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Hydrology and Flooding Impact Assessment
EIS Technical Report 11

HumeLink

EIS Technical Report 11 – Hydrology and Flooding Impact Assessment

Transgrid

May 2023

Executive Summary

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. HumeLink would connect to proposed Gugaa 500 kV substation and existing substations at Bannaby and Wagga Wagga as well as a future substation at Maragle in the Snowy Mountains (referred to as the future Maragle 500 kV substation), which is subject to a separate major project assessment and approval (reference SSI-9717, EPBC, 2018/836).

This Hydrology and Flooding Impact Assessment has been prepared in accordance with the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project issued on 14 March 2022 to address the potential construction and risks to the project. The assessment included data collection, review of existing studies, hydrological and hydraulic (flood) modelling and climate change assessment.

An initial desktop screening assessment based on local topography identified that the following proposed construction compounds are located on high ground with no regional or local flood risk: Snubba Road compound (C03), Honeysuckle Road compound (C07), Red Hill Road compound (C08) and Adjungbilly Road compound (C09).

Due to their proximity to waterways, further investigation was undertaken on the Wagga 330 kV substation compound (C01), Snowy Mountains Highway compound (C02), Maragle 500 kV substation compound (C05), Gregadoo Road compound (C06), Yass substation compound (C10), Woodhouselee Road compound (C11), Memorial Avenue compound (C14), Bowmans Lane compound (C15), Snubba Road compound (C16), Tumbarumba Accommodation Facility (AC1) and the proposed telecommunications hut.

Two-dimensional modelling identified the Snowy Mountains Highway compound (C02) would be the most impacted by flooding as the construction compound is located on a local overland flowpath. All other construction compounds, the worker accommodation facility and telecommunications hut have potential to result in minor flood impacts in storm events up to the 5% AEP and 2% AEP events respectively. These flood impacts would be managed through the site drainage design and stormwater management plan.

To assess flood risks during project operation, waterway intersections with the project footprint that were up to a third stream order based on the Hack's stream order analysis method were modelled with higher resolution. The assessment identified locations within the project footprint that would be impacted by the 1% AEP flood with high hazard.

The flood risks at the proposed locations of transmission line structures and access tracks have been assessed. Should they be placed within high flood risk areas, detailed design would need to consider flood risks including hydraulic loading and scour risk.

This hydrology and flooding impact assessment has identified generally minor adverse impacts on flood behaviour as a result of the project.

These impacts would be managed through proper implementation of the recommended management measures.

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Glossary and abbreviations

Abbreviation or term	Description
ACT	Australian Capital Territory
AEP	Annual Exceedance Probability - the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.
Afflux	Change in flood level between two scenarios
ARI	Average Recurrence Interval - the average, or expected, time between the occurrences of a given flood as big or larger than the selected event.
ARR	Australian Rainfall and Runoff. Referring to the 2019 Australian Rainfall and Runoff: A guide to flood estimation
BoM	Bureau of Meteorology
DPE	Department of Planning and Environment
DPI	Department of Primary Industries
EIS	Environmental Impact Statement
FFA	Flood Frequency Analysis
Floodplain	An area of land that is subject to flooding.
GSAM	Generalised South Australia Method
GSDM	Generalised Short-Duration method
Hydraulics	The science of water movement along channels, floodplains, pipes and other structures that convey water.
Hydrology	Assessment of rainfall and runoff processors in a catchment area.
IWL	Initial Water Level
Local drainage	Stormwater runoff along no defined waterway, sheet flow shallow in depth and localised to the point of interest. Can be managed by standard drainage practices
Local flooding	Flooding originating from local waterways that are tributaries to larger creeks and rivers. Requires trunk drainage scale infrastructure to manage.
LiDAR	Light Detection and Ranging
mAHD	metres above Australian Height Datum
NEM	National Electricity Market
NSW	New South Wales
OPGW	Optical Fibre Ground Wire
PMP	Probable Maximum Precipitation
Project footprint	The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction and any easement required during operation.
Regional flooding	Flooding originating from the main river system of the broader catchment eg Murrumbidgee River. Generally not able to be managed using proprietary drainage infrastructure.
RFFE	Regional Flood Frequency Estimation
SRTM	Shuttle Radar Topographic Mission
TAF	Topographical Adjustment Factor
TUFLOW	One and two dimensional hydrodynamic modelling software
WM Act	*Water Management Act 2000*

1 Introduction

1.1 Overview

The Australian energy landscape is transitioning to a greater mix of low-emission renewable energy sources, such as wind and solar. To support this transition, meet our future energy demands and connect Australian communities and businesses to these lower cost energy sources, the national electricity grid needs to evolve.

Transgrid proposes to increase the energy network capacity in southern New South Wales (NSW) through the development of around 360 kilometres of new 500 kilovolt (kV) high-voltage transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle. This project is collectively referred to as HumeLink. The project would be located across five Local Government Areas (LGAs) including Wagga Wagga City, Snowy Valleys, Cootamundra-Gundagai Regional, Upper Lachlan Shire and Yass Valley. The location of the project is shown on Figure 1-1.

HumeLink would involve construction of a new substation east of Wagga Wagga as well as connection to existing substations at Wagga Wagga and Bannaby and a future substation at Maragle in the Snowy Mountains (referred to as the future Maragle 500 kV substation). The future Maragle 500 kV substation is subject to a separate major project assessment and approval (reference SSI-9717, EPBC 2018/836).

The project would deliver a cheaper, more reliable and more sustainable grid by increasing the amount of renewable energy that can be delivered across the national electricity grid, helping to transition Australia to a low carbon future. It would achieve this by supporting the transfer of energy from existing renewable generation as well as facilitate development of new renewable generation in the Wagga Wagga and Tumut Renewable Energy Zones (REZs). The project would provide the required support for the network in southern NSW, allowing for the increase in transfer capacity between new renewable generation sources and the state’s demand centres of Sydney, Newcastle and Wollongong. The project would also improve the efficiency and reliability of the current energy transfer in this part of the network.

Furthermore, HumeLink would form a key part of the transmission line infrastructure that supports the transfer of energy within the National Electricity Market (NEM) by connecting with other major interconnectors. The NEM incorporates around 40,000 kilometres of transmission lines across Queensland (QLD), NSW, Australian Capital Territory (ACT), Victoria (VIC), South Australia (SA) and Tasmania (TAS).

Construction of the project is targeted to commence in 2024, subject to the required planning and regulatory approvals. Once construction has commenced, the project is estimated to take approximately 2.5 years to build and would become operational by the end of 2026.

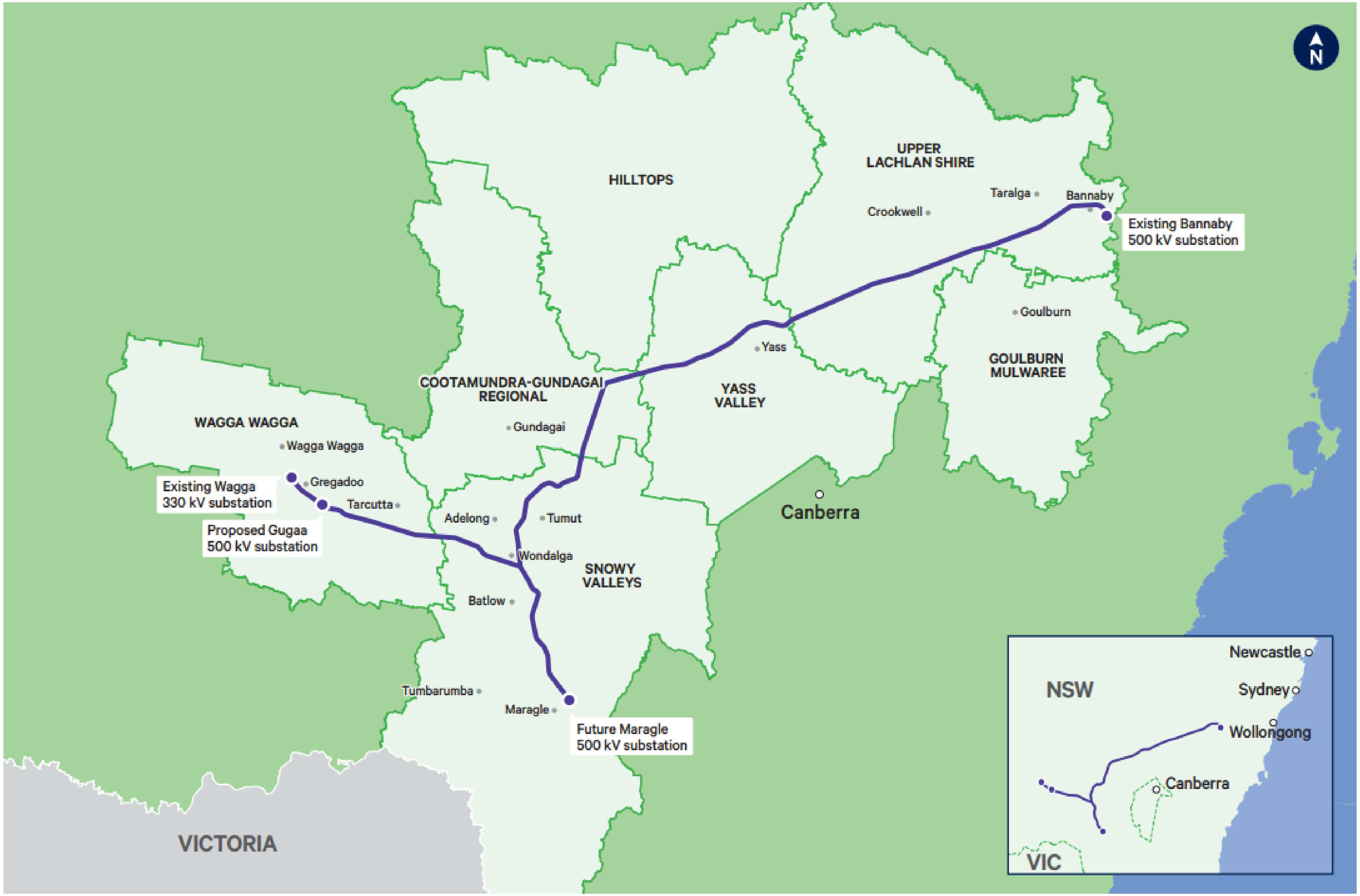
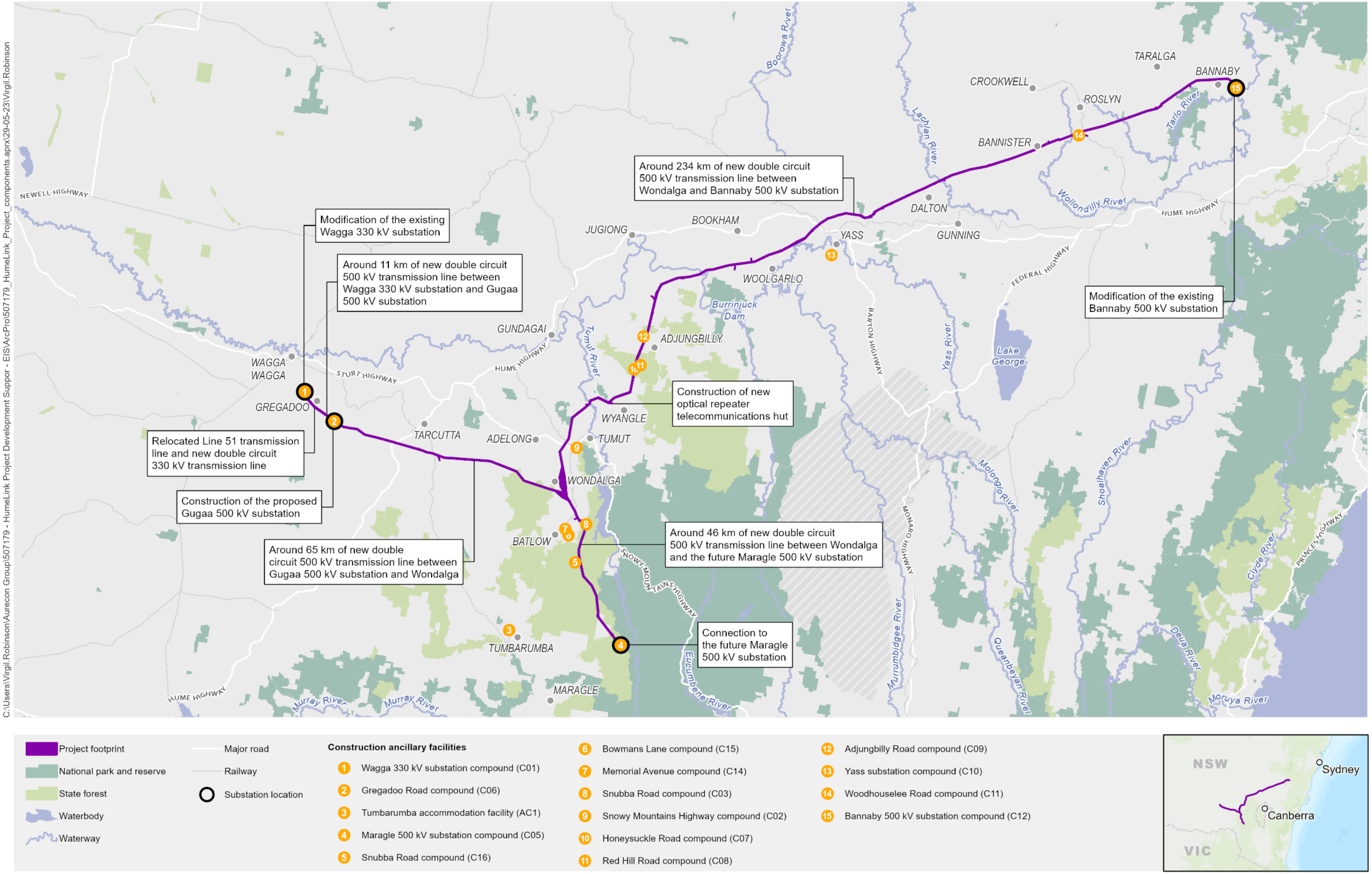


Figure 1-1 Location of the project

1.2 Key components

The project includes the following key components (refer to Figure 1-2):

- construction and operation of around 360 kilometres of new double circuit 500 kV transmission lines and associated infrastructure between Wagga Wagga, Bannaby and Maragle
- construction of a new 500/330 kV substation at Gregadoo (Gugaa 500 kV substation) approximately 11 kilometres south-east of the existing Wagga 330/132 kV substation (Wagga 330 kV substation)
- demolition and rebuild of a section of Line 51 (around two kilometres in length) as a double circuit 330 kV transmission line connecting into the Wagga 330 kV substation
- modification of the existing Wagga 330 kV substation and Bannaby 500/330 kV substation (Bannaby 500 kV substation) to accommodate the new transmission line connections
- connection of transmission lines to the future Maragle 500/330 kV substation (Maragle 500 kV substation, approved under the Snowy 2.0 Transmission Connection Project (SSI-9717))
- provision of one optical repeater telecommunications hut and associated connections to existing local electrical infrastructure
- establishment of new and/or upgraded temporary and permanent access tracks
- ancillary works required for construction of the project such as construction compounds, worker accommodation facilities, utility connections and/or relocations, brake and winch sites, and helipad/helicopter support facilities.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:925,000

0 20 40km

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 1-2: Key components of the project

1.3 Purpose and scope of this report

The purpose of this report is to assess the potential hydrology and flooding impacts from construction and operation of the project to support the environmental assessment in accordance with Division 5.2 of the *Environmental Planning and Assessment Act 1979*.

1.4 Secretary's environmental assessment requirements

This report has been prepared in accordance with the Planning Secretary's Environmental Assessment Requirements (SEARs) for the project (SSI-36656827) as well as relevant government assessment requirements, guidelines and policies, and in consultation with government agencies. Table 1-1 lists relevant matters of the SEARs addressed in this report. Further related water and soils issues identified within the SEARs are addressed in *Technical Report 10 – Phase 1 Contamination Assessment* and *Technical Report 12 - Surface Water and Groundwater Impact Assessment*.

Table 1-1 Secretary's Environmental Assessment Requirements

Subject	Secretary's Environmental Assessment Requirements	Assessment
Water	an assessment of the potential flooding impacts and risks of the project;	This technical report (Technical Report 11)

1.5 Structure of this report

The structure of this report is as follows:

- Chapter 1: Introduction
  - introduction and overview of project
- Chapter 2: Project description summary
  - description of key components of the project
- Chapter 3: Legislative and policy context
  - discussion on key legislation/policies/guidelines that were used to inform the approach for the assessment
- Chapter 4: Methodology
  - discussion on the key tasks that were undertaken to inform this assessment including steps involved and data sources used
- Chapter 5: Existing environment
  - description of surrounding environment and catchment topography
- Chapter 6: Construction impacts
  - discussion on possible hydrology and flooding impacts during construction of the project
- Chapter 7: Operational impacts
  - discussion on possible hydrology and flooding impacts during operation of the project
- Chapter 8: Cumulative impacts
  - discussion on potential cumulative flood impacts arising from current and future development within the vicinity of the project.
- Chapter 9: Management of impacts.

1.6 Key project terms

- Project footprint - The area that has been assumed for the purpose of this EIS to be directly affected by the construction and operation of the project. It includes the indicative location of project infrastructure, the area that would be directly disturbed during construction and any easement required during operation
- Study area - The study area is defined as the area analysed to determine the project impacts due to flooding.

2 Project description summary

The project description in this chapter is based on a concept design and indicative construction methodology for the project. The design and construction methodology would continue to be refined and confirmed during detailed design and construction planning by the construction contractors. Further details on the project are provided in Chapters 3 and 4 of the EIS.

2.1 Summary of key components of the project

Key components of the project are summarised in Table 2-1.

Table 2-1 Summary of key components of the project

Component	Description
Transmission lines and supporting infrastructure	
Transmission lines and structures	The project includes the construction of new 500 kV transmission line sections between: - Wagga 330 kV substation and Gugaa 500 kV substation (approximately 11 km) - Gugaa 500 kV substation and Wondalga (approximately 65 km) - Wondalga and Maragle 500 kV substation (approximately 46 km) - Wondalga and Bannaby 500 kV substation (approximately 234 km). The transmission line section between the Wagga 330 kV substation and proposed Gugaa 500 kV substation would operate at 330 kV under HumeLink. The project also includes the rebuild of approximately 2 km of Line 51 as a new 330 kV transmission line between the Wagga 330 kV substation and around Ivydale Road, Gregadoo. This would be adjacent to the new transmission line between the existing Wagga 330 kV and proposed Gugaa 500 kV substations. The 500 kV transmission lines would be supported on a series of free-standing steel lattice structures that would range between around 50 m up to a maximum of 76 m in height and generally spaced between 300 to 600 m apart. The typical transmission line structure height would be around 60 m. Earth wire and communications cables would be co-located on the transmission line structures. The 330 kV structures for the rebuild of Line 51 would range between 24 m and 50 m in height and have a typical height of 40 m. Indicative configurations of transmission line structures that may be used as part of the project are shown in Figure 1-2. The type and arrangement of the structures would be refined during detailed design. The footings of each structure would require an area of up to 450 m^2, depending on ground conditions and the proposed structure type. Additional disturbance at each structure site may be required to facilitate structure assembly and stringing.
Transmission line easements	The easements for the 500 kV transmission lines are typically 70 m wide. However, a number of locations may require wider easements of up to 110 m wide at transposition locations[1] and up to 130 m wide where the new transmission line would parallel the relocated section of Line 51. The easement provides a right of access to construct, maintain and operate the transmission line and other operational assets. The easement also generally identifies the zone of initial vegetation clearance and ongoing vegetation management to ensure safe electrical clearances during the operation of the lines. Vegetation management beyond the easement may also occur where nearby trees have the potential to fall and breach safety clearances.
Telecommunications hut	Telecommunications huts, which contain optical repeaters, would be required to boost the signal in the optical fibre ground wire (OPGW). One telecommunications hut would be required for the project. The telecommunications hut would be located adjacent to existing transmission line structures. Cables would be installed between the transmission line structure and the local power supply. The telecommunications hut would be surrounded by a security fence. A new easement would be established for the telecommunications hut power connection. The project also involves a telecommunications connection of OPGW between two proposed transmission line structures and the future Rye Park Wind Farm substation (SSD-6693). This removes the need for an additional telecommunications hut in this area of the project.

[1] Transposition is the periodic swapping of positions of the conductors of a transmission line in order to improve transmission reliability.

Component	Description
Substation activities	
Construction of the proposed Gugaa 500 kV substation	A new 500/330 kV substation would be constructed at Gregadoo, about 11 km south-east of the Wagga 330 kV substation. The substation would include seven new 500/330 kV transformers and three 500 kV reactors. The proposed Gugaa 500 kV substation is expected to occupy an area of approximately 170,000 m^2.
Modification of the existing Bannaby 500 kV substation	The existing Bannaby 500 kV substation on Hanworth Road, Bannaby would be expanded to accommodate connections for new 500 kV transmission line circuits. The modification would include changes to the busbars, line bays, bench and associated earthworks, steelwork, drainage, external fence, internal/external substation roads, secondary containment dams, sediment containment dams, cabling, and secondary systems. All of the works would be restricted to the existing substation property.
Modification of the existing Wagga 330 kV substation	The existing Wagga 330 kV substation on Ashfords Road, Gregadoo would be reconfigured to accommodate new bays for two new 500 kV transmission line circuits within the existing substation property. This would include modifications to the busbars, line bays, existing line connections, bench and associated earthworks, relocation of existing high voltage equipment, drainage, external fence, internal substation roads, steelwork, cabling, and secondary systems.
Connection to the future Maragle 500 kV substation	The project would connect to the future Maragle 500 kV substation approved under the Snowy 2.0 Transmission Connection Project (SS1-9717). Construction of the Maragle substation is proposed to be undertaken between 2023 and 2026. Further detail on the Snowy 2.0 Transmission Connection project is available at the Department of Planning and Environment's Major Projects website: **www.planningportal.nsw.gov.au/major-projects/project/10591.**
Ancillary facilities	
Access tracks	Access to the transmission line structures and the substations would be required during construction and operation. Wherever possible, existing roads, tracks and other existing disturbed areas would be used to minimise vegetation clearing or disturbance. Upgrades to existing access tracks may be required. In areas where there are no existing roads or tracks, suitable access would be constructed. This may include waterway crossings.
Construction compounds	Construction compounds would be required during construction to support staging and equipment laydown, concrete batching, temporary storage of materials, plant and equipment and worker parking required to construct the various elements of the project. Fourteen potential construction compound locations have been identified. The proposed use of the construction compounds and their proposed boundaries/layout would be refined as the project design develops in consultation with relevant stakeholders and the construction contractors.
Worker accommodation facility	Existing accommodation facilities within towns adjacent to the project would provide temporary accommodation for the majority of the construction workers. However, a potential shortage in accommodation has been identified close to the project footprint. A potential option to provide additional temporary worker accommodation during the construction period is the establishment of a temporary worker accommodation facility at the corner of Courabyra Road and Alfred Street, Tumbarumba to accommodate about 200 construction workers. The worker accommodation facility would consist of demountable cabins and would be connected to existing utilities. All required amenities for the accommodation facility would be provided including services and worker parking for light and heavy vehicles. However, the ultimate delivery of the project may include multiple temporary worker accommodation facilities in various forms, which would be outlined in the Worker Accommodation Strategy for the project. The strategy will be developed in consultation with councils, and other relevant stakeholders. Any new or changed worker accommodation facility would be subject to additional environmental assessment, as required.
Helipad/helicopter facilities	To facilitate construction of the project, helicopters may be used to deliver materials/equipment and transfer personnel to construction areas particularly within high alpine regions. To enable helicopters to operate safely and allow easy access to the site, a helicopter landing pad would be required. The helipad is expected to occupy an area of around 30 m by 30 m and would be remediated after construction. These areas would typically be located on existing disturbed land not subject to inundation and a reasonable distance from waterways, sensitive receivers, and drainage lines. Eight locations have been identified and assessed as potential helipad locations. The exact locations to be used would be confirmed during detailed design by the construction contractors. In addition to this, the existing facilities at the Wagga Wagga Airport, and Tumut Airport may be used.

Component	Description
Utility connections, adjustments, and protection	The project would require utility connections, adjustments, and protection. Such works include interfaces with other transmission lines and connections to existing services for temporary facilities. Potential impacts to existing services and utilities would be confirmed during detailed design and any proposed relocation and/or protection works would be determined in consultation with the relevant asset owners.

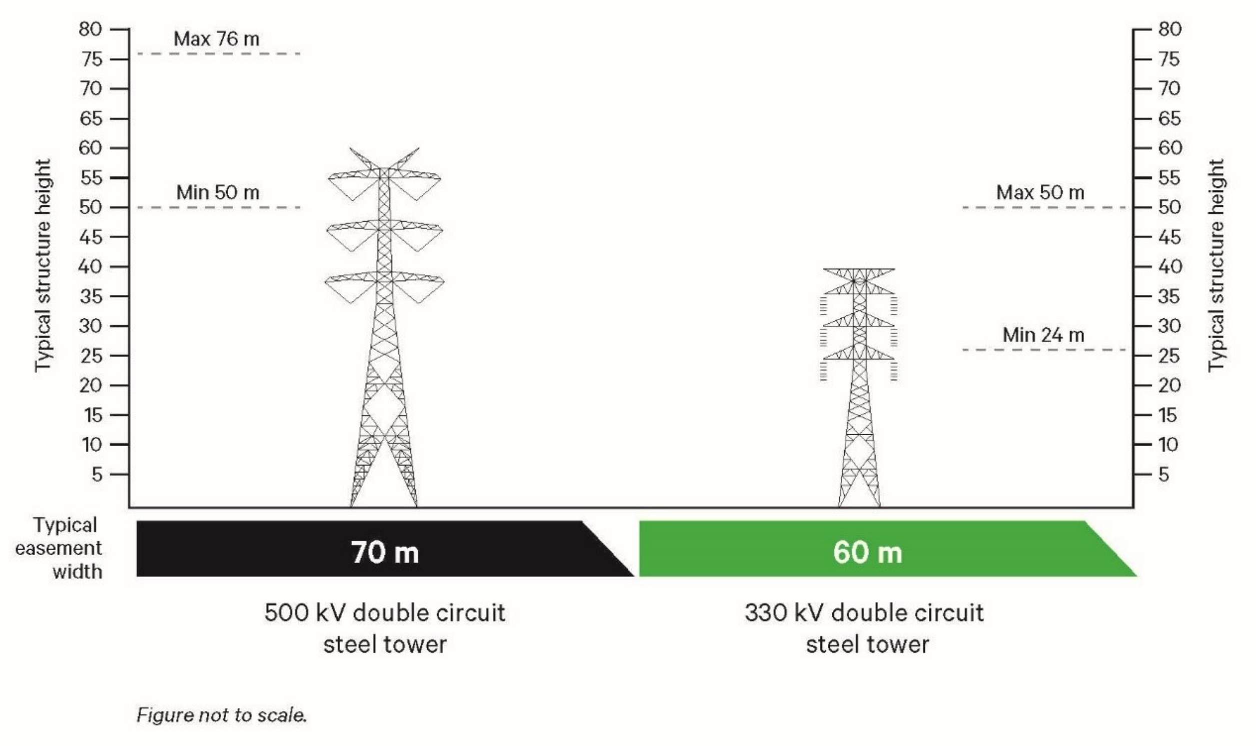


Figure 2-1 Indicative transmission line structure

2.2 Construction of the project

2.2.1 Construction activities

Key construction activities would generally include (but are not limited to):

- site establishment work, such as:
  - clearing of vegetation and topsoil
  - establishment of construction compounds and helipad/helicopter facilities
  - utility relocations and/or adjustments
  - construction of new access tracks and waterway crossings and/or upgrade of existing access tracks to transmission line structures
  - road improvement work
  - establishment of environmental management measures and security fencing
  - construction of temporary worker accommodation
- construction of the transmission lines, including:
  - earthworks and establishment of construction benches and brake and winch sites for each transmission line structure
  - construction of footings and foundation work for the new transmission line structures including boring and/or excavation, steel fabrication works and concrete pours
  - erection of the new transmission line structures
  - stringing of conductors, overhead earth wires and OPGW
  - installation of associated transmission line structure fittings inclusive of all earthing below ground level
- relocation of a section of Line 51, including:
  - demolition of the existing section of Line 51
  - erection of new transmission line structures for the rebuild of Line 51 in a new location
  - stringing of conductors, overhead earth wires and OPGW
  - installation of associated transmission line structure fittings inclusive of all earthing below ground level
- construction of the proposed Gugaa 500 kV substation, including:
  - bulk earthworks to form the substation bench, access roads, drainage and oil containment structures
  - installation of concrete foundations, bund walls, fire walls, noise walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment work and associated concrete pits, pipes and tanks including excavation
  - installation of new ancillary and equipment control buildings
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - erection of the substation site boundary security fencing, including site access gates
  - connection of the proposed transmission lines to the substation

- modification of the existing Wagga 330 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - demolition and removal of redundant electrical equipment, fencing and cabling
  - bulk earthworks to form the extended substation bench and modified drainage structures
  - installation of concrete foundations and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, and modified site stormwater drainage including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - testing and commissioning
  - connection of the proposed transmission lines to the substation
- modification of the existing Bannaby 500 kV substation to enable the proposed connection and operation of the new transmission lines, including:
  - bulk earthworks to form the extended substation bench, new access road, modified stormwater drainage, modified oil containment and modified sediment control structures
  - installation of concrete foundations, retaining walls, bund walls, fire walls and kerbs including excavation
  - installation of reinforced concrete and piled foundations for the electrical equipment and associated steel support structures
  - erection of galvanised steel structures to support electrical equipment
  - installation of electrical equipment on foundations and/or steel support structures
  - installation of electrical conduits, electrical trenches, site stormwater drainage, oil containment works and associated concrete pits, pipes and tanks including excavation
  - installation of conductors, cabling, wiring, electrical panels and electrical equipment
  - installation of fencing, lighting and other security features
  - demolish redundant fencing including footings and kerbs
  - testing and commissioning
  - connection of the proposed transmission lines to the substation
- connection of the proposed transmission lines to the future Maragle 500 kV substation, including:
  - stringing conductors between transmission line structures and the future Maragle 500 kV substation gantry (including overhead earth wire (OHEW) and OPGW)
  - installing droppers from the future substation gantry to the switchgear
- construction of the telecommunications hut, including:
  - bulk earthworks to form the pad for the hut
  - excavation and preparation for concrete foundations
  - installation of reinforced concrete and piled foundations
  - excavation and installation of electrical equipment conduits, trenches and general site drainage work

– installation of the building, site wiring and electrical equipment

– installation of security fencing and site access gates

- installation of buried cabling from the 500 kV transmission line structures to Rye Park Wind Farm substation
- testing and commissioning of new electrical infrastructure
- demobilisation and rehabilitation of areas disturbed by construction activities.

A number of activities are expected to commence in accordance with the project conditions of approval before the key construction activities outlined above. These activities are considered pre-construction minor work and would comprise low impact activities that would begin after planning approval but prior to approval of the Construction Environmental Management Plan.

2.2.2 Construction program

Construction of the project is targeted to commence in 2024 and is estimated to take about 2.5 years to complete. The project is expected to be fully operational by the end of 2026 (refer to Figure 2-2).

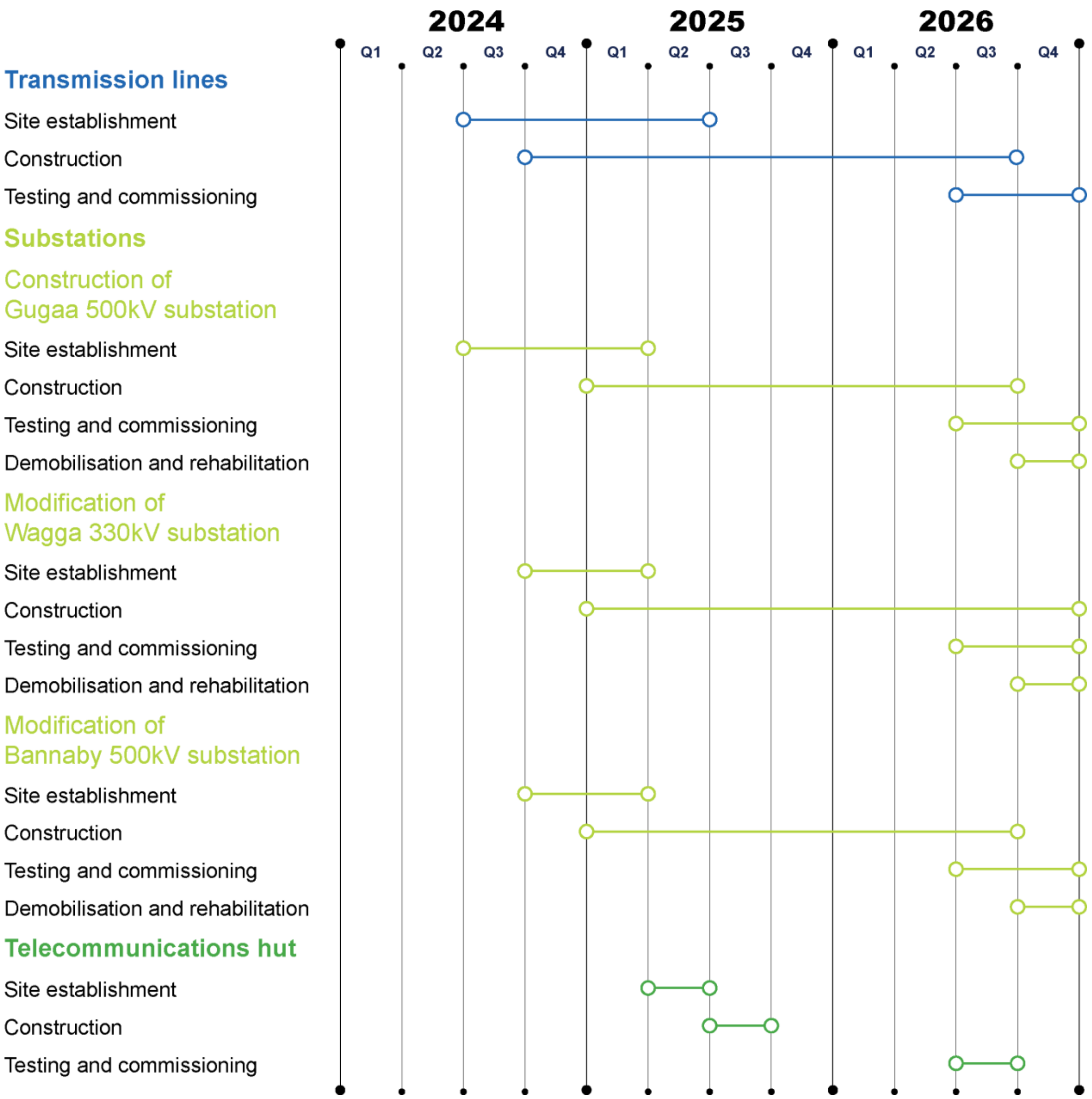


Figure 2-2 HumeLink indicative construction program

2.2.2.1 Indicative duration of construction activities

Construction at each transmission line structure would be intermittent and construction activities would not occur for the full duration at any one location. Durations of any particular construction activity, and inactive/respite periods, may vary for a number of reasons including (but not limited to):

- multiple work fronts
- resource and engineering constraints
- work sequencing and location.

Figure 2-3 presents an indicative duration of construction activities associated with an individual transmission line structure.

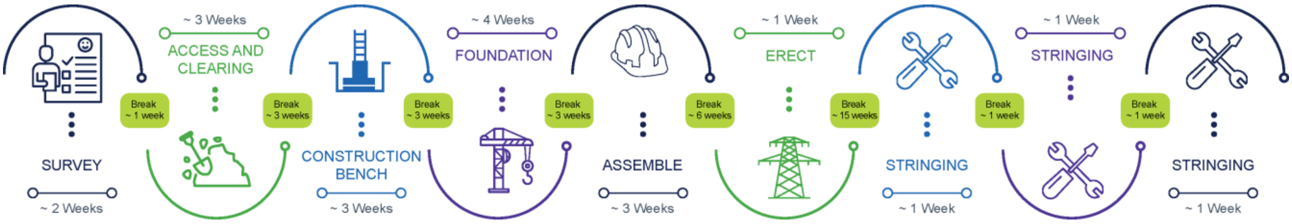


Figure 2-3 Indicative duration and sequence of construction activities for transmission line structures

Construction of the proposed Gugaa 500 kV substation could take up to 2.5 years.

2.2.3 Construction hours

It is expected that construction activities would largely be undertaken during standard construction hours. However, there would be times when working outside of standard construction hours would be required (as defined by the *Interim Construction Noise Guideline* (DECC, 2009)), subject to approval. As the details of construction methodology and project needs are developed, these hours will be refined for certain activities.

Where extended hours are proposed for activities in proximity to sensitive receivers, additional measures would be implemented and the work would be managed through an out-of-hours work protocol.

A series of work outside the standard construction hours is anticipated to include (but is not limited to) the following:

- transmission line construction at crossings of a main road or railway as these locations are expected to have restricted construction hours requiring some night work for activities such as conductor stringing over the crossing(s)
- work where a road occupancy licence (or similar) is required, depending on licence conditions
- transmission line cutover and commissioning
- the delivery of equipment or materials outside standard hours requested by police or other authorities for safety reasons (such as the delivery of transformer units)
- limited substation assembly work (eg oil filling of the transformers)
- connection of the new assets to existing assets under outage conditions (eg modification and/or connection work at Bannaby 500 kV substation, Wagga 330 kV substation and Maragle 500 kV substation), which is likely to require longer working hours
- emergency work to avoid the loss of lives and/or property and/or to prevent environmental harm
- work timed to correlate with system planning outages
- situations where agreement is reached with affected sensitive receivers
- activities that do not generate noise in excess of the applicable noise management level at any sensitive receiver.

2.2.4 Construction plant and equipment

An indicative list of construction plant and equipment likely to be required during construction is provided below:

- air compressor
- backhoe
- bobcat
- bulldozers
- concrete agitator
- concrete pump
- cranes (various sizes up to 400 tonnes)
- crawler crane with grab attachments
- drill and blast units and associated support plant/equipment
- drones
- dumper trucks
- elevated working platforms
- excavators (various sizes)
- flatbed hiab trucks
- fuel trucks
- generators
- graders
- helicopters and associated support plant/equipment
- mulchers
- piling rig
- pneumatic jackhammers
- rigid tippers
- rollers (10 to 15 and 12-15 tonnes)
- semi-trailers
- tilt tray trucks
- trenchers
- transport trucks
- watercarts
- winches.

2.2.5 Construction traffic

Construction vehicle movements would comprise vehicles transporting equipment, waste, materials and spoil, as well as workers' vehicles. A larger number of heavy vehicles would be required during the main civil construction work associated with the substations. Non-standard or oversized loads would also be required for the substation work (eg for transformer transport) and transportation of transmission line structure materials and conductors.

Hume Highway, Sturt Highway, Snowy Mountains Highway, Batlow Road and Gocup Road are the main national and state roads proposed to provide access to the project footprint. These roads would be supported by regional and local roads throughout the Local Government Areas (LGAs) of Wagga Wagga City, Snowy Valleys, Yass Valley, Cootamundra-Gundagai Regional and Upper Lachlan Shire that connect to the project footprint.

2.2.6 Construction workers

The construction worker numbers would vary depending on the stage of construction and associated activities. During peak construction activities, the project could employ up to 1,200 full time equivalent construction workers across multiple work fronts. It is expected that the maximum number of construction workers at any one location would not exceed 200.

2.2.7 Testing and commissioning

Prior to energisation of the infrastructure, a series of pre-commissioning activities would be conducted. This would include testing the new transmission lines and substation earthing, primary and secondary equipment.

2.2.8 Demobilisation and rehabilitation

Demobilisation and site rehabilitation would be undertaken progressively throughout the project footprint and would include the following typical activities:

- demobilisation of construction compounds and worker accommodation facility
- removal of materials, waste and redundant structures not required during operation of the project
- removal of temporary fencing and environmental controls.

2.3 Operation and maintenance of the project

The design life of the project is 50 years, which can be extended to more than 70 years for some assets.

The substations and transmission lines would be inspected by field staff and contractors on a regular basis, with other operational activities occurring in the event of an emergency (as required). The project would require about five workers (in addition to Transgrid's existing workers) during operation for ongoing maintenance activities. Likely maintenance activities would include:

- regular inspection (ground and aerial) and maintenance of electrical equipment
- general building, asset protection zone and access road/track
- vegetation clearing/trimming within the easement
- fire detection system inspection and maintenance
- stormwater drainage systems maintenance.

It is expected that these activities would only require light vehicles and/or small to medium plant (depending on the work required).

3 Legislative and policy context

Changes to the environment by the project as well as the management of natural processes are governed by relevant frameworks. The following sections summarise the key legislation and guidance relevant to the project.

3.1 NSW State legislation

3.1.1 Water Management Act 2000

The *Water Management Act 2000* (WM Act) is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. The WM Act is also intended to provide a formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

The intent and objectives of the WM Act have been considered as part of this assessment. Provisions of the WM Act require the development of management plans to deal with flooding regimes and the way they are managed in relation to risks to property and life and to ecological impacts. The WM Act also defines approvals required for carrying out works situated near a river or floodplain via flood work approvals or drainage work approvals. However, as per Section 5.23 of the EP&A Act, a water use approval, water management works or an activity approval (including a controlled activity approval) under Sections 89, 90 and 91 of the WM Act would not be required for State Significant Infrastructure.

3.2 Other policies and guidelines

3.2.1 NSW Flood Prone Land Policy

The *Flood Prone Land Policy* is administered by the Department of Planning and Environment (DPE). The main objective of the policy is to reduce the impact of flooding and flood liability on owners and occupiers of flood-prone land and reduce public and private losses. The policy recognises the benefits of use, occupation and development of flood-prone land.

The project crosses multiple floodplains within flood prone land. By default, it must adhere to the policy by considering the impact of the project on flooding and how this impact affects adjacent lands. This assessment then drives suitable mitigation measures to reduce the liability on those adjacent lands as per the policy statement.

