catchments of the project site that drain the site to the Georges River and Anzac Creek. Key features described below are shown on Figure 2.2.

2.2.1 Stormwater catchments and drainage systems

The existing stormwater conveyance system within the project site consists of pits, pipes and open channels which convey flow in a generally north-west direction across the site and discharge into the Georges River. The pipe network services the existing buildings and infrastructure located near the centre of the site. All but one of these local stormwater systems discharge to the Georges River, with one discharging to Anzac Creek. It is understood that only one out of an estimated total of nine discharge points to Georges River includes a non-return floodgate. The floodgate is installed on the lowest discharge point which forms the outlet of the Amiens wetland, with all other discharge points located at higher levels.

Two open channels are noted on site, an informal vegetated open channel in the north of the site abutting the property boundary of the adjacent ABB site and an open concrete-lined trapezoidal channel that flows westward through the site from the sag (or lowest) point in Moorebank Avenue to the Georges River.

Inspection of the project site conducted by Parsons Brinckerhoff on the 4 November 2010 observed the existing stormwater drainage network to be in poor condition. The concrete-lined open channel was blocked and/or covered by thick vegetation and erosion around the drop structure has placed its structural integrity at risk and the downstream gully has been significantly eroded.

Discharges into Anzac Creek occur from overland flow paths within the Royal Australian Engineers Golf Course in the south-east corner of the site. Areas within the golf course drain through open channels to road culverts underneath Moorebank Avenue which then discharge into Anzac Creek.

From a review of the local site topography and visual inspection of the area it appears that adjacent land east of the project site will also drain to the Georges River via the project site. These land areas are described below.

2.2.1.1 Defence National Storage and Distribution Centre

The Defence National Storage and Distribution Centre (DNSDC) is located on the eastern side of Moorebank Avenue on land leased from the Sydney Intermodal Terminal Alliance. The stormwater drainage network within this site currently discharges stormwater runoff via drainage infrastructure into the existing project site at two locations. The first discharge location is through the box culverts underneath Moorebank Avenue that connect to the open channel flowing west across the existing project site. The second discharge location is a 600mm diameter pipe that connects to grated pits on either side of the Moorebank Avenue road reserve located approximately 210 m north of Chatham Avenue.

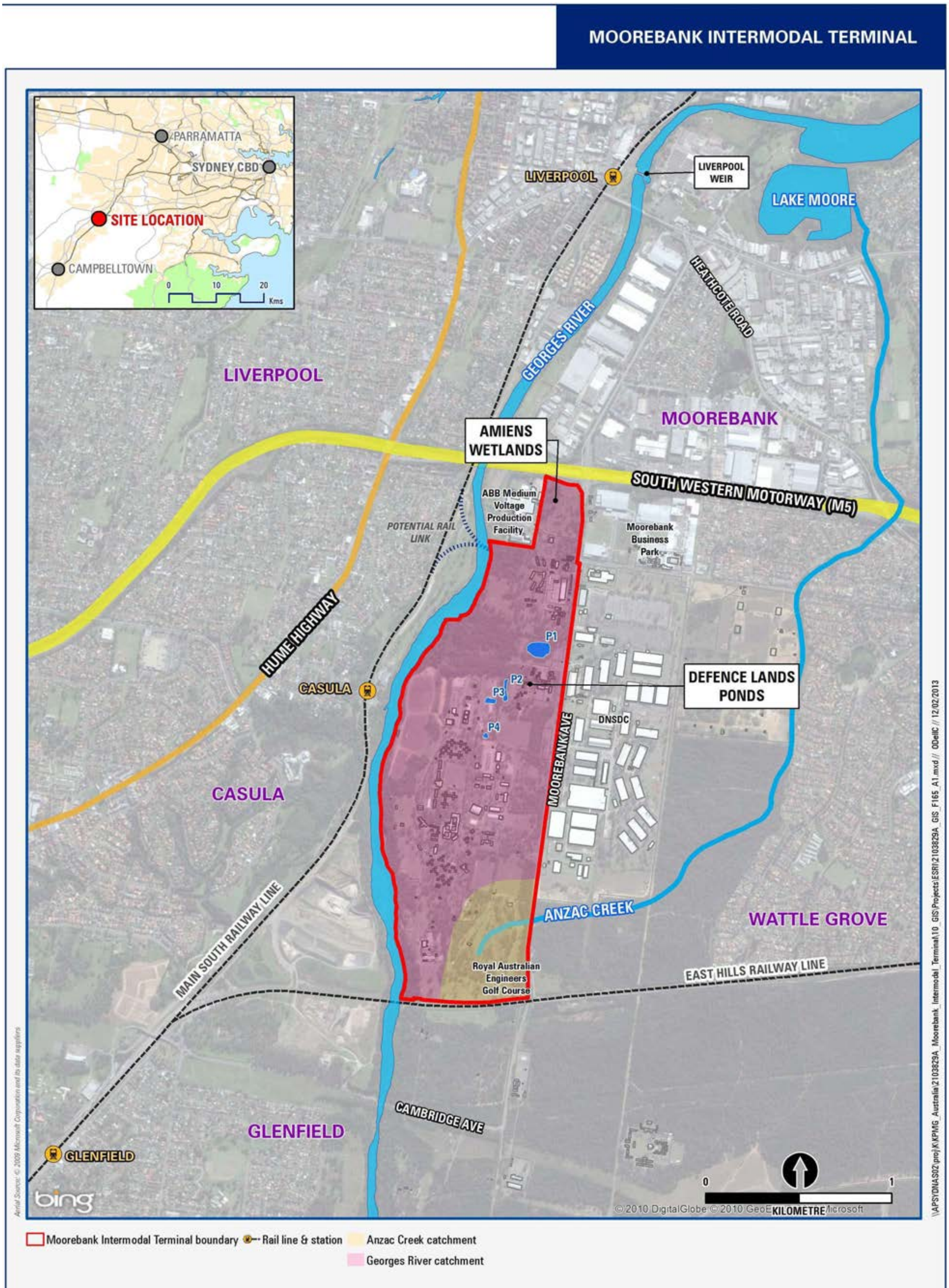


Figure 2.2: Existing waterbodies and surface drainage

Existing topography within the DNSDC site shows that the western side of the DNSDC produces overland stormwater flows towards Moorebank Avenue and is either intercepted by open channels on the eastern side of Moorebank Avenue or flows over Moorebank Avenue into the existing project site. The drainage channel on the eastern side of Moorebank Avenue connecting to the open channel through the project site has a shallow grade (<0.5%) and it is assumed that it does not have capacity to convey the 1% AEP flood event. It is therefore considered likely that runoff under extreme events will overtop the channel and spill over Moorebank Avenue onto the existing project site. The eastern side of the DNSDC produces overland flows away from the project site and into Anzac Creek.

The current road grading along Moorebank Avenue has very little fall (<0.5%) and it is assumed that very little flow travels along Moorebank Avenue and instead large storm events overflow from the DNSDC directly onto the project site.

2.2.1.2 M5 south-west motorway

The stormwater drainage from the M5 south-west motorway intersection with Moorebank Avenue (M5 intersection) to the north of the project site has been designed to discharge into the existing project site in events greater than or equal to the 1% AEP event. In events less than the 1% AEP event the M5 intersection drainage system has been designed to discharge to the Georges River via dedicated 1500 mm and 2100 mm diameter pipes fitted with non-return outlet floodgates. Flows exceeding the capacity of the drainage system have been designed to discharge from a surcharge pit within the road reserve and spill into the existing Amiens wetland which is situated to the north of the project site. However, it is not known if the system was designed to account for elevated tail water conditions in the Georges River that would occur during a flood event. Flood events within the Georges River will close the floodgates on the outlet pipes from the M5 intersection drainage and may cause flows to discharge from the surcharge pit in events more frequent than the 1% AEP event.

2.2.1.3 Moorebank Business Park

Based on available topographic information, the south-western corner of the Moorebank Business Park (approximately ¼ of the business park area) will contribute overland flows onto Moorebank Avenue and Anzac Avenue. Overland flows are expected to flow across and down the road to the primary sag point along Moorebank Avenue and subsequently onto the project site before discharging into the Georges River.

2.2.1.4 ABB site

A vegetated swale abutting the southern boundary of the ABB site runs beneath an overhead power line that crosses the Georges River. Based on the existing contours, this channel appears to convey surface flows from the surrounding area including the project site and may also collect surface runoff from the ABB site.

2.2.2 Stormwater and downstream receptor water quality

Surface flows and stormwater runoff from the Project Site currently drain to the Georges River and Anzac Creek (section 2.2.1). The quality of the stormwater discharging from the existing site to the Georges River is currently influenced by the developed areas of the site, site activities and several small to medium sized water bodies located within the site. These water bodies and site surface flows are shown on Figure 2.2.

A detailed assessment of the local and regional surface water quality is included in the Stormwater Management Plan (SMP) included in Appendix B. A summary of the on-site water bodies' water quality and the regional (Georges River) water quality is included below.

2.2.2.1 On-site water bodies

An environmental site assessment (ESA) was conducted in January 2011 by Parsons Brinckerhoff to assess and characterise the nature and likely extent of contamination at the site based on the areas of potential environmental concern (Parsons Brinckerhoff 2011). The following field parameters were collected at each surface water sampling location using a water quality meter. In summary:

- pH ranged between 6.47 to 9.37 indicating a wide range of values from slightly acidic to alkaline conditions
- electrical conductivity ranged from 65.4 to 528 µs/cm indicating fresh water
- temperature ranged from 20.3 to 30.4ºC
- dissolved oxygen ranged between 4.02 to 8.44 indicating that surface waters are well oxygenated.

While the majority of samples returned results below the laboratory quantitation limit, concentrations of copper, nickel and zinc were above the default trigger values provided in the ANZECC guidelines for these metals.

Based on the findings of the ESA, the soil and groundwater contamination identified at the site is unlikely to contribute significant additional impacts to the water quality within the Georges River. Impacts due to potential migration of contaminated groundwater and surface water from the site to the Georges River are considered to be low.

2.2.2.2 Georges River

Water quality sampling was undertaken as part of the aquatic survey for the SIMTA environmental assessment (Hyder 2011). The survey found that the majority of water quality parameters were within ANZECC guidelines for lowland aquatic ecosystems of south-eastern Australia. Some noted exceptions include pH and dissolved oxygen (DO%). The pH recording in Anzac Creek of 5.62 was below the lower guideline of 6.5. The DO% of Anzac Creek of 11.6% was considerably lower than the lower guideline of 60%.

A summary and description of data used to assess the baseline water quality conditions of the Georges River are provided in Table 2.2. The locations of sampling sites are shown in Figure 2.3.

Limitations exist in these data sets as they are discrete sampling events. Variability in these data and recorded values and concentrations outside of desired water quality objectives (WQOs) can be influenced by climatic environmental conditions at the time of sampling or errors in the sampling methodology.

A specific water quality monitoring programme for Georges River has been established for the project. This programme commenced in July 2013 and will run for two years. The programme involves monthly water quality sampling at five locations within the Georges River, along with analysis of antecedent rainfall and river flow conditions. Samples are analysed for the full range of water quality indicators, including field parameters, physical parameters, major ions, metals, nutrients, microbial indicators and hydrocarbons. Refer to Section 2.5.4.6 of the Stormwater Management Plan (Appendix B) for details of the programme.

The findings of the water quality monitoring programme to date are as follows:

- Weather conditions since commencement of the programme in July 2013 have been relatively dry with below average rainfall. The sampling events to date have therefore not captured a high flow event, and results to date reflect water quality for the lower range of flow conditions.
- Exceedances for total nitrogen (TN) and total phosphorus (TP) have been recorded for all monitoring locations.

- The single sampling location on Anzac Creek most commonly exceeds TN and TP trigger values, likely to be due to fertilisers used at the Golf Course.
- No major exceedances for metals have been recorded.
- Other exceedances have been recorded but none indicating unusual or long term trends of concern.
- In general the results to date reflect the prevailing low flow conditions.
- As the programme is approximately 50% complete and has been operating during predominantly low flow conditions, it is recommended that summary statistics from the programme be prepared at a more advanced stage of the programme when a longer term record is available that captures more variability in flow conditions.

MOOREBANK INTERMODAL TERMINAL

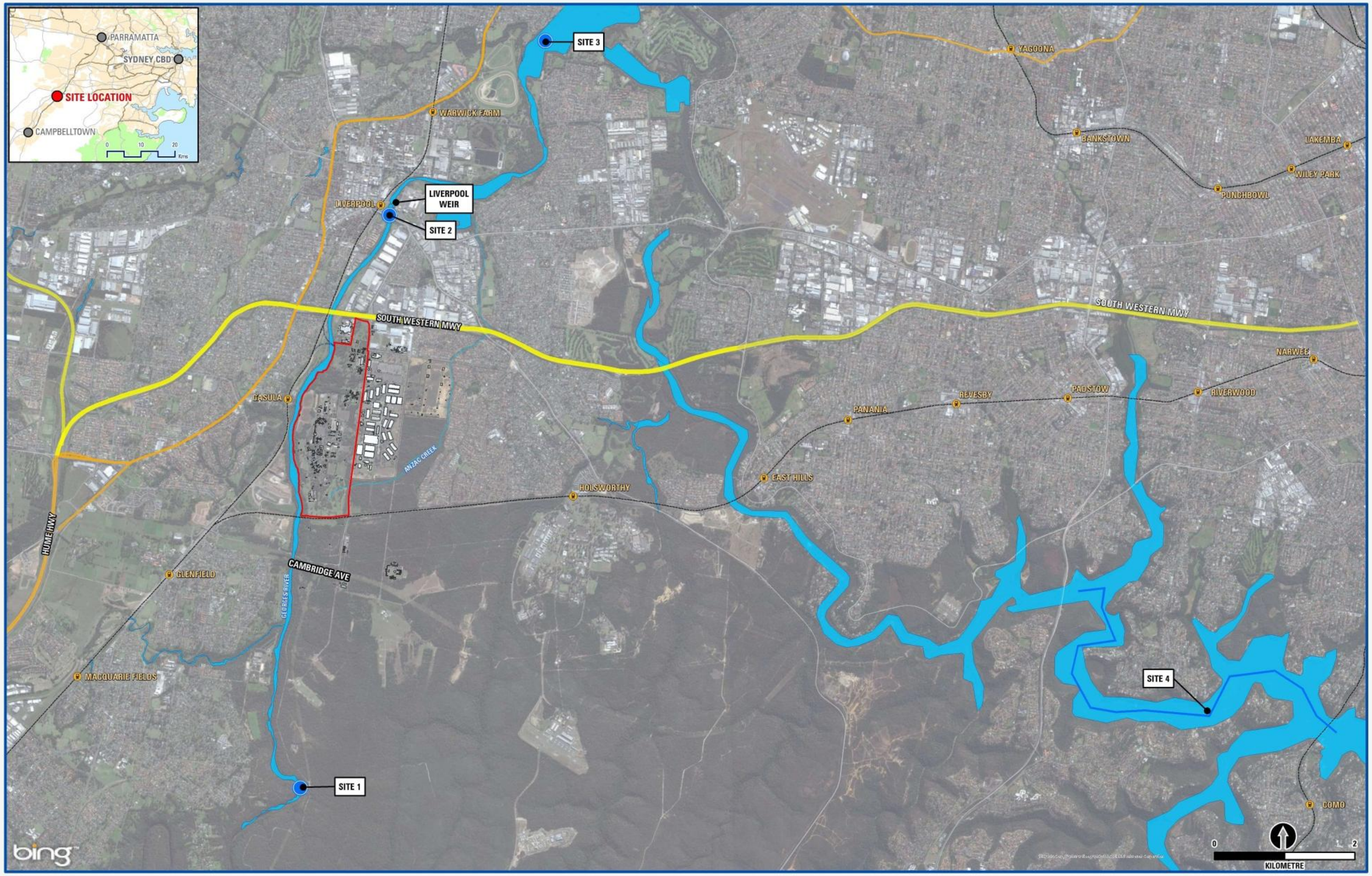


Figure 2.3: Existing water quality sampling sites

Moorebank Intermodal Terminal boundary · Rail line & station

Table 2.2 Existing water quality data

	Site 1 (refer to Figure 2.3)			Site 2 (refer Figure 2.3)			WQOs (Lowland rivers)	
Freshwater (Lowland rivers)	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**
pH	3.12	8.65	7.42	6.95	7.96	-	6.5	8.5
TN (µg/l)	210	650	360	530	1060	720		350
TP (µg/l)	10	20	10	15	78	35		25
Turbidity (NTU)	<1	14	3	1.7	63.1	24.1	6	50
EC (25°C)	86	323	244	-	-	-	125	2200
Chl *a* (µg/l)	-	-	-	<1	31.5	7.6		5
Estuarine	**Site 3**			**Site 4**			**WQOs (estuaries)**	
pH	4.84	8.1	-	-	-	-	7.0	8.5
TN (µg/l)	360	1670	940	-	-	-		300
TP (µg/l)	25	161	79	-	-	-		30
Turbidity (NTU)	3.2	68.5	23.7	2.2	24.9	7.75	0.5	10
EC (25°C)	-	-	-	-	-	-	-	-
Chl *a* (µg/l)	<1	17.6	5.3	2.5	4.6	5.7		4

Notes: TN =Total Nitrogen, TP = Total Phosphorus, NTU = Nephelometric Turbidity Units, EC = Electrical Conductivity, Chl*a* = Chlorophyll *a*

3. Impact assessment

This chapter outlines the potential impacts of the project for the early works, construction and operational phases. Where possible, individual impacts relating to a specific layout (northern, central and southern) have been identified but many of the impacts will be applicable for all the proposed layouts. Details of the project works are firstly outlined below then the impact assessment with respect to regional flooding and local stormwater are discussed. Measures to mitigate and manage the identified impacts are provided in Chapter 4 of this report.

