CABRAMATTA LOOP PROJECT

TECHNICAL REPORT

TECHNICAL REPORT 5 —
HYDROLOGY AND FLOODING IMPACT ASSESSMENT

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Australian Rail Track Corporation

Cabramatta Loop Project

Environmental Impact Statement

Technical Report 5 - Hydrology and Flooding Impact Assessment

August 2019

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Glossary and abbreviations

<table>
<tr><th>Term</th><th>Definition</th></tr>
<tr><td>Annual exceedance probability (AEP)</td><td>The annual exceedance probability is a measure of the frequency of a rainfall event. It is the probability that a given rainfall total, accumulated over a given duration, will be exceeded in any one year. A one per cent AEP event is a rainfall event with a one per cent chance of being exceeded in magnitude in any year.
The current Australian Rainfall and Runoff Guideline (Commonwealth of Australia, 2016) recommends the use of AEP terminology whereas historically, the term average recurrence interval (ARI) was used. Where reference documents have used ARI, this has been converted to an equivalent AEP using the information below (Bureau of Meteorology, 2016).
<table>
<tr><th>ARI (years)</th><th>AEP (per cent)</th></tr>
<tr><td>One</td><td>63</td></tr>
<tr><td>Two</td><td>39</td></tr>
<tr><td>Five</td><td>18</td></tr>
<tr><td>10</td><td>10</td></tr>
<tr><td>20</td><td>5</td></tr>
<tr><td>50</td><td>2</td></tr>
<tr><td>100</td><td>1</td></tr>
<tr><td>200</td><td>0.5</td></tr>
<tr><td>500</td><td>0.2</td></tr>
</table></td></tr>
<tr><td>Afflux</td><td>With reference to flooding, afflux refers to the predicted change, usually in flood levels, between two scenarios. It is frequently used as a measure of the change in flood levels between an existing scenario and a proposed scenario.</td></tr>
<tr><td>Australian Height Datum (AHD)</td><td>A common reference level used in Australia which is approximately equivalent to the height above sea level.</td></tr>
<tr><td>Average recurrence interval (ARI)</td><td>The average recurrence interval is a measure of the frequency of a rainfall event. It is the expected average value of the periods between exceedances of a given rainfall total accumulated over a given duration eg. 1 in 100 years.
However, this sometimes resulted in the term being misinterpreted as implying that the associated magnitude is only exceeded at regular intervals, and that it was referring to the elapsed time to the next exceedance. In fact, the periods between events of a similar magnitude are random and unpredictable.
For these reasons, the annual exceedance probability (AEP) is now the preferred terminology.</td></tr>
<tr><td>Blue Book</td><td>Managing Urban Stormwater: Soils and Construction Handbook.</td></tr>
<tr><td>Catchment</td><td>The area drained by a stream or body of water or the area of land from which water is collected.</td></tr>
<tr><td>Climate change event</td><td>In this report, the 1 per cent AEP climate change event is a 1 per cent AEP event including a 10 per cent increase in peak rainfall intensity to incorporate the possible future effects of climate change.</td></tr>
<tr><td>Datum</td><td>A level surface used as a reference in measuring elevations.</td></tr>
<tr><td>Discharge</td><td>Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.</td></tr>
<tr><td>Erosion</td><td>A natural process where wind or water detaches a soil particle and provides energy to move the particle.</td></tr>
</table>

Term	Definition
Flood	For the purposes of this report, a flood is defined as the inundation of normally dry land by water which escapes from, is released from, is unable to enter, or overflows from the normal confines of a natural body of water or watercourse such as rivers, creeks or lakes, or any altered or modified body of water, including dams, canals, reservoirs and stormwater channels.
Flood immunity	Flood immunity has been used in this report to describe the minimum AEP above which infrastructure must be set. So the flood level of a building required to have a flood immunity of the 1 per cent AEP must be set at a level above the 1 per cent AEP flood.
Flood liable land	Land which is within the extent of the probable maximum flood and therefore prone to flooding. See probable maximum flood.
Floodplain	The area of land subject to inundation by floods up to and including the probable maximum flood.
Floodway	The area of the floodplain where a significant portion of flow is conveyed during floods. Usually aligned with naturally defined channels.
Formation	A fundamental unit used in the classification of rock or soil sequences, generally comprising a body with distinctive physical and chemical features.
Geomorphology	Scientific study of landforms, their evolution and the processes that shape them. In this report, geomorphology relates to the form and structure of watercourses.
Groundwater	Subsurface water stored in pores of soil or rocks.
Hazard	The potential or capacity of a known or potential risk to cause adverse effects. See also Flood Hazard, which has a particular definition in the NSW Floodplain Development Manual and is described in this report
Hydraulics	The physics of channel and floodplain flow relating to depth, velocity and turbulence.
Hydrology	The study of rainfall and surface water runoff processes.
Impervious	In the context of this report, impervious surfaces are surfaces non-permeable to water. These include areas such as paved surfaces or rooves.
Infiltration	The downward movement of water into soil and rock, which is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Landform	A specific feature of the landscape or the general shape of the land.
LPI	NSW Land and Property Information
Meteorology	The science concerned with the processes and phenomena of the atmosphere, especially as a means of forecasting the weather.
Overbank	The portion of the flow that extends over the top of watercourse banks.
Overland flow path	The path that water can follow if it leaves the confines of the main flow channel. Overland flow paths can occur through private property or along roads. Water travelling along overland flow paths, often referred to as ‘overland flows’, may either re-enter the main channel or may be diverted to another watercourse.
Permeability	The capacity of a porous medium to transmit water.
Probable maximum flood (PMF)	The probable maximum flood is the maximum flood which can theoretically occur based on the worst combination of the probable maximum precipitation and flood-producing catchment conditions that are reasonably possible at a given location.
Project	The construction and operation of the Cabramatta Loop

Term	Definition
Project site	Refers to the area that would be directly disturbed by construction of the project (for example, as a result of ground disturbance and the construction of foundations for structures). It includes the location of construction activities, compounds and work sites, and the location of permanent operational infrastructure.
Riparian	Pertaining to, or situated on, the bank of a river or other water body.
Risk	The chance of something happening that will have an impact measured in terms of likelihood and consequence.
Risk assessment	Systematic process of evaluating potential risks of harmful effects on the environment from exposure to hazards associated with a particular product or activity.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Salinity	The total soluble mineral content of water or soil (dissolved solids); concentrations of total salts are expressed as milligrams per litre (equivalent to parts per million).
Sediment	Material of varying sizes that has been or is being moved from its site of origin by the action of wind, water or gravity.
Stream order	Stream classification system, where order 1 is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology relating to the branching of streams.
Study area	The study area for this report includes the catchments of Cabramatta Creek as shown on the figures. See also 'project site'.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Watercourse	Generic term used to refer to rivers, streams and creeks.
Water quality	Chemical, physical and biological characteristics of water. Also the degree (or lack) of contamination.
Water sharing plan	A legal document prepared under the *Water Management Act 2000* (NSW) that establishes rules for sharing water between the environmental needs of the river or aquifer and water users and also different types of water use.
Water table	The surface of saturation in an unconfined aquifer, or the level at which pressure of the water is equal to atmospheric pressure.

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Executive summary

Australian Rail Track Corporation (ARTC) proposes to construct and operate a passing loop for up to 1,300 metre length trains on the Southern Sydney Freight Line (SSFL) between Sydney Trains' Cabramatta and Warwick Farm stations. The Cabramatta Loop Project ('the project') would allow freight trains to pass and provide additional rail freight capacity along the SSFL.

The project is State significant infrastructure in accordance with Division 5.2 of the NSW Environmental Planning and Assessment Act 1979 (EP&A Act). As State significant infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This Hydrology and Flooding Technical Report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) issued on 17 May 2018 to describe the surface water environment present at the study area, assess impacts of the project on hydrology and flooding and identify mitigation measures to manage the project impact.

The assessment was based on a desktop review of available information regarding surface water as well as analysis and modelling undertaken for the project.

The project site from Cabramatta Road West overbridge to Hume Highway overbridge is located near Cabramatta Creek which drains to the Georges River.

The land use of Cabramatta Creek catchment is mainly medium-high density residential areas. Areas of parkland, as well as commercial and industrial development are also present. The project site is mainly located through parkland.

Key construction stage impacts include the potential for increased flooding and overland flow from construction worksites/compounds and stockpiles on flood-prone land.

Construction impacts would be managed through detailed planning and management of construction sites to avoid any adverse impacts.

The reference design comprises of new bridges over Sussex Street and Cabramatta Creek, These structures have been designed to tie in with the existing structures crossing the Cabramatta Creek waterway as well as the Sussex Street overpass. All of the new structures are on the eastern side of the existing rail corridor. This side is downstream of the Cabramatta Creek waterway and therefore has minimal impact on flows in this waterway.

The existing noise wall will be relocated to accommodate the new rail loop along with underground and other services. Further to this, Broomfield Street that runs adjacent to the rail corridor will be re-aligned to accommodate the widened rail corridor. This will involve relocating services within the road corridor including the stormwater drainage network that collects and conveys runoff from the immediate and surrounding catchment.

Assessment of the flood impacts for the full range of events from the five per cent Annual Exceedance Probability (AEP) (20-year average recurrence interval) event to the probable maximum flood (PMF) event was undertaken for flooding due to the presence of Cabramatta Creek within the project site. Flood mapping undertaken for the project indicates that at the project location, there would be a minimal increase in flood depth and extent due to the presence of the new bridges proposed over Cabramatta Creek and at Sussex Street. The post-development flood levels would generally not increase by more than 17 millimetres above existing levels for the one per cent Annual Exceedance Probability event, which satisfies the design limit adopted for the project.

Flooding impacts have also been assessed through the local catchment due to works along Broomfield Street. These impacts have been assessed for the 10 per cent, five percent and one per cent AEP events. The flood assessment indicated that some increases in flood level do occur due to the change to Broomfield Street with the current reference design, Impacts of around 58 mm above existing flood levels are predicted in a one per cent AEP event at up to seven properties and about 175 mm above existing flood levels at one property. However, the assessment indicated that the flooding impacts noted are generally confined to the front yard of these properties and the actual period of flooding would be less than one hour. Opportunities to reduce this impact will be sought during detailed design and would include potentially re-grading the proposed road levels to generally match the existing road levels where overland flow paths exist.

During detailed design for the works along Broomfield Street, further refinement of the design will be undertaken with the aim of not worsening existing flooding conditions. This would include looking at the grading of the road, notably around flow paths and trying match as close as possible the existing flow paths. This would be done in an effort to not worsen flooding affectation of surrounding properties.

A flood warning and evacuation plan would also be developed with consideration of emergency management of flooding for events up to and including the PMF.

1. Introduction

1.1 Overview

Australian Rail Track Corporation (ARTC) proposes to construct and operate a passing loop for up to 1,300 metre length trains on the Southern Sydney Freight Line (SSFL) between Sydney Trains' Cabramatta and Warwick Farm stations. The Cabramatta Loop Project ('the project') would allow freight trains to pass and provide additional rail freight capacity along the SSFL.

The project is State significant infrastructure in accordance with Division 5.2 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). As State significant infrastructure, the project needs approval from the NSW Minister for Planning and Public Spaces.

This report has been prepared to accompany the environmental impact statement (EIS) to support the application for approval of the project, and address the environmental assessment requirements of the Secretary of the Department of Planning and Environment (the SEARs), issued on 17 May 2018.

1.2 The project

1.2.1 Location

The project is generally located within the existing rail corridor between the Hume Highway and Cabramatta Road East road overbridges in the suburbs of Warwick Farm and Cabramatta. In addition, the project includes works to Broomfield Street adjacent to the rail corridor in Cabramatta.

The rail corridor is owned by the NSW Government (RailCorp) and leased to ARTC.

The location of the project is shown on Figure 1.1.

1.2.2 Key features

The key features of the project include:

- new rail track – providing a 1.65 kilometre long section of new track with connections to the existing track at the northern and southern ends
- track realignment – moving about 550 metres of existing track sideways (slewing) to make room for the new track
- bridge works – constructing two new bridge structures adjacent to the existing rail bridges over Sussex Street and Cabramatta Creek
- road works – reconfiguring Broomfield Street, Cabramatta for a distance of about 680 metres between Sussex and Bridge streets.

Ancillary work would include communication upgrades, works to existing retaining and noise walls, drainage work and protecting/relocating utilities. In addition, minor works in the form of new signalling would be installed at a number of locations within the rail corridor (indicative locations provided in the EIS).

The key features of the project are shown on Figure 1.2.

Further information on the project is provided in the EIS.

Figure 1.1 Location of the project

Figure 1.2 Key features of the project

1.2.3 Timing

Subject to approval of the project, construction is planned to start in early 2021, and is expected to take about two years. Construction is expected to be completed in early 2023.

It is anticipated that some features of the project would be constructed while the existing rail line continues to operate. Other features of the project would need to be constructed during programmed weekend rail possession periods when rail services along the line cease to operate. Possession periods typically occur for 48 hours four times per year.

1.2.4 Operation

The project would operate as part of the SSFL and would continue to be managed by ARTC. ARTC is not responsible for the operation of rolling stock. Train services are currently, and would continue to be, provided by a variety of operators.

Following the completion of works, the existing functionality of Broomfield Street would be restored, with one travel lane in each direction, kerb-side parking on both sides and a shared path on the western side of the street.

1.3 Purpose and scope of this report

The purpose of this report is to assess the hydrology and flooding impacts from the construction and operation of the proposal. This hydrology and flooding assessment addresses the relevant SEARs for the EIS, as outlined in Table 1.1 and the comments of both Liverpool City Council and Fairfield City Council and the Office of Environment and Heritage as outlined in Table 1.2, Table 1.2. The report:

- describes the existing hydrological and flooding environment.
- assesses the impacts of constructing and operating the proposal on the surrounding hydrological and flooding environment.
- recommends measures to mitigate the impacts identified.

Table 1.1 Secretary's environmental assessment requirements – flooding and water hydrology

Key issue	Requirement	Where is this addressed?
3 (2) Assessment of Key Issues	For each key issue the Proponent must: (a) describe the biophysical and socio economic environment, as far as it is relevant to that issue	Section 3
	(b) describe the legislative and policy context, as far as it is relevant to the issue	Section 1.5
	(c) identify, describe and quantify (if possible) the impacts associated with the issue, including the likelihood and consequence (including worst case scenario) of the impact (comprehensive risk assessment), and the cumulative impacts	Section 5 and 6
	(d) demonstrate how potential impacts have been avoided (through design, or construction or operation methodologies);	Refer to the EIS
	(e) detail how likely impacts that have not been avoided through design will be minimised, and the predicted effectiveness of these measures (against performance criteria where relevant)	Section 7

Key issue	Requirement	Where is this addressed?
7. Water – Hydrology	1. The Proponent must describe (and map) the existing hydrological regime for any surface and groundwater resource (including reliance by users and for ecological purposes) likely to be impacted by the project, including stream orders, as per the Biodiversity Assessment Method.	Section 3 and Technical Report 7 (regarding groundwater)
	2. The Proponent must assess (and model if appropriate) the impact of the construction and operation of the project and any ancillary facilities (both built elements and discharges) on surface and groundwater hydrology in accordance with the current guidelines, including:	Refer Appendix A and below
	(c) minimising the effects of proposed stormwater and wastewater management during construction and operation on natural hydrological attributes (such as volumes, flow rates, management methods and re-use options) and on the conveyance capacity of existing stormwater systems where discharges are proposed through such systems; and	Section 7
	3. The Proponent must identify any requirements for baseline monitoring of hydrological attributes.	Technical Report 7
9. Flooding	1. The Proponent must assess and (model where required) the impacts on flood behaviour during construction and operation for a range of flood events up to the probable maximum flood (taking into account sea level rise and storm intensity due to climate change).	Refer sections 5 and 6 and Appendix A

Table 1.2 Stakeholder comments relevant to this assessment

Stakeholder	Key issue	Comment	Where is this addressed?
Fairfield City Council	Flooding	The replacement section of shared pathway should be designed in accordance with Council's requirements (outlined in the letter) in relation to height and distance from the top of the bridge and bank	The shared path would be replaced to match the existing path. Refer to the project description in the EIS
Fairfield City Council	Flooding	The project should not create any adverse flooding impacts	Sections 5 and 6
Fairfield City Council	Flooding	Council's update to the TUFLOW model of Cabramatta Creek should be used to assess any possible flooding impacts	Contact with FCC indicated no TUFLOW model is available from FCC. Liverpool City Council was sought to source a TUFLOW model for the catchment and used to assess. See section 6
Fairfield City Council	Flooding	Provide details on the integration of the bridge works with Cabramatta Creek and the shared pathway	To be covered in design report and drawings