3.2.2 NSW Floodplain Development Manual

The *Floodplain Development Manual* (Department of Infrastructure, Planning and Natural Resources, 2005) provides guidance to stakeholders for managing flood risk. The manual applies to floodplains across NSW in both urban and rural areas. It provides the fundamental guidelines for development within the floodplain. It also supports the NSW Flood Prone Land policy and guides councils and the NSW Government through the floodplain risk management process.

The manual details the roles and responsibilities of various NSW agencies and includes information on the following:

- the preparation of flood studies, floodplain risk management studies and plans
- floodplain risk management options
- flood planning levels and areas
- hydraulic and hazard categorisation
- emergency response planning.

It should be noted that the guidance on hydraulic and hazard categorisation is now superseded by the hazard guidance outlined in *Australian Rainfall and Runoff* (Ball J, 2019). This flooding assessment has been carried out in accordance with these guidelines.

3.2.3 NSW Floodplain Risk Management Guidelines

The *NSW Floodplain Risk Management Guidelines* (NSW Department of Planning and Environment, 2022) focus on the preparation and implementation of floodplain risk management plans for councils. It complements the *Floodplain Development Manual*, providing guidance towards the development of floodplain risk management plans and management of flood-prone land with the objective of minimising flood damage.

The project does not cross any active council floodplain risk management areas, as such does not impact any existing plans. However, the assessment of impacts from the project considers the impact on flooding and how the risk profile of the area would change as a result of the project. This then informs suitable mitigation measures to minimise any impacts on flooding.

3.2.4 Australian Rainfall and Runoff 2019

The *Australian Rainfall and Runoff* (2019) (ARR 2019) guideline was published by Engineers Australia and is a governing document for hydrological and hydraulic analysis. It provides designers and analysts with tools, information and data for the assessment of design flood estimation in Australia.

This assessment adopts the latest approach to design flood terminology. Accordingly, all design events are quoted in terms of Annual Exceedance Probability (AEP) using percentage probability. Table 3-1 provides a summary of the relationship between Average Recurrence Interval (ARI) and AEP based on ARR 2019.

Table 3-1 Event nomenclature (taken from ARR 2019)

Exceedances per year	AEP (%)	AEP (1 in x) Years	ARI
1	63.21	1.58	1
0.05	39.35	2.54	2
0.22	20.00	5	4.48
0.20	18.13	5.52	5.00
0.11	10.00	10	9.49
0.05	5.00	20	20
0.02	2.00	50	50
0.01	1.00	100	100
0.01	0.50	200	200
0.002	0.20	500	500
0.0005	0.05	2,000	2,000

Note:

The values shown in bold indicate the adopted terminology.

4 Methodology

4.1 Overview of approach

The following key tasks were undertaken as part of the assessment to define the flood risk and impacts of the project:

- data collection and review
- review of existing flood studies
- hydrological and hydraulic (flood) modelling, including:
  - climate change assessment
  - Probable Maximum Precipitation (PMP) assessment.

Multiple hydraulic models were developed to simulate the flood behaviour across the project footprint. This included the development of both regional (project wide) and local hydraulic models. The regional model was developed to assess the flood impact of the transmission lines. The regional model included three hydrological catchments that are crossed by the project footprint (refer to Figure 4-1 for study area and catchment extents). The hydrological catchments include

- Murrumbidgee River catchment – outlet downstream of the town of Wagga Wagga
- Lachlan River catchment – outlet at Narrawa gauge station (Gauge station ID 412065)
- Wollondilly River catchment – outlet at Jooriland gauge station (Gauge station ID 212270).

Local flood models were developed to assess the impact of the temporary construction compounds, modification to the existing Wagga 330 kV and Bannaby 500 kV substations, construction of the proposed Gugaa 500 kV substation, connection to the future Maragle 500 kV substation, worker accommodation facilities and proposed telecommunications hut. The local model provides greater definition of local flood behaviour at a localised catchment scale.

4.2 Study area

The study area is defined as the area needed to be analysed to determine the project impacts due to flooding. The study area includes the project footprint and three hydrological catchments intersected by the project footprint.

The three hydrological catchments include Murrumbidgee River, Lachlan River and Wollondilly River catchments. The assessment analysed the hydrological characteristics of these catchments. The spatial extents of these catchments relevant to the project footprint to assess the flood impacts are presented in Figure 4-1 and have an approximate total area of 33,898 square kilometres.

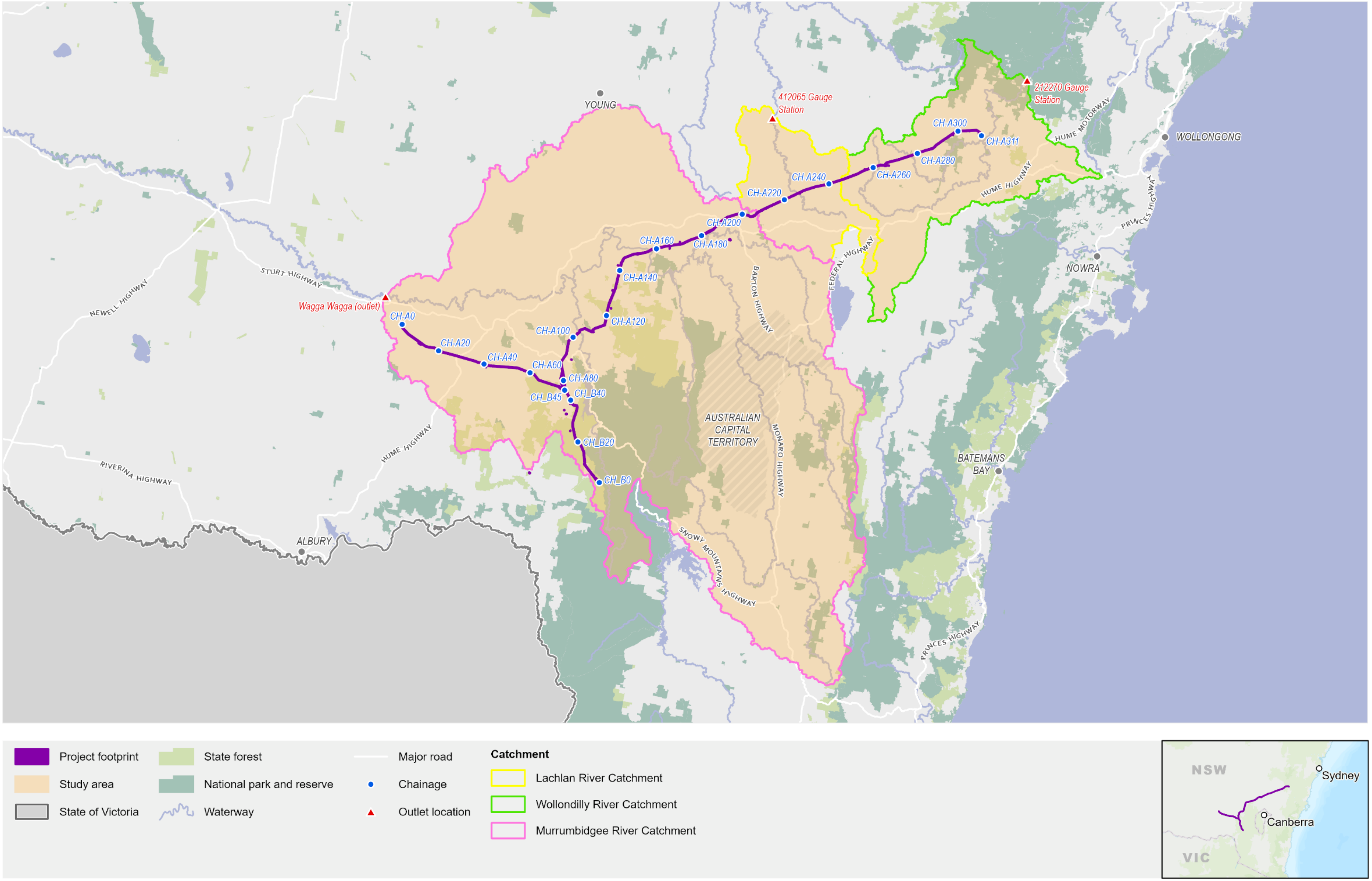
The three hydrological catchments within the study area are further described below:

- **Murrumbidgee River catchment** – The catchment area extends from the headwaters of the Murrumbidgee River to the town of Wagga Wagga. The catchment area associated with this section is approximately 26,927 square kilometres. The downstream extent was defined at the town of Wagga Wagga for modelling purposes.
- **Lachlan River catchment** - The catchment area extends from the western side of Great Dividing Range to the Lachlan River gauge station at Narrawa (Gauge station ID 412065). This represents the Lachlan River portion of the study area. The catchment has a total area of approximately 2,251 square kilometres. The gauge station was adopted as the outflow point given its proximity downstream from the project.

- **Wollondilly River catchment** – The catchment area extends from the eastern side of Great Dividing Range to the Wollondilly River gauge station at Jooriland (Gauge station ID 212270). This represents the Wollondilly River portion of the study area. The gauge station was adopted as the outflow point given its proximity downstream from the project footprint. The catchment area associated with this section of the project is approximately 4,720 square kilometres.

The Murrumbidgee River catchment is further split into sub-catchments given the multiple Murrumbidgee River tributaries that cross the project footprint. The selection of these sub-catchments was based on existing flow gauges downstream of the project footprint.

Details of these gauges are further presented in Section 4.3. Impacts of the project on the quantity of the region's surface water resources, including the Goobarragandra River, Lachlan River, Murrumbidgee River, Tarlo River, Tumut River, Wollondilly River, Yass River and Blowering Dam, Burrinjuck Dam and Wyangala Water Catchment Areas were assessed as part of the three main hydrological catchments.



C:\Users\Virgil.Robinson\Aurecon Group\507179 - HumeLink Project Development Suppor - EIS\ArcPro\507179_HumeLink_Flooding.aprx\19-05-23\Virgil.Robinson

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:1,500,000

0 30 60 km

Projection: GDA 1994 MGA Zone 55

FIGURE 4-1: Study area and primary catchment extents

4.3 Data collection

4.3.1 Data collection summary

The data used in this assessment were collected from various resources to assist in understanding the existing environment and provide inputs into the hydraulic assessment. Table 4-1 provides the summary of data that was obtained and adopted in the assessment.

Table 4-1 Data collection summary

Data type	Description	Use	Source
Project footprint and data	Project footprint and data includes indicative transmission line structure locations, access road horizontal alignments, construction compounds, telecommunications hut and substation locations.	Define project footprint and components	Transgrid
Shuttle Radar Topographic Mission (SRTM)	1 second SRTM Derived Hydrological Digital Elevation Model/LiDAR Data	Model topography representation	Elevation and Depth - Foundation Spatial Data (Elvis) https://elevation.fsdf.org.au/
Light Detection and Ranging (LiDAR) Current to 2022	1 m, 2 m and 5 m grid LiDAR based on availability at a location	Model topography representation	Elvis https://elevation.fsdf.org.au/
Gauge station data	Gauge station data such as location coordinates, discharge rate, data availability etc	Model calibration	Water NSW (https://realtimedata.waternsw.com.au/) Bureau of Meteorology (BoM) Water data online (http://www.bom.gov.au/waterdata/) NSW Flood Frequency Analysis (FFA) reconciled losses (https://data.arr-software.org/catchmentlosses/map)
Existing flood studies	Information on flood study methodology and flood result data	Understanding of previous assessments	Online resources including respective local council websites.
Total design rainfall grids	Areal and point total rainfall grids	Hydraulic modelling input	Obtained from BoM (http://www.bom.gov.au/water/designRainfalls/)
Temporal pattern increments	Areal and point temporal pattern increments data based on Darling Murray/East Coast South regions. Given the scale of model areal reduction has not been adopted, however will provide a more conservative results and is fit for purpose for this methodology.	Areal and point temporal pattern increments to pre-process total rainfall grids	Obtained from ARR data hub (https://data.arr-software.org/)
Bannaby 500 kV substation modification design levels and technical drawings	Design surface levels of Bannaby 500 kV substation modification. Understand the structural and access road extents	Define Bannaby 500 kV substation modification topography	Transgrid

Data type	Description	Use	Source
Flood impact report and associated flood modelling outputs and GIS layers undertaken by Lyall & Associates (2022)	Flood impact assessment of the proposed Gugaa 500 kV substation	Inform the impact of the proposed works for the Gugaa 500 kV substation that were able to be summarised in this study.	Transgrid

4.3.2 Topography

The SRTM gridded digital elevation model was utilised to represent the topography of the study area. SRTM data was adopted over LiDAR data due to its full coverage within the study area. The data used is hydrologically conditioned and drainage enforced, which means that the data has been processed using mapped streamlines, and therefore represents flow paths. The data has an approximate grid cell size of 25 metres. This data informed the delineation of catchments and related hydrological attributes.

Higher resolution LiDAR data (one, two and five metres depending on coverage) was used for areas with more complex flood behaviour or requiring greater resolution. These were mainly areas which had out of bank floodplain flow behaviour (ie unconfined flow) or smaller catchments covering the ancillary sites including the construction compounds and substations. Both the regional and local models were projected in GDA94 MGA55 zone.

The Bannaby 500 kV substation compound (C12) and Bannaby 500 kV substation modification are located within the GDA94 MGA56 zone. Therefore, the associated LiDAR data (which was only available in GDA94 MGA56 projection) was required to be converted into GDA94 MGA55 zone. This was undertaken using the QGIS Warp (reproject) tool adopting the “average” resampling method.

4.3.3 Catchments and flow gauge data

Multiple gauge stations were used as part of the model calibration process. The flow gauge stations adopted for the analysis are summarised in Table 4-2.

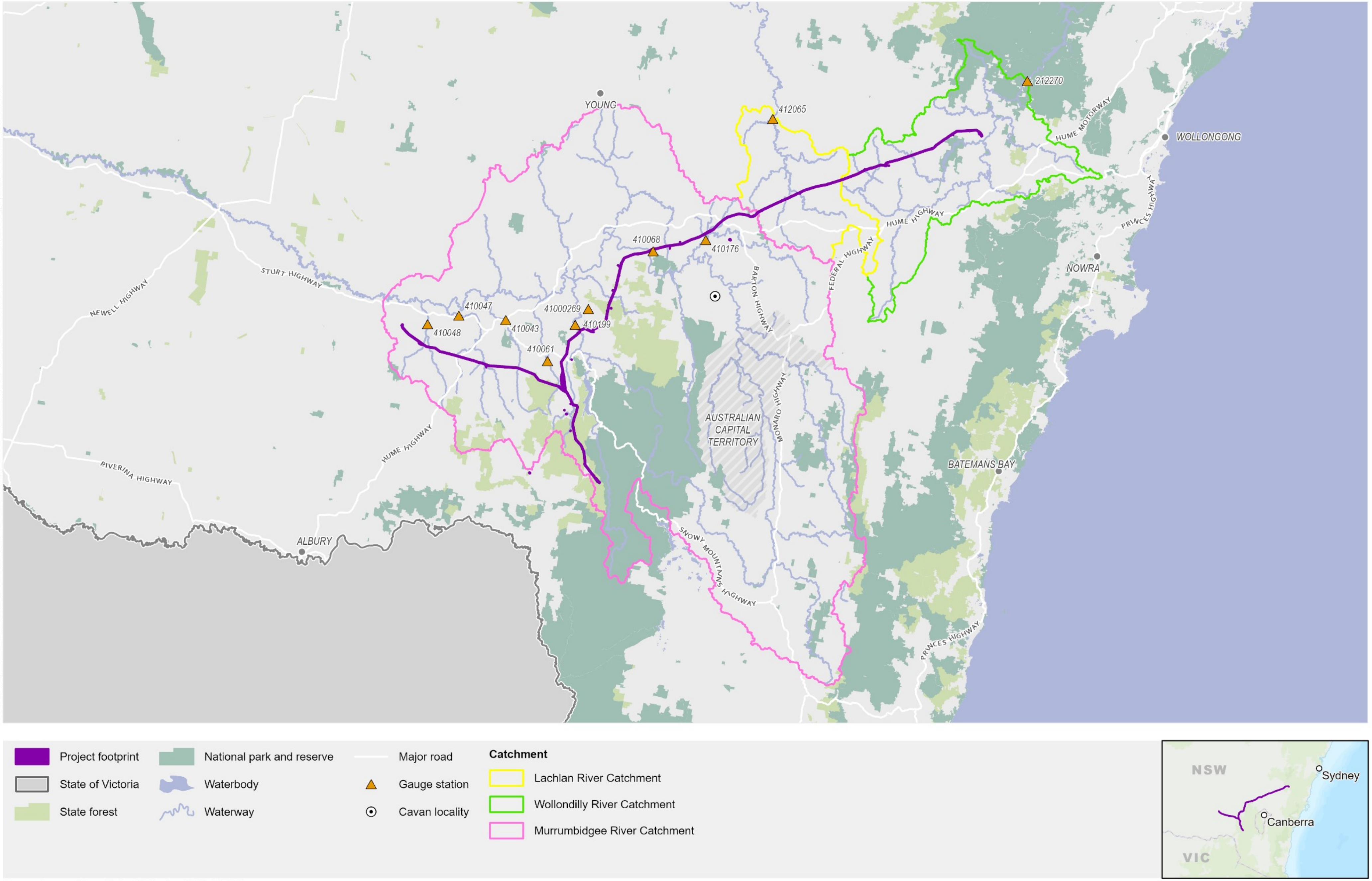
Figure 4-2 provides an overview of the adopted gauge catchments and the outlet location.

Table 4-2 Gauge data summary

Gauge ID	Gauge name	Catchment	Coordinates (Zone 55)		Approximate catchment area (km²)	Local government area	Years of data availability
			Easting	*Northing*			
410199	Tumut River at upstream Nimbo offtake	Murrumbidgee River Catchment	608807.8	6104884.0	2925	Snowy Valleys	2012-2022
41000269	Brungle Creek at Red Hill no.2	Murrumbidgee River Catchment	614352.4	6111529.0	113	Snowy Valleys	2012-2022
410043	Hillas Creek at Mount Adrah	Murrumbidgee River Catchment	579481.9	6106922.7	564	Cootamundra -Gundagai Regional	2003-2022
410047	Tarcutta Creek at Old Borambola	Murrumbidgee River Catchment	559698.8	6108756.1	1643	Wagga Wagga City	1999-2022
410048	Kyeamba Creek at Ladysmith	Murrumbidgee River Catchment	546477.1	6105146.6	557	Wagga Wagga City	1938-2022
410061	Adelong Creek at Batlow Road	Murrumbidgee River Catchment	597112.8	6089584.1	148	Snowy Valleys	1947-2022

Gauge ID	Gauge name	Catchment	Coordinates (Zone 55)		Approximate catchment area (km²)	Local government area	Years of data availability
			Easting	*Northing*			
410176	Yass River at upstream Burrinjuck Dam (riverview)	Murrumbidgee River Catchment	663902.8	6140651.9	1595	Yass Valley	1999-2022
410068	Murrumbidgee River at Glendale	Murrumbidgee River Catchment	641682.1	6135905.7	13274	Yass Valley	1954-2022
412065	Lachlan River at Narrawa	Lachlan River Catchment	692186.9	6191811.9	2251	Hilltops	1960-2022
212270	Wollondilly River at Jooriland	Wollondilly River Catchment	799642.4	6207800.7	4719	Wingecarribee Shire	1961-2022

The remaining Murrumbidgee catchment area were modelled as Murrumbidgee Lower and Murrumbidgee Upper catchments. The Murrumbidgee River catchment was split into an upper and lower section, approximately divided at the town of Cavan.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:1,500,000

0 30 60 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 4-2: Overview of gauge catchments

4.4 Review of flood studies

4.4.1 Existing flood studies

A review of previous flood investigations within the study area was undertaken. The review identified that most flood studies focussed on the towns and villages and there is limited flood study coverage of regional areas. The *Draft Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan* (WMA Water, 2021) and *Wagga Wagga Major Overland Flow Flood Study* (WMAWater, 2011) only intersected with part of project footprint and utilised for this assessment. The list of identified flood studies is shown in Table 4-3.

Table 4-3 Existing flood study summary

Study name	Date	Local government area	Area of interest
Draft Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan (WMA water)	Feb 2021	Wagga Wagga City	Wagga Wagga CBD and town
Wagga Wagga Major Overland Flow Flood Study (WMA water)	Aug 2011	Wagga Wagga City	Wagga Wagga CBD and town
Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan (WMA Water)	Apr 2018	Wagga Wagga City	Wagga Wagga, North Wagga Wagga and Forest Hill
Hume Highway upgrade Tarcutta Bypass – Environmental assessment (Parsons Brinckerhoff Australia Pty Limited)	Aug 2009	Wagga Wagga City	Tarcutta Village
Murrumbidgee River Wagga Wagga Flood Study (Webb, McKeown & Associates)	Sep 2004	Wagga Wagga City	City of Wagga Wagga
Tarcutta, Ladysmith and Uranquinty Floodplain Risk Management Studies and Plans (GRC Hydro)	Jun 2021	Wagga Wagga City	Tarcutta, Ladysmith and Uranquinty towns
Gundaroo Flood Study Report (WMA Water)	Mar 2016	Yass Valley	Town of Gundaroo
Murrumbateman, Bowning, Bookham and Binalong Flood Study (Lyall & Associates)	August 2010	Yass Valley	Murrumbateman, Bowning, Bookham and Binalong Villages
Sutton Flood Study (WMA water)	Mar 2016	Yass Valley	Town of Sutton
Yass Flood Study (WMA Water)	Mar 2016	Yass Valley	Town of Yass
The Village of Collector Flood Study (Lyall & Associates)	Feb 2014	Upper Lachlan Shire	The village of Collector
The Village of Crookwell Flood Study (Lyall & Associates)	Feb 2014	Upper Lachlan Shire	The village of Crookwell
The Village of Gunning (Lyall & Associates)	Feb 2014	Upper Lachlan Shire	The village of Gunning
The Village of Taralga (Lyall & Associates)	Feb 2014	Upper Lachlan Shire	The village of Taralga
Adelong Flood Plain Risk Management Study (Lyall & Associates)	Nov 2018	Snowy Valleys	Town of Adelong
Snowy Monaro Regional Council Flood and Floodplain Risk Management Studies (SMEC Pty Ltd)	June 2019	Snowy Monaro Regional	Town of Cooma, Bredbo, Berridale and Michelago
Cootamundra Flood Study (WMA Water)	Nov 2020	Cootamundra-Gundagai Regional	Town of Cootamundra

4.4.2 Proposed Gugaa 500 kV Substation Flooding Investigation

The flood assessment of the proposed Gugaa 500 kV substation was undertaken by Lyall & Associates and documented in a letter titled *Gugaa 500kV Substation Flooding Investigation* dated 9 September 2022. This study undertook a hydrological and hydraulic assessment of the catchment including an analysis of historical flood data and flood frequency analysis of Kyamba Creek catchment based on the Book Book stream gauge.

The analysis adopted the methods recommended by ARR 2019 with respect to design rainfall intensity, temporal patterns, aerial reduction factors and losses. The calibration process adopted varying losses to better match the flood frequency relationship for the Book Book stream gauge.

The assessment of flood behaviour impacts was undertaken using the two-dimensional hydraulic modelling software TUFLOW.

The full documentation of the investigation has been attached to this report as Attachment D.

4.5 Desktop assessment

The local model desktop assessment approach involved reviews of the local context and potential flood risk without any modelling. This method considered the local topography to understand proximity to waterways and direction of overland flow to inform whether local modelling would be required or not.

If the local flood risk was considered low, no modelling would be required and a local stormwater management design undertaken at the detailed design stage to mitigate flood risks. If the desktop assessment concluded that there was a local flood risk then modelling was undertaken. Section 6.2.1 briefly discusses the assessment for relevant sites.

4.6 Flood (hydraulic) modelling

The hydraulic analysis of flood behaviour across the project footprint was undertaken using the hydrodynamic modelling software TUFLOW (Release version 2020-10-AB). TUFLOW is an industry accepted software capable of simulating complex two-dimensional flood behaviour. The same modelling approach has been used to assess the construction and operational stages where a desktop assessment was not suitable.

The flood modelling has been split into two modelling scales: regional or local. This approach helps to focus on the project elements at a suitable level of detail to assess the risk of flooding and flood impact.

The project elements assessed at each scale is as follows:

- **Regional model:** project footprint focusing on the transmission line component of the project
- **Local model:** construction compounds, modification of the existing Wagga 330 kV and Bannaby 500 kV substations, connection to the future Maragle 500 kV substation, worker accommodation facilities and telecommunications hut. Note that the proposed Gugaa 500 kV substation has been assessed in the Lyall & Associates (2022) (refer to Section 4.4.2).

Further detail on the model development methodology, parameters and assumptions are provided in Attachment A.

Prior to the development of a local model, all the local model sites were assessed via a desktop assessment approach (refer to Section 4.5). This was to initially identify whether the flood risk could be suitably assessed without the need for modelling.

4.6.1 Regional model

The regional hydraulic models were created to understand the extent and characteristic of regional scale flooding. It aims to inform the flood risk to the main elements within the project footprint including the transmission line structures and access tracks.

The model used SRTM data for the representation of the topography and adopted a model resolution of 100 metres. Waterway crossings up to the third stream order based on Hack's stream order analysis method (refer to Attachment A) were represented at a finer grid scale to better represent flood behaviour interacting with the project.

The hydrology was applied as gridded rainfall across all catchment areas intersected by the project footprint. The flood risk along the project footprint was assessed for the 1% AEP event only, commensurate with the typical level of flood risk for transmission line structures.

The flood impact on the project was only assessed based on the project footprint area and not the specific project design elements. As such, the transmission line structures and access tracks have not been explicitly represented in the model. This is due to the smaller scale of these elements compared to the coarse scale of the regional model. As such, there would be no discernible impact on flooding that would influence the outcome of the assessment.

4.6.2 Local model

The local hydraulic models were created to understand the flood extent and characteristics for proposed construction compounds, substation work, worker accommodation facility and telecommunications hut. As discussed in Section 4.4.2, the flood data of the proposed Gugaa 500 kV substation and the nearby Gregadoo Road compound (C06) were informed by a separate flood study.

For the sites that were identified as requiring local modelling, the proposed construction compound, substation or worker accommodation facility was represented in the models as a fill pad with an elevation above the 1% AEP flood level. This conservative approach captured the influence of any potential filling or earthworks that may occur that would impact on local flooding, representing the worst-case scenario. The exception to this approach was at:

- Wagga 330 kV substation and Wagga 330 kV substation compound (C01)
- Gregadoo Road compound (C06)
- Yass substation compound (C10)
- Snubba Road compound (C16).

At these locations, no filling of the proposed construction compound footprint was applied. This is due to the sites being relatively flat (ie. less earthworks likely required) and/or the sites are located adjacent to existing substation locations.

The local model identifies the characteristics of overland flow at the local catchment scale. Based on the characteristics of the overland flow, it can be classified as either as local drainage or local flooding. Local drainage is typically defined as shallow ponding originating from smaller catchments and generally occurs adjacent to the location of interest. In comparison, local flooding is more extensive in terms of depth and extent and originates from larger catchments that extends beyond the immediate area.

The local flood models were simulated for the following events based on the following design flood immunity requirements:

- construction compounds – 1 in 20 years event (5% AEP)
- worker accommodation facility – 1 in 50 year event (2% AEP)
- substation benches – 1 in 100 years event (1% AEP)
- telecommunications hut – 1 in 100 years event (1% AEP).

4.6.2.1 Climate change assessment

An assessment of the impact of climate change was undertaken to capture the future climate risk with respect to flooding. Climate change is represented in the flood modelling as an increase in rainfall intensity in accordance with the latest climate change predictions. No sea level rise component was included as the project is not influenced by tidal processes.

Based on future climate projections extracted from the ARR Data Hub (2019), it is predicted that the 1% AEP rainfall intensity will increase by a factor of 20.2% for the Murrumbidgee River Catchment and Lachlan River catchment and 19.7% for the Wollondilly River catchment. These increases are predicted for the year 2090 and based on the Representative Concentration Pathway (RCP) 8.5.

4.6.2.2 Probable Maximum Precipitation (PMP)

The Probable Maximum Precipitation (PMP) depths were estimated using the Generalised Short Duration Method (GSDM) PMP estimation guidelines prepared by the BoM (BoM, 2003). These were then applied to the hydraulic models to derive the Probable Maximum Flood (PMF).

The Generalised Short-Duration Method is suitable to derive PMP data for durations up to six hours, suitable for small catchments (area less than 1000 square kilometres) anywhere in Australia. PMF modelling was undertaken only for the Wagga 330 kV substation and Bannaby 500 kV substation modification. The proposed Gugaa 500 kV substation was assessed through in the Lyall & Associates (2022) assessment (Attachment D).

Further details on the PMP estimation is presented in Attachment A.

4.6.3 Key assumptions

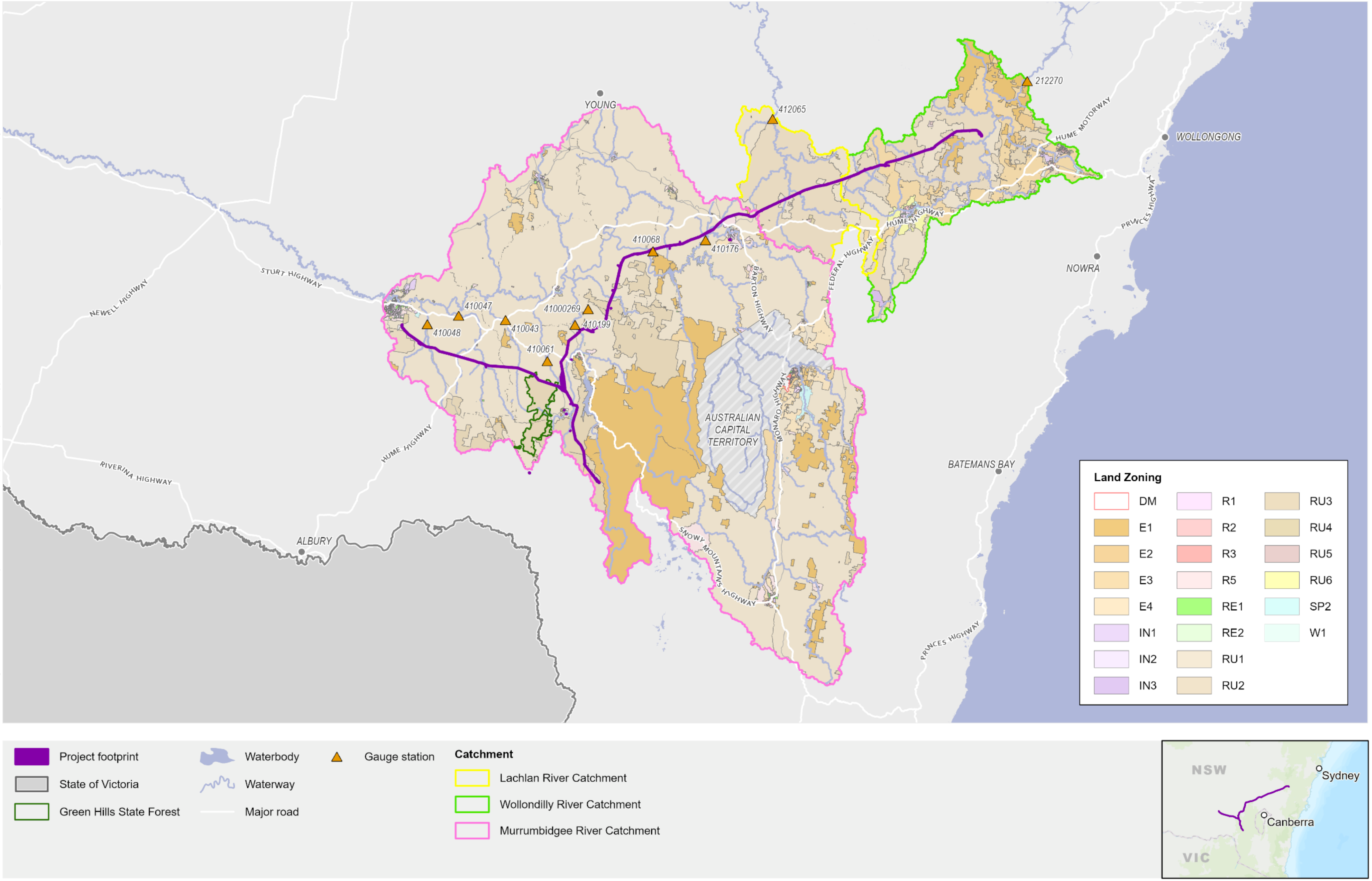
The following assumptions relate to this assessment:

- The transmission line structures and access roads were only assessed for flood risk in a regional scale flood event. The transmission line structures and access roads were not explicitly represented in the regional model as it was assumed that the impact on flooding would be negligible due to their scale compared to the regional scale flooding.
- Only major dams with an operating authority were included in the model with initial water level as discussed in Attachment A.
- The impact of local drainage was not assessed as a part of this assessment. Although the local models developed for this assessment captured local overland drainage and flooding, no representation of pits, pipes, culverts or bridges have been included due to limited availability of data. Based on the grid size and initial sensitivity testing, it is assumed that the flood impacts due to these structures would be minor.
- Given drainage structures within the catchments assessed have not been explicitly modelled due to data availability, it is assumed that general flood behaviour and the fundamental outcomes of this assessment would not be influenced by blockage of structures. In reality blockages of structures would influence flood behaviour, however, has not been captured in this assessment.
- No detailed outlet structures were represented in the modelling due to limited data availability. Initial water levels were not applied to minor dams. The natural representation of the minor dams is considered satisfactory given the modelling was calibrated to the flow gauges downstream, which largely captured the dam’s influence on flows.
- The catchment for Lake George was not included in the modelling. Lake George is located east of the Murrumbidgee River catchment, south of the Lachlan River catchment and south-west of the Wollondilly River catchment. The lake is a closed basin which is assumed to have no contribution to any catchment flow. Based on data from DPE, the lake has no outflow point and the stored water is lost through evaporation and underground seepage (NSW Department of Planning and Environment, 2022).
- Any filling of construction compounds would be reinstated to predevelopment levels following the construction period. Should this not be possible, the construction compound levels would effectively become permanent works and would require a flood impact assessment commensurate with the assessment undertaken for permanent works.

5 Existing environment

5.1 Catchment characteristics

This section discusses the characteristics of the hydrological catchments within the study area. An overall description of the primary catchments (Murrumbidgee River, Lachlan River and Wollondilly River) is presented, followed by a description of land use characteristics for sub-catchments (eg. Murrumbidgee River sub-catchment), based on the adopted flow gauge locations used in the flood modelling. The hydrological catchments, land use zones and waterways are shown in Figure 5-1.



Source: *Aurecon, Transgrid, DPE, Spatial Services (DCS), ESRI Basemap*

1:1,500,000

0 30 60 km

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 5-1: Study area hydrological catchments, land use zones, waterbodies and waterways

5.1.1 Murrumbidgee River catchment

The Murrumbidgee River is one of the major tributaries of the Murray–Darling basin. The catchment upstream limits are generally the Great Dividing Range to the east, the Lachlan catchment to the north, and the Murray catchment to the south. Yass River and Tumut River are two of the major tributaries within the catchment, which contributes to Murrumbidgee River flow.

Burrinjuck Dam is a key waterbody located within the Murrumbidgee River catchment with a storage capacity of 1,028,000 megalitres and a spill capacity of 2,506,000 megalitres per day (WaterNSW, 2022). Other key waterbodies located within the catchment include Blowering Dam, Talbingo Dam which are located along the Tumut River. The below sections discuss the land use characteristics of the adopted gauge station sub-catchments within the Murrumbidgee River catchment.

5.1.2 Murrumbidgee River sub-catchments

5.1.2.1 Tumut River at upstream Nimbo offtake (Gauge ID: 410199)

Tumut River is a tributary to the Murrumbidgee River located south of the study area. The gauge station data for the Tumut River sub-catchment were obtained from gauge 410199 located at Tumut River upstream of the Nimbo offtake.

Approximately 85 per cent of the sub-catchment is covered by dense forest area. Major water storages such as the Blowering Dam, Tabingo Dam and Jounama Dam are located within the gauge catchment area. These storage areas are all connected by the Tumut River which is the primary waterway for the catchment.

Tumut River has a shallow hydraulic gradient along the lower reaches with upstream areas being generally steep with multiple mountainous features. The project footprint crosses Tumut River immediately downstream of Blowering Dam and approximately 3.7 kilometres upstream of the sub-catchment gauge station.

The majority of the project footprint near Tumut is within the primary production (RU1) land zone with minor areas falling into rural small holdings (RU4). The project footprint east to Talbingo Dam is within the heavily vegetated Bago State forest within the forestry (RU3) land zone. Tumut is the major town of the catchment located downstream of the project.

5.1.2.2 Brungle Creek at Red Hill no.2 (Gauge ID: 41000269)

Brungle Creek is a tributary of Nimbo Creek located at the centre of the study area. The gauge station data of the Brungle Creek sub-catchment were obtained from gauge 41000269 located in Brungle Creek at Red Hill no.2.

The upper reaches of the sub-catchment are covered by bushland and dense forest. Brungle Creek is the main waterway flowing down to flatter parts of the catchment.

The majority of the project footprint falls within the primary production (RU1) land zone mostly covered with flat grass lands. The sub-catchment also encroaches into Red Hill nature reserve within the forestry (RU3) land zone.

5.1.2.3 Hillas Creek at Mount Adrah (Gauge ID: 410043)

Hillas Creek is a tributary of Murrumbidgee River located west of the study area. The gauge station data for the Hillas Creek sub-catchment were obtained from gauge 410043 at Mount Adrah. Upstream areas are mostly covered by Green Hills State forest with the western downstream area covered by heavily vegetated nature reserve.

Hillas Creek is the main waterway which is formed by the intersection of Yaven Yaven Creek and Nacki Nacki Creek, approximately four kilometres upstream from the catchment gauge station.

The sub-catchment is generally flat along the main waterway with steeper regions across the most upstream areas. The project footprint falls within the primary production (RU1) land zone which consist of open grass land areas.

5.1.2.4 Tarcutta Creek at Old Borambola (Gauge ID: 410047)

Tarcutta Creek is a tributary of Murrumbidgee River located west of the study area. The gauge station data for the Tarcutta Creek sub-catchment were obtained from gauge 410047at Borambola. Downstream areas of the sub-catchment are covered by bushland with areas of heavily vegetated forest areas across the upstream reaches. The catchment is generally flat with steeper regions across the most upstream areas. Tarcutta Creek is the main waterway draining the catchment, which flows via Tarcutta towards the gauge station. The project footprint completely falls within the primary production (RU1) land zone which consist of grasslands and farmlands.

5.1.2.5 Kyeamba Creek at Ladysmith (Gauge ID: 410048)

Kyeamba Creek is a tributary of Murrumbidgee River located west of the study area. The gauge station data for the Kyeamba Creek sub-catchment were obtained from gauge 410048at Ladysmith. This sub-catchment consists of mostly grasslands across generally flat topography with steep hills around the upper catchment extents.

Kyeamba Creek is the main waterway which is joined by O’Briens Creek approximately 5.5 kilometres upstream of the gauge station or approximately four kilometres downstream from the project footprint. Ladysmith is the main town within this sub-catchment, located upstream of catchment gauge station. The project footprint completely falls within the primary production (RU1) land zone which consist of grasslands and farmlands.

5.1.2.6 Adelong Creek at Batlow Road (Gauge ID: 410061)

Adelong Creek is a tributary of Murrumbidgee River located west of the study area. The gauge station data for the Adelong Creek sub-catchment were obtained from gauge 410061at Batlow Road.

This sub-catchment is located upstream of the town of Adelong. It is mostly covered by grassland across the downstream areas and Green Hills State forest across the upper reaches. Adelong Creek is the main waterway draining across lower flatter areas of the catchment. The upstream areas are mostly steeper along the catchment boundary.

The majority of the land zoning along the project footprint falls within the primary production (RU1) land zone with a small area within Green Hills State forest zoned as forestry (RU3).

5.1.2.7 Yass River at upstream of Burrinjuck Dam (Gauge ID: 410176)

Yass River is a tributary of Murrumbidgee River flowing via the town of Yass. The gauge station data for the Yass River sub-catchment were obtained from gauge 410176 at upstream of Burrinjuck Dam.

The topography is relatively flat with upstream areas covered by patches of dense forest. Downstream areas are mostly covered with bushlands and grasslands. The project footprint mostly consists of open space grasslands which fall within the primary production (RU1) as well as a small area covering the Village (RU5) land zones. The town of Yass is located 11 kilometres upstream to the catchment gauge station and south of the project.

5.1.3 Lachlan River catchment (Gauge ID: 412065)

The Lachlan River catchment within the study area borders the Murrumbidgee and Wollondilly catchments. The main waterway, the Lachlan River, flows in a northern direction within the study area, with multiple minor tributaries contributing to it as it heads downstream. There are no major waterbodies in the Lachlan River catchment within the study area.

The gauge station data were obtained from gauge 412065 (Lachlan River at Narrawa).

The catchment is generally flat and mostly covered by grass lands with a few patches of forest areas. Gunning is the major town located at the upstream catchment extent. The project footprint mostly falls within the primary production (RU1) and rural landscape (RU2) land use zones, which consist of farmlands and bushlands respectively.

5.1.4 Wollondilly River catchment (Gauge ID: 212270)

The Wollondilly River catchment is located east of the Lachlan catchment with key tributaries such as Wingecarribee River and Mulwaree River along with several minor tributaries. The catchment consists of Pejar Dam, Lake Sooley and Wingecarribee Dam as key waterbodies within the study area.

The catchment is generally flat and covered with open space grasslands. Few patches of vegetation are seen in upstream areas with heavier vegetated forest area seen across the downstream areas. Major towns within the catchment are Goulburn, Burradoo and Bowral. Goulburn is located at the upstream extent of the catchment while the towns of Burradoo and Bowral are located south of catchment gauge station.