3.1 Proposed project works

3.1.1 Early works

Early works will consist of the following:

- establishment of construction facilities, which may include a construction laydown area, site offices, hygiene units, kitchen facilities and wheel wash, if it is necessary to establish these facilities in a different location from that initially set up as part of the site rehabilitation works (refer section 8.1.2 above);
- demolition or relocation of existing buildings, structures and contaminated buildings not being removed as part of the MUR Project or the site rehabilitation works (refer section 8.1.1 and 8.1.2 above);
- some contaminated land remediation including removal of unexploded ordnance (UXO) and explosive ordnance waste (EXO) if found, removal of asbestos contaminated buildings and remediation of an area known to contain asbestos (as shown in Figure 8.2);
- relocation of trees, including hollow bearing trees (i.e. those that provide ecologically important roosting habitats);
- *service utility terminations and diversions;*
- establishment of the conservation area within the Project site including seed banking and planting; and
- heritage impact mitigation works including archaeological salvage of Aboriginal and European potential archaeological deposit (PAD) sites.

3.1.1.1 Conservation area

The project would establish the riparian vegetation between the Georges River and the 1% AEP flood level as a dedicated conservation area as part of early works. With the exception of the rail links and bridges over Georges River proposed to connect the MIMT site to the SSFL and the establishment of stormwater drainage channels, no further development is proposed in this area. The conservation area will be approximately 2.5 km in length and may be up to 250 m wide in some areas.

The conservation area would comprise vegetation that is to be retained and areas which are currently weed infested or cleared, which require rehabilitation.

3.1.2 Rail access connections and Georges River crossing

The project requires development of a rail crossing over the Georges River to connect the main project rail infrastructure to the SSFL (refer to Appendix C for detailed presentation of layouts). Three crossing options have been proposed and these include:

- Northern rail access option (crosses LCC land)
- Central rail access option (crosses Commonwealth Land (Lot 4 DP1130937))
- Southern rail access option (crosses Glenfield Landfill).

Each of these options have north and south bound connections to the SSFL. The development of the bridge crossing has the potential to have adverse impacts on flooding in the vicinity of the new structure. Hydraulic investigations have been undertaken to assess the afflux generated by each of the proposed rail crossing options and their associated piers within the Georges River and its floodplain adjacent to the Project site (refer Appendix A to this report).

Given that the options are still at the conceptual design stage, it is assumed that the crossing will consist of two single track rail bridges that converge near the crossing of the Georges River. The bridges would have multiple piers located both within the Georges River and within the Georges River floodplain. None of the rail access option bridges would orientate perpendicular to the river and instead would cross the main channel and floodplain at an oblique angle to the main flow direction. The piers, however, would be designed so that they are orientated in the direction of flow as far as possible to minimise afflux impacts.

Generally the bridge piers would be 1.8 m in diameter. In the floodplain these piers would extend below ground to their founding depth. The piers would be designed to be streamlined in shape to minimise afflux and scour of the bed and banks of the waterway. For the purposes of this assessment the piers have been assumed to be 1.8 m in diameter (as per the existing East Hills Rail Bridge) and located at 20 m intervals as a minimum. Piers located within the river channel would terminate above normal water level where they would be supported on a pile cap and a raft of piles. The bridge deck soffit would be set a minimum of 500 mm above the predicted 1% AEP flood level although headstocks would be partially submerged during this event.

The following sections outline the concept bridge layouts considered in this report. Further modelling of flood impacts would be undertaken during detailed design of the bridge to ensure flood impacts are minimised.

3.1.2.1 Northern rail access option

The northern rail access option proposes constructing a rail bridge to the northern area of the Project Site. The concept plan shows two separate single track rail bridges crossing the river that converge into a single double track structure on the eastern bank of the Georges River. The bridges would require a number of piers located both within the Georges River and within the Georges River floodplain. The bridge does not orientate perpendicular to the river and instead forms two arcs across the floodplain.

3.1.2.2 Central rail access option

The central rail access option proposes constructing a rail bridge in the central area of the Project site. The concept plan proposes two separate single track rail bridges crossing the Georges River before converging into a single double track arrangement within the main Moorebank IMT Project site. The bridges are likely to have piers located both within the Georges River and within the Georges River floodplain. The bridge does not orientate perpendicular to the river and instead forms two arcs across the floodplain.

3.1.2.3 Southern rail access option

The southern rail access option proposes constructing a rail bridge adjacent to the existing East Hills Rail Bridge, crossing the Georges River at the Southern end of the Project site. The concept plan shows two separate single track rails that cross the western floodplain of the Georges River through the Glenfield Landfill site before converging into a single double track bridge to cross the Georges River immediately downstream from the existing rail bridge.

To minimise potential flood impacts the bridge has been designed to hydraulically replicate the existing rail bridge (refer Appendix A for existing bridge 'Work as Executed Drawings').

3.1.3 General project infrastructure

The project will require the construction of warehouses, administration buildings, hardstand areas, roads, parking areas, the rail corridor, and container transfer and storage areas. With the exception of the conservation area it is anticipated that a majority of the Project Site will be utilised for the facilities and subsequently the percentage of impervious surfaces will be greatly increased from present conditions.

Stormwater quality and quantity will need to be managed so that proposed discharges have no impact on the downstream receiving environment, the Georges River and Anzac Creek. For each rail crossing option a conceptual stormwater flow breakdown has been developed in order to identify the minimum stormwater management infrastructure required. As all flows from the developed site will discharge directly into the Georges River and Anzac Creek, there are no stormwater pollution impacts on adjacent lands and the impact assessment has focused on the receiving waterways.

The key elements of the Project system include:

- piped 10% AEP drainage capacity from all hard stand areas
- piped 2% AEP drainage capacity from all rail corridors
- 1% AEP overland flows across the site
- direct piped drainage from upstream catchments across the developed site to Georges River
- direct piped drainage at the southern end of the site to Anzac Creek
- diversion of M5 surcharge to the developed site drainage and detention system
- diversion of runoff from Moorebank Business Park through open channels or box culverts crossing the developed site
- provision of overland flow paths across the site to detention basins which will discharge to Georges River
- constructed biofiltration/wetlands along the east bank of Georges River to treat site runoff prior to discharge to Georges River
- stormwater pollution prevention and treatment systems distributed across the site.

The proposed site drainage strategy has been developed to contain stormwater runoff for all events up to and including the 10% AEP design event in an underground piped network. Runoff from higher order events will surcharge the network and travel overland via the road network, dedicated open channels or via graded channels across the site. The proposed system should be designed to minimise disturbance to site operations as a result of a rainfall event or from a flood event within the Georges River. All outlets from the project stormwater system should be set above the 1% AEP design flood level in the Georges River.

Detention basins have been sized for each layout to detain stormwater runoff and reduce peak discharge flow rates to pre-development conditions (as required by LCC). Stormwater treatment measures will be included in the layout where possible and some measures include:

- grassed swales
- rain gardens
- sedimentation basins (at detention basin inlets)
- biofiltration basins and permanent ponds (at detention basin inlets).

The final stormwater treatment system should contain these or other approved equivalent measures in order to address LCC requirements for managing the quality of stormwater runoff from the site. The proposed stormwater management strategy has estimated the sizes of detention and biofiltration for each layout option.

For the construction phase of the project it is proposed that temporary sedimentation basins be built in the locations of the permanent basins then converted to permanent structures for the operational phase.

3.2 Regional flooding impacts

Development of the project site has been planned around existing regional flooding constraints which are in line with the NSW Flood Prone Land policy as outlined in the NSW Floodplain Development Manual (DIPNR 2005). As such infrastructure and changes to ground levels are only proposed within the low flood risk or no flood risk zones (refer to Figure 2.1). The areas of the site within the medium and high risk zones are primarily contained within the proposed conservation zone as identified in section 3.1.1. The exception to this is the rail bridge crossings of the Georges River which connects the site with the SSFL.

The bridge crossings can potentially have adverse impacts on flooding in the vicinity of the structure and the upstream catchment. A hydraulic investigation has been undertaken to assess the potential afflux (i.e. increase in flood levels) generated by the proposed rail crossings and associated piers within the Georges River and floodplain (refer to Appendix A).

3.2.1 Early works impacts

The impact of the early works on regional flooding is negligible. Establishment of the conservation area is the only works to take place within the flood affected area. As long as the materials and equipment for the conservation area is to be stored outside the flood zone then there will be no impact to regional flooding.

3.2.2 Construction phase impacts

Temporary works for the construction of the bridge piers and their foundations will likely involve temporary localised obstructions to flood flow within the main channel of the Georges River and on the floodplain. The occurrence of a large flood (greater than a 5% AEP) during construction when these temporary works are present in the channel and/or floodplain has the potential to increase flood levels locally upstream of the works. Occurrence of a large (greater than 5% AEP) flood during construction also has the potential to cause damage to the temporary works and result in debris from the works contributing to flood damage to land and property downstream. These impacts can be minimised through appropriate staging of the temporary works and employing a flood emergency plan which details the disassembly of works, preparation for flood waters prior to large flood event peaks reaching the site and recovery actions to enable works to resume as quickly as possible following the event. At this stage details of construction techniques to be employed are unknown and the effects of various flood events on construction phase works requires further investigation.

Construction of the remainder of the site will have minimal to no impact on regional flooding as these works are located out of the flood affected land.

3.2.3 Operational phase impacts

During the operation of the site the main potential impacts on regional flooding will be due to the new rail bridges required for the project. In order to assess these impacts the one-dimensional hydraulic modelling software package HEC-RAS was used to undertake the impact assessment. LCC's larger scale MIKE11 hydraulic model of the Georges River was available for the assessment and was used to verify the HEC-RAS model results, but was not possible to adapt for use in assessing impacts of any of the proposed rail access options (refer to Appendix A for details). The investigation was focussed on the 1% AEP design flood event as this is the key event for bridge serviceability and assessment of impacts of the bridge on regional flooding. The 1% AEP design flood event is also the principal flood planning event adopted by LCC and stipulated in the Georges River Floodplain Risk Management Study and Plan (Bewsher 2004).

The hydraulic modelling results are presented in Tables 3.1 to 3.3 below for the northern, central and southern rail access options.

The hydraulic modelling indicates that the maximum afflux for a 1% AEP event would occur immediately upstream of the proposed rail bridges for each option and would be limited to:

- 30 mm for the southern option
- 150 mm for the northern option
- 220 mm for the central option.

Upstream of the project site the southern option has the lowest afflux (despite having the bridge located at the upstream extent of the project site) with an afflux of 20 mm noted at the upstream cross section of the model. This compares to an afflux of 60 mm for the northern option and 90 mm for the central option. Due to limited modelling inputs, (the model has been built using cross sections at varied spacing of no less than 100 m which limits the definition of the flowpaths and may not account for all storage available) these estimated affluxes are likely to be larger than would actually occur and should be verified with more detailed modelling at detailed design.

The central and northern rail access options present new hydraulic restrictions across the floodplain in comparison to the southern rail access option which is located adjacent to and designed hydraulically similar to the existing East Hills Rail bridge. The location of the proposed southern bridge option adjacent to the existing rail bridge, and bridge design being hydraulically similar to the rail bridge are key reasons for the lesser impact on flood levels associated with this option in comparison with the northern and central rail access options.

The central option has the largest impact at the upstream model extent. This estimated impact would require further investigation and refinement through the development of the bridge design. As currently modelled it indicates a potential change to the flood level at the upstream extent of the model which could in turn affect flood planning considerations.

The southern rail access option traverses the western floodplain through the Glenfield Landfill. It is expected that an embankment and or a bridges/embankment formation for this crossing will have an impact on flood levels in the landfill. The flood risking mapping indicates that the landfill site is high flood risk hazard. Closer review of the flood risk mapping shows a similarity in the mapped extent of both the low and high hazard areas which suggests that any change to flood levels in the landfill would not change the flood extent and would affect only the depth of flooding. There may also be some impact on flood levels in the main river channel however, the alignment of the embankment (parallel) to the Georges River means that these impacts will be minor and are not likely to extend beyond the project boundary.

There are residences located upstream of the project site and it will be critical to ensure that flood impacts do not negatively affect these properties. The modelling indicates that none of the three rail access bridge options considered would increase the flood risk to these properties during a 1% AEP event as these properties are beyond the 1% AEP flood extent.

The flood investigation provided in Appendix A includes a series of hydraulic model cross-sections with superimposed flood levels for the existing and developed cases. The cross sections show that the increases in flood level do not translate to a significant increase in flood extent due to the flow being confined within a relatively steep-sided valley. The flood modelling results also indicate that flow velocities in the river are generally unaffected, with negligible increases predicted in the immediate vicinity of the proposed bridge.

This means that for land upstream of Cambridge Avenue, there are no changes to the floodplain risk management planning considerations as outlined in the Georges River Floodplain Management Study (Bewsher 2004). The river is confined to a narrow channel and the currently developed land is beyond the 1% AEP flood extent.

Cambridge Avenue crosses the Georges River to the south of the Project site on a low-lying bridge structure. As shown in Table 3.1 to Table 3.3, the predicated afflux upstream of Cambridge Avenue is 0.05 m under the northern rail access option, 0.11 m under the central rail access option and 0.01 m under the southern rail access option. While the bridge is low lying and currently flood prone, the predicted change in afflux will not change the flood hazard and subsequent management of a flood event at Cambridge Avenue.

Given that flood velocities and extents (and therefore the extent of the flood risk zones of the river and floodplain) are not significantly affected by the proposed rail access bridges it is considered that the impacts on regional flooding within the Georges River would be acceptable for the southern and northern options. Further assessment, design considerations and mitigation would be required for the central option.