Stakeholder	Key issue	Comment	Where is this addressed?
Fairfield City Council	Flooding	The new bridge should be designed in accordance with council's requirements (as outlined in the letter) in relation to height and distance from the top of the bank	The new bridge will be built to match the existing SSFL so as to minimise impacts on Cabramatta Creek. Refer to the project description in the EIS.
Liverpool City Council	Flooding	The proposal traverses high, medium and low flood risk areas of the Cabramatta Creek floodplain in Warwick Farm. There should be no adverse flooding impacts due to the proposed works	Section 5.2.1, 6.2, 7.1 and 7.2
Liverpool City Council	Flooding	Any increase in flood levels, extent and velocities should be mitigated by flood mitigation works	Section 5.2.1, 6.2, 7.1 and 7.2
Liverpool City Council	Flooding	A flood study should be undertaken in accordance with council's requirements (as outlined in the letter), including modelling and flood difference mapping of pre/post development, and submitted for council review	Section 5.2.1, 6.2, 7.1 and 7.2
Liverpool City Council	Flooding	Council's 2D TUFLOW model should be used for the flooding assessment	Section 5.2.1, 6.2, 7.1 and 7.2
Office of Environment and Heritage	Flooding	The EIS should ensure the use of the latest data from Liverpool and Fairfield Councils' relevant flood studies. Existing studies, including Cabramatta Creek Floodplain Risk Management Study and Plan (Bewsher, October 2004) and Georges River Floodplain Risk Management Study and Plan (Bewsher, May 2004). It is prudent to consult with these relevant councils to ensure the latest flood data is used.	Section 2, 3, 5 and 6
Office of Environment and Heritage		The EIS must map the following features relevant to flooding within the vicinity of the project, as described in the Floodplain Development Manual 2005 (NSW Government 2005) including: • Flood prone land • Flood planning area, the area below the flood planning level (areas below the 1 in 100 year flood level plus a freeboard) Hydraulic categorisation (floodway and flood storage areas).	Section 3, 5, 6, Appendix A and Appendix B
Office of Environment and Heritage		The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10 year, 1 in 100 year flood levels and the probable maximum flood PMF, or an equivalent extreme event.	Section 2, 5 and 6

Stakeholder	Key issue	Comment	Where is this addressed?
Office of Environment and Heritage		The EIS must model the effect of the proposed project (including earthworks) on the flood behaviour under the following scenarios: • Current flood behaviour for a range of design events as identified above The 1 in 200 and 1 in 500 year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Section 3, 5 and 6
Office of Environment and Heritage		Modelling in the EIS must consider and document: • The impacts of the project on existing flood behaviour for a full range of flood events including up to the probable maximum flood • The impact of the project on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards and hydraulic categories • Impacts of earthworks and stockpiles within the flood prone land up to the PMF level. The assessment should be based on understanding of cumulative flood impacts of construction and operational phase Whether appropriate mitigation measures required to offset potential flood risk arise from the project. Any proposed mitigation work should be modelled and assessed on the overall catchment basis in order to ensure it fit its purpose and meets the criteria of the Council where it is located and to ensure it has no adverse impact to surrounding areas.	Section 3, 5 and 6
Office of Environment and Heritage		The EIS must assess the impacts of the proposed project on flood behaviour, including: • Consistency with Councils' floodplain risk management plans • Compatibility with the flood hazard of the land • Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land • Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site	Section 3, 5 and 6

Stakeholder	Key issue	Comment	Where is this addressed?
		• Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and relevant Councils • Whether the proposal incorporates specific measures to manage risk to life from flood • Emergency management, evacuation and access, and contingency measures for the development during both construction and operational phases considering the full range of flood risk (based upon the probably maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES • Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	

1.4 Structure of this report

The structure of the report is outlined below.

- Section 1 provides an introduction to the report, including the legislative and policy context for the assessment, and relevant guidelines
- Section 2 describes the methodology for the assessment
- Section 3 describes the existing environment as relevant to the assessment
- Section 4 describes the proposed drainage works
- Section 5 describes the potential construction impacts of the project
- Section 6 describes the potential operational phase impacts of the project
- Section 7 describes the recommended mitigation measures for both construction and operational phase of the project.

1.5 Relevant legislation and guidelines

The following legislation and guidelines are relevant to this technical report:

1.5.1 Legislative Acts

Water Management Act 2000

The *Water Management Act 2000*, (WM Act) is administered by regulators including WaterNSW and Department of Industry: Water to manage water resources. The aim of the Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. Fresh water sources throughout NSW are managed by water sharing plans (WSPs) under the WM Act.

Principles of the WM Act relating to drainage and floodplain management include the need to avoid or minimise land degradation including soil erosion, compaction, geomorphic instability and waterlogging.

Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations (POEO) Act 1997*, is administered by the NSW Environment Protection Authority (EPA) and is implemented throughout NSW to protect, restore and enhance the quality of the environment. The aim of the POEO Act is to reduce risks to human health, provide increased opportunities for public involvement and participation in environment protection, rationalise, simplify and strengthen the regulatory framework for environment protection and improve the efficiency of administration of environment protection legislation.

Crown Land Management Act 2016

The *Crown Land Management Act 2016*, is administered by the NSW Department of Industry and is implemented to provide ownership, use and management of the Crown land of NSW. The aim of the Act is to provide clarity concerning the law applicable to Crown land, to require environmental, social, cultural heritage and economic considerations to be taken into account in decision-making about Crown land, provide for the consistent, efficient, fair and transparent management of Crown land, facilitate the use of Crown land by Aboriginal people of NSW and provide for the management of Crown land having regard to the principles of Crown land management.

1.5.2 Policies, guidelines and standards

Key guidelines referenced in the assessment include:

- Managing Urban Stormwater: Soils and Construction Volume 1, (Landcom, 2004) (the Blue Book)
- The Floodplain Development Manual - the management of flood liable land, (NSW Government, 2005) (the Floodplain Development Manual)
- Australian Rainfall and Runoff, (Commonwealth Government of Australia, 2016)
- Australian Rainfall and Runoff, (Engineers Australia, 1987).

A detailed list of reference material is provided in section 9.

NSW Floodplain Development Manual

The Floodplain Development Manual and NSW Flood Prone Land (NSW Government, 2005) policy concerns the management of flood-prone land within NSW. It provides guidelines in relation to the management of flood liable lands, including any development that has the potential to influence flooding, particularly in relation to increasing the flood risk to people and infrastructure. Activities of the project which have the potential to increase flood risk through, for example, increasing stormwater runoff would be subject to consideration under the Floodplain Development Manual.

Australian Rainfall and Runoff

Australian Rainfall and Runoff (ARR) (Engineers Australia, 2016) is the primary technical publication for hydrological estimates and design considerations. The draft consultation issue was finalised in November 2016 and was the result of a number of years' of updates to the previous version of Australian Rainfall and Runoff (Engineers Australia, 1987). The technical analysis and development of the original hydrologic and hydraulic models for the Cabramatta Loop project was commenced prior to finalisation of ARR 2016 and is therefore wholly based on the Engineers Australia version (1987).

2. Methodology

2.1 Overview

This assessment of surface water hydrology and flooding involved a desktop review and hydraulic modelling of design information provided by Australian Rail Track Corp Ltd.

The focus of this study will be to assess the potential flood impacts associated with the construction of an additional rail (passing loop) track between Cabramatta and Warwick Farm Railway Station. The study area for this report includes the catchments of Cabramatta Creek and the Georges River.

2.2 Desktop review

The desktop review activities comprised a collation and review of background information, previous reports and project information including:

- flood studies and floodplain risk management studies
- existing and future flooding conditions
- existing drainage infrastructure within and outside of the existing rail corridor, including detail survey information and Dial Before You Dig data.

2.3 Impact assessment

The following tasks were undertaken as part of the impact assessment:

- consideration of the location of the project site in the context of surrounding and upstream catchment areas and potential influence of downstream waterways
- identification of construction activities likely to cause an impact on drainage and flooding
- review of the reference design and activities likely to cause an impact on drainage and flooding
- identification and assessment of potential impacts through changes in surface water quantity, particularly increases or decreases in stormwater runoff and the sensitivity of the downstream waters. This is considered for both construction stage and during operation
- identification of potential impacts of changes in the flood regime and potential increases or decreases in flood risk to downstream areas
- assessment of the likely change in flood storage and potential flood flow paths to be expected as a result of the project
- broad assessment of the likely impact of climate change on the project which involved assuming under future climate conditions runoff from rainfall increases by 10 percent throughout the catchment
- establishment of baseline flood conditions and identifying existing flood conditions for the site, including:
  - an understanding of the existing flood depths
  - velocities across the site
  - flood hazard category
  - rate of inundation
  - available emergency access routes.

- assessment of potential impacts:
  - based on reference design information, the existing TUFLOW flood model was updated to simulate a post development scenario for a range of different AEP storm events
  - comparing the flood impacts against the base case scenario to identify the extent of the flood impacts
  - identifying any potential impacts on flooding during construction stage
  - identifying any potential impacts on flooding of neighbouring properties and assets due to changes to ground levels.

The impact assessment was supported by flood modelling. In this regard, Liverpool City Council provided an existing Cabramatta Creek flood model which was developed in 2011 (Bewsher, 2011) to inform a review the flood behaviour of the catchment. Further, the aim of the study was to review Cabramatta Creek Council's detention basin strategy performance to mitigate the impacts of development within the catchment.

For the present assessment the following flood modelling was undertaken:

- For Cabramatta Creek, the existing Cabramatta Creek flood model was used to define existing flood behaviour at the project site. The model was then updated to reflect the changes to the area proposed by the proposed Cabramatta Loop project, to assess flood impacts.
- A separate local flood model has been developed for Broomfield Street, Cabramatta. This model simulates overland flows in this area and was used to assess flooding impacts due to local drainage amendments and widening of the rail corridor along Broomfield Street, Cabramatta.

A summary of the flooding modelling undertaken for the Cabramatta Creek flooding assessment is provided in Table 2.1.

Table 2.1 Flood modelling undertaken

Location	Events Modelled	Modelling Approach	Results available for EIS
Cabramatta Creek	**Existing case:** Five per cent, two per cent, one per cent, 0.5 and 0.2 per cent AEP and one per cent AEP + 10 per cent increase for climate change and PMF **Developed case:** Five per cent, two per cent, one per cent, 0.5 per cent and 0.2 per cent AEP and one per cent AEP + 10 per cent increase for climate change* and PMF	TUFLOW	Flood level, velocity and hazard maps are presented in this report
Broomfield Street, Cabramatta	**Existing case:** 10 per cent, five per cent and one per cent AEP **Developed case:** 10 per cent, five per cent and one per cent AEP	TUFLOW	Flood level, velocity and hazard maps are presented in Appendix D

* Note: this climate change scenario has been chosen as it is required for the design criteria in terms of flood immunity for the track, as noted in Table 4.1.

2.4 Mitigation measures

Mitigation measures aim to reduce any potential adverse impacts on the environment from project activities. This includes:

- identification of measures and controls to mitigate impacts on surface water flooding
- broad assessment of the expected residual impacts on surface water flooding following implementation of measures and controls.

2.5 Stream order mapping

GIS data and aerial imagery was used to identify and map the stream order of watercourses in the study area. Mapping was completed for all stream lines identified on the New South Wales Land and Property Information (LPI) hydrolines layer.

Stream ordering followed the Strahler stream classification system where watercourses are given an 'order' according to the number of additional tributaries associated with each watercourse (Strahler, 1952).

2.6 Referenced data sources

The following key project documents and information were used in this assessment. Additional background data used to inform the existing environment analysis is documented in section 3.4.1.

Table 2.2 Key project reference documents

Document Reference	Description	Date
Various design documents	Bridge drawings, drainage layouts etc	January 2019
Various documents pertaining to construction	Construction compound schedule GIS database of construction compound and worksite indicative locations GIS locations of vehicle haulage routes	Various
Various email correspondence	Notes regarding proposed drainage across the project site including relocation of Broomfield Street, Cabramatta stormwater drainage network	Various
Flood Model	Flood model for Cabramatta Creek supplied by Liverpool City Council	December 2018

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3. Existing hydrological environment

3.1 Regional drainage catchments

The study area is shown on Figure 1.1 and incorporates the catchments for Cabramatta Creek and associated waterways to its confluence with Georges River.

The rail corridor through the entire study area drains to Cabramatta Creek and its tributaries. The project site, being largely developed and urbanised, is mostly impervious. Pervious areas are generally limited to the parks and landscaped areas adjacent to the project site. The wider study area (upstream and downstream catchment) has also been highly modified from its natural state by various forms of urban development and transport infrastructure.

The project site traverses the City of Liverpool Local Government Area (Liverpool LGA) and the City of Fairfield Local Government Area (Fairfield LGA) which are separated by Cabramatta Creek.

3.2 Local Topography and Drainage

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

The elevation of the rail corridor varies from around eight metres Australian Height Datum (AHD) at the crossing of Cabramatta Creek to 14.5 metres AHD near Cabramatta Station and is at around 9 metres AHD at Warwick Farm Station.

The track is located on fairly low lying land approximately one point two kilometres from the confluence of Cabramatta Creek. The natural topography is generally flat through the Cabramatta Creek floodplain and gently rising out of the low lying terrain towards Cabramatta Station. The rail corridor traverses through the floodplain, is located upon a large embankment varying in height up to 3 metres, and is in a cutting through to Cabramatta Station. At the Warwick Farm end of the main study area, the rail corridor is located generally at grade with the surrounding land, with the Hume Highway at this location raised on an embankment to grade separate the road-rail crossing.

Broomfield Street forms part of the project site where it runs adjacent to the rail corridor at the top of this local surface water catchment around Cabramatta Station downhill to the Sussex Street underpass. This road corridor includes a stormwater drainage line that collects and conveys stormwater runoff from the immediate surrounding area east to approximately the Hume Highway. This drainage line also collects runoff from within the rail corridor. The drainage line discharges at the bottom of Broomfield Street in to an open channel adjacent to 10 Sussex Street. This channel then flows for approximately 50 metres before it connects to Cabramatta Creek.

Drainage within the project site is described in section 3.4.2.

Stream order finding are detail in section 3.3.

3.3 Cabramatta Creek

Cabramatta Creek is a major tributary of the Georges River, located in the south-west of the Sydney Metropolitan region. The catchment has an area of about 74 kilometres squared. Most of the catchment area is located within the Liverpool City Council area. The north side of Lower Cabramatta Creek, downstream of Elizabeth Drive, is located within the Fairfield LGA. A small proportion of the upper catchment is also located within the City of Campbelltown LGA, and the Ingleburn Military Camp.