The gauge station data were obtained from gauge 212270 (Wollondilly River at Jooriland).

The project footprint crosses Pejar Dam area north of Goulburn. It mostly falls within the primary production (RU1) and rural landscape (RU2) land use zones which consist of farmland, grasslands and heavily vegetated forest areas. The Warragamba Dam storage area is located approximately 10 kilometres downstream of the gauge station outlet and 40 kilometres downstream of the project footprint.

5.2 Existing flood behaviour

The flood behaviour within the hydrological catchments in the study area is based on a review of the flood modelling results from the regional hydraulic modelling. Regional flooding is defined as flooding from the larger main river systems. Existing flood behaviour (depths and hazard) for key project crossings up to the Hack third stream order locations is presented in Attachment C with characteristics of the flooding summarised in Section 5.2.1.

5.2.1 Regional flooding overview

The upstream area of the Murrumbidgee River catchment is generally characterised by contained flow within the gully formation, as recorded at the Murrumbidgee River gauge at Glendale (Gauge ID 410068), with the exception of the Billilingra locality which experiences major regional flooding in the 1% AEP with flooding extending over two kilometres wide and depth ranging up to 18 metres, completely inundating Monaro Highway (refer to Attachment C, Map 62). However, this does not impact the project footprint given its significant distance upstream (south) of the project.

Based on the hydraulic modelling, the downstream area of the Murrumbidgee River catchment also experiences widespread floodplain flow. The flood extent is approximately three kilometres wide with a flood hazard classification of H5 or H6 in accordance with ARR 2019 (refer to Attachment B for flood hazard classifications). This extends from the towns of Gundagai to Wagga Wagga for an approximate length of 100 kilometres (Attachment C, Map 63). Murrumbidgee River tributaries such as Tarcutta Creek, Gocup Creek and Tumut River that intersect the project footprint experience shallow widespread flooding (refer to Attachment C, Map 64 and Map 65).

The Lachlan River catchment tributaries mostly experience contained flow along the project footprint during a 1% AEP event. However, the project footprint intersection at Jerrawa Creek experiences widespread flooding with flood hazard ranging up to H6 (Attachment C, Map 66). The upstream area of catchment near the Bredalbane locality experiences minor shallow flooding outside the main floodway with flood hazard ranging from H3 and lower. However, the downstream area of Bredalbane locality experiences flooding up to one kilometre in width with flood depth ranging up to seven metres with flood hazard ranging up to H6. Meadow Creek south of the town of Gunning overtops its banks with a flood extent up to 700 metres in width with flood hazard ranging up to H5. Both the Bredalbane and Gunning areas are also some distance away from the project (Attachment C, Map 67 and Map 68).

The project footprint crosses multiple tributaries at the upstream extent of the Wollondilly River catchment. Where they intersect the project footprint, flood flow is concentrated and contained within the gullies during a 1% AEP event. Further downstream away from the project footprint, Mulwaree River south of Goulburn and Wollondilly River east of Goulburn experience major regional flooding with flow widths of approximately 1.8 kilometres and flood depths between eight metres and 10 metres respectively. Flood hazard classification ranges from H2 to H6 (Attachment C, Map 69).

5.3 Flood history

The flood history at key towns near the project footprint was obtained from existing flood studies. The towns captured include Wagga Wagga, Adelong, Gunning and Yass.

5.3.1 Wagga Wagga

Wagga Wagga has experienced multiple large floods from the Murrumbidgee River catchment with flood levels exceeding 10.5 metres at the Hampden bridge gauge in 1852, 1853, 1870 and 1891. Following significant flooding in the 1950s, the CBD levee was constructed to provide flood protection for the town of Wagga Wagga. After the construction of the levee, major flood events occurred in 2010, 2012 and 1974. The flood levels of events in 2012 and 1974 exceeded 10.5 metres at the Hampden bridge gauge. The constructed levee provided adequate flood protection to stop inundation of the southern and main part of town for both flood events (WMA Water, 2018). At the time of reporting, Wagga Wagga has experienced recent flooding. Details and analysis of this event has not been documented as yet therefore has not been reflected in this report.

5.3.2 Adelong

Adelong experienced major flooding in 1984, 2010 and 2012. The flood event in October 2010 reached a peak of 4.61 metres (equivalent to 1% AEP event) on the Batlow Road stream, which was the largest recorded flood level in the 70 years of gauge data. The flood was primarily confined to commercial properties located along Tumut Street and at the northern end of Selwyn Street and residential properties located along Tumut Street also experienced above-floor flooding (Lyall & Associates, 2018).

The January 1984 and March 2012 flood reached a peak gauge height of 3.52 metres and 3.11 metres respectively, which is equalling to 2% AEP and 5% AEP events. The1984 flood caused minor flooding in property located along Tumut Street where the 2012 flood event was generally confined to the in-bank area of Adelong Creek.

5.3.3 Gunning

Gunning experienced major flooding in 2010 and 2012. During the 2012 event, floodwater inundated parts of the Gunning Showground while there were no reports of property experiencing above-floor inundation. At the Goulburn AWS telemetered gauge to the east of Gunning, 90 millimetres were recovered during the 2010 event and 123 millimetres were recorded during the 2012 event (Lyall & Associates, 2014).

5.3.4 Yass

The Yass River at Yass has experienced numerous flood events. The April 1870 flood event is one of the largest events in the town's history before official records began in 1915. The Bow Bridge and OHH Bridge, which were under construction, were both destroyed by the flood event. This made the Hume Bridge design level being raised by approximately 15 feet. After official records began in 1915, the town of Yass experienced its largest flood event in October 1959. During the 1959 event, the flood level peaked approximately four feet below the Hume Bridge. Based on the Yass Stream Gauge rating, it is estimated to have achieved a peak gauge height of 10 metres (WMA Water, 2016).

5.4 Flood risks

The flood risk at the proposed construction compounds and the worker accommodation facility are generally low. Snubba Road compound (C03), Honeysuckle Road compound (C07), Red Hill Road compound (C08), Adjungbilly Road compound (C09) and Woodhouselee Road compound (C11) are located at a higher elevation within the local catchment, unlikely at risk of local flooding.

Construction compounds such as Maragle substation compound (C05), Gregadoo Road compound (C06), Yass substation compound (C10), Bannaby 500 kV substation compound (C12), Memorial Avenue compound (C14), Bowmans Lane compound (C15), Snubba Road compound (C16) and Tumbarumba Accommodation Facility (AC1) are generally impacted by minor local flood risk or local drainage/overland flow paths through the site. Only the Snowy Mountains Highway compound (C02) experiences an impact from flooding along the southern side of the construction compound extent given its proximity to an existing drainage line. The flood risks are further discussed in Section 6.3.

6 Construction impacts

6.1 General

The assessment of flooding impacts during the construction phase can occur as:

- potential impacts on flood behaviour due to construction activities
- potential impacts of flooding on construction activities.

Both types of impact are expected where construction activities are located within the flood extent of major waterways. Each construction compound has been assessed for each type of impact on a site by site basis. This assessment is presented in the following sections.

At a local scale, there is a risk of scour and erosion from drainage and flooding. This may be caused by construction activities (eg. topsoil removal and waterway crossings for access tracks) and similarly it may be caused by flooding and drainage that then impact construction activities. The risk of scour and erosion would occur across exposed soil and unsealed surfaces where drainage and flood waters concentrate, resulting in loss of soil material, potentially undermining any foundations and erode temporary roads. Appropriate construction scour protection, sediment and erosion control management planning needs to be considered to avoid or minimise any potential flood impact or changes in local flood characteristics.

The construction compound extents presented in the flood maps are indicative only and their use, boundaries and layout will be confirmed during detailed design by the construction contractors.

6.2 Impact of construction activities on flooding

Construction activities have the potential to affect local flood behaviour and impacting nearby areas. Construction activities near waterways would divert overland flows impacting on flood behaviour and possibly resulting in flood impacts to adjacent areas. Typical construction activities would include:

- excavations for substation and transmission line structure foundations
- establishment of new and upgraded access tracks
- stockpiling of material
- modification of existing surface levels for construction compounds and worker accommodation facility.

Construction activities at each transmission line structure site would involve excavation up to five metres deep for the installation of foundations, which would be backfilled at completion. Excavation at substation locations would be relatively minimal. Other excavation activities would include levelling around the individual structure foundations, drainage and grading or preparation for construction bench at the structure site. Overall, the required earthworks are expected to be minor and to be carried out typically within each transmission line structure area proximity. Hence, changes to the local area flood characteristic would likely be minor and localised.

Areas at risk of flooding including the construction compound sites and the worker accommodation facility are assessed further using local flood modelling and discussed in the following sections.

6.2.1 Construction compound sites

Flood assessment undertaken for the construction compounds included desktop assessment and two-dimensional flood modelling. Flood modelling was undertaken only for construction compound locations with a potential to impact flooding. The flood impact summary and the type of assessment undertaken for each construction compound are provided in Table 6-1.

Table 6-1 Summary of construction compound impacts on local flooding

Construction compound	Assessment undertaken	Flood impact
Wagga 330 kV substation compound (C01)	Two-dimensional flood modelling	No regional or local flooding risk therefore no impact on flooding
Snowy Mountains Highway compound (C02)	Two-dimensional flood modelling	The southern boundary of the construction compound impacts flooding from the adjacent drainage line. No regional flood risk.
Snubba Road compound (C03)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Unlikely impacts on local flooding
Maragle 500 kV substation compound (C05)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint.
Gregadoo Road compound (C06)	Two-dimensional flood modelling	No regional flood risk. Local flooding interacting with site. No impact on flooding subject to fill extent.
Honeysuckle Road compound (C07)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding therefore no impact on flooding
Red Hill Road compound (C08)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding therefore no impact on flooding
Adjungbilly Road compound (C09)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding therefore no impact on flooding
Yass substation compound (C10)	Two-dimensional flood modelling	Existing shallow drainage line approximately 20 m wide through the northern extent of the substation. No adverse impacts upstream or downstream of the project footprint. No regional flood risk.
Woodhouselee Road compound (C11)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint.
Bannaby 500 kV substation compound (C12)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint
Memorial Avenue compound (C14)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint.
Bowmans Lane compound (C15)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint.
Snubba Road compound (C16)	Two-dimensional flood modelling	No adverse impacts upstream or downstream of the project footprint.

6.2.1.1 Wagga 330 kV substation compound (C01)

The Wagga 330 kV substation compound (C01) is located adjacent to the existing Wagga 330 kV substation between two existing drainage lines which is a tributary of Boiling Down Creek. As the construction compound is located adjacent to the existing Wagga 330 kV substation, no filling at the Wagga 330 kV substation compound (C01) has been assumed.

Based on the regional flood modelling, no regional flood risk has been identified. The local flood modelling results indicated no local drainage lines or overland flow paths through the construction compound in a 5% AEP event (refer to Wagga 330 kV substation compound (C01) with existing 5% AEP flood depth extent in Figure 6-1) . Given this, the proposed construction compound and consequent activities on the site would not have an impact on flooding.

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Construction compound

Cadastre

Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03

0.03 - 0.1

0.10 - 0.25

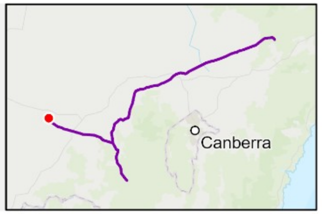
0.25 - 0.5

0.50 - 0.75

0.75 - 1

1.00 - 1.5

>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500

0 50 100m

Projection: GDA 1994 MGA Zone 55

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FIGURE 6-1: Wagga 330 kV substation compound (C01) existing 5% AEP flood depth (m)

6.2.1.2 Snowy Mountains Highway compound (C02)

The Snowy Mountains Highway compound (C02) is located north of an existing drainage line which is a tributary of Gilmore Creek. The construction compound has been modelled as an elevated fill pad across the full extent of the site, to represent the worst-case scenario.

Initial results indicate that any filling of the proposed site would obstruct the overland flow path running from east to west towards the Snowy Mountains Highway. This would result in offsite adverse impacts to the south of the construction compound footprint. The simplest approach to mitigate these impacts would be through limiting the extent of filling along the southern extent of the construction compound to limit disturbing the existing flood behaviour.

The central area bridging the east and west areas of the construction compound extent was also found to block overland flowpaths. Limiting filling of this area or providing suitably sized cross drainage culverts limited the impact on flooding. This scenario was modelled using the two-dimensional model and is presented in Figure 6-2. The results of the modelling indicated no significant increase in flood levels outside of the construction compound footprint.

The construction compound entrance off the Snowy Mountains Highway also has the potential to obstruct the highway table drain and the existing overland flowpath. To manage this, the construction compound driveway would require cross drainage to allow conveyance of flow under and/or over the driveway .

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

FIGURE 6-2: Snowy Mountains Highway compound (C02) 5% AEP Flood Level Afflux (m)

6.2.1.3 Snubba Road compound (C03)

Snubba Road compound (C03) is located east of the town of Batlow at an approximate elevation of 825 mAHD. The location of the construction compound is virtually on a ridge with drainage lines falling away from the construction compound. With effectively no upstream catchment area, risk of construction activities at this location impacting local flooding is unlikely. Figure 6-3 shows the construction compound footprint over the local topography. No flood modelling was undertaken at this construction compound.

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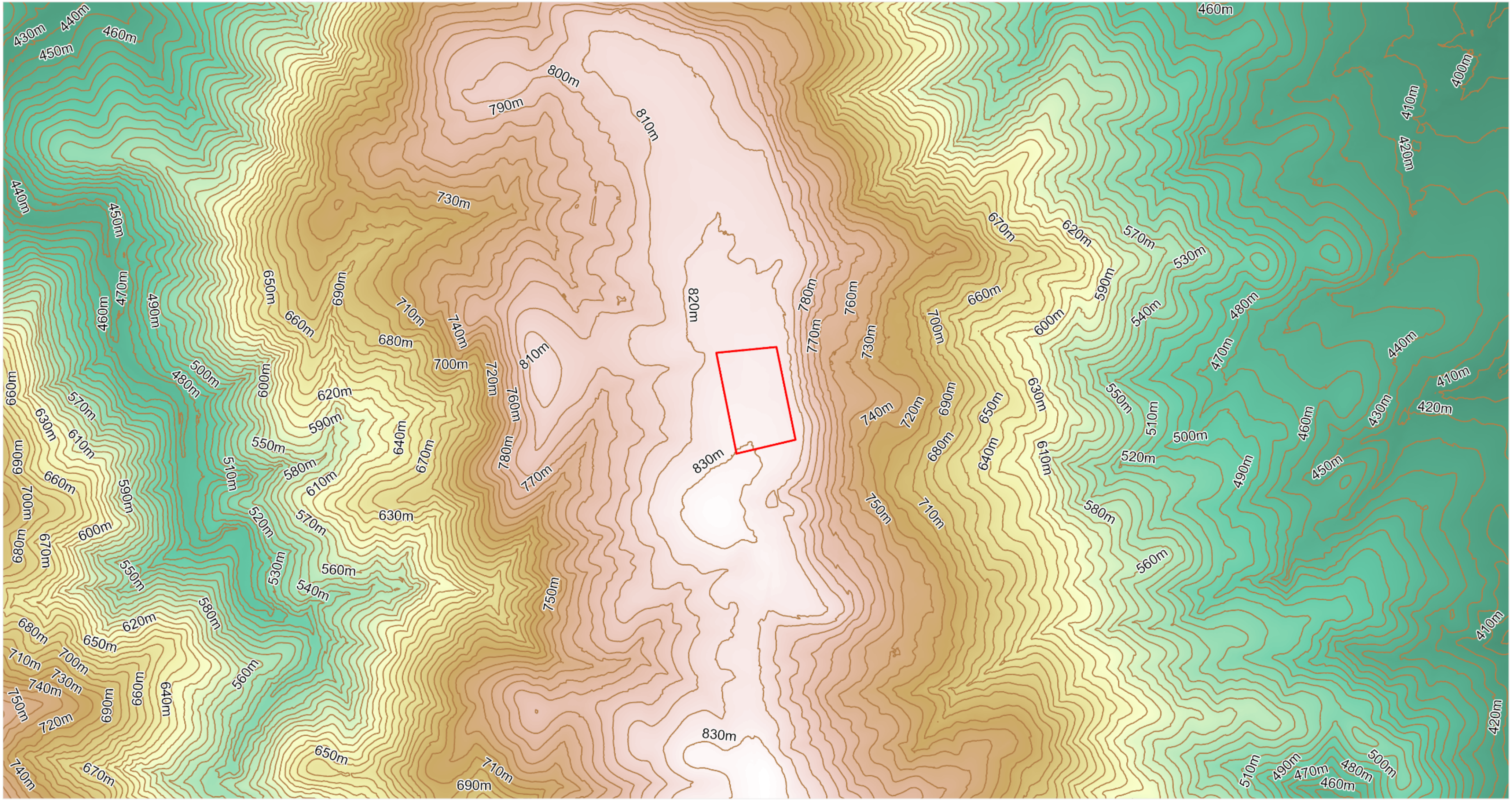


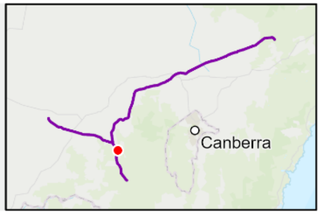
Construction compound

Surface level contour (10m AHD interval)

Lidar topography (mAHD)

890.663

0



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:11,500

0 270 540m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

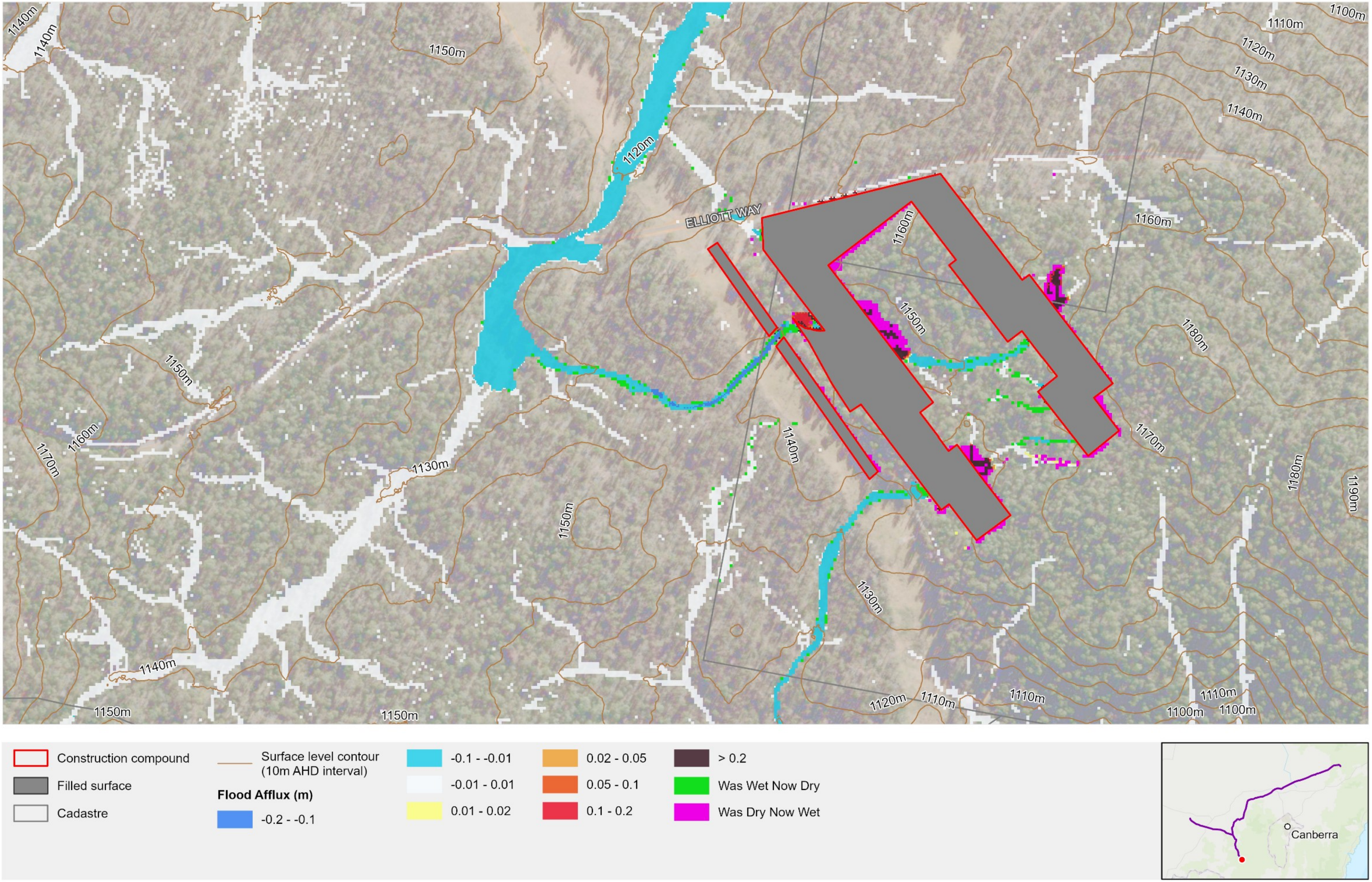
FIGURE 6-3: Snubba Road compound (C03) over local topography with surface level contours (mAHD)

6.2.1.4 Maragle 500 kV substation compound (C05)

The Maragle 500 kV substation compound (C05) is located between New Zealand Gully to the south and the tributary of Yorkers Creek to the north. The Maragle 500 kV substation compound (C05) is not impacted by regional or local flooding but rather by the local drainage. This is mainly a result of its location being higher up in the catchment and across steeper areas where stormwater runoff is mainly shallow overland flow rather than channelised flooding.

Based on the configuration of the footprint of the site, filling would cross multiple drainage lines, which would effectively create trapped low points for stormwater to pond around the site filling, adjacent to the construction compound. This would either require drainage diversions around the fill pad or cross drainage structures beneath the fill to convey stormwater along a similar alignment to pre-development conditions. Impact on local drainage is presented in Figure 6-4.

Adverse impacts outside of the project footprint is limited to minor ponding shown in pink in Figure 6-4. This would be managed through a stormwater management plan to developed as part of detailed design.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000

0 140 280m

Projection: GDA 1994 MGA Zone 55

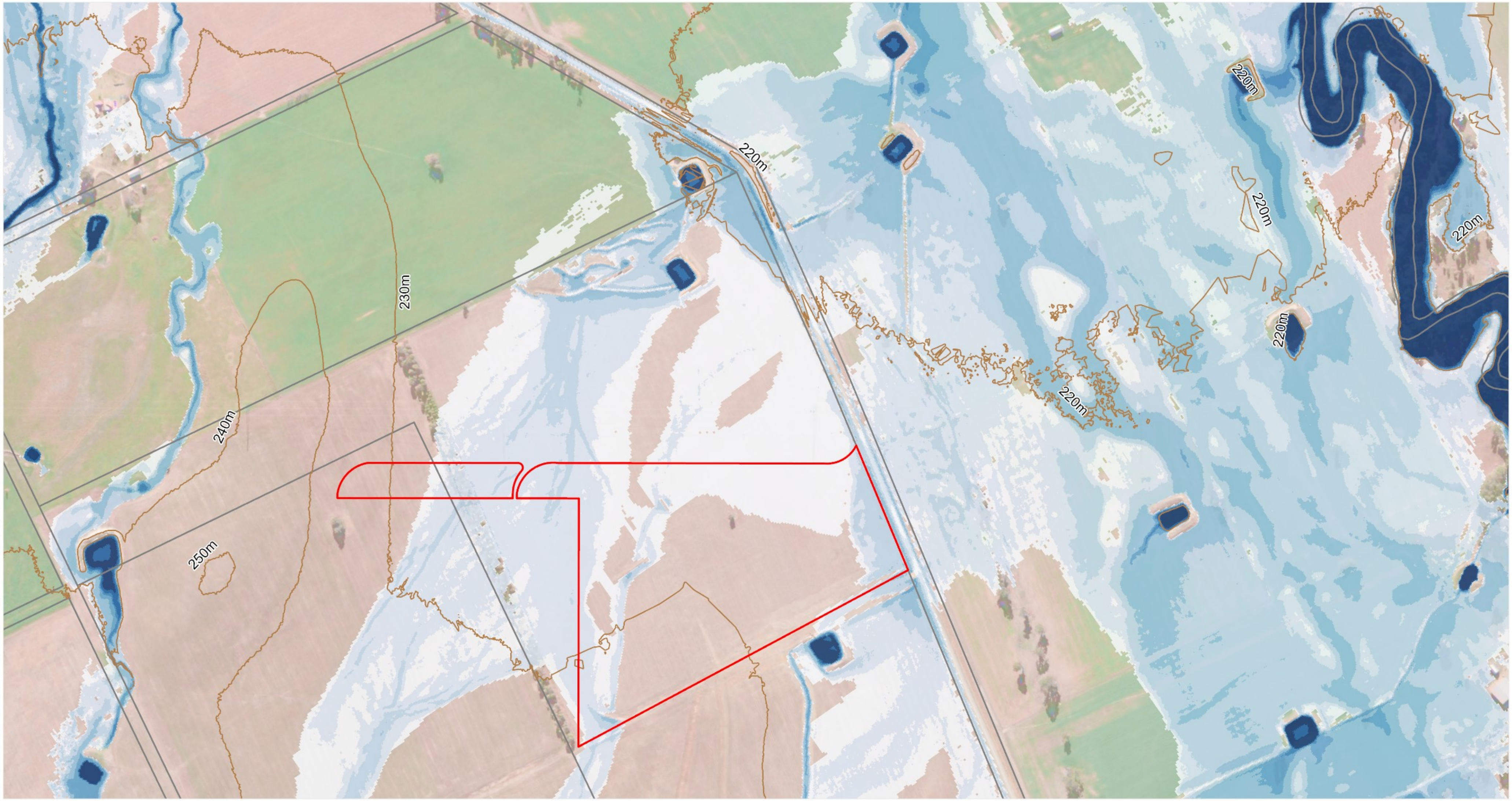
HumeLink **Hydrology and Flooding**

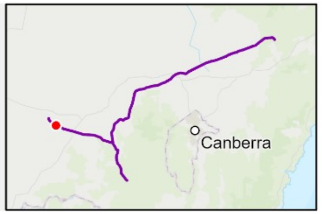
FIGURE 6-4: Maragle 500 kV substation compound (C05) 5% AEP Flood Level Afflux (m)

6.2.1.5 Gregadoo Road compound (C06)

The proposed Gregadoo Road compound (C06) is located approximately 850 metres upstream of O'Briens Creek. A natural drainage line flows through the northern and eastern construction compound extents (refer to Figure 6-5). Modelling undertaken by Lyall & Associates indicated that construction activities along the northern and the eastern extents of this construction compound could potentially impact the local flood characteristics, increasing flood levels across adjacent properties (Lyall & Associates, 2022).

To mitigate these potential impacts, filling of the site or stockpiling of material should be limited to areas predicted to have no risk of flooding. Alternatively, given that flooding at this location is likely to be widespread, extensive infrastructure such as cut-off drains and culverts would be required. Details of flood mitigation infrastructure would be developed as part of detailed design.





Construction compound
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)
<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000
0 140 280 m

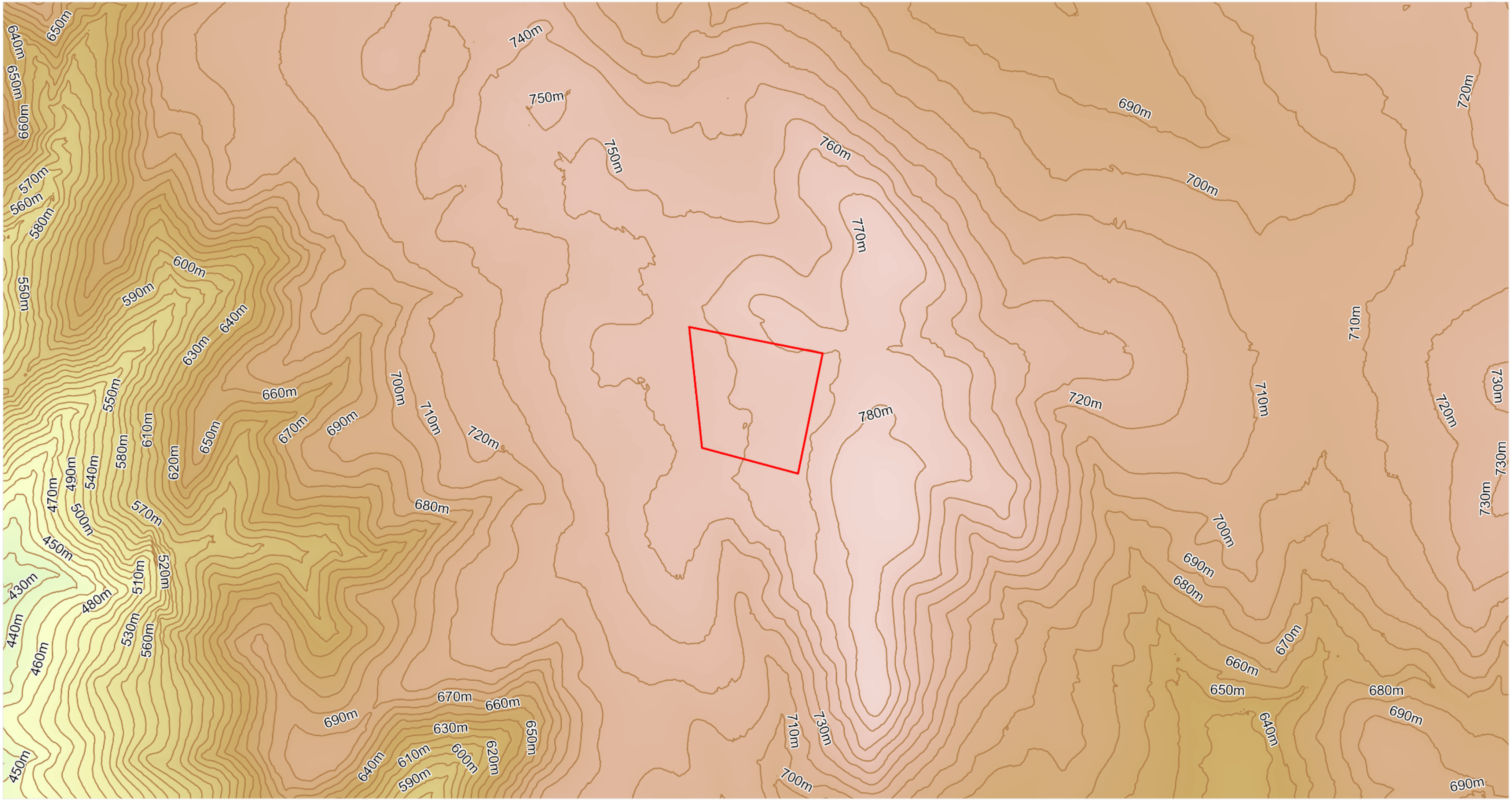
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

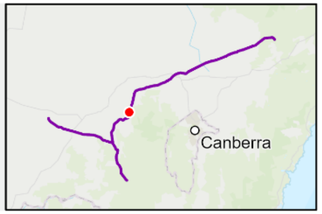
FIGURE 6-5: Gregadoo Road compound (C06) 5% AEP Flood Level (m)

6.2.1.6 Honeysuckle Road compound (C07)

The proposed Honeysuckle Road compound (C07) is located within the Red Hill State Forest. The construction compound is located near a ridge at an approximate elevation of 760 mAHD. With a minor upstream catchment area, the construction compound is unlikely at risk of local flooding. Thus, construction activities are not expected to impact the local flooding characteristics. Figure 6-6 shows the construction compound footprint over the local topography. No flood modelling was undertaken at this construction compound.



Construction compound	**Lidar topography (mAHD)**
Surface level contour (10m AHD interval)	838.796 – 0



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:9,500

0 220 440m

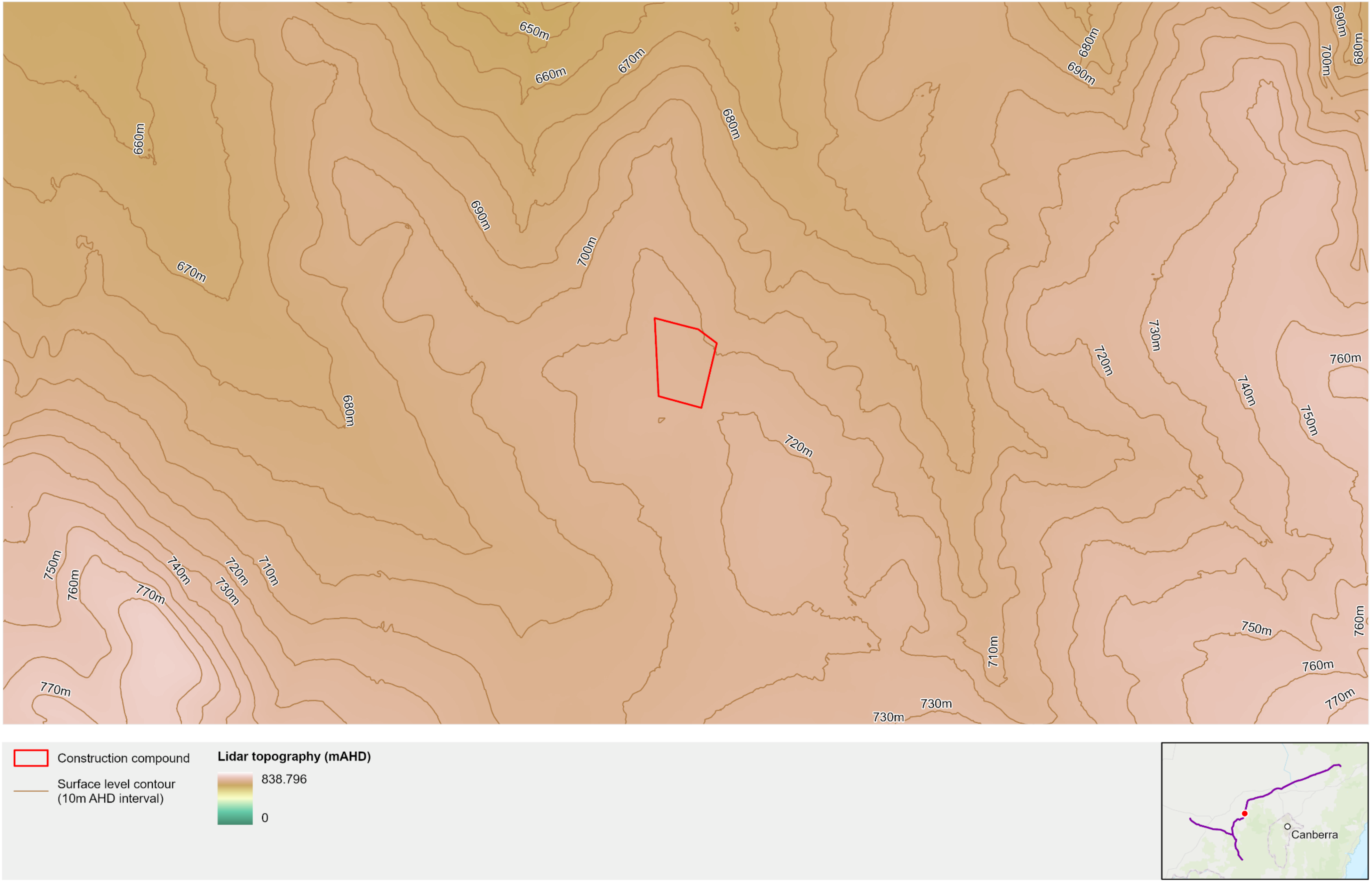
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-6: Honeysuckle Road compound (C07) over local topography with surface level contours (mAHD)

6.2.1.7 Red Hill Road compound (C08)

Red Hill Road compound (C08) is located at an approximate elevation of 710 mAHD north-east of the Honeysuckle Road compound (C07) (refer to Section 6.2.1). The location of the construction compound is near a ridge with drainage lines falling away and only a minor upstream catchment area, therefore unlikely at risk of local flooding. In consequence, construction activities are not expected to impact the local flooding characteristics. Figure 6-7 shows the construction compound footprint over the local topography. No flood modelling was undertaken at this construction compound.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:9,000

0 210 420m

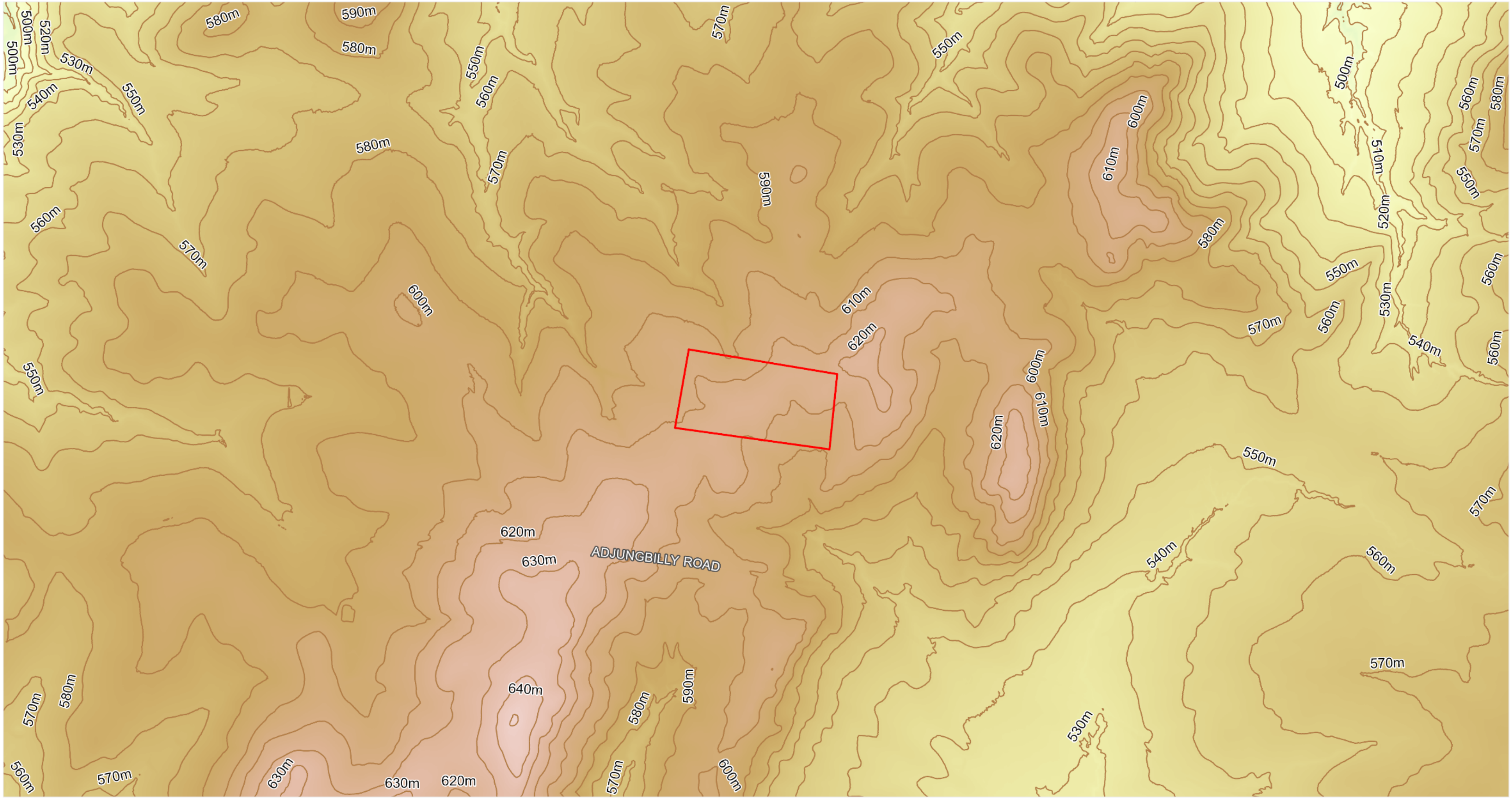
Projection: GDA 1994 MGA Zone 55

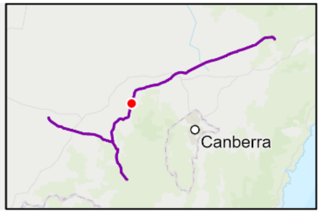
HumeLink **Hydrology and Flooding**

FIGURE 6-7: Red Hill Road compound (C08) over local topography with surface level contours (mAHD)

6.2.1.8 Adjungbilly Road compound (C09)

Adjungbilly Road compound (C09) is located northwest of Adjungbilly locality at an approximate elevation of 610 mAHD. The location of the construction compound is near a ridge with effectively no upstream catchment area, therefore unlikely at risk of local flooding. In consequence, construction activities are not expected to impact the local flooding characteristics. Figure 6-8 shows the construction compound footprint against local topography. No flood modelling was undertaken at this construction compound.