Table 3.1 Northern rail access option 1% AEP flood levels and afflux results

HEC-RAS model cross-section	Mike 11 Chainage	Location	Existing case flood levels (m AHD)	Developed case flood levels (m AHD)	Afflux (m)
38	100630	Upstream of Cambridge Avenue	12.74	12.79	0.05
32	101270	Upstream of East Hills line rail bridge	11.98	12.06	0.08
24	102390	Just upstream of Glenfield Creek confluence	10.97	11.09	0.12
19	103555	Downstream of Glenfield Creek confluence	10.92	11.05	0.13
15	104095	Upstream of M5 road bridge	10.69	10.84	0.15
14	104185	Upstream of M5 road bridge	10.69	10.84	0.15
13	104355	Upstream of M5 road bridge	10.52	10.60	0.08
12	104535	Just upstream of M5 road bridge	10.42	10.42	0.00
7	105560	Downstream of M5 road bridge	9.75	9.75	0.00

Table 3.2 Central rail access option 1% AEP flood levels and afflux results

HEC-RAS model cross-section	Mike 11 Chainage	Location	Existing case flood levels (m AHD)	Developed case flood levels (m AHD)	Afflux (m)
38	100630	Upstream of Cambridge Avenue	12.74	12.85	0.11
32	101270	Upstream of East Hills line rail bridge	11.98	12.13	0.15
24	102390	Just upstream of Glenfield Creek confluence	10.97	11.19	0.22
19	103555	Downstream of Glenfield Creek confluence	10.92	10.92	0.00
15	104095	Upstream of M5 road bridge	10.69	10.69	0.00
14	104185	Upstream of M5 road bridge	10.69	10.69	0.00
13	104355	Upstream of M5 road bridge	10.52	10.52	0.00
12	104535	Just upstream of M5 road bridge	10.42	10.42	0.00
7	105560	Downstream of M5 road bridge	9.75	9.75	0.00

Table 3.3 Southern rail access 1% AEP flood levels and afflux

HEC-RAS model cross-section	Mike 11 Chainage	Location	Existing case flood levels (m AHD)	Developed case flood levels (m AHD)	Afflux (m)
38	100630	Upstream of Cambridge Avenue	12.74	12.75	0.01
32	101270	Upstream of East Hills line rail bridge	11.98	12.01	0.03
24	102390	Just upstream of Glenfield Creek confluence	10.97	10.97	0
19	103555	Downstream of Glenfield Creek confluence	10.92	10.92	0
15	104095	Upstream of M5 road bridge	10.69	10.69	0
14	104185	Upstream of M5 road bridge	10.69	10.69	0
13	104355	Upstream of M5 road bridge	10.52	10.52	0
12	104535	Just upstream of M5 road bridge	10.42	10.42	0
7	105560	Downstream of M5 road bridge	9.75	9.75	0.00

3.2.4 Potential impacts of climate change on regional flooding

State Government and local council policy requires that new development be planned to cope with potential future climatic conditions. The frequency and intensity of extreme rainfall events in the Sydney area are predicted to increase as a result of climate change (Rafter and Abbs, 2009). This will result in an increase in the frequency and magnitude of flood events in the Georges River catchment.

The NSW Government's Floodplain Risk Management Guideline: Practical Consideration of Climate Change (DECC 2007) recommends assessment of 10, 20 and 30% increases in rainfall depths when making allowance for climate change. For this assessment, however, the rainfall depths input to the hydrological model developed for LCC were not available so the middle level of an increase to flows by 20% was adopted.

A qualitative assessment of the changed regional flooding impacts of the proposed rail bridge or of the changed flood risk to the developed site under climate change scenarios based on the proposed concept options (northern, central and southern rail access options) is presented as follows:

- Increases in rainfall intensity will cause increases in the magnitude of flood events for a given design flood in the Georges River. Increases in rainfall intensity do not necessarily cause a direct equivalent increase in peak flow for a given event as the flow response will depend on the catchment characteristics.
- Correspondingly, significant increases in flow do not necessarily cause significant increases in flood level or extent, as the flood level response in a large connected river channel and floodplain system may be relatively insensitive to changes in flow.
- For the Georges River adjacent to the Project Site, climate change would be expected to raise flood levels and extents to some degree, but the changes in flood levels are likely to be in the order of centimetres rather than metres for high order events such as the 1% AEP event.
- Under climate change scenarios the afflux caused by the new rail bridge for the 1% AEP event would be expected to be similar to that assessed without climate change in section 3.3.2. This is because the 500 mm clearance of the bridge soffit above the 1% AEP flood level without climate change allowance should accommodate the likely increase in the flood level under the climate change scenario.
- Due to the steep valley topography on the eastern floodplain, increases in flow due to climate change will not significantly affect the extent of the flood risk zones for most of the Project Site (refer to Figure 2.1). For the northern portion of the site the low flood risk zone extends across the site, indicating that the valley topography is flatter at this location. In this area the increased flow due to climate change is likely to result in an increase in the extent of the high and medium flood risk zones. However, as noted in section 3.1.1, this area will be a key part of the conservation zone set aside for rehabilitated vegetated areas and will not contain critical project infrastructure.

The following quantitative impact assessment (refer Table 3.4) for the northern rail access option was completed using the MIKE11 flood model, as the afflux from this option was between the southern and central options. The climate change assessment considered a 20% increase in flow. Results show a maximum 0.19 m afflux in the vicinity of the northern rail access option bridges, which is 0.04 m greater than the predicted afflux for the no climate change scenario.

Table 3.4 1% AEP flood levels and afflux results with climate change allowance for the northern rail access option

HEC-RAS model cross-section	Mike 11 Chainage	Location	Existing case flood levels (m AHD)	Developed case flood levels (m AHD)	Afflux (m)
38	100630	Upstream of Cambridge Avenue	13.52	13.59	0.07
32	101270	Upstream of East Hills line rail bridge	12.63	12.72	0.09
24	102390	Just upstream of Glenfield Creek confluence	11.49	11.65	0.16
19	103555	Downstream of Glenfield Creek confluence	11.48	11.65	0.17
15	104095	Upstream of M5 road bridge	11.24	11.43	0.19
14	104185	Upstream of M5 road bridge	11.23	11.42	0.19
13	104355	Upstream of M5 road bridge	11.03	11.14	0.09
12	104535	Just upstream of M5 road bridge	10.91	10.91	0
7	105560	Downstream of M5 road bridge	10.02	10.02	0

This indicates that the flood response in Georges River and the impacts of the Project on regional flooding are not significantly different under a conservative climate change scenario.

3.2.5 Cumulative impact on regional flooding

Cumulative impacts on regional flooding need to be considered because of the potential for overland flows from the SMITA site to enter the project site and subsequently contribute to flooding in the Georges River. Conversely, development of the project site will contribute to flows in the headwaters of Anzac Creek which flows through the SMITA site.

The potential overland flows travelling from the SIMTA site across the project site to the Georges River will be minor compared to the overall flow in the river during a flood event. The proposed stormwater measures for the project site are intended to control and capture flows across the site so the actual increase as a result of the cumulative runoff from both sites will not be noticeable.

The increase in flows from the project site that contribute to the Anzac Creek catchment will be significant. Currently, the Golf course ponds collect and detain these flows. The project will change the runoff characteristics of this upper catchment area and there will be an increase in flow in the Anzac Creek channel as a result of the project due to the change from golf course to hard stand areas. These increases in runoff will need to be managed by the stormwater management strategy.

3.3 Local stormwater catchment impacts

The project will involve a considerable increase in impervious surfaces at the site compared to current conditions. This section of impacts focuses on the local project site catchments and the Anzac Creek catchment with respect to stormwater quantity.

3.3.1 Early Works

The Early Works would not be expected to impact on the local stormwater catchments as existing drainage would continue to be used during this phase. If required, temporary basins for on-site detention would be constructed to manage runoff in line with erosion and sediment control plans. This would ensure that any discharge to receiving watercourses (Georges River) would be maintained at pre-development levels.

3.3.2 Construction phase impacts

Stormwater runoff from the site during construction will increase as the vegetation and topsoil is progressively cleared to construct the internal precincts, road network and other impervious areas. The construction phase will not be critical for increased runoff from the site however construction management techniques will be applied to reduce peak stormwater flows and velocities. These mitigation measures are covered further in the following section, and will employ temporary construction phase flow paths and combined onsite detention and sedimentation ponds to manage local flows and flooding events. The nominated contractor should also be required to develop a flood emergency plan involving the cessation of works and prevention of site works and debris from entering flood waters. The designation of flood events and warnings that will invoke the emergency flood plan should be addressed in the flood emergency plan and be determined by the contractor. The determination of these ‘significant flood’ events will vary across the site depending on the location and stage of works being undertaken.

3.3.3 Operational phase impacts

An assessment has been made of the increases in runoff rates from the developed site as part of the concept design Stormwater Management Plan (SWMP) (refer to Appendix 2).Tables 3.5, 3.6 and 3.7 below presents the peak flow estimates for the 1%, 2% and 10% AEP design storm events for the existing and developed site layouts. The sub-catchment areas are shown in the drawings provided with Appendix B.

The results for each layout shows that the rates of runoff from the developed site far exceed those for the existing site due to the considerable increase in impervious area, with a 300% increase in peak flows for the sub-catchments.

Without mitigation, this increase in runoff rate from the site would have the potential to increase flooding on the site itself and in the downstream receiving system of Georges River. Management of increased stormwater runoff flows and velocity are discussed in section 4.2.

Table 3.5 Northern rail connection stormwater runoff estimation

		10% AEP		2% AEP		1% AEP	
	Area (m^2)	Existing	Developed	Existing	Developed	Existing	Developed
Catchment 1	24,000	0.19	0.76	0.30	1.20	0.36	1.43
Catchment 2	140,000	0.82	3.27	1.30	5.19	1.55	6.20
Catchment 3	230,000	1.21	4.82	1.91	7.65	2.29	9.15
Catchment 4	277,000	1.42	5.70	2.26	9.04	2.70	10.81
Catchment 5	257,000	1.32	5.28	2.10	8.39	2.51	10.03
Catchment 6	192,000	1.05	4.19	1.66	6.66	1.99	7.96

Table 3.6 Central rail connection option stormwater runoff estimation

		10% AEP		2% AEP		1% AEP	
	Area (m^2)	Existing	Developed	Existing	Developed	Existing	Developed
Catchment 1	24,000	0.19	0.76	0.30	1.20	0.36	1.43
Catchment 2	140,000	0.82	3.27	1.30	5.19	1.55	6.20
Catchment 3	230,000	1.21	4.82	1.91	7.65	2.29	9.15
Catchment 4	277,000	1.42	5.70	2.26	9.04	2.70	10.81
Catchment 5	257,000	1.32	5.28	2.10	8.39	2.51	10.03

Table 3.7 Southern rail connection stormwater runoff estimation

		10% AEP		2% AEP		1% AEP	
	Area (m^2)	Existing	Developed	Existing	Developed	Existing	Developed
Catchment 1	24,000	0.19	0.76	0.30	1.20	0.36	1.43
Catchment 2	140,000	0.82	3.27	1.30	5.19	1.55	6.20
Catchment 3	230,000	1.21	4.82	1.91	7.65	2.29	9.15
Catchment 4	277,000	1.42	5.70	2.26	9.04	2.70	10.81
Catchment 5	257,000	1.32	5.28	2.10	8.39	2.51	10.03
Catchment 6	192,000	1.05	4.19	1.66	6.66	1.99	7.96

3.3.4 Cumulative impact

Cumulative impacts of a combination of the development of the project site and the SIMTA site have been discussed in section 3.2.5 above. Stormwater runoff from the SIMTA site and the Moorebank Business Park has the potential to enter the project site. These additional flows are only likely to occur during event greater than the 10% AEP rainfall event as the local stormwater system is not likely to contain flows greater than that 10% AEP. These additional flows will impact the local stormwater system by increasing the presence of overland flows through the site and will need to be managed. It is assumed that the SIMTA development will manage flows to existing conditions. The final build stormwater strategy will consider current and future occurring overland flows through the site.

3.3.5 Potential impacts of climate change on local stormwater catchment flooding

As discussed in section 3.2.4, the relevant climate change scenarios to consider for impacts on site runoff are increases in flow up to 30%. In the absence of rainfall depth data relating to this model, a 20% increase in flow has been considered. Such increases in rainfall intensity will produce similar increases in rates of runoff from the developed impervious areas of the site.

Without mitigation, these increases in runoff from the site drainage catchments would increase the frequency of surcharging of the site drainage system and nuisance flooding of the site that would be manifested by localised ponding of stormwater in depressions and sag points of roads, surcharging of stormwater pits and overtopping of drainage channels and ponds/basins.

3.4 Surface water quality impacts

Construction and operation of the Project have the potential to impact water quality in the Georges River catchment if appropriate management and mitigation measures are not applied. The following processes have the potential to impact water quality in downstream receptors:

- changes to the physical properties of water, such as:
  - increased sediment load
  - change in flow regimes in the Georges River
  - increase in gross pollutants such as litter
- changes to the chemical properties of water, such as:
  - increased nutrient concentration
  - increased toxicants
- changes to biological properties, such as:
  - pathogens and bacteria in the water as a result of accidental spillage/leaks of wastewater from site facilities
  - macro algae and phytoplankton, as a result of nutrient enrichment.

Various design measures and management and mitigation measures are proposed to avoid and mitigate water quality impacts, as discussed below and in section 4.2.

3.4.1 Early works

The development of the conservation area within the flood risk zone may have an impact to downstream water quality if a flood event occurs. Should a flood event occur during establishment of this area could result in significant loss of topsoil and vegetation which will pollute the Georges River, being the downstream waterway. The impacts of the early works on the local stormwater catchments will be minor as along as comprehensive erosion and sediment control plan is developed for the site. This is discussed further in section 4.

3.4.2 Construction phase impacts

Construction activities have the potential to influence water quality. During construction the key impacts on stormwater quality would include the potential mobilisation and erosion of soils on the Project site due to land disturbance. Mobilised soils have the potential to increase sediment loads and sedimentation of receiving water bodies.

To effectively manage and mitigate potential construction phase impacts, stormwater infrastructure and sediment basins designed to capture surface water and stormwater runoff from the Project site would be constructed from the outset during the construction works. This will enable any stormwater pollutants to be treated on site prior to discharge to the Georges River.

Piling activities in the Georges River for the construction of the railway bridge has the potential to mobilise sediment on the river bed and expose potential acid sulphate soils. Accidental spills of chemicals and other hazardous construction materials and potential uncontrolled discharge of contaminants to receiving waterways also have the potential to impact water quality.

Construction activities that have the potential to influence storm water quality include vegetation removal, earthworks (cut and fill), dewatering excavations, piling, stockpiling of spoil and construction materials, construction of fill and embankments, and fuel and oil spills. If uncontrolled and not managed correctly, these activities have the potential to result in the following impacts to local storm water quality:

- increased turbidity of waterways and drainage lines
- increased nutrient loads to receiving waterways
- changes to groundwater levels and systems
- changed concentration of stormwater pollutants
- changes to volume and velocities of surface water drainage
- sedimentation of creeks and drainage lines.

An increase in suspended sediment loads in surface water runoff would increase the turbidity of nearby waterways potentially resulting in sedimentation which can smother aquatic vegetation and habitat. Nutrients, heavy metals and pesticides typically occur in the particulate phase which in turn can have an impact on the chemical processes that influence water quality.

In order to manage and mitigate potential impacts to water quality, appropriate erosion and sediment controls measures would be implemented during the construction phase of the Project (section 4.3.1).

3.4.3 Operational phase impacts

During the operational phase of the MIMT, land use changes and site activities have the potential to impact the Georges River and Anzac Creek water quality through surface water discharge. Key surface water impacts during the operational phase include a potential increase in stormwater pollutants and changes to the discharge volume and velocities.

Uncontrolled spills and leaks of fuels or oils associated with vehicle and rail transport and the use and storage of chemicals and hazardous substances could potentially contaminate stormwater runoff. The impact of accidental spills could be substantial depending on the volume of the spill and the nature of the substance.

Broad brush MUSIC modelling was undertaken for the northern layout (since the layouts are conceptual) to determine the likely annual pollutant loading contribution of the MIMT through stormwater discharges. Estimated annual loads were compared between the pre-developed site and the developed site with and without typical types of stormwater treatment. The results of this modelling are shown in Table 3.8 below.

Total suspended solids, hydrocarbons and total phosphorus annual loads from the developed site are all estimated to decrease when compared to the pre-developed site due to the use of stormwater treatment measures (of which there are currently none). The one exception is an increase in the total nitrogen annual load. It should be noted that this is an estimate of annual loads over a typical year of rainfall in NSW. As the annual volume of stormwater will also increase, the pollutant concentrations will be significantly less than predevelopment concentrations due to dilution and therefore no increases in existing stormwater pollutant concentrations in downstream waterways is expected from the developed site for these common stormwater pollutants. It is noted that the Healthy Rivers Commission inquiry report (HRC, 2001) noted that numeric WQOs for nutrients (including total nitrogen) should not, as a general rule, be used for regulatory purposes; and the naturally turbid Georges River would be able to sustain higher nutrient loads without the development of algal blooms (HRC, 2001).

