HENRY LAWSON DRIVE UPGRADE STAGE 1A

REVIEW OF ENVIRONMENTAL FACTORS AND ENVIRONMENTAL IMPACT STATEMENT

FLOODING ASSESSMENT REPORT

FINAL REPORT

July 2021

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NOTE ON FLOOD FREQUENCY TERMINOLOGY

The frequency of flood events is generally referred to in terms of their Annual Exceedance Probability (AEP) or Average Recurrence Interval (ARI). For example, for a flood magnitude having five per cent AEP, there is a five per cent probability (or 1 in 20 chance) that there would be floods of greater magnitude each year. As another example, for a flood having a 20 year ARI, there would be floods of equal or greater magnitude once in twenty years on average. The approximate correspondence between these two systems is:

Annual Exceedance Probability (AEP) per cent	Average Recurrence Interval (ARI) years
0.2	500
0.5	200
1	100
5	20
10	10
20	5
50	2
1 EY(1)	1
2 EY(1)	0.5

1. Floods more frequent than 50% AEP are expressed in terms of the number of exceedances per year (EY).

In this report the frequency of flood events generated by runoff from the catchments within the study area (ie catchment flooding) is referred to in terms of their AEP, for example a 1% AEP flood.

The frequencies of peak water levels derived from ocean flooding are also referred to in terms of their AEP; for example, a 1% AEP peak ocean water level.

The report also refers to the Probable Maximum Flood (PMF). This flood occurs as a result of the probable maximum precipitation (PMP) on the catchments within the study area. The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. The PMP is used to estimate PMF discharges using a catchment hydrologic model that simulates the conversion of rainfall to runoff. The PMF is defined as the upper limiting value of floods that could reasonably be expected to occur and defines the extent of flood prone land (i.e. the floodplain).

GLOSSARY OF TERMS AND ABBREVIATIONS

Term	Meaning
AEP	Annual exceedance probability. The chance of a rainfall or a flood event exceeding a nominated level in any one year, usually expressed as a percentage. For example, if a peak flood level has an AEP of five per cent, it means that there is a five per cent chance (that is one-in-20 chance) of being exceeded in any one year. The frequency of floods is generally referred to in terms of their AEP or ARI. In this report the frequency of floods generated by runoff from the study catchments is referred to in terms of their AEP, for example a 1% AEP flood.
Afflux	Increase/decrease in water level resulting from a change in conditions. The change may relate to the watercourse, floodplain, flow rate, tailwater level, etc.
AHD	Australian height datum. A common national surface level datum approximately corresponding to mean sea level.
ARI	Average recurrence interval. An indicator used to describe the frequency of a rainfall or a flood event, expressed as an average interval in years between events of a given magnitude. For example, over a long period of say 200 years, a flood equivalent to or greater than a 20 year ARI event would occur 10 times. A 20 year ARI flood has a one-in-5 chance of occurrence in any one year. See also AEP.
ARR 1987	Australian Rainfall and Runoff (Institute of Engineers Australia (IEAust) 1987).
ARR 2019	Australian Rainfall and Runoff (Geosciences Australia (GA) 2019).
BAL	Bankstown Airport Limited
BoM	Bureau of Meteorology.
Box culvert	A culvert of rectangular cross section.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Climate change	A change in the state of the climate that can be identified (for example by statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period of time, typically decades or longer (IPCC 2007).
Climate projection	A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which in turn is based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (IPCC 2007).
Construction ancillary facilities	Temporary facilities during construction that include, but are not limited to, construction work areas, sediment basins, temporary water treatment plants, pre-cast yards and material stockpiles, laydown areas, parking, maintenance workshops and offices, and construction ancillary sites.

Term	Meaning
Construction ancillary site	An area used as the base for construction activities, usually for the storage of plant, equipment and materials, and/or construction site offices and worker facilities.
CEMP	Construction Environmental Management Plan.
DCP	Development control plan.
DECC	Department of Environment and Climate Change (now DPIE EES).
DECCW	Department of Environment, Climate Change and Water (now DPIE EES).
Detailed design	The stage of design where project elements are designed in detail, suitable for construction.
DIPNR	Department of Infrastructure, Planning and Natural Resources (now DPIE EES).
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving (e.g. metres per second [m/s]).
DoP	Department of Planning (now DPIE).
DPIE	Department of Planning, Industry and Environment (formerly DoP).
DPIE EES	Department of Planning, Industry and Environment – Environment Energy and Science.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
DRAINS	A computer simulation program which converts rainfall patterns to stormwater runoff and generates discharge hydrographs. These hydrographs can then be routed through networks of piped drainage systems, culverts, storages and open channels using the DRAINS software to calculate hydraulic grade lines and analyse the magnitude of overflows. Alternatively, discharge hydrographs generated by DRAINS can be used as inflows to alternative hydraulic models (such as the TUFLOW two-dimensional hydraulic modelling software) to calculate water surface levels and flooding patterns.
Earthworks	All operations involving the loosening, excavating, placing, shaping and compacting of soil or rock.
Emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
EIS	Environmental Impact Statement.
EIS Proposal	Areas of the overall proposal occurring on land mapped as Coastal Wetlands subject to assessment as designated development under Division 4.1 of the Environment Planning & Assessment Act 1979
Embankment	An earthen structure where the road (or other infrastructure) is located above the natural surface.
FDM	*Floodplain Development Manual* (Department of Planning, Infrastructure and Natural Resources (DIPNR) 2005).
Fill	The material placed in an embankment.

Term	Meaning
Flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunamis.
Flood affectation	The extent to which a property or area of land is affected by flooding.
Flood fringe area	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood immunity	Relates to the level at which a particular structure would be clear of a certain flood event.
Flood prone land	Land susceptible to flooding by the Probable Maximum Flood. Note that the flood prone land is synonymous with flood liable land.
Flood storage area	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event (i.e. flood prone land).
Floodplain Risk Management Plan	A management plan developed in accordance with the principles and guidelines in the *Floodplain Development Manual* (FDM), (DIPNR 2005). Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
Floodway area	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flow velocity	A measure of how fast how fast water is moving, for example, metres per second (m/s).
FPA	Flood Planning Area. The area of land below the Flood Planning Level and thus subject to flood planning controls.
FPLs	Flood Planning Levels. The combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
Freeboard	A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as the difference in height between the adopted Flood Planning Level and the peak height of the flood used to determine the Flood Planning Level. Freeboard provides a factor of safety to compensate for uncertainties in the estimation of flood levels across the floodplain, such as wave action, localised hydraulic behaviour and impacts that are specific event related, such as levee and embankment settlement, and other effects such as “greenhouse” and climate change. Freeboard is included in the Flood Planning Level.

Term	Meaning
GSDM	Generalised Short Duration Method. A method prescribed by BoM for estimating the Probable Maximum Precipitation for catchments up to 1,000 square kilometres in area.
Hazard	A source of potential harm or a situation with a potential to cause loss. In relation to the *NSW Floodplain Development Manual* (FDM), (DIPNR 2005) the hazard is flooding which has the potential to cause damage to the community.
Hydraulics	The term given to the study of water flow in waterways, in particular the evaluation of flow parameters such as water level and velocity.
Hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
Hydrology	The term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of discharge hydrographs for a range of floods.
Hyetograph	A graph which shows how rainfall intensities or depths vary with time during a storm burst. A design hyetograph shows the distribution of rainfall over a design storm burst.
IFD	Intensity-Frequency-Duration.
Impact	Influence or effect exerted by a project or other activity on the natural, built and community environment.
Inbank area	The area of a creek or watercourse below its top of bank levels.
Inundation	The spreading of a flood over an area.
IPCC	Intergovernmental Panel on Climate Change.
LGA	Local government area.
LiDAR	Light detection and ranging. A form of aerial survey used to measure ground elevations.
Local drainage	Smaller scale drainage systems in urban areas. Commonly defined as areas where the depth of inundation along overland flow paths is less than 150 millimetres during a 1% AEP storm.
m	Metres. Used to define a length.
m AHD	Metres above Australian Height Datum. Used to define an elevation above Australian Height Datum.
m^2	Square metres. Used to define an area.
m^3	Cubic metres. Used to define a volume.
m^3/s	Cubic metres per second. Used to quantify a flowrate.
Main stream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
Major overland flow	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam. Also referred to as overland flooding.

Term	Meaning
Mathematical/ computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
Merits based approach	The merits based approach weighs social, economic and environmental impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well-being of the State's rivers and floodplains.
MHWLS	Mean high water level spring
Overland flooding	Refer major overland flow.
Peak discharge	The maximum discharge occurring during a flood event.
Peak flood level	The maximum water level occurring during a flood event.
PMF	Probable maximum flood. The flood that occurs as a result of the Probable Maximum Precipitation (PMP) on a study catchment. The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically feasible to provide complete protection against this event. The PMF defines the extent of flood prone land (i.e. the floodplain).
PMP	Probable maximum precipitation. The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. The PMP is used to estimate PMF discharges using a catchment hydrologic model which simulates the conversion of rainfall to runoff.
Pre-proposal conditions	Conditions (within the study area) prior to the construction of the Henry Lawson Drive Upgrade Stage 1A. This includes details of projects that are presently under construction or will be constructed prior to the Henry Lawson Drive Upgrade Stage 1A project (such as the Tower Road intersection upgrade).
Proposal	The overall proposal of the Stage 1A upgrade inclusive of all activities impacting areas within the overall proposal boundary.
PRM	Probabilistic rational method.
Probability	A statistical measure of the expected chance of flooding (see annual exceedance probability).
RCBC	Reinforced Concrete Box Culvert.
RCP	Reinforced Concrete Pipe.
Representative Concentration Pathway	A greenhouse gas concentration trajectory adopted by the Intergovernmental Panel on Climate Change.
REF	Review of Environmental Factors
REF Proposal	The majority of the overall proposal subject to assessment under Division 5.1 of the Environment Planning & Assessment Act 1979.

Term	Meaning
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the *NSW Floodplain Development Manual* (DIPNR 2005) it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
RL	Reduced level. The reduced level is the vertical distance between an elevation and an adopted datum plane such as the Australian Height Datum (AHD).
Runoff	The amount of rainfall which actually ends up as stream flow, also known as rainfall excess.
Scour	The erosion of material by the action of flowing water.
SEARs	Secretary's Environmental Assessment Requirements and specifications for an environmental assessment prepared by the Secretary of the NSW Department of Planning and Environment under Division 4.1 of the Environmental Planning and Assessment Act 1979 (NSW).
SES	NSW State Emergency Services.
Spoil	Surplus excavated material.
Stage	Equivalent to water level (measured with reference to a specified datum).
Stockpile	Temporarily stored materials such as soil, sand, gravel and spoil/waste.
Surcharge	Overflow from a creek, waterbody, overland flow or drainage system.
Surface water	Water flowing or held in streams, rivers and other water bodies in the landscape.
Transport	Transport for NSW

ES1 EXECUTIVE SUMMARY

Overview

This report deals with the findings of an investigation which was undertaken to assess flood related issues associated with the construction and operation of the Henry Lawson Drive Upgrade Stage 1A (the proposal). **Figure 1.1** in **Section 1.3** of this report shows the extent of the proposal, the majority of which is categorised as Review of Environmental Factors (REF) proposal area with the exception of three discrete Environmental Impacts Statement (EIS) proposal areas that are located within mapped coastal wetlands (denoted EIS proposal areas 1, 2 and 3).

This report has been prepared to support the preparation of both the REF and EIS for the overall proposal. **Sections 1** to **3** provide details of the background to the assessment. An outline is provided of relevant government legislation, policies and guidelines that were taken into consideration in the assessment. Details are also provided of the methodology that was adopted in the definition of flood behaviour in the vicinity of the proposal and also the impact that it would have on flood behaviour.

This report addresses the Secretary's Environmental Assessment Requirements (SEARs). The SEARs only apply to the areas of the proposal occurring on Coastal Wetlands, mapped under the State Environmental Planning Policy (Coastal Management) 2018.

Existing environment

The proposal is located on the floodplain of the Georges River and one of its minor tributaries which is known locally as Milperra Drain. The surrounding land use comprises low density residential and commercial type development, as well as recreational zoned land along the alignment of Milperra Drain and the eastern bank of the Georges River. Bankstown Aerodrome is a dominant man-made feature within the Georges River and Milperra Drain catchments in the immediate vicinity of the proposal.

Section 4 contains a brief description of the characteristics of the Georges River and Milperra Drain catchments as they relate to the proposal area. **Section 4** also includes a description of the nature of flooding under present day (or pre-proposal) conditions in the vicinity of the proposal in terms of:

- mainstream flooding along the Georges River (referred to in this report as ‘Georges River flooding’)
- mainstream flooding and major overland flow along the Milperra Drain and the broader Milperra area (referred to in this report as ‘Milperra catchment flooding’).

Section 4.3.1 contains a list of figures that show flood behaviour due both Georges River and Milperra catchment flooding. Flood behaviour is defined for events ranging between 50% and 0.2% Annual Exceedance Probability (AEP), as well as the Probable Maximum Flood (PMF).

The key findings of the investigation in regards to Georges River flooding were as follows:

i. The section of Henry Lawson Drive to the north of Tower Road is impacted by flooding from the Georges River during a 5% AEP event over a length of about 1.2 kilometres (200 metres of which is located within the proposal boundary) and to a maximum depth of about 0.9 metres. Flooding from the Georges River during a 5% AEP event will also inundate a 1.2 kilometre length of Milperra Road to the east of Henry Lawson Drive to a maximum depth of about 1 metre.

ii. Floodwater that surcharges the eastern bank of the Georges River during a 1% AEP event will inundate the full length of Henry Lawson Drive and Milperra Road within the proposal area to a maximum depth of over 3 metres. The floodwater would also inundate Henry Lawson Drive a distance of 1.1 kilometres to the north and 300 metres to the south of the proposal, while flooding along Milperra Road will extend over a distance of 1.1 kilometres to the east of the proposal.

iii. The extent and depth of flooding to Henry Lawson Drive and Milperra Road, both within the proposal area and in its immediate vicinity, would limit the ability to improve their level of flood immunity as part of the proposal.

iv. Due to their low lying nature, the EIS proposal areas will experience frequent inundation due to floodwaters that originate in the Georges River.

The key findings of the investigation in regards to Milperra catchment flooding were as follows:

i. The section of Milperra Road to the east of Henry Lawson Drive is impacted by floodwater that surcharges the main channel of Milperra Drain where it runs through the Bankstown golf course during a 10% AEP storm event. It is noted that flooding would be confined to the outer lanes and to relatively shallow depths of 0.2 metres or less.

ii. During a 1% AEP storm on the Milperra catchment in the absence of elevated flood levels in the Georges River, flooding from the Milperra Drain would inundate the section of Milperra Road to the east of Henry Lawson Drive across its full width. Flooding due to runoff from the Milperra catchment would pond in the Georges River golf course to a level that is about 0.1 metres below the adjacent level of Henry Lawson Drive.

iii. During a 1% AEP storm on the Milperra catchment in combination with a 5% AEP flood in the Georges River, peak flood levels in the vicinity of the proposal area are controlled by flood levels in the Georges River. Under this combination of flooding, the peak flood level at the Auld Avenue bridge is about 0.3 metres above its deck level. Floodwaters would also inundate the northern and eastern portions of the proposal area as a result of peak flood levels in the Georges River.

iv. All three EIS proposal areas would experience frequent inundation due to runoff from the Milperra catchment. EIS proposal area 1 is inundated by runoff that is conveyed by the box culvert that crosses Henry Lawson Drive to the north of Tower Road, while EIS proposal area 2 is inundated by runoff that is conveyed by the box culvert that crosses Milperra Road to the east of Henry Lawson Drive. Due to its low lying nature, EIS proposal area 3 would be inundated by flow that originates from the section of Milperra Drain where it runs through the Bankstown golf course.

Impacts during construction

An assessment was carried out of the flood risk associated with the construction of the proposal as well as the potential impacts that proposed construction activities could have on flood behaviour. For the purpose of this assessment the proposal area was split into the following three areas of work (denoted work areas (WA) 1 to 3 in this report for ease of reference):

- Henry Lawson Drive north work area (WA1)
- Milperra Road work area (WA2)
- Henry Lawson Drive south work area (WA3)

A range of construction activities would be undertaken within each work area that would include:

- construction ancillary sites containing a range of facilities to support construction across the work areas, including offices, staff amenities, parking and storage areas for plant, equipment and materials, as well as fencing
- earthworks to construct the road works, including excavation to the foundation level of the new road pavement, installation of fill material to widen road embankments and construct the approach embankments of the new bridge, as well as excavation of drainage channels and to install new drainage pipes and box culverts
- bridge construction for the new bridge over Milperra Drain at Henry Lawson Drive, including the erection of a temporary working platform to install bridge piers.

Figure 5.1 (2 sheets) shows the locations of the construction work areas, ancillary sites (denoted ancillary sites C1 to C4) and temporary piling platform for bridge construction (denoted working platform WP1) that are referred to in this report. It also shows the location of three existing transverse drainage structures that would be upgraded or extended as part of the proposal (denoted transverse drainage structures PXD01, PXD02 and PXD03).

Table 5.1 in **Section 5.1** provides a summary of the assessed flood risk at each construction work area and their associated activities, as well as the potential impact these construction activities could have on flood behaviour. **Figure 5.1** (2 sheets) shows the extent to which Georges River flooding affects each construction work area, while **Figure 5.2** (2 sheets) shows the corresponding extents based on Milperra catchment flooding.

Potential flood risk to construction activities

Construction ancillary sites:

- Construction ancillary sites located on the floodplain, particularly in areas of high hazard[1], pose a safety risk to construction personnel. All four proposed construction ancillary sites include land that would be suitable for site facilities that is located outside areas of high hazard flooding due to a 1% AEP Milperra catchment flood event in the absence of elevated flood levels in the Georges River.
- While construction ancillary sites C1 and C2 are located on land that is outside areas of high hazard during a 1% AEP Georges River flood event, flooding to construction ancillary sites C3 and C4 would be unsafe to construction personnel during this event. It will therefore be necessary to implement emergency response procedures in order to manage the risk that flooding to these two construction ancillary sites would pose to construction personnel and equipment. Flooding from the Georges River takes a longer time to peak compared to Milperra catchment flooding which would provide more time to enable flood warning and response procedures to be implemented.
- Construction ancillary sites C1, C3 and C4 include land that would be inundated during a 5% AEP flood. In accordance with standard Transport procedures contingency planning would be required should site facilities be located in these areas.

[1] High hazard flooding is defined in the *Floodplain Development Manual* (Department of Planning, Infrastructure and Natural Resources (DIPNR) 2005) as flooding that is a possible danger to personal safety, where evacuation by trucks and able-bodied adults would be difficult and where there is potential for significant structural damage to buildings.

Earthworks:

- The inundation of the earthworks by floodwater has the potential to cause scour of disturbed surfaces and the transport of sediment and construction materials into the receiving waterways. It would therefore be necessary to plan, implement and maintain measures that are aimed at managing the diversion of floodwater either through or around the construction areas.

Bridge construction:

- In order to construct the central pier for the new Milperra Drain it is likely that the footprint of the temporary working platform would be located across part of the main channel of Milperra Drain in an area that would be frequently inundated by flow. It would therefore be necessary to design and construct the temporary working platform to manage the potential for scour and transport of material into Milperra Drain, whilst also maintaining a passage for the conveyance of floodwater through the construction site.

Potential impacts of the proposed construction activities on flood behaviour

Construction ancillary sites:

- While the impact of the four construction ancillary sites on flood behaviour in both the Georges River and Milperra catchment is likely to be relatively minor and localised, there is the potential for materials stored within the ancillary sites to be displaced and transported along the Georges River should a flood occur during the construction of the proposal.

Earthworks:

- The potential impact of the proposed earthworks in all three work areas on flood behaviour are not expected to be significantly greater than those under operational conditions. The exception to this is at the outlet of existing drainage structures where there is the potential for the proposed earthworks to impact on local catchment runoff discharging from the culverts unless measures are implemented to maintain temporary drainage paths through the work areas during the upgrade, extension or replacement of the existing drainage structures. This would apply to the outlet of transverse drainage structure PXD1 (located within EIS proposal area 1 in Henry Lawson Drive north work area (WA1)), transverse drainage to the east of Henry Lawson Drive (within EIS proposal area 2 in the Milperra Road work area (WA2)) and south of Milperra Road (within the Henry Lawson Drive south work area (WA3)).
- There is a risk of scour to any exposed surfaces and the transport of sediment into the adjacent watercourses should flooding occur during the construction of the proposal that inundates the areas of earthworks.

Bridge construction:

- The working platform for the construction of the new Auld Avenue bridge has the potential to obstruct the conveyance of flow in Milperra Drain during events more frequent that 50% AEP. This in turn may impact on the extent and depth of inundation and flow velocities in Milperra Drain.

While the findings of the assessment provide an indication of the potential impacts of construction activities on flood behaviour, further investigation would need to be undertaken during detailed design as layouts and staging diagrams are further developed. Consideration would also need to be given to setting an appropriate hydrologic standard for mitigating the impacts of construction activities on flood behaviour, taking into account their temporary nature and therefore the likelihood of a flood of a given AEP occurring during the construction period.

Impacts during operation

An assessment was carried out of the flood risk to the proposal and the impact it would have on flood behaviour during operation if appropriate mitigation measures are not incorporated into its design.

Figure 5.3 (2 sheets) shows the key features of the proposal that formed the basis of the assessment, the details of which are summarised in **Section 5.2**.

Potential flood risk to the proposal

Table 5.2 provides a summary of the assessed flood risk to the project against the adopted criteria outlined in **Section 3.2**. The assessment found that:

- While the upgrade of the roads within the proposal area would maintain the existing level of flood immunity, opportunities to improve the level of immunity is constrained by the impact raising the new sections of road above existing levels would have on flood behaviour in development adjacent to the proposal.
- In regards to Georges River flooding the assessment found:
    - the proposed upgrade of the section of Henry Lawson Drive to the north of Milperra Road would be inundated by floodwater that surcharges the river during storms more frequent than 20% AEP
    - the proposed upgrade of the sections of Milperra Road and Henry Lawson Drive to its south would both have a 10% AEP level of flood immunity against Georges River flooding.
- In regards to Milperra catchment flooding the investigation found:
    - the proposed upgrade of Henry Lawson Drive to the north and south of Milperra Road would have a 1% AEP level of flood immunity against Milperra catchment flooding in the absence of elevated flood levels in the Georges River
    - the proposed upgrade of Milperra Road would have about a 10% AEP level of flood immunity against Milperra catchment flooding.
- Floodwater that surcharges the Georges River during a 1% AEP event and inundates Milperra Road and the sections of Henry Lawson Drive to its north and south would be hazardous to persons and vehicles using these sections of road, but would be no worse than under pre-proposal conditions.
- Based on the current design the new bridge over Milperra Drain would provide 0.3 metres of freeboard between the underside of the bridge structure and the peak 1% AEP flood level. In comparison the existing bridge would be submerged by 0.3 m below the same peak flood level.