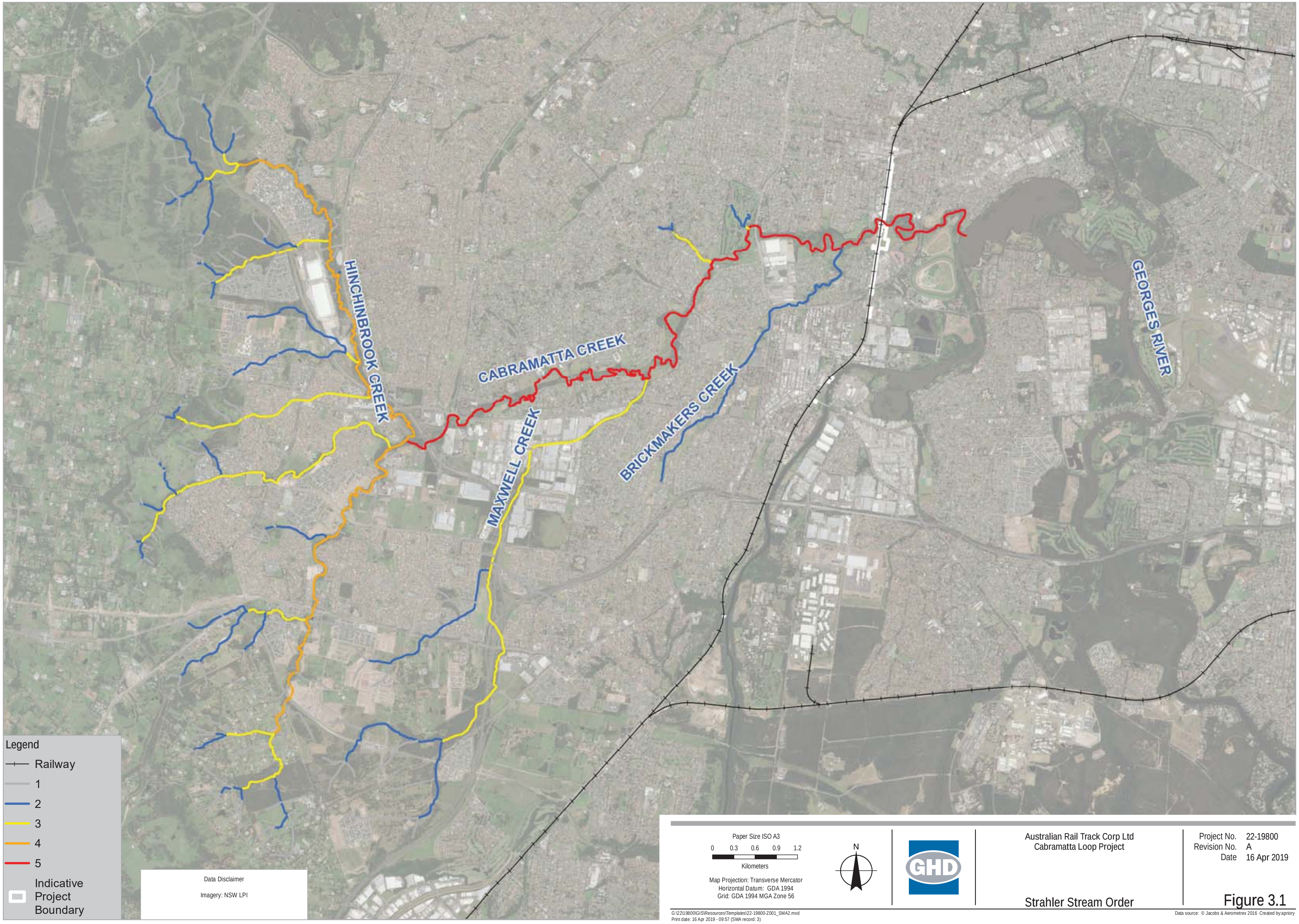
The land use of Cabramatta Creek catchment is mainly high density residential buildings. Areas of parkland, as well as commercial and industrial development are also present. The project site is mainly located through parkland, with the catchment generally consisting of parkland and open spaces concentrated along the creek reserve/floodplain areas. This includes bushland and riparian vegetation which are of ecological and recreational importance including the Elouera Nature Reserve, according to *Cabramatta Creek Floodplain Risk Management Study and Plan* (Bewsher, 2004). Management of the river is shared between Fairfield City Council and Liverpool City Council.

The Cabramatta Creek commences in the rural residential suburb of Denham Court, near the southern extent of the catchment. The upper reaches consist of a number of detention basins, built in conjunction with development in the area.

Numerous urban developments have taken shape throughout the catchment within a number of suburbs. Tributaries of the creek including Maxwells Creek have been modified from their natural state and turned in to a grassed trapezoidal channel downstream of Jedda Road, continuing through to the confluence with Cabramatta Creek.

Cabramatta Creek is a fifth order stream at the rail crossing location (refer Figure 3.1). Significant tributaries of Cabramatta Creek include, from upstream to downstream:

- Hinchinbrook Creek
- Maxwells Creek
- Brickmakers Creek.



Strahler Stream Order

Figure 3.1

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Print date: 16 Apr 2019 - 09:57 (SMA record: 3)

Data source: © Jacobs & Aerometrex 2016 Created by:apriory

3.4 Existing flood information

This section provides a summary of a number of local flood studies which describe existing flooding and drainage in the catchments, including the project site, and an overview of floodplain risk management.

3.4.1 Background information sources

In addition to the project documents referenced in section 2.6, the following flood studies were reviewed to provide background on the existing flooding regime within the project site and study areas:

- the existing Cabramatta Creek Floodplain Management Study and Plan (Bewsher, 2017)
- Fairfield City Overland Flood Study (SKM, 2004)
- Cabramatta Creek Flood Study and Basin Strategy Review (Bewsher, 2011).

3.4.2 Catchment flood behaviour

Cabramatta Creek

The Cabramatta Creek catchment is typical of many urbanised catchments in that the predominance of impervious surfaces means that rainfall is quickly converted into surface water runoff. The rainfall runoff response means that floods may develop quickly following the onset of intense rainfall events. Flood waters in the main Cabramatta Creek rise within a matter of hours following the onset of intense rainfall, making advance warning difficult. Figures summarising the existing flooding conditions for the project site and the immediate surrounds are provided on Figure 3.2 to Figure 3.8 as well as Appendix A. Further details of existing flooding conditions within the project site are provided in section 3.4.3

Local Drainage and Overland Flooding

Surface water from within the rail corridor is captured by a track drainage system and subsequently conveyed in to the local drainage network maintained by Council via trunk drainage network to the receiving waterway (Cabramatta Creek → Georges River → Botany Bay).

Further to this, there are a number of open drainage channels that drain in to the track drainage network described above. The open channels are both earth lined and concrete open dish drain type elements.

The capacity of the existing elements within the rail corridor is currently unknown but only cater for rainfall runoff that falls within the rail corridor. External catchments are managed by other drainage systems.

A local overland flow path exists down Broomfield Street. Currently a stormwater drainage pipe exists underneath Broomfield Street to collect runoff from the roadway and adjacent areas within the catchment. This asset currently belongs to Fairfield City Council with connections to other stormwater pipes within the roadway as well as drainage pipes from the rail corridor. This pipe network outlets in to a channel adjacent to 10 Sussex Street that continues in to Cabramatta Creek. This outlet location also includes two other pipe outlets from local drainage lines that exist in the area.

When this pipe capacity is exceeded, overland flow paths continue down Broomfield Street with the roadway acting as a conveyance for these flows. The flows continue to the end of Broomfield Street where they flow in to the channel where the pipe outlets.

The channel that conveys flows to Cabramatta Creek is heavily vegetated throughout its length of approximately 50 metres.

3.4.3 Existing flooding conditions within the study area

This section provides additional details regarding existing flooding and drainage specific to the project site.

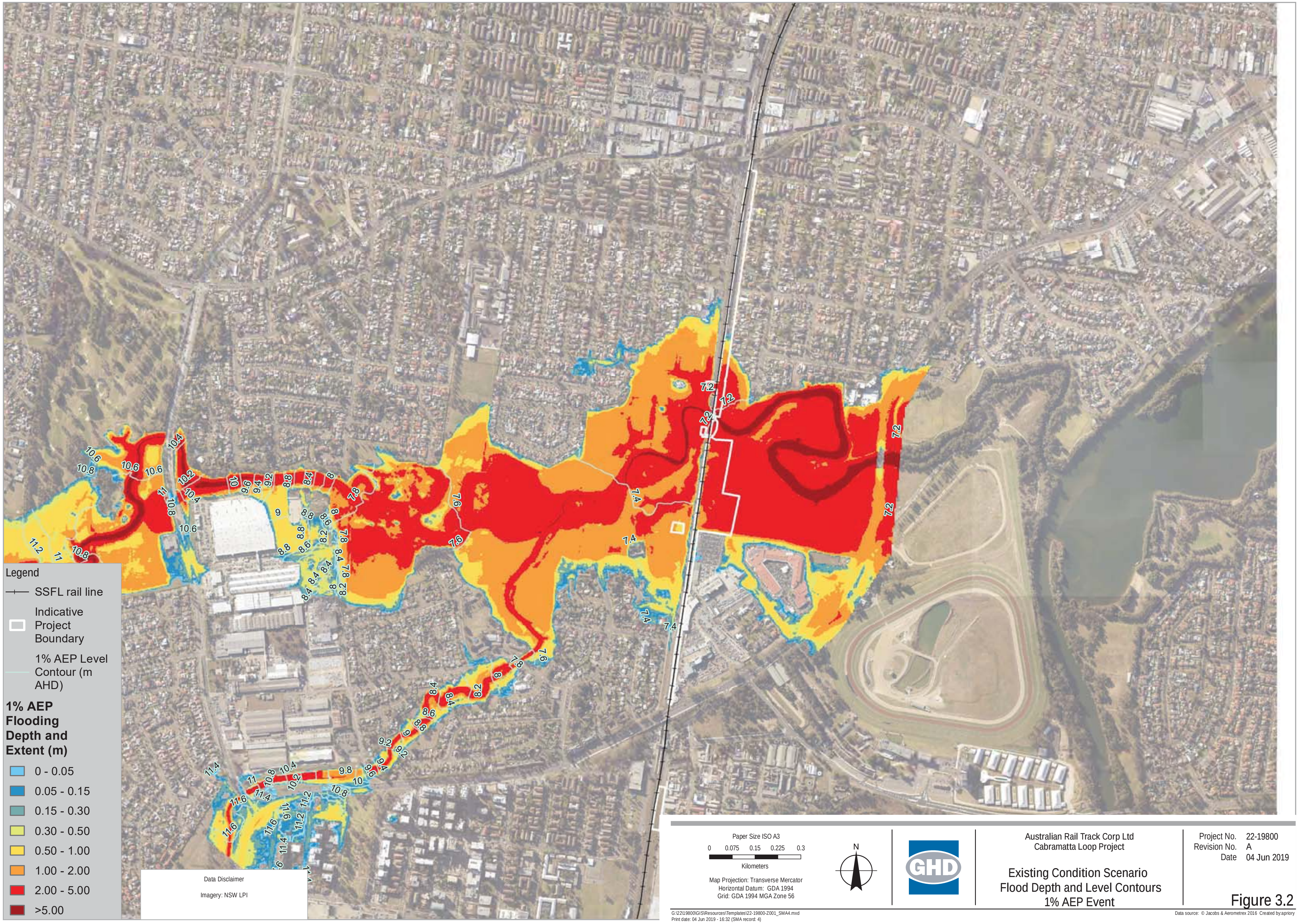
The project site from Cabramatta Road West overbridge to Hume Highway overbridge is affected by flooding from Cabramatta Creek during the 0.5 per cent AEP event and above. The majority of the construction site in the parkland is located within a high flood risk precinct.

Existing modelling in the Cabramatta Creek area has been undertaken considering the whole of catchment flooding upstream of the project site. From this modelling it is observed that in relation to the project site, specifically in Jacquie Osmond Reserve, the five per cent AEP event and one per cent AEP event existing condition flood level is about 6.2 m AHD and 7.2 m AHD respectively.

For the five per cent and one per cent event, houses on the following streets have existing flooding issues, these include houses are located closest to Cabramatta Creek and Brickmakers Creek:

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

Largely the rail corridor is unaffected except under rare to extreme rainfall conditions.



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Existing Condition Scenario
Flood Depth and Level Contours
1% AEP Event

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 3.2

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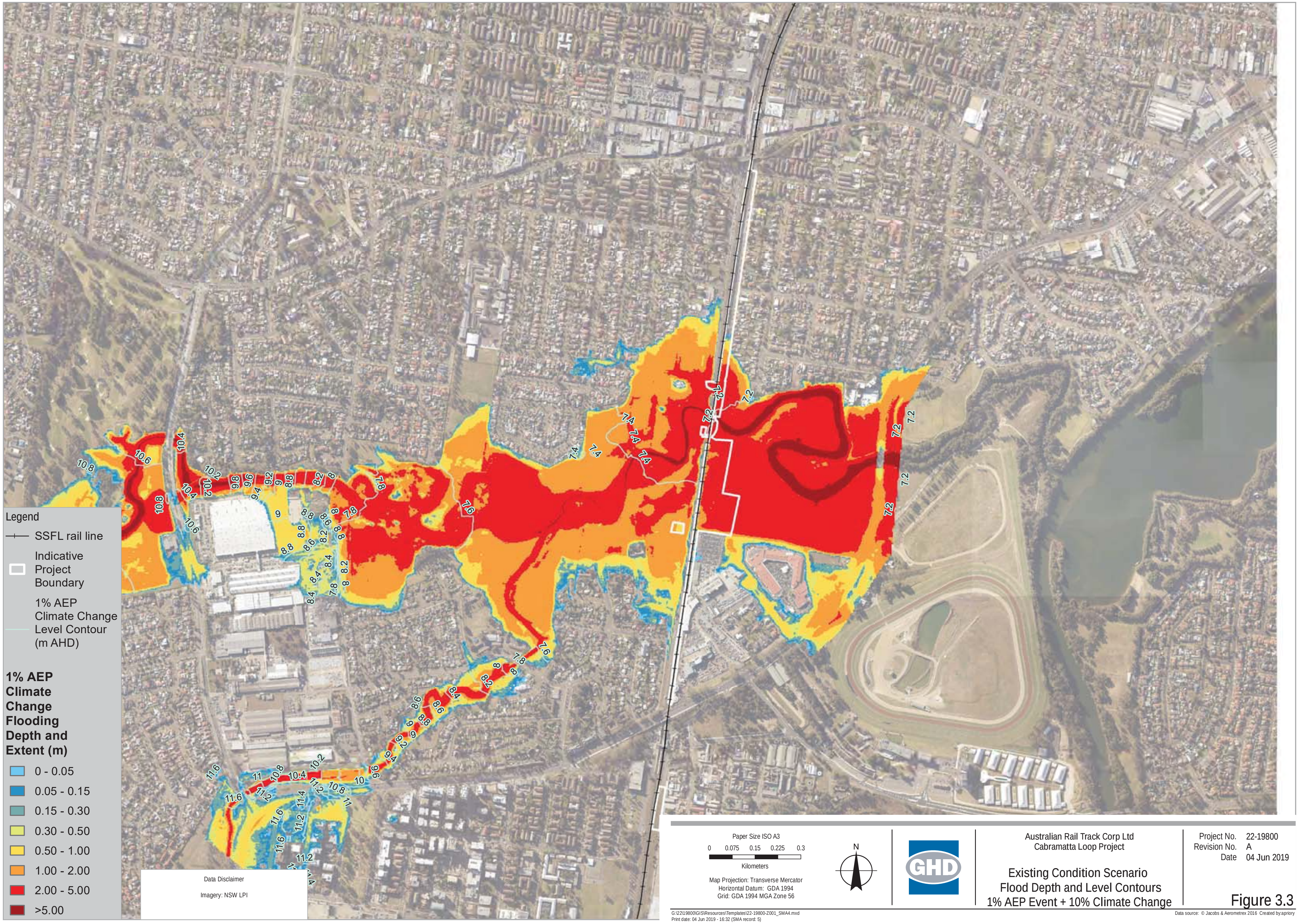
Legend
SSFL rail line
Indicative Project Boundary
1% AEP Climate Change Level Contour (m AHD)
1% AEP Climate Change Flooding Depth and Extent (m)
0 - 0.05
0.05 - 0.15
0.15 - 0.30
0.30 - 0.50
0.50 - 1.00
1.00 - 2.00
2.00 - 5.00
>5.00
Data Disclaimer
Imagery: NSW LPI
Paper Size ISO A3
0 0.075 0.15 0.225 0.3
Kilometers
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56
N
GHD
Australian Rail Track Corp Ltd
Cabramatta Loop Project
Existing Condition Scenario
Flood Depth and Level Contours
1% AEP Event + 10% Climate Change
Project No. 22-19800
Revision No. A
Date 04 Jun 2019
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Print date: 04 Jun 2019 - 16:32 (SMA record: 5)
Data source: © Jacobs & Aerometrex 2016 Created by:apriory