Table 3.8 MUSIC modelling of stormwater pollutants

Stormwater variable	Pre-developed Site	Developed Site (pre-treatment)	Developed Site (post-treatment)	% Reduction from pre-developed site runoff
Total Suspended Solids (kg/yr)	161,000	370,000	90,500	44%
Hydrocarbons (kg/yr)	315	484	270	14%
Total Phosphorus (kg/yr)	256	741	234	9%
Total Nitrogen (kg/yr)	2,000	3,770	2,330	-17%

The proposed measures are intended to be effective for reducing the key water pollutants identified for the site. The ANZECC Guidelines and the Georges River Health Monitoring Program (GRCC 2011) will both be considered before finalisation of the proposed measures.

Preliminary calculations have been undertaken to estimate the area of water quality treatment required to meet best management objectives. In NSW these objectives are generally accepted as 90% removal of gross pollutants, 80% removal of Total Suspended Solids (TSS), 55% removal of Total Nitrogen (TN) and 40% removal of Total Phosphorus (TP). The following Tables 3.9, 3.10 and 3.11 summarise the area of treatment required for each layout.

Table 3.9 Northern rail connection option treatment area requirement estimation

Drainage sub-catchment area reference	Catchment area (m^2)	Approx. treatment area requirement (m^2)
Catchment 1	24,000	60
Catchment 2	140,000	350
Catchment 3	230,000	575
Catchment 4	277,000	692.5
Catchment 5	257,000	642.5
Catchment 6	192,000	480
Total	**1,120,000**	**2,800**

Table 3.10 Central rail connection option treatment area requirement estimation

Drainage sub-catchment area reference	Catchment area (m^2)	Approx. treatment area requirement (m^2)
Catchment 1	24,000	60
Catchment 2	173,000	432.5
Catchment 3	560,000	1,400
Catchment 4	292,000	730
Catchment 5	234,000	585
Total	**1,283,000**	**3,208**

Table 3.11 Southern rail connection option treatment area requirement estimation

Drainage sub-catchment area reference	Catchment area (m^2)	Approx. treatment area requirement (m^2)
Catchment 1	24,000	60
Catchment 2	190,000	475
Catchment 3	190,000	475
Catchment 4	440,000	1,100
Catchment 5	223,000	557.5
Catchment 6	288,000	720
Total	**1,355,000**	**3,388**

Stormwater treatment systems, designed in accordance with NSW best practice guidelines, would function to retain and reduce stormwater pollutants and improve the stormwater quality discharging from the MIMT. Substantial reductions in pollutant concentrations can be obtained through the use of stormwater improvement devices. The Project should include a treatment train approach of catchpits, raingardens, swales, bio-filtration and detention basins to treat stormwater before discharging to the Georges River and Anzac Creek (section 4.2).

Without stormwater treatment, the quality of the stormwater runoff from the developed site that is discharged to the Georges River will be considerably worse than under existing conditions and could lead to further degradation of the downstream water quality in the Georges River system. The implementation of stormwater treatment at the developed MIMT would reduce the annual stormwater pollutant loads that are currently discharging from site. Further, stormwater treatment on the developed MIMT site would improve stormwater quality currently discharging from the site.

The improved quality of stormwater discharging from site supports the objectives of the environmental values for waterways affected by urban development in the Georges River catchment in that the water quality is maintained or improved throughout the catchment.

3.4.4 Cumulative impacts

As identified above, cumulative impacts will be a result of both developments of this project as well as the SIMTA site. In terms of cumulative water quality impacts, these are likely to be minor as they will be associated with an increase in runoff volumes and therefore concentrations will be less. However, should runoff from both sites not be managed effectively then there will be an impact to pollutant loads that needs to be mitigated.

4. Mitigation measures

This chapter outlines mitigation measures to minimise and prevent impacts both within the project site and external to the project site. As previously indicated, there are three layout options currently proposed for the site so the mitigation measures have been developed such that they could be applied to each proposed layout. Further details of the stormwater management measures are given in Appendix B.

4.1 Early works

The early works will mainly take place outside of the flood affected areas except for the development of the conservation area. The following measures would be implemented during the early works to minimise impacts to the Georges River, Anzac Creek, local and regional water quality and to minimise the impact of a flood event on the early works program. Measures include:

- A soil and water management plan would be developed prior to starting works in the conversation area. This plan would include erosion and sediment control plans and procedures to manage and minimise potential environmental impacts associated with developing this area.
- Locate site compounds, stockpiling areas and storage areas for sensitive plant, equipment and hazardous materials above an appropriate design flood level, to be determined based on the duration of the construction works.
- Implement a flood emergency response and evacuation plan for the conservation area works that allows works sites to be safely evacuated and secured in advance of flooding occurring at the site. This plan should also include recovery actions to be implemented following a flood and therefore allow the site works to resume as quickly as possible following a flood event.

4.2 Regional flooding mitigation measures

As discussed in section 1, development of the project site has been planned around existing regional flooding constraints, and the only element of the project that has a potential impact on regional flooding is the construction and operation of the rail bridge crossing of the Georges River which connects the site with the SSFL. Mitigation measures are therefore focussed on the rail access bridge.

4.2.1 Construction phase mitigation

The following measures would be implemented to avoid adverse flooding impacts in the Georges River system during construction of the rail bridge crossing:

- Locate site compounds, stockpiling areas and storage areas for sensitive plant, equipment and hazardous materials above an appropriate design flood level, to be determined based on the duration of the construction works.
- Implement a flood emergency response and evacuation plan for the works that allows works sites to be safely evacuated and secured in advance of flooding occurring at the site.
- For the building of the bridges implement a staged construction process that minimises temporary obstruction of flow in the main channel and floodplain at all times.
- For the building of the bridges design temporary works to resist forces and pressures that could occur during the appropriate design flood event adopted for the construction project.

- For the site in general, provide temporary diversion channels around temporary works obstructions to allow low and normal flows to safely bypass the works areas.

4.2.2 Operational phase mitigation

During detailed design the following measures should be considered to ensure bridge crossing result in minimal impact to the existing flood risk in the Georges River channel and floodplain. The following further design considerations and investigations are recommended as part of the detailed design to ensure adverse impacts continue to be avoided:

- The design of the bridges should ensure structural stability under an appropriate upper limiting flood event, typically the 1 in 2000 year AEP event or other event of similar magnitude.
- A detailed scour assessment of the structures should be undertaken and a scour protection scheme for the bridge abutments and piers should be designed to ensure structural stability and avoid erosion of the channel and floodplain bed local to the structures.
- Further design optimisation of the bridges should consider reducing the afflux impacts as far as possible. The bridge piers should be designed to minimise obstruction to flow and associated afflux under potential blockage and/or debris build-up scenarios.
- Further hydraulic modelling should be undertaken to quantify the impact of climate change on afflux caused by the bridges and on hydraulic loading on the bridge structures.
- For the central option, further design of the structure and alignment and/or consideration of compensatory measures will need to be undertaken to reduce the impact of this option.

4.3 On-site stormwater management

4.3.1 Construction phase mitigation

A key feature of the on-site stormwater management measures during construction will be installation of site-wide temporary erosion and sediment controls. The design and performance criteria for these measures should be detailed within an Erosion and Sediment Control Plan (ESCP) for the site. The ESCPs will be designed in accordance with best management practices and the relevant stormwater management publications including:

- Managing Urban Stormwater: Soils and Construction (‘the Blue Book’), Volume 1 (Landcom 2004)
- Managing Urban Stormwater: Soils and Construction - Installation of Services, Volume 2A (OEH 2008)
- Managing Urban Stormwater: Soils and Construction - Main Road Construction, Volume 2D (OEH 2008).

Biofiltration and detention basins which form part of the proposed stormwater management strategy should be excavated at the outset of the early works with the intention of the excavated basins being used for temporary construction phase sedimentation basins. Once the early works have been completed, these temporary construction phase sedimentation basins can be developed into the permanent biofiltration and detention basins as site development requires them.

During Project Phase A, all major stormwater pipes and culverts (600 mm diameter and larger) and main channels and outlets should be installed. Minor drainage and upstream systems will then be progressively connected to the major drainage elements during each phase of construction as required.

The general principles of soils and water management are provided in the Blue Book (Landcom 2004) and would be adopted during the construction phase of the Project. A soil and water management plan would be developed prior to land disturbance that would include erosion and sediment control plans and procedures to manage and minimise potential environmental impacts associated with construction of the Project.

The following management and mitigation measures would be implemented during construction to minimise soil and water impacts:

- An ESCP would be prepared in accordance with Volume 1 of *Managing Urban Stormwater: Soils and Construction* (Landcom 2004). The ESCP would be established prior to the commencement of construction of each stage of development and be updated as relevant to the changing construction activities.
- Clean runoff from upstream undisturbed areas would be diverted around the site to minimise overland flow through the disturbed areas.
- Stabilised surfaces would be reinstated as quickly as practicable after construction.
- All stockpiled materials would be stored in bunded areas and away from waterways to avoid sediment-laden runoff potentially entering the waterways.
- Sediment would be prevented from moving off-site and sediment-laden water prevented from entering any watercourse, drainage line or drainage inlet.
- Erosion and sediment control measures would be regularly inspected (particularly following rainfall events) to monitor their effectiveness and stability.
- Erosion and sediment control measures would be left in place until the works are complete or areas are stabilised.
- Temporary erosion control and energy dissipation measures would be installed to protect receiving environments from erosion.
- Works would be managed during rainfall (or whilst the ground remains sodden) to minimise vehicle disturbance to the topsoil.
- Procedures to maintain acceptable water quality and for the management of chemicals and hazardous materials (including spill management procedures, use of spill kits and procedures for refuelling and maintaining construction vehicles/equipment) would be implemented during construction.
- Vehicles and machinery would be properly maintained to minimise the risk of fuel/oil leaks.
- Routine inspections of all construction vehicles and equipment would be undertaken for evidence of fuel/oil leaks.
- All fuels, chemicals and hazardous liquids would be stored within an impervious bunded area in accordance with Australian standards and Environmental Protection Authority Guidelines.
- Emergency spill kits would be kept on-site at all times. All staff would be made aware of the location of the spill kits and be trained in their use.
- Construction plant, vehicles and equipment would be refuelled off-site, or in designated re-fuelling areas located at a minimum distance of 50 metres from drainage lines or waterways.
- If landfill cells at the Glenfield Landfill are to be affected then prepare site specific erosion and sediment control measures to ensure pollutants do not enter the Georges River.

4.3.2 Operational phase mitigation

A key design criterion adopted in the stormwater strategy is that the rate of stormwater runoff from the developed site should not exceed the pre-developed (existing) site rate of stormwater runoff, as required by LCC. The stormwater strategy has been (refer to Appendix B) developed to consider all LCC design specifications and relevant RailCorp and ARTC design requirements associated with the project. Where identifiable, upstream inflows have been considered as part of the design in order to address potential cumulative impacts of nearby development. Therefore, there are no adverse impacts on peak flow rates and flow volumes for runoff from the developed site. Key features of the system that allow this to be achieved and which would be included within the detailed design are as follows:

- The stormwater system should be designed such that flow from low order events (up to and including the 10% AEP event from the main part of the site and up to and including the 2% AEP event for the rail corridor) would be conveyed within the formal drainage systems and flows from rarer events (up to the 1% AEP event) would be conveyed in controlled overland flow paths.
- An on-site detention system is proposed that would detain flow and control discharge rates to Georges River at pre-development rates.

The system should also incorporate extensive measures to control the water quality of runoff from the site prior to discharge to the Georges River. These include:

- A stormwater treatment system incorporating sedimentation and bio-filtration basins upstream of the stormwater detention basins.
- The use of on-site infiltration has been incorporated into the design through the distribution of swale drains and rain gardens across the site.

There are opportunities for further mitigation measures to be incorporated into the stormwater management system. The Liverpool Development Control Plan, Part 2.4, Development in Moorebank Defence Lands (Liverpool City Council, 2008) provides the following suggestions, which would be considered during detailed design:

- Polish water from on-site runoff by directing runoff into on-site dry creek gravel beds with macrophyte plants.
- Use drainage swales adjacent to entry roads instead of kerbs to slow down stormwater runoff and increase on-site infiltration.
- Collection of roof rainwater for re-use on site.

Other opportunities for the site include the installation of gross pollutant traps (GPTs) at the outlets of the pipe system before discharge into the sedimentation basins.

Given the intended purpose of the site, the extent of impervious surfaces, such as roads, pavement and roofing, would increase substantially. Impervious surfaces and vegetated areas should be encouraged and incorporated into the design at any opportunity. This will increase sub-surface water flow during rain events and reduce the discharge of stormwater pollutants. Also, disturbance at the outlets from the on-site detention basins should be minimised by considering measures proposed in the Georges River Strategic Bank Stabilisation Plan (LCC 2012).

As the project will contain a number of different land uses, specific stormwater treatment systems may be required as pre-treatment to protect the integrity of the downstream sedimentation and biofiltration basins. The best practice pre-treatment systems will need to address potential contaminants associated with each land use at the detailed design stage. In addition to this, rain gardens and swales should be incorporated where area permits. In particular, specific treatment measures may be required on the Glenfield Landfill site if landfill cells are to be impacted.

Additional runoff from the future development of the Sydney Intermodal Terminal Alliance (SIMTA) site (currently occupied by the existing DNSDC) should also be taken into consideration at the detailed design stage. The three 2700 mm x 1500 mm culverts that allow runoff from the existing DNSDC area to pass through the Project Site should be reassessed should any SIMTA development increase impervious areas. The impacts of the SIMTA have not been assessed at this stage as detailed design details of the SIMTA development are not currently available. In addition, ensuring runoff rates do not exceed existing conditions will ensure there are no changes to flood flows within the Anzac Creek catchment. The 1% AEP flood is confined to the channel for the upper reaches of the Anzac Creek catchment and subsequently the Anzac Creek Floodplain Management Study did not identify any risk management measures (BMTWBM 2005).

5. Conclusions

The proposed Moorebank Intermodal Terminal project is located on the eastern bank of the Georges River in south west Sydney, a major watercourse for both environmental and social aspect that governs flooding on a regional scale within south west Sydney. It has therefore been important to assess the impact of the project of both the regional and local surface water environments. This report specifically addresses the NSW EARs and the Commonwealth EIS requirements. The report covers surface water related aspects such as flooding and site stormwater quantity and quality.

Following a review of all the requirements there were several key areas that were critical for the surface water assessment, these included:

- change in hydrologic regime, in particular, change in flooding, stormwater runoff quantity
- impact of project on water quality, including sediment and erosion, stormwater quality, stormwater pollution (accidental spills etc.).

Design assumptions relating to the rail bridge crossings of the Georges River (for all three layouts) and a stormwater strategy have been developed to address the requirements of LCC and particular requirements relating to discharge of stormwater to the Georges River and surface water management relating to the proposed rail corridor.

The assessment has identified that the impacts from the project on regional flooding are relatively minor for the southern and northern option and do not significantly affect the existing flood risk associated with the Georges River and its floodplain. The rail bridge crossings do cause minor afflux upstream however, it is recommended that these impacts be further minimised through design refinement of the bridge and bridge related infrastructure at a later stages of design. For the central rail crossing, further assessment is required and mitigation measures required to reduce the afflux resulting from this option.

The proposed stormwater drainage system has incorporated an on-site detention system to maintain existing peak flow rates so there would be no net increase in stormwater runoff from the Project Site. Further development of the stormwater management system during detailed design should consider water re-use opportunities.

Stormwater runoff quality from the site is a critical issue due the current ‘stressed’ condition of the mid and lower Georges River catchment. Best practice stormwater treatment features including sedimentation and bio-retention basins have been incorporated into the stormwater management strategy to ensure adverse impacts on water quality in the Georges River are avoided. Further opportunities would also be investigated during detailed design and will need to consider potential contaminants from disturbing landfill cells on the Glenfield Landfill site.

During construction, stormwater management, both quantity and quality, will be the key issues requiring management. Appropriate application of the best construction practices through development and implementation of an ESCP would minimise pollution incidents from the site. Also locating stockpiles, storage areas and sensitive plant and equipment out of high and medium flood risk zones would minimise the risk of flood damage during construction.