Impact of the proposal on flood behaviour

The assessment found there is the potential to increase peak flood levels in adjoining development at a number of locations due to the raised level of Henry Lawson Drive and the obstruction this would have on flow that presently overtops the road due to coincident Georges River and Milperra catchment flooding.

The following potential impacts on Georges River flooding have been identified:

i. Peak 2% and 1% AEP flood levels would be increased in an area to the west of Henry Lawson Drive between Newbridge Road and the Auld Avenue bridge that includes several residential properties by a maximum of 0.08 m, and 0.03 m, respectively.

ii. Peak 2% and 1% AEP flood levels would be increased in an area to the west of Henry Lawson Drive, north of Milperra Road that includes an existing shared user path. Flooding along the shared user path would be increased by a maximum of 0.1 m on an existing depth of about 0.2 m during a 2% AEP event, and by 0.05 m on an existing depth of about 0.5 m during a 1% AEP event.

iii. Peak 1% AEP peak flood levels would be increased within two commercial premises that lie to the east of Henry Lawson Drive and north of Milperra Road by a maximum of 0.02 m on existing depths of between 0.1 and 0.3 m. While impacts are mainly confined to areas of landscaping, driveway and carparking, there is a car wash facility that would experience an increase in the depth of inundation of 0.02 m on an existing depth of 0.3 m.

The following potential impacts on Milperra catchment flooding have been identified:

i. There would be an increase in the depth and extent of ponding within a commercial property that lies to the south of Tower Road during storms that surcharge the internal drainage system. The depths of inundation within the property would be increased by a maximum of 0.04 m during a 10% and 1% AEP event on existing depths of between 0.2 and 0.3 m.

ii. During a 1% AEP storm in combination with a 5% AEP flood in the Georges River there would be an increase in the depth and extent of inundation within the front yards of four residential properties that lie on the western side of Henry Lawson Drive between Newbridge Road and the Auld Avenue bridge.

iii. During a 1% AEP storm in combination with a 5% AEP flood in the Georges River, peak flood levels along the section of Milperra Drain where it runs to the east (upstream) of Henry Lawson Drive would be increased by a maximum of 0.013 m, with impacts extending to several industrial type properties that front Ashford Avenue and Milperra Road.

During detailed design the road alignment will be further refined in order to minimise the increase in proposed road levels along the sections of Henry Lawson Drive at its intersection with Milperra Road with the aim of mitigating its impact on peak flood levels in adjoining development.

The investigation found that while the current design would have only a minor impact on peak flows in the Georges River and Milperra Drain, there is the potential for a localised increase in scour potential due to a localised increase in flow velocities at the outlet of new, upgraded or extended drainage structures. During detailed design, scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity. This would include the outlet to transverse drainage structures PXD01 and PXD02 which are located in EIS proposal areas 1 and 2, respectively.

In regards to the proposed works within the EIS proposal areas the potential impacts on flood behaviour under pre-proposal conditions can be summarised as follows:

i. The road widening and associated fill embankments within EIS proposal areas 1 and 2 in isolation would be expected to have a relatively localised impact on flood behaviour. However, in combination with the overall proposal the works within EIS proposal areas 1 and 2 would respectively contribute to the changes in flood behaviour in the reach of the Georges River to the north of Milperra Road, and the reach of Milperra Drain to the east of Henry Lawson Drive that are described in this report.

ii. The provision of new or upgraded drainage infrastructure in EIS proposal areas 1 and 2 to accommodate the proposed road widening has the potential for a localised increase in scour potential due to a localised increase in flow velocities at the outlet of new, upgraded or extended drainage structures. During detailed design, scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity.

iii. Works within EIS proposal area 3 are related to the provision of a temporary ancillary site to support the construction of the proposal. Subject to the suitable reinstatement of the ancillary site following the construction of the proposal then works within EIS proposal area 3 would have no significant impact on flood behaviour.

Impact of future climate change on flood behaviour

The investigation found that the increase in rainfall intensities associated with future climate change has the potential to increase the frequency and depth of flooding that occurs to the roads within the proposal area. Unless suitable mitigation measures are incorporated into the detailed design of the proposal then the increase in rainfall intensities under future climate change conditions also has the potential to increase the frequency with which flooding in adjoining development would be exacerbated as a result of the proposal.

Consistency with Council floodplain risk management plans

Plans for the management of flood risks within the Georges River and Milperra catchments are respectively set out in the following documents:

- *Georges River Floodplain Risk Management Study and Plan* (Volumes 1 & 2) (Bewsher Consulting (BC) 2004)
- Floodplain Risk Management Study and Plan for Sub-Catchments of the Mid Georges River (BMT WBM 2017)

The proposed upgrade of Henry Lawson Drive is considered to be consistent with the floodplain risk management plans set out in BC 2004 and BMT WBM 2017 for the following reasons:

- Subject to the provision of suitable mitigation measures during detailed design, the project would have only a minor impact on peak 1% AEP flood levels and flow velocities within areas outside the project footprint. Increases in PMF levels are also considered minor in terms of the relative increase in flood hazard and changes in the extent of inundation. As a result, it is considered that the project would have no significant impact on the extent of the floodplain or its hazard categorisation as defined in BC 2004 and BMT WBM 2017.

- Subject to the provision of suitable mitigation measures during detailed design, it is also considered that the proposal is consistent with the objectives of the Bankstown Local Environment Plan (LEP) in terms of managing its impact on flood behaviour.
- The proposal would maintain the existing level of flood immunity to Henry Lawson Drive, Milperra Road and Newbridge Road and therefore would not adversely affect existing emergency response arrangements and access during time of flood.
- The proposal includes the acquisition of No. 439 Henry Lawson Drive, Milperra which is identified in the voluntary purchase scheme set out in BC 2004. This would provide the opportunity to restore the site in a flood compatible manner, the details of which will be developed during detailed design in consultation with Canterbury Bankstown City Council.
- Given the extent of works that are proposed as part of the project and the generally minor nature of their impact on flood behaviour, it is also considered that the project would not preclude or limit any of the structural measures identified in BC 2004 and BMT WBM 2017.

Consistency with the Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment

The proposal is considered to be consistent with the flood related principles set out in the *Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment* for the following reasons:

- The proposal would result in no significant change to the periodic flooding to Milperra Drain and other riverine ecosystems.
- There would be no change to the pollution hazard posed by the upgrade of the existing road during times of flood.
- Subject to the incorporation of mitigation measures identified in **Sections 5.2.1** and **6.3**, the proposal would have only a minor impact on flood behaviour, including those resulting from the filling of flood prone land.

Cumulative impacts

The proposal has the potential for cumulative impacts on flood behaviour in combination with the following projects that are located in its vicinity:

- Flower Power development at 479 Henry Lawson Drive, Milperra (existing)
- Widening of Milperra Drain within Bankstown golf course (in construction)
- Bankstown Airport redevelopment (in construction)
- Henry Lawson Drive and Tower Road intersection upgrade (proposed)
- Milperra Road and Murray Jones Drive intersection upgrade (proposed)

Subject to the incorporation of the mitigation measures that are identified in **Sections 5.2.1** and **6.3**, then the proposal would have only a minor and relatively localised impact on flood behaviour. It is therefore expected that the cumulative impacts of the proposal in combination with the projects in its vicinity would also be minor in nature.

The following projects are located in areas of the Georges River floodplain that are well removed from the proposal and are therefore not expected to result in cumulative impacts on flood behaviour:

- Henry Lawson Drive and Rabaul Road intersection upgrade
- Riverlands subdivision at 56 Prescott Parade, Milperra

Management of impacts

Section 6 sets out the approach that will be adopted during the detailed design phase to manage the flood risk to the proposal, as well as the impact it would have on flood behaviour through:

- documenting procedures and measures that are aimed at managing the risk of flooding to the proposal, as well as the potential for adverse impacts on existing flood behaviour within its vicinity
- identifying appropriate design standards for managing the flood risk during the construction and operational phases of the project
- including procedures aimed at reducing the flooding threat to human safety and infrastructure
- including controls that are aimed at mitigating the impact of the proposal (during construction and operation) on flood behaviour.

While the findings of the assessment presented in **Section 5.1** provide an indication of the potential impact construction activities would have on flood behaviour, further investigations will need to be undertaken during detailed design with the benefit of more detailed site layouts and staging diagrams. **Section 6.2** contains a range of potential measures which could be implemented in order to reduce the impact of construction activities on flood behaviour.

The assessment of flood behaviour during the operation of the proposal has provided an understanding of the scale and nature of the flood risk to the proposal infrastructure, as well as its impact on flooding in surrounding areas. A broad outline of measures which would need to be implemented during the detailed design phase in order to manage the proposal related flood risks and impacts are outlined in **Section 6.3**. The design of the proposal would need to incorporate measures that are aimed at:

- minimising adverse impacts on surrounding development for flood up to 1% AEP event;
- mitigating impacts on flood behaviour in properties where existing buildings would experience above-floor inundation during floods up to the 1% AEP event
- assessment of impacts during floods up to the PMF in the context of impacts on critical infrastructure and flood hazard
- minimising the potential for an increase in scour and erosion in areas downstream of the proposal, particularly within EIS proposal areas 1 and 2 that are located downstream of transverse drainage structures.

1 INTRODUCTION

Transport for NSW (Transport) is proposing to upgrade Henry Lawson Drive Upgrade between Keys Parade, Milperra, to Tower Road, Bankstown Aerodrome (known as the Henry Lawson Drive Upgrade Stage 1A) (the overall proposal). The proposal consists of upgrading a 1.3 kilometre length of Henry Lawson Drive and an additional 480 metres along Milperra Road, including intersection upgrades.

This Flooding Assessment Report has been prepared to assess the potential flood related impacts of the proposal. It will support a Review of Environmental Factors (REF) being prepared by Transport under Division 5.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and an Environmental Impact Statement (EIS) being prepared under Division 4.1 of the EP&A Act.

1.1 Proposal background

The overall proposal forms the first stage of the progressive upgrade to 7.5 kilometres of Henry Lawson Drive between the intersections of Hume Highway, Villawood, and the M5 South Western Motorway, Milperra.

The upgrade would help ease existing traffic issues and increase traffic capacity at key intersections to help meet growing demand, with residential, commercial and industrial development in the surrounding area expected to increase in the coming years. The upgrade would be delivered in three stages.

Subject to approval, construction of the Stage 1A proposal may commence in early 2023 and would take about two years to complete. Other stages of upgrading Henry Lawson Drive would be developed and assessed separately in the future.

1.2 Proposal location and setting

The overall proposal is located around 20 kilometres south west of the Sydney CBD in the City of Canterbury-Bankstown local government area. The proposal is mainly along Henry Lawson Drive and includes intersection upgrades at Tower Road, Newbridge/ Milperra Road and Auld Avenue.

Henry Lawson Drive is a key connection for traffic moving between the Hume Highway, Milperra Road /Newbridge Road and the M5 Motorway. It is also used for local travel trips between residences and services. In terms of heavy vehicle access, Henry Lawson Drive is designated as a B-Double access route that connects surrounding large industrial areas of Milperra, Revesby, Chipping Norton and Moorebank.

The proposal is located to the east of the Georges River and surrounding recreational areas. There are a number of Coastal Wetlands within and surrounding the proposal associated with the Georges River.

Located to the south west of the proposal, is a residential area with detached housing and sporting fields and passive recreation areas. To the south east, is the Bankstown Golf Course and urban bushland areas. North of Milperra Road comprises retail and commercial development that backs onto the Bankstown Airport and land currently being redeveloped, all of which access Henry Lawson Drive via Tower Road. Located north of Tower Road is the Georges River Golf Course.

1.3 Proposal overview

Key features of the overall proposal are described in the following sections and shown in **Figure 1.1**.

1.3.1 Key features of the REF proposal

Key features of the REF proposal include:

- widening Henry Lawson Drive from two to four lanes
- upgrading the signalised intersection of Henry Lawson Drive and Tower Road including:
    - an additional right turn lane from Tower Road onto Henry Lawson Drive
    - a new channelised short left-turn lane from Henry Lawson Drive (southbound) onto Tower Road
    - an additional right turn lane from Henry Lawson Drive (northbound) onto Tower Road
    - retaining the pedestrian crossing across Henry Lawson Drive on the southern side of the intersection.
- upgrading the signalised intersection of Henry Lawson Drive and Milperra Road /Newbridge Road including:
    - an additional right turn lane on the Milperra Road and Newbridge Road approaches to Henry Lawson Drive
    - an additional through lane on the Henry Lawson Drive southbound approach
    - the removal of the bus only lane on Milperra Road to provide an additional right turn lane on the Henry Lawson Drive northbound approach.
- removing the dedicated left turn slip lane into the ALDI and fast-food area with access being retained via a standard property driveway
- retaining the existing bus stop on Milperra Road (eastbound) and moving the westbound bus stop 20 metres to the west
- altering access to Auld Avenue to a “left in/left out” only configuration
- installing a new Henry Lawson Drive road bridge (over Milperra Drain) to the south of Auld Avenue (referred to as the Auld Avenue bridge) to carry northbound traffic and retaining the existing bridge for southbound traffic
- constructing new footpaths on the eastern side of Henry Lawson Drive to connect Tower Road to the existing bus stop on the eastbound lanes of Milperra Road and a new footpath on the southern side between Henry Lawson Drive to the bus stop on the westbound lanes of Milperra Road
- widening the shared user pathway between Flower Power (Keys Parade) and Newbridge Road to three metres and reconstructing footpaths along the western side of Henry Lawson Drive, where required
- adjusting existing drainage, including lengthening culverts, installing new drainage infrastructure and water quality controls
- relocating utilities (including electrical, gas, water and telecommunications)
- final roadworks including pavement, kerb and gutters, signs, lighting and line marking

- ancillary work for the project including, but not limited to road furniture, tie-in works, landscaping, earthworks and the like
- temporary ancillary compounds, stockpile sites and associated facilities.

1.3.2 Key features of the EIS proposal

Key features of the EIS proposal are identified below for each EIS Proposal Area.

EIS proposal area 1 – Henry Lawson Drive opposite Tower Road

The key features of EIS proposal area 1 are:

- widening of Henry Lawson Drive northbound lanes
- installing of fill embankments along the edge of the new carriageway to meet existing ground levels
- extending existing stormwater culvert and installing outlet scour protection measures
- installing additional stormwater drainage infrastructure and water quality treatments
- installing a vegetated channel along the toe of the new fill embankment
- adjusting the existing shared path to suit the new re-alignment and to connect it back to the existing path
- installing road furniture, including road safety barriers.

EIS proposal area 2 – Milperra Road opposite Bankstown Airport

The key features of the EIS proposal area 2 are:

- installing a new bus stop relocated from its existing position on Milperra Road
- installing a section of a new footpath to the bus stop (connecting to the remainder of the new path to Henry Lawson Drive – REF proposal)
- installing fill embankments along the edge of the new carriageway to meet existing ground levels
- extending existing stormwater culvert and installing outlet scour protection measures
- installing additional stormwater drainage infrastructure connecting to the outlet of the extended culvert
- installing road furniture, including road safety barriers.

EIS proposal area 3 – Henry Lawson Drive opposite Auld Avenue

The key features of the EIS proposal area 3 are:

- removing of existing ancillary structures
- installing temporary fencing, flagging of exclusion boundaries & temporary erosion and sediment controls for use as an ancillary facility and construction area
- installing fill embankments along the edge of the new carriageway to meet existing ground levels
- stabilising the ground surface following the completion of construction to minimise erosion.

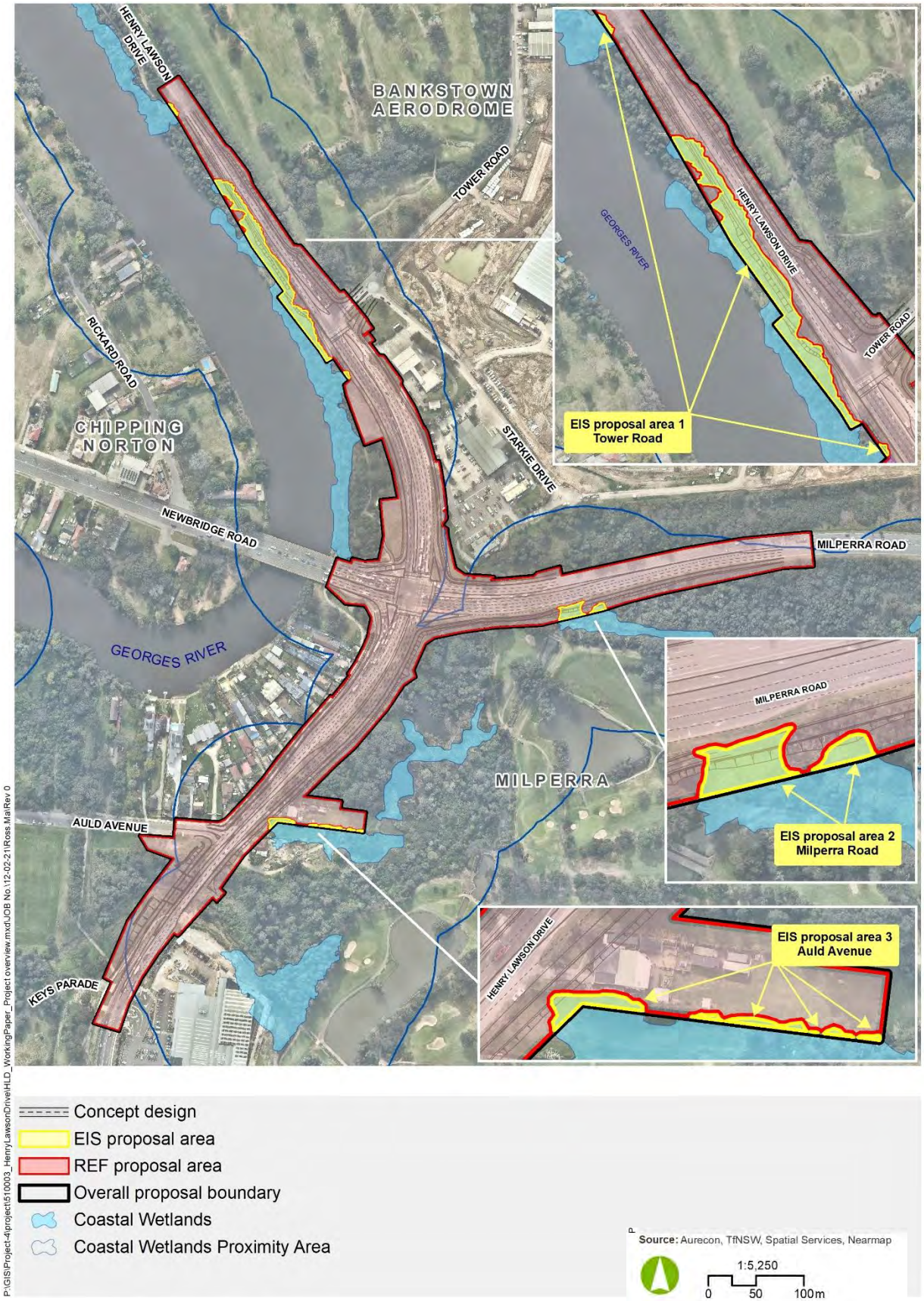

Figure 1.1 – Proposal overview

1.4 Purpose and scope of this report

This report has been prepared to support the preparation of the REF and EIS for the proposal. The REF has been prepared for the majority of the proposal, where Transport can approve works under the State Environmental Planning Policy (Infrastructure) 2008 (referred to as the 'REF proposal'). However, as part of the proposal is located within areas mapped as coastal wetlands under the State Environmental Planning Policy (Coastal Management) 2018, this is subject to an EIS. The work within mapped coastal wetlands is deemed designated development and is referred to as the 'EIS proposal'. These areas are shown in **Figure 1.1**.

The purpose of this report is to document the potential flooding impacts from the construction and operation of the proposal. This flooding assessment addresses the relevant SEARs for the EIS, as outlined in **Table 1.1**. The report:

- describes the existing environment with respect to flood behaviour
- assesses the impacts of constructing and operating the proposal on flood behaviour
- recommends measures to mitigate the identifiable flood related impacts that are attributable to the proposal.

1.4.1 Secretary's Environmental Assessment Requirements

As sections of the proposal intersect with areas mapped as Coastal Wetlands, an EIS has been prepared to assess the proposal under Division 4.1 of the EP&A Act. For this EIS, SEARs have been issued by the Department of Planning, Industry and Environment, which describe assessment requirements. The requirements relevant to the flood assessment for the EIS proposal area are presented in **Table 1.1**.

TABLE 1.1
SEARS RELEVANT TO THIS ASSESSMENT

Reference	Requirement	Where addressed in this report
Coastal Processes	• the effects of coastal processes and coastal hazards including the effects of sea level rise and climate change	Tidal conditions in Botany Bay that were adopted in the flood assessment were based on those in the *Georges River Flood Study* (BMT 2020a), the details of which are discussed in **Section 3.3**. The potential impact of the proposal on flow velocities and therefore scour potential and sedimentation in the receiving drainage lines is discussed in **Section 5.2.1**. An assessment of the potential impact on the volume of sediment in surface runoff discharging from the proposal, which would also impact on sedimentation in the receiving drainage lines, is provided in the Surface Water Assessment Report. The effects of sea level rise and climate change on flood behaviour in the vicinity of the proposal is discussed in **Section 5.2.3** of this report.

Reference	Requirement	Where addressed in this report
	• consistency with coastal zone management plans, floodplain risk management plans and flood hazards associated with the land	**Section 5.2.2** presents the findings of a review of the proposal in terms of its consistency with council and state government flood related plans. **Section 5.1.1** includes discussion on the potential flood hazard at proposed construction ancillary sites, while **Section 5.2.1** contains an assessment of the impact that the operation of the proposal would have on the hazardous nature of flooding.
Groundwater and surface water	• flooding – consideration of the impacts of the proposal on the hydraulic and hydrologic regime of the area.	**Sections 5.1** and **5.2** respectively present the findings of an assessment of the impact that the proposal would have on the existing flooding regime during its construction and operation.