Figure 3.3

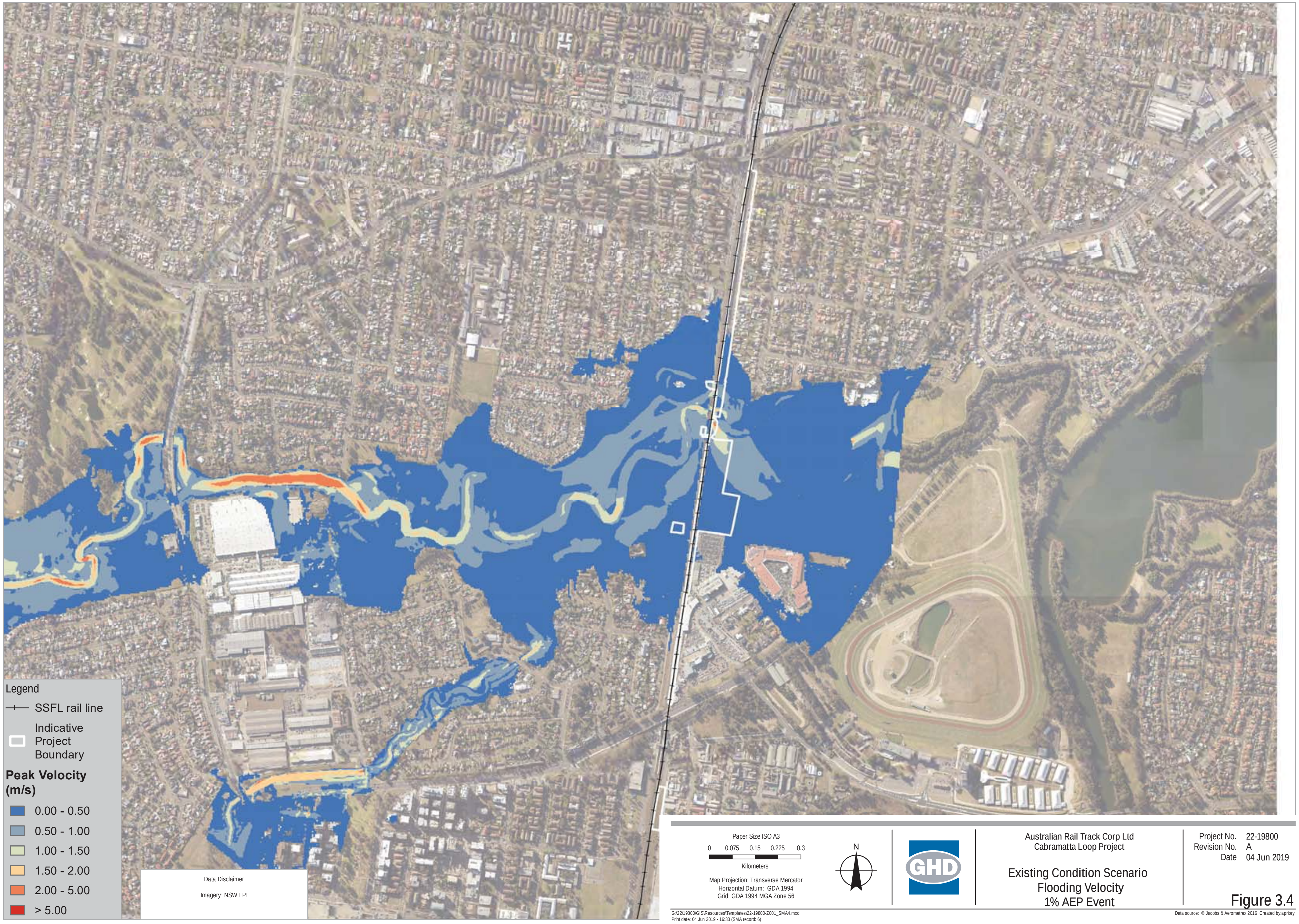

Figure 3.4

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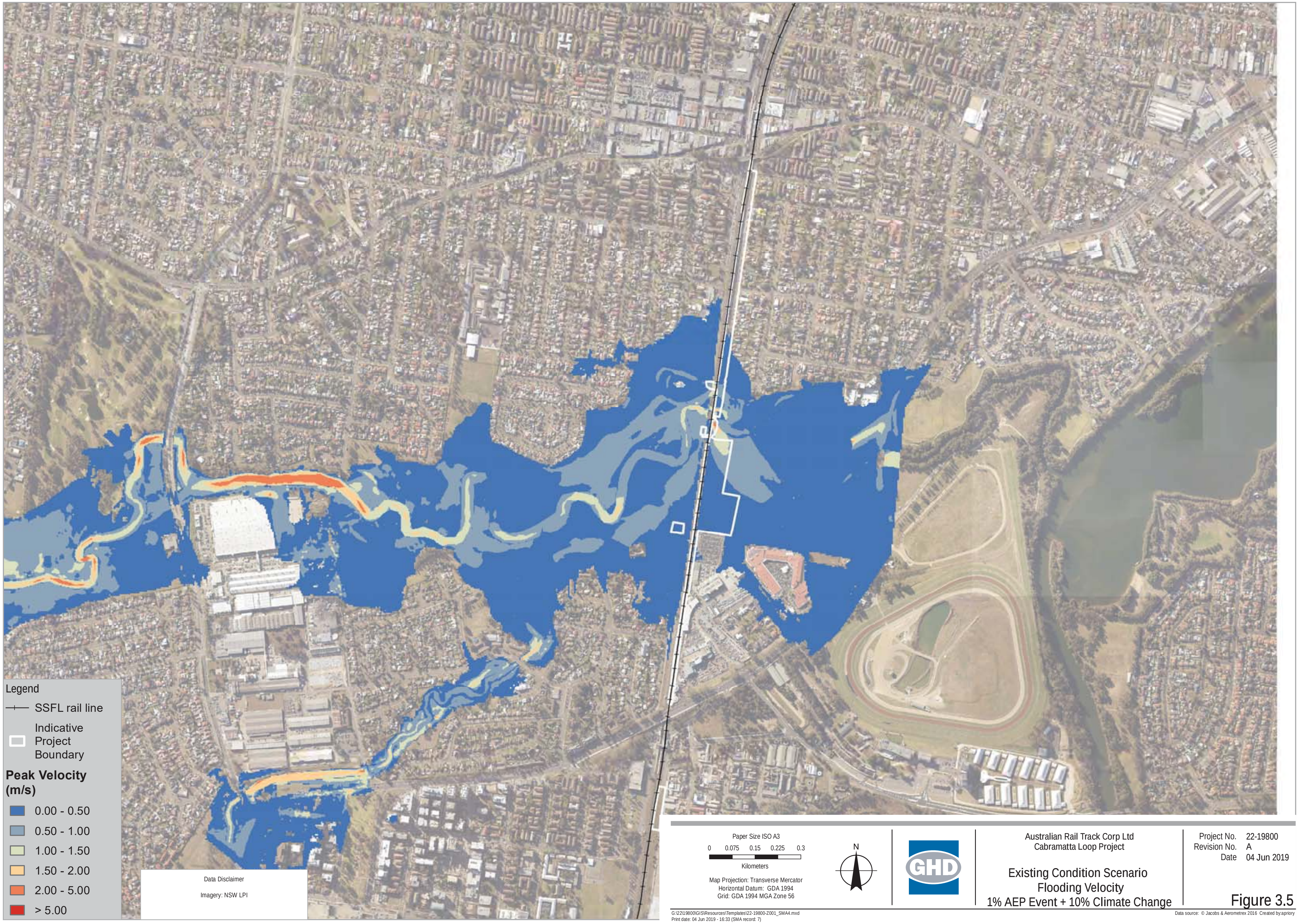
Data source: © Jacobs & Aerometrex 2016 Created by:apriory



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Existing Condition Scenario
Flooding Velocity
1% AEP Event + 10% Climate Change

Project No.	22-19800
Revision No.	A
Date	04 Jun 2019

Figure 3.5

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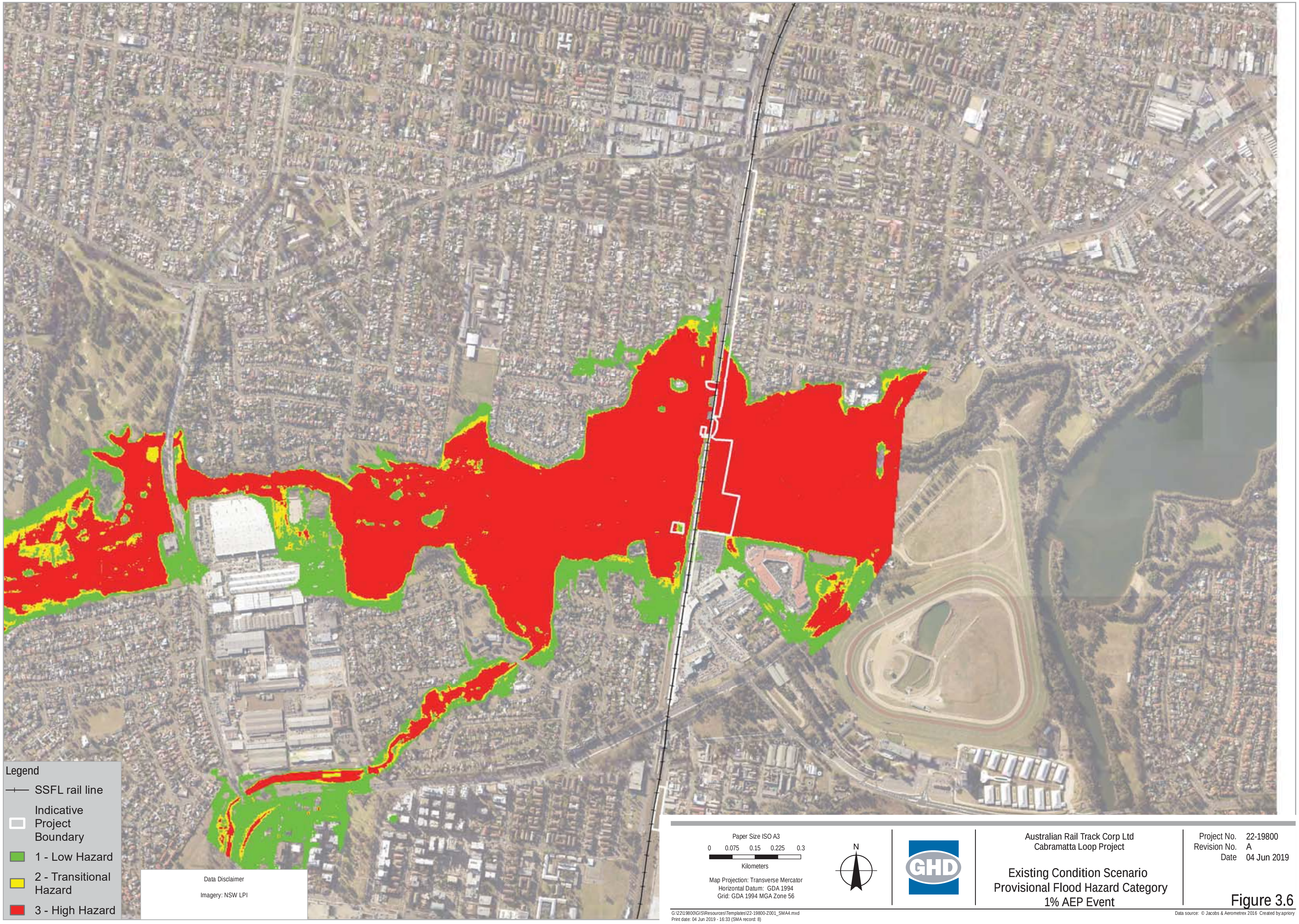

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Existing Condition Scenario
Provisional Flood Hazard Category
1% AEP Event

Figure 3.6

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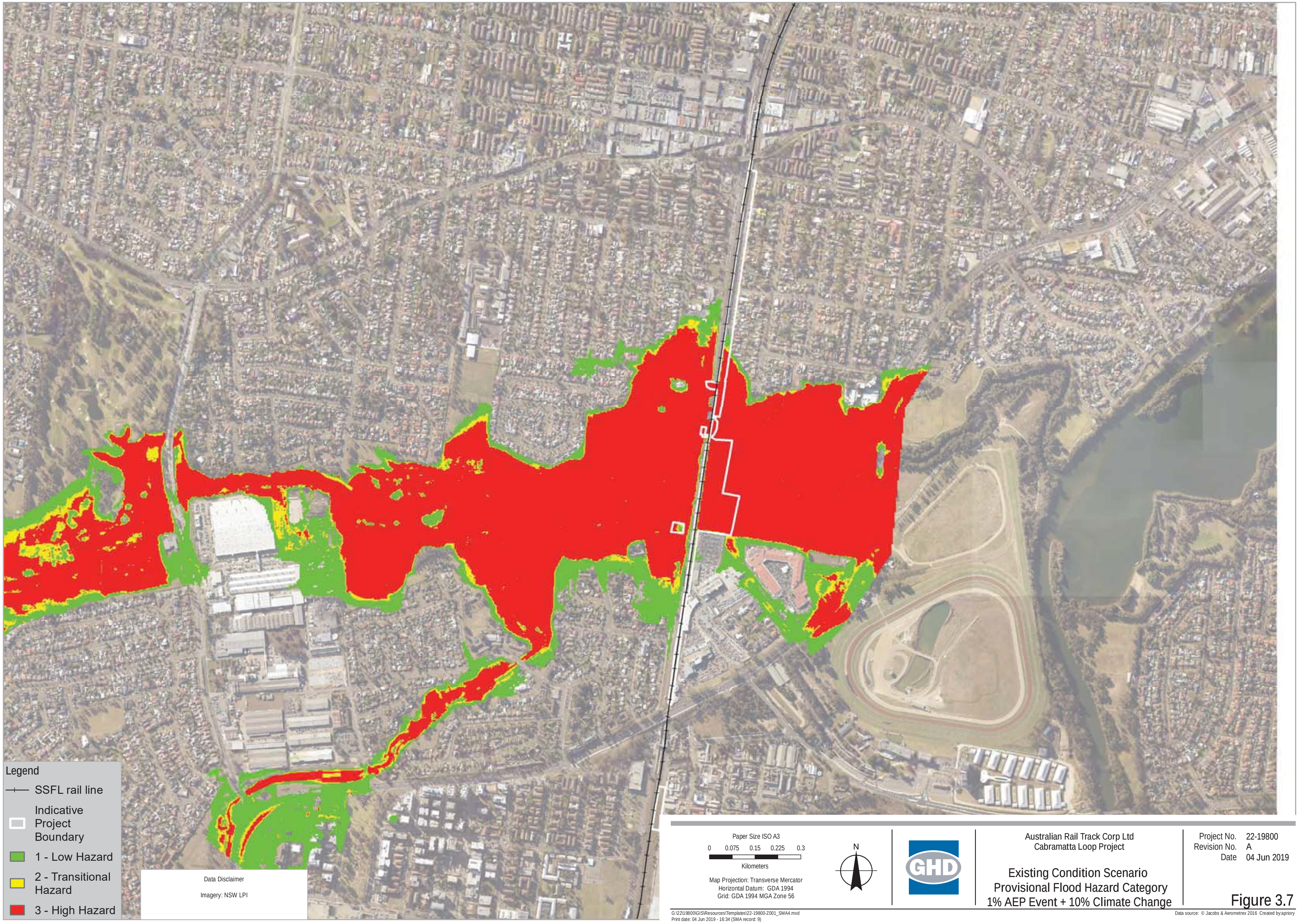
Data source: © Jacobs & Aerometrex 2016 Created by:apriory



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Existing Condition Scenario
Provisional Flood Hazard Category
1% AEP Event + 10% Climate Change

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 3.7

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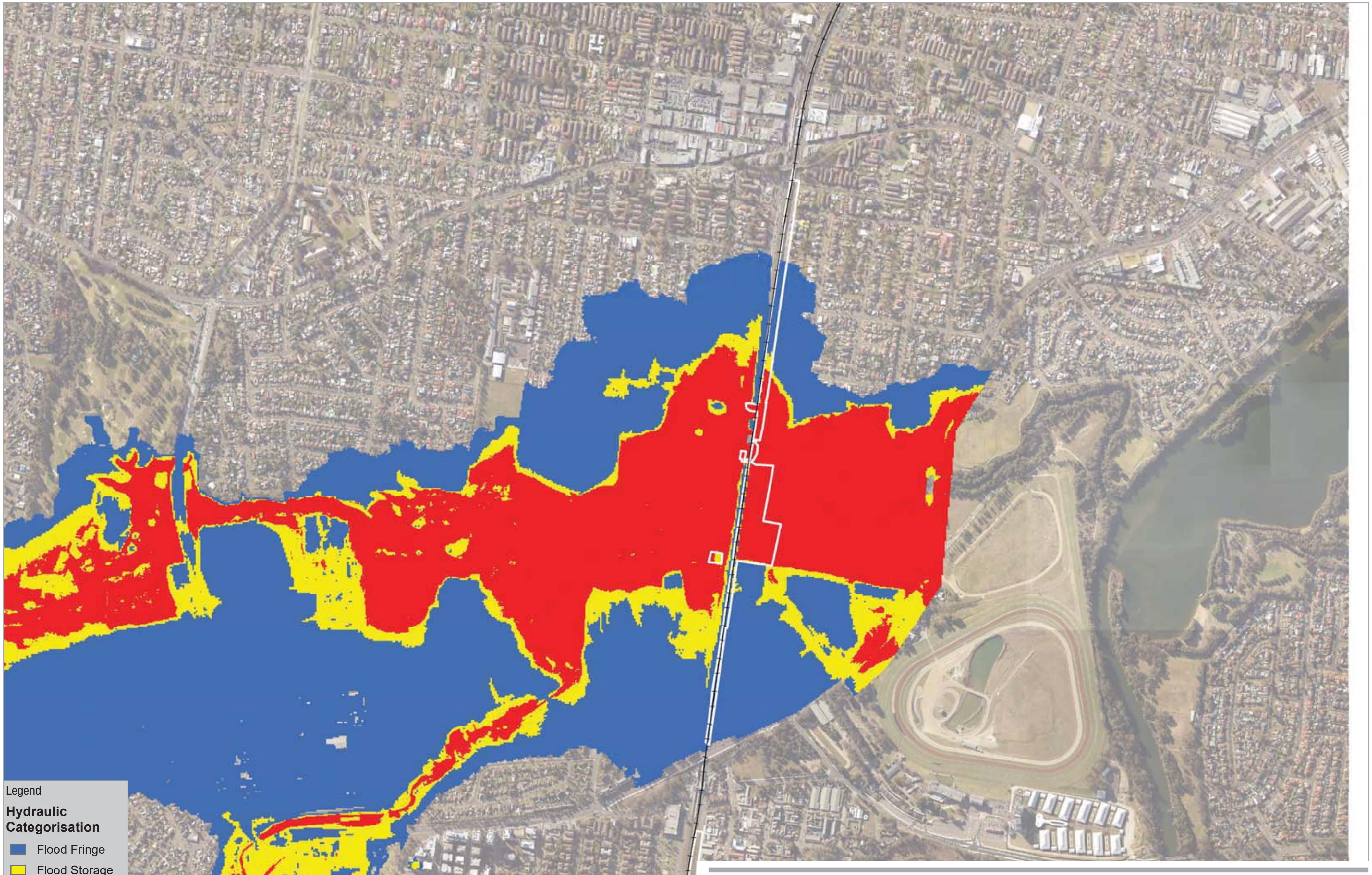
Data source: © Jacobs & Aerometrex 2016 Created by:apriory



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Existing Condition Scenario
Hydraulic Categorisation

Figure 3.8

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Print date: 04 Jun 2019 - 16:34 (SMA record: 10)

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3.4.4 Ongoing Flood Risk Management

Georges River catchment

The Georges River Floodplain Risk Management Study and Plan (Bewsher, 2004) discussed a number of potential floodplain management measures. However, no specific measures were recommended or incorporated within the project site from this study

Cabramatta Creek

The Cabramatta Creek Flood Study and Plan (Bewsher, 2004) discussed a number of potential floodplain management measures. However, no specific measures were recommended or incorporated within the project site from this study.