Further refinement of the design and development of maintenance plans for the site would ensure surface water related impacts are minimised and managed appropriately.

6. References

Australia New Zealand Environment Conservation Council, National Water Quality Management Strategy Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000.

Bewsher Consulting, Georges River Floodplain Risk Management Study, May 2004.

BMT WBM, Anzac Creek Floodplain Risk Management Study and Plan, May 2008.

Department of Environment and Conservation (DEC) 2006, Using the ANZECC guidelines and water quality objectives in NSW.

Department of Environment and Climate Change (DECC) 2007, Floodplain Risk Management Guideline: Practical Consideration of Climate Change.

Environmental Protection Agency (EPA), Results of the Nationwide Urban Runoff Program, Volume 1 – Final Report, December 1983.

Georges River Combined Councils Committee (GRCCC), Community River Health Monitoring Program Report Card Autumn 2011, http://www.georgesriver.org.au/.

Healthy Rivers Commission (HRC) Independent Inquiry into the Georges River – Botany Bay System – Final Report 2001.

Hyder Consulting, Stormwater and Flooding Environmental Assessment SIMTA, 2011.

KPMG, Parsons Brinckerhoff and Deloitte, *Moorebank Intermodal Terminal Project Summary: Detailed Business Case* (April 2012).

Landcom 2004, Managing Urban Stormwater – Soils and Construction Volume 1.

Liverpool City Council development control plan no. 49 for Amiens, Yulong and DNSDC sites Moorebank international technology park Moorebank Avenue, Moorebank, 2008, http://www.liverpool.nsw.gov.au/developmentcontrolplans.htm.

Liverpool City Council, NSW Development Design Specification D5: Stormwater Drainage Design. January 2003, http://www.liverpool.nsw.gov.au/constructionanddesignspecifications.htm.

Liverpool City Council, NSW Development Design Specification D7: Erosion Control and Stormwater Management. October 2003, http://www.liverpool.nsw.gov.au/constructionanddesignspecifications.htm.

Liverpool City Council On-Site Stormwater Detention Technical Specification, January 2003, http://www.liverpool.nsw.gov.au/constructionanddesignspecifications.htm.

NSW Office of Water, NSW Water Quality and River Flow Objectives, Catchment at a glance, 2013 (http://www.environment.nsw.gov.au/ieo/GeorgesRiver/caag.htm).

Pilgrim, DH, (ed)., Australian Rainfall and Runoff - A Guide to Flood Estimation, Institution of Engineers, Australia, Barton, ACT, 1987.

Rafter, T and D Abbs, 2009, Calculation of Australian extreme rainfall within GCM simulations using Extreme Value Analysis.

RailCorp TMC 421, Track Drainage, Version 1.2, December 2009. http://engineering.railcorp.nsw.gov.au/Disciplines/Civil/TMC_421_V1_2.pdf.

Regional Environmental Planning Policy (REP) No.2 – Georges River catchment, http://www.planning.nsw.gov.au/list-of-regional-plans.

Upper Georges River Flood Study, Department of Land and Water Conservation in conjunction with Liverpool City Council, December 2000.

Appendix A

Design Flood Impact Assessment

Moorebank Intermodal Company

Moorebank Intermodal Transport Project

Flood Impact Assessment

25 June 2014

PARSONS BRINCKERHOFF
A BALFOUR BEATTY COMPANY

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1. Introduction

Moorebank, located in South-West Sydney, is being considered as a future site for an intermodal terminal (IMT) planned to handle container traffic from Port Botany and interstate rail freight. The Moorebank IMT (or the 'Project') will provide an integrated transport solution for the movement of freight to, from and within the Sydney basin.

The primary function of the Moorebank IMT is to be a transfer point in the logistics chain for shipping containers and to handle both international import/export cargo (IMEX) and domestic interstate and intrastate (regional) cargo.

The Project requires the development of a rail crossing of the Georges River connecting the main IMT site to the Southern Sydney Freight Line (SSFL). Three options have been proposed for this crossing; a northern option; a central option; and a southern option.

The development of a new bridge crossing can potentially have adverse impacts on flooding in the vicinity of the new structure. A hydraulic investigation has been undertaken to assess the afflux generated by each of the three potential locations of the proposed rail crossing and its associated piers within the Georges River and its floodplain adjacent to the Project site. The investigation is based upon Mike11 hydraulic model data received from Liverpool City Council and assumed bridge geometry aimed at minimising potential flood impacts. Analysis has been performed for the 1% Annual Exceedence Probability (AEP) storm event and an 'extreme flood' event.

2. Background

2.1 Flood history

The Georges River has a history of flooding. Historical records date back as far as the 1860's, with most records relating to levels recorded at the Liverpool Weir, located approximately 2 km downstream of the northern boundary of the Project site. The most recent major flood occurred in 1988 and was estimated to have a 5% AEP. The 1988 flood resulted in over 1,000 properties being inundated along the Georges River and an estimated $18M in damages.

The Georges River catchment is one of Australia's most populated catchments. The history of flooding from the Georges River and the high level of development within the river floodplain has resulted in the flood behaviour being extensively studied. Flood studies have included construction of a scale physical model of the river as well as mathematical and hydraulic modelling. Several hydraulic models of the Upper and Lower Georges River system were combined to form one overall Georges River flood model. This model has been used for this project and is further discussed in section 2.2.

2.2 Existing hydraulic models

The Georges River Model Study (Liverpool City Council, 1999) developed a MIKE11 hydraulic model of the Georges River, extending 46 km from the Georges River confluence with Bunbury Curran Creek (approximately 2 km upstream of the southern boundary of the Project site) to Botany Bay.

This model is essentially an amalgamation of two earlier MIKE11 flood models developed for the Upper Georges River Flood Study, (DLWC, 1998) and the Georges River Mathematical Modelling Study (PWD, 1992). The section of the model running past the Project site was originally from the Upper Georges River Flood Study, (DLWC, 1998). The MIKE 11 model was calibrated to reproduce the results of physical modelling carried out for the Georges River Flood Study (PWD, 1991).

For the assessment of flood behaviour in the vicinity of the Project site the MIKE11 flood model was obtained from Liverpool City Council and re-run to understand the existing flood behaviour at the Project site. The flood model extends from 2 km upstream of the southern boundary of the site to Botany Bay approximately 42 km downstream of the northern boundary of the Project site. Model cross sections are generally at an interval of 180–230 m in the vicinity of the Project site. There are 19 cross sections (Ch. 101650–104535 m) which border the project site as shown in Figure 2.1.

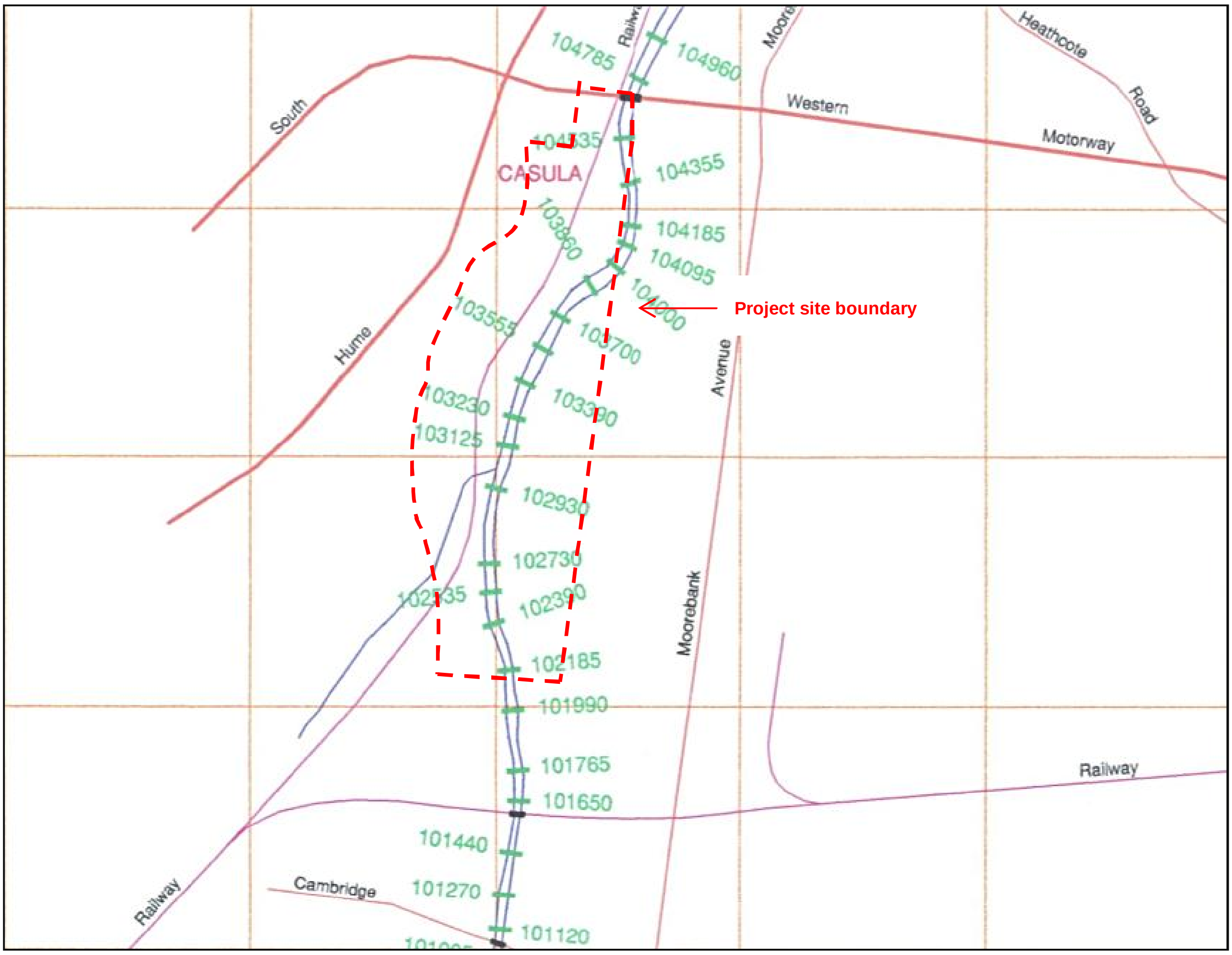


Figure 2.1 **Georges River Mike11 flood model cross sections in the vicinity of the proposed Moorebank IMT site (extracted from Figure 2.2, Georges River Model Study, Liverpool City Council, 1999)**

The model includes critical flood events for the 5%, 2% and 1% AEP storm events[1] in addition to the predicted 'Extreme Flood Event'. Inflows used for the modelling were based on a WBNM rainfall runoff model of the catchments upstream of Liverpool Weir for the 5%, 2% and 1% AEP events developed during the Georges River Flood Study (PWD, 1991). The hydrographs were calibrated with hydrographs recorded at Liverpool Weir. The critical duration for the 5%, 2% and 1% AEP flood events was found to be 36 hours. The WBNM model (PWD, 1991) also produced Extreme Flood Event (EFE) hydrographs. The flood study stated that 'the extreme flood event terminology was used rather than Probable Maximum Flood because the Probable Maximum Precipitation estimates provided at the time by the Bureau of Meteorology were interim values' (PWD, 1991). The Georges River Flood Study (PWD, 1991) determined that the 12 hour event was critical for the EFE at and above Liverpool and the 36 hour storm was critical further downstream. Hence, for the Moorebank IMT site the 12 hour storm produces the highest flood levels for the EFE and is the critical storm.

The 1% AEP peak flow adopted from this study was 1,877 m^3/s and the EFE peak flow 4,807 m^3/s.

1 At the time that the Georges River Model Study was completed it was industry practice to use the terminology Average Recurrence Interval (ARI) instead of Annual Exceedance Probability (AEP) which is now the industry preferred terminology for events rarer than the 10% AEP. AEP is defined as 'The probability that an event will be exceeded in any one year.' It is noted that the 5%, 2% and 1% AEP events are approximately equivalent to the 20 year, 50 year, and 100 year ARI events respectively.

2.3 Rail bridge design

The Project requires the development of a rail crossing of the Georges River connecting to the Southern Sydney Freight Line (SSFL). Three options have been proposed for the location of this crossing; a northern option; a central option; and a southern option (refer section 2.3.1, section 2.3.2, and section 2.3.3 for further details). The development of this bridge crossing has the potential to have adverse impacts on flooding in the vicinity of the new structure. Hydraulic investigations have been undertaken to assess the afflux generated by each of the proposed rail crossing options and their associated piers within the Georges River and its floodplain adjacent to the Project site.

The following sections describe the ‘concept’ bridge designs as assessed for this flood impact assessment. Further modelling of flood impacts will be required to be undertaken during detailed design of the bridge to ensure flood impacts are minimised.

2.3.1 Southern option

The ‘Southern Option’ proposes constructing a rail bridge adjacent to the existing East Hills Rail Bridge, crossing the Georges River at the Southern end of the Project site (refer to Figure 2.2). The bridge design shows two separate single track rails that cross the western floodplain of the Georges River through the Glenfield Landfill site before converging into a single double track bridge to cross the Georges River immediately downstream from the existing rail bridge.

To minimise potential flood impacts the bridge has been designed to hydraulically replicate the existing rail bridge (refer Appendix A for existing bridge ‘Work as Executed Drawings’). Key design principles include:

- the proposed bridge deck and noise barriers are to be set at the same level as the existing rail bridge. The soffit of these bridge decks is noted to be approximately 1.3 m above the 1% AEP flood level
- piers and abutments are to be the same size, shape and hydraulically aligned with the existing rail bridge to minimise afflux and scour of the bed and banks of the waterway. It is noted that the existing bridge has 1.8 m diameter piers located at 30.7 m intervals.

2.3.2 Northern option

The ‘Northern Option’ proposes constructing a rail bridge to the northern area of the Project Site (refer to Figure 2.3). The bridge design shows two separate single track rail bridges that converge into a single double track bridge on the eastern bank of the Georges River. The bridges would require numerous piers located both within the Georges River and within the Georges River floodplain. The bridge does not orientate perpendicular to the river and instead forms two arcs across the floodplain.

To minimise potential flood impacts the bridge design incorporates the following key principles:

- the proposed soffit of the bridge deck is to be set at a minimum of 500 mm above the predicted 1% AEP flood level
- bridge abutments should not encroach on the waterway areas of the Georges River
- piers should be designed to be streamlined in shape to minimise afflux and scour of the bed and banks of the waterway. For the purposes of this assessment the piers have been assumed to be 1.8 m in diameter (as per the existing East Hills Rail Bridge) and located at 20 m intervals.

2.3.3 Central option

The 'Central Option' proposes constructing a rail bridge in the central area of the Project site (refer to Figure 2.4). The bridge design proposes two separate single track rail bridges that converge into a single double track bridge on the eastern bank of the Georges River. The bridges have many piers located both within the Georges River and within the Georges River floodplain. The bridge does not orientate perpendicular to the river and instead forms two arcs across the floodplain.

To minimise potential flood impacts the bridge design incorporates the following key principles:

- the proposed soffit of the bridge deck is to be set at a minimum of 500 mm above the predicted 1% AEP flood level
- bridge abutments should not encroach on the waterway areas of the Georges River
- piers should be designed to be streamlined in shape to minimise afflux and scour of the bed and banks of the waterway. For the purposes of this assessment the piers have been assumed to be 1.8 m in diameter (as per the existing East Hills Rail Bridge) and located at 20 m intervals.