1.5 Structure of this report

The structure of the report is outlined below:

- **Section 1** provides a brief overview of the proposal and the purpose of this report.
- **Section 2** sets out the relevant government legislation, policies and guidelines that were taken into consideration during the assessment.
- **Section 3** sets out the methodology that has been adopted in the definition of flood behaviour in the vicinity of the proposal and also the impact the proposal would have on flood behaviour. The chapter also contains a summary of the criteria and standards that have been adopted for the assessment based on consideration of the relevant government legislation, policies and guidelines.
- **Section 4** contains a brief description of the catchments through which the proposal runs. This chapter of the report also provides a description of flood behaviour in the vicinity of the proposal under present day (i.e. pre-proposal) conditions.
- **Section 5** deals with the flood risks to the proposal and its impact on flood behaviour during the construction and operation of the proposal. The chapter also presents the findings of an assessment of the potential impact of future climate change on flood behaviour, as well as the impact that a partial blockage of major hydraulic structures would have on flood behaviour in the vicinity of the proposal. The chapter also describes the potential cumulative impacts on flooding patterns that would result from the proposal in combination with other proposals in its vicinity.
- **Section 6** outlines potential measures to mitigate the construction and operational (i.e. post-construction) related impacts of the proposal on flooding conditions in adjacent development and to manage the risk of flooding to the proposal.
- **Section 7** contains a list of references cited in this report.
- **Annexure A** contains a series of figures which show flooding patterns for design storms with annual exceedance probabilities (AEPs) of 50%, 5%, 2%, 0.5% and 0.2%. **Annexure A** also contains a series of figures showing that show the change in peak flow velocities under post-project conditions during a 1% AEP storm.

The scales on figures referred to in this report are applicable when printed at A3 size. The figures referred to in **Sections 4** and **5** are located after **Section 7** of this report.

2 LEGISLATIVE AND POLICY CONTEXT

This section summarises the legislation, guidelines and/or policies driving the approach to the assessment. Relevant commonwealth, state and local government policies and guidelines are discussed in **Sections 2.1.1**, **2.1.2** and **2.1.3**, respectively.

2.1 Relevant legislation, policies and guidelines

2.1.1 Commonwealth guidelines

Australian Rainfall and Runoff

Australian Rainfall and Runoff (ARR) is a national guideline for the estimation of design flood characteristics in Australia. The application of the procedures, inputs and parameters set out in ARR is an important component in the provision of reliable and robust estimates of design flood behaviour to ensure that projects such as the upgrade of Henry Lawson Drive are designed in a manner that manages the impact of flooding.

The third edition of ARR was released in 1987 (ARR 1987) (Institute of Engineers Australia (IEAust) 1987), while a fourth edition of ARR was issued in 2019 (ARR 2019) (Geoscience Australia (GA) 2019).

The hydrologic and hydraulic models (collectively referred to as 'flood models') that were relied upon for the present investigation were based on models that were developed as part of the following studies that were undertaken for Canterbury Bankstown City Council:

- *Georges River Flood Study* (BMT 2020a)
- *Milperra Catchment Flood Study* (BMT WBM 2015)

BMT 2020a investigated hydrologic modelling approaches based on ARR1987 and a draft version of ARR 2019 that was released in 2016 (ARR 2016). Based on a comparison of peak flow estimates from the two modelling approaches it was decided to adopt the procedures in ARR 1987 as it gave a better match to peak flows derived from a flood frequency analysis of stream gauge records at the Liverpool Weir and was also consistent with Canterbury Bankstown City Council's existing flood mapping and flood planning levels.

For consistency with BMT 2020a the assessment of flood behaviour in the Georges River as part of the present investigation was also based on ARR 1987 procedures.

As WBM BMT 2015 was prepared prior to the release of both ARR 2016 and ARR 2019 it was based on the procedures in ARR 1987. For the purpose of the present investigation the flood models that were developed as part of WBM BMT 2015 have therefore been updated using the procedures in ARR 2019.

2.1.2 State legislation, policies and guidelines

Floodplain development manual

The *Floodplain Development Manual* (FDM) (DIPNR 2005) incorporates the NSW Government's Flood Prone Land Policy, the primary objectives of which are to reduce the impact of flooding and flood liability on owners and occupiers of flood prone property and to reduce public and private losses resulting from floods, whilst also recognising the benefits of use, occupation and development of flood prone land.

The FDM forms the NSW Government's primary technical guidance for the development of sustainable strategies to support human occupation and use of the floodplain, and promotes strategic consideration of key issues including safety to people, management of potential damage to property and infrastructure and management of cumulative impacts of development. Importantly, The FDM promotes the concept that proposed developments be treated on their merit rather than through the imposition of rigid and prescriptive criteria.

Flood and floodplain risk management studies undertaken by local councils as part of the NSW Government's Floodplain Management Program are carried out in accordance with the merits based approach promoted by the FDM. A similar merits based approach has been adopted in the assessment of the impacts the proposal would have on existing flood behaviour and also in the development of a range of potential measures which would be aimed at mitigating the impact of the proposal on the existing environment. In accordance with the FDM, the hydraulic and hazard categorisation of the floodplain was also considered when assessing the impact of the proposal on existing flood behaviour as well as the impact of flooding to the proposal and its users.

Guideline on development controls on low risk flood areas

In January 2007 the NSW Government issued Planning Circular PS 07-003 *New guideline and changes to section 117 direction and EP&A Regulation on flood prone land* which provided an overview of its new guideline to the FDM titled *Guideline on Development Controls on Low Flood Risk Areas*. More specifically, the circular provided advice on a package of changes concerning flood-related development controls on residential development on land subject to events above the 1% AEP flood and up to the Probable Maximum Flood (PMF) (i.e. land that is affected by flooding during events that are greater than 1% AEP in magnitude). These areas are sometimes known as low flood risk areas.

Guideline on Development Controls on Low Flood Risk Areas confirmed that unless there are exceptional circumstances, councils should adopt the 1% AEP flood as the basis for deriving the Flood Planning Level (FPL) for residential development. In proposing a case for exceptional circumstances, a council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. The guideline also notes that unless there are exceptional circumstances, councils should not impose flood related development controls on residential development on land above the residential FPL (low flood risk areas). However, the guideline does acknowledge that controls may need to apply to critical infrastructure (such as hospitals and airports) and consideration given to evacuation routes and vulnerable developments (such as aged care facilities and schools) in areas above the 1% AEP flood.

Based on the above requirements, the assessment of the impacts the proposal would have on existing flood behaviour and also the future development potential of flood affected land outside the proposal area relates to:

- all storms with AEPs up to 1% in intensity in the case of residential type development (and by default commercial and industrial type development)
- storms with AEPs greater than 1% in intensity in the case of critical infrastructure (such as hospitals) and vulnerable developments (such as aged care facilities and schools).

Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) and associated regulations set out the system of environmental planning and assessment for the state of New South Wales.

In July 2009 the NSW Minister for Planning issued a list of directions to local councils under section 117(2) of the EP&A Act. *Direction 4.3 - Flood Prone Land* applies to all councils that contain flood prone land within their LGA and requires that:

- A draft Local Environmental Plan (LEP) shall include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the FDM (including the Guideline on Development Controls on Low Flood Risk Areas).
- A draft LEP shall not rezone land within the Flood Planning Areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.
- A draft LEP shall not contain provisions that apply to the Flood Planning Areas which:
    - Permit development in floodway areas
    - Permit development that will result in significant flood impacts to other properties
    - Permit a significant increase in the development of that land
    - Are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services or
    - Permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.
- A draft LEP must not impose flood related development controls above the residential FPL for residential development on land, unless a council provides adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).
- For the purposes of a draft LEP, a council must not determine a FPL that is inconsistent with the FDM (including the Guideline on Development Controls on Low Flood Risk Areas) unless a council provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

The above requirements and how they have been considered in the assessment are similar those outlined in the preceding section for *Guideline on Development Controls on Low Flood Risk Areas*.

Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment

The Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment contains planning principles that are to be applied when:

- councils prepare a local environmental plans that applies to land within the Georges River catchment,
- a consent authority determines a development application within the Georges River catchment,

- or a public authority or another person proposes to carry out development or an activity which does not require development consent but which has the potential to adversely affect the water quality, river flows, flood regime or ecosystems within the Georges River catchment.

The aims and objectives of the Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment are:

- to maintain and improve the water quality and river flows of the Georges River and its tributaries and ensure that development is managed in a manner that is in keeping with the national, State, regional and local significance of the Catchment,
- to protect and enhance the environmental quality of the Catchment for the benefit of all users through the management and use of the resources in the Catchment in an ecologically sustainable manner,
- to ensure consistency with local environmental plans and also in the delivery of the principles of ecologically sustainable development in the assessment of development within the Catchment where there is potential to impact adversely on groundwater and on the water quality and river flows within the Georges River or its tributaries,
- to establish a consistent and coordinated approach to environmental planning and assessment for land along the Georges River and its tributaries and to promote integrated catchment management policies and programs in the planning and management of the Catchment,
- to provide a mechanism that assists in achieving the water quality objectives and river flow objectives agreed under the Water Reform Package.

Part 2, Section 9 of the Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment contains the following clause related to flooding:

> *(3)* ***Flooding***
>
> *The following are to be recognised -*
>
> *(a) the benefits of periodic flooding to wetland and other riverine ecosystems,*
>
> *(b) the pollution hazard posed by development on flood liable land in the event of a flood,*
>
> *(c) the cumulative environmental effect of development on the behaviour of flood water and the importance of not filling flood prone land.*

Floodplain risk management guidelines

Scientific evidence shows that climate change is expected to lead to sea level rise and an increase in flood producing rainfall intensities. The significance of these effects on flood behaviour would vary depending on geographic location and local topographic conditions. Climate change impacts on flood producing rainfall events show a trend for larger scale storms and increased depths of rainfall. Future impacts on sea levels are likely to result in a continuation of the rise in levels which has been observed over the last 20 years.

The NSW Government's *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007) recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities of between 10 and 30 per cent. Under current climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce about

a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce about a 0.2% AEP flood. On current projections the increase in rainfalls within the design life of the proposal is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit.

Based on the recommendations set out in DECC 2007 the 0.5% AEP and 0.2% AEP design storms were adopted as being analogous to an increase in 1% AEP design rainfall intensities of 10 and 30 per cent respectively, for assessing the impact future climate change could have on flooding conditions in the vicinity of the proposal. This range of potential increases also encompasses the values given in ARR 2019, which suggests a potential increase in rainfall intensities of between 9.5% and 19.7% by 2090 for Representative Concentration Pathways of between 4.5 and 8.5.

Climate Change 2007: The Physical Science Basis. Summary for Policymakers (Intergovernmental Panel on Climate Change (IPCC) 2007)) includes trends that indicate that average global sea level rise (not including ice flow melt) may be between 0.18 to 0.59 metres by between 2090 and 2100. Adding to this the ice flow melt uncertainty of up to 0.2 metres gives an adjusted global range of 0.18 to 0.79 metres.

IPCC 2007 and recent CSIRO modelling (see for example *Projected Changes in Climatological Forcing Conditions for Coastal Erosion in NSW* (McInnes et al 2007)) indicates that mean sea levels along the NSW coast are expected to rise by more than the global mean. Combining the relevant global and local information indicates that sea level rise on the NSW coast is expected to be in the range of 0.18 to 0.91 metres by between 2090 and 2100.

In its *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007), the NSW Government recommended sensitivity analyses be undertaken to assess the potential impact of sea level rise in the range 0.18 to 0.91 metres, dependent on the relevant proposal time horizon.

In 2009 the NSW Government released its *Sea Level Rise Policy Statement* (NSW Government 2009) which supported adaptation to projected sea level rise impacts. The policy statement included sea level rise planning benchmarks for use in assessing potential impacts of projected sea level rise in coastal areas, including flood risk and coastal hazard assessment. These benchmarks were a projected rise in sea level (relative to 1990 mean sea level) of 0.4 metres by 2050 and 0.9 metres by 2100, based on work carried out by the IPCC and CSIRO. In its *Flood Risk Management Guide: Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments* (DECCW 2010), the NSW Government recommended that these benchmark rises should be used to assess the sensitivity of flood behaviour to future sea level rise.

In 2012 the NSW Government announced its *Stage 1 Coastal Management Reforms* (NSW Government 2012). As part of these reforms, the NSW Government no longer recommends state-wide sea level rise benchmarks, with local councils now having the flexibility to consider local conditions when determining local future hazards.

In the absence of a formal State Government policy on sea level rise benchmarks, the previously recommended rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 have been adopted for assessing the impact future climate change could have on flooding conditions in the vicinity of the proposal. This approach is consistent with both the *Georges River Estuary Coastal Zone Management Plan* (Georges River Combined Councils' Committee (GRCCC) 2013) as well as the Georges River Tidal Inundation Study (BMT 2018) that was prepared on behalf of Georges River Council to assess the impact of sea level rise on an increase in tidal inundation in the lower reach of the Georges River.

2.1.3 Council policies and guidelines

The proposal is located in the former City of Bankstown local government area. The *Bankstown Local Environmental Plan 2015*, which still applies to land located in the former City of Bankstown local government area contains the following clause (Clause 6.3) relating to flood planning:

> *"(1) The objectives of this clause are as follows:*
>
> *(a) to minimise the flood risk to life and property associated with the use of land,*
>
> *(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,*
>
> *(c) to avoid significant adverse impacts on flood behaviour and the environment.*
>
> *(2) This clause applies to land at or below the flood planning level.*
>
> *(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:*
>
> *(a) is compatible with the flood hazard of the land, and*
>
> *(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and*
>
> *(c) incorporates appropriate measures to manage risk to life from flood, and*
>
> *(d) will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and*
>
> *(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.*
>
> *(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published by the NSW Government in April 2005, unless it is otherwise defined in this clause.*
>
> *(5) In this clause, flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard."*

The above approach is consistent with the NSW Government's *Guideline on Development Controls on Low Flood Risk Areas* which confirms that unless there are exceptional circumstances, councils should adopt the 1% AEP flood as the basis for deriving the FPLs for residential development.

The *Bankstown Development Control Plan 2015* was prepared to guide development in accordance with the *Bankstown Local Environmental Plan 2015.* Part B12 of the *Bankstown Development Control Plan 2015* includes a set of flood related controls that have been developed based on the merits based approach that is set out in the FDM to manage the impact of flooding on development as well as the impact that development would have on existing flood behaviour.

The requirements of the *Bankstown Local Environmental Plan 2015* and the *Bankstown Development Control Plan 2015*, and how they have been considered in the assessment are similar to those outlined in the preceding section for *Guideline on Development Controls on Low Flood Risk Areas*.

In May 2021 the NSW Government issued the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 that sets out changes to the flood planning clauses of the the *Bankstown Local Environmental Plan 2015* that are proposed to take effect on 14 July 2021. The proposed updates to the flood planning clauses under the Standard Instrument (Local Environmental Plans) Amendment (Flood Planning) Order 2021 are aimed at supporting better management of flood risk and building greater resilience in communities located on floodplains during floods greater than 1% Annual Exceedance Probability up to the Probable Maximum Flood (PMF). As floods larger than the 1% AEP event, up to the PMF have already been taken into consideration in the assessment that is presented in this report, the proposed updates to the flood planning clauses in the *Bankstown Local Environmental Plan 2015* would not affect the assessment outcomes.

3 METHODOLOGY

This section describes the methodology used to undertake the flooding assessment.

3.1 Key tasks

The key tasks comprising the flood assessment were broadly as follows:

- Review of available data and existing flood studies of the catchments within which the proposal is located
- Development of a set of hydrologic and hydraulic models (collectively referred to as 'flood models') of the catchments that are located within the study area
- Flood modelling and preparation of exhibits showing flood behaviour under present day (ie pre-proposal) conditions for design floods with AEPs of 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2%, as well as the PMF
- Assessment of the potential impact the proposal (both during its construction and operation) would have on flood behaviour for the aforementioned design flood events
- Assessment of the impact future climate change would have on flood behaviour under operational conditions
- Assessment of the impact a partial blockage of major hydraulic structures would have on flood behaviour under operational conditions
- Assessment of potential measures which aim to mitigate the risk of flooding to the proposal and its impact on existing flood behaviour.

The followings sections of this report set out the methodology which was adopted in the assessment of flood behaviour under pre-proposal conditions and during both the construction and operational phases of the proposal.

3.2 Summary of adopted assessment criteria and standards

Table 3.1 sets out the flood related assessment criteria and standards that have been established for the proposal with due consideration of the policies and guidelines outlined in the preceding sections of this report.

In accordance with the FDM, the hydrologic standards adopted are based on matching the level of protection to the likelihood and consequence of flooding. A merits based approach has been adopted in the assessment of the impacts the proposal would have on existing flood behaviour and also in the development of a range of potential measures which are aimed at mitigating its impact on the existing environment.

TABLE 3.1
SUMMARY OF ADOPTED ASSESSMENT CRITERIA AND STANDARDS

Aspect	Requirement
Flood risks to the proposal	
Impact of flooding on proposed construction activities	• Construction related flood risks need to be evaluated in the context of the construction period in order to set requirements that are commensurate to the period of time that the risk exposure occurs. To this end, this report identifies the risks associated with each construction activity such that informed decisions can be made on the flood criteria that are set as part of the Construction Environmental Management Plan (CEMP) for the proposal.
Upgrade of the existing road	• As a minimum, the upgrade of the existing road is to ensure the existing level of flood immunity (ie. the magnitude of flood that does not cause inundation to the travel lanes) is not reduced by the proposal. • Ideally, the upgrade of the existing road is to provide a 1% AEP level of flood immunity where feasible based on the extent of upgrade requirements, the hydrologic standard of the existing local road network and site constraints.
Duplication of existing bridge waterway crossings	• As a minimum, the duplication of existing bridge waterway crossings is to maintain the same level of clearance between the underside of the bridge structure and the peak 1% AEP flood level that is provided by the existing bridge. • Ideally, new bridges are to provide a minimum clearance of 0.5 metres between the underside of the bridge structure and the 1% AEP flood level due to local catchment flooding where this is feasible based on existing site constraints.
Impact of future climate change on flooding to the proposal	• The assessment of the potential impact future climate change could have on flood behaviour in the vicinity of the proposal was based on: o Increases in 1% AEP design rainfall intensities ranging between 10 and 30 per cent in accordance with the NSW Government's *Floodplain Risk Management Guideline: Practical Considerations of Climate Change* (DECC 2007)[1] o Rises in sea level of 0.4 metres by 2050 and 0.9 metres by 2100 based on the NSW Government's *Sea Level Rise Policy Statement* (NSW Government 2009)

Continued over

Aspect	Requirement
Impact of the proposal on flood behaviour	
Impact of construction activities on flood behaviour	• Construction related flood impacts are to be evaluated in the context of the construction period in order to set requirements that are commensurate to the period of time that the exposure to the potential impacts occurs. To this end, this report identifies the potential impacts associated with the proposal such that informed decisions can be made on the flood criteria that are set as part of the CEMP.
Impact of proposal on flood behaviour in existing development	• Floods up to 1% AEP in magnitude are to be considered in the assessment of measures that are required to mitigate any adverse impacts on flood behaviour attributable to the proposal. • Changes in flood behaviour under larger floods up to the PMF event are also to be assessed in order to identify impacts on critical infrastructure (such as hospitals) and vulnerable development (such as aged care facilities and schools), as well as to identify potentially significant changes in flood hazard as a result of the proposal.
Impact of the proposal on flood behaviour under future climate change conditions	• The assessment of the impact the proposal would have on flood behaviour under future climate change conditions was based on assessing the effect of the proposal on pre-proposal flood behaviour during a 0.5 % and 0.2 % AEP event.[1]

1. For the purpose of this assessment the 0.5% and 0.2% AEP events were adopted as being analogous to increases in 1% AEP design rainfall intensities of 10 and 30 per cent, respectively.

3.3 Definition of flood behaviour under pre-proposal conditions

In order to define the nature of flooding in the vicinity of the proposal it was necessary to develop a set of computer-based flood models. Separate flood models were developed to define flood behaviour in the vicinity of the proposal as a result of:

- mainstream flooding along the Georges River (referred to in this report as 'Georges River flooding')
- mainstream flooding and major overland flow along the Milperra Drain and the broader Milperra area (referred to in this report as 'Milperra catchment flooding').

The definition of Georges River flooding was based on a flood model that was originally developed as part of BMT 2020a (denoted in this report as the 'Georges River flood model'). Design discharge hydrographs used as input to the Georges River flood model were based on a series of hydrologic models of the Georges River and its tributaries that were developed as part of the *Georges River Flood Study* (Public Works Department (PWD), 1991). As part of BMT 2020a a hydraulic model was developed using the TUFLOW modelling software.

The definition of Milperra catchment flooding was based on a flood model that was originally developed as part of WBM BMT 2015 (denoted in this report as the 'Milperra catchment flood model') and subsequently updated as part of a letter report entitled *"Milperra Assessment"* (BMT 2020b). As part of BMT 2020b the flood model was updated to include additional survey of

the section of Milperra Drain in the vicinity of Henry Lawson Drive, as well as LiDAR survey that was flown in 2019 over the area of the Flower Power development at 479 Henry Lawson Drive, Milperra. A 'direct rainfall' approach was adopted whereby rain is applied to the grid of the two-dimensional hydraulic model which was developed using the TUFLOW modelling software.

The flood models that were developed as part of BMT 2020a and WBM BMT 2015 were updated for the purpose of the present investigation in order to more accurately define flood behaviour in the vicinity of the proposal. The definition of ground levels in the vicinity of the proposal were updated using detailed survey that was collected by Transport. The location, level and dimensions of drainage pits, pipes and box culverts in the vicinity of the proposal were updated or added to the flood models using detailed survey that was collected by Transport.

Details of the proposed upgrade of the Henry Lawson Drive and Tower Road intersection were incorporated into the flood models based on 50 per cent detailed design drawings that were prepared by AECOM on behalf of Bankstown Airport Limited (BAL).

Within the Georges River flood model, ground levels over the recently constructed Flower Power development at 479 Henry Lawson Drive, Milperra were updated using aerial survey that was flown in 2019, which is consistent with the approach adopted in BMT 2020b to update the Milperra catchment flood model.

Tidal boundary conditions in the Georges River flood model were based on those adopted in BMT 2020, which comprised a representative tidal cycle with a peak tidal water level corresponding to the Mean High Water Springs (MHWS) in Botany Bay.

Coincident Georges River and Milperra catchment flooding was based on the combinations adopted in WBM BMT 2015. Consideration was also given to the impact of the proposal on Milperra catchment flooding in the absence of elevated flood levels in the Georges River. For this purpose a tailwater level of 0.7 metres AHD was adopted, which is consistent with that adopted in both WBM BMT 2015 and BMT 2020b.

As noted in **Section 2.1.1** the flood model that was developed as part of WBM BMT 2015 was updated using the procedures set out in ARR 2019 for the derivation of design rainfall intensities, temporal patterns and losses. As part of these updates the 'direct rainfall' approach that was adopted in WBM BMT 2015 was replaced with a traditional rainfall runoff modelling approach over the area in the vicinity of the proposal. The DRAINS hydrologic modelling software was used to generate discharge hydrographs which were then applied to the TUFLOW model as internal point source and region inflows.

The results from the updated Georges River and Milperra catchment flood models were compared to the peak flood levels from BMT 2020a and BMT 2020b.

Flood behaviour in the vicinity of the proposal was defined for a range of events with AEPs of between 50% and 0.2%, as well as the PMF. Figures were prepared for each event showing the indicative extent and depth of inundation, as well as the direction and relative velocity of flow. Figures were also prepared showing the hydraulic and hazard categorisation during a 1% AEP event, which were defined using the procedures set out in the *Floodplain Development Manual* (DIPNR 2005).