3.4.5 Emergency Management

The applicable emergency management plan for the study area is the South West Metropolitan Emergency Management District Disaster Plan (NSW Government, 2012). Through this plan the assigned contractor along with relevant authorities will prepare site evacuation plans to assist in the event of a flood and should consist of procedures to notify relevant authorities about site safety issues.

Local Flood Plans (LFP) are subordinate plans of the Local Disaster Plan. LFPs outline the roles and responsibilities for the NSW State Emergency Service (SES) and other agencies during flood events in relation to flood preparation, management and recovery. There is a local flood plan for the Georges River developed by NSW SES (NSW Government, 2018) and is applicable to this area as the plan covers the study area along with the wider catchment and discusses NSW SES plans for the area in the event of an emergency.

Flood emergency management during extreme weather is managed currently under ARTC procedure OPE-PR-014 Monitoring and Responding to Extreme Weather Events.

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4. Proposed works impacting hydrology and flooding

4.1 Design Criteria

As no detailed design criteria relating to flooding and drainage has been made available for this project, the adopted approach took the criteria used on similar urban rail infrastructure projects recently and is summarised in Table 4.1, Table 4.2 and Table 4.3. This flooding criteria has been adopted based on current practices for similar infrastructure projects in an urban setting and aims to minimise impacts on surrounding properties, taking into consideration the current flood affectation of that property.

Table 4.1 Minimum flood immunity

Infrastructure	Minimum flood immunity	Comment
Above-ground track	One per cent AEP climate change event *	For mainstream flood when measured to track formation at the edge of ballast

* Note: A 10 per cent increase in rainfall intensity above the one per cent AEP rainfall intensity has been included to make allowance for the future effects of climate change.

Adopted design criteria for the proposed drainage system are summarised in Table 4.2. Proposed design criteria in relation to flood impacts are provided in Table 4.3.

Table 4.2 Drainage system design criteria

Infrastructure	Design Criteria	Comment
Track drainage	Capacity up to one per cent AEP climate change event where subject to overland flooding Two per cent AEP + 10 per cent increase in rainfall intensity elsewhere	The existing track immunity is relatively high
	No net increase in discharge rates to downstream systems for all events up to and including the one per cent AEP event	On-site detention to be provided as required
On-site detention basin spillways	Designed to provide controlled discharge flows for events up to and including the one per cent AEP climate change event	N/A
Stormwater outlets	Prevention of scour up to 2 per cent AEP + 10 per cent increase in rainfall intensity	Impacts to be checked and mitigated against for events up to the 1 per cent AEP climate change event
Stormwater inlets	Allowance in design for partial blockage	Industry practice to be adopted

Table 4.3 Design criteria for flood impacts on adjoining lands

Flooding Characteristic	Proposed criteria for flooding on adjoining lands
Duration of flooding	Maximum increase in time of inundation of one hour in a 1 per cent AEP event.
Maximum increase in flood level at properties where floor levels are already exceeded in a 1 per cent AEP event	10 mm
Maximum increase in flood level at properties where floor levels are not exceeded in a 1 per cent AEP event	50 mm
Increase in flood velocities	Identification of measures to be implemented to minimise scour and dissipate energy at locations where flood velocities are predicted to increase.

Note: Of the above criteria, only increases in flood levels and velocities have been modelled at this stage.

4.2 Drainage infrastructure

Proposed changes to drainage infrastructure at key locations are discussed below. Numerous other amendments to track drainage and cross drainage are proposed and are discussed in section 7. In general, changes to existing drainage infrastructure in the project site would be undertaken to:

- duplicate bridges crossing Cabramatta Creek and Sussex Street adjacent to the existing SSFL
- widen embankment adjacent to existing SSFL to accommodate the passing loop
- replace assets in poor condition if any
- revise existing track drainage to cater for additional and re-aligned track and improve existing capacity issues (if any exist).

Broomfield Street

Proposed changes to the drainage infrastructure along Broomfield Street entails the re-alignment of the existing stormwater along Broomfield Street, discharging to Cabramatta Creek. The re-alignment is required to accommodate a new retaining wall and the realigned Broomfield Street to be constructed at the location of the existing pipe. The following is required:

- Re-align the stormwater drainage pipe along the kerb of the realigned Broomfield Street. Pipe diameters generally match existing pipe diameters, with the pipe diameter increasing from 1200 mm to 2/750 mm diameter pipes at the Sussex Street intersection with Broomfield Street. This size continues to the outlet headwall at Cabramatta Creek.
- New pits along the kerb and channel of the proposed realigned Broomfield Street.

4.3 Construction

Construction of the project would commence once all necessary approvals are obtained, and the detailed design is complete.

4.3.1 Pre-construction works

During the early stages of construction, various preparatory works would be undertaken such as site establishment works and construction access provision. Early stage works would also include:

- installation of environmental controls, including sediment and erosion controls

- stormwater drainage channel protection and diversion works
- any necessary flood mitigation measures to manage changes to overland flows as a result of this project.

4.3.2 Construction and maintenance access

Construction compounds and worksites would be located both within the rail corridor and in external locations. Currently the compounds are targeted to be located at three locations across the project site, the largest being at on the western side of Jacquie Osmond Reserve. There are also a number of other sites where construction activities would be undertaken, or where support would be provided for other construction areas.

Construction access to the Cabramatta Loop rail corridor would be carefully controlled and co-ordinated to minimise disturbance and inconvenience to landholders. Access to the project site would be via the access track adjacent to the rail corridor and Lawrence Hargrave School, Warwick Farm commencing off Station Street. Further detail on construction access is provided in Technical Report 1 – Traffic, transport and parking impact assessment.

Any new access along the corridor would be formed and stabilised. Where access crosses drainage flow paths, drainage culverts of adequate capacity would be provided across the access track to keep vehicle tyres out of the water whilst facilitating drainage.

4.3.3 Construction compounds and worksites

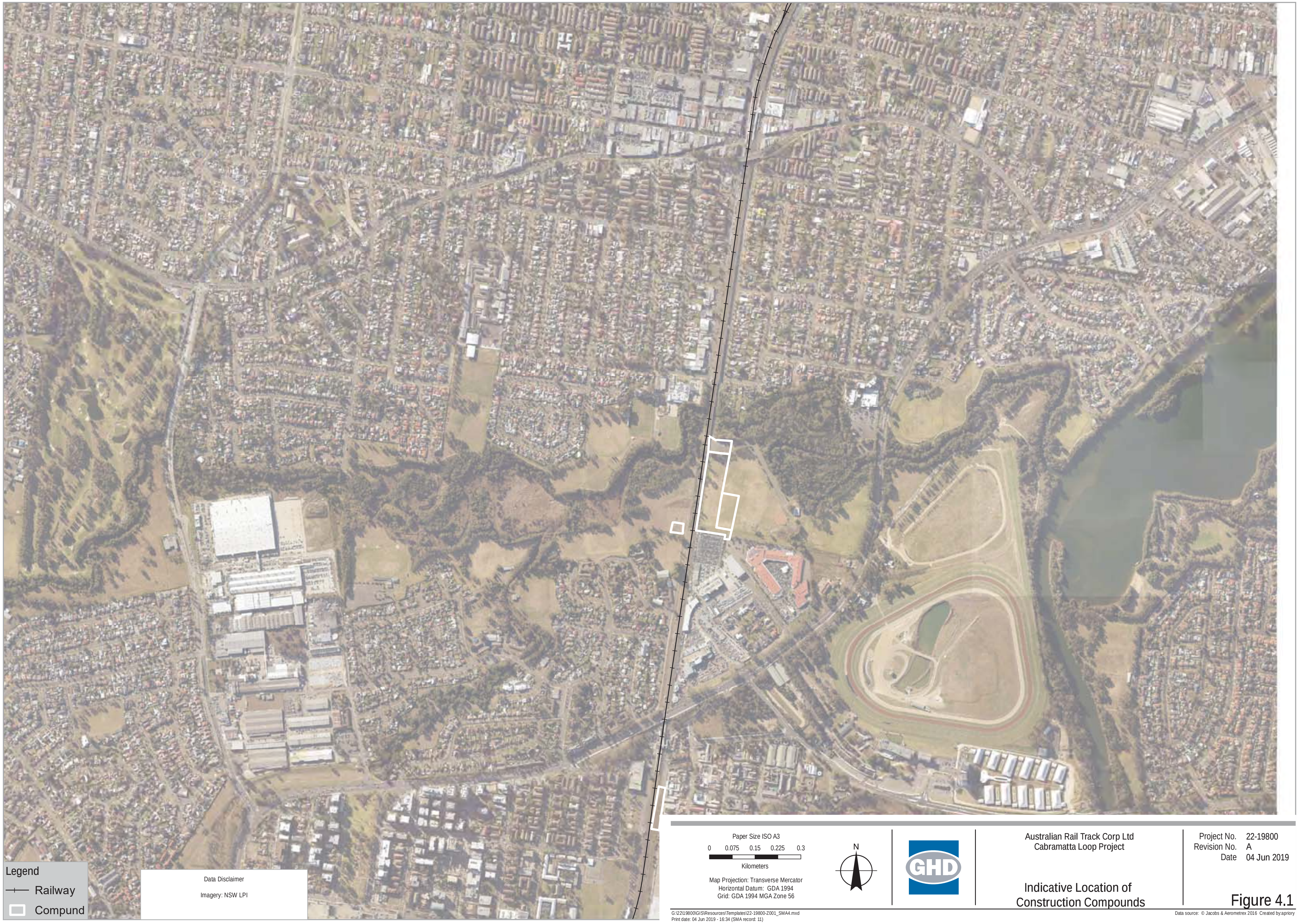
Construction compounds and worksites would be located both within the rail corridor and in external locations (ie. Jacquie Osmond Reserve). They would be located:

- at least 50 metres from watercourses or major drainage structures unless a detailed site specific erosion and sediment control plan is implemented
- above the five per cent AEP flood level (one in 20 year ARI flood level) where possible. It should be noted that much of Jacquie Osmond Reserve is high risk flood precinct.

Indicative locations for the construction compounds are shown in Figure 4.1. Some of these are within areas identified as existing flood hazard areas. Worksite information and potential construction stage impacts resulting from these are discussed in section 7.1. Should the construction contractor identify a need for additional sites, these will be included in the Construction Environmental Management Plan (CEMP) or relevant subplan.

4.3.4 Stockpiles

Stockpiles of raw materials or spoil are targeted to be located adjacent to the existing SSFL in Jacquie Osmond Reserve, it is expected this area will be hoarded off and stockpile materials managed within the hoarded area. These stockpiles should permit drainage away from the track to reduce potential flooding impacts.



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Indicative Location of
Construction Compounds

Figure 4.1

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Data source: © Jacobs & Aerometrex 2016 Created by:apriory

5. Construction impacts

5.1 Flood risk assessments

An assessment of the potential impacts and measures to avoid, mitigate or minimise them during the construction phase is provided in Table 5.1. The risks and impacts listed are discussed in the following sections.

Table 5.1 Potential construction risks and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate and minimise impacts
Hydrologic		
Impact on surface water flow in watercourses	• Changed surface flow paths across the project site due to the presence of site compounds/stockpiles etc.	• Install drainage works prior to or concurrent with site compound set-up and/or stockpiling.
Hydraulic issues		
Impact of widening the rail corridor	• Additional impacts downstream of structures	• Install drainage works prior to or concurrent with rail formation construction to minimise potential adverse impacts
Working in the floodplain or flood prone areas	• Impact to construction workers working on flood prone land	• Locate construction compounds outside flooded areas, where practicable. • Locate stockpiles where they do not impact flow paths and patterns, where possible • Prepare wet weather working and construction flood management plans.

5.1.1 Impact of surface flow paths across the rail corridor

Surface flow paths across the rail corridor have the potential to:

- impact on the flood immunity of the track, where the track passes through existing overland flow paths. Increases in the duration of inundation, flood levels, and flood extents may impact on the safety and operations of the freight line where design criteria and thresholds are exceeded.
- result in changes in flow patterns, which may lead to undesired downstream flood impacts.

The proposed location of the construction compounds within the five per cent AEP flood extent means that there is a five per cent (or greater) chance that these compounds would be flooded in any year.

Due to the generally small sizes of these construction compounds, relative to the size of the floodplain, it is considered that any associated impacts are likely to be minimal. These minimal impacts may include change in overland flow paths and change in flood level, depth and velocity.

Options to relocate these compounds and careful planning of compound layouts and management and planning of construction activities, have been considered. However, constraints exist within the project area relating to proximity of the site as well as the extent of the floodplain within the proposed construction area.

Construction compound locations adjacent to creeks or within floodplains need to duly consider the flood risk during the construction period.

5.1.2 Impact of widening the rail corridor

Widening the rail corridor could create several potential impacts during construction:

- increase the upstream flood level and flood extent as a result of the increase in obstructions in the flow path due to additional bridge piers and construction methods used to construct the piers
- increase in flood level and flood extent as a result of the additional embankment fill and storage of materials within the floodplain which will remove flood storage areas from the floodplain during larger flooding events.

5.1.3 Impact of stockpile materials in or near floodplain areas

Stockpiling material in or near the floodplain could create potential impacts including:

- losing floodplain storage areas potentially leading to increases in flood level and extent beyond the rail corridor boundary
- movement of the stockpile material and deposition of material in downstream waterways potentially creating a change to the flooding characteristics of downstream waterway/s.

Stockpiled material would be located in site compounds. Therefore the greatest potential for the above impacts to occur would be when stockpiles are located in the compound in Jacquie Osmond Reserve (C3) during heavy rainfall or flooding events. The implementation of the mitigation measures provided in section 7.1, including limiting the duration of time stockpiles remain in place at compound C3 and planning works to consider the upcoming weather forecast, would minimise the potential for these impacts.

5.2 Flooding and drainage outcomes

The following potential impacts on stormwater quantity and flooding are expected. A soil and water management plan (SWMP) would be required for the project site generally, with site-specific plans required at construction compounds and major worksites to manage and reduce the risk of flooding and drainage impacts associated with the works.

5.2.1 Works in the floodplain

Predicted flood extent information is available for Cabramatta Creek. The main construction area (see Figure 4.1) in Jacquie Osmond Reserve is almost wholly indicated to be within the floodplain.

Obstruction of flow paths due to the presence of construction works has the potential to:

- redistribute flood flows and impact downstream development
- mobilise construction equipment or debris and cause downstream safety or water quality impacts.