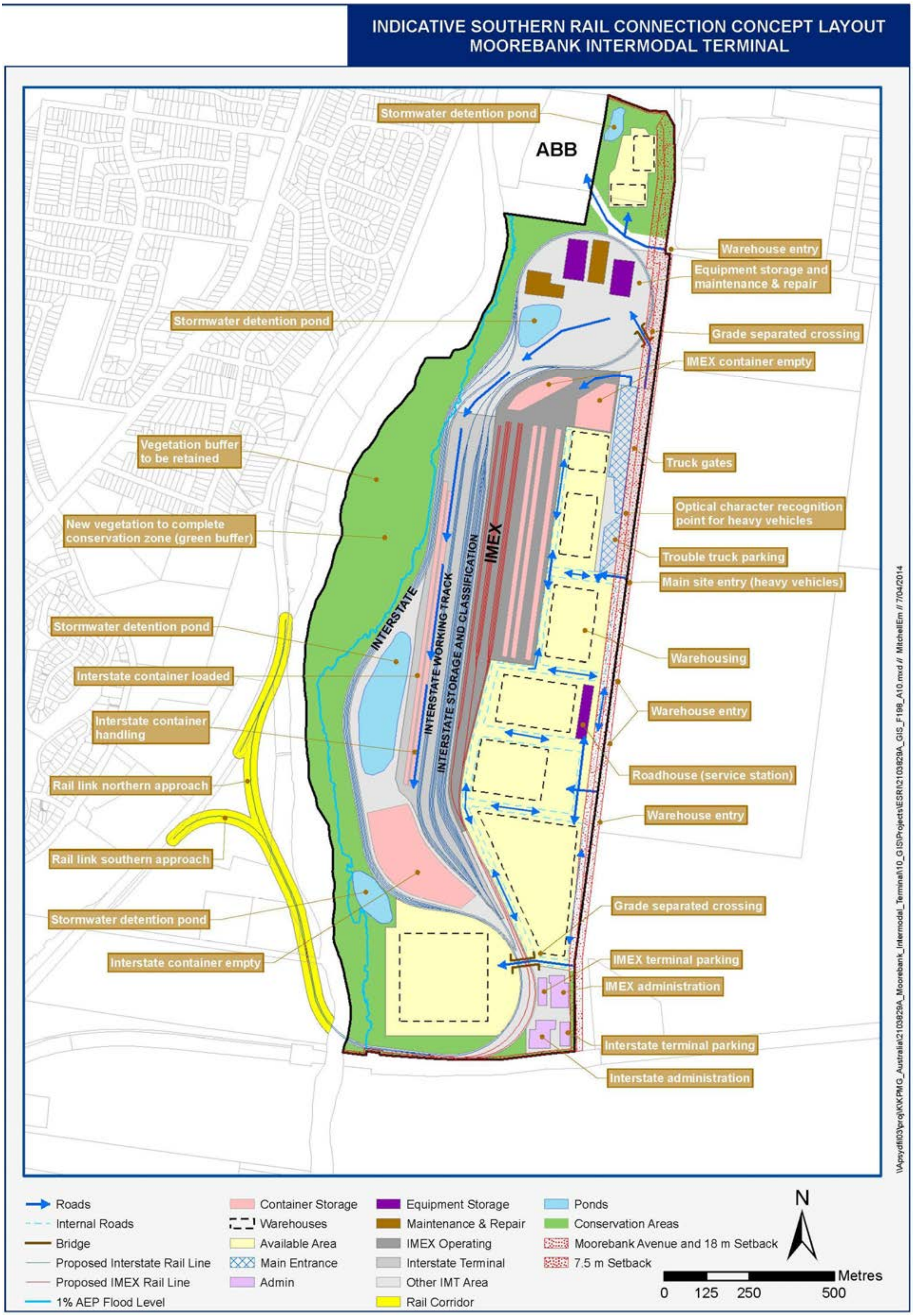


Figure 2.2 Southern Rail Connection Concept Layout

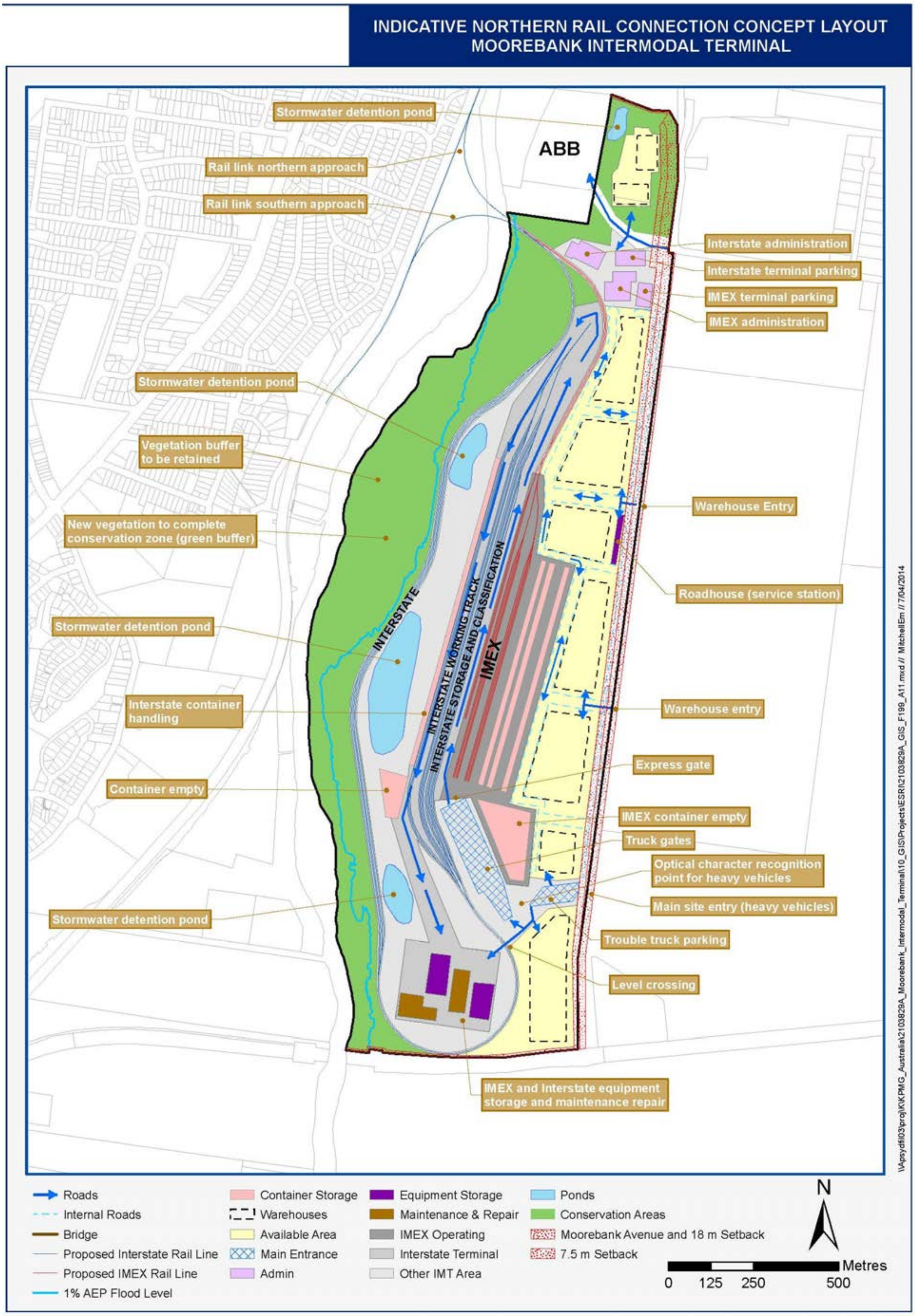


Figure 2.3 Northern Rail Connection Concept Layout

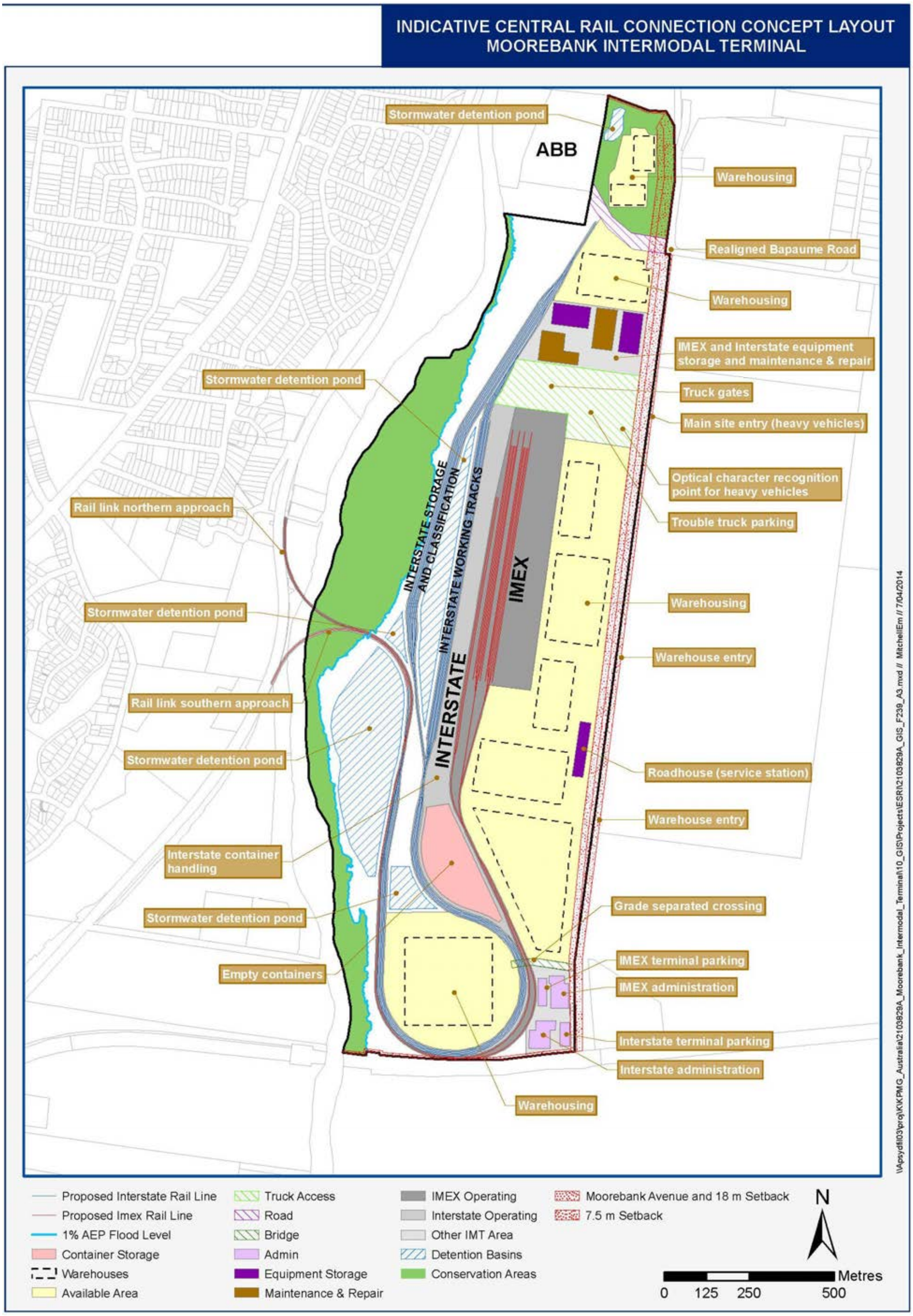


Figure 2.4 **Central Rail Connection Concept Layout**

3. Flood risk zones

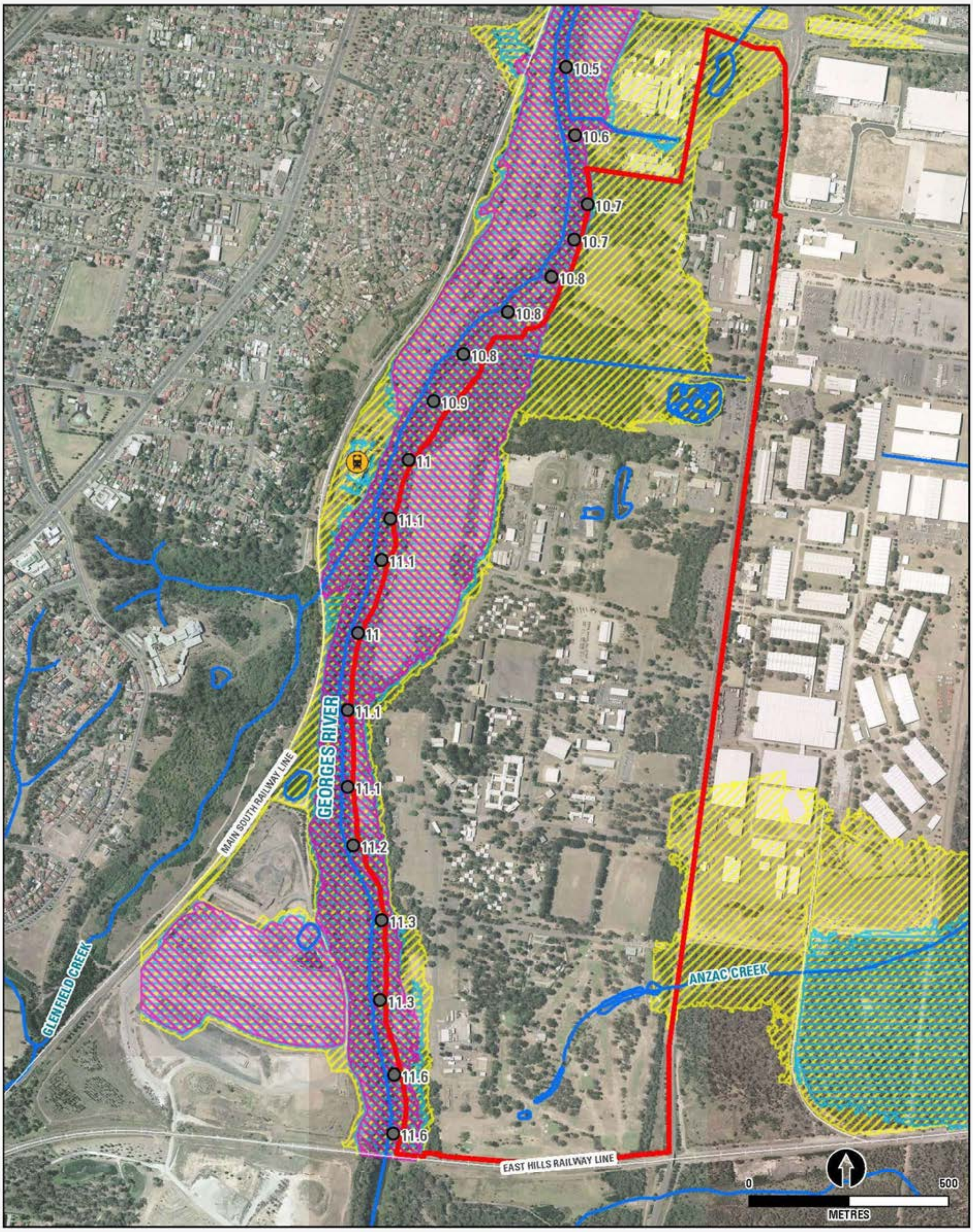
Figure 3.1 shows the flood risk in the vicinity of the Project site. The flood risk zone mapping has been provided by Liverpool City Council and is based on the Mike11 modelling results produced for the Georges River Model Study (Liverpool City Council, 1999).

The flood zone mapping shows that high and medium flood risk is largely confined to the Georges River active floodplain areas. Approximately 25% of the Project site is classified as high or medium flood risk land. A further 29% of the Project site is classified as low flood risk land and the remaining 46% is not considered at risk of flooding.

Table 3.1 Project site flood risk category breakdown

Flood Risk Category	Category definition	Project area affected (ha)	Percentage of project site affected
High flood risk	Areas within 1% AEP flood extent and subject to high hydraulic hazard or evacuation difficulties.	23.6	12%
Medium flood risk	Areas within 1% AEP flood extent and not subject to high hydraulic hazard or evacuation difficulties.	25.5	13%
Low flood risk	All other flood liable land i.e. within the PMF flood extent.	56.8	29%
No flood risk	All other areas i.e. all areas outside the PMF flood extent.	90.9	46%

MOOREBANK INTERMODAL TERMINAL



Moorebank Intermodal Terminal boundary
Drainage
Rail line

Flood risk probability*
Low risk
Medium risk
High risk

100 year water level mAHD (existing conditions)

* Flood risk based on data supplied by Liverpool City Council (January, 2011)

Figure 3.1: Existing flood risk probability map

3.1 Development constraints

Development on the site is subject to the Liverpool Development Control Plan, 2008 (DCP) which details the specific controls which are enforced within the various flood risk categories i.e. high, medium, low and no flood risk. The project site has areas located in all four of the flood risks categories. Areas categorised as high, medium or low flood risk are subject to flood related development controls. Other areas of the site (i.e. no flood risk) are not subject to development controls related to flooding of the Georges River but may be subject to other constraints to ensure adequate surface water management (including surface water flooding).