A description of flood behaviour in the vicinity of the proposal under pre-proposal conditions is presented in **Section 4.3**, while a summary of the figures that show flooding behaviour under pre-proposal conditions is contained in **Section 4.3.1**.

3.4 Assessment of construction related impacts

A qualitative assessment was made of the construction related issues associated with flooding along the proposal based on indicative construction areas and activities as provided in the current design. The locations of surface works, construction ancillary sites and working platforms for bridge construction were overlaid onto the indicative flood extents for events with AEPs of 50%, 10%, 5% and 1%, as well as the PMF. This provided an understanding of the likelihood that flooding could occur in the vicinity of construction activities.

The potential flood risk to construction activities, as well as their impact on existing flood behaviour were assessed based on an understanding of flood behaviour under pre-proposal conditions during a 1% AEP event.[2] Consideration was also given to the potential for localised overland flooding to occur in construction areas.

Section 5.1 of this report deals with the impact that flooding could have on construction activities. It also includes an assessment of the impact that construction activities could have on flood behaviour external to the proposal footprint.

3.5 Assessment of operational related impacts

The structure of the TUFLOW model that was originally developed to define flood behaviour under pre-proposal conditions was adjusted to incorporate details of the proposal under operational conditions. The results of modelling a range of events with AEPs of between 50% and 0.2%, as well as the PMF were used to prepare a series of figures showing flooding patterns under operational conditions and afflux diagrams[3] showing the impact the proposal would have on flood behaviour.

Section 5.2.1 provides a summary of key features of the proposal that were incorporated into the hydraulic models used to define flood behaviour in its vicinity, as well as a discussion on the impacts that the proposal would have on flood behaviour during its operation.

3.6 Impact of future climate change on flood behaviour

The following sections describe the approach that was adopted to assess the potential impact of future climate change on flooding to the proposal, as well as the impact that the proposal may have on flood behaviour under future climate change conditions. The findings of this assessment are contained in **Section 5.2.3** of this report.

[2] While the 1% AEP event has been adopted for the purpose of the preliminary assessment, as per the design criteria set out in **Table 3.1**, the management of flood impacts during the construction of the project will need to consider the period of risk exposure in establishing an appropriate flood standard.

[3] Afflux is an increase in peak flood levels caused by a change in floodplain or catchment conditions. A positive afflux represents an increase and conversely a negative afflux represents a decrease in peak flood levels when compared to pre-project conditions.

3.6.1 Impact of future climate change on flooding to the proposal

Based on the adopted assessment criteria set out in **Table 3.1**, the following scenarios were adopted as being representative of the likely lower and upper estimates of future climate change related impacts over the design life of the proposal:

- Scenario 1 – based on an assumed 10 per cent increase in currently adopted design rainfall intensities, together with a rise in sea level of 0.4 metres.
- Scenario 2 – based on an assumed 30 per cent increase in currently adopted design rainfall intensities, together with a rise in sea level of 0.9 metres.

Table 3.2 shows the combination of catchment flooding and coincident storm tide conditions that were used to define the 1% AEP design flood envelopes under Scenario 1 and 2 climatic conditions.

TABLE 3.2
DERIVATION OF DESIGN FLOOD ENVELOPES FOR ASSESSMENT OF POTENTIAL CLIMATE CHANGE IMPACTS – 1% AEP EVENT

Scenario	George River and Milperra Catchment flood(1)	Downstream condition in Botany Bay(2,3)
Current Conditions	1% AEP	Mean high water level spring (MWHLS) [0.7 m AHD]
Scenario 1	Based on 1% AEP rainfall intensities increased by 10%(1)	MHWLS plus 0.4 m [1.1 m AHD]
Scenario 2	Based on 1% AEP rainfall intensities increased by 30%(1)	MHWLS plus 0.9 m [1.6 m AHD]

1. Design rainfall intensities for the 0.5% and 0.2% AEP events were adopted as being analogous to the 1% AEP design rainfall intensities increased by 10 per cent and 30 per cent, respectively.
2. Applied to the Georges River flood model only.
3. Values in [ ] relate to adopted peak tide level.

3.6.2 Impact of the proposal on flood behaviour under future climate change conditions

The predicted impact that the proposal may have on flood behaviour under potential future climate change conditions was based on assessing its effect on pre-proposal flood behaviour during a 0.5% and 0.2% AEP event as proxies for assessing the sensitivity to an increase in rainfall intensity on the 1% AEP event due to future climate change.

3.7 Impact of a partial blockage of major hydraulic structures on flood behaviour

The assessment of the impact that a partial blockage of major hydraulic structures may have on flood behaviour was based on guidance provided in ARR 2019, as well as *AR&R Revision Projects – Project 11 – Blockage of Hydraulic Structures* (IEAust 2013).

In regards culvert structures, IEAust 2013 recommends the adoption of a 20 per cent blockage factor where the height of a culvert is less than three metres or its width is less than five metres, while ARR 2019 recommends that the adopted blockage factor be based on the size of the largest 10% of debris relative to the size of the waterway opening; the availability, mobility and transportability of the debris; and the magnitude of the flood event.

With due consideration to these guidelines, the structure of the hydraulic model was adjusted to include a 20 per cent blockage factor which was applied to all transverse drainage culvert structures along the proposal (ie. culvert structures that convey runoff from the catchments upstream of the proposal area).

The impact an accumulation of debris on existing and proposed bridge structures over Milperra Drain was also assessed given the potential impact on flood behaviour in the vicinity of the proposal. The impact a one metre thick raft of debris lodged beneath the underside of the existing bridge structures, in combination with a four metre wide raft of debris lodged on the upstream side of each pier over the full height of the clear opening, was assessed as part of the investigation. The debris raft that was applied represents approximately 30 per cent of the waterway area of the existing bridge. The debris raft was applied to the upstream face of the existing bridge. As the proposed bridge is downstream and in-line with the existing bridge no additional blockage factor was applied to the proposed bridge.

The findings of the blockage related impact assessment are contained in **Section 5.2.4**.

4 EXISTING ENVIRONMENT

4.1 Overview

The REF and EIS proposal areas are both located within the following two catchments:

- Georges River
- Milperra Drain

Milperra Drain forms part of the much larger Georges River catchment which drains to Botany Bay. **Section 4.2** provides a brief description of the two catchments including drainage features in the vicinity of the proposal. **Section 4.3** provides a description of the nature of main stream flooding and major overland flow in the vicinity of the proposal under present day (ie pre-proposal) conditions. Main stream flooding and major overland flow have collectively been termed 'flooding' within this report.

4.2 Catchment description

4.2.1 Georges River

The Georges River is about 100 kilometres long and has a total catchment area of approximately 960 square kilometres. From its headwaters near Appin, the river flows north towards Campbelltown, through Liverpool and the Chipping Norton Lakes Scheme, and then east through Bankstown to Botany Bay.

The upper catchment area, south of Campbelltown, is still in its natural forested state. From Campbelltown to Liverpool, the steep river valley gives way to more gently undulating terrain. Development starts to become more prevalent on either side of the river towards Liverpool.

Despite the extent of development along the section of river downstream of Liverpool, riparian vegetation remains along significant lengths of its banks, including in the vicinity of the proposal.

The tidal limit of the river is at the Liverpool weir which was constructed in 1836 as a causeway crossing and to create a convenient source of water for Liverpool. The 20 km reach of the river downstream of the weir, between Liverpool and Picnic Point, includes the major floodplain area of the river. This area (which includes the study area), being located within the south-west portion of Sydney's metropolitan area, is heavily urbanised and there are significant flood problems.

The final 20 km of the lower river, between Picnic Point and Botany Bay is typical of a deeply incised broad estuary and hence there are numerous bays and small inlets. Intensive development has occurred along both banks of the river, most of which is perched high above river flood levels. Major tributaries in the lower river include Salt Pan Creek and the Woronora River.

The Newbridge Road bridge, which crosses the Georges River to the west of the proposal area, is a relatively high level structure which has a deck level of around 7.5 m AHD.

Figure 4.1, sheet 1 shows that the section of the proposal area to the north of Milperra Road runs along the eastern bank in close proximity to the Georges River. The section of Henry Lawson Drive between Milperra Road and Tower Road is kerb and guttered, with runoff controlled by a series of pit and pipe drainage systems that include two outlets that discharge into the Georges River along its eastern bank.

The section of Henry Lawson Drive to the north of Tower Road that lies within the proposal area is on fill embankment where runoff flows off the road as relatively shallow 'sheet' flow into the adjoining areas where it is conveyed overland to the Georges River. **Figure 4.1**, sheet 1 shows that a portion of the adjoining area to the west of the road is located within the EIS proposal boundary (EIS proposal area 1).

Survey of the area shows the section of Henry Lawson Drive to the north of Tower Road has an elevation of around 2.5 metres AHD.

A 2.4 metres wide by 1.2 metres high box culvert crosses Henry Lawson Drive about 100 metres to the north of Tower Road where it discharges into the Georges River (denoted existing transverse drainage structure EXD01 on **Figure 4.1**, sheet 2). The box culvert controls runoff from a portion of the Georges River Golf Course and Bankstown Aerodrome, which is conveyed to the box culvert via a grassed lined channel that runs through the golf course. **Figure 4.1**, sheet 2 shows that the outlet of the box culvert is located within the EIS proposal boundary (EIS proposal area 1).

4.2.2 Milperra Drain

Milperra Drain has a catchment area of approximately 10 square kilometres, the extent of which is shown on **Figure 4.1**, sheet 1. Milperra Drain runs from east to west over a length of about 4.5 kilometres and joins the Georges River on its left (eastern) bank a distance of approximately 1.7 kilometres downstream of the Newbridge Road Bridge.

A large part of the catchment lies to the north of Milperra Road and is drained by four small tributaries that run through Bankstown Aerodrome land. A fifth tributary drains the south-eastern portion of the catchment.

The terrain is flat to undulating with ground levels rising from around 1.0 metres AHD at the confluence with the Georges River to around 70 metres AHD in the north-east.

The catchment contains a variety of land usage, with extensive areas of open space, which includes the Bankstown Aerodrome at its centre. A heavy concentration of industry is present adjacent to the middle to lower reaches of Milperra Drain between Milperra Road and Ashford Avenue. Areas of residential development are located in the upper reaches of the drainage system which is typically piped along most of its length.

The section of Milperra Drain where it runs through the Bankstown Golf Course to the south of the proposal area comprises a vegetated channel of varying width. Canterbury Bankstown City Council is in the process of widening the channel over a 570 metre length of the drain where it runs through the northern portion of the golf course.

There is little to no fall in the invert of Milperra Drain where it runs through the Bankstown Golf Course to Henry Lawson Drive. Downstream of Henry Lawson Drive invert levels fall from an elevation of around 0.0 m AHD beneath the existing bridge to around –1.0 m AHD at the location where Milperra Drain discharges to the Georges River.

Between the golf course crossings and the Georges River, the Milperra Drain is natural in its condition and of limited capacity due to the presence of dense vegetation on both the in bank and overbank areas of the watercourse.

Figure 4.1, sheet 2 shows the area of Milperra Road and Henry Lawson Drive within the proposal area that presently drains to Milperra Drain. Runoff from this section of road is controlled by a series of pit and pipe drainage systems that discharge to Milperra Drain along its northern bank.

Henry Lawson Drive where it crosses Milperra Drain is located on a bridge structure that comprises four spans of a total length of 32 metres (denoted Auld Avenue bridge on **Figure 4.1**, sheet 2).

A 1.5 metres wide by 1.2 metres high box culvert crosses Milperra Road about 190 metres east of its intersection with Henry Lawson Drive where it discharges into Milperra Drain on its northern bank (denoted existing transverse drainage structure EXD02 on **Figure 4.1**, sheet 2). The box culvert controls runoff from an area of reserve to the north of Milperra Road, as well as a portion of Bankstown Aerodrome. **Figure 4.1**, sheet 1 shows the area into which this box culvert discharges is located within the EIS proposal boundary (EIS proposal area 2).

4.3 Description of existing flood behaviour

4.3.1 General

The following sections of the report provide a brief description of patterns of both Georges River and Milperra catchment flooding under pre-proposal conditions. The following figures are also referred to in the following discussion:

- **Figures 4.2**, **4.3** and **4.4** (2 sheets each) show the indicative extent and depth of inundation due to Georges River flooding for a 10% and 1% AEP event, as well as the PMF event, respectively.
- **Figures 4.5**, **4.6** and **4.7** (2 sheets each) show the indicative extent and depth of inundation due to Milperra catchment flooding for a 10% and 1% AEP event, as well as the PMF event, respectively.
- **Annexure A** contains a series of figures that show patterns of Georges River and Milperra catchment flooding in the vicinity of the proposal for 50%, 5%, 2%, 0.5% and 0.2% AEP events. **Annexure A** also contains a series of figures that show the provisional hazard of land for a 1% AEP flood event.

4.3.2 Georges River flooding

For the purpose of describing existing flood behaviour in the Georges River catchment, the following discussion has been limited to mainstream flooding in the vicinity of the proposal.

During a 20% AEP event, floodwater from the Georges River will overtop its eastern bank and inundate a section of Henry Lawson Drive to the north of Tower Road over a length of about 1.2 kilometres and to a maximum depth of about 0.9 metres. At this depth floodwaters would be unsafe to vehicles and persons. It is noted that the section of Henry Lawson Drive that is inundated is mainly located outside the proposal area with the exception of a 200 metre length at the northern end of the proposal.

Floodwater from the Georges River will back up Milperra Drain and overtop the deck of the Auld Avenue bridge to a depth of 0.3 metres during a 5% AEP event, while the section of Henry Lawson Drive to the south of the bridge will be inundated over a 260 metres length (140 metres of which is located within the proposal area) and to a maximum depth of 1 metre.

Floodwater from the Georges River that backs up Milperra Drain during a 5% AEP event will also inundate a 1.2 kilometre length of Milperra Road to the east of Henry Lawson Drive to a maximum depth of 1 metre. The depth of floodwater along both Henry Lawson Drive and Milperra Road would be hazardous to vehicles and persons.

Floodwater that surcharges the eastern bank of the Georges River as well as Milperra Drain during a 1% AEP event will inundate the full length of Henry Lawson Drive and Milperra Road within the proposal area. The section of Henry Lawson Drive at the northern end of the proposal area would be inundated to a maximum depth of over 3 metres. The floodwater would also inundate Henry Lawson Drive over a distance of 1.1 kilometres to the north and 300 metres to the south of the proposal, while flooding along Milperra Road will extend over a distance of 1.1 kilometres to the east of the proposal.

Floodwater that surcharges the Georges River across its eastern bank during a 1% AEP event will also inundate a number of residential properties that are located to the south of the Newbridge Road bridge, as well as commercial properties on the western side of Henry Lawson Drive to the north of Milperra Road.

The proposal area will be inundated to depths of between 6 and 8 metres during the PMF. **Figure 4.4**, sheet 1 shows that significant depths of flooding will occur across the broader area in the vicinity of the proposal.

The extent and depth of flooding to Henry Lawson Drive and Milperra Road, both within the proposal area and in its immediate vicinity, would limit the ability to improve their level of flood immunity as part of the proposed road upgrade.

Due to their low lying nature the areas within the EIS proposal boundary will experience frequent inundation due to floodwaters that originate in the Georges River.

4.3.3 Milperra catchment flooding

This section provides a description of mainstream flooding along the Milperra Drain, as well as major overland flow along the drainage lines and overland flow paths within the local catchments in the vicinity of the proposal.

During storms as frequent as 50% AEP, floodwater will surcharge the section of Milperra Drain that runs to the south of the proposal area where it will inundate areas of Bankstown golf course to depths that exceed 1 metre in a number of locations. Floodwater will also surcharge the main channel of Milperra Drain to the west (downstream) of Henry Lawson Drive where it will inundation the section of Auld Avenue that is located adjacent to Gordon Parker Reserve.

During a 10% AEP storm event Milperra Road will be inundated by floodwater that surcharges the main channel of Milperra Drain about 200 metres to the east of Henry Lawson Drive. It is noted that flooding would be confined to the outer lanes and to relatively shallow depths of 0.2 metres or less.

During a 1% AEP storm on the Milperra catchment in the absence of elevated flood levels in the Georges River, flooding from the Milperra Drain will inundate the full width of Milperra Road about 200 metres to the east of Henry Lawson Drive. Under this combination of flooding the peak flood level at the Auld Avenue bridge is about 1 metre below the top of deck level. Flow that arrives at the inlet to the transverse drainage structure that crosses Henry Lawson Drive to the north of

Tower Road (denoted transverse drainage structure EXD01 on **Figure 4.6** sheet 2) will pond to a depth of 1.8 metres above its inlet, which is still 0.1 metres below the edge of road level.

During a 1% AEP storm on the Milperra catchment in combination with a 5% AEP flood in the Georges River, peak flood levels in the vicinity of the proposal area are controlled by flood levels in the Georges River. Under this combination of flooding the peak flood level at the Auld Avenue bridge is about 0.3 metres above its deck level. Floodwaters would also inundate the northern portion of the proposal area as a result of peak flood levels in the Georges River.

All three areas within the EIS proposal boundary would experience frequent inundation due to runoff from the Milperra catchment. EIS proposal area 1 is inundated by runoff that is conveyed by the box culvert that crosses Henry Lawson Drive to the north of Tower Road, while EIS proposal area 2 is inundated by runoff that is conveyed by the box culvert that crosses Milperra Road to the east of Henry Lawson Drive. Due to its low lying nature EIS proposal area 3 would be inundated by flow that originates from the section of Milperra Drain where it runs through the Bankstown golf course.

5 IMPACT ASSESSMENT

This chapter deals with the flood risks to the proposal and its impact on flood behaviour during the construction and operation of the proposal. The chapter also describes the potential cumulative impacts on flooding patterns that would result from the proposal in combination with other proposals in its vicinity.

5.1 Impacts during construction

This section provides an assessment of the flood risk associated with the construction of the proposal, as well as an overview of the potential impacts that the proposed construction activities could have on flood behaviour. For the purpose of this assessment the proposal area has been split into the following three areas of work (labelled work area (WA) 1 to 3 in this report for ease of reference):

- Henry Lawson Drive north work area (WA1)
- Milperra Road work area (WA2)
- Henry Lawson Drive south work area (WA3)

This section also provides an assessment of the flood risks associated with the four construction ancillary sites (denoted C1 to C4) and temporary piling platform (P1) that are identified in Chapter 3.3 (Construction activities) of the REF.

Figure 5.1 (2 sheets) shows the locations of the construction work areas, ancillary sites and temporary piling platform that are referred to in this report.

5.1.1 Potential flood risks at construction work areas

Without the implementation of appropriate management measures, the inundation of the construction work areas and ancillary sites by floodwater has the potential to:

- cause damage to the proposal works and delays in construction programming
- pose a safety risk to construction workers
- detrimentally impact the downstream waterways through the transport of sediments and construction materials by floodwater
- obstruct the passage of floodwater and overland flow through ancillary works such as site sheds, stockpiles and some types of temporary fencing, which in turn could exacerbate flooding conditions in existing development located outside the construction footprint.

Table 5.1 at the end of this section provides a summary of the assessed flood risk at each construction work area and their associated activities. **Figure 5.1** (2 sheets) shows the extent to which Georges River flooding of varying magnitude affect each construction work area, while **Figure 5.2** (2 sheets) shows the corresponding extents based on Milperra catchment flooding.[4] Further details of each construction ancillary site and the associated activities is provided in Chapter 3.4 (Ancillary facilities) of the REF.

[4] The flood extents shown on **Figure 5.2** (2 sheets) are based on Milperra catchment flooding in the absence of elevated flood levels in the Georges River.

Construction ancillary sites

Figure 5.1 (2 sheets) shows the location of four construction ancillary sites (denoted C1 to C4) that are proposed to support construction across the work areas. Each ancillary site would contain a range of site facilities that would include offices, staff amenities, parking and storage areas for plant, equipment and materials, as well as fencing. **Table 5.1** provides a summary of the ancillary facilities within each work area.

The flood affectation of the four ancillary sites can be summarised as follows:

- Georges River site (C1):
    - A relatively localised area in the north of the site would be inundated by Georges River flooding during a 5% AEP event, while the majority of the site would be inundated to a maximum depth of 1.2 metres during a 1% AEP event.
    - The site is not impacted by Milperra catchment flooding for events up to 1% AEP in magnitude.
- Newbridge Road site (C2):
    - The site is not impacted by Georges River flooding for events up to 5% AEP in magnitude.
    - The full extent of the site would be inundated by Georges River flooding during a 2% AEP event to a maximum depth of 0.3 metres, increasing to 0.6 metres during a 1% AEP event.
    - The site is not impacted by Milperra catchment flooding for events up to 1% AEP in magnitude.
- Henry Lawson Drive site (C3):
    - A relatively localised area in the east of the site would be inundated by Georges River flooding during a 20% AEP event, while the majority of the ancillary site would be inundated to a depth of between 0.5 and 2.2 metres during a 5% AEP event. During a 1% AEP event the site would be inundated to a depth of between 1.5 and 3.3 metres due to Georges River flooding.
    - The south-eastern portion of the site would be inundated by floodwaters that originate in Milperra Drain during storms more frequent than 50% AEP in magnitude, while almost half of the site would be inundated during a 5% AEP event to a maximum depth of 1.1 metres. During a 1% AEP event about two thirds of the site would be inundated by floodwaters that originate in Milperra Drain to a maximum depth of 1.4 metres.
- Auld Avenue site (C4):
    - The site is not impacted by Georges River flooding for events up to 10% AEP in magnitude.
    - The majority of the site would be inundated by Georges River flooding during a 5% AEP event to a maximum depth of 0.6 metres, increasing to 1.6 metres during a 1% AEP event.
    - The site is not impacted by Milperra catchment flooding for events up to 1% AEP in magnitude.

Sites facilities located on the floodplain, particularly in areas of high hazard[5], pose a safety risk to construction personnel. All four proposed construction ancillary sites include land that would be suitable for site facilities that is located outside areas of high hazard flooding due to a 1% AEP Milperra catchment flood event in the absence of elevated flood levels in the Georges River.

While ancillary sites C1 and C2 are located on land that is outside areas of high hazard during a 1% AEP Georges River flood event, flooding to ancillary sites C3 and C4 would be unsafe to construction personnel during this event. It will therefore be necessary to implement emergency response procedures in order to manage the risk that flooding to ancillary sites C3 and C4 would pose to construction personnel and equipment. Flooding from the Georges River takes longer to peak compared to Milperra catchment flooding, which would provide more time to enable flood warning and response procedures to be implemented. A broad outline of potential mitigation measures aimed at managing the risk of flooding to site facilities is provided in **Section 6.2**.

Construction ancillary sites C1, C3 and C4 include land that would be inundated during a 5% AEP flood. In accordance with standard Transport procedures contingency planning would be required should site facilities be located in these areas.