The proposed location of the construction compounds within Jacquie Osmond Reserve within the five per cent AEP flood extents means that there is a five per cent chance that these compounds and work areas would be flooded in any year.

Due to the generally small sizes of these construction compounds, relative to the size of the floodplain, it is considered that any associated impacts are likely to be minimal.

Construction compound locations adjacent to creeks or within floodplains need to duly consider the flood risk during the construction period.

5.2.2 Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

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

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

This could result in localised modifications to existing flooding patterns, flow volumes, and velocities.

Temporary diversions would be required to divert surface water runoff around construction work sites. This may involve excavations and embankments, which would alter localised flow patterns. These changes would be temporary, specific to a certain activity in a particular location and limited to the construction phase of that activity. The landform would generally be restored to the pre-works condition following construction.

Construction would result in a small increase in impervious areas such as the extent of the railway corridor and at the project site, adjacent to Broomfield Street, which would have the potential to increase the volume of water flowing to watercourses. As well construction compounds and material lay down areas could contribute to this impacts as well. However, the change in impervious area would be negligible compared to the overall catchment area.

Any flood impacts during construction are expected to be localised and relatively minor, and would be managed by implementing the measures provided in section 7.1. This would include, wherever possible, implementation of replacement drainage in advance of any disconnections or diversions (refer to section 7.1).

The locations of work areas and compounds within designated flood hazard areas would not result in flood affectation of other properties, assets and infrastructure.

5.2.3 Consistency with Council floodplain risk management plans

Relevant plans produced by Liverpool City Council and Fairfield City Council (Bewsher, 2004) are described in section 3.4. Construction of this project would not prevent or compromise the proposed works outlined in this document if not already undertaken. Construction works are therefore considered to not impact or interact with Council's floodplain risk management plans.

5.2.4 Compatibility with the flood hazard of the land

Some construction activities, work sites and compounds would be located in areas where there is an existing flood hazard. However, due to the generally small sizes of compounds and work sites relative to the size of the floodplain, minimal impacts on flood hazard would result.

5.2.5 Downstream velocity and scour potential

There is the potential for temporary drainage works to impact overland flow paths during construction. This could divert or concentrate flows, potentially resulting in the scouring of downstream areas, particularly where soil has been exposed during construction. Construction contractor should apply construction soil and erosion control best-practice in managing the site. This impact should be mitigated in accordance with the Blue Book (DECC, 2008).

5.2.6 Revision of existing emergency management

With the implementation of mitigation measures provided in section 7.1, impacts on existing emergency management arrangements are expected to be minimal during construction. Ongoing liaison with NSW SES in relation to their South West Metropolitan Emergency Management District Disaster Plan (NSW Government, 2012) should be undertaken. Consideration to ARTC's procedure OPE-PR-014 Monitoring and Responding to Extreme Weather Events and the LFP for the Georges River (NSW SES, 2018) should be given also.

As well relevant stakeholder consultation would be undertaken during detailed design and the construction period to achieve this.

5.3 Cumulative impacts

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

There is a minor development proposal current for a multi-storey residential development on the corner of Broomfield Street and Cabramatta Road East. This proposal could potentially have an impact on the study area given its location upstream of the project area with part of the site at the subject of this proposal within the same surface water catchment as the project. Given the existing nature of the site is urban development, this development would not be expected to have a large additional impact on flooding and hydrology in the area.

6. Operational impacts

6.1 Flood risk assessment

An assessment of the potential flooding risks, and measures to avoid, mitigate or minimise them during operation is provided in Table 6.1. The risks and impacts listed are discussed in the following sections.

Table 6.1 Potential impacts and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Hydrologic		
Impact on surface flow in watercourse and flows in channels / drainage structures	• Modified surface flow volume or rate downstream of the rail corridor	• Avoid installation of drainage elements that create localised surface water ponding • Provide detention basins prior to discharge to existing drainage network where an increase in drainage capacity is proposed
	• Changed surface flow paths across rail corridor	• Minimise regrading of terrain along the rail corridor • Install appropriately sized pipes/conveyance structures along the rail corridor
Hydraulic issues		
Impact of widening the rail corridor	• Increased upstream flooding depths, extents and hazard • Increased upstream flood durations • Increased upstream impacts on buildings • Increased impacts on adjacent infrastructure (e.g. road closures) • Additional impacts downstream of structures	• Construct any structural elements on downstream side of rail corridor
Impact of providing increased drainage capacity	• Increased downstream flooding depths, extents and hazard • Increased downstream flood durations and reduced emergency access • Increased downstream impacts on buildings • Increased impacts on adjacent infrastructure (e.g. road closures) • Increased downstream velocities and scour potential	• Provide detention basins prior to connection to existing external drainage systems • Do not reduce watercourse flow areas • Local scour protection works in unlined channels
Impact of filling / works in flood storage areas	• Increases in flood levels, or hazard • Changes in flow paths	• Avoid building in flood storage areas • Provide additional capacity/mitigation if required

6.1.1 Impact of modified surface flow volume or rate downstream of the rail corridor

Construction cut and fill volumes were taken into consideration during floodplain modelling. Based on the modelling undertaken there would be a loss of storage within the floodplain of approximately 690 metres cubed due to the addition of fill.

During operation, ongoing modification to flow volumes and rates downstream of the rail corridor could occur as a result of changes to the flow rate and/or duration of flow through stormwater drainage that is constructed for the project. This could create additional erosion either upstream or downstream of the stormwater drainage pipes or increased local flood potential where flow conditions are modified (see also below in section 6.1.2). It is expected that these changes are only minor and will not have significant impact. However, any existing rip rap that is impacted or removed during construction would be reinstated. This would include the provision of rip rap around the piers and abutments of Cabramatta Creek bridge.

6.1.2 Impact of widening the rail corridor

Widening the rail corridor could create several potential impacts including:

- increase the upstream flood level and flood extent as a result of the increase in obstructions in the flow path due to additional bridge piers proposed to be constructed
- increase in flood level and flood extent as a result of the additional embankment fill which will remove flood storage areas from the floodplain during larger flooding events
- change in velocity distribution predict through some of the floodplain, namely around Jacquie Osmond Reserve.

It is noted that the project has been designed so that the new rail formation would be above the one per cent AEP climate change event in order to meet the flood immunity criteria detailed above in Table 4.1.

6.1.3 Impact of providing increased drainage capacity / conveyance area

Increased pipe and/or drainage capacity would allow greater flows through the project site to the downstream areas with potential impacts including:

- increasing flow depths, durations and hazard downstream of the stormwater drainage pipes
- increased load on the downstream outlet location
- altered flow paths downstream where the capacity of the drainage into which the upgraded pipe network outlet is overwhelmed.

6.2 Hydrologic and hydraulic modelling results

The key hydrologic and hydraulic outcomes from the project in relation to flooding in the Cabramatta area are summarised in Table 6.2. Mapping of the expected change in flood level, velocity and flood hazard compared to existing conditions is provided on Figure 6.1 to Figure 6.6.

Table 6.2 Design performance against flooding criteria (Cabramatta Creek Flooding)

Key Criteria	Cabramatta Creek	Adjacent Lands	Public Roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No increase in flooding in the majority of the study area for one per cent AEP climate change event. 2) Where there is increase in flood level, increase is 11 mm or less up to the one per cent AEP climate change event 3) Floor level survey and detailed analysis required to assess above floor impacts at ±10 mm level.	1) No adjacent roads impacted in one per cent AEP climate change event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event	Floor level survey not available. Any potential flooding above-floor will be assessed during detailed design		
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Achieved		
Increase in flood velocities – identification of mitigation measures	A number of locations benefit from flood velocity decrease. Selected locations of velocity increases are generally <0.25 m/s for flood events up to one per cent AEP plus climate change event. Events in excess of this see some wider spread velocity increases but <0.35 m/s (also noted this is in a 0.2 per cent AEP event, a very rare to extremely rare flooding event).		

As shown on Figure 6.1 to Figure 6.6, the proposed modifications and addition to the bridges over Cabramatta Creek and Sussex Street would minimally impact the flooding of Cabramatta Creek for the full range of flood events from the five per cent AEP to the PMF event. Therefore there would be little adverse impact to the surrounding community.

Minimal increases in flooding are expected in the majority of the study area for the one per cent AEP plus climate change event. Most of the areas where increases are predicted are only up to 16-17 mm in flood events up to the 0.2 per cent AEP event. Impacts in the one per cent AEP event are negligible (less than 10 mm). In the PMF event, an extremely rare event, these impacts are more pronounced at around 75 mm. It should be noted that this is an extreme flooding event and in areas already significantly flooded where the rail formation is already predicted flooded by several metres depth.

Where increases in flood level are predicted, these are less than the 50 mm design criteria across the range of events up to the 0.2 per cent AEP. This means for the design criteria of one per cent AEP the flood level increase due to the Cabramatta Loop has a negligible impact and therefore achieves the criteria.

Similarly, increases in velocities are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event. Existing velocities in these locations are generally less than 2 m/s which is considered slow enough that any increases won't cause adverse impacts on surrounding environments.

As a result, no substantial changes in existing flood hazard are predicted with the constructed Cabramatta Loop in place. These impacts are considered acceptable given they achieve the design criteria described above and where larger impacts are expected, this is only in an extremely unlikely event in areas that are already impacted by a large flood.

Broomfield Street

The Broomfield Street works have been assessed using a separate hydraulic model developed in TUFLOW to design the flooding behaviour of the local drainage catchment in this area. The key hydrologic and hydraulic outcomes from the project in relation to flooding in this area are summarised below.

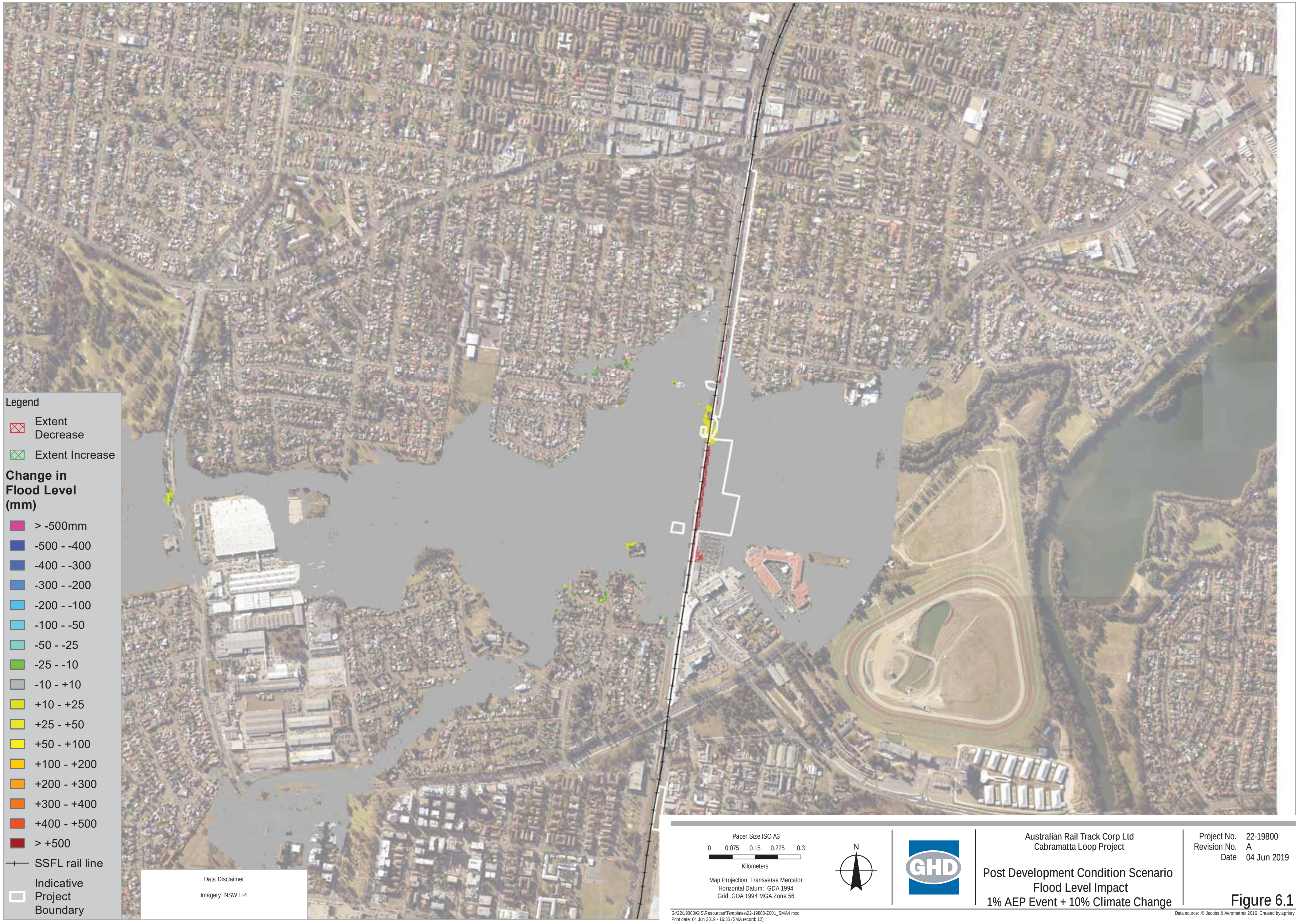
Table 6.3 Design performance for Broomfield Street upgrades against flooding criteria

Key Criteria	Broomfield Street	Public Roads
Maximum increase in time of inundation of one hour in a one per cent AEP event	Achieved	1) No adjacent roads impacted in one per cent AEP event
Maximum increase of 10 mm in flood level at properties where floor levels are already exceeded in a one per cent AEP event.	Detailed floor level survey not available. However based on available information, over floor flooding in a local 1 per cent AEP event is unlikely for dwellings along Broomfield Street. This is due to be confirmed during detailed design.	
Maximum increase of 50 mm in flood level at properties where floor levels are not exceeded in a one per cent AEP event	Increase beyond this criteria was noted at 8 properties along Broomfield Street. For 7 of the 8 properties, an increase of up to 58 mm is anticipated during a one per cent AEP event. That is an increase of up to 8mm greater than the proposed criteria. One of the 8 properties is likely to experience an increase in flood level of up to 175 mm. This is an increase of 125mm above the proposed criteria. The model shows this being confined to a small area (about 20 square metres) in the front yard. For 6 of the 8 properties (including the one noted above), this increase in flood level during the one per cent AEP event would be confined to the front yard and away from the dwelling. At the remaining 2 properties, the impact would be closer to the front of the property. Both dwellings are high set, and based on existing information, considered unlikely to experience over floor flooding. This is due to be confirmed during detailed design.	

Key Criteria	Broomfield Street	Public Roads
Increase in flood velocities – identification of mitigation measures	A number of locations benefit from flood velocity decrease. Selected locations of velocity increases are generally <0.25 m/s for flood events up to one per cent AEP event.	

The model used to assess the flooding impact on Broomfield Street was simulated for the 10 per cent and five per cent AEP events in addition to the one per cent event. The results for the one per cent AEP event are the most impactful in terms of both flood level and flooding velocities. No adverse impacts were noted in the other events above the design criteria.

For full discussion on the Broomfield Street local flood assessment, including flood maps, see Appendix D.