The Liverpool DCP (2008) details many development controls for land subject to Georges River flooding as well as local overland flow flooding. A summary of some of the key flood risk development controls that apply to the proposed development are provided in Table 3.2.

Table 3.2 Key flood risk zone development constraints (Liverpool DCP (2008))

Flood Risk Category	Category definition
High flood risk	▪ unsuitable for commercial and industrial development ▪ only suitable for recreational and non-urban uses such as parkland and agriculture.
Medium flood risk	▪ floor levels of buildings, operational and storage areas must be 500 mm above the 1% AEP flood level Buildings and structures must be designed to withstand floodwaters ▪ development must not increase flood effects elsewhere off the site ▪ floodways must be preserved and not obstructed ▪ land filling within the 1% AEP floodplain unacceptable unless compensatory excavation occurs to prevent net flood storage loss.
Low flood risk	▪ for commercial and industrial developments the controls are similar to those for medium flood risk areas; however landfilling does not require compensatory excavation.
No flood risk	▪ suitable for commercial and industrial development ▪ unconstrained by Georges River flood risk development controls.

4. Assessment of flood impacts

4.1 Overview

Development of the Project site has been planned around existing flooding constraints. As such infrastructure and changes to ground levels is only proposed within low flood risk or no flood risk zones. The exception to this is the rail bridge crossing of the Georges River which connects the site with the Southern Sydney Freight Line (SSFL). Three options have been proposed for this crossing; a northern option; a central option; and a southern option. Further details of these proposed crossings was provided in section 2.3.

The development of the bridge crossings can potentially have adverse impacts on flooding in the vicinity of the new structure. A hydraulic investigation has been undertaken to assess the afflux generated by each of the proposed rail crossings and its associated piers within the Georges River and its floodplain adjacent to the Project site.

4.2 Assessment methodology

4.2.1 MIKE11 model

The MIKE11 model provided by Liverpool City Council was rerun to ensure results correlated with the existing results files provided. The model was successfully verified.

Modifications to the network component of the MIKE11 model were attempted. Despite numerous attempts, run simulations of this model could not be successfully generated due to the incomplete set of MIKE11 files received from Liverpool City Council.

The large size and complexity of the model and incomplete set of model files received made achieving stability in the model at the beginning of simulations difficult.

4.2.2 HEC RAS model development

As documented above, the MIKE11 model was not able to be manipulated to assess the impacts of the proposed Georges River railway crossings. The intent of the assessment was to assess the impact so a decision was thereby made to replicate the model using an alternative one-dimensional hydrological modelling software, HECRAS. The model was truncated to represent a shorter reach of the Georges River in the vicinity of the Project site, therefore providing a more practical tool for assessing impacts associated with the proposed rail crossing.

4.2.2.1 Cross sections

Forty one cross-sections from the Liverpool City Council Mike11 model were copied into HECRAS for the Upper Georges River reach from cross section 100000 to 106540 (just downstream of the Liverpool Weir). These cross-sections were renamed to conform to HEC RAS naming conventions and were renamed descending from 41 to 1 (see Appendix B for each corresponding cross section name).

4.2.2.2 Manning's roughness

Manning's 'n' roughness coefficients were translated from the MIKE11 model to the HEC RAS model. MIKE11 uses a global coefficient (unless specified otherwise) and applies ratios to each cross-section. These ratios were converted into manning's 'n' values for entry into the HEC RAS cross-sections.

4.2.2.3 Structures and floodplain storages

The existing East Hills railway bridge was excluded from the Liverpool City Council MIKE11 model. Whilst the reason for this is not known, this bridge is very high and it is assumed that it would have minimal impact on flood levels for regular flood events. For this assessment this structure was added to the HEC RAS model based on 'Work As Executed' drawings of the structure (refer to Appendix A) to assess the impacts for the 1% AEP flood event.

The road crossing at MIKE11 model cross-section 101057 (Cambridge Avenue) was entered into the HECRAS model as a twin culvert. This has been represented in a HEC RAS in a similar manner to how it is represented in the MIKE11 model.

The 'east basin' and 'west basin' in the MIKE11 model representing the Georges River floodplain storage areas were represented in the HECRAS cross section geometry rather than as storages.

4.2.2.4 Boundary conditions

The HEC RAS model was run as a steady state model. The peak flow rates from the 1% AEP hydrograph and the EFE hydrograph used in the MIKE11 model were applied to the HECRAS model. This peak flow rate for the 1% AEP event is 1,877 m^3/s and for the EFE is 4,807 m^3/s.

The peak water level at Liverpool Weir (MIKE11 cross-section 106535) represents a reasonable estimate of the downstream water levels on the truncated HEC RAS river reach and has been used as a downstream boundary. The peak water levels (9.2 mAHD for the 1% AEP event and 11.8 mAHD for the EFE) were applied at the downstream boundary of the truncated HECRAS model.

4.2.3 HEC RAS modelling scenarios and calibration

4.2.3.1 Model calibration

The HEC RAS model was run (steady state) using the above parameters to attempt to match the MIKE11 model results. The HEC RAS model generally predicted water levels approximately 500 mm higher than the MIKE11 model for the 1% AEP event. This can likely be attributed to the HEC RAS model being run in steady state and therefore not able to account for the flow attenuating effect of floodplain storage areas included in the MIKE11 model.

To counter the differences observed between the HEC RAS and Mike11 models, the manning's 'n' values in the HEC RAS model were reduced by 25%. While this approach would not normally be considered an appropriate method to calibrate the HEC RAS model; it does however provide a way to at least provide similar flood levels at the point of interest and allow for reasonable comparison of results. Following adjustment of the Manning's 'n' values the results showed that the flood levels are similar at the northern (downstream) end of the Project site (HEC RAS cross-section 14, MIKE11 cross-section 104185) and varies less than 160 mm up at the southern (upstream) end of the Project Site.

4.2.3.2 Existing scenario

The above comparisons/model calibration were made prior to adding the existing East Hill Rail Bridge to the model to ensure a comparative representation of the floodplain was in both models. Addition of the existing rail bridge to the model resulted in no change to flood levels downstream of the rail bridge, but an increase in flood levels immediately upstream of the rail bridge by 70 mm in comparison to the HEC RAS model results without this bridge included. This flood level increase reduced to 40 mm by the upstream extent of the model (approximately 1.4 km upstream of the Project site).

This model, inclusive of the rail bridge was adopted as the existing case HEC RAS model.

4.2.3.3 Southern option

To represent the proposed bridge, the existing East Hills Rail Bridge has been duplicated in the model. The proposed bridge deck and noise barriers have been represented at the same level as the existing rail bridge. Piers and abutments have been represented as the same size and shape and in the same locations across the waterway as those for the existing rail bridge to minimise afflux and scour of the bed and banks of the waterway. It is noted that the existing bridge has 1.8 m diameter piers located at 30.7 m intervals.

4.2.3.4 Northern option

There are a number of different approaches that can be adopted to model the effect of the northern option bridge in the model. Due to the complexity of the bridge design (refer to section 2.3.2) two different methods have been adopted to assess the afflux and the results compared. In each of these methods, each pier is assumed to be round and 1.8 m in diameter and therefore bridge skew has no impact on the pier width in relation to the flow direction. The double piers at the dual rail part of the bridge are aligned perpendicular to the flow.

Method 1 – Projection of piers onto existing cross sections

The location of each pier was projected onto the nearest upstream and downstream cross-sections. In some instances, the projection of piers in the northern single rail branch coincide with the projection of piers in the southern single rail branch and therefore overlap on a single cross section. Since the bridge extends over three cross-sections (HECRAS cross-sections 12, 13, and 14), two separate bridge structures were represented.

The eccentricity of the bridge and its piers has not been allowed for and cannot be allowed for in HECRAS without creating a number of interpolated cross-sections between each of the piers (this is provided in Method 2).

Method 2 – Insertion of interpolated sections

Ten interpolated sections were created between cross-section 13 and cross-section 14 and a further ten between cross-section 12 and cross-section 13. This allows for the piers to be better represented according to their longitudinal position. Overlapping piers, as referred to in Method 1, are able to be represented individually due to the increase in cross-sections.

4.2.3.5 Central Option

To represent the central option bridge crossing a similar approach has been taken to representation of the northern option crossing. Each pier is assumed to be round and 1.8 m in diameter and therefore bridge skew has no impact on the pier width in relation to the flow direction. The double piers at the dual rail part of the bridge are assumed to be aligned perpendicular to the flow.

Based on the results of the assessment of the Northern Option (refer section 4.2.3.4 and results section 5.2.2.) the central option bridge has been represented following Method 2 – insertion of interpolated cross sections.

5. Results

5.1 Existing flood levels

5.1.1 Comparison of baseline MIKE11 and HECRAS Results

Table 5.1 summarises the flood levels at selected cross-sections produced for the 1% AEP flood event in MIKE11 and the baseline HEC RAS model.

Table 5.1 Comparison between Mike11 and HECRAS baseline 1% AEP river levels

Cross-Section ID	MIKE11 Chainage	MIKE11	HECRAS
40	100225	12.87	12.90
38	100630	12.66	12.68
32	101270	11.82	11.92
31	101440	11.69	11.87
30	101650	11.59	11.75
24	102730	11.09	10.97
23	102930	11.05	11.03
22	103125	11.06	11.08
19	103555	10.85	10.92
15	104095	10.70	10.70
14	104185	10.70	10.70
13	104355	10.57	10.53
12	104535	10.49	10.42
7	105560	9.86	9.75

As can be observed from the table, the flood levels are similar. A full set of results for each cross-section can be found within Appendix B.

5.1.2 Impact of addition of existing Rail Bridge to HEC RAS model

Table 5.2 summarises the flood levels at selected cross-sections estimated for the 1% AEP flood event in the baseline HEC RAS model and the HEC RAS model updated to include the existing East Hills Rail Bridge.

Table 5.2 Comparison between baseline HEC RAS model and HEC RAS model with addition of existing rail bridge for 1% AEP river levels

Cross-Section ID	Baseline HEC RAS (no rail bridge) (mAHD)	HEC RAS model with existing rail bridge (mAHD)	Afflux (m)
40	12.90	12.96	0.05
38	12.68	12.74	0.05
32	11.92	11.98	0.06
31	11.87	11.94	0.07
30	11.75	11.75	0
24	10.97	10.97	0
23	11.03	11.03	0
22	11.08	11.08	0
19	10.92	10.92	0
15	10.70	10.69	0
14	10.70	10.69	0
13	10.53	10.52	0
12	10.42	10.42	0
7	9.75	9.75	0

Note that the existing East Hills Rail bridge location is located between cross sections 30 and 31.

Addition of the existing rail bridge to the model resulted in no change to flood levels downstream of the rail bridge, but an increase in flood levels immediately upstream of the rail bridge by 70 mm in comparison to the HEC RAS model results without this bridge included. This increase in flood level reduced to 40 mm by the upstream extent of the model (approximately 1.4 km upstream of the Project site). A full set of results for each cross-section can be found within Appendix B. To ensure a more complete representation of the existing floodplain hydraulics the existing case model including the existing East Hills Rail Bridge has been adopted as the ‘existing’ case Hec Ras model. A similar approach to development of an existing conditions flood model was adopted for the Part 3A Concept Plan Application for the Sydney Intermodal Terminal Alliance (SIMTA) proposal (Hyder, 2013). The HEC RAS model developed for the SIMTA assessment also incorporated the existing rail bridge into the modelling and is reported to have similar estimated flood levels.

5.1.3 Existing flood levels

Table 5.3 provides a summary of flood levels at selected cross-sections in the vicinity of the Project Site that have been adopted for this impact assessment, as representative of existing 1% AEP and 'extreme flood event' flood levels. A full set of flood levels for each cross-section in the model can be found within Appendix B.

Table 5.3 Existing flood levels

Cross-Section ID	1% AEP (mAHD)	Extreme Flood Event (mAHD)
40	12.95	18.42
38	12.73	17.63
32	11.98	16.99
31	11.94	16.90
30	11.75	15.91
24	10.97	14.09
23	11.03	14.69
22	11.08	14.71
19	10.92	14.32
15	10.7	14.03
14	10.7	14.02
13	10.53	13.77
12	10.42	13.70
7	9.75	13.21

5.2 Impact assessment

5.2.1 Southern option

Table 5.4 shows the modelled flood levels at selected cross sections for both the 1% AEP event and the extreme flood event under both the existing and the proposed southern bridge crossing option. This table also shows the afflux that would result from the proposed southern option. A full set of flood levels for each cross-section in the model can be found within Appendix B.

Table 5.4 Southern option flood levels and afflux

Cross-Section ID	1% AEP (mAHD)			Extreme Flood Event (mAHD)		
	Existing	Proposed	Afflux	Existing	Proposed	Afflux
40	12.96	12.96	0	18.42	19.06	0.64
38	12.74	12.75	0.01	17.63	17.95	0.32
32	11.98	12.01	0.03	16.99	17.49	0.5
31	11.94	11.97	0.03	16.90	17.42	0.52
30	11.75	11.75	0	15.91	15.91	0
24	10.97	10.97	0	14.09	14.09	0
23	11.03	11.03	0	14.69	14.69	0
22	11.08	11.08	0	14.71	14.71	0
19	10.92	10.92	0	14.32	14.32	0
15	10.69	10.69	0	14.03	14.03	0
14	10.69	10.69	0	14.02	14.02	0
13	10.52	10.52	0	13.77	13.77	0
12	10.42	10.42	0	13.70	13.7	0
7	9.75	9.75	0	13.21	13.21	0

Note that the proposed Southern Option bridge location is between cross sections 30 and 31

The hydraulic modelling indicates that the maximum afflux for a 1% AEP event would occur immediately upstream of the rail bridges and would be no more than 30 mm. Estimated afflux drops to 0.0 mm by cross section 40 (approximately 1.2 km upstream of the proposed bridge). This bridge option has the smallest afflux of the three bridge options considered (refer to sections 5.2.2 and 5.2.3 below). The location of this bridge option adjacent to the existing rail bridge, and bridge design being hydraulically similar to the rail bridge are key reasons for the minimal impact to flood levels in comparison to the northern and central bridge options.

5.2.2 Northern option

The following tables summarises the flood levels at selected cross-sections for the 1% AEP and the extreme flood event under both the existing conditions and the proposed northern bridge crossing option. Table 5.5 summarises the proposed flood levels obtain using method 1 while Table 5.6 summarises the proposed flood levels obtained using method 2 (as described in section 4.2.3.4) estimated for low for Method 1 and Method 2 for the existing scenario and for the proposed bridge design.