Earthworks

Earthworks will be required across all the construction work areas in order to construct the road works. This would include excavation to the foundation level of the new road pavement and installing fill material to widen road embankments and to construct the approach embankments of the new bridge.

The level of flood affectation of the proposed earthworks within each construction work area in regards to Georges River flooding can be summarised as follows:

- The northern portion of the Henry Lawson Drive north work area (WA1) is located on land that is inundated by floodwater that surcharges the eastern bank of the Georges River during a 20% AEP event. The area impacted includes EIS proposal area 1. During a 1% AEP Georges River flood the full extent of earthworks within WA1 would be inundated to a maximum depth of over 3 metres.
- The proposed earthworks associated with widening Milperra Road along its southern side within the Milperra Road work area (WA2) are located on land that is impacted by floodwater that surcharges the Georges River and backs up Milperra Drain during a 10% AEP event. The area impacted includes EIS proposal area 2. During a 5% AEP event the full extent of earthworks along the section of Milperra Road to the east of Henry Lawson Drive would be inundated by floodwater originating from the Georges River to a maximum depth of about 2 metres, increasing to 3 metres during a 1% AEP event.

[5] High hazard flooding is defined in the *Floodplain Development Manual* (Department of Planning, Infrastructure and Natural Resources (DIPNR) 2005) as flooding that is a possible danger to personal safety, where evacuation by trucks and able-bodied adults would be difficult and where there is potential for significant structural damage to buildings. High hazard flooding is initially categorised based on the depth and velocity of flooding but can be revised through the provision of effective flood emergency planning and response procedures to reduce the consequences of flooding if there is sufficient warning time.

- The earthworks within the Henry Lawson Drive south work area (WA3) is located on land that typically lies above the 5% AEP George River flood with the exception of an area along its western side, to the south of Auld Avenue bridge that would be impacted by floodwater that backs up Milperra Drain during floods as frequent as 10% AEP. During a 1% AEP Georges River flood the full extent of earthworks within WA3 would be inundated to a maximum depth of over 2 metres.

The level of flood affectation of the proposed earthworks within each construction work area in regards to Milperra catchment flooding can be summarised as follows:

- The proposed earthworks associated with the widening of Henry Lawson Drive along its eastern side within the Henry Lawson Drive north work area (WA1) are located on land that is inundated by runoff that surcharges an adjacent channel that runs through the Georges River golf course during storms as frequent as 50% AEP. The proposed earthworks along the western side of Henry Lawson Drive includes an area of land within EIS proposal area 1 that would be frequently inundated by runoff that is conveyed by the box culvert that crosses Henry Lawson Drive to the north of Tower Road.
- The proposed earthworks associated with the widening of Milperra Road along its southern side within the Milperra Road work area (WA2) are located on land that is inundated by runoff that surcharges the section of Milperra Drain that runs through the Bankstown golf course during storms as frequent as 50% AEP. The proposed earthworks along the southern side of Milperra Road also includes an area of land within EIS proposal area 2 that would be frequently inundated by runoff that is conveyed by the box culvert that crosses Milperra Road to the east of Henry Lawson Drive.
- The earthworks within the Henry Lawson Drive south work area (WA3) are located on land that typically lies above the 1% AEP Milperra catchment flood with the exception of some relatively localised areas around the Auld Avenue bridge that would be exposed to relatively frequent inundation due to their low lying nature.

The inundation of the earthworks by floodwater has the potential to cause scour of disturbed surfaces and the transport of sediment and construction materials into the receiving waterways. It would therefore be necessary to plan, implement and maintain measures that are aimed at managing the diversion of floodwater either through or around the construction areas. A broad outline of potential mitigation measures is provided in **Section 6.2**.

Bridge construction

The existing Auld Avenue bridge would be duplicated as part of the proposal. Based on the current design, the proposed bridge would comprise a two span arrangement with the central pier located on the northern bank of Milperra Drain. **Figure 5.1**, sheet 2 shows the potential extent of a temporary working platform that would be provided to construct the central pier and to support cranes that are required to install various bridge components including precast sections and beams (denoted working pad WP1).

In order to construct the central pier for the new bridge it is likely that the footprint of the temporary working platform would be located across part of the main channel of Milperra Drain in an area that would be frequently inundated by flow. It would therefore be necessary to design and construct the temporary working platform to manage the potential for scour and transport of material into Milperra Drain, whilst also maintaining a passage for the conveyance of floodwater through the construction site. **Section 6.2** provides a summary of potential measures to manage these impacts.

5.1.2 Potential impacts of construction activities on flood behaviour

Construction activities have the potential to exacerbate flooding conditions when compared to both pre-proposal and operational conditions. This is because construction activities typically impose a larger footprint on the floodplain due to the need to provide temporary structures, such as ancillary sites, outside the operational proposal footprint which would be removed following the completion of construction activities.

A qualitative assessment was undertaken of the potential impacts that construction activities could have on flood behaviour, the key findings of which are summarised in **Table 5.1**. The potential impacts are largely described for the overall proposal (the majority being relevant to the REF proposal). Where impacts occur to areas of the EIS proposal, this is identified and described.

The key findings of the investigation in terms of the impact of proposed construction activities on flood behaviour can be summarised as follows:

i. While the impact of the four ancillary sites on flood behaviour in both the Georges River and Milperra catchment is likely to be relatively minor and localised, there is the potential for materials stored within the ancillary sites to be displaced and transported along the Georges River should a flood occur during the construction of the proposal.

ii. The potential impact of the proposed earthworks in all three work areas on flood behaviour are not expected to be significantly greater than those under operational conditions. The exception to this is at the outlet of existing drainage structures where there is the potential for the proposed earthworks to impact on local catchment runoff discharging from the culverts unless measures are implemented to maintain temporary drainage paths through the work areas during the modification of existing drainage structures. This would apply to the outlet of transverse drainage structure PXD1 (located within EIS proposal area 1 in Henry Lawson Drive north work area (WA1)), transverse drainage to the east of Henry Lawson Drive (within EIS proposal area 2 in the Milperra Road work area (WA2)) and south of Milperra Road (within the Henry Lawson Drive south work area (WA3)).

iii. Should flooding occur during the construction of the proposal that inundates the areas of earthworks within all three work areas there is a risk of scour to any exposed surfaces and the transport of sediment into the adjacent watercourses unless measures are implemented to cover exposed areas.

iv. The working platform for the construction of the new Auld Avenue bridge has the potential to obstruct the conveyance of flow in Milperra Drain during events more frequent that 50% AEP. This in turn may impact on the extent and depth of inundation and flow velocities in Milperra Drain.

While the findings of the assessment provide an indication of the potential impacts of construction activities on flood behaviour, further investigation would need to be undertaken during detailed design, as layouts and staging diagrams are further developed. Consideration would also need to be given to setting an appropriate hydrologic standard for mitigating the impacts of construction activities on flood behaviour, taking into account their temporary nature and therefore the likelihood of a flood of a given AEP occurring during the construction period.

Measures aimed at mitigating the impacts of construction activities on flood behaviour will be developed further during the detailed design phase and included in the Construction Environment Management Plan (CEMP) for the proposal. Further details on the range of measures which will be implemented to mitigate the potential construction related impacts of the proposal are outlined in **Section 6.2**.

TABLE 5.1
SUMMARY OF ASSESSED FLOOD RISKS AND POTENTIAL IMPACTS AT PROPOSED CONSTRUCTION WORK AREAS

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Henry Lawson Drive north (WA1)	Georges River ancillary site (C1)	5% AEP	1% AEP	✓	✓	x	x	Should a 5% AEP Georges River flood occur during the construction of the proposal then the site would be inundated, albeit over a relatively localised area of about 150 m^2 and to a maximum depth of 0.4 m. Should a 2% AEP Georges River flood occur during the construction of the proposal the majority of the site would be inundated to maximum depth of 1.0 m, increasing to 1.2 m during a 1% AEP Georges River flood. The site is not impacted by Milperra catchment flooding for events up to 1% AEP in magnitude.	The proposed site facilities and the storage of materials has the potential to obstruct the conveyance of flow from the Georges River should a flood event greater than 5% AEP in magnitude occur during the construction phase of the proposal. The resulting impacts on flood behaviour are likely to be relatively localised given the extent of Georges River flooding relative to the extent of the ancillary site. However, there is also the potential for materials stored within the ancillary site to be displaced and transported along the Georges River. The proposed activities associated with the site would not impact on Milperra catchment flooding for events up to 1% AEP.
	Other areas within WA1 (including EIS proposal area 1)	More frequent than 20% AEP	More frequent than 50% AEP	x	x	✓	x	Should a 20% AEP Georges River flood occur during construction of the proposal the portion of WA1 to the north of Tower Road would be inundated to depths that are typically between 0.5 and 1.5 m. The area impacted includes EIS proposal area 1.	Should a flood occur on the Georges River during the construction of the proposal then there is a risk of scour to any exposed surfaces and the transport of sediment into the Georges River. The impact of the proposed earthworks on changes to flood behaviour in the Georges

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Henry Lawson Drive north (WA1)								Should a 1% AEP Georges River flood occur during the construction of the proposal the full extent of earthworks within WA1 would be inundated to a maximum depth of over 3 m. Local catchment runoff that surcharges a channel that runs through the Georges River golf course would inundate the proposed earthworks along the eastern side of Henry Lawson Drive during storms as frequent as 50% AEP. The proposed earthworks along the western side of Henry Lawson Drive within EIS proposal area 1 is located on land that is frequently inundated by runoff that discharges from the box culvert that crosses the road corridor to the north of Tower Road.	River is not expected to be significantly greater than those under operational conditions in this area. The proposed earthworks along the western side of Henry Lawson Drive within EIS proposal area 1 have the potential to impact on local catchment runoff discharging from the box culvert that crosses the road to the north of Tower Road unless the works are staged in a manner that maintains a temporary flow path through the site during the extension of the box culvert.
Milperra Road (WA2)	Newbridge Road ancillary site (C2)	2% AEP	1% AEP	✓	✓	x	x	Should a 2% AEP Georges River flood occur during the construction of the proposal the full extent of the site would be inundated to a maximum depth of 0.3 m, increasing to 0.6 m during a 1% AEP event. The site is not impacted by Milperra catchment flooding for events up to 1% AEP in magnitude.	Site facilities, material storage and associated perimeter fencing have the potential to obstruct the conveyance of flow from the Georges River should a flood event greater than 5% AEP in magnitude occur during the construction phase of the proposal. The resulting impacts on flood behaviour are likely to be relatively localised given the extent of Georges River flooding relative to the

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Milperra Road (WA2)									extent of the ancillary site. However, there is also the potential for materials stored within the ancillary site to be displaced and transported along the Georges River. The proposed activities associated with the site would not impact on Milperra catchment flooding for events up to 1% AEP.
	Other areas within WA2 (including EIS proposal area 2)	20% AEP	50% AEP	x	x	✓	x	Should a 10% AEP Georges River flood occur during the construction of the proposal then floodwater would back up the Milperra Drain and inundate an area of proposed earthworks along the southern side of Milperra Road that includes EIS proposal area 2. Should a 5% AEP Georges River flood occur during the construction of the proposal then the full extent of earthworks along the section of Milperra Road to the east of Henry Lawson Drive would be inundated to a maximum depth of about 2 m, increasing to 3 m during a 1% AEP event. The proposed earthworks along the southern side of Milperra Road would be inundated by runoff that surcharges the section of Milperra Drain that runs through	Should a flood occur on the Georges River during the construction of the proposal of 10% AEP magnitude or greater then there is a risk of scour to any exposed surfaces and the transport of sediment into the Georges River. The impact of the proposed earthworks on changes to flood behaviour in the Georges River is not expected to be significantly greater than those under operational conditions in this area. The proposed earthworks along the southern side of Milperra Road within EIS proposal area 2 have the potential to impact on local catchment runoff discharging from the box culvert that crosses the road about 200 m east of Henry Lawson Drive (denoted transverse drainage structure PXD02 on **Figure 5.2**, sheet 2) unless the works are staged in a

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Milperra Road (WA2)								the Bankstown golf course during storms as frequent as 50% AEP. The proposed earthworks along the southern side of Milperra Road also includes an area of land within EIS proposal area 2 that would be frequently inundated by runoff that is conveyed by the box culvert that crosses Milperra Road to the east of Henry Lawson Drive.	manner that maintains a temporary flow path through the site during the extension of the box culvert.
Henry Lawson Drive south (WA3)	Henry Lawson Drive ancillary site (C3) (including EIS proposal area 3)	20% AEP	More frequent than 50% AEP	✓	✓	x	x	Should a 20% AEP Georges River flood occur during the construction of the proposal then a relatively localised area in the south-east corner of the site would be inundated, albeit over a relatively localised area of about 280 m^2 and to a maximum depth of 0.4 m. Should a 5% AEP Georges River flood occur during the construction of the proposal the majority of the site would be inundated to a depth of between 0.5 and 2.2 m, increasing to between 1.5 and 3.3 m during a 1% AEP event. Due to the low lying nature of the south-eastern portion of the site it would be inundated by flow that surcharges the section of Milperra Drain where it runs through the Bankstown golf course during	While facilities and materials located within the ancillary site have the potential to displace floodwater that backs up from both the Georges River and Milperra Drain, impacts on flood behaviour for events up to 1% AEP are likely to be minor given the extent of flooding relative to the extent of the ancillary site. However, there is the potential for materials stored within the ancillary site to be displaced and transported along Milperra Drain and the Georges River. The above impacts would apply to both the REF proposal area as well as EIS proposal area 3.

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Henry Lawson Drive south (WA3)								storms more frequent than 50% AEP. Should a 5% AEP storm event occur on the Milperra catchment during the construction of the proposal then almost half of the site would be inundated to a maximum depth of 1.1 metres, while the majority of the site would be inundated to a maximum depth of 1.4 m during a 1% AEP storm event.	
	Auld Avenue ancillary site (C4)	10% AEP	5% AEP	✓	✓	x	x	Should a 5% AEP Georges River flood occur during the construction of the proposal then the majority of the site would be inundated to a maximum depth of 0.6 metres, increasing to 1.6 metres during a 1% AEP event. Should a 5% AEP Georges River flood occur during the construction of the proposal the majority of the site would be inundated to a depth of 0.6 m, increasing to 1.6 m during a 1% AEP Georges River flood. The site is not impacted by Milperra catchment flooding for storm events up to 1% AEP in intensity in the absence of elevated flood levels in the Georges River.	While facilities and materials located within the ancillary site have the potential to displace floodwater that backs up from both the Georges River and Milperra Drain, impacts on flood behaviour for events up to 1% AEP are likely to be minor given the extent of flooding relative to the extent of the ancillary site. However, there is the potential for materials stored within the ancillary site to be displaced and transported along Milperra Drain and the Georges River.

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Henry Lawson Drive south (WA3)	Auld Avenue bridge working platform (WP1)	More frequent than 20% AEP	More frequent than 50% AEP	x	x	x	✓	The area where the working platform would be located is frequently inundated by both Georges River and Milperra Drain flooding. Should a 20% AEP Georges River flood occur during the construction of the proposal then the area where the working platform is proposed would be inundated to a depth of over 3 m, increasing to more than 4 m during a 1% AEP event. Should a 1% AEP design storm occur over the Milperra catchment during the construction of the proposal in the absence of elevated flood levels in the Georges River then the area where the working platform is proposed would be inundated to a depth of over 1 m.	The working platform for the construction of the new Auld Avenue bridge has the potential to obstruct the conveyance of flow in Milperra Drain during events more frequent that 50% AEP. This in turn may impact on the extent and depth of inundation and flow velocities in Milperra Drain.
	Other areas within WA3	20% AEP	More frequent than 50% AEP	x	x	✓	x	An area of proposed earthworks along the western side of Henry Lawson Drive, to the south of Auld Avenue bridge would be impacted by floodwater that backs up Milperra Drain should a 10% AEP flood or greater occur during the construction of the proposal. The remainder of the proposed earthworks within work area WA3 are located on land that typically lies above the 5% AEP George River flood.	Should a flood occur on the Georges River during the construction of the proposal of 10% AEP magnitude or greater then there is a risk of scour to any exposed surfaces and the transport of sediment into the Georges River. The impact of the proposed earthworks on changes to flood behaviour in the Georges River is not expected to be significantly greater than those under operational

Construction work area[1]	Compounds / other areas[1]	Threshold of flooding[2]		Proposed construction activities[3]				Description of existing flood behaviour (pre-mitigation)	Potential impacts of construction activities on flood behaviour
		Georges River flooding	Milperra catchment flooding	Site facilities[4]	Material storage and stockpiling[5]	Earthworks[6]	Bridge construction[7]		
Henry Lawson Drive south (WA3)								Should a 1% AEP Georges River flood occur during the construction of the proposal the full extent of earthworks within WA3 would be inundated to a maximum depth of over 2 metres. The proposed earthworks are located on land that typically lies above the 1% AEP Milperra catchment flood with the exception of some relatively localised areas around the Auld Avenue bridge and the outlet to the pipe culvert that crosses the road to the south of Milperra Road that would be exposed to relatively frequent inundation due to their lying nature.	conditions in this area. The proposed earthworks along the eastern side of Henry Lawson Drive to the south of Milperra Road have the potential to impact on local catchment runoff discharging from the pipe culvert that crosses the road to the north of Tower Road unless the works are staged in a manner that maintains a temporary flow path through the site during the construction of the new pipe culvert.

Notes:

1. Refer **Figure 5.1** (2 sheets) for location of ancillary sites and other facilities.
2. The assessed threshold of flooding is based on pre-proposal conditions. Refer **Figure 5.1** (2 sheets) for flood extent mapping under pre-proposal conditions.
3. Refer to **Section 5.1.1** for a description of flood risks associated with ancillary sites and other activities.
4. Site facilities include offices, staff amenities, parking and storage areas for plant, equipment and materials.
5. Material storage and stockpiling includes stockpiling and treatment of excavated material.
6. Earthworks includes construction of road and drainage works.
7. Bridge construction includes working platforms for the construction of piers and to support cranes for the installation of various bridge components.

5.2 Impacts during operation

This section provides an assessment of the flood risk to the proposal and the impact it would have on flood behaviour during operation if appropriate mitigation measures are not incorporated into its design. The assessment has been based on the current design for the proposal. The findings of an assessment into the potential impacts of future climate change and impacts of a partial blockage of major hydraulic structures on flood behaviour under operational conditions are also presented.

5.2.1 Potential flood risk to the proposal and its impact on flood behaviour

Inundation of the proposal by floodwater during its operation has the potential to cause damage to infrastructure, impact on traffic and pose a safety risk to road users. The proposal also has the potential to exacerbate flooding and drainage conditions in adjacent development. An assessment was undertaken of the flood risk to the proposal in its as-built form, as well as the impact it would have on the characteristics of flooding in adjacent areas.

Figure 5.3 (2 sheets) shows the general design arrangement of the proposal including the following features that formed the basis of the flood assessment:

- Henry Lawson Drive would be widened from two to four lanes between a location south of the Auld Avenue bridge and a location north of Tower Road, including the upgrade of its intersections with Milperra Road/Newbridge Road and Tower Road. The extent of road works is shown on **Figure 5.3**, sheet 2 as 'road design strings'.
- The existing transverse drainage structure that crosses Henry Lawson Drive to the north of Tower Road would be extended on its downstream (western) side to accommodate the proposed widening of the road formation (denoted transverse drainage structure PXD01 on **Figure 5.3**, sheet 2).
- The existing transverse drainage structure that crosses Milperra Road to the east of Henry Lawson Drive would also be extended on its downstream (southern) side to accommodate the proposed widening of the road formation (denoted transverse drainage structure PXD02 on **Figure 5.3**, sheet 2).
- The existing transverse drainage structure that crosses Henry Lawson Drive to the south of Milperra Road would be replaced with a new transverse drainage structure that would control runoff from the area upstream (west) of the road (denoted transverse drainage structure PXD03 on **Figure 5.3**, sheet 2).
- The existing piped drainage systems along Henry Lawson Drive, Milperra Road and Newbridge Road would be upgraded to accommodate the proposed road works. The upgraded drainage systems along the section of Henry Lawson Drive to the north of Milperra Road would discharge via vegetated channels to the inlet and outlet of transverse drainage structure PXD01 (denoted drainage outlets D01 and D02 on **Figure 5.3**, sheet 2), or directly to the Georges River at the location of an existing drainage outlet (denoted drainage outlet D03 on **Figure 5.3**, sheet 2). The upgraded drainage systems along Newbridge Road, Milperra Road and the section of Henry Lawson Drive to their south would discharge to Milperra Drain at the locations of existing drainage outlets (denoted drainage outlets D04 to D012 on **Figure 5.3**, sheet 2).
- A series of vegetated swales and bio-retention systems would be provided at the outlets to the new drainage systems to treat runoff discharging from the new road pavements, the details of which are discussed in more detail in the Surface Water Assessment Report.

- The existing Auld Avenue bridge would be duplicated with a new bridge structure to its west (downstream side). Based on the current design the new bridge structure would comprise a two span arrangement with the central pier located on the northern bank of Milperra Drain.

The assessed design would be subject to further development during the detailed design stage.

Potential flood risk to the proposal

Table 5.2 provides a summary of the assessed flood risk to the proposal against the adopted criteria outlined in **Section 3.2**. The assessment found that:

- While the upgrade of the roads within the proposal area would maintain the existing level of flood immunity, opportunities to improve the level of immunity is constrained by the impact raising the new sections of road above existing levels would have on flood behaviour in development adjacent to the proposal.
- The proposed upgrade of the section of Henry Lawson Drive to the north of Milperra Road would be inundated by floodwater that surcharges the Georges River during storms more frequent than 20% AEP, while the proposed upgrade of the sections of Milperra Road and Henry Lawson Drive to its south would both have a 10% AEP level of flood immunity against Georges River flooding.
- The proposed upgrade of Milperra Road would have about a 10% AEP level of flood immunity against Milperra catchment flooding, while during a 1% AEP event floodwater that surcharges Milperra Drain would inundate the road to a maximum depth of 0.4 m.
- The proposed upgrade of Henry Lawson Drive to the north and south of Milperra Road would have a 1% AEP level of flood immunity against Milperra catchment flooding in the absence of elevated flood levels in the Georges River.
- The sections of Henry Lawson Drive and Newbridge Road within the proposal areas are not impacted by Milperra catchment flooding during a 1% AEP event in the absence of elevated flood levels in the Georges River. Inundation to Milperra Road during this event would typically be of low hazard to persons and vehicles.
- Floodwater that surcharges the Georges River during a 1% AEP event and inundates Milperra Road and the sections of Henry Lawson Drive to its north and south would be hazardous to persons and vehicles using these sections of road, but would be no worse than under pre-proposal conditions.
- Based on the current design the new bridge over Milperra Drain would provide 0.3 metres of freeboard between the underside of the bridge structure and the peak 1% AEP flood level that would result from Milperra catchment flooding in the absence of elevated flood levels in the Georges River. In comparison the underside of the existing bridge would be submerged by 0.3 m below the same peak flood level. The peak 1% AEP flood level that would result from Georges River flooding would inundate the deck of the new bridge to a depth of 0.7 m, and the existing bridge to a depth of 1.3 m.