Australian Rail Track Corp Ltd
Cabramatta Loop Project

Post Development Condition Scenario
Flood Level Impact
1% AEP Event + 10% Climate Change

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 6.1

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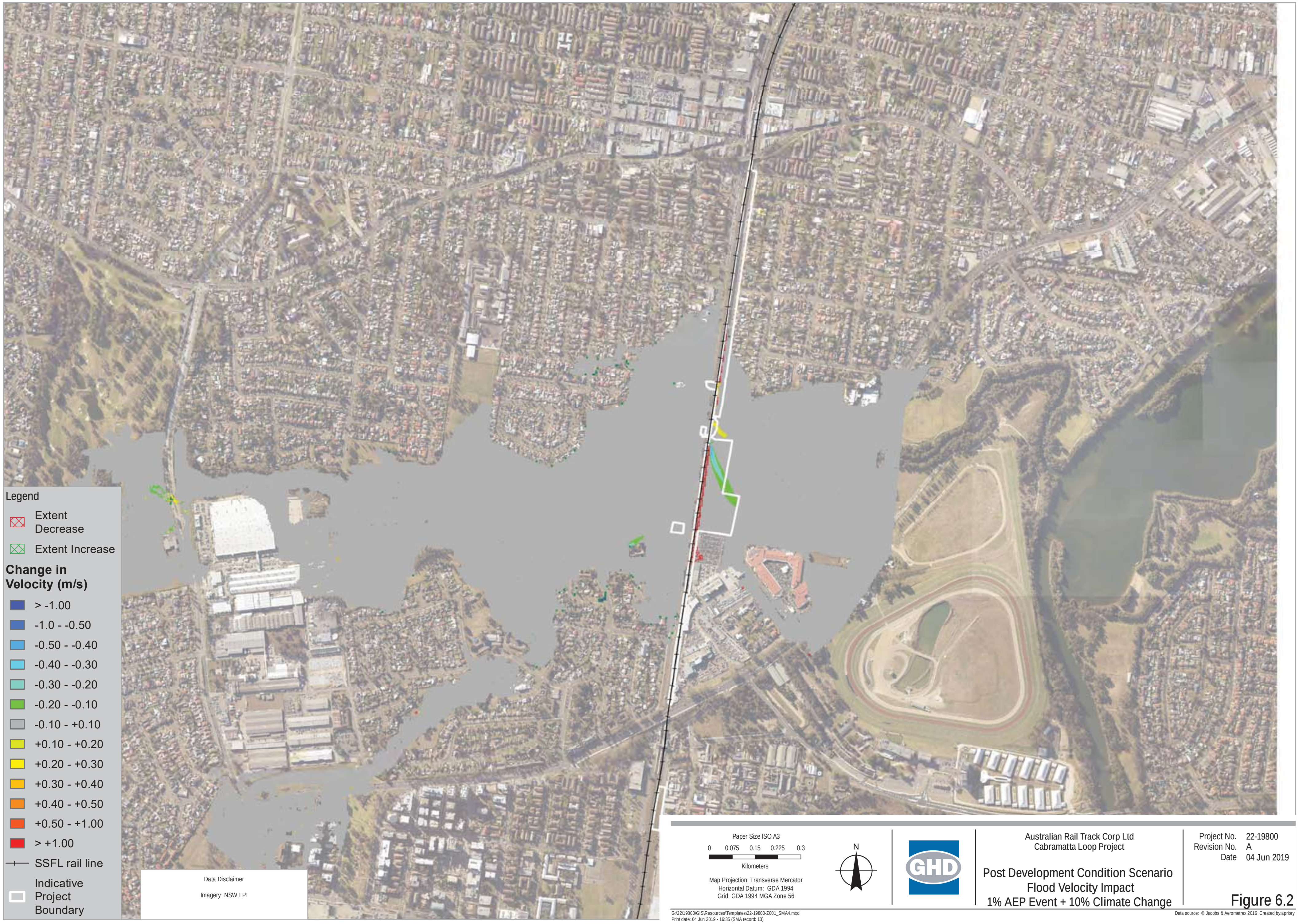

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Post Development Condition Scenario
Flood Velocity Impact
1% AEP Event + 10% Climate Change

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 6.2

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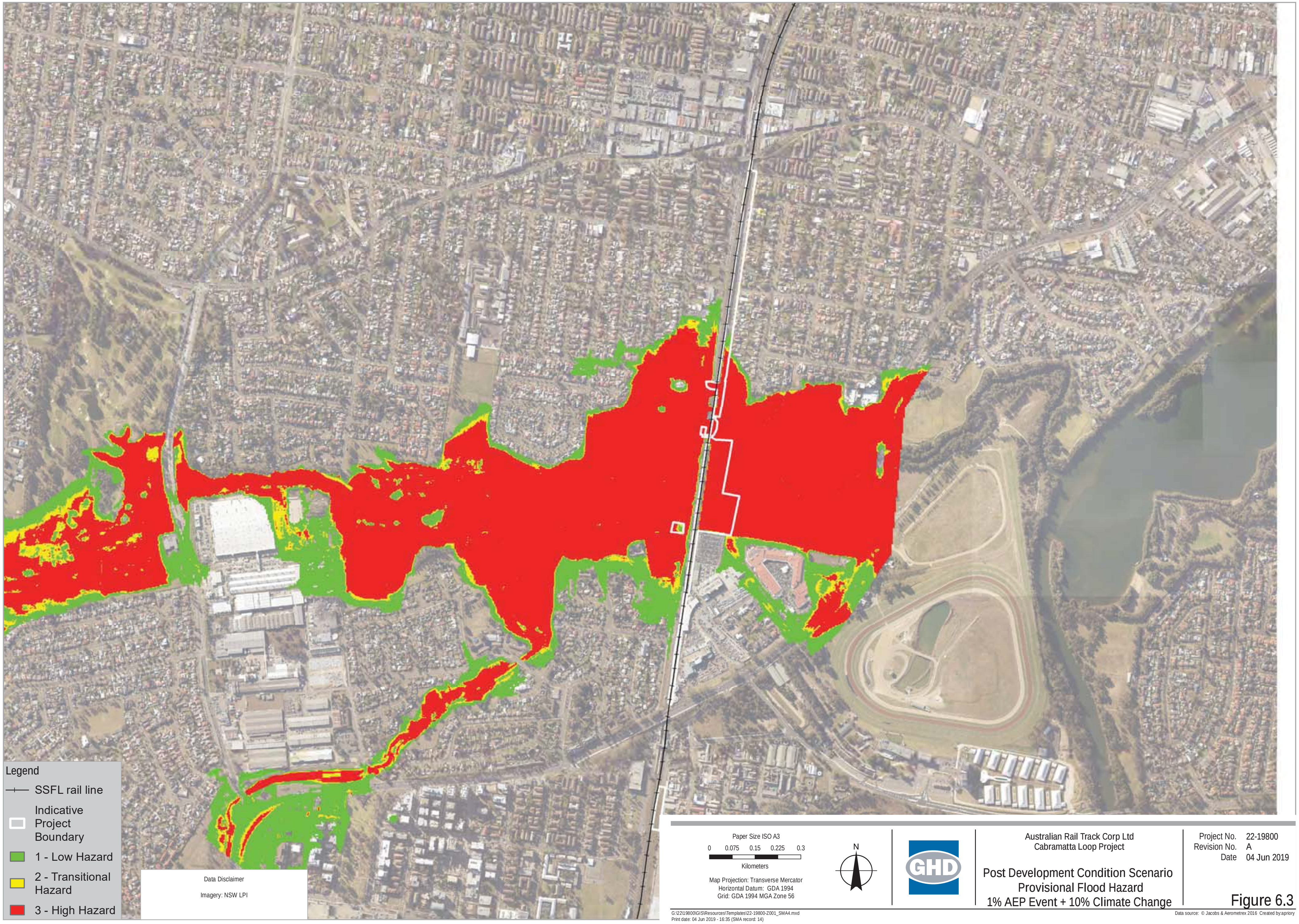

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Post Development Condition Scenario
Provisional Flood Hazard
1% AEP Event + 10% Climate Change

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 6.3

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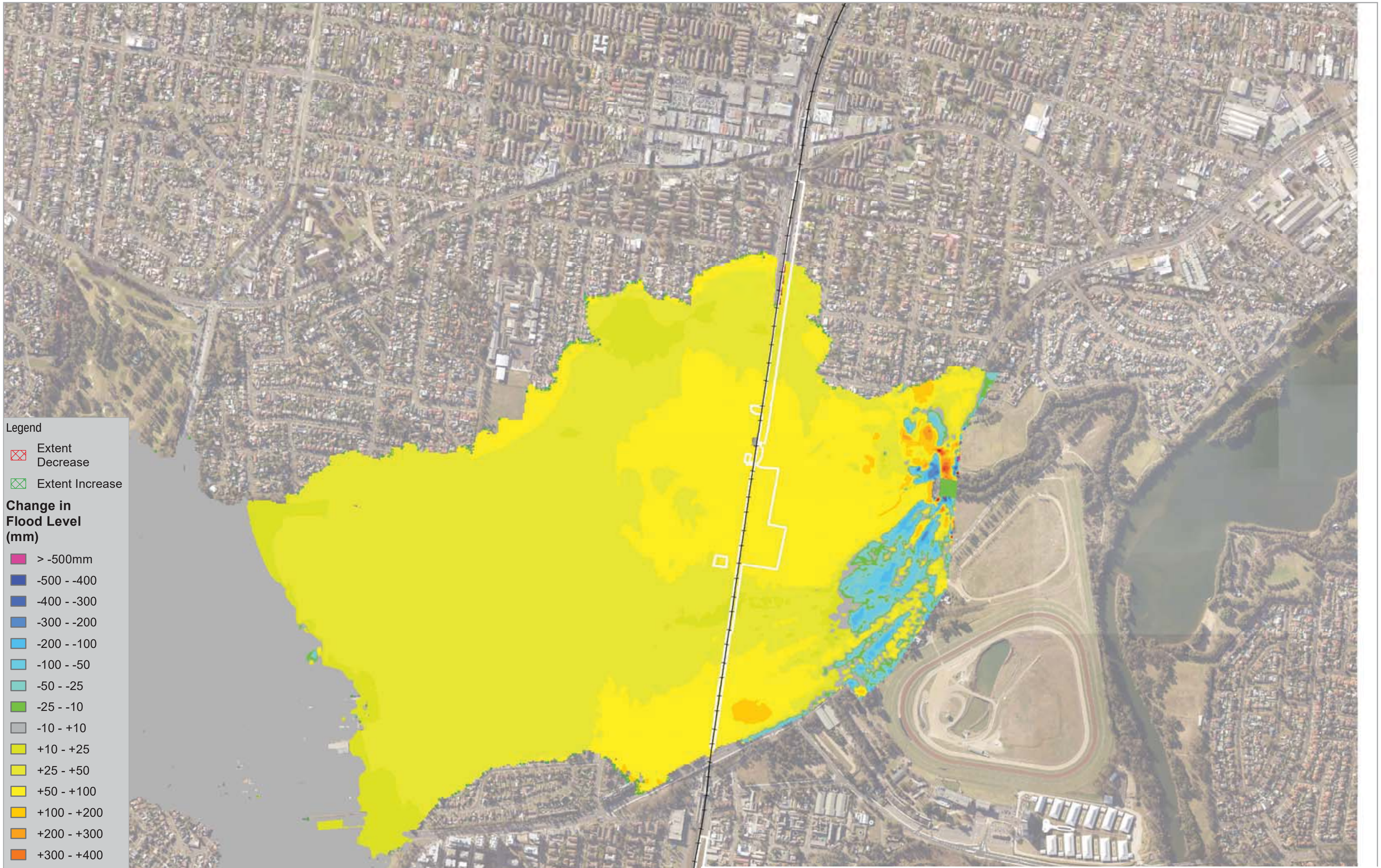

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Post Development Condition Scenario
Flood Level Impact
PMF Event

Figure 6.4

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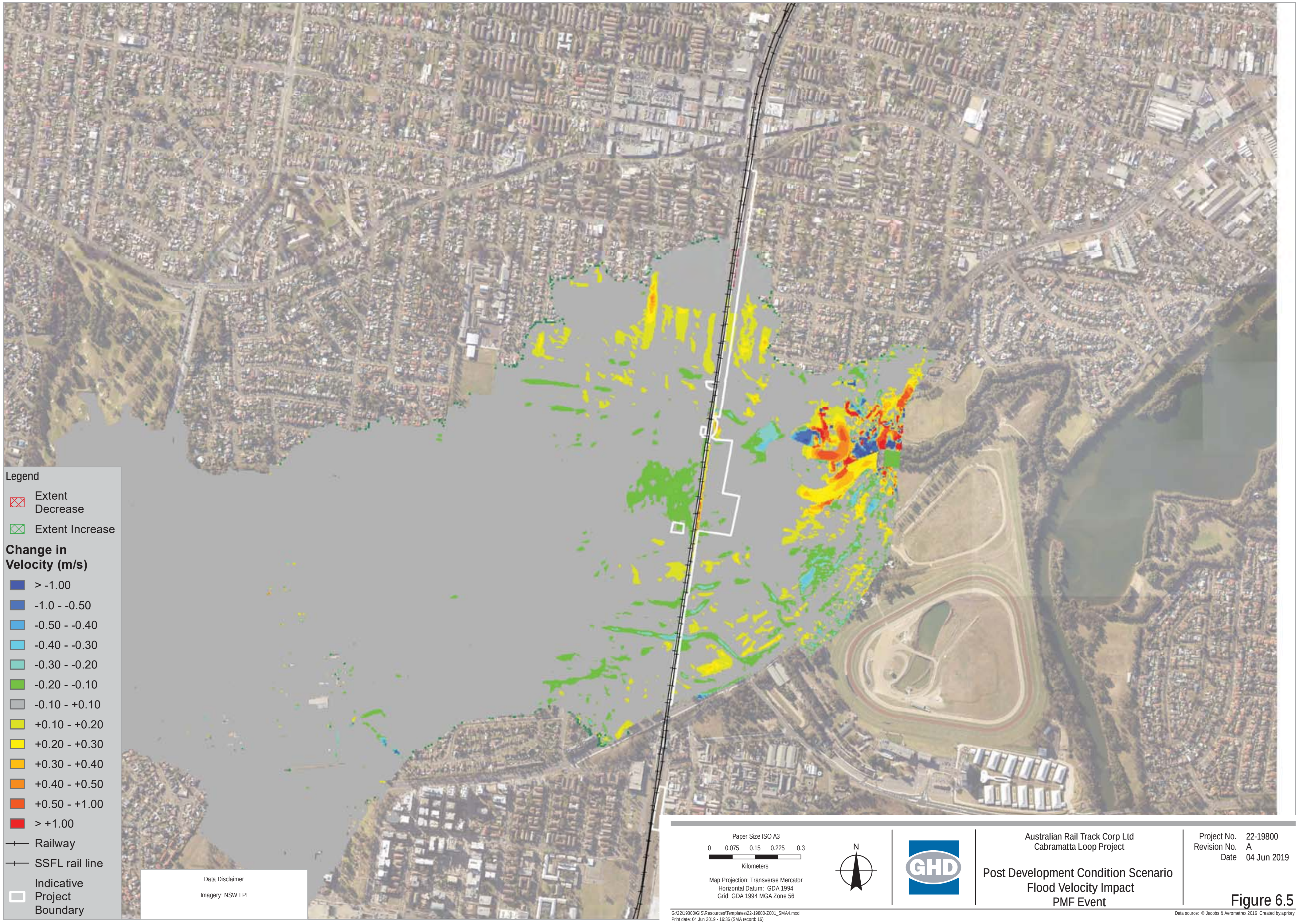

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Post Development Condition Scenario
Flood Velocity Impact
PMF Event

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 6.5

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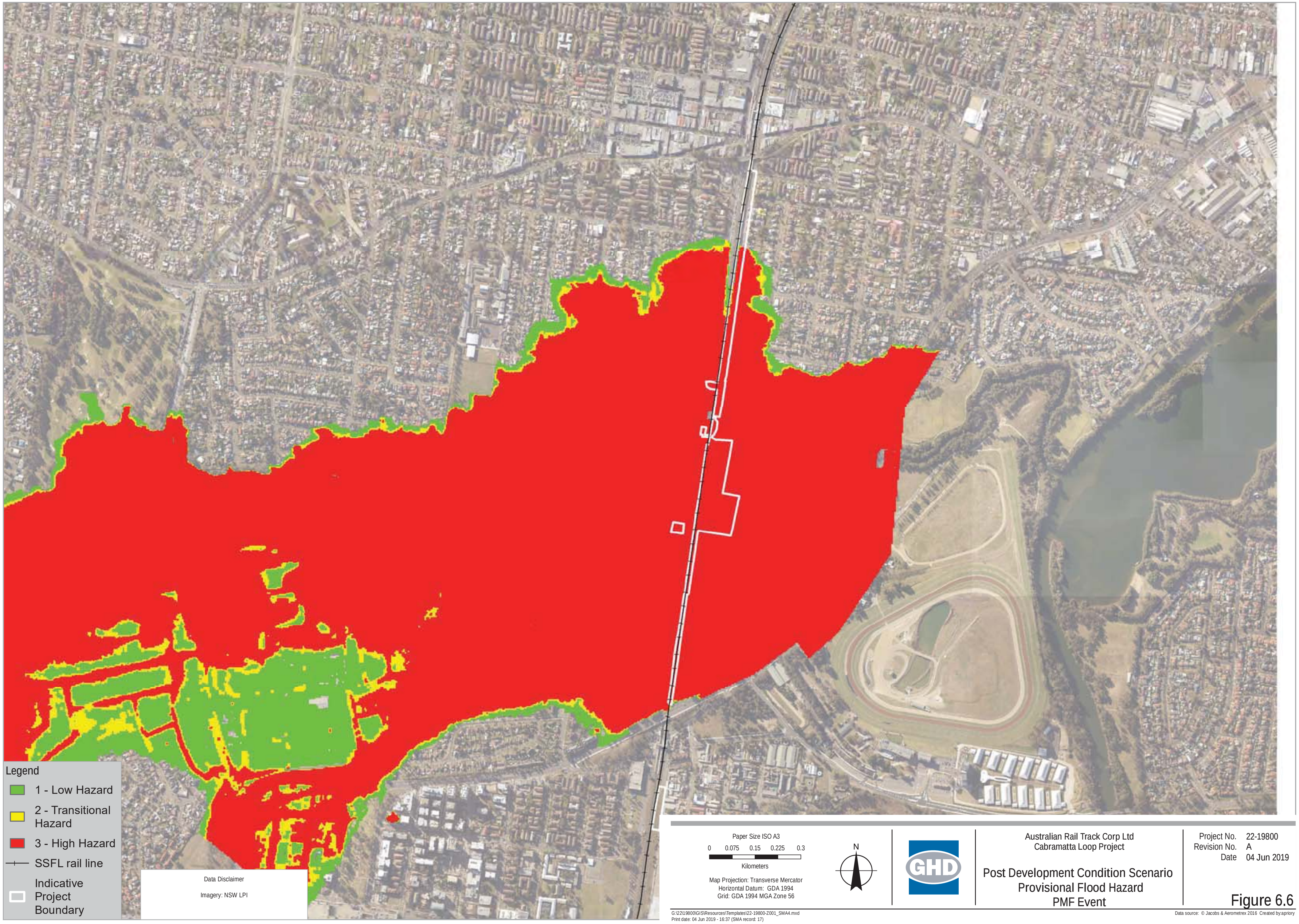

Australian Rail Track Corp Ltd
Cabramatta Loop Project

Post Development Condition Scenario
Provisional Flood Hazard
PMF Event

Project No. 22-19800
Revision No. A
Date 04 Jun 2019

Figure 6.6

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Print date: 04 Jun 2019 - 16:37 (SMA record: 17)

Data source: © Jacobs & Aerometrex 2016 Created by:apriory

6.3 Flooding and drainage outcomes

6.3.1 Potential for detrimental increases in the flood affectation of other properties, assets and infrastructure

As noted in section 6.2, the most flood affected parts of both the project site and surrounding study area are located within the Cabramatta Creek floodplain. The key outcomes in relation to flooding in Cabramatta are summarised in Table 6.2 and Figure 6.1 to Figure 6.6.