Construction compound

Surface level contour (10m AHD interval)

Value

727.436

302.886

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:12,500

0 290 580 m

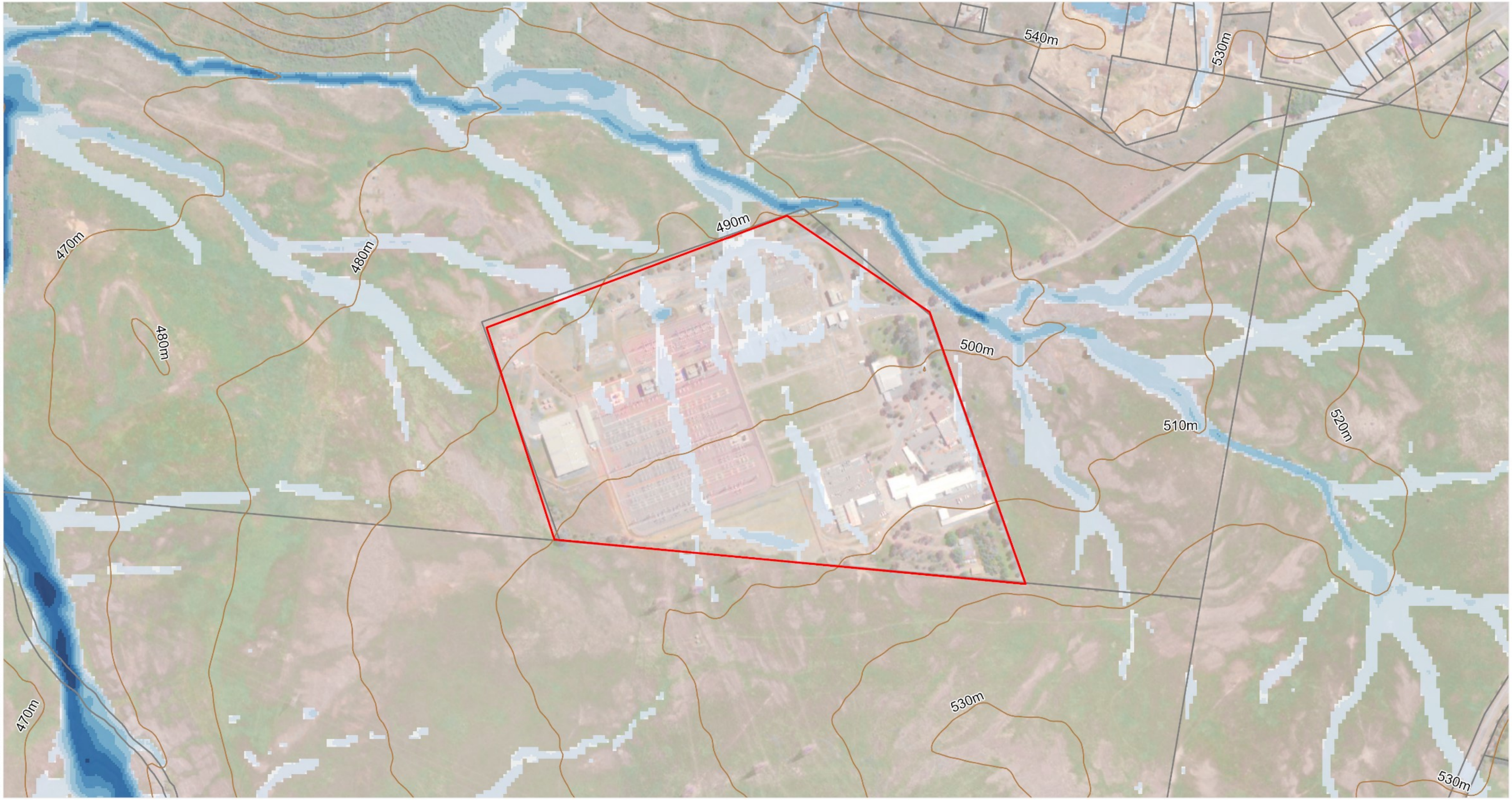
Projection: GDA 1994 MGA Zone 55

FIGURE 6-8: Adjungbilly Road compound (C09) over local topography with surface level contours (mAHD)

6.2.1.9 Yass substation compound (C10)

The Yass substation compound (C10) is located at Transgrid's existing Yass 330 kV substation. The modelling approach for this location has assumed that no earthworks would be undertaken to tie into the existing substation levels.

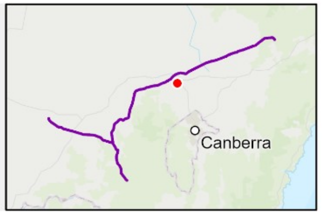
Shallow drainage lines can be observed within the construction compound extents flowing through the northern compound extent (refer to Figure 6-9 shows the existing flood risk to the site). With no earthworks proposed, the Yass substation compound (C10) is not expected to impact existing flood conditions.



Construction compound
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000
0 110 220m

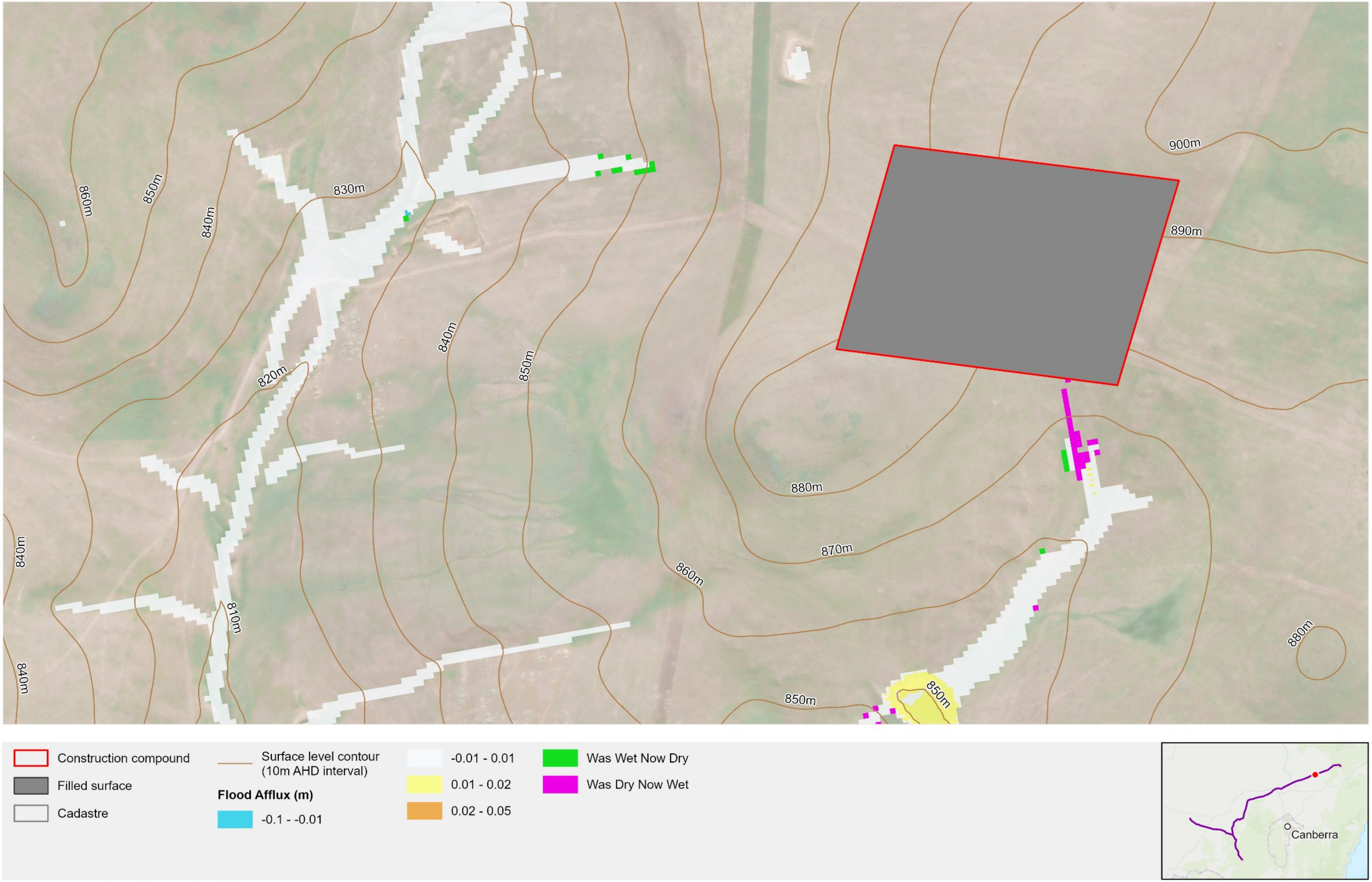
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-9: Yass substation compound (C10) existing 5% AEP flood depth (m)

6.2.1.10 Woodhouselee Road compound (C11)

Woodhouselee Road compound (C11) is located approximately 1,100 metres upstream of Wollondilly River, north-east of Pejar Dam. Local flood modelling indicated that while filling at this location would result in changes to flood behaviour (afflux), the flood impacts would be localised and negligible. Any potential flood impacts would be managed through the stormwater management plan.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,250

0 75 150 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-10: Woodhouselee Road compound (C11) 5% AEP Flood Level Afflux (m)

6.2.1.11 Bannaby 500 kV substation compound (C12)

The Bannaby 500 kV substation compound (C12) is located east of the rural locality of Bannaby and is set at an approximate elevation of 650 mAHD. It includes three separate areas (northern, western and eastern) located south of Transgrid's existing Bannaby 500 kV substation as shown in Figure 6-11.

The construction compound areas are generally located uphill and only interact with local drainage. Construction activities at these areas are predicted to result in only minor adverse impacts to flooding. The western compound area has the potential to divert drainage to the south onto the adjacent property resulting in a minor increase in flood level of between 10 and 20 millimetres.

At the northern and eastern areas, where increases in flood levels are predicted, the impacts would be contained either within the existing substation footprint or between the eastern and western areas. These adverse impacts are localised and account for an increase of up to about 100 millimetres in a 5% AEP event. The flooding is localised within construction compound footprint. As such these impacts would be managed through fill extent limitations and stormwater management, which will be developed as part of the detailed design stage.

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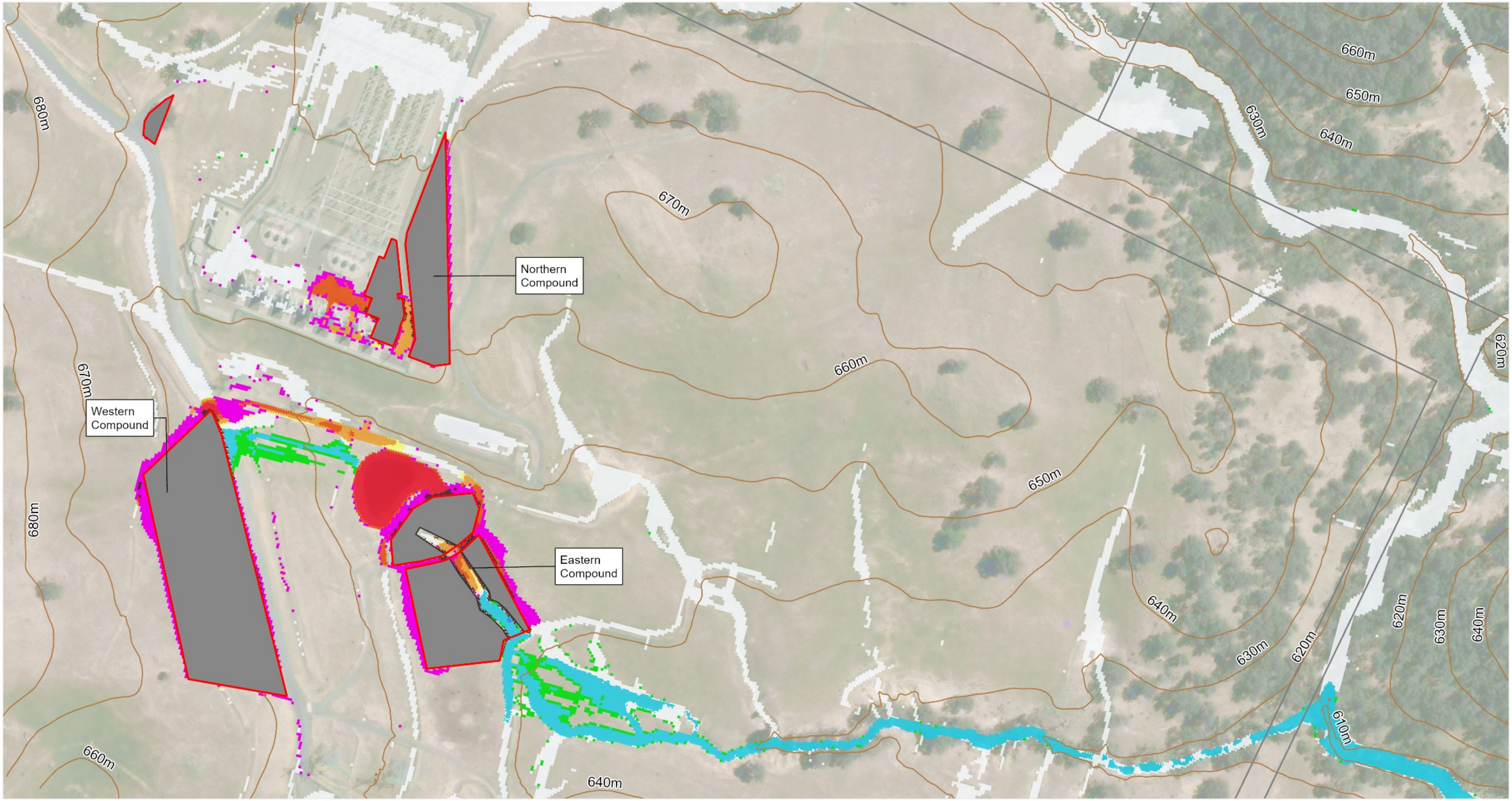
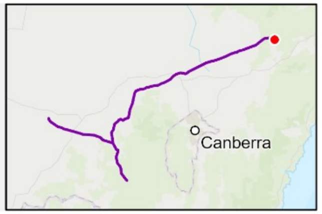


Construction compound
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Afflux (m)

- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2
- Was Wet Now Dry
- Was Dry Now Wet



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,000
0 70 140m

Projection: GDA 1994 MGA Zone 55

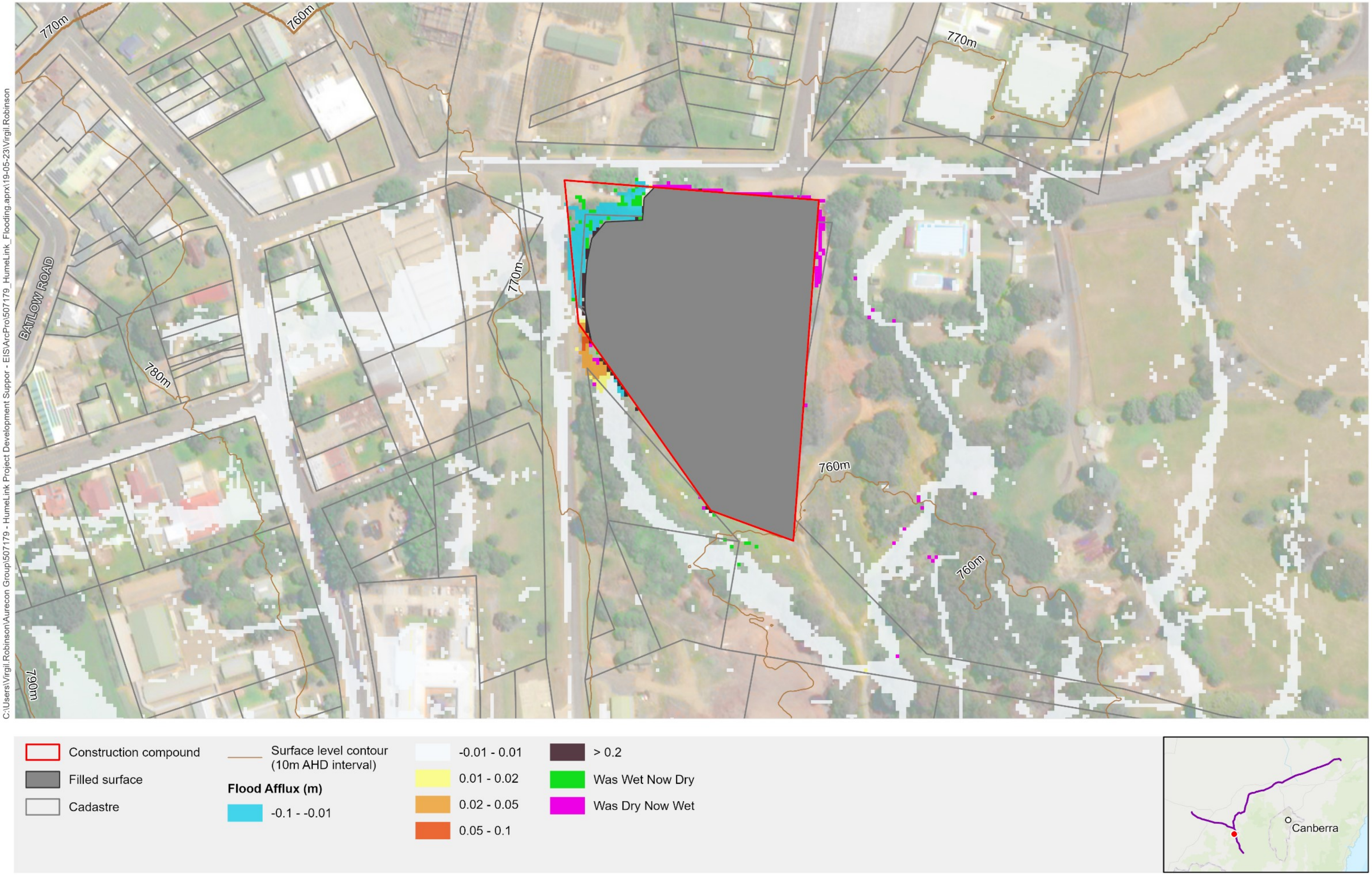
HumeLink **Hydrology and Flooding**

FIGURE 6-11: Bannaby 500 kV substation compound (C12) 5% AEP Flood Level Afflux (m)

6.2.1.12 Memorial Avenue compound (C14)

The Memorial Avenue compound (C14) is located east of the rural locality of Batlow and is at an approximate elevation of 765 mAHD. It is located near a ridge with only minor upstream catchments. However, the north-western part of the site would intercept an existing drainage flow path, potentially causing some localised afflux outside of the proposed construction compound footprint.

The simplest mitigation approach would be limiting the extent of filling at the north-western compound extent. The flood afflux results of this scenario are shown in Figure 6-12 and indicate that filling at this location would likely result in negligible localised flood impacts.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,000

0 40 80m

Projection: GDA 1994 MGA Zone 55

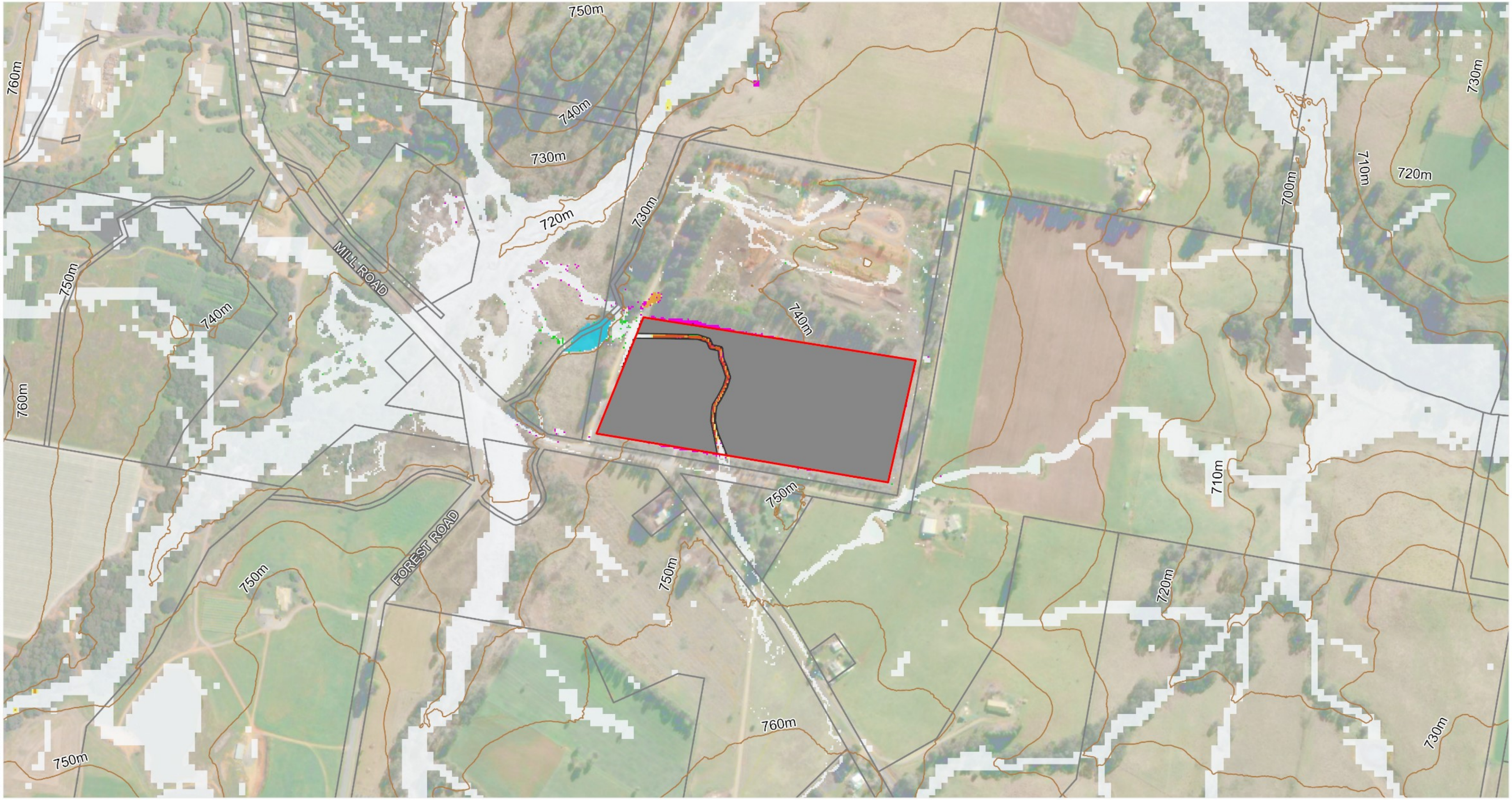
HumeLink **Hydrology and Flooding**

FIGURE 6-12: Memorial Avenue compound (C14) 5% AEP Flood Level Afflux (m)

6.2.1.13 Bowmans Lane compound (C15)

Bowmans Lane compound (C15) is located approximately two kilometres south-east of Batlow. It is situated at an approximate elevation of 1,326 mAHD and about 200 metres upstream of Little Gilmore Creek.

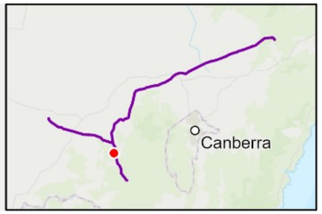
The construction compound was initially modelled as an elevated fill pad across the full extent of the site, to represent the worst-case scenario. This obstructed the existing drainage flow line through the central area of the site which flows into Little Gilmore Creek downstream. Given this, an alternative scenario was modelled by maintaining the existing drainage flowpath within or around the site. No resulting adverse flood impacts are predicted under this management scenario for the 5% AEP event as shown in Figure 6-13.



Construction compound	Surface level contour (10m AHD interval)
Filled surface	
Cadastre	

Flood Afflux (m)

- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2
- Was Wet Now Dry
- Was Dry Now Wet



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

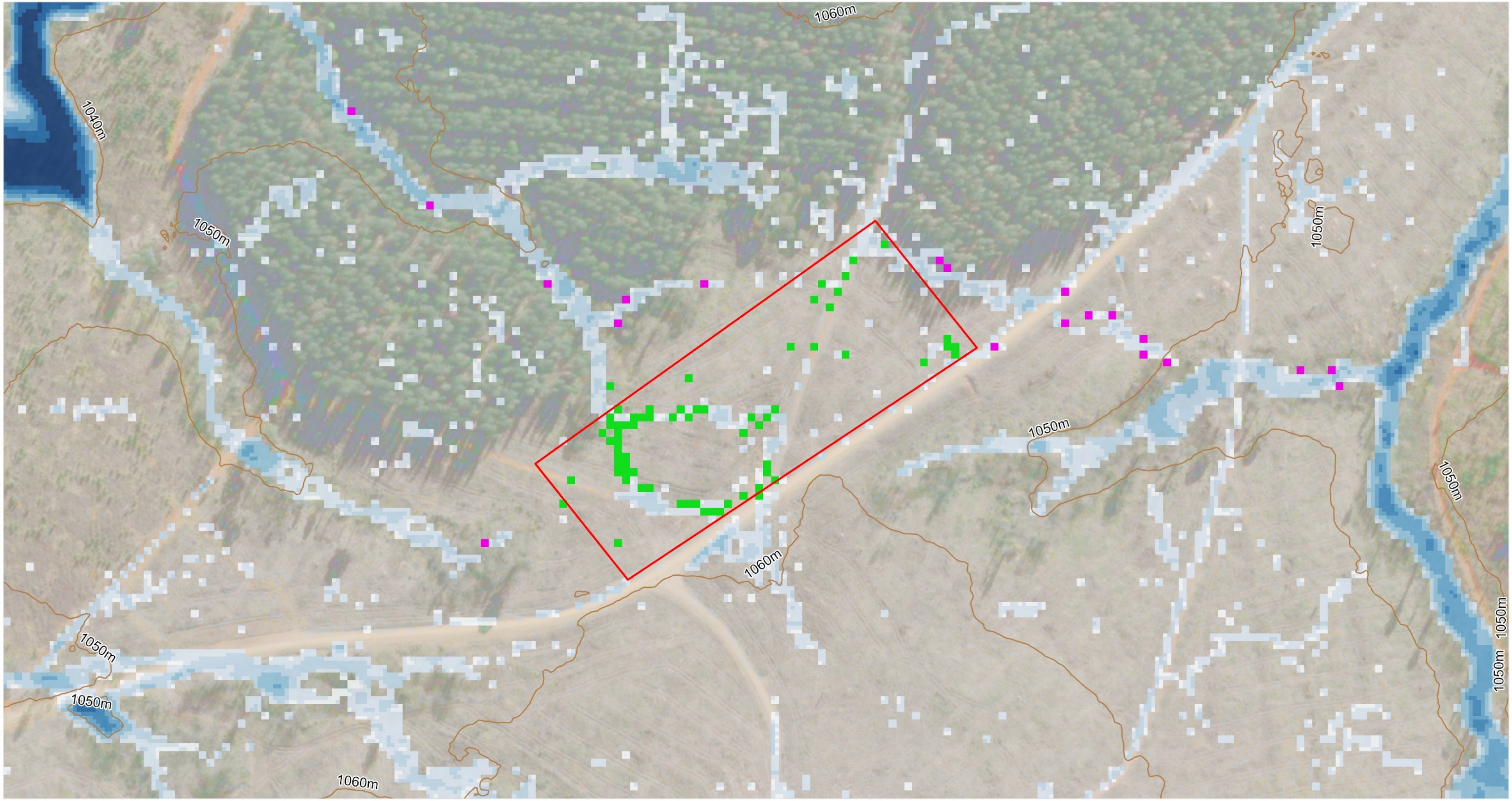
FIGURE 6-13: Bowmans Lane compound (C15) 5% AEP Flood Level Afflux (m)

6.2.1.14 Snubba Road compound (C16)

Snubba Road compound (C16) is located in the Bago State Forest and is at an approximate elevation of 1,055 mAHD. It is located approximately 450 metres upstream of Gilmore Creek on its western side and approximately 300 metres upstream of Ridings Creek on its eastern side.

The site is assumed to be at existing grade with no fill represented, however filling would be possible with suitable internal stormwater management infrastructure in place.

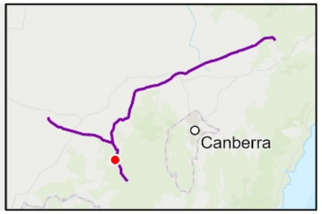
It is understood that the existing trees have been cleared across the construction compound footprint. This is reflected in the reduction in flood levels on the site shown in Figure 6-14. With suitable stormwater management measures in place, no adverse impacts to flooding are expected.



Construction compound
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)
<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5

Was Wet Now Dry
Was Dry Now Wet



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500

0 50 100m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-14: Snubba Road compound (C16) 5% AEP Flood Level Afflux (m)

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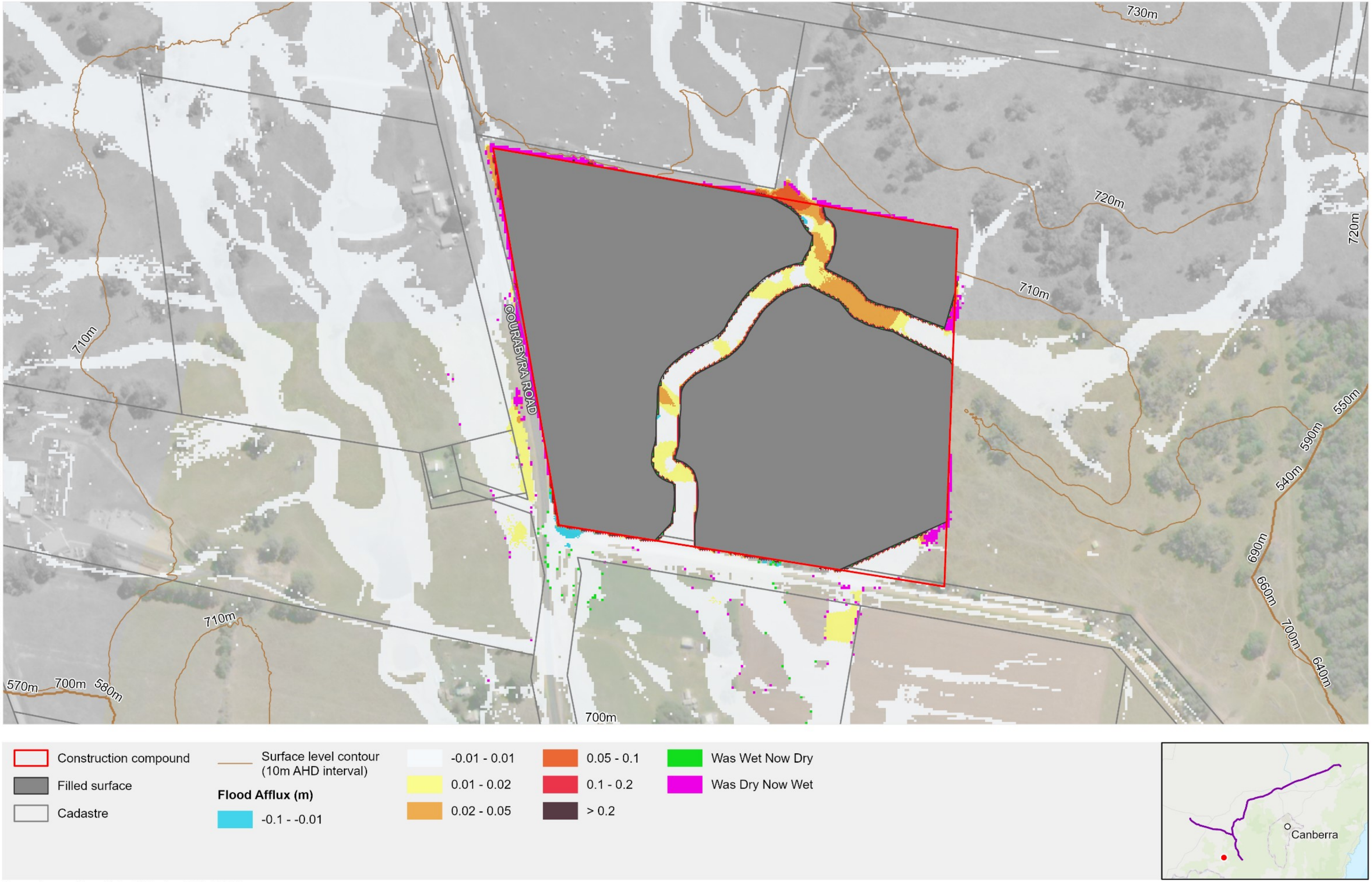
6.2.2 Tumbarumba Accommodation Facility (AC1)

A temporary worker accommodation facility has been identified to accommodate up to 200 construction workers for the project. This facility would be located on the corner of Courabyra Road and Alfred Street, Tumbarumba, located within the Upper Murray River catchment. Located approximately 2.5 kilometres north-east of Tumbarumba, at an approximate elevation of 705 mAHD.

The footprint of the site intersects an existing drainage line that runs virtually through the central part of the site. Modelling showed that obstructing this drainage line would result in adverse flood impacts across adjacent properties. However, maintaining an overland flowpath of at least 20 metres wide and limiting any fill extents to avoid the drainage line would minimise flood impacts in the 2 % AEP event. This scenario is shown in Figure 6-15. Residual adverse impacts would be managed through suitable fill extent limitations and site stormwater management, to be developed during detailed design.



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-15: Tumbarumba Accommodation Facility (AC1) 2% AEP Flood Level Afflux (m)

6.3 Impact of flooding on construction activities

6.3.1 Substations, transmission lines and access tracks

Flooding has a potential to impact the construction activities including construction of the new substation, transmission lines and access track work, and modification work of existing substations. Potential flooding impacts on construction activities are present where work is proposed in flood prone areas. During construction, the stockpiling of spoil, topsoil, materials, equipment and machinery has the potential to be washed away or scoured out by overland flows in a flood event, particularly those located near waterways and drainage lines. Excavations has the potential to become filled with flood water, requiring dewatering, and embankments may become unstable. These site based risks would be managed through a Construction Environmental Management Plan (CEMP) that would outline practices and risk management measures to mitigate site specific risks from flooding.

Section 7.2 presents the degree of flood affectation for the respective infrastructure during operation. The maps specified in Table 7-1 can be used to inform the flood impacts for transmission lines and access tracks. Section 7.2.3 discusses the impact of flooding at the substation locations. It shows that the Wagga 330 kV substation experiences insignificant flood impact while the Bannaby 500 kV substation and proposed Gugaa 500 kV substation would require flood risk management measures to minimise impacts on construction activities.

6.3.2 Construction compounds

The flood impact summary and the type of assessment undertaken for construction compounds is provided in Section 6.2. Two-dimensional modelling was undertaken only for construction compound locations with potential local flood risk.

Table 6-2 Summary of impacts of flooding on construction compounds

Construction compound	Assessment undertaken	Impact of flooding
Wagga 330 kV substation compound (C01)	Two-dimensional flood modelling	No regional flood risk. Possible minor local flooding for consideration in detailed design. Local drainage management required.
Snowy Mountains Highway compound (C02)	Two-dimensional flood modelling	Major impact on southern area of construction compound site. Minor impacts along northern and southern ends
Snubba Road compound (C03)	Desktop assessment based on topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding
Maragle substation compound (C05)	Two-dimensional flood modelling	No regional or local flood risk. Local drainage management required.
Gregadoo Road compound (C06)	Two-dimensional flood modelling	Minor impact on the eastern and western ends of the site by shallow overland flowpaths.
Honeysuckle Road compound (C07)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding
Red Hill Road compound (C08)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding
Adjungbilly Road compound (C09)	Desktop assessment based on surface topography	Located on high ground. No regional flood risk. Unlikely at risk of local flooding
Yass substation compound (C10)	Two-dimensional flood modelling	No regional flood risk. Minor local flood risk via multiple overland flowpaths through the site.
Woodhouselee Road compound (C11)	Two-dimensional flood modelling	Located on high ground. No regional or local flood risk.

Construction compound	Assessment undertaken	Impact of flooding
Bannaby 500 kV substation compound (C12)	Two-dimensional flood modelling	Mainly the eastern construction compound area experiences flood impact from nearby drainage line with minor impact on the northern and western compounds. There is no regional flood risk.
Memorial Avenue compound (C14)	Two-dimensional flood modelling	No regional flood risk. Minor local flood risk via multiple overland flowpaths through the site.
Bowmans Lane compound (C15)	Two-dimensional flood modelling	No regional flood risk. Minor local flood risk via multiple overland flowpaths through the site.
Snubba Road compound (C16)	Two-dimensional flood modelling	No regional flood risk. Minor local flood risk via multiple overland flowpaths through the site.

The flooding depths presented in 'design scenarios' for construction compounds (refer to Sections 6.3.2.1 to 6.3.2.10) indicates the expected flooding depths with filling in place, rather than under pre-development conditions. Where fill is needed to achieve a level of flood immunity, the assessment has identified the approximate minimum level of fill required to achieve the specified flood immunity for the respective infrastructure. The approximate minimum level for each construction compound is presented in Attachment E.

As stated in Section 2.1, to facilitate construction of the project, helicopters may be used to deliver materials/equipment and transfer workers to construction areas particularly within the high alpine regions. Several construction compounds have been identified to include helipad(s) and are considered generally suitable, with the helipad(s) locations to be confirmed during detailed design. Specific helipad locations would consider such issues as drainage lines and local flooding risks identified in this section.

6.3.2.1 Wagga 330 kV substation compound (C01)

The Wagga 330 kV substation compound is located approximately 300 metres upstream of the nearest waterway and is not impacted by regional flooding. It is assumed that this site would not require filling given the proximity to the existing Wagga 330 kV substation.

During a 5% AEP event, local catchment ponding would be seen around the site with no notable flow paths or drainage lines impacting the site (refer to Section 6.2.1). As such, activities at this proposed construction compound location are not expected to be impacted by flooding.

6.3.2.2 Snowy Mountains Highway compound (C02)

The Snowy Mountains Highway compound (C02) is located north of an existing drainage line, which is a tributary of Gilmore Creek. Regional modelling indicated there is a risk of possible backwater influence from Gilmore Creek into the existing drainage line. Given this, further analysis was undertaken using Flow Master software to determine a suitable tailwater condition for the local model. This was done using the Manning's approach for irregular channels and adopting the 1% AEP critical flow from the upstream gauge station (Gilmore Creek gauge station at Gilmore, Gauge ID 410059).

The analysis identified that the 1% AEP peak water level at Gilmore Creek, downstream of the construction compound, would be approximately 278.39 mAHD. In comparison, the approximate surface elevation of the construction compound is 288.0 mAHD. Therefore, with approximately 10 metres difference between the regional peak water level and the construction compound location, any flooding from Gilmore Creek is unlikely to influence the flood characteristics of existing drainage lines or to impact the proposed construction compound in the 1% AEP event. Hence the tail water conditions would also not influence flood in a 5% AEP event. Figure 6-16 shows the expected water level for the 1% AEP event at Gilmore Creek.

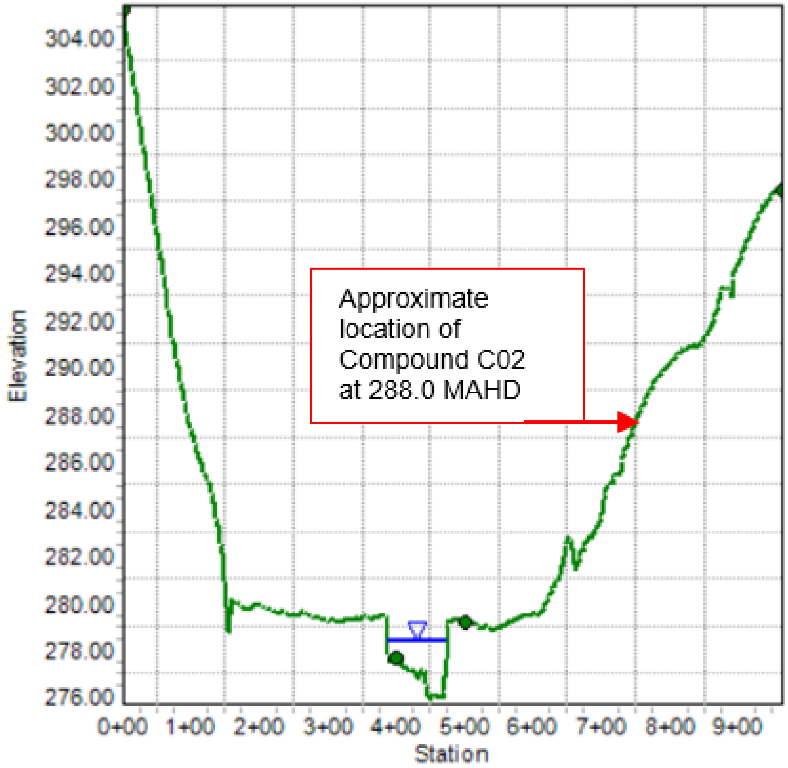
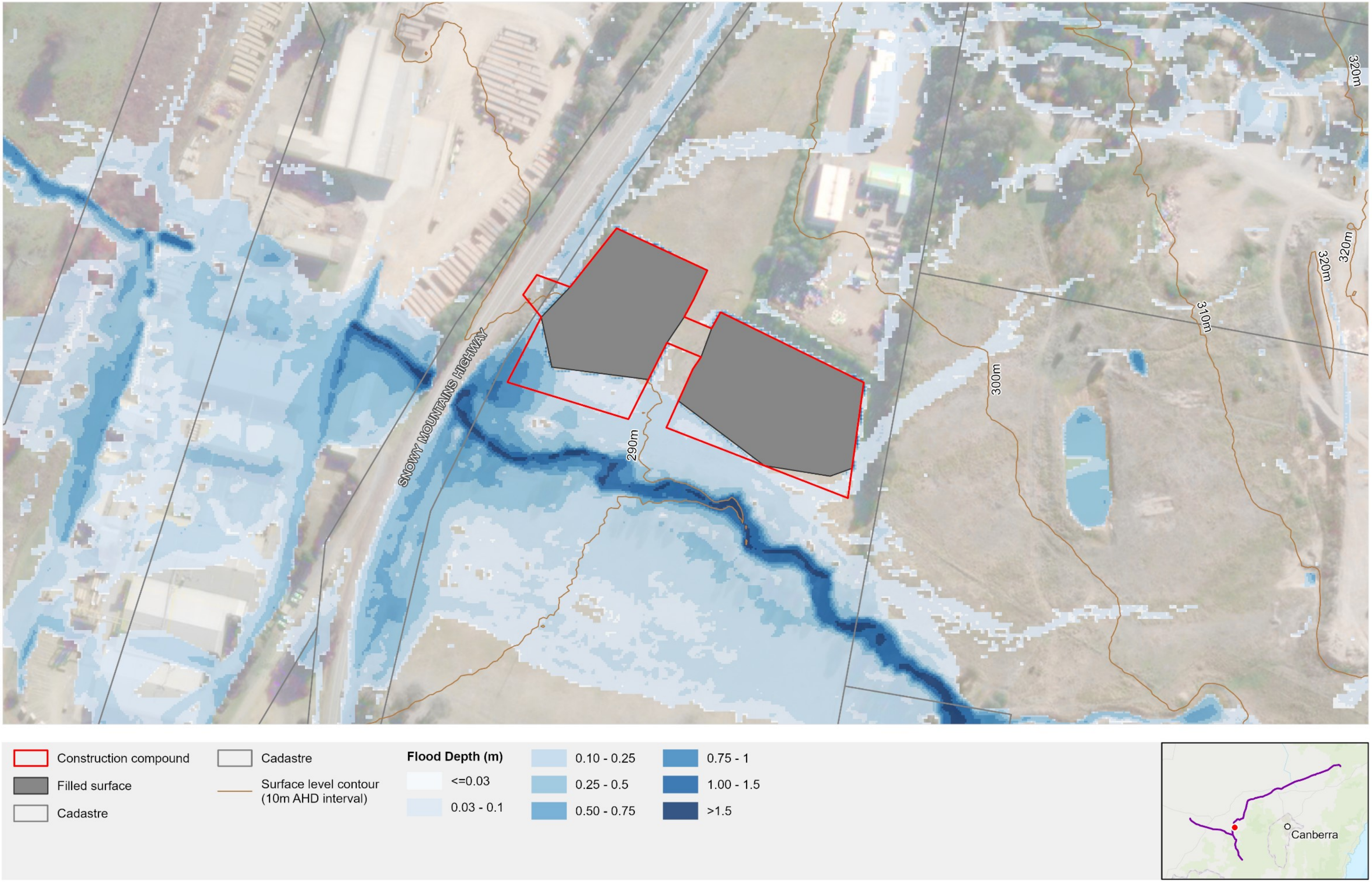


Figure 6-16 Flow Master Analysis (Gilmore Creek cross section)

The Snowy Mountains Highway compound (C02) would be impacted by local catchment flooding along the existing drainage line flowing across the southern side of the site. The 5% AEP flood depths are shown in Figure 6-17.