Impact of the proposal on flood behaviour

An assessment was carried out into the impact that the proposal would have on flood behaviour under pre-proposal conditions. The findings of the assessment are summarised in **Table 5.3** in terms of changes to peak flood levels, depths and extents of inundation, and **Table 5.4** in terms of changes in peak flows and velocities.

The following figures showing flooding patterns and impacts under operational conditions should be referred to when reading the following discussion:

- **Figure 5.3** (2 sheets) shows flooding patterns under operational conditions during a 10% AEP Georges River flood event, while **Figure 5.4** (2 sheets) shows the impact that the proposal would have on flood behaviour in terms of changes in peak 10% AEP Georges River flood levels.[6] Corresponding results for a 1% AEP and PMF Georges River flood event are provided in **Figures 5.5** to **5.8** (2 sheets each), while **Figures A.14** to **A.23** in **Annexure A** show flooding patterns and impacts under operational conditions during Georges River flood events with AEPs of 20%, 5%, 2%, 0.5% and 0.2%.
- **Figure 5.9** (2 sheets) shows flooding patterns under operational conditions during a 10% AEP Milperra catchment flood event, while **Figure 5.10** (2 sheets) shows the impact that the proposal would have on flood behaviour in terms of changes in peak 10% AEP Milperra catchment flood levels[4]. Corresponding results for a 1% AEP and PMF Milperra catchment flood event are provided in **Figures 5.11** to **5.14** (2 sheets each), while **Figures A.24** to **A.37** in **Annexure A** show flooding patterns and impacts under operational conditions during Milperra catchment flood events with AEPs of 50%, 20%, 5%, 2%, 0.5% and 0.2%, as well as a 1% AEP storm event in the absence of elevated flood levels in the Georges River.
- **Figure A.13** in **Annexure A** shows peak flow velocities under pre-proposal conditions during a 1% AEP event, while **Figure A.38** shows the impact that the proposal would have in terms of changes in peak flow velocities during a 1% AEP event.

The assessment found there is the potential to increase peak flood levels in adjoining development at a number of locations due to the raised level of Henry Lawson Drive and the obstruction this would have on flow that presently overtops the road due to both Georges River and Milperra catchment flooding. The following potential impacts on Georges River flooding have been identified:

i. Peak 2% AEP and 1% AEP flood levels would be increased in an area to the west of Henry Lawson Drive, south of Milperra Road that includes several residential properties by a maximum of 0.08 m, and 0.03 m, respectively.

ii. Peak 2% AEP and 1% AEP flood levels would be increased in an area to the west of Henry Lawson Drive, north of Milperra Road that includes an existing shared user path. Flooding along the shared user path would be increased by a maximum of 0.1 m on an existing depth of about 0.2 m during a 2% AEP event, and by 0.05 m on an existing depth of about 0.5 m during a 1% AEP event.

[6] Changes in peak flood levels are denoted on the figure as “afflux”. An afflux of plus or minus 0.01 metres is considered to be within the order of accuracy of the flood model. The figure also shows changes in the extent of inundation that could be caused by the construction of the project. A reduction in the extent of inundation is denoted “Land rendered flood free”, while an increase in the extent of inundation is denoted “Additional area of land flooded” as a result of the proposal.

iii. Peak 1% AEP peak flood levels would be increased within two commercial premises that lie to the east of Henry Lawson Drive and north of Milperra Road by a maximum of 0.02 m on existing depths of between 0.1 and 0.3 m. While impacts are mainly confined to areas of landscaping, driveway and carparking there is a car wash facility that would experience an increase in the depth of inundation of 0.02 m on an existing depth of 0.3 m.

The following potential impacts on Milperra catchment flooding have been identified, which can also be attributed to the raised level of Henry Lawson Drive and its obstruction on flow that presently overtops the road:

i. There would be an increase in the depth and extent of ponding within the commercial property that lies to the south of Tower Road during storms that surcharge the internal drainage system. The depths of inundation within the property would be increased by a maximum of 0.04 m and an existing depth of 0.2 metres during a 10%, and by a maximum of 0.03 m on an existing depth of 0.3 metres during a 1% AEP event.

ii. During a 1% AEP storm in combination with a 5% AEP flood in the Georges River there would be an increase in the depth and extent of inundation within the front yards of four residential properties that lie on the western side of Henry Lawson Drive between Newbridge Road and the Auld Avenue bridge.

iii. During a 1% AEP storm in combination with a 5% AEP flood in the Georges River peak flood levels along the section of Milperra Drain where it runs to the east (upstream) of Henry Lawson Drive would be increased by a maximum of 0.013 m, with impacts extending to several industrial properties that front Ashford Avenue and Milperra Road.

During detailed design the road alignment will be further refined in order to minimise the increase in proposed road levels along the sections of Henry Lawson Drive at the Auld Avenue bridge and at its intersection with Milperra Road with the aim of mitigating its impact on peak flood levels in adjoining development.

The investigation found that while the current design would have only a minor impact on peak flows in the Georges River and Milperra Drain, there is the potential for a localised increase in scour potential due to a localised increase in flow velocities at the outlet of new, upgraded or extended drainage structures. During detailed design, scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity. This would include the outlet to transverse drainage structures PXD01 and PXD02 which are located in EIS proposal areas 1 and 2, respectively.

Summary of impacts associated with proposed works within the EIS proposal area

In regards to the proposed works within the EIS proposal areas, the potential impacts on flood behaviour under pre-proposal conditions can be summarised as follows:

i. The road widening and associated fill embankment within EIS proposal area 1 in isolation would be expected to have a relatively localised impact on flood behaviour in the Georges River and the local drainage lines that cross the proposal to the north of Milperra Road. However, in combination with the overall proposal, the works within EIS proposal area 1 would contribute to the changes in flood behaviour over areas to the north of Milperra Road that are described in this section of the report.

ii. The road widening and associated fill embankment within EIS proposal area 2 in isolation would be expected to have a relatively localised impact on flood behaviour in Milperra Drain and the local drainage lines that cross the proposal to the east of Henry Lawson Drive. However, in combination with the overall proposal the works within EIS proposal area 2 would contribute to the changes in flood behaviour along the section of Milperra Drain to the east of Henry Lawson Drive that are described in this section of the report.

iii. The provision of new or upgraded drainage infrastructure in EIS proposal areas 1 and 2 to accommodate the proposed road widening has the potential for a localised increase in scour potential due to a localised increase in flow velocities at the outlet of new, upgraded or extended drainage structures. During detailed design, scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity.

iv. Works within EIS proposal area 3 are related to the provision of a temporary ancillary site to support the construction of the proposal. Subject to the suitable reinstatement of the site following the construction of the proposal then works within EIS proposal area 3 would have no significant impact on existing flood behaviour.

5.2.2 Consistency with council and state government flood related plans

Council floodplain risk management plans

Plans for the management of flood risk within the Georges River and Milperra catchments are respectively set out in the following documents:

- *Georges River Floodplain Risk Management Study and Plan* (Volumes 1 & 2) (BC 2004)
- *Floodplain Risk Management Study and Plan for Sub-Catchments of the Mid Georges River* (BMT WBM 2017)

Both of the above documents define the hazard categorisation of the floodplain and set out general, non-structural and location specific structural measures with varying priority rankings to manage the flood risk associated with development within the respective study areas. BC 2004 covers the section of the Georges River floodplain within the City of Canterbury-Bankstown, Liverpool and Sutherland Shire local government areas, while WBM BMT 2017 covers the sub-catchments of the Georges River within the City of Canterbury-Bankstown local government area that comprise Milperra, Kelso Swamp, East Hills, Lucas Road, Picnic Point, Morris Gully and Little Salt Pan Creek.

General non-structural measures set out in BC 2004 and BMT WBM 2017 include:

- updates to Canterbury Bankstown City Council's Local Environment Plan and associated Development Control Plan to establish planning controls to development in flood prone areas to manage its flood risk, as well as its impact on flooding in existing development
- improvements to emergency response measures, such as better utilisation of flood warning systems
- improvements to flood awareness, such as the implementation of a community flood education program
- the preparation of a Local Flood Plan in collaboration with NSW State Emergency Services (SES).

Structural measures set out in BC 2004 and BMT WBM 2017 include:

- the adoption of a voluntary purchase scheme to purchase properties in hazardous areas and convert them to more flood compatible uses, including a number of properties along the eastern side of Henry Lawson Drive between Newbridge Road and Auld Avenue bridge
- the provision of detention basins and the upgrade of stormwater drainage infrastructure, including several within the Milperra catchment
- channel improvement works, including the section of Milperra Drain that runs through the Bankstown golf course.

The proposed upgrade of Henry Lawson Drive is considered to be consistent with the floodplain risk management plans set out in BC 2004 and BMT WBM 2017 for the following reasons:

- The findings of the assessment presented in **Section 5.2.1** of this report show that subject to the provision of suitable mitigation measures during detailed design, the proposal would have only a minor impact on peak 1% AEP flood levels and flow velocities within areas outside the proposal area. Increases in PMF levels are also considered minor in terms of the relative increase in flood hazard and changes in the extent of inundation. As a result, it is considered that the proposal would have no significant impact on the extent of the floodplain or its hazard categorisation as defined in BC 2004 and BMT WBM 2017.
- Subject to the provision of suitable mitigation measures during detailed design, it is also considered that the proposal is consistent with the objectives of the Bankstown LEP in terms of managing its impact on flood behaviour.
- The proposal would maintain the existing level of flood immunity to Henry Lawson Drive, Milperra Road and Newbridge Road and therefore would not adversely affect existing emergency response arrangements and flood access.
- The proposal includes the acquisition of No. 439 Henry Lawson Drive, Milperra which is identified in the voluntary purchase scheme set out in BC 2004. This would provide the opportunity to restore the site in a flood compatible manner, the details of which will be developed during detailed design in consultation with Canterbury Bankstown City Council.
- Given the extent of works that are proposed as part of the proposal and the generally minor nature of their impact on flood behaviour, it is also considered that the proposal would not preclude or limit any of the structural measures identified in BC 2004 and BMT WBM 2017.

Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment

Based on the assessment presented in **Section 5.2.1**, the proposal is considered to be consistent with the flood related principles set out in the *Greater Metropolitan Regional Environmental Plan No 2 - Georges River Catchment* for the following reasons:

- The proposal would result in no significant change to the periodic flooding to Milperra Drain and other riverine ecosystems.
- There would be no change to the pollution hazard posed by the upgrade of the existing road during times of flood.
- Subject to the incorporation of the mitigation measures identified in **Sections 5.2.1** and **6.3**, the proposal would have only a minor impact on flood behaviour, including those resulting from the filling of flood prone land.

5.2.3 Impact of future climate change on flood behaviour

Impact of flood behaviour under future climate change conditions on the proposal

The increase in rainfall intensities attributable to future climate change has the potential to increase the frequency that flooding occurs to the roads within the proposal area. For example:

- the section of Henry Lawson Drive to the north of Tower Road is presently inundated during a 20% AEP Georges River flood (which occurs on average once every 5 years), whereas under future climate change it could be inundated during a 40% AEP Georges River flood (which occurs on average once every 2 years)
- the section of Milperra Road to the east of Henry Lawson Drive is presently inundated during a 5% AEP Georges River flood (which occurs on average once every 20 years), whereas under future climate change it could be inundated during a 10% AEP Georges River flood (which occurs on average once every 10 years
- the section of Henry Lawson Drive to the south of Milperra Road is presently inundated during a 5% AEP Georges River flood (which occurs on average once every 20 years), whereas under future climate change it could be inundated during a 10% AEP Georges River flood (which occurs on average once every 10 years
- the section of Henry Lawson Drive to the north of Tower Road is presently not inundated during a 1% AEP Milperra catchment flood in the absence of elevated flood levels in the Georges River, whereas under future climatic conditions it would be inundated to relatively shallow depths of between 0.06 and 0.13 m.

The increase in rainfall intensities attributable to future climate change also has the potential to increase the depth of inundation to the proposal. A summary of peak 1% AEP flood levels at key locations along the proposal for current climatic conditions, as well as for the assessed future climate change scenarios set out in **Table 3.1** are shown in **Table 5.5** at the end of this chapter.

The investigation found that sea level rise under future climate change conditions would have only a minor impact on peak flood levels in the vicinity of the proposal.

Impact of the proposal on flood behaviour under future climate change conditions

As noted in **Section 3.6.2**, the 0.5% and 0.2% AEP events were adopted as proxies for assessing the sensitivity to an increase in 1% AEP design rainfall intensities of between 10% and 30% due to future climate change.

In regards to Georges River flooding:

- **Figure 5.6** shows the impact of the proposal on flood behaviour during a 1% AEP event under current climatic conditions, while **Figures A.21** and **A.23** in **Annexure A** show the impact that the proposal would on flood behaviour during a 0.5% and 0.2% AEP event.
- The assessment of flood impacts across a range of events has identified that the proposal has the greatest potential for increases in peak flood levels in adjoining development as a result of Georges River flooding during a 2% and 1% AEP event. The increase in rainfall intensities under future climate change will mean that the rainfall intensities that produce these flood events will occur more frequently. That is, unless suitable mitigation measures are incorporated into the proposal, then the impacts shown on **Figure 5.6** will occur on a more frequent basis than once every 100 years on the average.

- Comparison of **Figure A.21** and **A.23** with **Figure 5.6** shows that there would be either no change or a reduction in the flood impacts during a 1% AEP flood that are attributable to the proposal under the lower and upper bound future climate change scenarios.

In regards to Milperra catchment flooding:

- **Figure 5.12** shows the impact of the proposal on flood behaviour during a 1% AEP event under current climatic conditions, while **Figures A.35** and **A.37** in **Annexure A** show the impact that the proposal would on flood behaviour during a 0.5% and 0.2% AEP event.
- The assessment of flood impacts across a range of events in combination with and without elevated flood levels in the Georges River has identified that the proposal has the greatest potential for increases in peak flood levels in adjoining development as a result of flooding in the Milperra catchment during 1% AEP event, in combination with a 5% AEP flood on the Georges River. The increase in rainfall intensities under future climate change will mean that the rainfall intensities that produce these flood events will occur more frequently. That is, unless suitable mitigation measures are incorporated into the proposal, then under future climate change conditions the impacts shown on **Figure 5.12** will occur on a more frequent basis when compared to current climatic conditions.
- Comparison of **Figure A.35** and **A.37** with **Figure 5.12** shows that there would be either no change or a reduction in the flood impacts during a 1% AEP flood that are attributable to the proposal under the lower and upper bound future climate change scenarios.

5.2.4 Impact of a partial blockage of major hydraulic structures on flood behaviour

Table 5.6 shows the impact a partial blockage of major hydraulic structures would have on peak flood levels at key locations along the proposal. The assessment showed that a partial blockage of major hydraulic structures would generally have only a minor impact on flooding to the proposal.

TABLE 5.2
SUMMARY OF FLOOD RISKS TO THE PROPOSAL

Proposal element and adopted criteria	Location	Georges River flooding[1]			Milperra catchment flooding[1,2]			Assessed flood risk
		Level of flood immunity	Peak flood level (m AHD) *[Depth of inundation (m)]*		Level of Immunity	Peak flood level (m AHD) *[Depth of inundation (m)]*		
			10% AEP[3]	1% AEP[3]		10% AEP[3]	1% AEP[3]	
Upgrade of existing road: • maintain the level of flood immunity of the existing road • where feasible improve the level of immunity to 1% AEP.	Henry Lawson Drive north of its intersection with Milperra Road (incl. EIS proposal area 1)	More frequent than 20% AEP	4.0 *[1.5]*	5.8 *[3.3]*	Rarer than 1% AEP	2.4 *[Not flooded]*	2.5 *[Not flooded]*	While this section of the proposal would not be impacted by Milperra catchment flooding during a 1% AEP event, it would be inundated by floodwater that surcharges the Georges River during floods more frequent than 20% AEP, which is the same as pre-proposal conditions. The depth of flooding along the road during a 10% and 1% AEP Georges River flood would be hazardous to persons and vehicles, but no worse than that under pre-proposal conditions. Opportunities to improve the level of flood immunity are constrained by the impact increasing the level of the road would have on flood behaviour in adjoining areas.
	Milperra Road and Newbridge Road (incl. EIS proposal area 2)	10% AEP	3.2 *[Not flooded]*	5.5 *[1.8]*	About 10% AEP	3.5 *[<0.1]*	3.8 *[0.4]*	This section of the proposal would be impacted by floodwater that surcharges the Georges River during events greater than 10% AEP, and by floodwater that surcharges the Milperra Drain during events greater than 20% AEP, both of which are the same as pre-proposal conditions. While flooding across the road during a 1% AEP Milperra catchment flood is low hazard in nature, the depth of inundation due to Georges River flooding of the same AEP would be hazardous to persons and vehicles, but no worse than existing conditions. Opportunities to improve the level of flood immunity are constrained by the impact increasing the level of the road would have on flood behaviour in adjoining areas.

Proposal element and adopted criteria	Location	Georges River flooding[1]			Milperra catchment flooding[1,2]			Assessed flood risk
		Level of flood immunity	Peak flood level (m AHD) *[Depth of inundation (m)]*		Level of Immunity	Peak flood level (m AHD) *[Depth of inundation (m)]*		
			10% AEP[3]	1% AEP[3]		10% AEP[3]	1% AEP[3]	
Upgrade of existing road: • maintain the level of flood immunity of the existing road • where feasible improve the level of immunity to 1% AEP.	Henry Lawson Drive south of its intersection with Milperra Road (incl. EIS proposal area 3)	10% AEP	3.2 *[Not flooded]*	5.5 *[1.9]*	1% AEP	3.1 *[Not flooded]*	3.5 *[Not flooded]*	While this section of the proposal would not be impacted by Milperra catchment flooding during a 1% AEP event, it would be inundated by floodwater that surcharges the Georges River flooding during events greater than 10% AEP, which is the same as pre-proposal conditions. The depth of flooding along the road during a 1% AEP Georges River flood would be hazardous to persons and vehicles, but no worse than that under pre-proposal conditions. Opportunities to improve the level of flood immunity is constrained by the impact increasing the level of the road would have on flood behaviour in adjoining areas.
Duplication of existing waterway bridges: • maintain the level of clearance provided by the existing bridge • where feasible provide 0.5 m clearance between the underside of the bridge and the peak 1% AEP local catchment flood level.	Auld Avenue bridge	10% AEP	3.2 *[Not flooded]*	5.5 *[1.3]*	1% AEP	3.1 *[Not flooded]*	3.5 *[Not flooded]*	Based on the current design the underside of the new bridge over Milperra Drain would be located 0.3 m above the peak 1% AEP flood level due to Milperra catchment flooding in the absence of elevated flood levels in the Georges River. In comparison the underside of the existing bridge is submerged by 0.3 m below the same peak 1% AEP flood level. The deck new bridge would be inundated to a depth of 0.7 m during a 1% AEP George River flood, compared to a depth of 1.3 m at the existing bridge.

1. Peak flood levels are based on current climatic conditions and no blockage to major hydraulic structures. Refer **Sections 5.2.3** and **5.2.4** for an assessment of the impact of future climate change and a partial blockage of major hydraulic structures on peak flood levels at key locations along the length of the proposal.
2. Peak flood levels shown are the result of Milperra catchment flooding in the absence of elevated flood levels in the Georges River.

TABLE 5.3
SUMMARY OF IMPACTS OF THE PROPOSAL ON FLOOD BEHAVIOUR - CHANGES IN PEAK FLOOD LEVELS AND DEPTHS

Flooding mechanism	Changes in peak flood levels and depths
Georges River flooding	• There would be negligible changes in peak flood levels outside of the proposal area for floods up to 5% AEP. • During a 2% AEP and 1% AEP event there would be an increase in peak flood levels in an area to the west of Henry Lawson Drive, north of Milperra Road. The greatest increase would occur during a 2% AEP event where peak flood levels would be increased by a maximum of 0.15 m on existing depths of about 0.2 m. During a 1% AEP event, peak flood levels would be increased by a maximum of 0.06 m on existing depths of between 0.2 and 0.6 m. The area impacted includes a section of shared user path where peak 2% AEP flood levels would be increased by 0.1 m on an existing depth of about 0.2 m, while peak 1% AEP flood levels would be increased by 0.05 m on an existing depth of about 0.5 m. • During a 2% AEP and 1% AEP event there would also be an increase in peak flood levels in an area to the west of Henry Lawson Drive, south of Milperra Road that includes several residential properties. Again the greatest increase would occur during a during a 2% AEP event where peak flood levels would be increased by 0.08 m, while peak 1% AEP flood levels would be increased by 0.03 m. • During a 1% AEP event there would be an increase in peak flood levels within two commercial premises that lie to the east of Henry Lawson Drive and north of Milperra Road. Increases in peak flood levels would occur to a maximum of 0.02 m on existing depths of between 0.1 and 0.3 m. While impacts are mainly confined to areas of landscaping, driveway and carparking, there is a car wash facility that would experience an increase in depth of inundation of 0.02 m on an existing depth of 0.3 m. The above increases in peak flood levels in areas outside the proposal area are due to the raised level of Henry Lawson Drive under post-proposal conditions which leads to an increase in the obstruction it has on floodwater that surcharges the Georges River. During detailed design the road alignment will be further refined with the aim of minimising the increase in road levels and therefore impacts on peak flood levels compared to pre-proposal conditions. • There would be negligible change in peak flood levels during a PMF. • The road widening and associated fill embankment within EIS proposal area 1 in isolation would be expected to have a relatively localised impact on flood behaviour in the Georges River. However, in combination with the overall proposal the works within EIS proposal area 1 would contribute to the changes in flood behaviour over areas to the north of Milperra Road that are described above.
Milperra catchment flooding	• During a 10% AEP storm there would be an increase in the depth of ponding upstream of transverse drainage structure PXD01 by a maximum of 0.1 m, with impacts mainly confined to the inbank area of the channel that runs through the Georges River golf course and discharges to the transverse drainage structure. • During a storm event on the Milperra catchment in the absence of elevated flood levels in the Georges River there would be an increase in the depth and extent of inundation within a relatively localised section of the Georges River golf course to the north of Tower Road as a result of the proposed widening of Henry Lawson Drive and the redistribution of flow discharging from the road corridor. Conversely, as a result of this redistribution of flow

Flooding mechanism	Changes in peak flood levels and depths
Milperra catchment flooding	there would also be some localised areas where the depth and extent inundation within the golf course would be decreased. • During storms that surcharge the drainage system within the commercial property to the south of Tower Road there would be an increase in the depth and extent of ponding within the property, which is due to the raised level of Henry Lawson Drive and therefore its obstruction to overland flow that presently discharges onto the road from the property. The depths of inundation within the property would be increased by a maximum of 0.04 m during a 10% and 1% AEP event on existing depths of between 0.2 and 0.3 m, respectively. The refinement of the road design during detailed design to lower finished levels along this section of Henry Lawson Drive that is discussed under Georges River flooding would also reduce its impact on Milperra catchment flooding. • During a 1% AEP storm in combination with a 5% AEP flood in the Georges River there would be the following increases in peak flood levels in areas outside the proposal boundary: o There would be an increase in the depth and extent of inundation within the front yards of four residential properties that lie on the western side of Henry Lawson Drive between Newbridge Road and the Auld Avenue bridge, which is due to the raised level of Henry Lawson Drive and therefore its obstruction overland flow that presently discharges onto the road from the adjoining properties. Depths of inundation would be increased by 0.3 m which would lead to an increase in the extent of inundation from about 60 m^2 (pre-proposal conditions) to 440 m^2 (post-proposal conditions). Again, the refinement of the road design during detailed design to lower finished levels along this section of Henry Lawson Drive that is discussed under Georges River flooding would also reduce its impact on Milperra catchment flooding. o Peak flood levels along the section of Milperra Drain where it runs to the east (upstream) of Henry Lawson Drive would be increased by a maximum of 0.013 m, with impacts extending over a significant area of the Bankstown golf course, as well as in several industrial properties that front Ashford Avenue and Milperra Road. The increase in peak flood levels is due to the raised level of the new Auld Avenue bridge and its approaches in relation to the existing bridge structure. During detailed design the road alignment will be further refined with the aim of minimising the increase in road levels and therefore the proposal related impacts on peak flood levels. • During a 1% AEP storm in the absence of elevated flood levels in the Georges River there would be a reduction in peak flood levels along the section of Milperra Drain where it runs to the east (upstream) of Henry Lawson Drive by a maximum of 0.07 m, while conversely there would be an increase in peak flood levels along the section of Milperra Drain where it runs to the west (downstream) of Henry Lawson Drive by a maximum of 0.04 m. These changes in peak flood levels are due to the reduced vegetation and therefore increased hydraulic efficiency of the section below the new Auld Avenue bridge. It is noted that the areas where peak flood levels are increased to the west of Henry Lawson Drive are mainly confined to open space within Vale of Ah and Gordon Parker reserves. • Peak PMF levels across the section of Milperra Drain to the east (upstream) of Henry Lawson Drive would be increased by a maximum of 0.04 m, with impacts extending to residential and industrial areas to the south and east of the Bankstown golf course. These impacts are attributed to the raised level of the new Auld Avenue bridge and its approaches in relation to the existing bridge structure. The increases in PMF levels are considered minor in terms of the relative increase in both the depth and extent of flooding. • The road widening and associated fill embankment within EIS proposal area 2 in isolation would be expected to have a relatively localised impact on

Flooding mechanism	Changes in peak flood levels and depths
	flood behaviour in Milperra Drain and the local drainage lines that cross the proposal to the east of Henry Lawson Drive. However, in combination with the overall proposal the works within EIS proposal area 2 would contribute to the changes in flood behaviour along the section of Milperra Drain to the east of Henry Lawson Drive that are described above. • Works within EIS proposal area 3 are related to the provision of a temporary ancillary site to support the construction of the proposal. Subject to the suitable reinstatement of the site following the construction of the proposal, then works within EIS proposal area 3 would have only a minor impact on existing flood behaviour.