The conclusion of the assessment is that the proposed structural elements would generally limit impacts on area surrounding the project site.

With respect to the proposed changes to Broomfield Street, it is noted the proposed design would result in a marginal increase in existing flood levels at approximately eight lots located along Broomfield Street (up to 58 millimetres increase during a one per cent AEP event for seven of the eight lots). Current information indicates that the dwellings located on these lots have floor levels above the flood level under local flooding conditions. Further, these lots are already subject to flooding under existing conditions, as described in section 3.4. Currently during a 10 per cent AEP event, flood depths are predicted to be between 50 and 100 millimetres, while during a one per cent AEP event flood depths are predicted to be between 150 to 200 millimetres. The duration of flooding in a one per cent AEP event is not expected to last more than half an hour. Analysis of this design flood event shows that these flood depths rise and subside quite quickly and the duration of inundation lasts less than half an hour. This is summarised in Table 6.3. The detailed design of Broomfield Street should consider this impact and potential mitigation.

6.3.2 Consistency with applicable Council floodplain risk management plans

As noted in section 6.2, structural works and the proposed changes to Broomfield Street associated with the project are compatible with local floodplain risk management plans, as this plan does not propose any activities around the project site. On this basis, the project should not prevent or compromise any proposed works under the local floodplain risk management plan.

6.3.3 Compatibility with the flood hazard of the land

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

6.3.4 Downstream velocity and scour potential

Scouring of the existing waterway could cause deposition of materials in to downstream waterways causing altered floodplain characteristics as well as compromised existing or proposed structures.

As described in Table 6.2 and Table 6.3 increases in velocities are estimated to be generally less than 0.25 metres per second at all locations for the one per cent AEP plus climate change event. Existing velocities in these locations are generally less than two metres per second which is considered slow enough that any increases won't cause adverse impacts on surrounding environments. Events in excess of this see some wider spread velocity increases but these are less than 0.35 metres per second and only occur during a 0.2 per cent AEP event, which is a very rare to extremely rare flooding event.

Where any minor localised increases in flooding velocity are predicted, energy dissipation would be provided, possibly by way of rock protection and/or appropriate material, to minimise scour potential where appropriate. Native vegetation would also be reinstated by way of a vegetation management plan.

6.3.5 Revision of existing emergency management

With the implementation of mitigation measures provided in section 7.2, impacts on existing emergency management arrangements are expected to be minimal during operation. Ongoing liaison with NSW SES in relation to their South West Metropolitan Emergency Management District Disaster Plan (NSW Government, 2012) should be undertaken and if necessary update of ARTC's procedure OPE-PR-014 Monitoring and Responding to Extreme Weather Events should be undertaken also.

6.4 Cumulative impacts

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

There is a minor development proposal current for a multi-storey residential development on the corner of Broomfield Street and Cabramatta Road East. This proposal could potentially impact on the study area given it sits upstream of the area with part of the site within the same surface water catchment as the project. Given the existing nature of the site is urban development, this development would not be expected to have a large if any additional impact on flooding and hydrology in the area for the operational phase of the project.

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7. Recommended mitigation measures

7.1 Construction

7.1.1 Flooding and drainage

Construction phase mitigation measures would generally include:

- temporary drainage or drainage diversions to be installed as necessary so that stormwater drainage function is not impeded during construction of new stormwater drainage lines and connections to existing stormwater network.

A comprehensive list of mitigations measures appears below in Table 7.1.

Table 7.1 Potential construction risks and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate and minimise impacts
Hydrologic		
Impact on surface water flow in watercourses	• Changed surface flow paths across the project site due to the presence of site compounds/stockpiles etc.	• Install drainage works prior to or concurrent with site compound set-up and/or stockpiling • Works within or near Cabramatta Creek will be undertaken with consideration given to the NSW Department of Primary Industries (Water) *Guidelines for controlled activities on waterfront land – Riparian corridors* (2018).
Hydraulic issues		
Impact of widening the rail corridor	• Additional impacts upstream and downstream of structures	• Install drainage works prior to or concurrent with rail formation construction to minimise potential adverse impacts • Avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required • Consider how the works will affect the existing stormwater network such that alternatives are in place prior to any disconnection or diversion of stormwater infrastructure.
Working in the floodplain or flood prone areas	• Impact to construction workers working on flood prone land	• Locate stockpiles where they do not impact flow paths and patterns • Prepare wet weather working and construction flood management plans.

Review of the proposed layout of construction compounds including siting of buildings, stockpile locations and plant would be undertaken where these are located within or partially within flood liable land. Management procedures would be put in place to address construction activities during wet weather and flooding. This would include:

- Appropriate controls to cease work in flood prone areas when a severe weather warning is issued, as once the onset of a large rainfall event occurs, the onset of flooding would be relatively quick, as noted earlier in this report.
- Where possible, construction and drainage activities should be planned considering the upcoming weather forecast to minimise the risks from potential heavy rainfall and major surface runoff events.

Although planning of activities in this manner would not prevent construction during periods of potentially heavy rainfall, the risk of having disturbed construction areas or unpreparedness during heavy rainfall periods would be reduced.

Additional management measures that should be implemented also include the following:

- Management measures would be developed and implemented in accordance with *Soils and Construction – Managing Urban Stormwater Volume 1* (Landcom, 2004) and *Volume 2A* (DECC, 2008). In accordance with these guidelines, management measures would be designed to manage a 10 per cent AEP rainfall event. This will be detailed further in the Soil and Water Management Plan (SWMP), to be developed during the construction management planning phase.
- The site layout and staging of construction activities would:
  - avoid or minimise obstruction of overland flow paths and limit the extent of flow diversion required
  - limit the extent and duration of time that excavations remain open or stockpiles remain in place, particularly within the floodplain
  - consider how works would affect the existing stormwater network such that alternatives are in place prior to any disconnection or diversion of stormwater infrastructure.
- Detailed construction planning would consider flood risk for compounds and work sites near Jacquie Osmond Reserve and Cabramatta Creek. This would include identification of measures to, where feasible and reasonable, not worsen existing flooding characteristics up to and including the one per cent AEP event in the vicinity of the project. Not worsen is defined as:
  - a maximum increase flood levels of 50 millimetre in a one per cent AEP flood event
  - a maximum increase in time of inundation of one hour in a one per cent AEP flood event
  - no increase in the potential for soil erosion and scouring from any increase in flow velocity in a one per cent AEP flood event.
- A flood management procedure is to be incorporated into the Construction and Environmental Management Plan. This will include appropriate controls to be implemented during wet weather or forecasts of heavy rain and a flood warning and evacuation plan for emergency management of flooding up to the PMF event. The preparation of this procedure would be undertaken in consultation with stakeholders. These would include Liverpool City Council and Fairfield City Council and the NSW SES. Such a review may also include a wider review of local flood emergency planning.

7.1.2 Flood event monitoring

It would be impractical to monitor the flood impacts during an individual flood event but rainfall forecast should be continuously monitored throughout the construction period. Therefore, should a flood event occur during the construction phase, the following would be undertaken:

- The construction area would be inspected for damage and any required maintenance completed.
- The presence of any culvert blockages in the construction area, if present, would be recorded and cleaning undertaken as required.
- The form and location of any implemented mitigation measures would be recorded.

7.1.3 Residual impacts

Residual impacts of the project would include increases in flood level in rare to extreme flood events of greater than the one per cent AEP climate change event. This would include impacts to surrounding properties including increased flood depth and potential flood damages during a flood event.

Further to this, risks to working in the floodplain are unavoidable to some level. However, preparation of the flood management procedure detailed in section 7.1.1 would help manage the residual impact, to the extent practicable.

7.2 Operation

7.2.1 Flooding and drainage

A number of flooding events have been assessed to understand the likelihood of flooding impacts from the proposed project to the surrounding floodplain area including downstream. The structural elements as they are currently designed are predicted to cause minimal impacts on surrounding areas for events up to and including the one per cent AEP climate change event. The proposed Broomfield Street works require further refinement during the detailed design phase to minimise impacts noted in the sections above.

The residual risks remaining would be addressed through either further design development and/or specific mitigation measures outlined below.

A comprehensive list of mitigations measures appears below in Table 7.2.

Table 7.2 Potential impacts and mitigation measures

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
Hydrologic		
Impact on surface flow in watercourse and flows in channels / drainage structures	• Modified surface flow volume or rate downstream of the rail corridor	• Avoid installation of stormwater drainage elements that create localised surface water ponding Further assessment and design refinement will be undertaken during detailed design with the objective of not exceeding the following flooding characteristics during the one per cent AEP event: • A maximum increase in time of inundation of one hour in a one per cent AEP event • A maximum increase in 50 mm in inundation at properties were floor levels are currently not exceeded • A maximum increase in 10 mm in inundation at properties were floor levels are currently exceeded. In the event this cannot be met further mitigation would be proposed in consultation with the relevant councils.
	• Changed surface flow paths across the project site	• Minimise regrading of terrain along the rail corridor • Install appropriately sized stormwater drainage pipes along the rail corridor
Hydraulic issues		
Impact of widening the rail corridor	• Increased upstream flooding depths, extents and hazard • Increased upstream flood durations • Increased upstream impacts on buildings	• The design has included consideration of this by constructing the bridges on the downstream side of the rail corridor and matching the location of piers and abutments to the existing bridges, so that impacts on flow hydraulics are minimised.

Risk	Potential impacts	Measures to avoid, mitigate or minimise impacts
	• Increased impacts on adjacent infrastructure (e.g. road closures) • Additional impacts downstream of structures	
Impact of providing increased stormwater drainage capacity	• Increased downstream flooding depths, extents and hazard • Increased downstream flood durations and reduced emergency access • Increased downstream impacts on buildings • Increased impacts on adjacent infrastructure (e.g. road closures) • Increased downstream velocities and scour potential	• Do not reduce watercourse flow areas • Reinstatement of local scour protection works in unlined channels, including Cabramatta Creek, where present. • Where feasible and reasonable, detailed design will result in no net increase in stormwater runoff rates in all storm events, unless it can be demonstrated that increased runoff rates as a result of the project would not increase downstream flood risk.
Impact of filling / works in flood storage areas	• Increases in flood levels, or hazard • Changes in flow paths	• Avoid filling in flood storage areas where there is potential for adverse impacts on surrounds • Provide additional capacity/mitigation if required
Impact of re-alignment of Broomfield Street	• Changes to hydraulic flow regime • Increase in flood levels predicted for properties adjacent to Broomfield Street	• Refine the design to mitigate flood level increases beyond the design criteria • Include drainage elements that at least match existing drainage elements

Further design development

The current road design for the Broomfield Street area is noted to increase flood level in a number of lots along Broomfield Street. While the dwellings on these lots are generally high-set, with floor levels above the local one per cent AEP flood event, refinement to the design will be necessary during further design stages, to mitigate flood level increases beyond the design criteria.

In undertaking further refinement, the current road grading proposed will be looked at in comparison to the existing road grading, and where possible, this will be revised where overland flow paths exist to match closely the existing grading. Further to this, local raising of ground levels could be investigated in an attempt to confine flooding to within the road corridor and avoid flooding from extending in to adjacent properties as it currently does. Close examination would need to be undertaken as part of this investigation so as to not create high hazard flood areas within the current roadway where they do no currently exist.

7.2.2 Flood event monitoring

The project is designed to meet the flood immunity criteria of remaining flood free in events up to and including the one per cent AEP climate change event. Flooding of the Cabramatta Loop rail line is expected to be a rare occurrence because the rail line is designed to be constructed at the same level as the existing SSFL.

It is recommended that the infrastructure be inspected after all flood events to identify any flood damage that may need to be rectified and identify associated maintenance activities.

Flood emergency management

If necessary, review and amendment to the local flood emergency planning should be undertaken. This should be undertaken in consultation with stakeholders including Fairfield City Council and Liverpool City Council and the NSW SES.

Scour and velocity

Any existing rip rap that is impacted or removed during construction would be reinstated. This would include the provision of rip rap around the piers and abutments of Cabramatta Creek bridge.

7.2.3 Residual impacts

Residual impacts of the project would include increases in flood level in rare to extreme flood events of greater than the one per cent AEP climate change event. This would include impacts to surrounding properties including increased flood depth, potential flood damages during a flood event and emergency access during times of flooding.

The proposed Broomfield Street works require further refinement during the detailed design phase to minimise impacts noted in the sections above. Potential options for refinement to the design are included above in section 7.2.1.

8. Conclusion

A hydrology and flooding assessment was carried out for the project. The assessment drew on the following sources of information including:

- a desktop review of available drainage and flooding information
- analysis undertaken of the flooding for Cabramatta Creek

The project site is located in a highly urbanised environment. Under existing conditions, the project site is subject to mainstream flooding varying in severity due to the large upstream catchment as well as backwater effects from the Georges River nearby when also in flood.

Key construction stage impacts include:

- The potential for increased sediment being discharged to downstream systems as a result of construction activities
- Flooding and overland flow issues caused by the presence of construction worksites and compounds on flood liable land

Construction impacts would be managed through implementation of SWMPs in accordance with the Blue Book and detailed planning and management of construction sites to avoid impacting overland flow paths without appropriate mitigation.

A flood warning and evacuation plan as part of a flood management plan would be developed for emergency management of flooding up to the PMF event during construction activities

Key residual construction stage impacts include flooding to construction worksites and compounds during construction, with associated potential downstream impacts.

In the operational stage, structural measures for the bridge elements incorporated into the design as well as the rail embankment are predicted to not adversely impact adjacent lands in major flood for events up to and including the one per cent AEP climate change event.

The proposed realignment of Broomfield Street has been assessed in terms of flooding impact. This has demonstrated that some flooding impacts exist outside of the design criteria with the current reference design. During this assessment it has been noted that while dwellings are likely not affected by over floor flooding from the local catchment, the modelling has predicted some impact to lots along Broomfield Street.

The area-wide emergency management of flooding should be followed during the operational phase.

In terms of residual operational impacts, there are negligible increases to flood depths along key access routes which are predicted in both the one per cent AEP and the one per cent AEP event plus climate change, though some of these areas are already predicted to be substantially flooded under existing conditions. The design would be further refined to reduce the residual risks associated with the modifications to Broomfield Street. This refinement would include looking at the current grading of the road for the proposed design against the existing road and attempting to match as close as possible where overland flow paths exist.

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