Flood hazard is generally H1 at the eastern and southern end of the construction compound. On the south-western end, flood depths of up to one metre are predicted, resulting in an ARR 2019 hazard up to H4 along the south-western compound extent (refer to Figure 6-18). Subject to the level of filling or proposed operations in the south-western corner of the site, flood mitigation measures as discussed in Chapter 9 would be required as part of site safety operations.

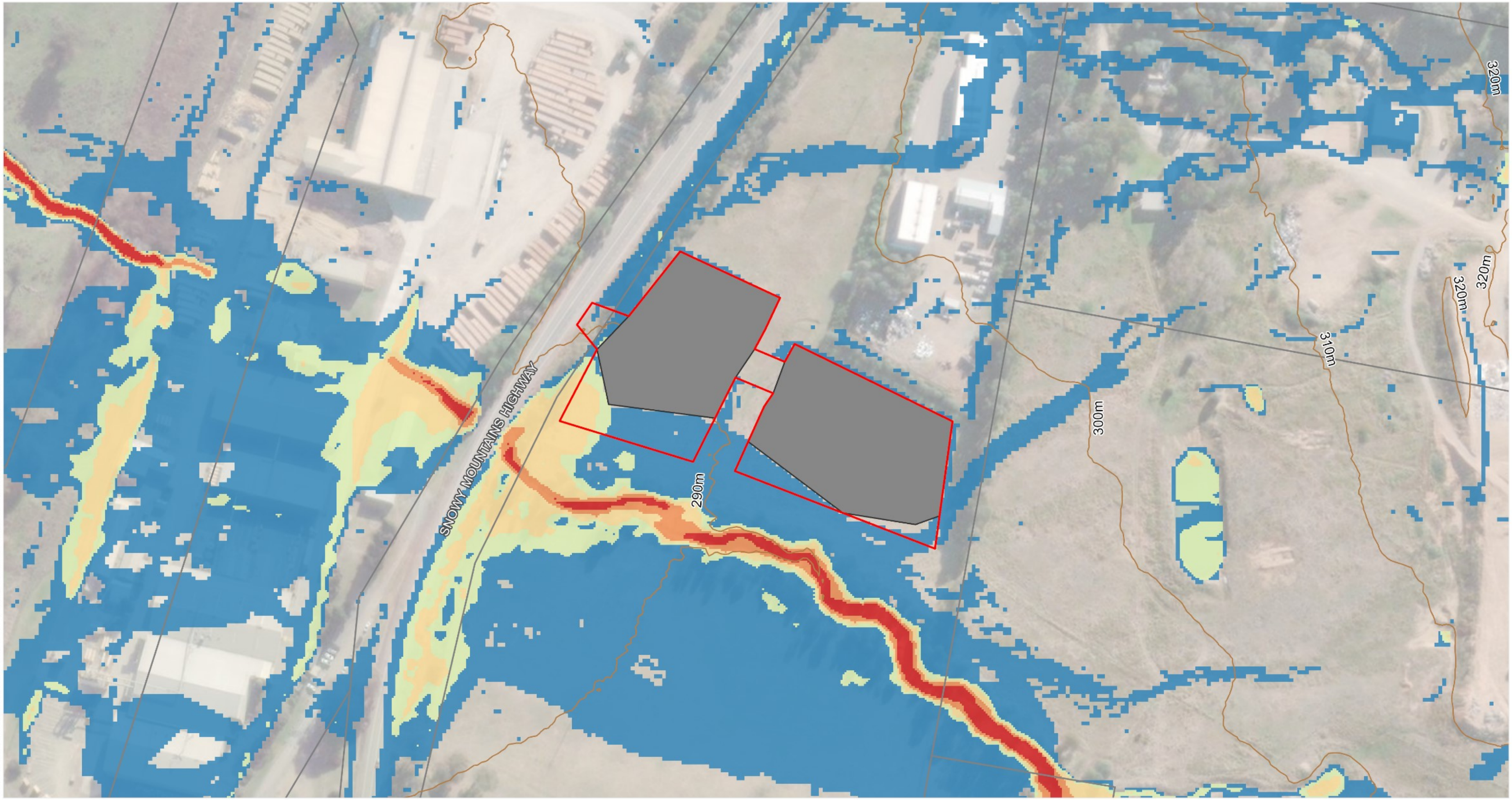


Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

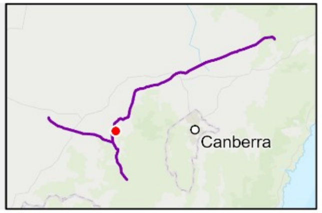
FIGURE 6-17: Snowy Mountains Highway compound (C02) 5% AEP Flood Depth (m) - Design Scenario



Construction compound
Filled surface
Surface level contour (10m AHD interval)
Cadastre

ARR 2019 Flood Hazard Classification

H1
H3
H4
H5
H6



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,000
0 40 80m

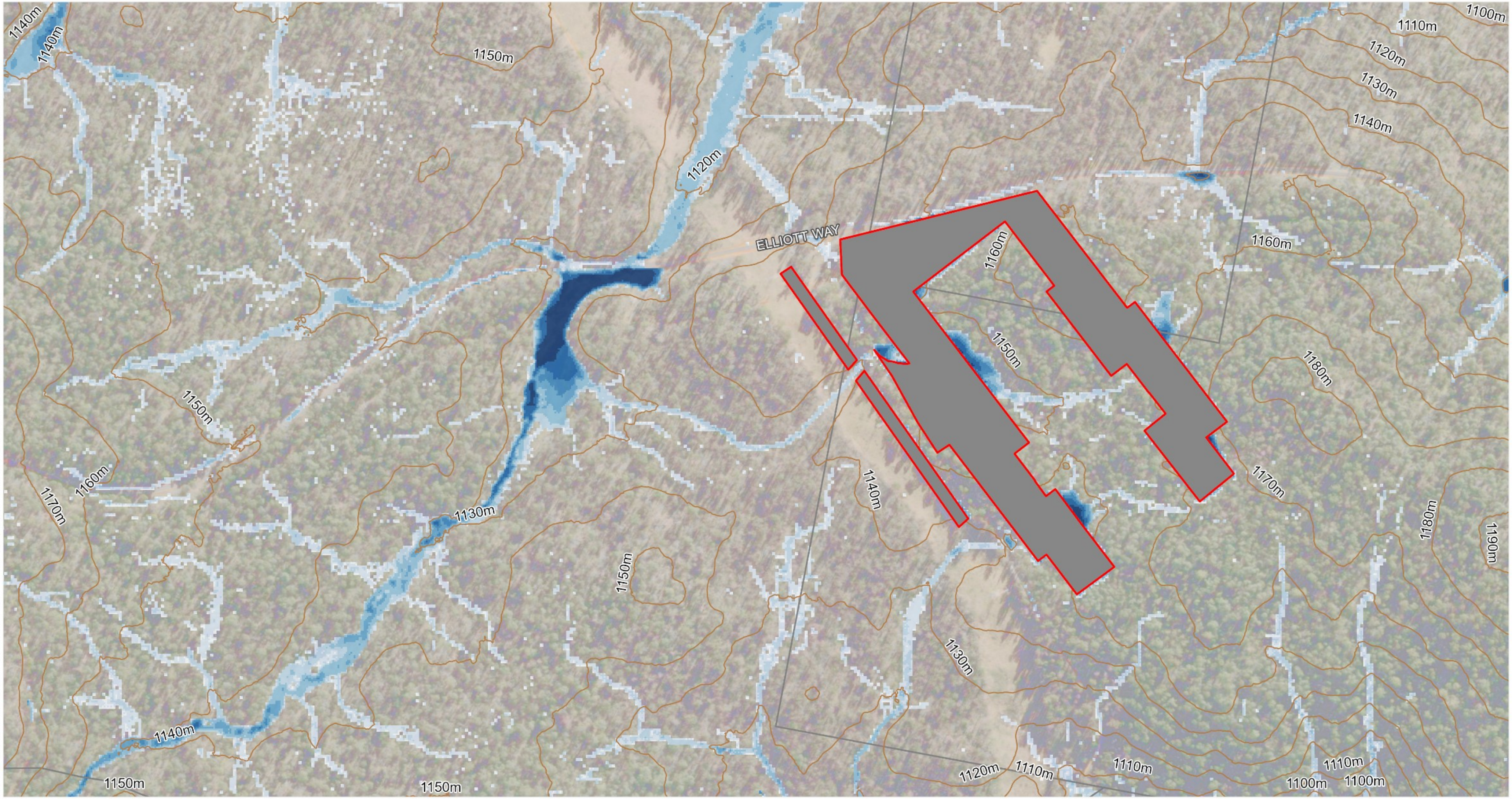
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-18: Snowy Mountains Highway compound (C02) 5% AEP Flood Afflux (m)

6.3.2.3 Maragle 500 kV substation compound (C05)

The Maragle 500 kV substation compound (C05) is located at an elevated area between Yorkers Creek to the north and New Zealand Gully to the south. The construction compound would be mainly impacted by local upstream drainage, which has the risk of being trapped in and around the construction compound footprint (refer to Figure 6-19). The need for drainage corridor through the site to maintain the existing drainage behaviour or a stormwater management strategy to manage these potential impacts would be considered further during detailed design.



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Construction compound

Filled surface

Cadastre

Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03

0.03 - 0.1

0.10 - 0.25

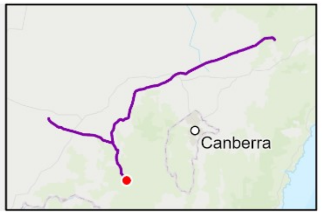
0.25 - 0.5

0.50 - 0.75

0.75 - 1

1.00 - 1.5

>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000

0 140 280 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-19: Maragle 500 kV substation compound (C05) flood risk in a 5% AEP event flood depth (m) - Design Scenario

6.3.2.4 Gregadoo Road compound (C06)

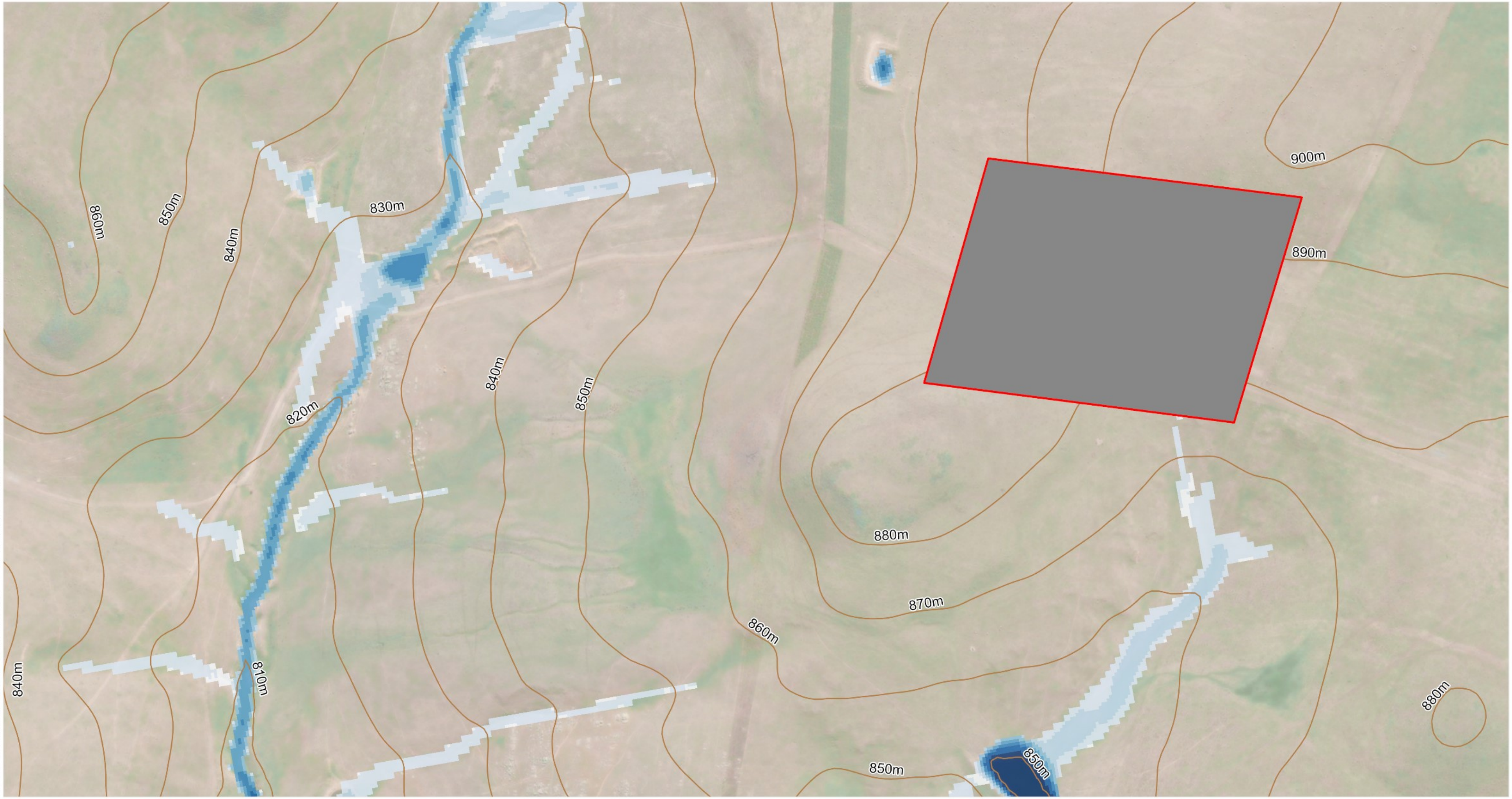
The assessment of flood risk for the Gregadoo Road compound (C06) was undertaken by Lyall & Associates (2022) (refer Attachment D). Based on their assessment, the site would experience local flooding along the eastern and western ends of the construction compound in a 5% AEP event from shallow sheet flow (refer to Figure 6-5). The need for a drainage corridor through the site to maintain the existing drainage behaviour or a stormwater management strategy to manage these potential impacts would be considered further during detailed design.

6.3.2.5 Yass substation compound (C10)

Flood modelling results shows that the Yass substation compound (C10) would experience minor local flooding along the north-eastern end of the construction compound in the 5% AEP event from shallow sheet flow (refer to Figure 6-9). As the flooding is considered minor, this can be managed through the stormwater management plan for the site.

6.3.2.6 Woodhouselee Road compound (C11)

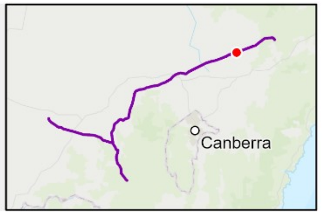
The flood modelling results shows that the Woodhouselee Road compound (C11) would not be impacted by local or regional flooding during the 5% AEP, as shown in Figure 6-20. This is mainly due to the location of the construction compound in a higher elevation.



Construction compound
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,250
0 75 150m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

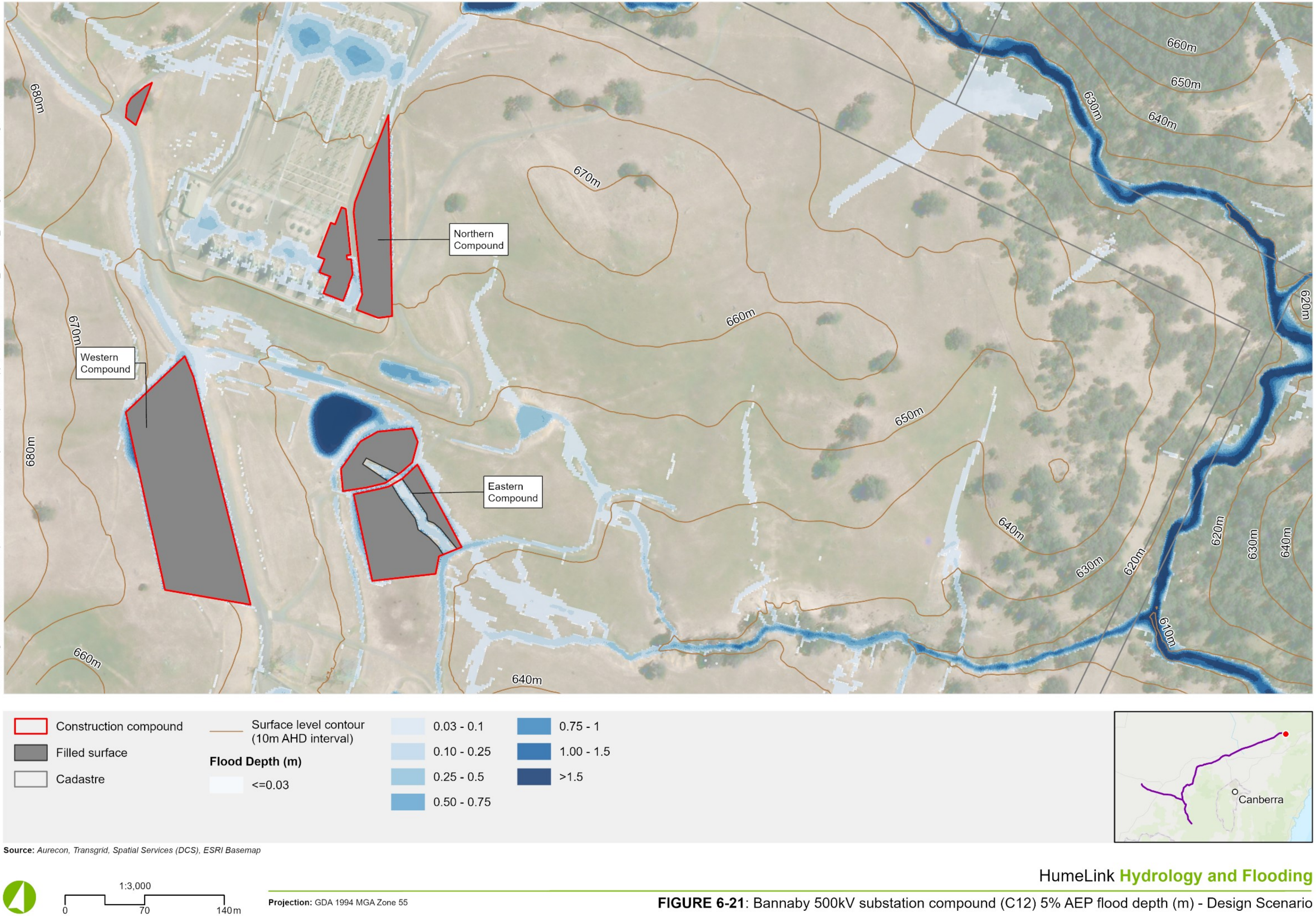
FIGURE 6-20: Woodhouselee Road compound (C11) 5% AEP flood depth (m) - Design Scenario

6.3.2.7 Bannaby 500 kV substation compound (C12)

The Bannaby 500 kV substation compound (C12) is located east of the rural locality of Bannaby and is set at an approximate elevation of 650 mAHD. It includes three separate areas (northern, western and eastern) located south of Transgrid’s existing Bannaby 500 kV substation as shown in Figure 6-11.

The northern and western areas of the construction compound are predicted to have some minor impact from overland flow ponding around the upstream edges of the construction compound footprints. The eastern compound area is located immediately downstream of an existing basin, as shown in Figure 6-21. The basin is understood to have an outlet structure consisting of a 900 millimetre by 900 millimetre pit with a 375 millimetre diameter outlet pipe. This was incorporated in the local model and modelled to discharge through the middle of the proposed construction compound footprint. No filling of the construction compound footprint was applied from the basin outlet to maintain a basin outlet flowpath. In the 5% AEP event, the existing basin is predicted to overtop and interact with the eastern compound area.

The model generally predicted flood hazard of H1 around the three compound extents and up to H3 around the eastern compound (refer to Figure 6-22). The flood risk is generally minor and localised around the construction site footprint. The need for a drainage corridor through the site to maintain the existing drainage behaviour or a stormwater management plan to manage these potential impacts would be considered further during detailed design.



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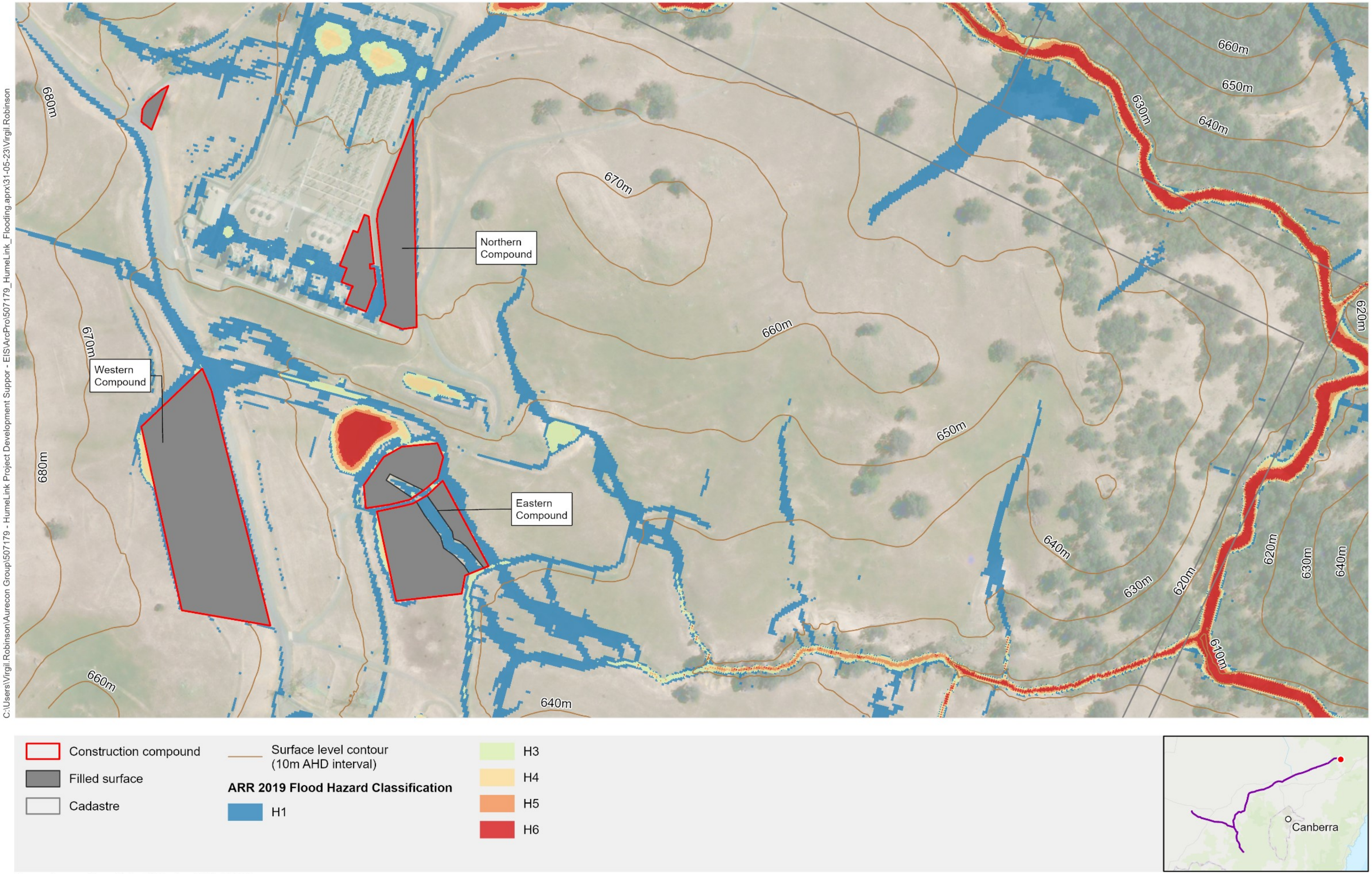
Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-21: Bannaby 500kV substation compound (C12) 5% AEP flood depth (m) - Design Scenario



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

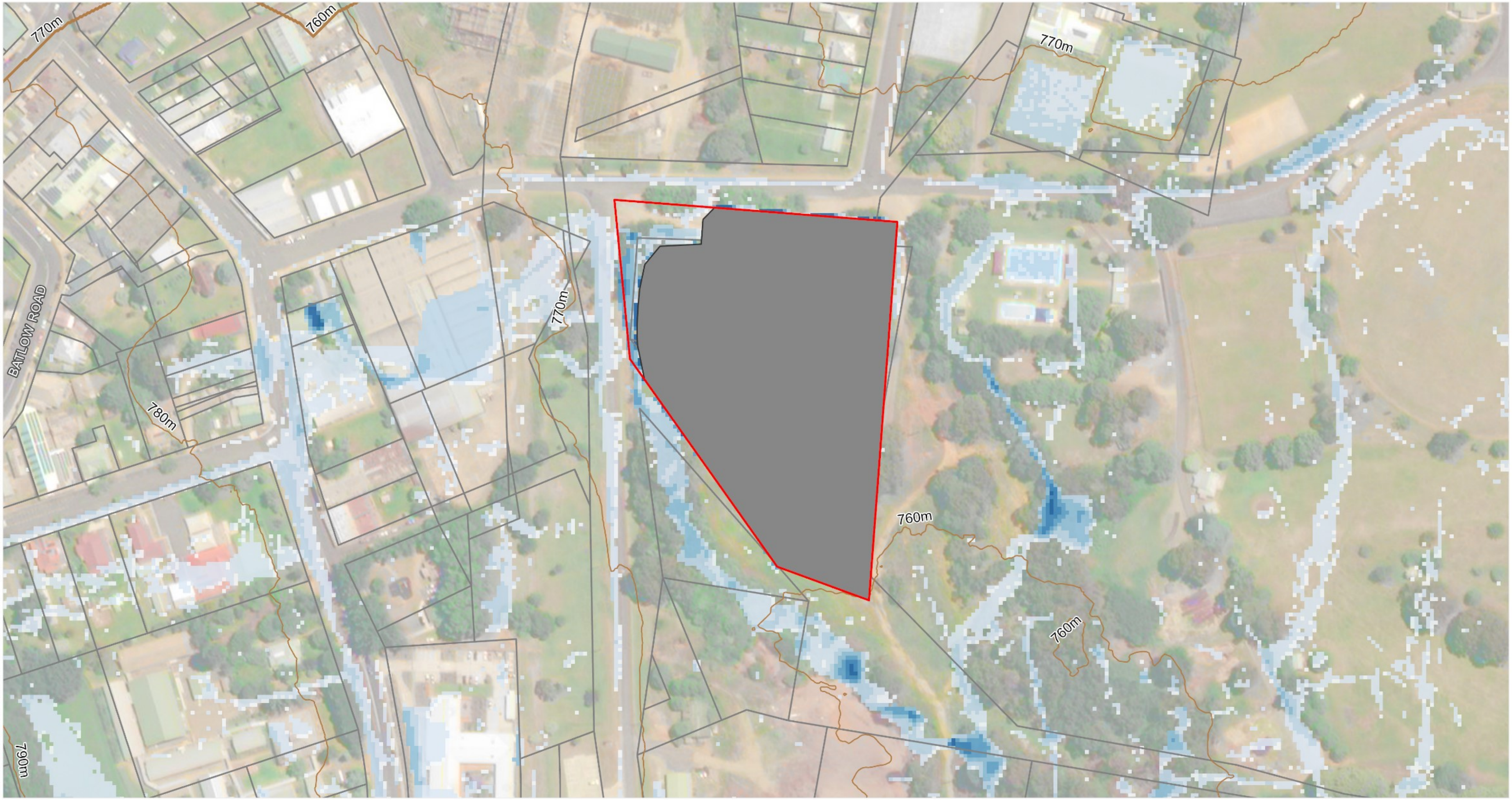
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-22: Bannaby 500kV substation compound (C12) 5% AEP flood hazard - Design Scenario

6.3.2.8 Memorial Avenue compound (C14)

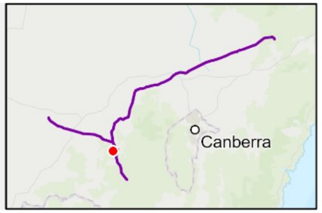
The Memorial Avenue compound (C14) would experience flooding across the north-western extent of the site, as shown in the depth mapping in Figure 6-23. The flood hazard along this flowpath ranges up to H3 classification. Construction activities along the existing drainage line should be avoided to minimise impact of flooding. This will be considered further during detailed design.



Construction compound
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

- <=0.03
- 0.03 - 0.1
- 0.10 - 0.25
- 0.25 - 0.5
- 0.50 - 0.75
- 0.75 - 1
- 1.00 - 1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,000
0 40 80m

Projection: GDA 1994 MGA Zone 55

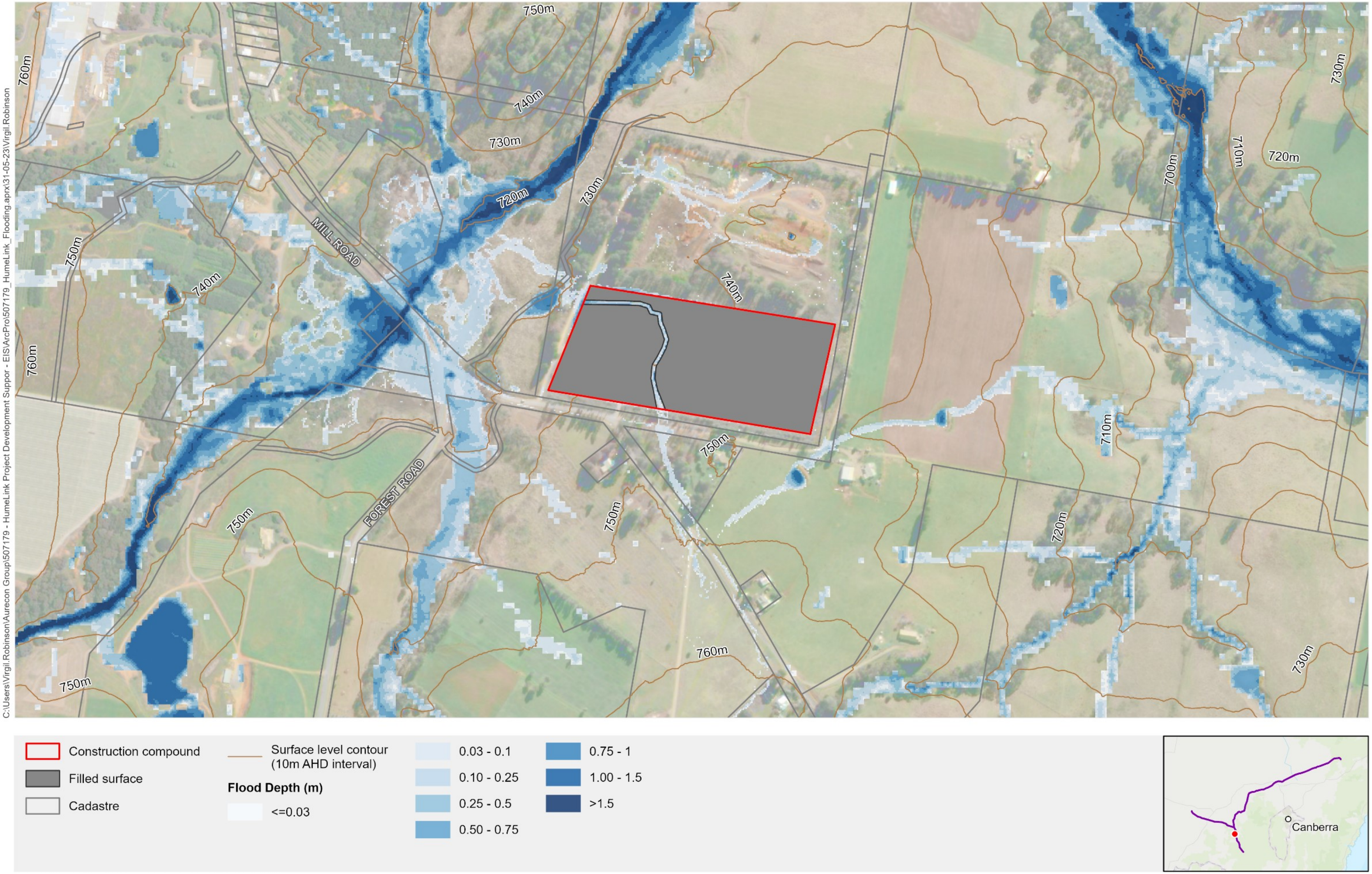
HumeLink **Hydrology and Flooding**

FIGURE 6-23: Memorial Avenue compound (C14) 5% AEP flood depth (m) - Design Scenario

6.3.2.9 Bowmans Lane compound (C15)

The Bowmans Lane compound (C15) would mainly be impacted by local drainage which flows through the compound footprint. This is considered as minor drainage and could be managed by limiting construction activities across this area and allowing a suitable corridor to maintain drainage as shown in Figure 6-24.

As an alternative, drainage diversion around the site could be considered once the site layout is better understood and managed as part of the stormwater management plan during detailed design. The drainage line appears minor however any approvals for this activity would need to be confirmed.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000

0 110 220 m

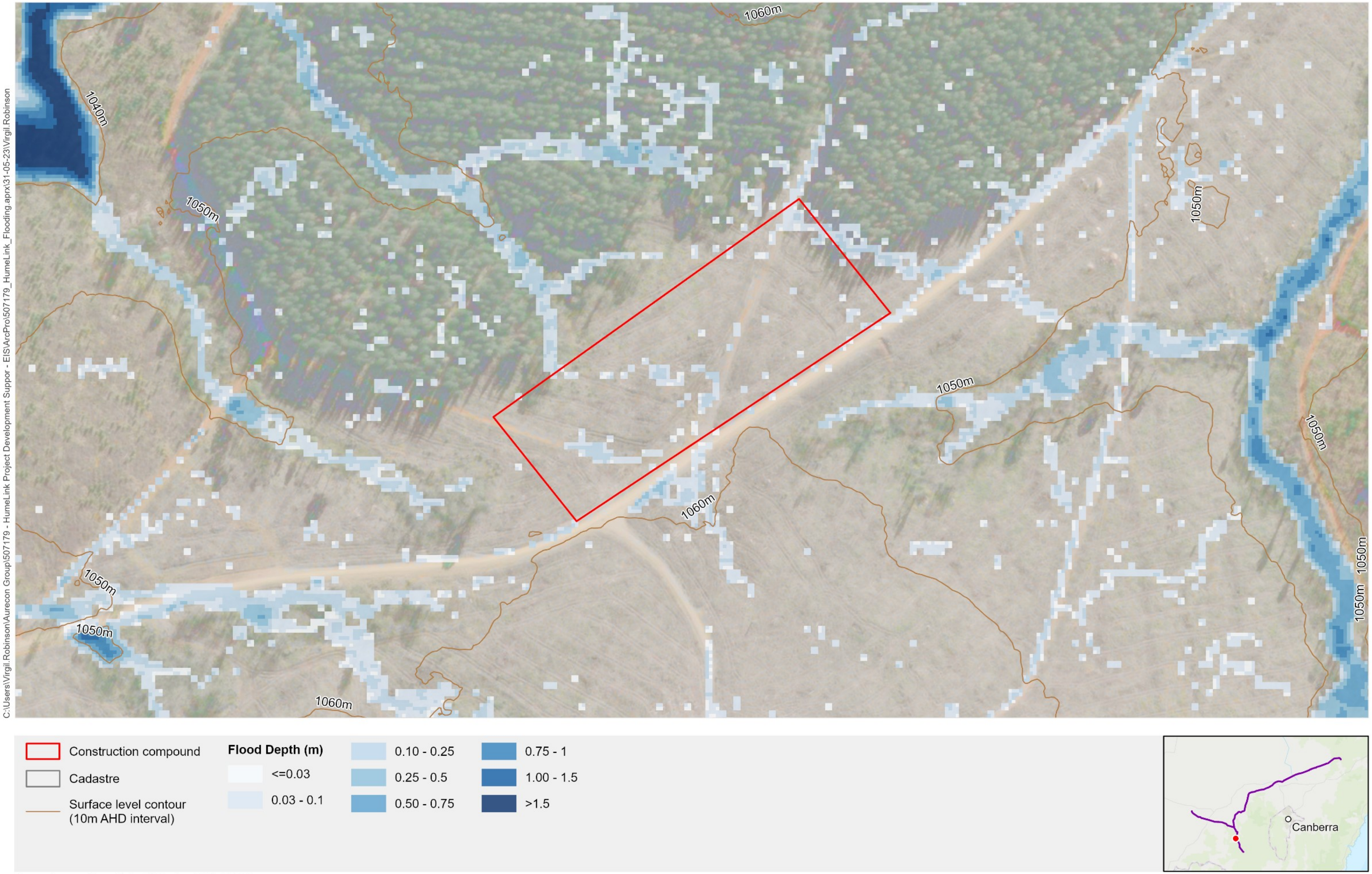
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-24: Bowmans Lane compound (C15) 5% AEP flood depth (m) - Design Scenario

6.3.2.10 Snubba Road compound (C16)

The Snubba Road compound (C16) is mainly impacted by local drainage across the site as shown in Figure 6-25. This impact can be managed by limiting construction activities across low lying areas, strategic filling of certain areas subject to consequential flood impacts and implementing a suitable stormwater management plan.



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500
0 50 100m

Projection: GDA 1994 MGA Zone 55

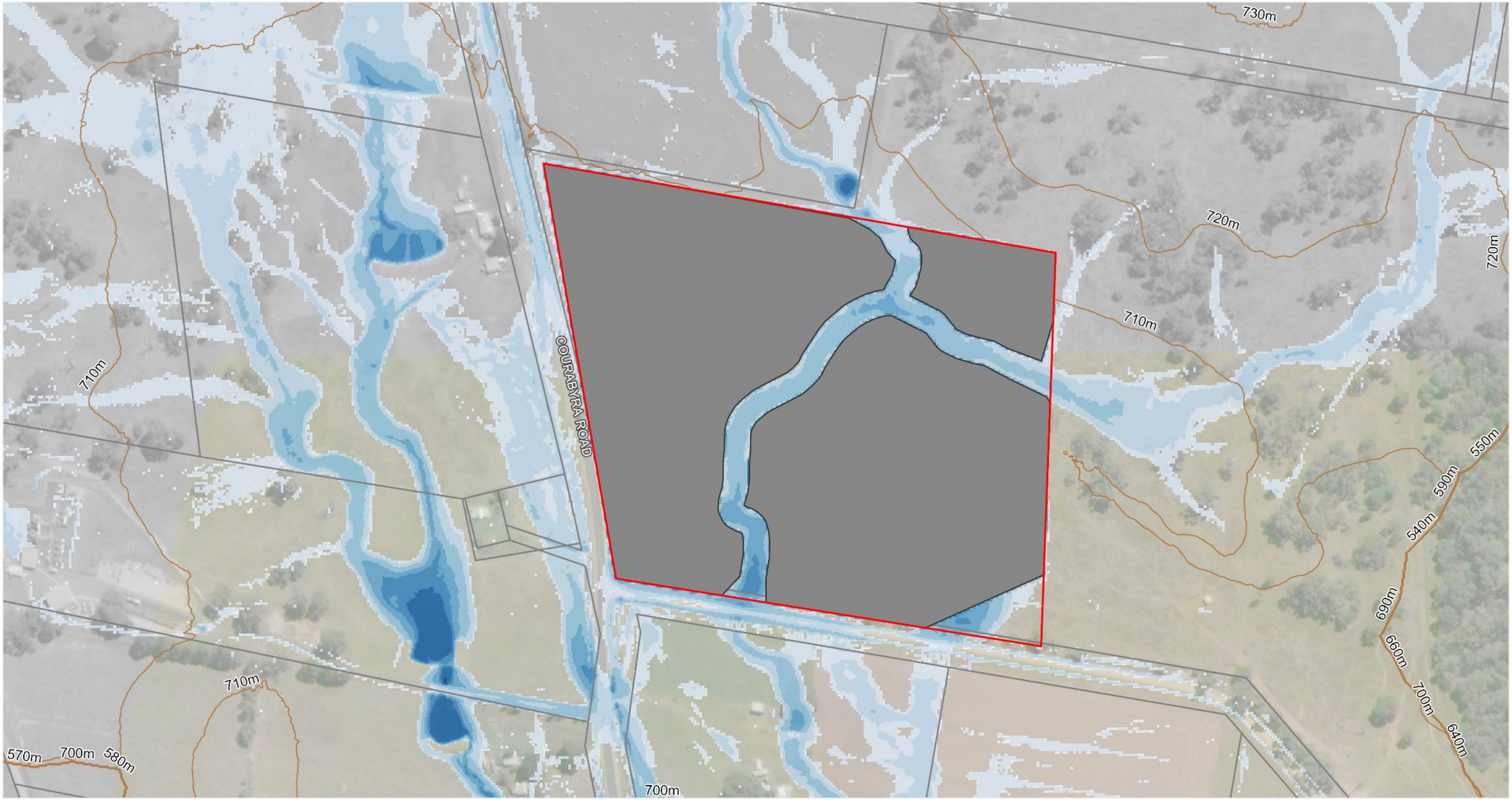
HumeLink **Hydrology and Flooding**

FIGURE 6-25: Snubba Road compound (C16) 5% AEP flood depth (m) - Design Scenario

6.3.3 Tumbarumba Accommodation Facility (AC1)

The Tumbarumba Accommodation Facility (AC1) would mainly be impacted by local flooding along existing drainage lines through the site. The impact of flooding could be minimised by limiting construction activities along the drainage lines and allowing a suitable corridor as shown in Figure 6-26. Furthermore a stormwater management plan would also be required and developed further during detailed design.