TABLE 5.4
SUMMARY OF IMPACTS OF THE PROPOSAL ON FLOOD BEHAVIOUR - CHANGES IN PEAK FLOWS AND VELOCITIES

Flooding mechanism	Changes in peak flows and velocities
Georges River flooding	• The proposal would have negligible impact on flow velocities during Georges River flooding.
Milperra catchment flooding	• **Figure A.38**, sheet 2 in **Annexure A** shows the impact that the proposal would have on peak 1% AEP flow velocities during a Milperra catchment flood in the absence of elevated flood levels in the Georges River. • While there would be minor changes in the peak flow that discharges from transverse drainage structures PXD01 (within EIS proposal area 1), PXD02 (within EIS proposal area 2) and PXD03, there is the potential for localised increases in scour potential due to localised increases in flow velocities at the outlet of the extended or new structures. During detailed design, scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity. • Drainage channels would be provided downstream of drainage outlets D01 (within EIS proposal area 1) and D02 that would control flow discharging from these pavement drainage systems to the inlet and outlet of transverse drainage structure PXD01. • There would be minor changes in peak flows and velocities downstream of drainage outlet D03. Based on the current design the existing drainage outlet would be maintained at this location, which would also assist in minimising changes in downstream velocities. • While proposed drainage outlets D04, D05, D06 (within EIS proposal area 2), D07, D08 and D09 would have a minor impact on flow behaviour in Milperra Drain, there is the potential for a localised increase in scour potential due to the concentrated discharge of runoff from the new drainage outlets. During detailed design scour protection and energy dissipation measures would be incorporated into the design of the drainage outlets to manage localised increases in flow velocity. • Drainage channels would be provided downstream of drainage outlets D10, D11 and D12 that would control flow discharging from these pavement drainage systems to Milperra Drain.

TABLE 5.5
SUMMARY OF PEAK 1% AEP FLOOD LEVELS – CURRENT AND FUTURE CLIMATE CHANGE CONDITIONS (m AHD)

Proposal element	Location	Georges River flooding[1]			Milperra catchment flooding[1,2]			Potential impacts of future climate change on flood behaviour
		Current conditions[3]	Scenario 1[4]	Scenario 2[4]	Current conditions[3]	Scenario 1[4]	Scenario 2[4]	
Upgrade of existing road	Henry Lawson Drive north of its intersection with Milperra Road	5.83	6.02 *[0.19]*	6.31 *[0.48]*	2.46 2.50	2.56 *[0.10]*	2.63 *[0.17]*	The depth of inundation due to Georges River flooding would be increased from 1.9 m under current climatic conditions, to between 2.1 and 2.4 m under future climate change conditions. While this section of road is not inundated under current climatic conditions, under future climatic conditions it would be inundated by between 0.06 and 0.13 m.
	Milperra Road and Newbridge Road	5.54	5.78 *[0.24]*	6.14 *[0.60]*	3.76 3.37	3.81 *[0.05]*	3.90 *[0.14]*	The depth of inundation due to Georges River flooding would be increased from 1.8 m under current climatic conditions, to between 2.0 and 2.4 m under future climate change conditions. The depth of inundation due to Milperra catchment flooding would be increased from 0.4 m under current climatic conditions, to between 0.45 and 0.54 m under future climate change conditions.
	Henry Lawson Drive south of its intersection with Milperra Road	5.54	5.77 *[0.23]*	6.13 *[0.59]*	3.54 3.5	3.61 *[0.05]*	3.71 *[0.17]*	The depth of inundation due to Georges River flooding would be increased from 1.9 m under current climatic conditions, to between 2.1 and 2.5 m under future climate change conditions. The depth of inundation due to Milperra catchment flooding would be increased from 0.05 m under current climatic conditions, to between 0.1 and 0.22 m under future climate change conditions.

Proposal element	Location	Georges River flooding[1]			Milperra catchment flooding[1,2]			Potential impacts of future climate change on flood behaviour
		Current conditions[3]	Scenario 1[4]	Scenario 2[4]	Current conditions[3]	Scenario 1[4]	Scenario 2[4]	
Duplication of existing waterway bridge	Auld Avenue bridge	5.54	5.77 *[0.23]*	6.13 *[0.59]*	3.54 4.23	3.61 *[0.07]*	3.71 *[0.17]*	The depth of overtopping of the existing Auld Avenue bridge due to Georges River flooding would be increased from 1.3 m under current climatic conditions, to between 1.5 and 1.9 m under future climate change conditions. Based on the current design the depth of overtopping of the new bridge would be 0.6 m less than that of the existing bridge. The existing and proposed duplication of the Auld Avenue Bridge would not be overtopped by Milperra catchment flooding under current or future climatic conditions.

1. Peak flood levels quoted to two decimal places for ease of comparison only. Adopted peak flood levels for design purposes should be rounded off to the nearest 0.1 m.
2. Peak flood levels shown are the result of Milperra catchment flooding in the absence of elevated flood levels in the Georges River.
3. Where applicable peak flood levels are quoted at the location with the smallest freeboard or greatest depth of inundation.
4. Values in brackets represent the increase in peak flood level relative to current climatic conditions.

TABLE 5.6
IMPACT OF A PARTIAL BLOCKAGE OF MAJOR HYDRAULIC STRUCTURES ON PEAK 1% AEP MILPERRA CATCHMENT FLOOD LEVELS (m AHD)[1,2]

Proposal element	Location	Without blockage	With blockage[3]	Potential impact of a partial blockage on flood behaviour
Upgrade of existing road	Henry Lawson Drive north of its intersection with Milperra Road	2.46	2.58 *[0.12]*	The peak 1% AEP flood level due to a partial blockage of transverse drainage structure PXD01 would be at the same level as the edge of road.
	Milperra Road and Newbridge Road	3.77	3.77 *[0.00]*	There would be no change in peak flood 1% AEP flood level due to a partial blockage of transverse drainage structure PXD02, which is due to flood levels being driven by backwater flooding from Milperra Drain.
	Henry Lawson Drive south of its intersection with Milperra Road	3.54	3.56 *[0.02]*	A partial blockage of the Auld Avenue bridge would impact on flooding to the section of Henry Lawson Drive south of Milperra Road.
Duplication of existing waterway bridge	Auld Avenue bridge	3.54	3.56 *[0.02]*	A partial blockage of the Auld Avenue bridge would have a relatively minor impact on peak flood levels.

1. Peak flood levels quoted to two decimal places for ease of comparison only. Adopted peak flood levels for design purposes should be rounded off to the nearest 0.1 m.
2. Peak flood levels shown are the result of Milperra catchment flooding in the absence of elevated flood levels in the Georges River.
3. Values in brackets represent the increase in peak flood level relative to 'without blockage' conditions.

5.3 Cumulative impacts

This section presents the findings of an assessment of the potential impacts the proposal would have on flood behaviour in combination with the following other projects in its vicinity:

- Flower Power development at 479 Henry Lawson Drive, Milperra
- Widening of Milperra Drain within Bankstown golf course
- Bankstown Airport redevelopment
- Henry Lawson Drive and Rabaul Road intersection upgrade
- Riverlands subdivision at 56 Prescott Parade, Milperra
- Henry Lawson Drive and Tower Road intersection upgrade
- Milperra Road and Murray Jones Drive intersection upgrade

Where information was available the above projects were incorporated into the flood model representing pre-project conditions, the details of which is described in **Section 3.3**.

The assessment was based on impacts during the operation of the proposal only, given the short term nature of exposure to potential flood impacts during its construction together with the likely timing of the proposal with other projects in its vicinity.

The findings of the assessment of potential cumulative impacts on flood behaviour are summarised below.

Flower Power development:

- The recently constructed Flower Power development comprises a new retail centre with car parking that is located on the southern overbank of Milperra Drain to the east of where it crosses Henry Lawson Drive at Auld Avenue bridge. It is expected that the development would have been undertaken in accordance with the flood related requirements of the *Bankstown Local Environmental Plan 2015* and the *Bankstown Development Control Plan 2015*, details of which are summarised in **Section 2.1.3** of this report.
- Subject to the incorporation of the mitigation measures that are identified in **Sections 5.2.1** and **6.3**, then the project would have only a minor impact on flood behaviour in Milperra Drain. It is therefore expected that the cumulative impacts of the proposal in combination with the Flower Power development would also be minor in nature.

Widening of Milperra Drain within Bankstown golf course:

- Canterbury Bankstown City Council has recently undertaken widening works along the section of Milperra Drain where it runs through the Bankstown golf course.
- According to the *Milperra Drain Widening Review of Environmental Factors* (Cardno 2018), the widening of Milperra Drain would result in a reduction in the depth of flooding at a number of properties along Ashford Avenue and Milperra Road. No increases in flood levels attributable to the widening works are identified in Cardno 2018.
- Subject to the incorporation of the mitigation measures that are identified in **Sections 5.2.1** and **6.3**, then the project would have only a minor impact on flood behaviour in Milperra Drain. It is therefore expected that the proposal would not adversely affect the reductions in flood levels in Milperra Drain that are attributable to the widening works within the Bankstown golf course.

Bankstown Airport redevelopment:

- Bankstown Airport Limited (BAL) is currently in the process of redeveloping the Bankstown Airport, the details of which are set out in the *Bankstown Airport Masterplan 2019* (BAL 2019). Bankstown Airport covers an area of approximately 300 hectares that comprises a significant portion of the catchments draining to the local drainage lines that cross the proposal area, including Milperra Drain.
- To manage the impact that the redevelopment of the Bankstown Airport could have on flow behaviour in these local drainage lines, the *Bankstown Airport Masterplan 2019* includes a Flooding and Stormwater Management Strategy that was developed by BAL in consultation with Canterbury Bankstown City Council. The Flooding and Stormwater Management Strategy for the redevelopment of the Bankstown Airport includes the provision of detention basins that are aimed at mitigating the impact of the redevelopment on flood behaviour in the receiving drainage lines.
- Subject to the incorporation of the mitigation measures that are identified in **Sections 5.2.1** and **6.3**, then the project would have only a minor impact on flood behaviour in the drainage lines that cross the proposal area. It is therefore expected that the cumulative impacts of the proposal in combination with the Bankstown Airport redevelopment development would also be minor in nature.

Henry Lawson Drive and Rabaul Road intersection upgrade:

- No cumulative impacts on flood behaviour are expected as the Henry Lawson Drive and Rabaul Road intersection upgrade is located in an area of the Georges River floodplain that is remote from the proposal.

Riverlands subdivision:

- No cumulative impacts on flood behaviour are expected as the Riverlands subdivision is located in an area of the Georges River floodplain that is remote from the proposal.

Henry Lawson Drive and Tower Road intersection upgrade:

- The upgrade of the Henry Lawson Drive and Tower Road intersection by BAL involves road widening works which, in combination with the proposal, has the potential for cumulative impacts on flood behaviour in the Georges River.
- Given the minor nature of the impacts that are attributable to the proposal in the vicinity of Tower Road, it is expected that the cumulative impacts of it in combination with the Henry Lawson Drive and Tower Road intersection upgrade would also be minor in nature.

Milperra Road and Murray Jones Drive intersection upgrade:

- The upgrade of the Milperra Road and Murray Jones Drive intersection by BAL involves the widening of existing road which, in combination with the proposal, has the potential for cumulative impacts on flood behaviour in Milperra Drain.
- Given the minor nature of impacts that are attributable to the proposal in the vicinity of Murray Jones Drive, it is expected that the cumulative impacts of it in combination with the Milperra Road and Murray Jones Drive intersection upgrade would also be minor in nature.

6 MANAGEMENT OF IMPACTS

6.1 Approach

The assessment of flood impacts has provided an understanding of the scale and nature of the flood risk to the proposal, as well as the increased flood risks on the surrounding environment during its construction and operation. Further assessment will be undertaken during the detailed design phase of the proposal that will build on the flood assessment presented in this report and will be based on further design development and flood modelling where required. The approach to this further flood assessment will be based on:

- The identification of flood risk to the proposal, including the consideration of local drainage characteristics and a partial blockage of waterway structures on flood behaviour.
- The identification of potential flood impacts on the existing environment and future development potential of land, including the collection of floor level survey where required to confirm whether there would be an increase in the frequency and depth of above-floor inundation to existing residential, commercial and industrial buildings.
- The identification of design and flood mitigation measures that will be implemented to manage the risk of flooding to proposed operations and not worsen existing flooding characteristics during construction and operation, including erosion and scour.
- The identification of measures to be implemented during the construction of the proposal in order to prepare for a flood, as well as the procedures that will need to be implemented during a flood.

The following sections outline measures which will be considered to manage the flood risk and impacts during the construction and operational phases of the proposal.

6.2 Management of construction impacts

A broad outline of measures which will be considered for incorporation into the CEMP in order to manage construction related flood risk and impacts are outlined below.

Earthworks

- Surface earthworks within all three work areas (WA1 to WA3) are affected by Georges River and Milperra catchment flooding to varying degrees. Flow that currently discharges onto the areas of proposed earthworks has the potential to cause scouring of disturbed surfaces, as well as the transport of sediment and construction materials. It will therefore be necessary to plan, implement and maintain measures which are aimed at intercepting flow from areas upstream of the proposal and diverting it in a controlled manner either through or around the construction work areas and/or covering areas of exposed earthworks at the onset of heavy rainfall or predicted flooding in the Georges River. It will therefore be necessary to plan, implement and maintain measures which are aimed at:
    - intercepting flow from areas upslope of the proposal and diverting it in a controlled manner whether through or around the construction work areas
    - implementing construction practices that minimise the potential for scour through stabilisation of disturbed surfaces
    - covering areas of exposed earthworks at the onset of heavy rainfall or predicted flooding in the Georges River.

Site facilities and flood emergency management within ancillary sites

- As a minimum, site facilities are to be located outside high flood hazard areas based on a 1% AEP Milperra catchment flood in the absence of elevated flood levels in the Georges River. Ideally site facilities are to also be located outside areas of high hazard flooding from the Georges River. For site facilities located within areas of high hazard due to Georges River flooding it will be necessary to implement measures to monitoring for flooding alerts in the Georges River and a set of procedures for the evacuation of construction personnel.
- The CEMP is to also include contingency planning for site facilities that are located in areas that are inundated by either the Georges River or Milperra catchment flooding during a 5% AEP event.
- For site facilities located within the floodplain, the CEMP is to identify how risks to personal safety and damage to construction facilities and equipment will be managed.
- The CEMP will need to include details of:
    - the procedure to monitor accurate and timely weather and river level data, and disseminate warnings to construction personnel of impending flood producing rain or predicted flooding in the Georges River
    - an evacuation plan for construction personnel should a severe weather warning or flood alert for the Georges River be issued.

Material storage and stockpiling within ancillary sites

- The storage of hazardous material is to ideally be confined to areas that are not subject to flooding during a 1% AEP extent or either:
    - stored in a manner that prevents their mobilisation during times of flood
    - be removed from the floodplain at the onset of a Georges River flood.
- The CEMP will define the flood immunity criteria for material storage and stockpile areas proposed to be located on land that is inundated during a 1% AEP event. These criteria will be based on the duration of stockpiling operations, the type of material stored, the nature of the receiving drainage lines and also the extent to which the stockpile would impact flooding conditions in adjacent areas. The frequency at which each ancillary site is impacted by flooding is summarised in **Table 5.1**.

Bridge construction

- Temporary working platforms that may be required on the overbank of Milperra Drain to construct the new bridge would be constructed using clean rock fill and installed in a manner that minimises its impact on the in-bank area of the watercourse.

Management of adverse flood impacts on existing development

- The CEMP will need to include details and procedures to manage the potential for proposed construction activities to adversely impact on flood behaviour in adjacent development.
- The layout of the ancillary sites and material storage areas, as well as temporary working platforms will need to be designed to:

- Limit the extent of works located in floodway areas
- Divert overland flow either through or around work areas in a controlled manner
- Minimise adverse impacts on flood behaviour in adjacent development.

- Measures to manage residual flood impacts may include:
  - staging construction to limit the extent and duration of temporary works on the floodplain
  - ensuring construction equipment and materials are removed from floodplain areas at the completion of each work activity or should a weather warning be issued of impending flood producing rain
  - providing temporary flood protection to properties identified as being at risk of adverse flood impacts during any stage of construction of the proposal
  - developing flood emergency response procedures to remove temporary works during periods of heavy rainfall.

6.3 Management of operational impacts

A broad outline of measures which will be considered during the detailed design phase in order to manage operational related flood risks and impacts are outlined below.

Upgrade of existing roads

- As a minimum, the upgrade of the existing roads is to be configured to ensure the existing level of flood immunity is not reduced by the proposal.
- Measures to improve the existing level of flood immunity are to be further investigated during detailed design.

New bridge over Milperra Drain

- The new bridge crossing over Milperra Drain is to provide a level of clearance to the peak 1% AEP flood level that is no less than the existing bridge.

Management of adverse flood impacts on the existing environment

- A detailed hydrologic and hydraulic (flood) assessment of the impacts of the proposal on flood behaviour and the associated measures which are required to mitigate those impacts will be undertaken during detailed design.
- Works within the floodplain will be designed to minimise adverse impacts on surrounding development for flooding up to the 1% AEP event in magnitude. Assessment will also be made of impacts during floods up to the PMF in the context of impacts on critical infrastructure and flood hazards.
- Subject to the flood assessment during detailed design a detailed ground survey (including floor levels of buildings) may need to be undertaken in affected areas to determine whether the proposal would increase flood damages in adjacent development (i.e. in properties where there is a potential for increases in peak flood levels for events up to 1% AEP in magnitude).

- The design of the proposal will need to incorporate measures that are aimed at mitigating its impact on flood behaviour in properties where existing buildings would experience above-floor inundation during floods up to the 1% AEP event.
- During detailed design the road alignment will be further refined in order to minimise the increase in proposed road levels along the sections of Henry Lawson Drive at the Auld Avenue bridge and at its intersection with Milperra Road with the aim of mitigating its impact on peak flood levels in adjoining development.
- Localised increases in flow velocities at the outlets that are to be upgraded, relocated or new stormwater drainage systems will be mitigated through the provision of scour protection and energy dissipation measures.