Table 5.5 Northern option (Method 1) flood levels and afflux

Cross-Section ID	1% AEP (mAHD)			Extreme Flood Event (mAHD)		
	Existing	Proposed	Afflux	Existing	Proposed	Afflux
40	12.96	13.01	0.05	18.42	18.6	0.18
38	12.74	12.79	0.05	17.63	17.82	0.19
32	11.98	12.06	0.08	16.99	17.31	0.32
31	11.94	12.01	0.07	16.90	17.23	0.33
30	11.75	11.83	0.08	15.91	16.25	0.34
24	10.97	11.08	0.11	14.09	14.59	0.5
23	11.03	11.14	0.11	14.69	15.14	0.45
22	11.08	11.18	0.1	14.71	15.19	0.48
19	10.92	11.03	0.11	14.32	14.8	0.48
15	10.69	10.82	0.13	14.03	14.65	0.62
14	10.69	10.82	0.13	14.02	14.63	0.61
13	10.52	10.57	0.05	13.77	14.23	0.46
12	10.42	10.42	0	13.70	14.04	0.34
7	9.75	9.75	0	13.21	13.42	0.21

Note that the proposed northern option bridge is located between sections 12 and 14

Table 5.6 Northern option (Method 2) flood levels and afflux

Cross-Section ID	1% AEP (mAHD)			Extreme Flood Event (mAHD)		
	Existing	Proposed	Afflux	Existing	Proposed	Afflux
40	12.96	13.01	0.05	18.42	19.15	0.73
38	12.74	12.79	0.05	17.63	18.07	0.44
32	11.98	12.06	0.08	16.99	17.62	0.63
31	11.94	12.02	0.08	16.90	17.54	0.64
30	11.75	11.84	0.09	15.91	16.51	0.6
24	10.97	11.09	0.12	14.09	15.2	1.11
23	11.03	11.16	0.13	14.69	15.62	0.93
22	11.08	11.19	0.11	14.71	15.67	0.96
19	10.92	11.05	0.13	14.32	15.32	1

Cross-Section ID	1% AEP (mAHD)			Extreme Flood Event (mAHD)		
	Existing	Proposed	Afflux	Existing	Proposed	Afflux
15	10.69	10.84	0.15	14.03	15.24	1.21
14	10.69	10.84	0.15	14.02	15.22	1.2
13	10.52	10.6	0.08	13.77	14.85	1.08
12	10.42	10.42	0	13.70	14.13	0.43
7	9.75	9.75	0	13.21	13.21	0

Note that the proposed northern option bridge is located between sections 12 and 14

The greatest 1% AEP event afflux (150 mm) is shown to occur at cross-section 14 and 15 using bridge modelling Method 2. Given that the Method 2 appears to provide the more conservative afflux estimates it is recommended that the results from this method be considered in preference to method 1 results. As shown in Table 5.6 afflux drops to about 50 mm by cross section 40 (located approximately 4 km upstream of the proposed bridge).

5.2.3 Central option

Table 5.7 shows the modelled flood levels at selected cross sections for both the 1% AEP event and the extreme flood event under both the existing and the proposed central bridge crossing option. This table also shows the afflux that would result from the proposed central option. A full set of flood levels for each cross-section in the model can be found within Appendix B.

Table 5.7 Central option flood levels and afflux

Cross-Section ID	1% AEP (mAHD)			Extreme Flood Event (mAHD)		
	Existing	Proposed	Afflux	Existing	Proposed	Afflux
40	12.96	13.06	0.1	18.42	19.2	0.78
38	12.74	12.85	0.11	17.63	18.17	0.54
32	11.98	12.13	0.15	16.99	17.74	0.75
31	11.94	12.09	0.15	16.90	17.65	0.75
30	11.75	11.92	0.17	15.91	16.65	0.74
24	10.97	11.19	0.22	14.09	15.53	1.44
23	11.03	11.13	0.1	14.69	15.04	0.35
22	11.08	11.08	0	14.71	14.71	0
19	10.92	10.92	0	14.32	14.32	0
15	10.69	10.69	0	14.03	14.03	0
14	10.69	10.69	0	14.02	14.02	0
13	10.52	10.52	0	13.77	13.77	0
12	10.42	10.42	0	13.70	13.7	0
7	9.75	9.75	0	13.21	13.21	0

Note that the proposed central bridge crossing is located between cross sections 22 and 24

As shown, modelling indicates that the maximum afflux for a 1% AEP event would occur immediately upstream of the proposed rail bridge and would be a maximum of 220 mm. Estimated afflux is still in the order of 100 mm at cross section 40 (located approximately 2.5 km upstream of the proposed bridge). Afflux generated from this bridge option is similar to but higher than the northern bridge option. It shows the greatest afflux of the three options considered. The central and northern bridge options present new hydraulic restrictions across the floodplain in comparison to the southern option which is located adjacent to and designed hydraulically similar to the existing East Hills Rail bridge.

While the central option presents the greatest afflux of the three bridge options considered, it is noted that the risk associated with the 1% AEP to houses upstream of the project site would not be affected. No additional flooding to properties would occur as a result of the central option.

5.3 Sensitivity testing

Sensitivity testing was undertaken based on revised tailwater level used in the model. The modelling has adopted a tailwater level as the peak water level at the Liverpool Weir. This water lever varies over time and is a reflection of the original hydrodynamic MIKE11 model. To assess the effects of a lower tailwater level (i.e. below the peak water level), a sensitivity test has been made with a tailwater level of 8.5 m AHD. The existing case model and the Southern bridge crossing option have been again used for the sensitivity test with resulting afflux compared to that modelled using the original tailwater level.

Table 5.8 Sensitivity of afflux results to reduced tailwater level

Cross-Section ID	1% AEP flood level with reduced model tailwater level		
	Existing	Proposed	Afflux
40	12.83	12.85	0.02
38	12.61	12.62	0.01
32	11.81	11.84	0.03
31	11.76	11.79	0.03
30	11.56	11.56	0
24	10.72	10.72	0
23	10.77	10.77	0
22	10.83	10.83	0
19	10.64	10.64	0
15	10.37	10.37	0
14	10.38	10.38	0
13	10.18	10.18	0
12	10.04	10.04	0
7	9.23	9.23	0

The affluxes calculated with the reduced tailwater are relatively similar to those calculated by the original modelling and often reduced in some sections. It can be concluded that while changes to the tailwater level change absolute water levels (as is expected) it does little to affect the predictions of affluxes generated by the proposed bridge.

6. Conclusions

The hydraulic modelling indicates that the maximum afflux for a 1% AEP event would occur immediately upstream of the proposed rail bridges for each option and would be limited to:

- 30 mm for the southern option
- 150 mm for the northern option
- 220 mm for the central option.

Upstream of the project site the southern option has the smallest afflux (despite having the bridge located at the upstream extent of the project site) with no afflux noted at the upstream cross section of the model. This compares to an afflux of 40 mm for the northern option and 90 mm for the central option. It should be noted that these are likely to be a conservative estimates of afflux due to limited modelling inputs.

The central and northern bridge options present new hydraulic restrictions across the floodplain in comparison to the southern option which is located adjacent to and designed hydraulically similar to the existing East Hills Rail bridge. The location of the proposed southern bridge option adjacent to the existing rail bridge, and bridge design being hydraulically similar to the rail bridge are key reasons for the smaller impact to flood levels associated with this option in comparison to the northern and central bridge options.

There are residences located upstream of the project site and it will be critical to ensure that flood impacts do not negatively affect these properties. The modelling indicates that none of the three bridge options considered would increase the flood risk to these properties during a 1% AEP event.

The Casula Powerhouse arts centre is in a low hazard area and above the 1% AEP flood level. The road into the centre also appears to be above the 1% AEP flood level. Whilst some of the parkland adjacent to the centre may be affected, the modelling indicates that none of the three bridge options considered would increase the flood risk to the arts centre during a 1% AEP event.

To minimise potential flood impacts bridge design should incorporate the following key principles:

- the proposed soffit of the bridge deck is to be set at a minimum of 500 mm above the predicted 1% AEP flood level (or in the case of the Southern option, the deck and noise barriers should be designed at the same level as the existing rail bridge)
- bridge abutments should not encroach on the waterway areas of the Georges River
- piers should be designed to be streamlined in shape to minimise afflux and scour of the bed and banks of the waterway (the southern option should adopt piers that are the same size and shape and that are hydraulically aligned with the existing rail bridge).

Sensitivity testing has indicated that variations to the input parameters (e.g. tailwater levels) do not have a significant impact on the affluxes predicted by the model.

As the MIKE11 model was simplified to a HECRAS model to enable afflux results to be calculated, the HECRAS model should be limited in its use to calculating afflux in the vicinity of the proposed bridge. The MIKE11 model is a more comprehensive model and should be used to determine flood levels across the reaches modelled for the adopted design.

It is recommended that further modelling be undertaking during further design phases to confirm afflux generated by the proposed bridge and potential flood impacts. This future modelling may also facilitate refinement of the bridge design to reduce impacts.

7. References

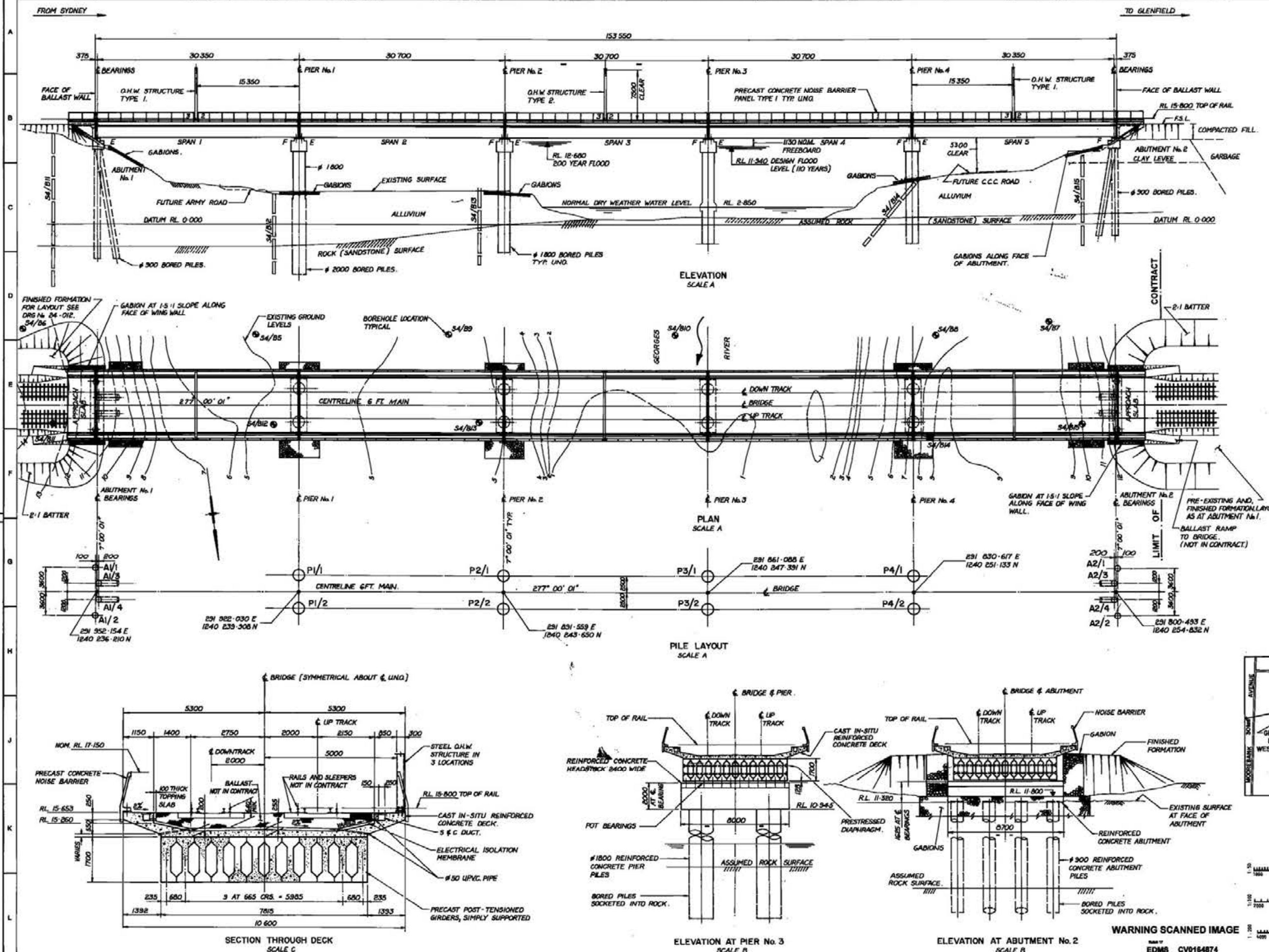
Bewsher Consulting, 1999, *Georges River Model Study (DRAFT).*

Bewsher Consulting, 2004, *Georges River Floodplain Management Study and Plan.*

Hyder Consulting, August 3013, *Transitional Part 3A Concept Application, SIMTA Moorebank Intermodal Terminal Facility – Flood Study and Stormwater Management.*

Appendix A

East Hills Rail Bridge work as executed drawings



GENERAL NOTES

DESIGN SPECIFICATION
ANZRC RAILWAY BRIDGE DESIGN MANUAL, 1974 WHERE APPLICABLE OTHERWISE NAASRA BRIDGE DESIGN SPECIFICATION, 1976.

DESIGN LOADINGS

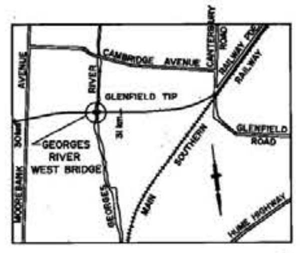
NUMBER OF TRACKS LOADED	2 TRACKS
LOADING	M270 PLUS IMPACT
DESIGN SPEED	115 KPH FOR M270 140 KPH FOR XPT
DERAILMENT LOADING	M270 BETWEEN BALLAST KERBS
WALKWAY	5 kPa
TEMPERATURE RANGE	35° to 3°C, MEAN 16°C
DIFF'L TEMPERATURE ON DECK	12.5°C (WITH BALLAST)
DESIGN FLOOD LEVEL	RL 11.94 AHD 110 YEAR (1873)
STREAM FLOOD VELOCITY	1.8 m/s AVERAGE WITH LOG IMPACT OR 3m DEBRIS
MINING SUBSIDENCE	150mm MAXIMUM ±0.5mm/m HORIZONTAL STRAIN
DIFFERENTIAL SETTLEMENT	5mm DUE TO SETTLEMENT 30mm DUE TO MINING
SEISMICITY	ZONE A
SAFE BEARING CAPACITY OF SANDSTONE FOUNDATION	4.0 MPa END BEARING

DIMENSIONS
REDUCED LEVELS AND KILOMETRAGES ARE IN METRES. ALL OTHER DIMENSIONS ARE IN MILLIMETRES.

DATUM IS A.H.D., CO-ORDINATES ARE PLANAR. CO-ORDINATES BASED ON T.P. AT 30km 644·118m. REFER DRG. Nº FOR TRACKWORK LAYOUT.

LIST OF DRAWINGS

TITLE	DRAWING Nº
GENERAL ARRANGEMENT	24-001
PIERS	24-002
ABUTMENTS - CONCRETE AND PILES	24-003
ABUTMENTS - REINFORCEMENT	24-004
INTERIOR GIRDERS	24-005
EXTERIOR GIRDERS	24-006
DECK SLAB	24-007
MISCELLANEOUS DETAILS - SHEET 1.	24-008
MISCELLANEOUS DETAILS - SHEET 2.	24-009
NOISE BARRIER AND O.H.W. STRUCTURE	24-010
EARTHWORKS PLAN & LONGITUDINAL SECTION	24-011
TYPICAL EARTHWORKS SECTIONS & DETAILS	24-012
SEDIMENTATION POND & DRAINAGE DETAILS	24-013



LOCALITY PLAN
NOT TO SCALE

SCALE C
SCALE B
SCALE A

WARNING SCANNED IMAGE
EDMS CV0164874

Nº	AMENDMENT	DES.CONS	GHD	SRA
C	MARKED UP AS WORK AS EXECUTED DRAWINGS 20-8-86			
B	KILOMETERAGES REMOVED & NOTES ADDED 15-5-85			
	ISSUED FOR CONSTRUCTION CONTRACT EHC6 12-4-85			
A	ISSUED FOR TENDER. CONTRACT Nº EHC 6. 19-10-84.			

DRAWING REFERENCE

EARTHWORKS PLAN & LONGITUDINAL SECTION	24-011
TYPICAL EARTHWORKS SECTIONS & DETAILS	24-012

DESIGN CONSULTANT: CMPS CROOKS MICHELL PEACOCK STEWART PTY LIMITED, ENGINEERS MANAGERS

DRAWN D.D./L.K. CHECKED A.N. PRINCIPAL DATE 22-10-84

PROJECT MANAGEMENT CONSULTANT: GHD Gutteridge, Haskins & Davey
PROJECT OFFICE, 20 REGENT ST, RAILWAY SQUARE NSW, TELEPHONE (02) 699 9455

State Rail Authority of NSW
EHC East Hills-Campbelltown Railway

WORK AS EXECUTED

GEORGES RIVER WEST BRIDGE
GENERAL ARRANGEMENT

DRAWING Nº 24-001 AMDT C

AO