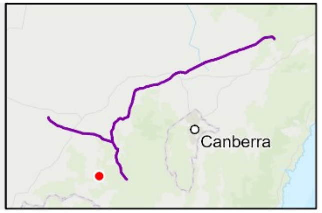
The approximate level of filling required to achieve the required level of flood protection is presented in Attachment E.



Construction compound
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,000
0 70 140 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 6-26: Tumbarumba Accommodation Facility (AC1) 2% AEP flood depth (m) - Design Scenario

7 Operational impacts

7.1 Impact of operations on flooding

7.1.1 Transmission lines and access tracks

The footings of each transmission line structure would require an area of up to 450 square metres, depending on ground conditions and the proposed transmission line structure type. The top of the footing area would mostly be open apart from the base transmission line structure footing connection. Thus, if the transmission line structures are located within a flood prone area (refer to Section 7.2.1), only the base footing connection would impact flooding. Given their size, these footings are expected to only influence flood levels and flow paths local to the structure. As a result, it is not expected that the impact on flooding (if any) would extend beyond the project footprint. Any impacts would be minor and localised.

No specific level of flood immunity was required for access tracks. These tracks would predominantly be at grade to minimise the importation of fill and therefore are not expected to result in any major adverse impacts. Any impacts would be minor and localised.

Depending on the desired level of serviceability, filling may be required at some of the access tracks. This may then call for suitably sized cross drainage culverts or bridge structures to divert flood waters away from the access track. Where a high level of service and/or large cross drainage structures are required, a review of the impact on flooding should be undertaken during the development of the detailed design.

Where excavation is proposed, minor changes in flow direction and levels may result due to the creation of new sags and gullies. This may result in an increase in flood levels and scour risk due to the concentration of flows. These impacts are likely to be localised and minor in nature and would be sufficiently managed through the implementation of measures, such as flow spreaders and appropriate scour protection. These measures would be developed further during detailed design.

7.1.2 Telecommunications hut

As assessed in Section 7.2.2, the proposed telecommunications hut is outside of the regional and local flood extent up to the 1% AEP event. As such, this structure would not result in adverse impacts on flooding.

7.1.3 Substations

7.1.3.1 Proposed Gugaa 500 kV substation

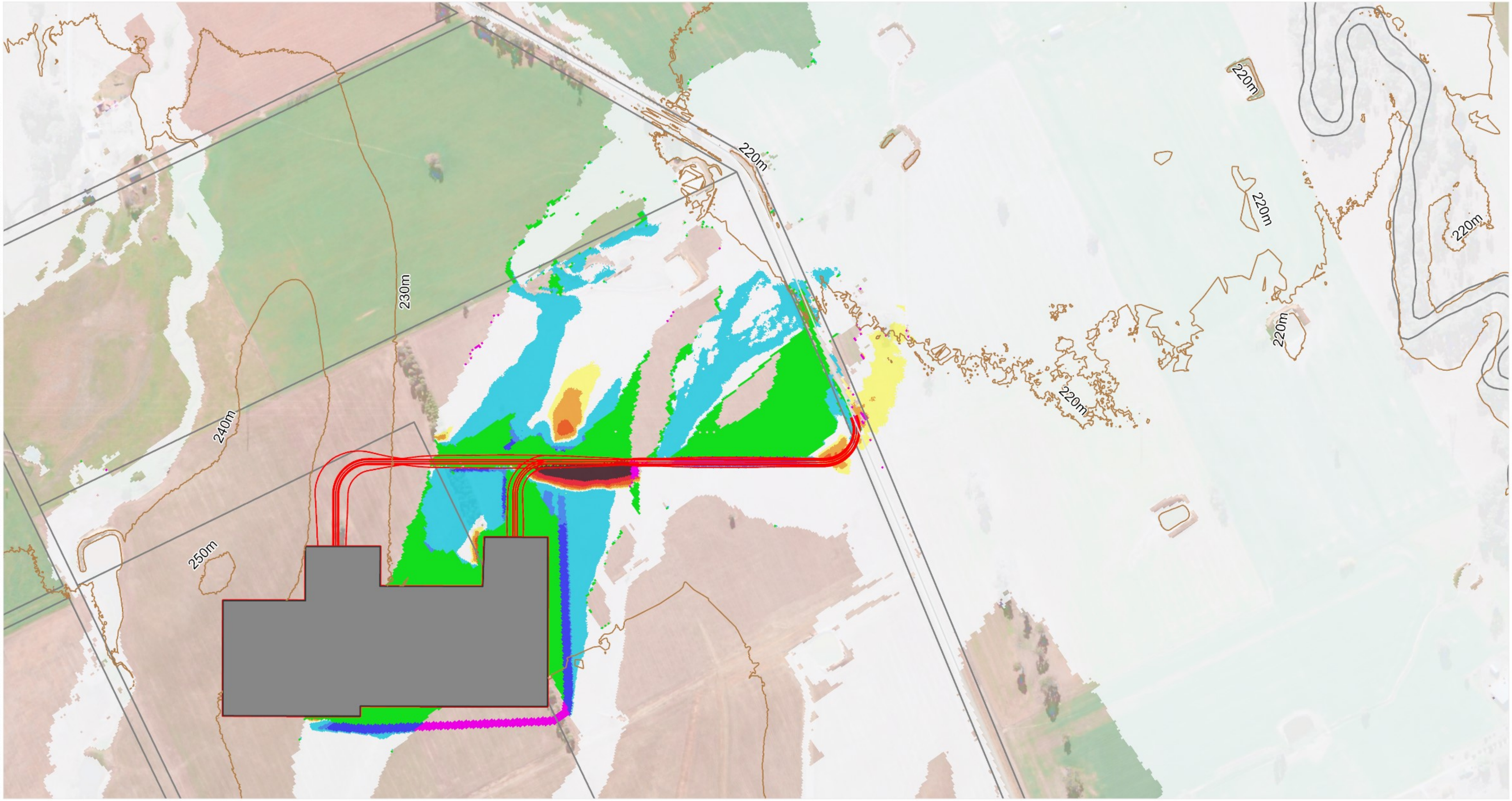
The proposed Gugaa 500 kV substation would be constructed at Gregadoo, about 11 kilometres south-east of the Wagga 330 kV substation as part of the project. The proposed Gugaa 500 kV substation site is located immediately west of the Gregadoo Road compound (C06). The site is situated approximately 1,200 metres west of O'Briens Creek which discharges to Kyeamba Creek, approximately two kilometres north of Gregadoo East Road.

Flood investigation undertaken by Lyall & Associates (2022) has specifically investigated the impact of this substation in detail (refer Attachment D). Based on the flood behaviour, the proposed site would obstruct existing overland flow from the south. As a result, increases in flood levels would likely occur along the southern boundary of the site. The current design of the proposed Gugaa 500 kV substation includes fill levels higher than the PMF level. As such, no overtopping of the fill pad would occur. Residual flood impacts would require refinement of the drainage infrastructure.

Preliminary mitigation measures include a newly added trapezoidal shaped channel south of the proposed Gugaa 500 kV substation site to intercept and convey upstream flow around the southern and eastern sides of the fill extent (Lyall & Associates, 2022). In addition, several culverts were proposed:

- four 1,800 millimetre wide by 1,200 millimetre high box culverts beneath the access road where it crosses the aforementioned trapezoidal shaped channel.
- one 1,800 millimetre wide by 1,200 millimetre box culvert which is required to drain surface runoff beneath the access road at a location approximately 80 metres to the west of the trapezoidal shaped channel
- one 450 millimetre diameter pipe beneath the access road at its intersection with Livingstone Gully Road.

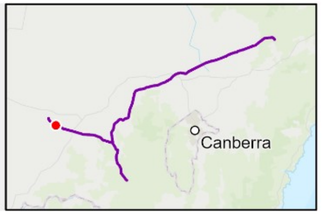
Figure 7-1 presents the resulting flood impact with the mitigation measures in place, allowing flood water to flow along the proposed access road which connects to Livingstone Gully Road. Livingstone Gully Road would experience some localised increase in flood levels at the intersection with the proposed access road (shown in red in Figure 7-1). Residual flood impacts would be managed through drainage design which will be developed during detailed design.



Substation extent
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Afflux (m)

- <= -0.2
- -0.2 - -0.1
- -0.1 - -0.01
- -0.01 - 0.01
- 0.01 - 0.02
- 0.02 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- > 0.2
- Was Wet Now Dry
- Was Dry Now Wet



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000

0 140 280 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-1: Gugaa 500 kV substation 1% AEP flood afflux (m)

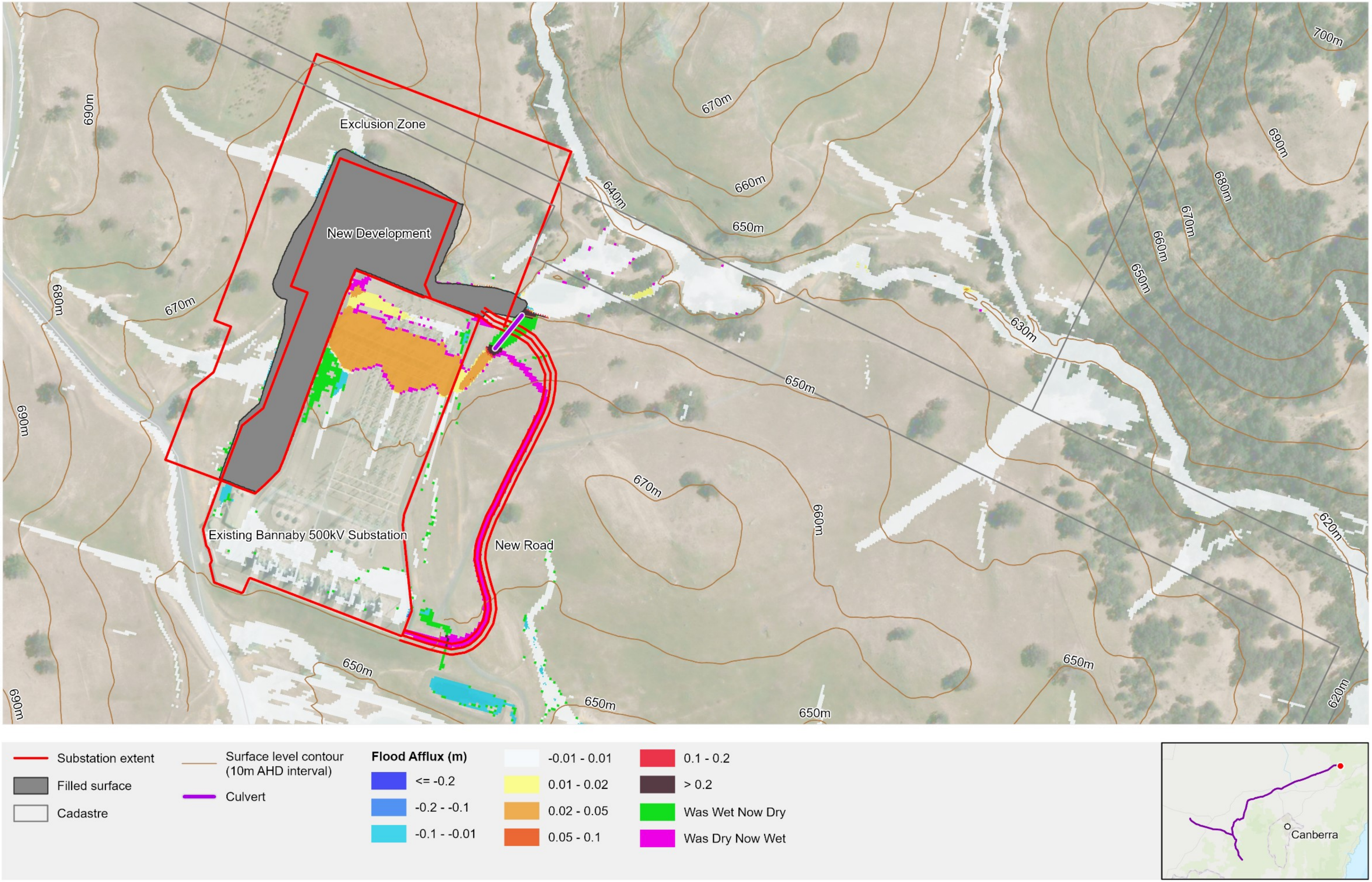
7.1.3.2 Bannaby 500 kV substation modification

The Bannaby 500 kV substation modification would involve extending the existing substation footprint by approximately 6.28 hectares to the north. The extension of Bannaby substation (the Bannaby extension)was assessed for impact on flooding in the regional and local models. No regional flood risk was identified.

The local flood model used available design surface levels to represent hydraulic controls. Where design information was not available, the surface levels were estimated. This approach relates mainly to the access road as shown in Figure 7-2.

The Bannaby extension is situated in the upstream reaches of its local catchment and crosses local drainage flowpaths with a site grading of 2.4% toward the existing substation. This grading would divert overland flows and increase the risk of flood water ponding on the existing substation infrastructure and the new access road. To mitigate this impact, five 1.2 metre diameter reinforced concrete pipes at 5% slope were introduced into the model at the northern end of the new road (refer to Figure 7-2 for culverts location) to mitigate the impact of the road blocking the flow path. As a result, the flood impact assessment indicated negligible change in flood level downstream with localised increases within the existing substation site (refer to Figure 7-3).

Local drainage management would be refined during detailed design to mitigate the potential for flooding at the existing substation and the new road. A review of the impacts outside of the project footprint would also need to be undertaken to confirm impacts are not significant.



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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

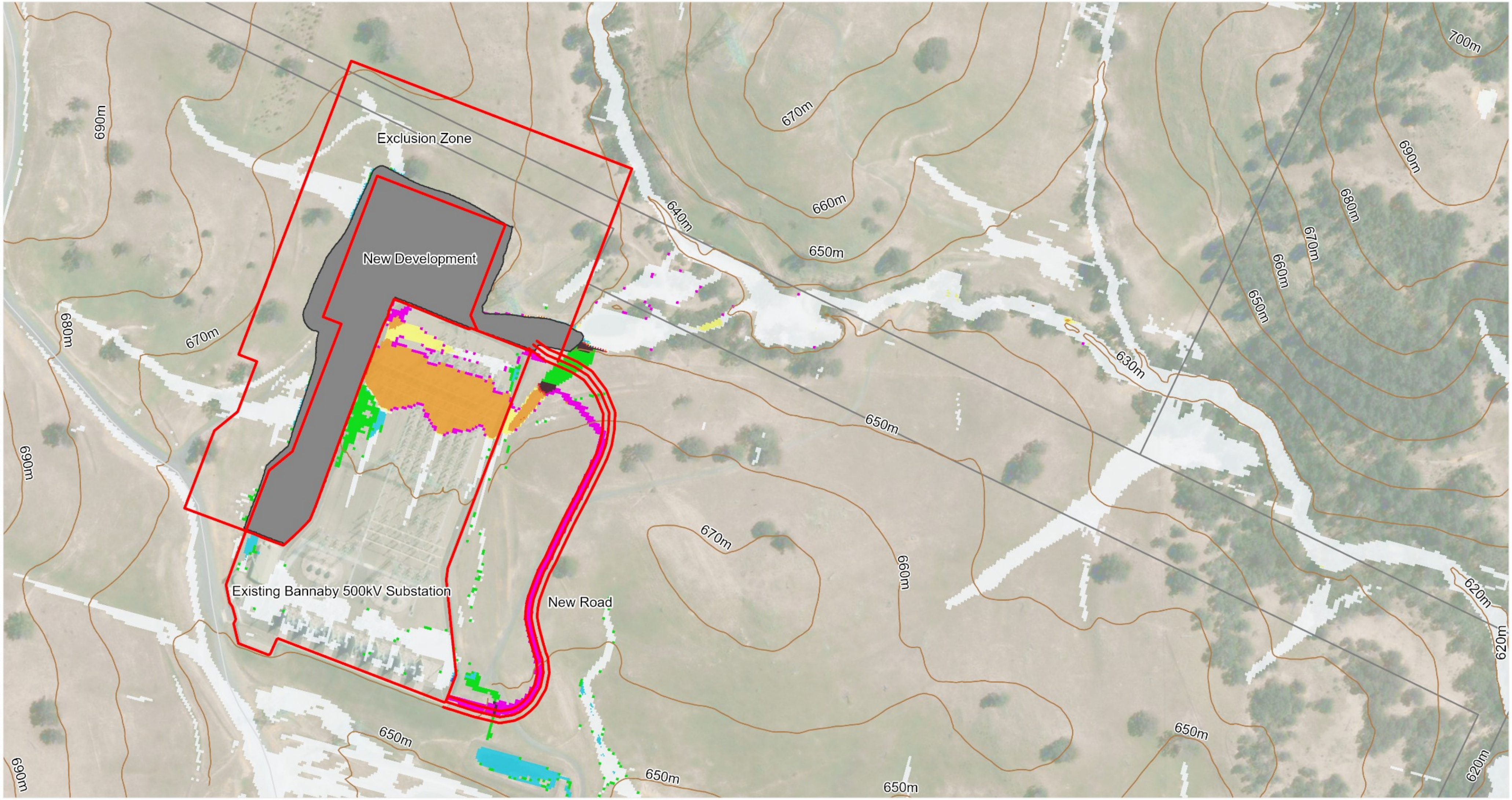
1:3,000

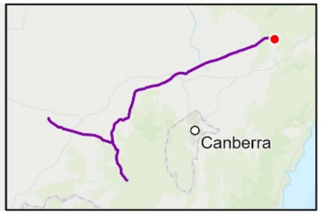
0 70 140m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-2: Potential flood mitigation culvert





Substation extent
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Afflux (m)

<= -0.2
-0.2 - -0.1
-0.1 - -0.01
-0.01 - 0.01
0.01 - 0.02
0.02 - 0.05
0.05 - 0.1
0.1 - 0.2
> 0.2
Was Wet Now Dry
Was Dry Now Wet

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,000
0 70 140 m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-3: Bannaby 500 kV substation 1% AEP residual flood impact (afflux (m)) with mitigation

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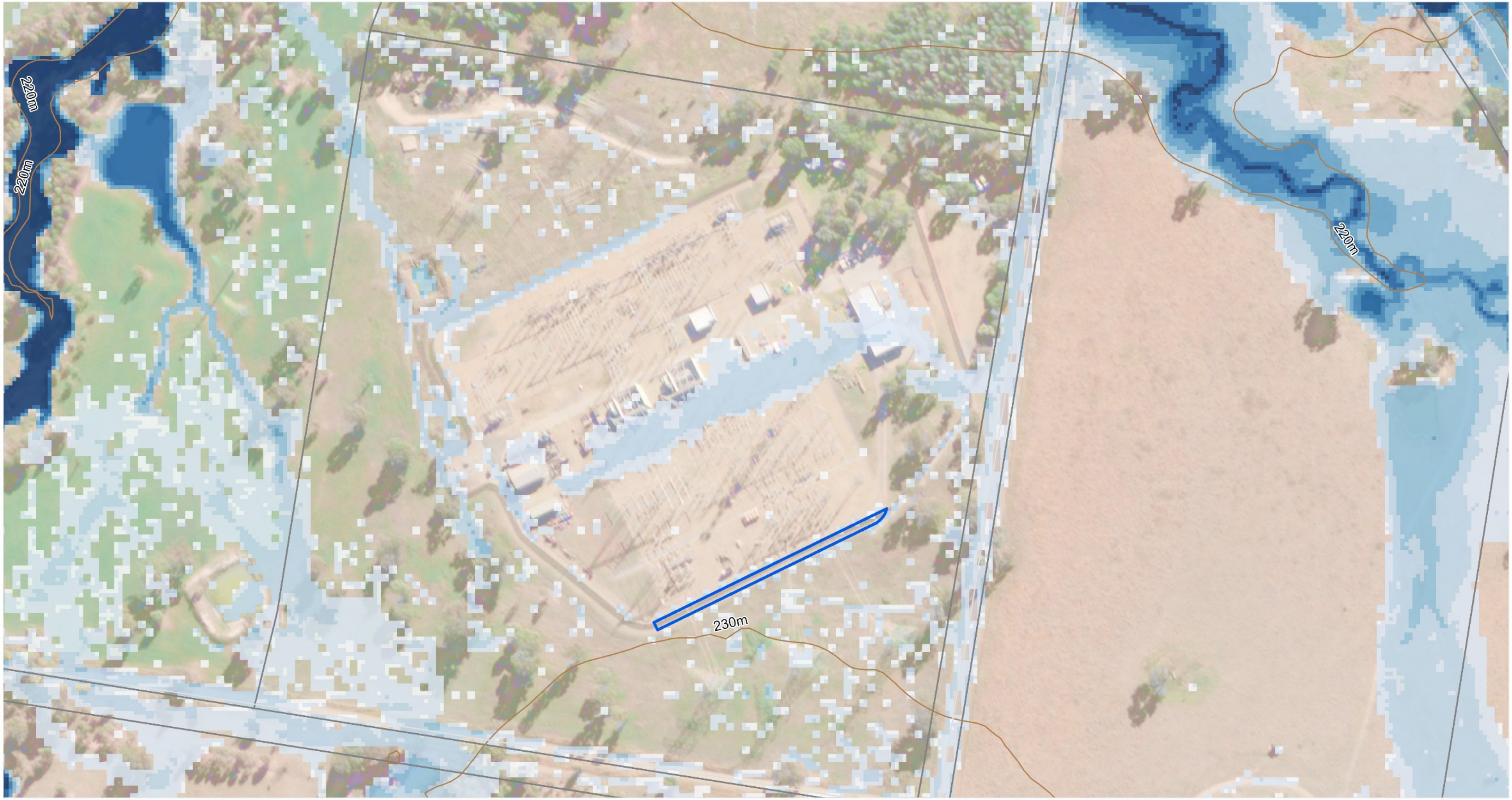
7.1.3.3 Wagga 330 kV substation modification

The Wagga 330 kV substation modification would involve reconfiguration of the existing Wagga 330 kV substation on Ashfords Road, Gregadoo to accommodate new bays for two new 500 kV transmission line circuits within the existing substation property boundary. This would include modifications to the busbars, line bays, existing line connections, bench and associated earthworks, relocation of existing high voltage equipment, drainage, external fence, internal substation roads, steelwork, cabling, and secondary systems. The Wagga 330 kV substation modification is assumed to be at existing grade with no filling proposed.

There is no risk of regional flooding based on the regional scale modelling undertaken (refer to Section 7.2).

No local drainage lines or overland flow paths were identified across the substation based on the local modelling results (refer to Figure 7-4). Given this, the Wagga 330 kV substation modification would not have an impact on flooding, subject to confirmation of proposed earthworks and operation activities across the site. A suitable stormwater management plan would be required to capture any changes and consequential flood impacts at detailed design stage.



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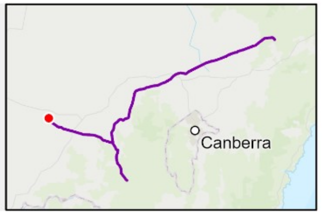
New substation development area
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500
0 50 100m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-4: Wagga 330kV substation 1% AEP flood depth (m)

7.2 Impact of flooding on operations

7.2.1 Transmission lines and access tracks

The project would establish new transmission line structures between Wagga Wagga, Maragle and Bannaby, spaced between 400 to 600 metres apart. The height of transmission line structures would be up to 76 metres.

Based on the form of the transmission line structures and the height of the transmission lines, flooding is unlikely to impact the transmission lines and therefore their operation.

Access to the transmission line easement during operation would be mostly through existing public and private roads and tracks. New access tracks would be created for construction where required and may be retained during operation of the project to provide safe access to the respective infrastructure for maintenance activities.

The access tracks which cross or are near waterways are more likely to be impacted by floods. This presents the need for regular maintenance to monitor scour risk and the condition of drainage infrastructure. However, the access tracks are not expected to be used during heavy rain or flood events. The design of access tracks should consider the required elevation of the road and suitable cross drainage to achieve the desired level of flood immunity where applicable.

The flood risk to the transmission line structures and access tracks within the project footprint was informed by the flood modelling. The flooding in the 1% AEP event impacting the project was classified as either Minor, Moderate or Major based on the following definitions:

- **Minor** – Flooding appears confined along the gully formation. Topography is generally steep with low risk to the project, manageable through design development.
- **Moderate** – Flooding is mostly out of bank with less than 250 metres in extent. Topography is generally flat. Consideration of the impact on the project where proposed infrastructure is sensitive to being flooded.
- **Major** – Flooding is mostly out of bank with more than 250 metres in extent. Topography is generally flat. More challenging to manage flood impact in comparison to other identified definitions. Locating critical infrastructure or infrastructure that requires uninterrupted access in these areas should consider the impact of the flood risk in the design and operations.

A summary of the impact assessment of the regional flood risk is presented in Table 7-1. Regional flood depth and hazard mapping for each location have been provided in Attachment C. Waterway crossing locations are referenced using chainages which are presented in Attachment C. Chainage references are for the purposes of referencing the location of the waterway intersections discussed in this report only.

The below sections present further commentary for the waterway crossings that have been classified as having 'Major' flood impact.

The hazard mapping and discussion of hazard classifications are based on the ARR 2019 hazard classifications presented in Attachment B.

Table 7-1 Summary of flood impact screening on the project

River Intersection	Catchment	Gauge catchment	Flood characteristic classification	Map ID
Tywong Creek	Murrumbidgee catchment	Kyeamba Creek at Ladysmith (410048)	Major	Map 1a & 1b
O'Briens Creek			Major	Map 2a & 2b
Kyeamba Creek			Major	Map 3a & 3b
Tooles Creek			Minor	Map 4a & 4b
Keajura Creek	Murrumbidgee catchment	Tarcutta Creek at Old Borambola (410047)	Moderate	Map 5a & 5b
College Creek			Minor	Map 6a & 6b
Tarcutta Creek/Umbango Creek			Major	Map 7a & 7b
Yaven Yaven Creek	Murrumbidgee catchment	Hillas Creek at Mount Adrah (410043)	Minor	Map 8a & 8b
Nacki Nacki Creek			Minor	Map 9a & 9b
Adelong Creek	Murrumbidgee catchment	Adelong Creek at Batlow Road (410061)	Minor	Map 10a & 10b
Wilsons Creek			Minor	Map 11a & 11b
Yorkers Creek	Murrumbidgee catchment	Tumut River at upstream Nimbo offtake (410199)	Minor	Map 12a & 12b
Plain Creek			Major	Map 13a & 13b
Long Creek			Minor	Map 14a & 14b
Honeysuckle Creek			Minor	Map 15a & 15b
Buddong Creek/Sheep Yard Creek			Minor	Map 16a & 16b
Yellowin Creek			Minor	Map 17a & 17b
Snubba Creek			Minor	Map 18a & 18b
Gilmore Creek			Moderate	Map 19a & 19b
Tumut River/Gocup Creek			Major	Map 20a & 20b
Brungle Creek	Murrumbidgee catchment	Brungle Creek at Red Hill no.2 (41000269)	Minor	Map 21a & 21b
Adjungbilly Creek	Murrumbidgee catchment	Murrumbidgee catchment – no nearby catchment gauge	Moderate	Map 22a & 22b
Oak Creek (1)			Minor	Map 23a & 23b
O'Briens Creek			Minor	Map 24a & 24b
Cart Road Creek (1)			Moderate	Map 25a & 25b
Yellow Clay Creek			Minor	Map 26a & 26b
Rocky Creek			Minor	Map 27a & 27b
Dicks Gully			Minor	Map 27a & 27b
Murrumbidgee River			Minor	Map 28a & 28b
Oak Creek (2)			Minor	Map 29a & 29b
Jugiong Creek			Minor	Map 30a & 30b
Cart Road Creek (2)			Minor	Map 31a & 31b
Bogolong Creek			Minor	Map 32a & 32b
Woolgarlo Creek			Moderate	Map 33a & 33b
Washpen Creek	Murrumbidgee catchment	Yass River at upstream Burrinjuck Dam (410176)	Minor	Map 34a & 34b
Bowning Creek			Minor	Map 35a & 35b
Derringullen Creek			Minor	Map 35a & 35b
Derringullen Creek (2)			Moderate	Map 36a & 36b

River Intersection	Catchment	Gauge catchment	Flood characteristic classification	Map ID
Derringullen Creek (3)			Minor	Map 37a & 37b
Cooks Creek			Minor	Map 38a & 38b
Flacknell Creek	Lachlan River catchment	Lachlan River at Narrawa (412065)	Moderate	Map 39a & 39b
Felled Timber Creek			Minor	Map 40a & 40b
Jerrawa Creek			Major	Map 41a & 41b
Lachlan River			Minor	Map 42a & 24b
Merrill Creek (1)			Minor	Map 43a & 43b
Merrill Creek (2)			Minor	Map 44a & 44b
Middle Creek			Minor	Map 45a & 45b
Humes Creek			Moderate	Map 46a & 46b
Ryans Creek	Wollondilly catchment	Wollondilly River at Jooriland (212270)	Minor	Map 47a & 47b
Kialla Creek			Minor	Map 48a & 48b
Middle Creek			Minor	Map 49a & 49b
First Creek			Minor	Map 50a & 50b
Wollondilly River/Pejar Creek			Minor	Map 51 & 51b
Pejar Creek			Minor	Map 52a & 52b
Steeves Creek			Minor	Map 52a & 52b
Melamalong Creek			Minor	Map 53a & 53b
Tarlo River			Moderate	Map 54a & 54b
Turallo Creek			Minor	Map 55a & 55b
Kings Creek			Minor	Map 56a & 56b
Cowpers Creek			Minor	Map 57a & 57b
Myrtie Creek			Minor	Map 58a & 58b
Kerrewary Creek			Minor	Map 59a & 59b
Bannaby Creek (1)			Minor	Map 60a & 60b
Bannaby Creek (2)			Minor	Map 61a & 61b

7.2.1.1 Tywong Creek Intersection

The flooding at the Tywong Creek intersection within the project footprint (between chainage CH-A6 & CH-A7) indicates a potential impact to transmission line structures and their associated access tracks during a 1% AEP event. This flooding is classified as major flooding in this assessment.

Flooding at this location is mostly out of bank and shallow with flood depths ranging up to 0.5 metres as shown in Figure 7-5, and therefore is classified as Major. The out of bank flood hazard is generally low, classified as H1 (generally safe for vehicles, people and buildings) & flood hazard within the creek cross section ranges up to H3 (refer to Map 1b in Attachment C and Attachment B for flood hazard classifications).

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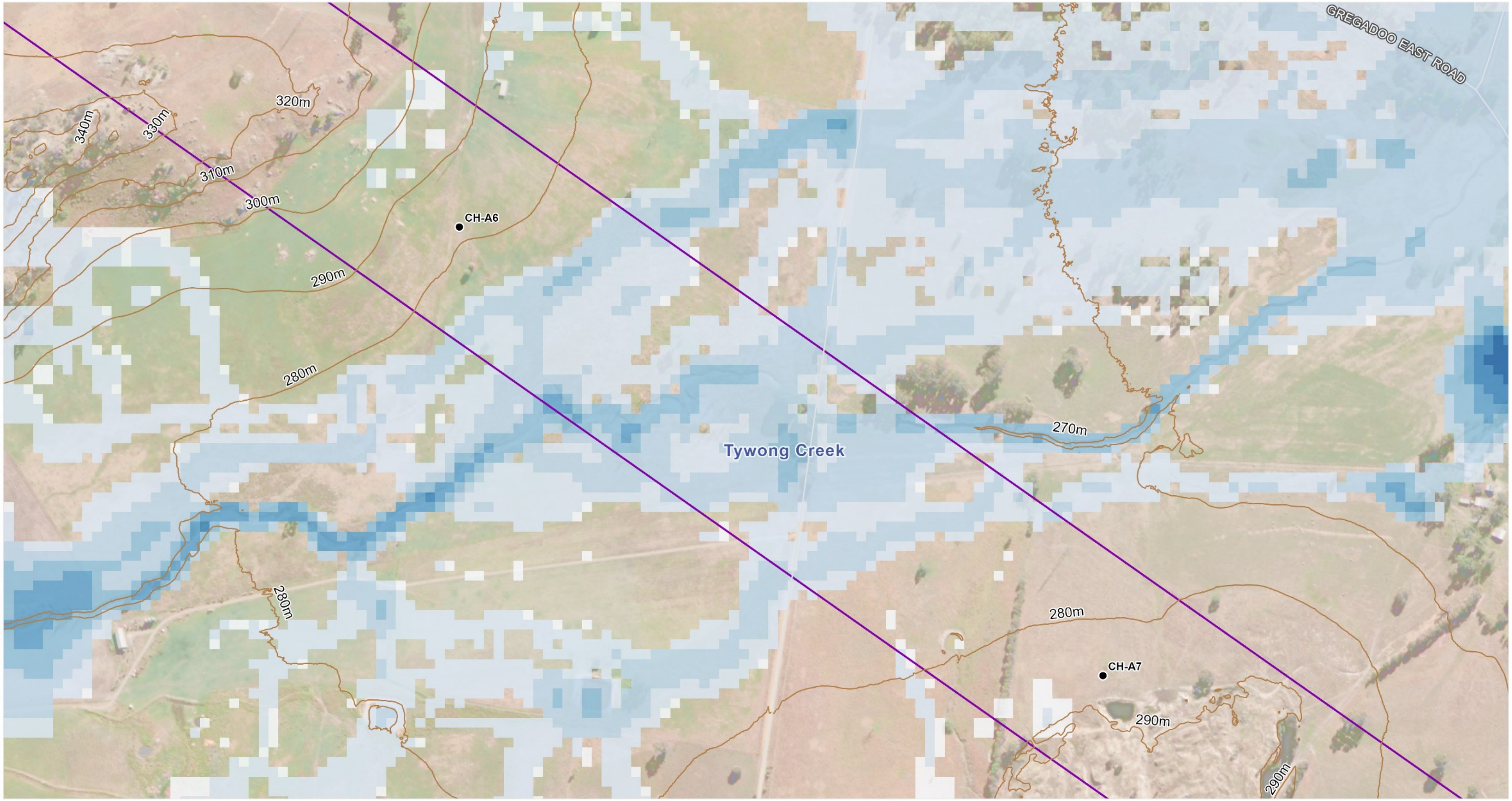


Project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

<=0.03

0.03 - 0.1

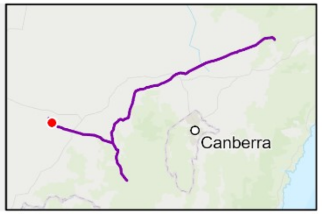
0.10 - 0.25

0.25 - 0.5

0.50 - 0.75

0.75 - 1

1.00 - 1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

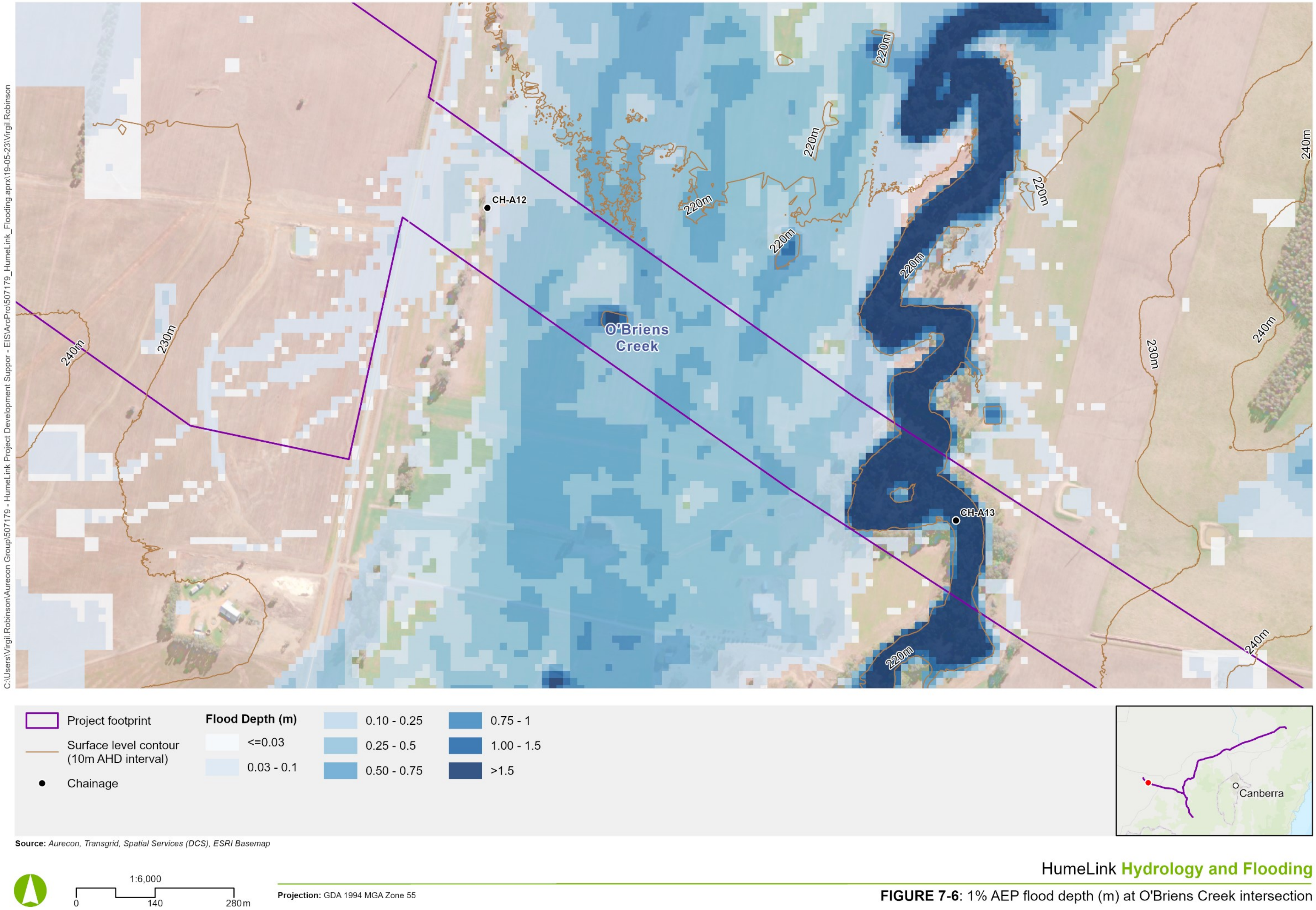
HumeLink **Hydrology and Flooding**

FIGURE 7-5: 1% AEP flood depth (m) at Tywong Creek intersection

7.2.1.2 O'Briens Creek Intersection

The project footprint is expected to be impacted by flooding at the O'Briens Creek intersection between Chainage CH-A12 & CH A13 and is classified as major flooding in this assessment. The flooding at this location is mostly out of bank with flood depth ranging up to one metre (refer to Figure 7-6).

The out of bank flooding reaches hazard levels up to H4 which is unsafe for people and vehicles (refer to Map 2b in Attachment C).