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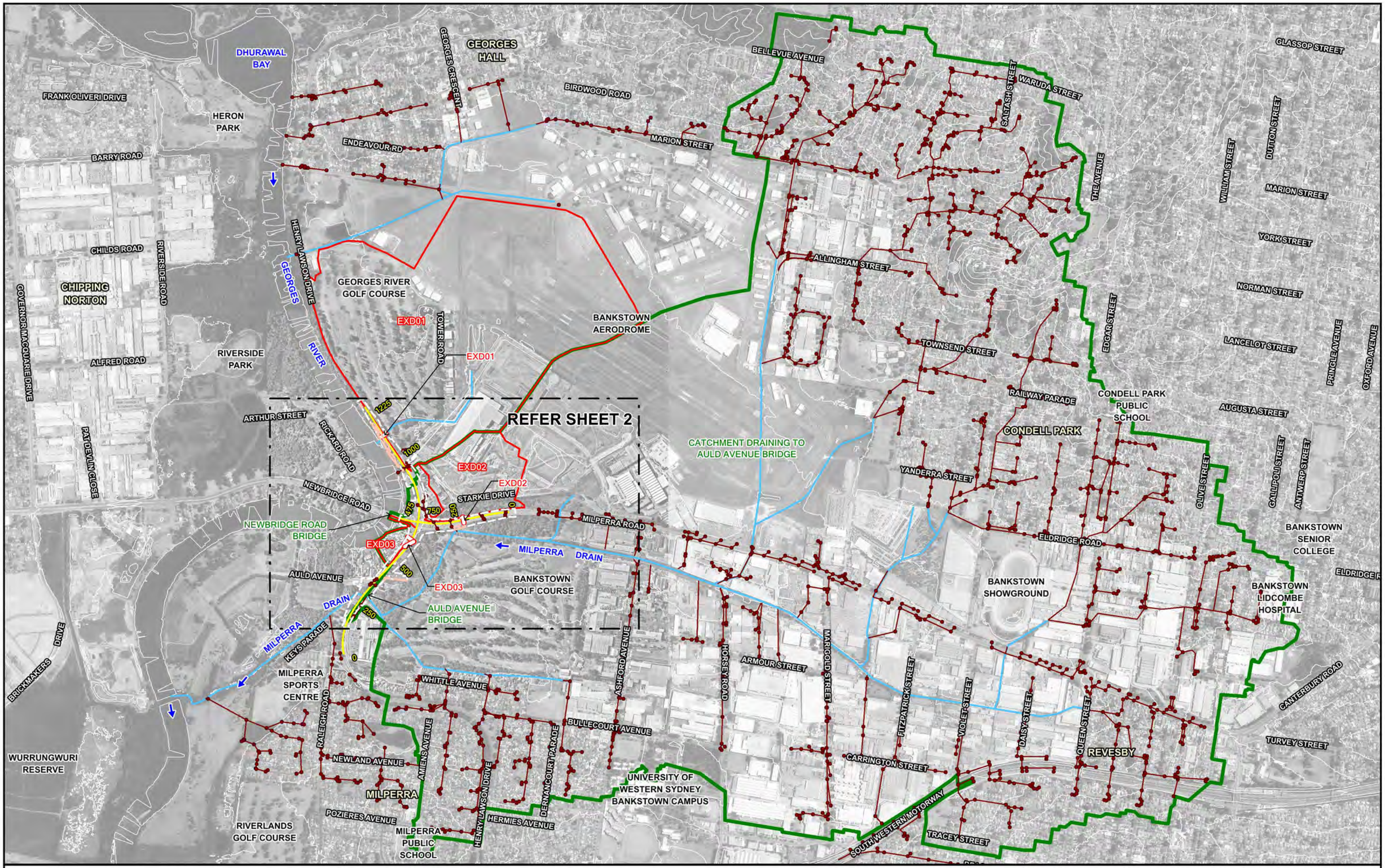
FIGURES



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Lyall & Associates

LEGEND

EXD01 — Existing Transverse Drainage Structure and Identifier

EXD01 — Extent of Catchment Draining to Existing Transverse Drainage Structure and Identifier

Extent of Milperra Drain Catchment Draining to Auld Avenue Bridge

Existing Drainage Line

250 500 — Road Alignment and Chainage

Existing Stormwater Drainage System

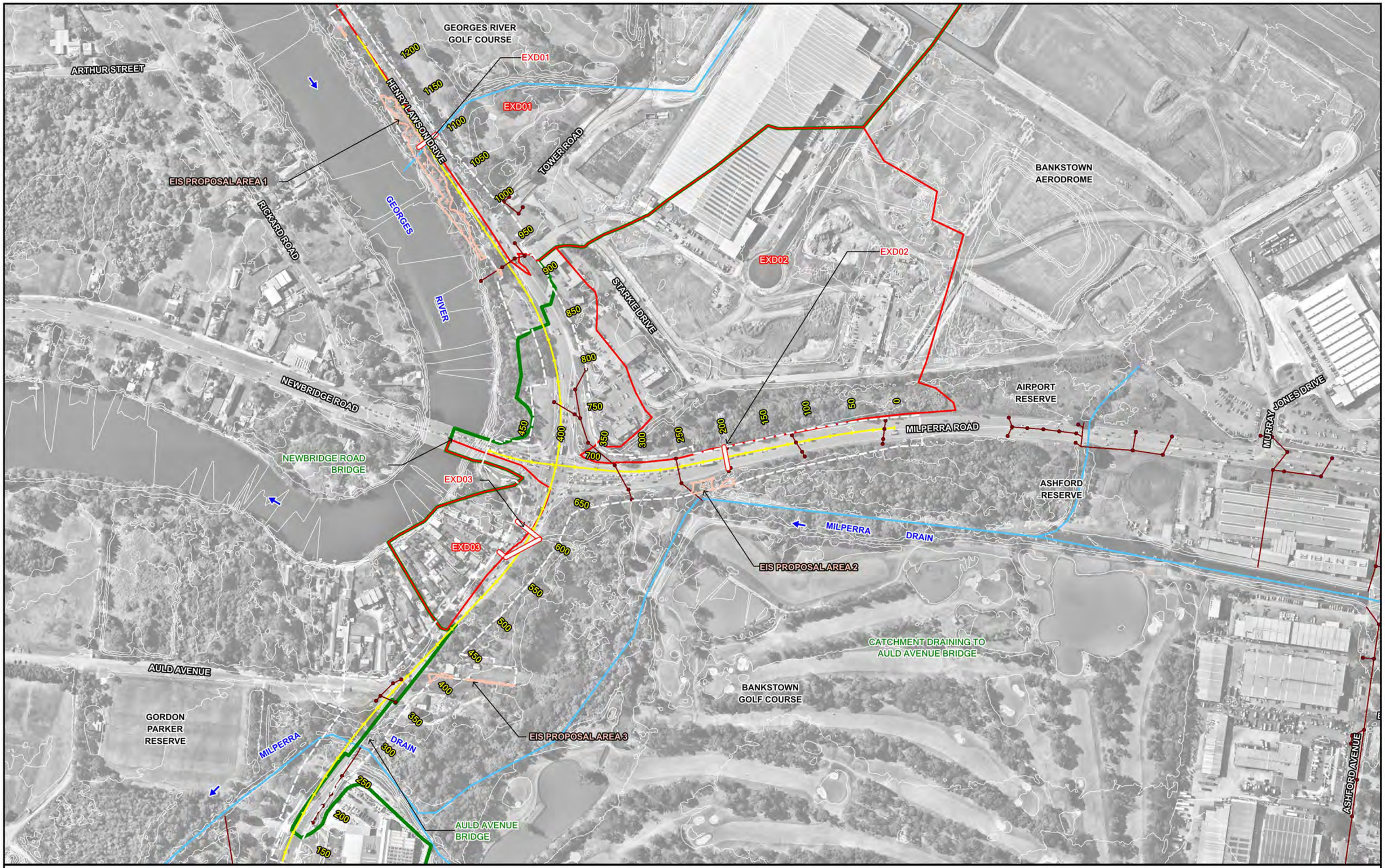
Overall Proposal Boundary

EIS Proposal Area

HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.1
(Sheet 1 of 2)

CATCHMENT PLAN AND EXISTING DRAINAGE LAYOUT



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LEGEND

EXD01 — Existing Transverse Drainage Structure and Identifier

EXD01 — Extent of Catchment Draining to Existing Transverse Drainage Structure and Identifier

Extent of Milperra Drain Catchment Draining to Auld Avenue Bridge

Existing Drainage Line

250 500 — Road Alignment and Chainage

Existing Stormwater Drainage System

Overall Proposal Boundary

EIS Proposal Area

HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.1
(Sheet 2 of 2)

CATCHMENT PLAN AND EXISTING DRAINAGE LAYOUT

Indicative Depth of Inundation (m)

- 0.10 to 0.20
- 0.20 to 0.30
- 0.30 to 0.40
- 0.40 to 0.50
- 0.50 to 0.60
- 0.60 to 0.70
- 0.70 to 0.80
- 0.80 to 0.90
- 0.90 to 1.00
- > 1.00

DHURAWAL BAY
FRANK OLIVERI DRIVE
HERON PARK
BARRY ROAD
CHILDS ROAD
CHIPPING NORTON
GOVERNOR MACQUARIE DRIVE
RIVERSIDE ROAD
ALFRED ROAD
RIVERSIDE PARK
HENRY LAWSON DRIVE
GEORGES RIVER
ARTHUR STREET
PAT DEVLIN CLOSE
RICKARD ROAD
NEWBRIDGE ROAD
GEORGES CRESCENT
GEORGES HALL
BIRDWOOD ROAD
ENDEAVOUR RD
BELLEVUE AVENUE
MARION STREET
GEORGES RIVER GOLF COURSE
TOWER ROAD
BANKSTOWN AERODROME
ALLINGHAM STREET
SALTASH STREET
WARUDA STREET
THE AVENUE
WILLIAM STREET
YORK STREET
NORMAN STREET
EDGAR STREET
TOWNSEND STREET
LANCELOT STREET
PRINGLE AVENUE
OXFORD AVENUE
RAILWAY PARADE
CONDELL PARK PUBLIC SCHOOL
AUGUSTA STREET
CONDELL PARK
YANDERRA STREET
OLIVE STREET
GALLIPOLI STREET
ANTWERP STREET
BANKSTOWN SENIOR COLLEGE
ELDRIDGE ROAD
BANKSTOWN SHOWGROUND
BANKSTOWN LIDCOMBE HOSPITAL
ELDRIDGE R
REFER SHEET 2
1225
1000
750
500
250
0
STARKIE DRIVE
MILPERRA ROAD
MILPERRA DRAIN
AULD AVENUE
DRAIN
BANKSTOWN GOLF COURSE
BRICKMAKERS DRIVE
KEYS PARADE
MILPERRA SPORTS CENTRE
WHITTLE AVENUE
ASHFORD AVENUE
HORSLEY ROAD
ARMOUR STREET
MARIGOLD STREET
FITZPATRICK STREET
VIOLET STREET
DAISY STREET
QUEEN STREET
CANTERBURY ROAD
TURVEY STREET
REVESBY
CARRINGTON STREET
SOUTH WESTERN MOTORWAY
TRACEY STREET
WURRUNGWURI RESERVE
RALEIGH ROAD
NEWLAND AVENUE
AMIENS AVENUE
BULLECOURT AVENUE
DERNANCOURT PARADE
MILPERRA
HENRY LAWSON DRIVE
HERMIES AVENUE
POZIERES AVENUE
MILPERRA PUBLIC SCHOOL
RIVERLANDS GOLF COURSE
UNIVERSITY OF WESTERN SYDNEY BANKSTOWN CAMPUS

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Scale: 1:15,000

LEGEND

- Road Alignment and Chainage (250, 500)
- Modelled Stormwater Drainage Network
- Overall Proposal Boundary
- EIS Proposal Area

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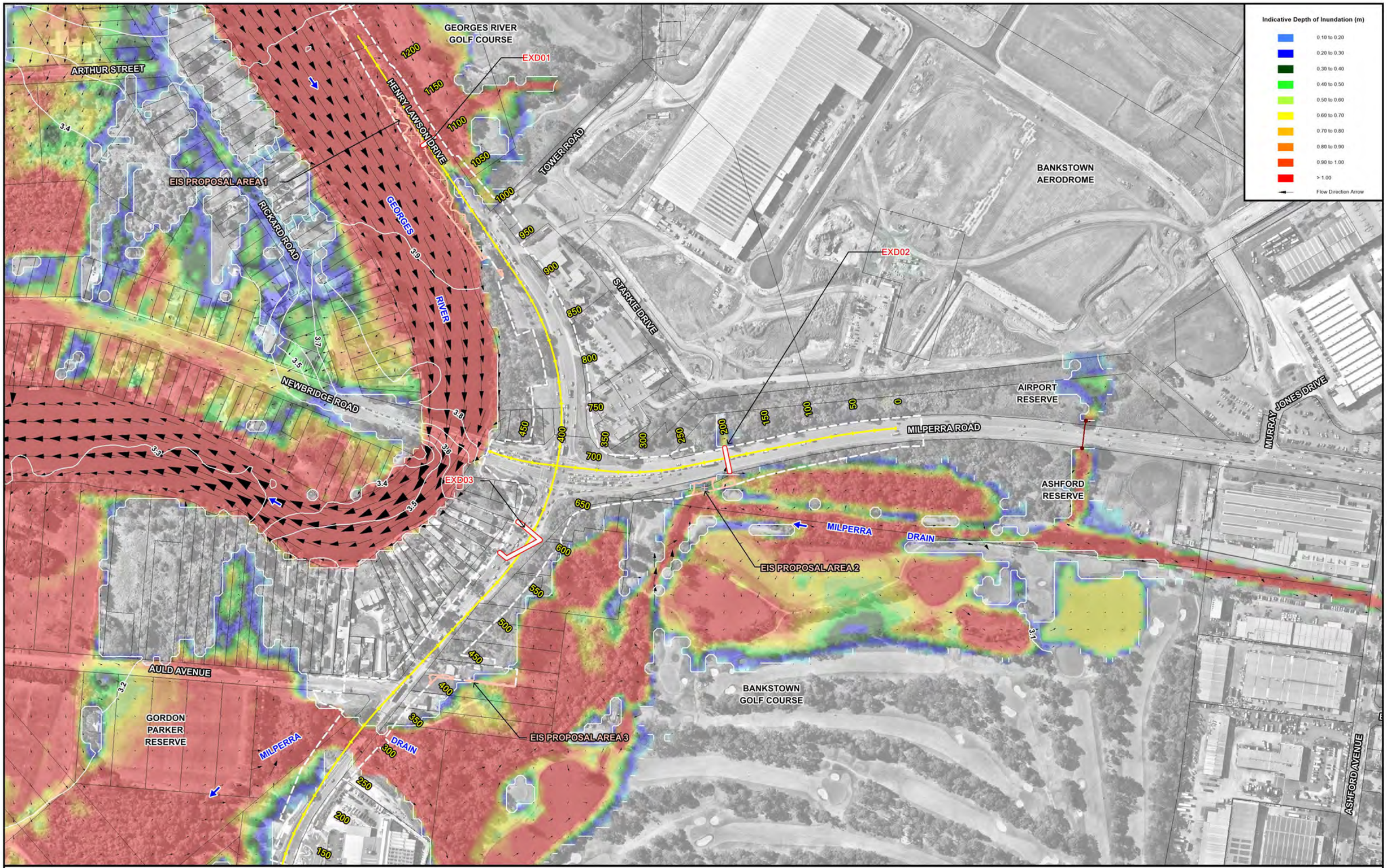
HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.2
(Sheet 1 of 2)

PATTERNS OF MAIN STREAM FLOODING - PRE-PROPOSAL CONDITIONS
10% AEP GEORGES RIVER FLOOD EVENT



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Scale: 1:4,000

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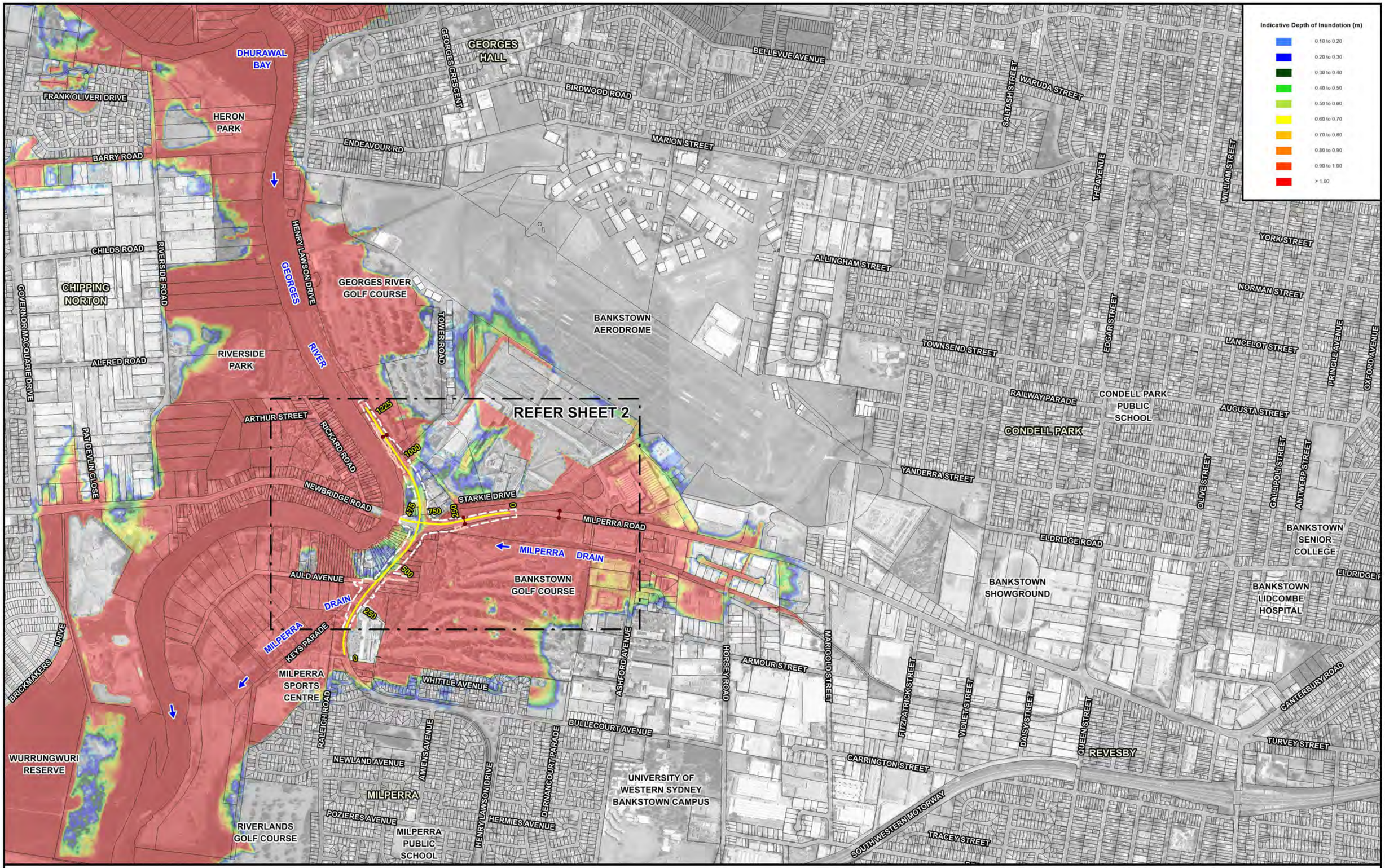
LEGEND

- Road Alignment and Chainage (250 500)
- Modelled Stormwater Drainage Network
- Water Surface Elevation Contours (m AHD) (3.6)
- Overall Proposal Boundary
- EIS Proposal Area
- Existing Transverse Drainage Structure and Identifier (EXD01)

HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.2
(Sheet 2 of 2)

PATTERNS OF MAIN STREAM FLOODING - PRE-PROPOSAL CONDITIONS
10% AEP GEORGES RIVER FLOOD EVENT



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Scale: 1:15,000

250 500

Road Alignment and Chainage

Modelled Stormwater Drainage Network

LEGEND

Overall Proposal Boundary

EIS Proposal Area

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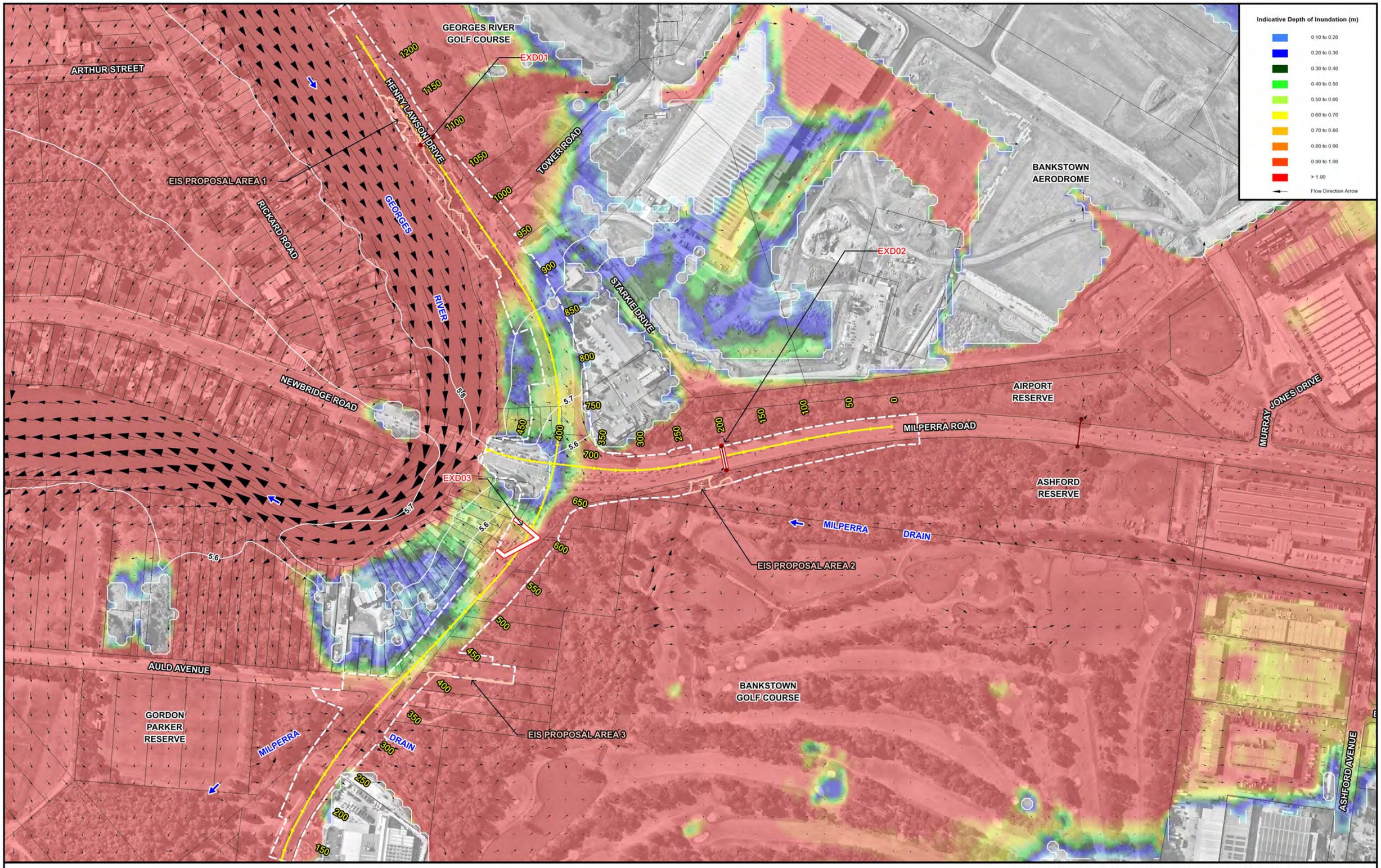
HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.3
(Sheet 1 of 2)

PATTERNS OF MAIN STREAM FLOODING - PRE-PROPOSAL CONDITIONS
1% AEP GEORGES RIVER FLOOD EVENT



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HENRY LAWSON DRIVE UPGRADE STAGE 1A REF/EIS
ENVIRONMENTAL WORKING PAPER: FLOODING

Figure 4.3
(Sheet 2 of 2)

PATTERNS OF MAIN STREAM FLOODING - PRE-PROPOSAL CONDITIONS
1% AEP GEORGES RIVER FLOOD EVENT