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

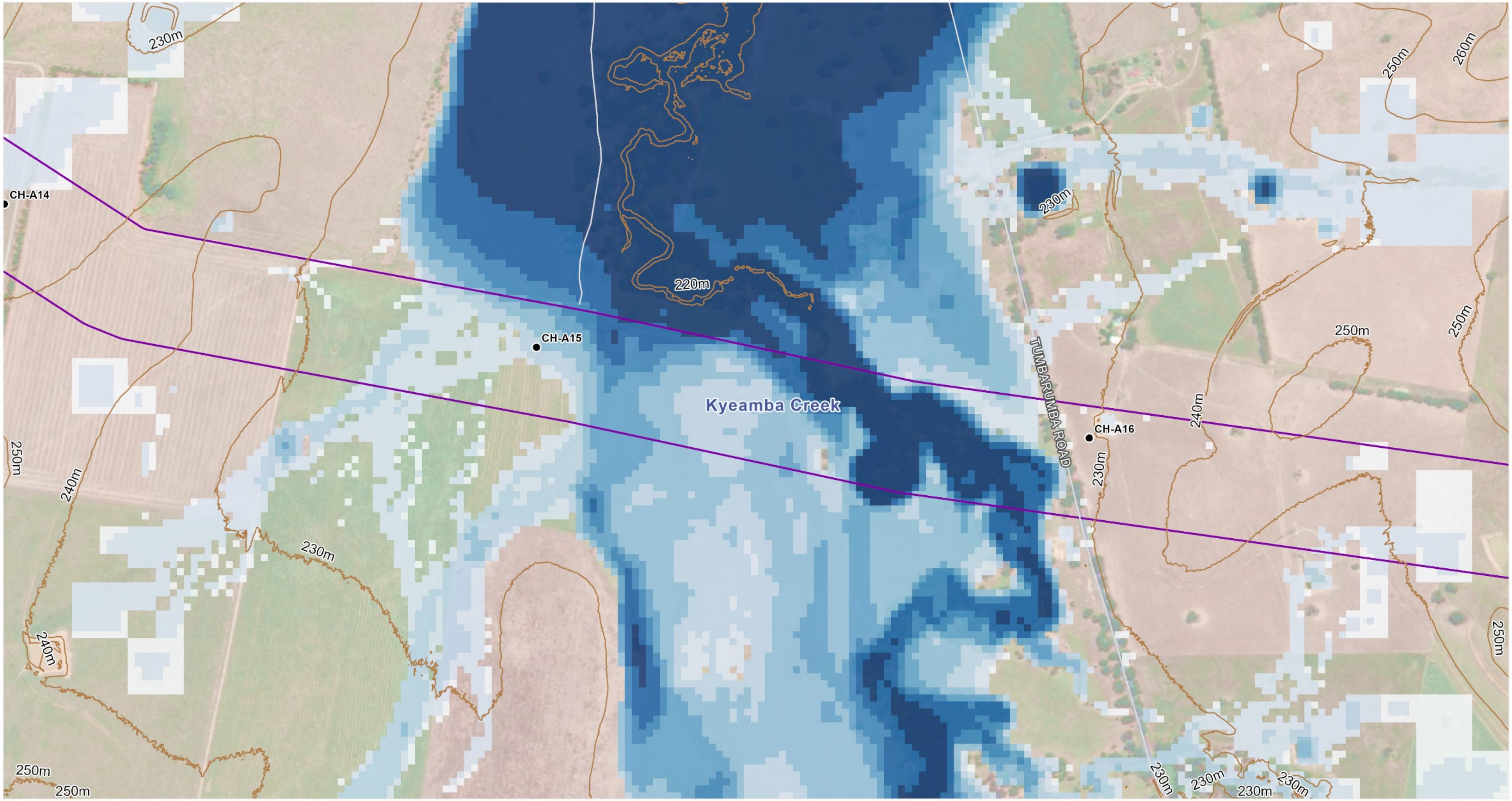
Projection: GDA 1994 MGA Zone 55

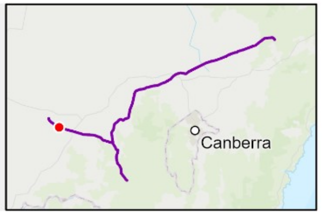
HumeLink **Hydrology and Flooding**

FIGURE 7-6: 1% AEP flood depth (m) at O'Briens Creek intersection

7.2.1.3 Kyeamba Creek Intersection

The Kyeamba Creek intersection at chainage CH-A13 is classified as major flood in this assessment. As shown in Figure 7-7, the out of bank flooding ranges up to a depth of 1.5 metres and a flood hazard up to H5, which is unsafe for vehicles and people with all building types vulnerable to structural damage (refer to Map 3b in Attachment C).





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Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:7,000

0 160 320m

Projection: GDA 1994 MGA Zone 55

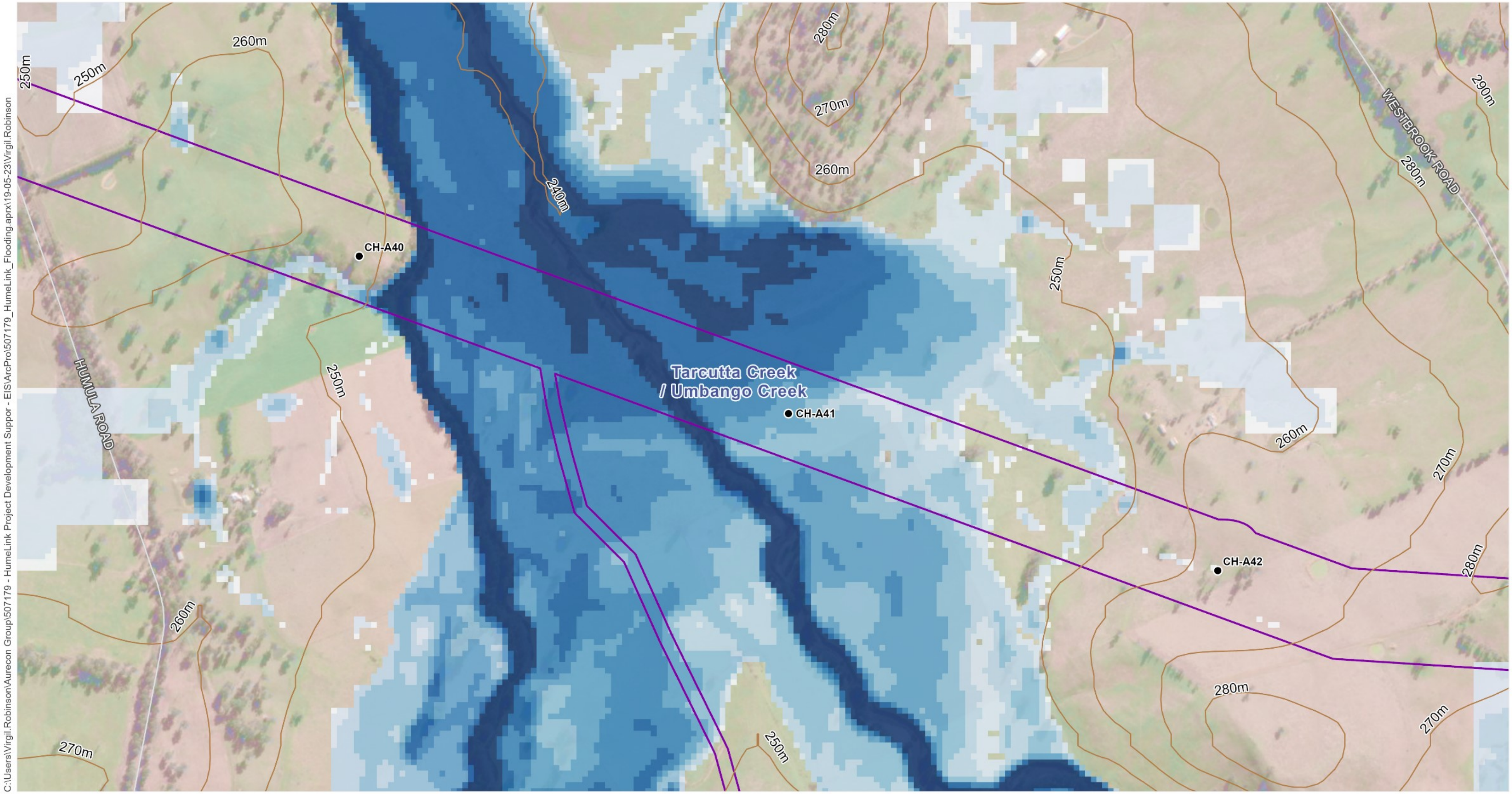
HumeLink **Hydrology and Flooding**

FIGURE 7-7: 1% AEP flood depth (m) at Kyeamba Creek intersection

7.2.1.4 Tarcutta Creek/Umbango Creek Intersection

Widespread flooding at the Tarcutta Creek and Umbango Creek intersections are predicted (between chainage CH-A40 & CH-A41) and classified as major flooding in this assessment. The final location of transmission line structures would need to consider the impact of flooding on the adopted transmission line structure location and their associated access tracks, which will be determined during detailed design in consultation with construction contractor.

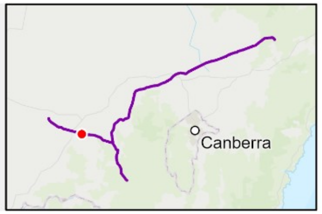
Flooding at this location is mostly out of bank with flooding from both waterways interacting. The project footprint in this location is inundated during the 1% AEP flood event with an approximate depth range from 0.03 metres to 1.6 metres (refer to Figure 7-8) and a flood hazard classification of H3 to H4 (refer to Attachment B for flood hazard classifications) across the floodplain (refer to Map 7b in Attachment C).



Project footprint
Surface level contour (10m AHD interval)
Chainage

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:8,500
0 200 400m

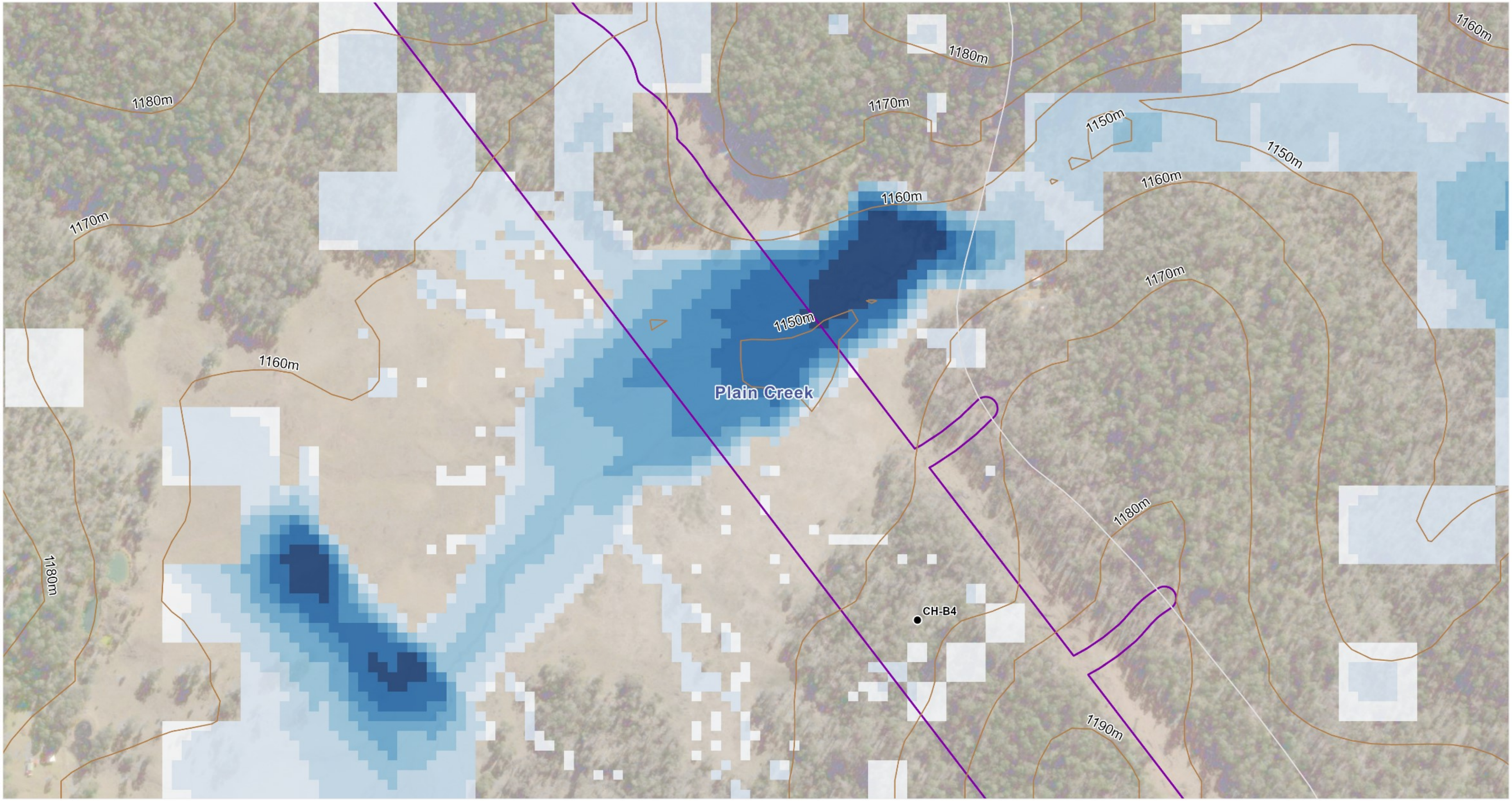
Projection: GDA 1994 MGA Zone 55

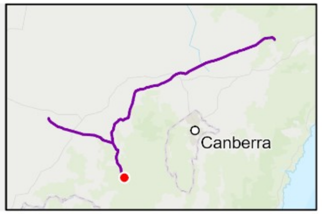
HumeLink **Hydrology and Flooding**

FIGURE 7-8: 1% AEP flood depth (m) at Tarcutta Creek / Umbango Creek intersection

7.2.1.5 Plain Creek Intersection

The flooding at the Plain Creek intersection (between chainage CH-B4 and CH-B5) indicates a potential impact to transmission line structures and their associated access tracks during 1% AEP event. Flooding in this event has an approximate depth range from 0.15 metres to 1.5 metres (refer to Figure 7-9) with a flood hazard classification of H3 to H4 across the floodplain (refer to Map 13b in Attachment C). The flooding is classified as major flooding in this assessment





Project footprint

Surface level contour (10m AHD interval)

Chainage

Flood Depth (m)

<=0.03	0.10 - 0.25	0.75 - 1
0.03 - 0.1	0.25 - 0.5	1.00 - 1.5
	0.50 - 0.75	>1.5

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:5,000

0 110 220m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

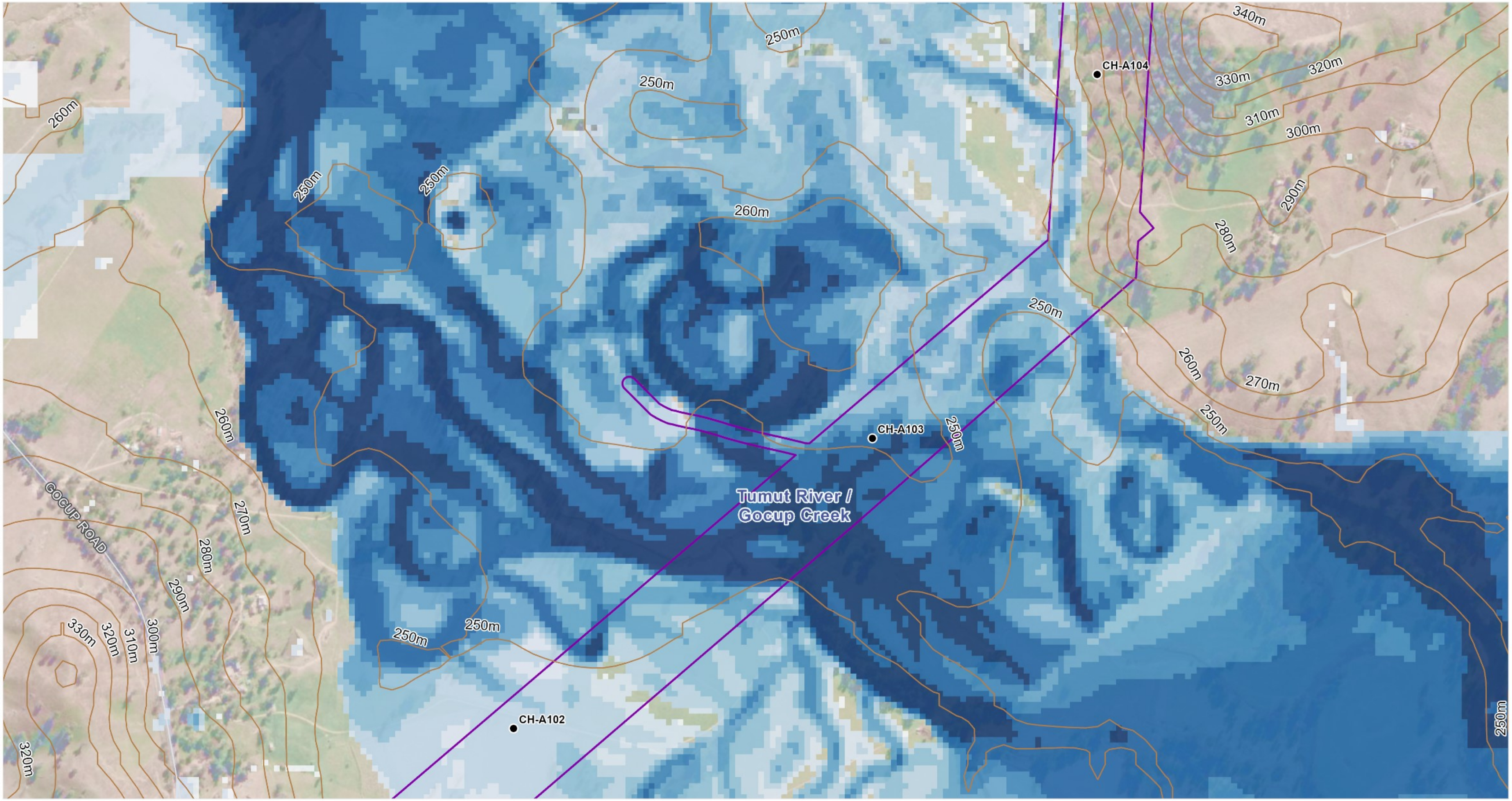
FIGURE 7-9: 1% AEP flood depth (m) at Plain Creek Intersection

7.2.1.6 Tumut River/Gocup Creek Intersection

The project footprint is expected to be impacted by flooding at the Tumut River/Gocup Creek intersection between chainage CH-A102 and CH-A104. Tumut River and Gocup Creek flow parallel to each other in a north-westerly direction, which then joins at their confluence approximately 4.5 kilometres downstream from the project.

Flooding in the 1% AEP event is mostly out of bank floodplain flow ranging from a few hundred millimetres up to 2.6 metres deep. This is due to combined flows from both the Tumut River and Gocup Creek, inundating a widespread area. The flooding is classified as major flooding in this assessment

Transmission line structures and associated access tracks in this area could be impacted by flood waters in this event. Depending on the location, the flood hazard is predicted to reach up to H5 (vulnerable to structural damage) (refer to Figure 7-10 for 1% AEP flood extent and Map 20b in Attachment C).



Project footprint
Surface level contour (10m AHD interval)
Chainage

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5

Canberra

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:8,500

0 200 400m

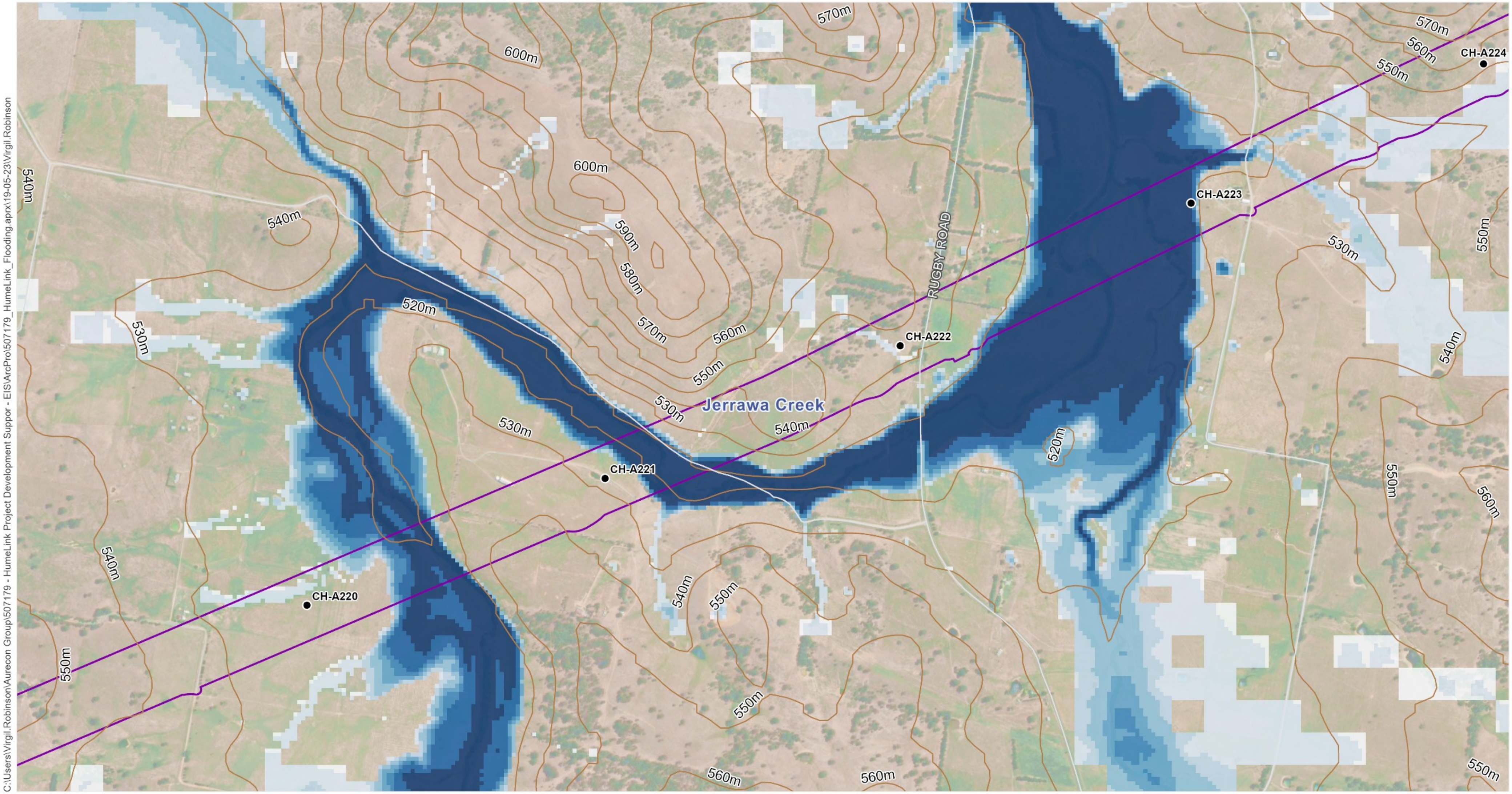
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-10: 1% AEP flood depth (m) at Tumut River / Gocup Creek intersection

7.2.1.7 Jerrawa Creek Intersection

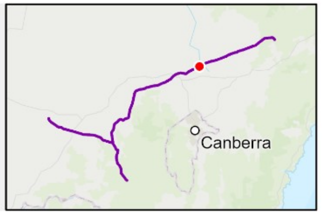
Jerrawa Creek flows in a northerly direction to the town of Dalton between chainage CH-A222 & CH-A223. Flooding is widespread and relatively deep, potentially impacting transmission line structures at this location during the 1% AEP flood event (refer to Figure 7-11) and classified as major flood in this assessment. Flood depths of up to 3.4 metres in this event with a flood hazard category of H5 (vulnerable to possible structural damages) is predicted (refer to Map 41b in Attachment C).



Surface level contour (10m AHD interval)

Flood Depth (m)

- <=0.03
- 0.03 - 0.1
- 0.10 - 0.25
- 0.25 - 0.5
- 0.50 - 0.75
- 0.75 - 1
- 1.00 - 1.5
- >1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:12,000

0 280 560m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

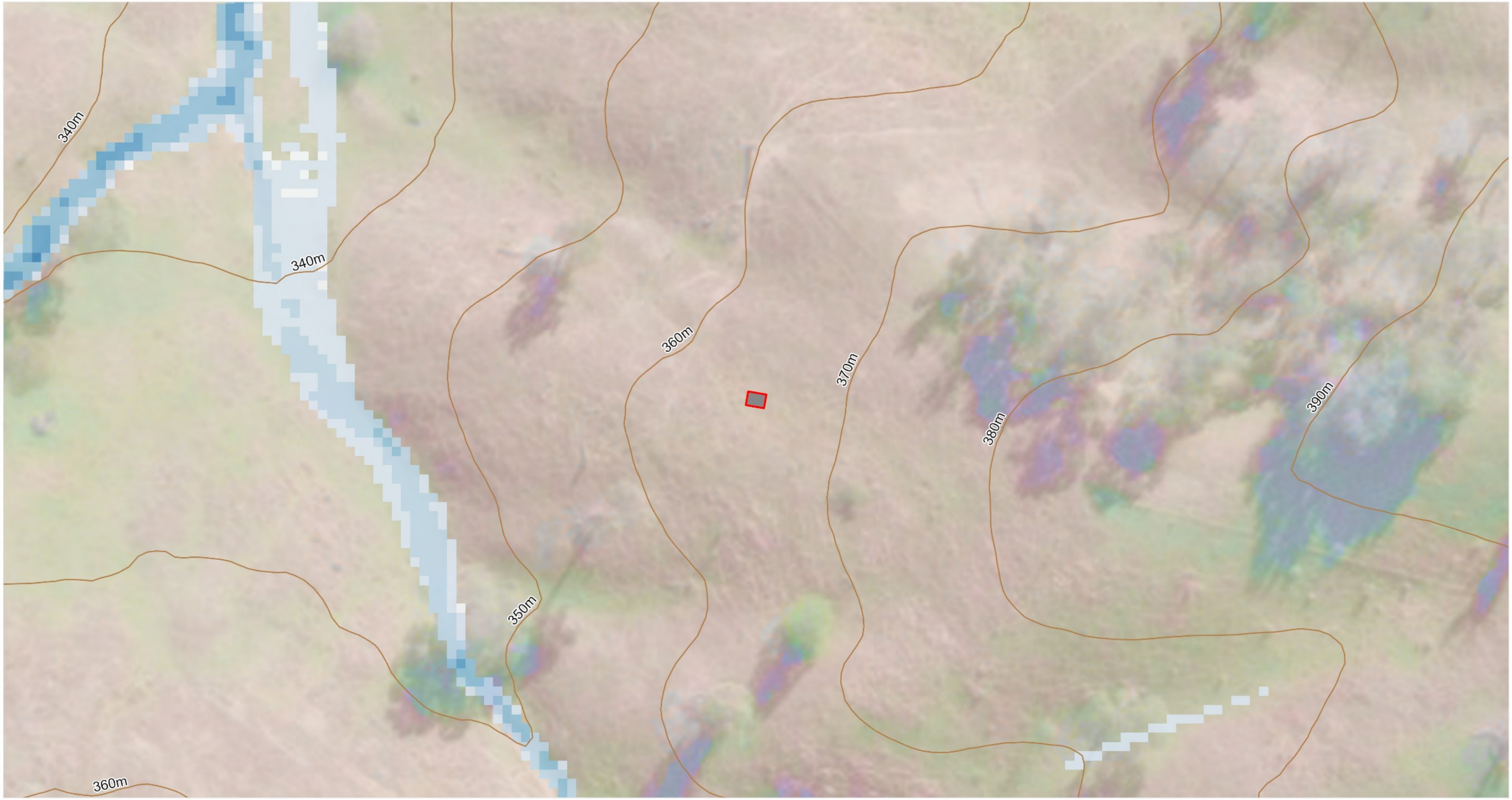
FIGURE 7-11: 1% AEP flood depth (m) at Jerrawa Creek intersection

7.2.2 Telecommunications hut

A telecommunications hut for optical repeaters would be located along the transmission lines to boost the signal in the Optical Fibre Ground Wire (OPGW). The telecommunications hut would be a small hut located near a transmission line structure, with cable connections to the earth wire on the transmission line structure and to a local distribution line for its power supply.

The flood impact on the proposed telecommunications hut has been modelled at both regional and local scale to understand the flood risk to the infrastructure. Based on the modelling, the telecommunications hut has not been identified as at-risk of flooding from either local or regional flooding in a 1% AEP flood event.

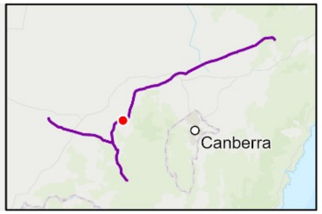
Figure 7-12 shows the modelled flood depth in the vicinity of the telecommunications hut in the local 1% AEP design flood event.



Construction compound
Filled surface
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:850
0 20 40m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-12: Telecommunications hut flood risk in a 1% AEP flood event - flood depth (m)

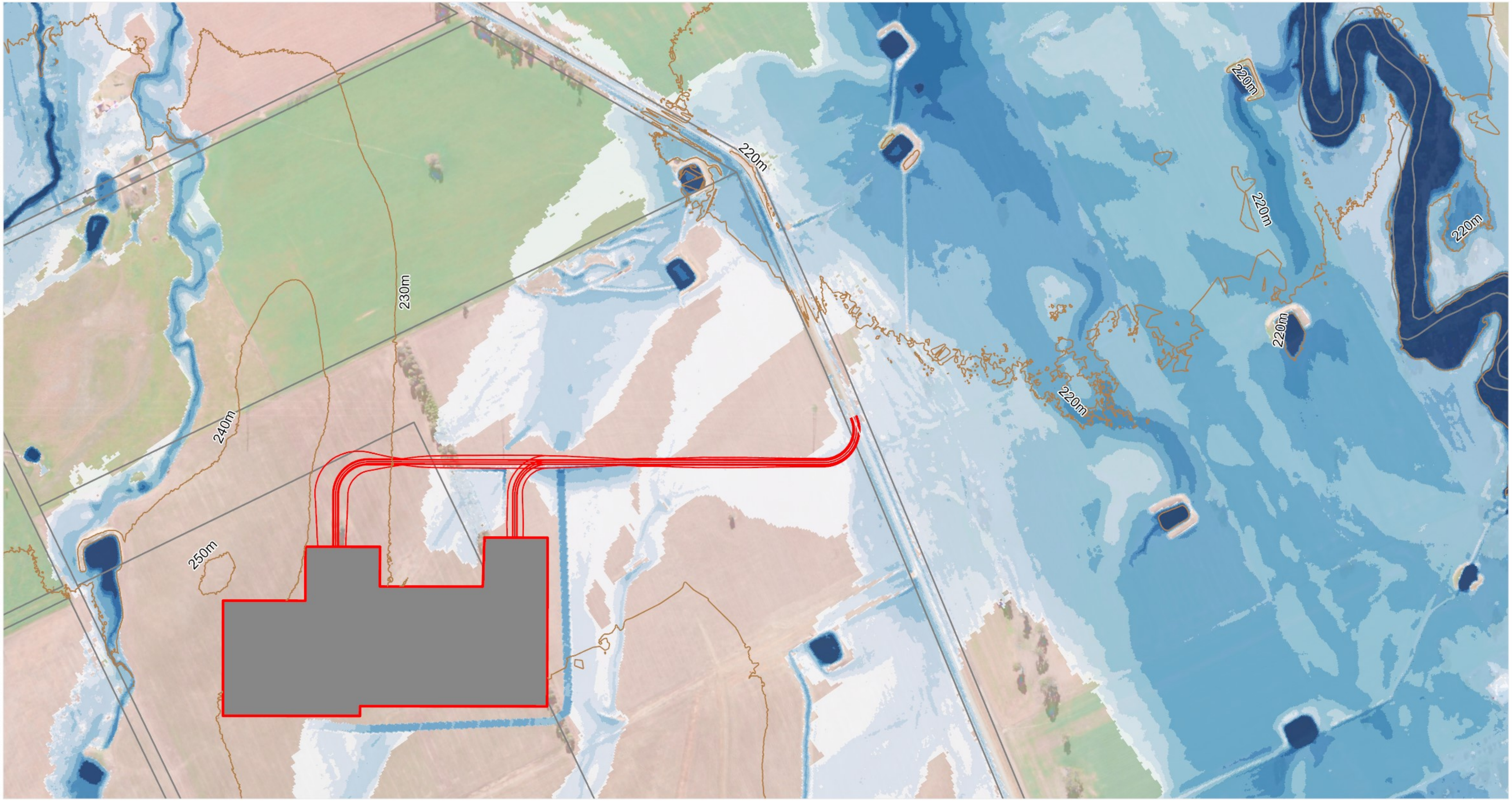
7.2.3 Substations

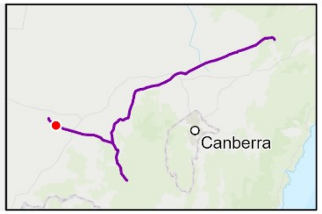
Where fill is needed to achieve a level of flood immunity to provide flood protection, the assessment has identified the approximate minimum level of fill required to achieve the specified flood immunity for the respective infrastructure. These approximate minimum levels are presented in Attachment E.

7.2.3.1 Proposed Gugaa 500 kV substation

The flood investigation undertaken by Lyall & Associates identified that an existing drainage line (tributary of O'Briens Creek) would become blocked by the proposed Gugaa 500 kV substation, as shown in Figure 7-13. The assessment recommended drainage mitigation in the form of a trapezoidal shaped channel and a series of culvert structures to capture upstream water from the existing drainage line and divert overland flow around the substation footprint.

The diversion of flows would result in a flood depth of up to 0.6 metres along the southern side of the proposed access road to the Gugaa 500 kV substation site. The level of impact to operations would be subject to the adopted design levels of the substation site and consequently the access road. Flood mitigation measures would be considered in further detail during detailed design.





Filled surface
Substation extent
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

<=0.03
0.03 - 0.1
0.10 - 0.25
0.25 - 0.5
0.50 - 0.75
0.75 - 1
1.00 - 1.5
>1.5

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:6,000
0 140 280m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-13: Gugaa 500 kV substation flood risk in a 1% AEP event flood depth (m) - Design Scenario

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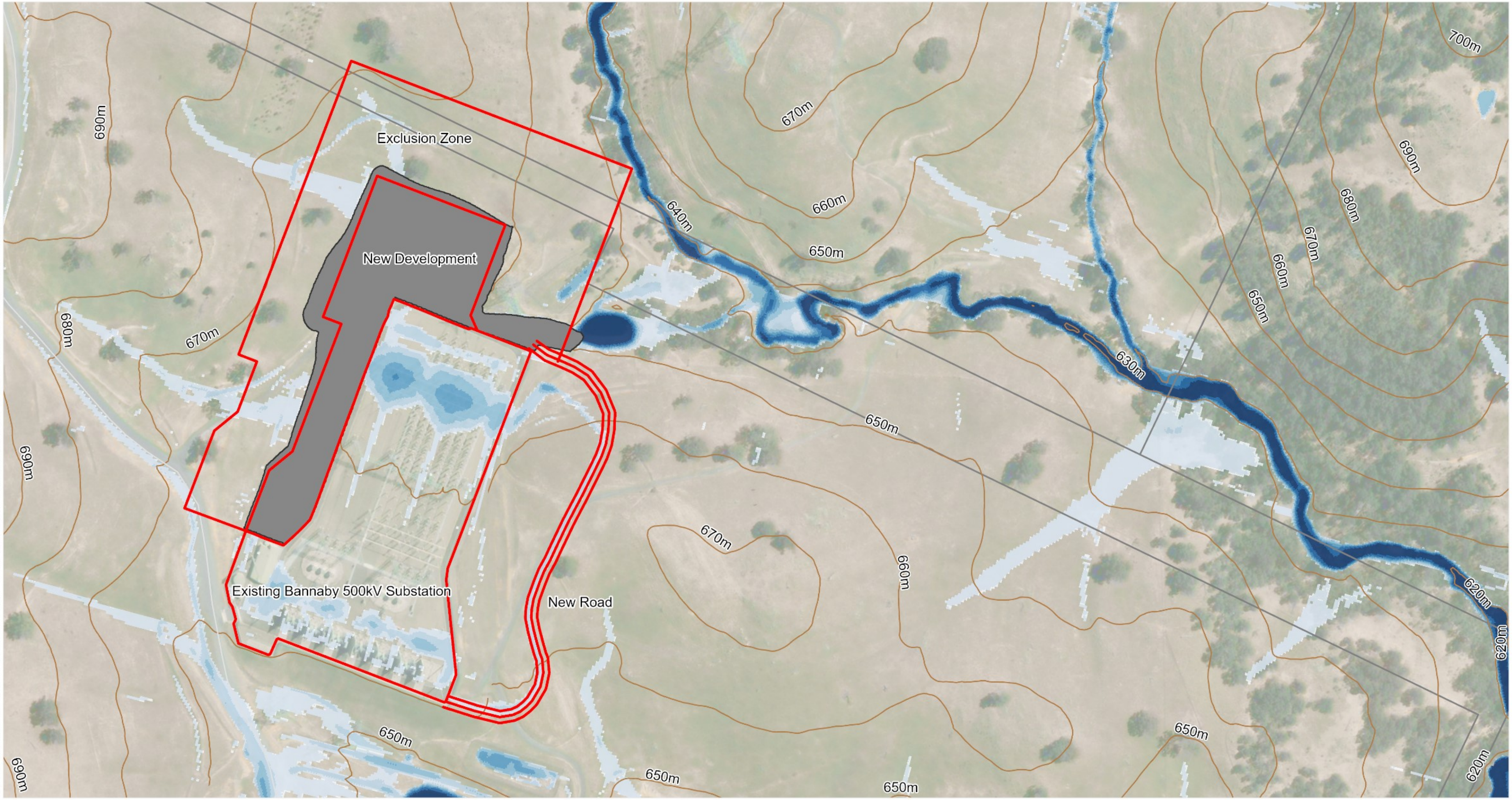
7.2.3.2 Bannaby 500 kV substation modification

As the Bannaby 500 kV substation is located along a tributary of the Wollondilly River., it has no distinct waterways interacting with the substation. As a result, flooding in this area is caused by local drainage catchments and shallow overland flow (refer to Figure 7-14) that heads to Wollondilly River.

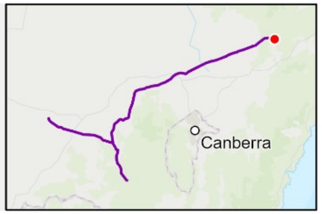
The proposed access road to the Bannaby extension would form an obstruction to a drainage line and require cross drainage structures to minimise the impact of flooding on the existing substation. The cross drainage capacity was represented by five 1.2 metre diameter reinforced concrete pipes with a 5% slope located at the northern road extent (refer to Figure 7-2). Residual ponding on the existing substation remains and requires further development at detailed design stage to improve drainage of the site.



- Substation extent
- Filled surface
- Cadastre
- Surface level contour (10m AHD interval)

Flood Depth (m)

- <=0.03
- 0.03 - 0.1
- 0.10 - 0.25
- 0.25 - 0.5
- 0.50 - 0.75
- 0.75 - 1
- 1.00 - 1.5
- >1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,000

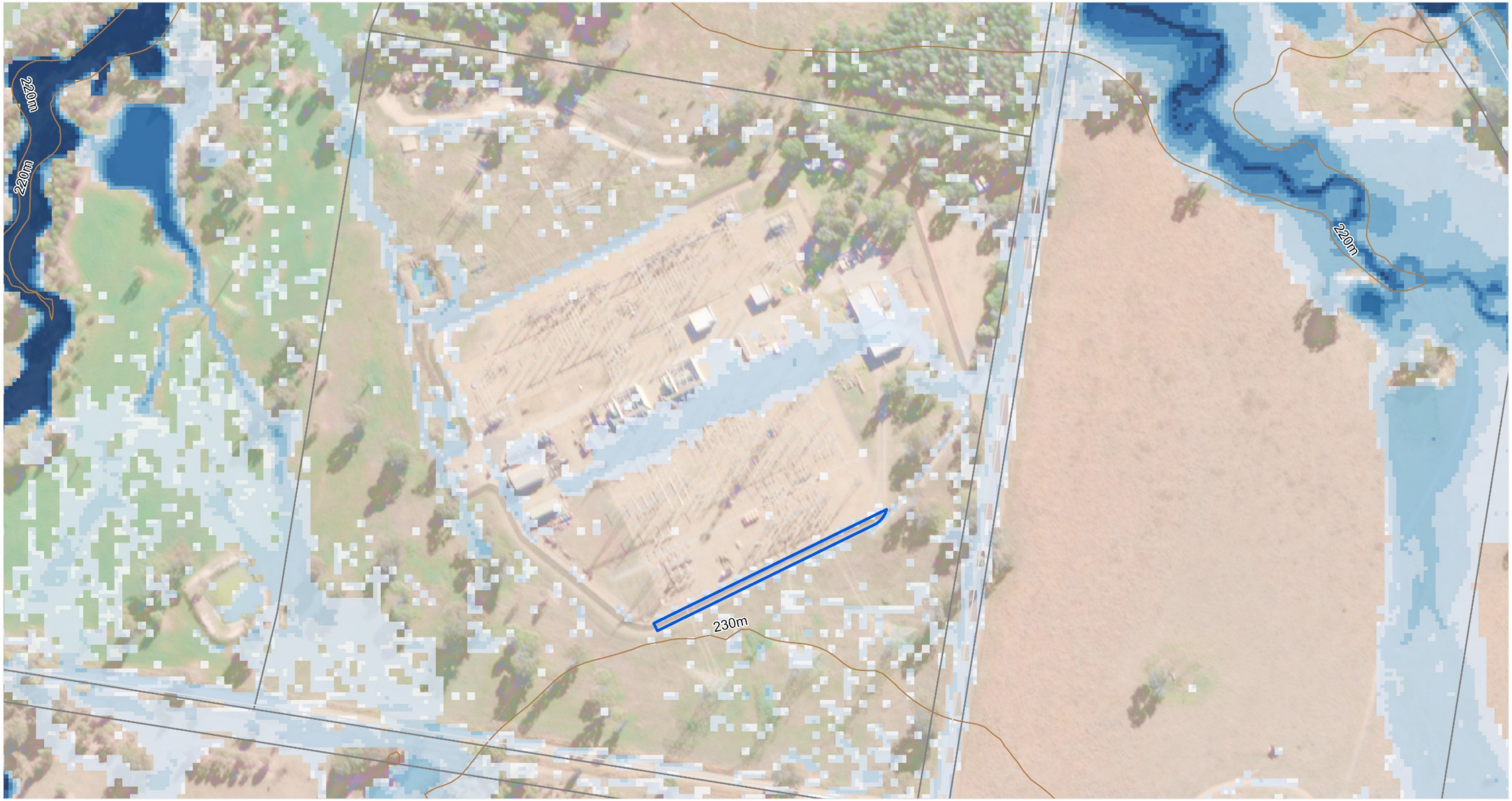
0 70 140m

Projection: GDA 1994 MGA Zone 55

FIGURE 7-14: Bannaby 500 kV substation flood risk in a 1% AEP event - flood depth (m)

7.2.3.3 Wagga 330 kV substation modification

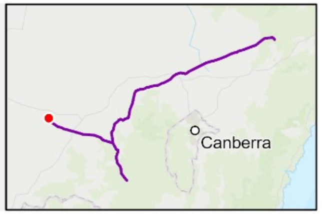
Wagga 330 kV substation modification would remain within the existing substation property boundary. As such, it is assumed that the modification would not require filling. In a 1% AEP event, local catchment ponding is expected around the site with no notable flow paths or drainage lines impacting the site and as such the new area of the modified Wagga 330 kV substation is not expected to be impacted by flooding.



New substation development area
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

- <=0.03
- 0.03 - 0.1
- 0.10 - 0.25
- 0.25 - 0.5
- 0.50 - 0.75
- 0.75 - 1
- 1.00 - 1.5
- >1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500
0 50 100m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-15: Wagga 330 kV substation flood risk in a 1% AEP event flood depth (m) - Existing Scenario

7.2.4 Compatibility with hazard and hydraulic characteristics

The flood assessment has identified that the sensitive operational elements of the project (namely the proposed Gugaa 500 kV substation, modified Bannaby 500 kV and Wagga 330 kV substations and the new telecommunications hut) are not at risk of regional scale flooding based on the regional flood modelling (refer to Section 7.2). Local flood risks around the Bannaby 500 kV and Wagga 330 kV substations are known given that these are existing Transgrid substations that have been in operation for some time. Local flood risks at the proposed Gugaa 500 kV substation are considered minor and would be manageable through appropriate design strategies. Given this, the proposed new substation, substation extension and telecommunication hut location are considered compatible with the existing flood hazard and hydraulic characteristics of the land.

The transmission line structures are proposed in areas of varying flood risk and hazard classification. There are some opportunities to mitigate the flood risk at some of the locations through infrastructure relocation. However, compared to substations, the transmission line structures would be considered less sensitive to flooding given their structural characteristics and placement of the sensitive electrical components well above ground level and above predicted 1% AEP flood level. The transmission line structures would be suitably designed to withstand hydraulic impacts. The proposed locations of the transmission line structures are considered compatible with the existing flood hazard and hydraulic characteristics of the land.

7.3 Impact of climate change

The impact of climate change has been assessed for the proposed Gugaa 500 kV substation, Bannaby 500 kV substation modification and Wagga 330 kV substation modification.

For Bannaby 500 kV substation and Wagga 330 kV substation, the assessment adopted a rainfall increase which aligns with the RCP8.5 (Representative Concentration Pathway) for the year 2090. This correlates to an approximate 20% increase in rainfall intensity ARR Data Hub (2019). Allowance for increase in sea level rise was not applicable given the substation locations.

For the proposed Gugaa 500 kV substation, Lyall & Associates (2022) adopted the 0.2% AEP flood event as a proxy for the 1% AEP change scenarios. This flood event is in the order of a 15% increase in rainfall compared to the 1% AEP event.

The impact of climate change on flooding (flood risk to the substations) and the change in the impact on flooding resulting from the substations are presented in Table 7-2.

Table 7-2 Summary of climate change impact

Substation	Present climate 1% AEP flood level (mAHD)	Increase in 1% AEP flood levels due to climate change (mm)	Change in impact (afflux) on flooding (mm)
Gugaa 500 kV	221 - 226	5 - 10	150
Bannaby 500 kV	658.5 – 651.5	25	35
Wagga 330 kV	226 - 227	20	N/A

Note:
-Gugaa 500 kV substation results are extracted from *Gugaa 500 kV Substation Flooding Investigation* (Lyall & Associates, 2022) and reflect the results for the 0.5% AEP and 0.2% AEP events.
-Results presented are typical values in the vicinity of the substation

The results indicate that climate change would have a minor impact on flood risk with increases in flood levels in the order of approximately 20 millimetres by the year 2090 for all three substation sites. This increase has no discernible impact at the substations.

The proposed Gugaa 500 kV substation has been designed to above the PMF level, and therefore would not be impacted by the future climate risk.

At the Bannaby 500 kV substation, future climate risk of increase in rainfall intensity presents no notable impact to the substation apart from increasing the demand on the capacity of the local drainage network.

The Wagga 330 kV substation would see a similar outcome however being a flatter site, the increases are spread over a larger area, potentially making it more challenging to manage the drainage requirements.

From the perspective of the impact of the substation on flooding, the proposed Gugaa 500 kV and Bannaby 500 kV substations propose extensive filling. However, the change in the impact of the development is similar to that under present climate conditions. At the Wagga 330 kV substation, no changes in the impact of the substation works are predicted given the limited extent of works.

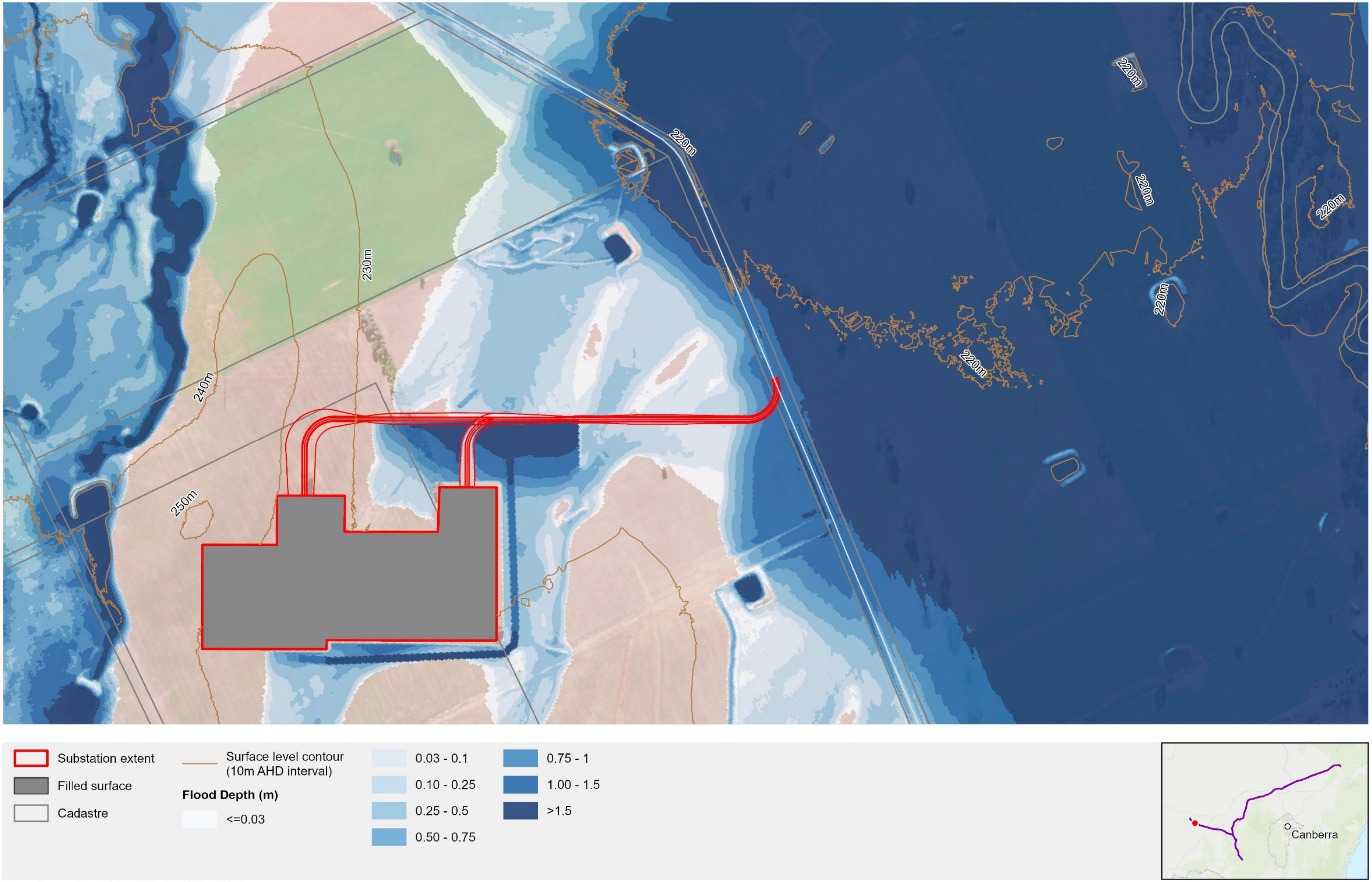
7.4 Impact of Probable Maximum Flood

7.4.1 Gugaa 500 kV substation

The proposed substation fill pad level has been represented at an elevation above the PMF flood level in the assessment undertaken by Lyall & Associates (2022). It is understood that this is to provide flood immunity and mitigate any flood risk to the proposed Gugaa 500 kV substation.

During PMF, flooding along the proposed trapezoid channel located south to the proposed substation experiences a flood depth of up to 2.1 metres, exceeding the channel capacity and up to 2.3 metres at the proposed substation access road (refer to Figure 7-16) (based on the *Gugaa Flood Investigation* (Lyall & Associates, 2022)) (refer to Attachment D).

The substation access road levels should be reduced allowing flood water to overtop during the PMF event, minimising water ponding behind the road. Subject to other operational reasons, providing flood immunity to the access road in a PMF event would not provide much benefit as the access to the substation via Livingstone Gully Road would be inundated due to flooding (refer to Figure 7-16).



C:\Users\Virgil.Robinson\Aurecon Group\507179 - HumeLink Project Development Suppor - EIS\ArcPro\507179_HumeLink_Flooding.aprx\19-05-23\Virgil.Robinson

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

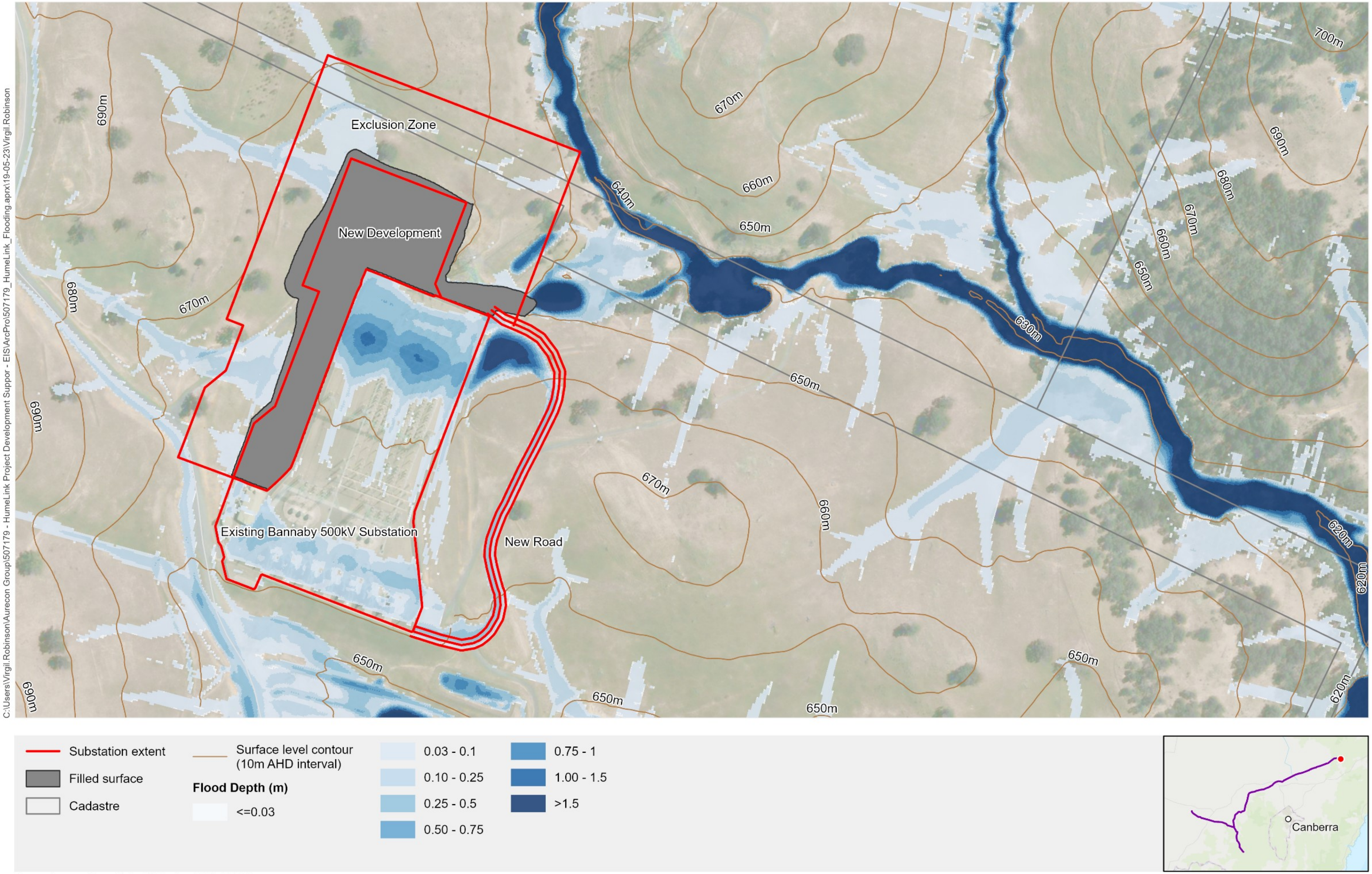
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-16: Gugaa 500kV substation flood risk in PMF (depth)

7.4.2 Bannaby 500 kV substation modification

As identified, the Bannaby 500 kV substation is located in the upper reaches of its catchment and mainly experiences overland flows from local upstream drainage lines. In a PMF event, the overland flow is more extensive than 1% AEP event with more significant ponding occurring between the existing substation and the new road. Flood depths in this event reach up to 3.2 metres and are predicted to pond up against the new road (refer to Figure 7-17).



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:3,000

0 70 140 m

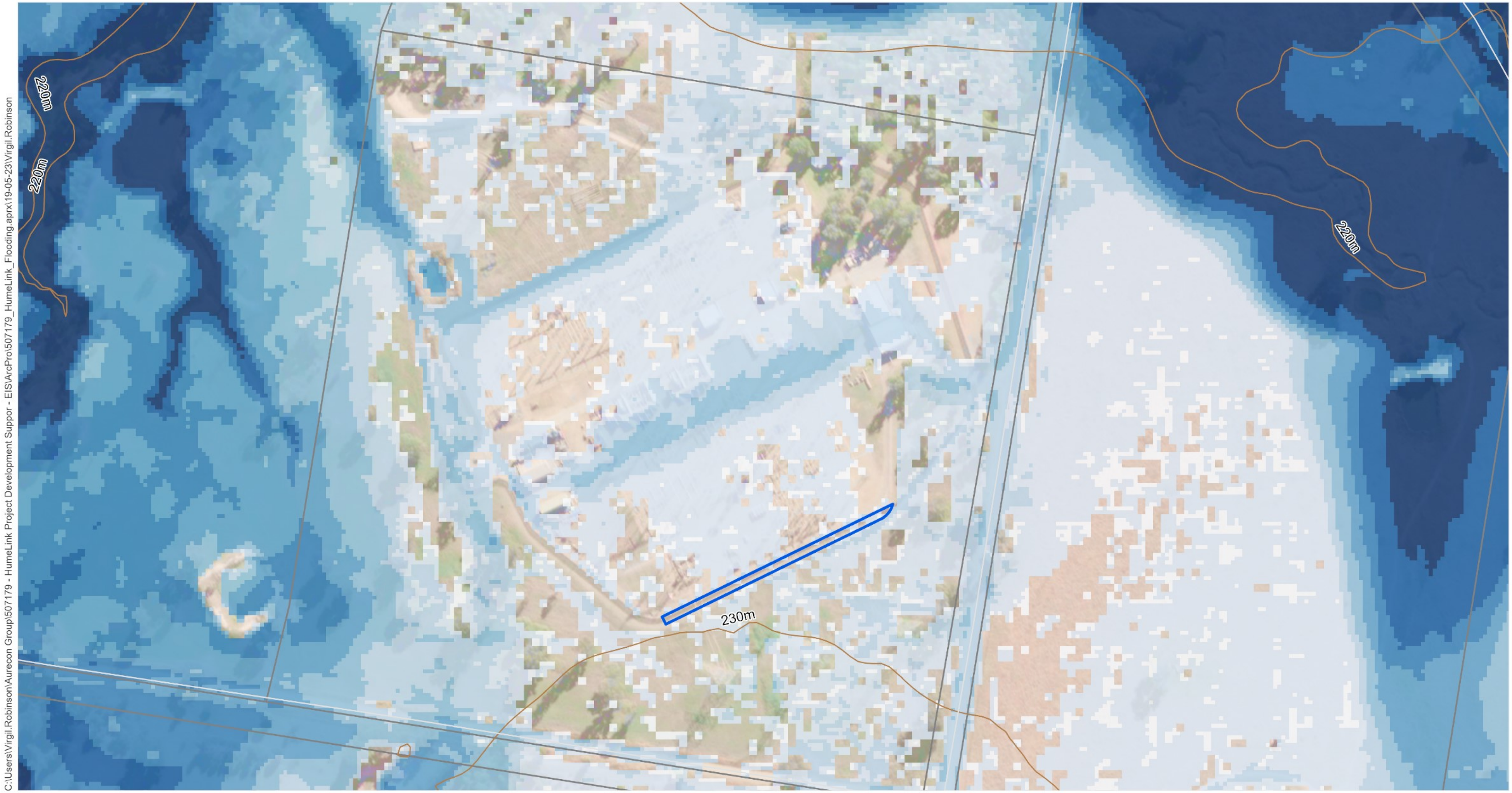
Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-17: Bannaby 500 kV substation flood risk in PMF event - flood depth (m)

7.4.3 Wagga 330 kV substation modification

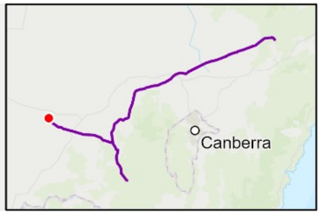
The Wagga 330 kV substation modification would be generally inundated up to 0.3 metres of flood depth during the PMF (refer to Figure 7-18). Due to the area being flat, the flooding is widespread and majority of the existing substation would be impacted by shallow flooding.



New substation development area
Cadastre
Surface level contour (10m AHD interval)

Flood Depth (m)

- <=0.03
- 0.03 - 0.1
- 0.10 - 0.25
- 0.25 - 0.5
- 0.50 - 0.75
- 0.75 - 1
- 1.00 - 1.5
- >1.5



Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

1:2,500

0 50 100m

Projection: GDA 1994 MGA Zone 55

HumeLink **Hydrology and Flooding**

FIGURE 7-18: Wagga 330 kV substation flood risk in PMF event flood depth (m) - Existing Scenario

7.5 Impact on existing regional flood risk management

7.5.1 Flood risk management

Flood risk management is typically managed by local councils focused on populated centres. No flood risk management plans have been identified covering the project footprint as the project avoids heavily populated areas. Some construction compounds such as Wagga 330 kV substation compound (C01), Yass substation compound (C10), Memorial Avenue compound (C14) and Bowmans Lane compound (C15) would be located near developed areas. However, of those identified, no existing flood risk management plans are applicable. Based on the localised works associated with the construction compounds and the level of flood impacts anticipated, the project is highly unlikely to impact on any existing flood risk management plans, strategies or procedures.

7.5.2 Emergency management

The project extends across the local government areas (LGAs) of Wagga Wagga City, Cootamundra-Gundagai Regional, Snowy Valleys, Yass Valley and Upper Lachlan Shire. Emergency management for each area is set out in the respective flood emergency sub-plans for each LGA. The sub-plans cover preparedness, response and recovery stages for flood events. The NSW SES generally have primary responsibility for flood response management. Local sub-plans were readily available for all council areas in respective council websites apart from Cootamundra-Gundagai Regional LGA. No specific evacuation routes or strategies have been outlined within the available sub-plans.

The BoM provides notification of flood information across the areas, primarily focussed on the populated centres. This information is then interpreted by the SES and local councils which then act accordingly. Given that the project largely crosses unpopulated areas, flood intelligence during a flood event would primarily come from interpretation of available information and inform ground units.

The project is not expected to impact on any existing emergency management in the area. Appropriate emergency management would be prepared in consultation with respective local SES and councils .

8 Cumulative impacts

8.1 Overview

Assessing cumulative impacts involves the consideration of the proposed impact in the context of hydrology and flooding. The assessment of cumulative impacts also considers projects that are currently under development, or at the planning state that may also influence the assessment of this project's potential impacts. Cumulative impacts can potentially arise from the interaction of the construction and operation activities of the project and other future projects nearby.

The cumulative impact assessment was prepared in accordance with the *Cumulative Impact Assessment Guidelines for State Significant Projects* (DPE, 2022). Projects with the potential for cumulative impacts with the project were identified through a review of publicly available information and environmental impact assessments from the following databases in March 2023:

- DPE's Major Projects register
- NSW Government's Southern Regional Planning Panel project register
- NSW Independent Planning Commission project register
- EPBC Act Public Portal
- Transport for NSW Projects Map.

Searches were limited to the LGAs of Wagga Wagga City, Snowy Valleys, Yass Valley, Cootamundra-Gundagai Regional Upper Lachlan Shire, Goulburn-Mulwaree, and Hilltops.

Based on the above searches, the following projects are to be considered in the cumulative impact assessment for each of the key matters:

- EnergyConnect (NSW – Eastern Section)
- Gregadoo Solar Farm
- Jeremiah Wind Farm
- Rye Park Wind Farm
- Victoria to NSW Interconnector West (VNI West)
- Snowy 2.0 - Transmission Connection
- Snowy 2.0 - Main Works
- Inland Rail – Albury to Illabo
- Crookwell 3 Wind Farm.

Figure 8-1 shows the location of relevant future projects with respect to HumeLink's project footprint.

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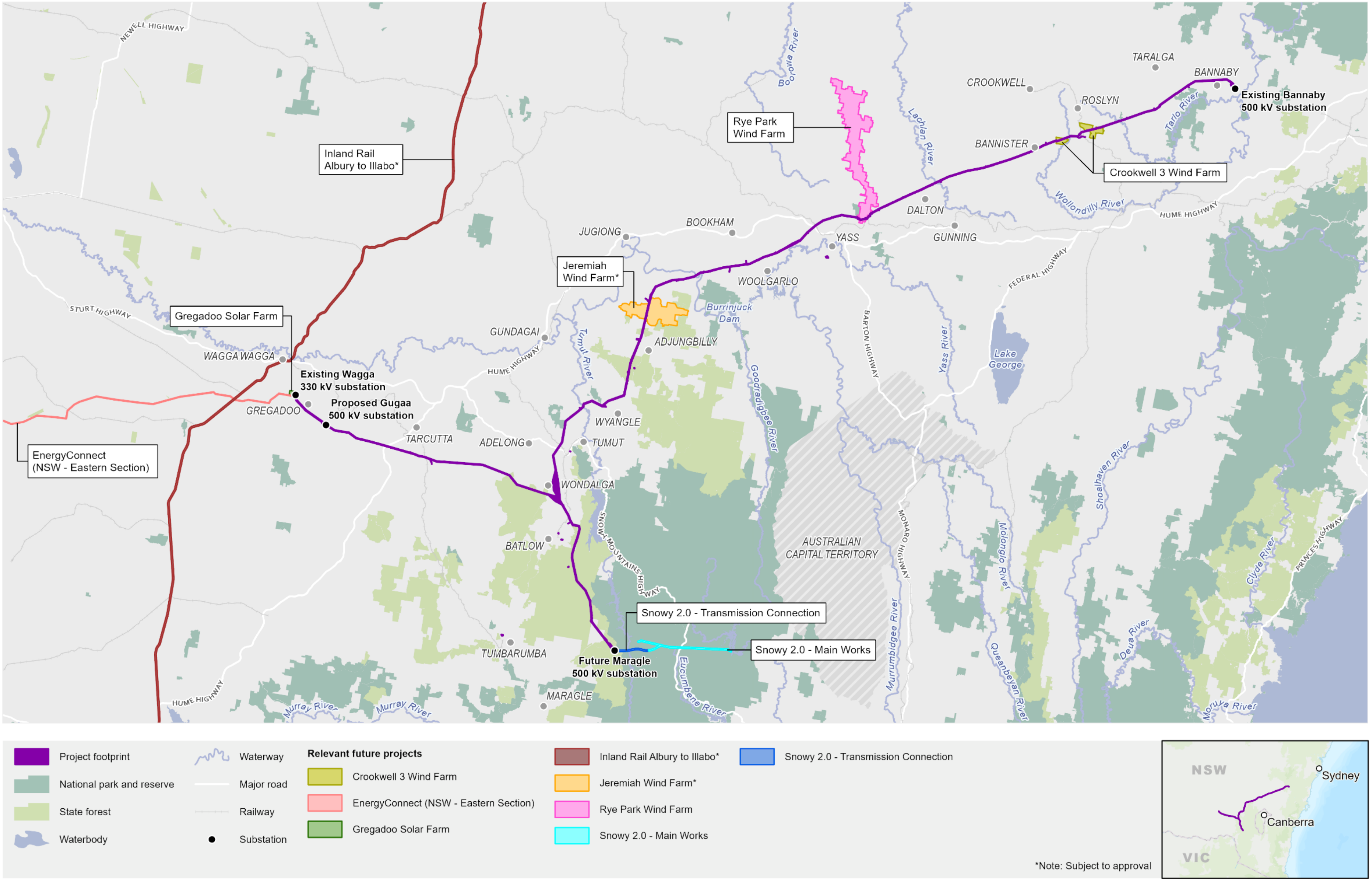

Source: *Aurecon, Transgrid, Spatial Services (DCS), ESRI Basemap*

Projection: GDA 1994 MGA Zone 55

HumeLink **Historic Heritage Impact Assessment**

FIGURE 8-2: Relevant future projects

8.2 Relevant projects

The summary of identified cumulative impacts are provided in Table 8-1.

Table 8-1 Summary of cumulative impacts identified

Project	Details	Distance/interface	Timing	Hydrology and flooding impacts
EnergyConnect (NSW – Eastern Section)	▪ The project includes a new transmission line connecting the existing Buronga substation and existing Wagga substation, and construction of the new Dinawan substation (170 km west of Wagga Wagga). The new transmission line comprises: – 375 kilometres of new 330 kilovolt double circuit transmission line and associated infrastructure between the Buronga substation and the proposed Dinawan substation. – 162 kilometres of new 500 kilovolt double circuit transmission line (operated at 330 kilovolts) and associated infrastructure between the proposed Dinawan substation and the existing Wagga 330kV substation. – Connection of the proposed transmission lines to the proposed Dinawan 330kV substation. ▪ Construction of a new 330kV substation around 30km south of Coleambally, referred to as the proposed Dinawan substation. ▪ Upgrade and expansion of the Wagga Wagga substation to accommodate the new transmission line connectors including – Installation of new line bays. – Relocation and upgrade of existing bays and associated electrical and civil works. ▪ The project also involves associated infrastructure (optical repeater structures), new and/or upgrade of access tracks as required and ancillary works to support construction.	▪ HumeLink and EnergyConnect (NSW – Eastern Section) both require upgrades of the existing Wagga substation. ▪ EnergyConnect works are proposed approximately between Wagga Wagga to the north and the catchment of Kyeamba Creek gauge at Ladysmith (Gauge ID 410048) to the south.	▪ early 2023 – late 2024 ▪ upgrade and expansion of the existing Wagga substation as part of EnergyConnect (NSW – Eastern Section) is scheduled to be completed by August 2024.	▪ The Hydrology and Flooding Impact Assessment Technical Paper, prepared by WSP as part of the project Environmental Impact Statement (EIS) (WSP, 2021), states that the upgrade and expansion of the existing Wagga 330 kV substation is not within local flood prone land and therefore impacts to or from flooding are not anticipated. Similarly, no impacts are anticipated as a result of HumeLink and therefore no cumulative impacts are expected.

Project	Details	Distance/interface	Timing	Hydrology and flooding impacts
	▪ The construction of the transmission lines and substation facilities would take around 30 months. The upgraded Wagga substation and new Dinawan 330 kV substation are expected to be operational by late-2024. Site decommissioning and remediation would extend around six months beyond the commissioning (operational) phase, with estimated completion in mid-2025.			
Gregadoo Solar Farm	▪ The Gregadoo Solar Farm would be located about 13 km south-east of Wagga Wagga, adjacent to the Wagga 330 kV substation. The project is proposed to comprise construction, operation and decommissioning of a maximum 47MW solar farm and associated infrastructure. ▪ The EIS for the project was approved in 2021. Construction is expected to commence in 2023 with nine months of construction period. The project is expected to be operational early 2024. ▪ The development site would occupy approximately 96 hectares of the 150 hectares of Lot area with available access from Boiling Down Road, Gregadoo.	▪ The Gregadoo Solar Fam is located on land (Lot 11 DP 1043022) immediately west of the existing Wagga 330 kV substation. ▪ Gregadoo Solar Farm is proposed to connect to existing Wagga 330 kV substation on the northern side of substation. ▪ The road network adjacent to the existing Wagga 330 kV substation would be used by both projects.	▪ Construction is expected to commence mid-2023 and would take nine months to complete.	▪ Located east of the Wagga 330 kV substation compound. As discussed in Section 6.2.1.1 and 6.3.2.1, no flood impacts are expected due to compounds and substation modification. Hence, no changes in flood behaviour and cumulative impact are expected at Gregadoo Solar Farm. ▪ The EIS for Gregadoo Solar Farm (NGH Environmental, 2018) states that due to the nature of the infrastructure, the development would unlikely impact inundation of any floodplain environment, hence, no changes in flood behaviour and cumulative impact are expected from Gregadoo Solar Farm.
Jeremiah Wind Farm	▪ The proposed Jeremiah Wind Farm is located approximately 29 km east of Gundagai in the Adjungbilly area. ▪ The project proposes a 65 turbine wind farm with a maximum tip height of 300 m, battery energy storage system and associated ancillary infrastructure.	▪ HumeLink transmission lines would pass through the Jeremiah Wind Farm development area.	▪ Project approval anticipated in 2023. ▪ Construction expected to be 24-30 months.	▪ Based on the type of infrastructure proposed (ie mostly wind turbine towers), it is anticipated that the wind farm would have limited influence on flooding. The proposed wind farm is likely to be located outside of high flood risk areas, with minor and localised flood impact, if any. With no flood impacts identified from HumeLink in this area, no cumulative flood impacts are expected.

Project	Details	Distance/interface	Timing	Hydrology and flooding impacts
Rye Park Wind Farm	▪ The project is located to the west of Rye Park, to the north-west of Yass and south-east of Boorowa. ▪ Modified project includes maximum 80 wind turbines with a maximum tip height of 200 m. The project also includes construction of associated infrastructure (substations, operation and maintenance facilities) and upgrades to local roads. ▪ A 330 kV switching station is proposed to the north of the HumeLink transmission line at Bango. ▪ The EIS was approved in 2017, modification 1 was approved in 2021 and modification 2 is in preparation in 2022.	▪ HumeLink transmission lines would pass through the southern end of the wind farm project boundary at Bango (near Bango Nature Reserve). ▪ HumeLink includes the connection of optical ground wire (OPGW) from the HumeLink 500 kV transmission line into the Rye Park 330 kV switching station auxiliary services building (the Rye Park Wind Farm substation).	▪ Under construction since December 2021 with commissioning scheduled for June 2023 ▪ The Environmental Assessment ((EPURON, 2014)) suggested an 18-24 month construction period.	▪ No specialist flood impact assessment was submitted as part of the Rye Park Wind Farm EIS. Due to the nature of the infrastructure (ie mostly turbine towers), no resulting flood impact is anticipated. With no flood impact predicted from HumeLink in this location, no cumulative impact on flooding is expected.
Victoria to NSW Interconnector West (VNI West)	▪ The project involves targeted interconnector expansion between Victoria and NSW to address transmission network limitations, and improve supply reliability. ▪ VNI West is still in scoping/market modelling phase to assess the technical and economic viability of expanding transmission interconnector capacity between Victoria and NSW. ▪ Several options have been developed with new interconnector corridors (VNI 6 – 8) connecting to the existing Wagga substation.	▪ VNI West may require connection at the existing Wagga 330 kV substation (depending on preferred option).	▪ Construction proposed to commence in 2026 with commissioning by 2028.	▪ No specialist flood impact assessment on the VNI West project is currently available. Due to the nature of the infrastructure (ie transmission towers), no resulting flood impact is anticipated. With no flood impact predicted from the HumeLink project in this location, no cumulative impact on flooding is expected.

Project	Details	Distance/interface	Timing	Hydrology and flooding impacts
Snowy 2.0 - Transmission Connection	▪ The Snowy 2.0 – Transmission Connection involves a new transmission connection between the proposed Snowy 2.0 pumped hydro and generation project to the existing high voltage transmission network. This includes: – A new substation located within Bago State Forest (Maragle substation) and adjacent to Transgrid's existing Line 64 that forms a 330 kV connection between Upper and Lower Tumut switching stations. – Upgrade and widening of an existing access road of Elliot Way to the substation including the construction of new driveways into the 330 kV and 500 kV switchyards. – Two new 330kV overhead double-circuit transmission lines from the Snowy 2.0 cable yard to the new substation. – Short overhead 330 kV transmission line connection (approximately 300 metres in length) comprising both steel lattice structures and pole structures as required between the substation and Line 64. ▪ An EIS has been exhibited.	▪ HumeLink to connect to the new Maragle substation being constructed as part of the Snowy 2.0 - Transmission Connection project.	▪ Construction expected to begin in late 2023 with expected completion by end of 2025.	▪ During construction, there is a potential impact to the local flood behaviour due to existing overland flow alterations or obstructions, however this would be avoided given that construction scheduling would avoid overlap between the two projects. The construction of switchyard is scheduled to be completed by first quarter of 2024 commissioning, rehabilitation and demobilisation are scheduled to be completed in the second quarter of 2024 (Jacobs, 2021). The HumeLink construction schedule is planned to commence in mid-2024, which would avoid construction overlap. Hence there would not be any cumulative impacts as a result of Snowy 2.0 - Transmission Connection during the construction phase. ▪ During operation, the hydrology assessment prepared for the project as part of the Snowy 2.0 Transmission Connection EIS concludes that the project is not expected to cause any significant adverse impacts on flooding to any nearby properties or infrastructure during operation (Jacobs, 2021). As there is no impact on flooding is expected from the HumeLink project in this location, no cumulative impact on flooding from both projects is anticipated.
Snowy 2.0 - Main Works	▪ The project includes an underground pumped hydro power station and ancillary infrastructure. ▪ The main works at Talbingo Reservoir site include excavated rock placement, portal construction and tunnelling, access roads and ancillary facilities for emplacement activities and tunnelling support	▪ Talbingo Reservoir site is approximately 5 km east of the HumeLink project footprint.	▪ Construction began in October 2020 with expected completion by 2026.	▪ According to the Snowy 2.0 Main Works EIS (EMM Consulting, 2019), there would be no major flood impact expected during the construction or operational phase. With no impact on flooding from HumeLink in this area, no cumulative impacts are expected.

Project	Details	Distance/interface	Timing	Hydrology and flooding impacts
Inland Rail – Albury to Illabo	▪ Upgrade 185 km of rail track from Albury to Illabo which passes through Wagga Wagga.	▪ Roughly 9 km north-west of existing Wagga 330 kV substation.	▪ Construction is proposed to commence in early 2024 and is expected to take about 16 months.	▪ The Inland Rail is approximately 8 km downstream of the Humelink western extent of the project footprint. The flood impact due HumeLink (transmission towers and Wagga 330 kV substation compound) would be insignificant therefore no cumulative is anticipated. ▪ According to Inland Rail - Albury to Illabo EIS (Technical Paper 11 - Hydrology, flooding and water quality) (WSP, 2022), no changes to the existing drainage and flood conditions is expected in 1% AEP. Such that no cumulative impact on flooding is anticipated.
Crookwell 3 Wind Farm	▪ 16 wind turbines up to 157 metres in height, connected to the grid via the 330 kV transmission line.	▪ Project site is within the project footprint.	▪ Detailed design and pre-construction activities are being carried out with main construction work expected to take about 18 months once commenced.	▪ Due to the nature of the infrastructure (ie mostly turbine towers) no resulting flood impact is anticipated. With no flood impact predicted from HumeLink in this location, no cumulative impact on flooding is expected.

9 Management of impacts

9.1 Overview of approach

The hydrology and flood impact assessment has identified generally minor adverse impacts on flood behaviour during construction and operation. Given that the proposed construction compounds and substations are generally located near or on minor drainage lines and overland flowpaths. The adverse impacts were typically a result of obstruction to flow due to potential earthworks. Where notable instances of this occurred, the general approach has been the following in relation to managing flood and drainage impacts at construction compounds and substations:

- Limiting filling across existing overland flowpaths and drainage lines is recommended by allowing for the drainage corridor through the site.
- Where the above is not feasible, suitable drainage (ie channels or underground pipes) may be required to convey flows through or around the site to limit upstream impacts. Subject to the adopted strategy, On Site Detention (OSD) may also be required to mitigate any increases in flow caused by the proposed development. The final approach will be determined during detailed design.
- Where filling is not proposed and no drainage is required, consideration of site layout, stockpiling and material storage is required to minimise risk of flood damage.

Flood impacts during construction would be managed through appropriate site drainage design and in accordance with site specific stormwater management plans developed during detailed design, as required.

The derived mitigation measures for the project are presented in Section 9.3.

9.2 Avoidance and minimisation of impacts

With an understanding of the flood risk to the project, avoidance and minimisation of adverse flood impacts is possible through relocation of the proposed transmission line infrastructures outside of the identified flood risk areas. This may not be possible for all infrastructure, however, should be considered in the first instance if practical to do so.

With respect to transmission line structures and access tracks, adverse impacts on flooding are not anticipated. Placing these outside of high flood risk areas would primarily avoid or minimise the risk to operations and facilitate a higher level of service or flood immunity.

No flood risk has been identified for the telecommunications hut.

A small number of construction compounds have been identified at risk of some level of overland flow interaction and are at low risk of flooding. The risks can be managed through site drainage and local flood management strategies. The Snowy Mountain Highway compound (C02) is predicted to experience major flooding on southern extent of the site and would benefit from either adopting the suggested management option (refer to Section 6.2.1) or relocation to a less flood prone location.

General construction practices for all project components should adopt:

- spreading excess excavated material evenly around the site similar to existing levels after completion of the foundation backfilling
- removing excess excavated material from the site that would influence drainage and flood behaviour and disposing them in accordance with the appropriate waste classification
- locating stockpiling and chemical storage areas outside the flood prone area and considering temporary remediation works to limit any possible influence on flooding due to earthworks and stockpiling.

9.3 Summary of mitigation measures

Table 9-1 provides the proposed mitigation measures currently identified to be required for the project based on the impact assessment.

Table 9-1 Summary of mitigation measures

Ref	Impact	Mitigation measures	Timing	Relevant location
HF1	Drainage design and stormwater management	Suitable on-site drainage design and stormwater management strategies and plans will be implemented to limit adverse flood impacts on surrounding properties during construction.	Detailed design and construction	All construction compounds
HF2	Impact of earthworks to establish new access tracks on flooding	The detailed design will consider the potential impacts on flooding associated with earthworks for new access tracks and the need for cross drainage culverts or bridge structures. The cross drainage infrastructure will be sized appropriately to minimise adverse flood impacts.	Detailed design	Access tracks
HF3	Impact on flooding at the Snowy Mountains Highway construction compound (C02)	Overland flow up to the 5% AEP event across the southern extent of the Snowy Mountains Highway compound (C02) is to remain unobstructed from bulk filling, site infrastructure and/or stockpiling. Selective placement of sensitive or vulnerable infrastructure (eg electrical equipment, buildings, machinery, stockpiles, pedestrianised areas etc) will be considered in flood prone areas.	Detailed design	Snowy Mountains Highway compound (C02)
HF4	Impact on flooding and drainage at construction compounds and Bannaby 500KV substation	Existing drainage and overland flowpaths will be maintained at the Maragle substation compound (C05), Gregadoo Road compound (C06) and Bannaby 500 kV substation. Where filling is required, suitable drainage design and stormwater management strategies and plans will be implemented to limit adverse flood impacts on surrounding properties. Selective placement of sensitive or vulnerable infrastructure (eg electrical equipment, buildings, machinery, stockpiles, pedestrianised areas etc) will be allocated to areas away from drainage lines. On site detention will be incorporated where increases in site stormwater discharges exceed predevelopment flows and will be designed in accordance with the *Blue Book* (Landcom, 2004).	Detailed design and construction	Maragle substation compound (C05), Gregadoo Road compound (C06) and Bannaby 500 kV substation
HF5	Impact on flooding and drainage at Gugaa 500 kV substation	Suitably sized cut-off drains and cross drainage culverts will be designed and constructed to maintain existing flood behaviour around and downstream of the substation footprint.	Detailed design and construction	Proposed Gugaa 500 kV substation

10 Conclusion

This report documents the hydrology and flood impact assessment carried out for the HumeLink project.

An initial desktop screening assessment based on local topography identified that the following proposed construction compounds are located on high ground with no regional or local flood risk: Snubba Road compound (C03), Honeysuckle Road compound (C07), Red Hill Road compound (C08) and Adjungbilly Road compound (C09).

The Wagga 330 kV substation compound (C01), Snowy Mountains Highway compound (C02), Maragle 500 kV substation compound (C05), Gregadoo Road compound (C06), Yass substation compound (C10), Woodhouselee Road compound (C11), Memorial Avenue compound (C14), Bowmans Lane compound (C15), Snubba Road compound (C16), Tumbarumba Accommodation Facility (AC1) and the proposed telecommunications hut were all identified for further investigation due to their proximity to waterways. Two-dimensional hydraulic modelling was undertaken to assess the flood risk of these construction compounds in more detail.

The modelling identified the Snowy Mountains Highway compound (C02) would be the most impacted by flooding. The compound is located within a local overland flowpath and is at risk for major flooding. Flood prone areas where sensitive infrastructure or stockpiling cannot be located, provision of a wide overland floodway easement is recommended at this location as a recommended mitigation measure. All other construction compounds and the worker accommodation facility have potential to result in minor flood impacts in storm events up to the 5% AEP and 2 % AEP events respectively that could be managed through the site drainage design. No impact to the telecommunications hut was identified.

The assessment also identified some locations within the project footprint within the 1% AEP flood extents with high flood hazard. During detailed design, either relocation of the transmission line structures or designing for the hydraulic loading and scour risk would be required to manage the flood hazard.

The report identified relevant flood mitigation and management measures for both operational and construction phases of the project as applicable. The resulting impacts from and on flooding is considered generally minor or low risk that can be managed through proper implementation of the recommended management measures.

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